Universal Serial Bus

Power Delivery Specification

Revision:	3.2
Version:	1.1
Release Date:	2024-10

Revision History

Revision	Version	Comments	Issue Date
1.0	1.0	Initial release Revision 1.0	5 July, 2012
1.0	1.1	Including errata through 31-October-2012	31 October 2012
1.0	1.2	Including errata through 26-June-2013	26 June, 2013
1.0	1.3	Including errata through 11-March-2014	11 March 2014
2.0	1.0	Initial release Revision 2.0	11 August 2014
2.0	1.1	Including errata through 7-May 2015	7 May 2015
2.0	1.2	Including errata through 25-March-2016	25 March 2016
2.0	1.3	Including errata through 11-January-2017	11 January 2017
3.0	1.0	Initial release Revision 3.0	11 December 2015
3.0	1.0a	Including errata through 25-March-2016	25 March 2016
3.0	1.1	Including errata through 12-January-2017	12 January 2017
3.0	1.2	Including errata through 21-June-2018	21 June 2018
3.0	2.0	Including errata through 29-August-2019	29 August 2019
3.1	1.0	Including errata through May 2021	May 2021
3.1	1.1	Including errata through July 2021 This version incorporates the following ECNs: • EPR Clarifications • Define AMS starting point	July 2021
3.1	1.2	Including errata through October 2021 This version incorporates the following ECNs: • Clarify use of Retries • Battery Capabilities • FRS timing problem • PPS power rule clarifications • Peak current support for EPR AVS APDO	October 2021
3.1	1.3	This version incorporates the following ECNs: • Robust EPR Source Operation • EPR Source Caps Editorial • SRC PPS behavior in low current request • Enter USB	January 2022
3.1	1.4	Editorial changes This version incorporates the following ECNs: • Capabilities Mismatch Update • Chunking Timing Issue • OT Mitigation	April 2022

Revision	Version	Comments	Issue Date
3.1	1.5	Editorial changes This version incorporates the following ECNs: • Timer Description Corrections • Change Source_Info Requirements • AMS Update	July 2022
3.1	1.6	Editorial changes This version incorporates the following ECNs: • USB4® V2 Updates • Data Reset Issues • Increase tSenderResponse • PPS Power Limit Bit Update • Support for Asymmetric Mode • Timer Description Corrections Revisited	October 2022
3.1	1.7	Editorial Changes This version incorporates the following ECNs: • Data Reset Invalid Reject Handling • Source request • Source Transition • EPR Entry	January 2023
3.1	1.8	Editorial Changes This version incorporates the following ECNs: • Slew rate exemption for Power Role Swap. • EUDO cable speed clarification. • Update to PPS Requirements. • Deprecate Interruptibility. • Section 7.3 restructure and update.	April 2023
3.1	1.9	Editorial Changes	July 2023

Revision	Version	Comments	Issue Date
3.2	1.0	This version incorporates the following ECNs: • VDM-use Conditions. • tTypeCSinkWaitCap. • tFirstSourceCap Clarification • Hard Reset Clarification. • Unrecognized Country Code • EPR Entry Process-1 • SPR AVS Definition • EPR Power Rules Clarifications	October 2023
3.2	1.1	This version incorporates the following ECNs: • Power Transition time from EPR to PR_Swap • Capabilities Mismatch Update • Deprecate GotoMin and GiveBack Features and Update Power Reserve • EPR Entry requirements Clarification • EPRMDO and Entry Clarification. • Remove 10.2.4 power sharing between ports • Source PDP rating field clarifications • Source Power Rules update. • Source_Info Message Clarifications. • Correction to BMC description. • EPR Source cap clarification. • Delaying of VCONN Swap. • EPR_Request in SPR Mode. • Generic transition diagram. • Removing the usage of Ping message • Sink Standby • Source Info Support	October 2024

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1 Introduction

USB has evolved from a data interface capable of supplying limited power to a primary provider of power with a data interface. Today many devices charge or get their power from USB Ports contained in laptops, cars, aircraft or even wall sockets. USB has become a ubiquitous power socket for many small devices such as cell phones and other hand-held devices. Users need USB to fulfill their requirements not only in terms of data but also to provide power to, or charge, their devices simply, often without the need to load a driver, in order to carry out "traditional" USB functions.

There are, however, still many devices which either require an additional power connection to the wall, or exceed the USB default current in order to operate. Increasingly, international regulations require better energy management due to ecological and practical concerns relating to the availability of power. Regulations limit the amount of power available from the wall which has led to a pressing need to optimize power usage. The USB Power Delivery Specification has the potential to minimize waste as it becomes a standard for charging devices that are not satisfied by ***[USBBC 1.2]*** or ***[USB Type-C 2.4]***.

Wider usage of wireless solutions is an attempt to remove data cabling but the need for "tethered" charging remains. In addition, industrial design requirements drive wired connectivity to do much more over the same connector.

USB Power Delivery is designed to enable the maximum functionality of USB by providing more flexible power delivery along with data over a single cable. Its aim is to operate with and build on the existing USB ecosystem; increasing power levels from existing USB standards, for example ***[USBBC 1.2]***, enabling new higher power use cases such as USB powered Hard Disk Drives (HDDs), laptops and monitors.

With USB Power Delivery the power direction is no longer fixed. This enables the product with the power (USB Host or Peripheral) to provide the power. For example, a display with a supply from the wall can power, or charge, a laptop. Alternatively, USB Chargers are able to supply power to laptops and other Battery powered devices through their, traditional power providing, USB Ports.

USB Power Delivery enables Hubs (including Hubs embedded in other devices such as docks or monitors) to become the means to optimize power management across multiple peripherals by allowing each device to take only the power it requires, and to get more power when required for a given application. ***Optionally*** the Hubs can communicate with the PC to enable even more intelligent and flexible management of power either automatically or with some level of user intervention.

USB Power Delivery allows low power cases such as headsets to Negotiate for only the power they require. This provides a simple solution that enables USB devices to operate at their optimal power levels.

The Power Delivery Specification, in addition to providing mechanisms to Negotiate power also can be used as a side-band channel for standard and vendor defined messaging. The specification enables discovery of cable Capabilities such as supported speeds and current levels. Power Delivery enables alternative modes of operation by providing the mechanisms to discover, enter and exit Modes such as EPR Mode, USB4® Mode or Alternate Modes.

1.1 Overview

This specification defines how USB Devices can Negotiate for more current and/or higher or lower voltages over the USB cable (using the USB Type-C® CC wire as the communications channel) than are defined in the ***[USB 2.0]***, ***[USB 3.2]***, ***[USB4]***, ***[USB Type-C 2.4]*** or ***[USBBC 1.2]*** specifications. It allows Devices with greater power requirements than can be met with today's specification to get the power they require to operate from V*BUS* and Negotiate with external power sources (e.g., Chargers).

In addition, it allows a Source and Sink to swap Power Roles such that a USB Device could supply power to the USB Host. For example, a display could supply power to a laptop to operate or charge its Battery. This specification also adds a mechanism to swap the Data Roles such that the upstream facing Port becomes the downstream facing Port and vice versa. It also enables a swap of the end supplying V*CONN* to a powered cable.

The USB Power Delivery Specification is guided by the following principles:

- Works seamlessly with legacy USB Devices.

- Compatible with existing spec-compliant USB cables.
- Minimizes potential damage from non-compliant cables (e.g., ‘Y’ cables etc.).
- Optimized for low-cost implementations.

This specification defines mechanisms to discover, enter and exit Alternate Modes defined either by a standard or by a particular vendor. These Alternate Modes can be supported either by the Port Partner or by a cable connecting the two Port Partners.

The specification defines mechanisms to discover the Capabilities of cables which can communicate using Power Delivery.

To facilitate optimum charging, the specification defines two mechanisms a USB Charger can Advertise for the device to use:

1) A list of Fixed Supply voltages each with a maximum current. The device selects a voltage and current from the list. This is the traditional model used by devices that use internal electronics to manage the charging of their Battery including modifying the voltage and current actually supplied to the Battery. The side-effect of this model is that the charging circuitry generates heat that can be problematic for small form factor devices.

2) A list of programmable voltage ranges, in SPR PPS Mode, each with a maximum current. The device requests a voltage (in 20mV increments) that is within the Advertised range and a maximum current. The USB PPS Charger delivers the requested voltage until the maximum current is reached at which time the USB PPS Charger reduces its output voltage so as not to supply more than the requested maximum current. During the high current portion of the charge cycle, the USB PPS Charger can be directly connected (through an appropriate safety device) to the Battery. This model is used by devices that want to minimize the thermal impact of their internal charging circuitry.

3) A list of adjustable voltage ranges, in SPR AVS Mode or EPR AVS Mode, each with a maximum current. The device requests a voltage (in 100mV increments) that is within the Advertised range and a maximum current. The USB AVS Charger delivers the requested voltage.

1.2 Purpose

The USB Power Delivery specification defines a power delivery system covering all elements of a USB system including USB Hosts, USB Devices, Hubs, Chargers and cable assemblies. This specification describes the architecture, protocols, power supply behavior, connectors and cabling necessary for managing power delivery over USB at up to 100W in SPR Mode and 240W in EPR Mode. This specification is intended to be fully compatible with and extend the existing USB infrastructure. It is intended that this specification will allow system OEMs, power supply and Peripheral developers adequate flexibility for product versatility and market differentiation without losing backwards compatibility.

USB Power Delivery is designed to operate independently of the existing USB bus defined mechanisms used to Negotiate power which are:

- ***[USB 2.0]***, ***[USB 3.2]*** in band requests for high power interfaces.
- ***[USBBC 1.2]*** mechanisms for supplying higher power (not mandated by this specification).
- ***[USB Type-C 2.4]*** mechanisms for supplying higher power.

Initial operating conditions remain the USB Default Operation as defined in ***[USB 2.0]***, ***[USB 3.2]***, ***[USB Type-C 2.4]*** or ***[USBBC 1.2]***.

- The DFP sources ***vSafe5V*** over V*BUS*.
- The UFP consumes power from V*BUS*.

1.2.1 Scope

This specification is intended as an extension to the existing ***[USB 2.0]***, ***[USB 3.2]***, ***[USB Type-C 2.4]*** and ***[USBBC 1.2]*** specifications. It addresses only the elements required to implement USB Power Delivery. It is targeted at power supply vendors, manufacturers of ***[USB 2.0]***, ***[USB 3.2]***, ***[USB Type-C 2.4]*** and ***[USBBC 1.2]*** platforms, devices and cable assemblies.

Normative information is provided to allow interoperability of components designed to this specification. ***Informative*** information, when provided, illustrates possible design implementation.

1.3 Section Overview

This specification contains the following sections:

Table 1.1 Section Overview

Section	Description
Section 1, "Introduction"	Introduction, conventions used in the document, list of terms and abbreviations, references, and details of parameter usage.
Section 2, "Overview"	Overview of the document including a description of the operation of *PD* and the architecture.
Section 3, "USB Type-A and USB Type-B Cable Assemblies and Connectors"	Mechanical and electrical characteristics of the cables and connectors used by *PD*. Section ***Deprecated***. See ***[USBPD 2.0]*** for legacy *PD* connector specification.
Section 4, "Electrical Requirements"	Electrical requirements for *Dead Battery* operation and cable detection.
Section 5, "Physical Layer"	Details of the *PD PHY Layer* requirements
Section 6, "Protocol Layer"	*Protocol Layer* requirements including the *Message*s, timers, counters, and state operation.
Section 7, "Power Supply"	Power supply requirements for both *Provider*s and *Consumer*s.
Section 8, "Device Policy"	*Device Policy Manager* requirements. *Policy Engine Atomic Message Sequence* (*AMS*) diagrams and state diagrams
Section 9, "States and Status Reporting"	*PDUSB Device* requirements including mapping of *VBUS* to USB states. *System Policy Manager* requirements including descriptors, events, and requests.
Section 10, "Power Rules"	*PDP Rating* definitions for *PD*.
Section A, "CRC calculation"	Example *CRC* calculations.
Section B, "Message Sequence Examples (Deprecated)"	Scenarios illustrating *Device Policy Manager* operation. ***Deprecated***
Section C, "VDM Command Examples"	Examples of *Structured VDM* usage.Section ***Deprecated***.
Section D, "BMC Receiver Design Examples"	*BMC* Receiver Design Examples.
Section E, "FRS System Level Example"	*FRS* System Level Example.

1.4 Conventions

1.4.1 Precedence

If there is a conflict between text, figures, and tables, the precedence ***Shall*** be tables, figures, and then text.

In there is a conflict between a generic statement and a more specific statement, the more specific statement ***Shall*** apply.

1.4.2 Keywords

The following keywords differentiate between the levels of requirements and options.

Table 1.2 Keywords

Keyword	Definition
Conditional Normative	***Conditional Normative*** is a keyword used to indicate a feature that is mandatory when another related feature has been implemented. Designers are mandated to implement all such requirements, when the dependent features have been implemented, to ensure interoperability with other compliant devices.
Deprecated	***Deprecated*** is a keyword used to indicate a feature, supported in previous releases of the specification, which is no longer supported.
Discard	See ***Discarded***.
Discarded	***Discard***, ***Discards*** and ***Discarded*** are equivalent keywords indicating that a *Packet* when received ***Shall*** be thrown away by the *PHY Layer* and not passed to the *Protocol Layer* for processing. No ***GoodCRC*** *Message* ***Shall*** be sent in response to the *Packet*.
Discards	See ***Discarded***.
Ignore	See ***Ignored***.
Ignored	***Ignore***, ***Ignores*** and ***Ignored*** are equivalent keywords indicating *Messages* or *Message* fields which, when received, ***Shall*** result in no special action by the receiver. An ***Ignored*** *Message* ***Shall*** only result in returning a ***GoodCRC*** *Message* to acknowledge *Message* receipt. A *Message* with an ***Ignored*** field ***Shall*** be processed normally except for any actions relating to the ***Ignored*** field.
Ignores	See ***Ignored***.
Informative	***Informative*** is a keyword indicating text with no specific requirements, provided only to improve understanding.
Invalid	***Invalid*** is a keyword when used in relation to a *Packet* indicates that the *Packet*'s usage or fields fall outside of the defined specification usage. When ***Invalid*** is used in relation to an *Explicit Contract* it indicates that a previously established *Explicit Contract* which can no longer be maintained by the *Source*. When ***Invalid*** is used in relation to individual *K-codes* or *K-code* sequences indicates that the received *Signaling* falls outside of the defined specification.
May	***May*** is a keyword that indicates a choice with no implied preference.
May Not	***May Not*** is a keyword that is the inverse of ***May***. Indicates a choice to not implement a given feature with no implied preference.
N/A	***N/A*** is a keyword that indicates that a field or value is not applicable and has no defined value and ***Shall Not*** be checked or used by the recipient.
Normative	See ***Shall***.
Optional	***Optional***, ***Optionally*** and ***Optional Normative*** are equivalent keywords that describe features not mandated by this specification. However, if an ***Optional*** feature is implemented, the feature ***Shall*** be implemented as defined by this specification.
Optional Normative	See ***Optional***.
Optionally	See ***Optional***.

Table 1.2 Keywords (Continued)

Keyword	Definition
Reserved	***Reserved*** is a keyword indicating bits, bytes, words, fields, and code values that are set-aside for future standardization. Their use and interpretation ***May*** be specified by future extensions to this specification and ***Shall Not*** be utilized or adapted by vendor implementation. A ***Reserved*** bit, byte, word, or field ***Shall*** be set to zero by the sender and ***Shall*** be ***Ignored*** by the receiver. ***Reserved*** field values ***Shall Not*** be sent by the sender and ***Shall*** be ***Ignored*** by the receiver.
Shall	***Shall*** and ***Normative*** are equivalent keywords indicating a mandatory requirement. Designers are mandated to implement all such requirements to ensure interoperability with other compliant devices.
Shall Not	***Shall Not*** is a keyword that is the inverse of ***Shall*** indicating non-compliant operation.
Should	***Should*** is a keyword indicating flexibility of choice with a preferred alternative; equivalent to the phrase "it is recommended that…".
Should Not	***Should Not*** is a keyword is the inverse of ***Should***; equivalent to the phrase "it is recommended that implementations do not…".
Static	***Static*** is a keyword indicating that a field that never changes.
Valid	***Valid*** is a keyword that is the inverse of ***Invalid*** indicating either a Packet or *Signaling* that fall within the defined specification or an *Explicit Contract* that can be maintained by the *Source*.

1.4.3 Numbering

Numbers that are immediately followed by a lowercase "b" (e.g., 01b) are binary values. Numbers that are immediately followed by an uppercase "B" are byte values. Numbers that are immediately followed by a lowercase "h" (e.g., 3Ah) or are preceded by "0x" (e.g., 0xFF00) are hexadecimal values. Numbers not immediately followed by either a "b", "B", or "h" are decimal values.

1.5 Related Documents

Document references listed in *Table 1.3, "Document References"* are inclusive of all approved and published ECNs and Errata.

Table 1.3 Document References

Bookmark Reference	Title
[DPTC2.1]	DisplayPort^{TM} Alt Mode on *USB Type-C* Standard *www.vesa.org*.
[IEC 60950-1]	IEC 60950-1:2005 Information technology equipment – Safety – Part 1: General requirements: Amendment 1:2009, Amendment 2:2013. *www.iec.ch*.
[IEC 60958-1]	IEC 60958-1:2021 Digital Audio Interface Part:1 General. *www.iec.ch*.
[IEC 62368-1]	IEC 62368-1:2018 Audio/Video, information, and communication technology equipment – Part 1: Safety requirements. *www.iec.ch*.
[IEC 62368-3]	IEC 62368-3:2017 Audio/video, information, and communication technology equipment - Part 3: Safety aspects for DC power transfer through communication cables and ports *www.iec.ch*.
[IEC 63002]	IEC 63002:2021 Interoperability specifications and communication method for external power supplies used with computing and consumer electronics devices *www.iec.ch*.
[ISO 3166]	ISO 3166 international Standard for country codes and codes for their subdivisions. *http://www.iso.org/iso/home/standards/country_codes.htm*.
[TBT3]	see [USB4] Chapter 13 for Thunderbolt^{TM} 3 device operation.
[UCSI]	*USB Type-C* Connector System Software Interface (UCSI) Specification *https://www.usb.org/documents*.
[USB 2.0]	Universal Serial Bus 2.0 Specification, *https://www.usb.org/documents*.
[USB 3.2]	Universal Serial Bus 3.2 Specification *https://www.usb.org/documents*.
[USB Type-C 2.4]	Universal Serial Bus Type-C Cable and Connector Specification, *https://www.usb.org/documents*.
[USB4]	Universal Serial Bus 4 Specification (USB4®), *https://www.usb.org/documents*.
[USBBC 1.2]	Universal Serial Bus Battery Charging Specification plus Errata (referred to in this document as the Battery Charging specification). *https://www.usb.org/documents*.
[USBPD 2.0]	Universal Serial Bus Power Delivery Specification, *https://www.usb.org/documents*.
[USBPDCompliance]	USB Power Delivery Compliance Test Specification, *https://www.usb.org/documents*.
[USBPDFirmwareUpdate 1.0]	Universal Serial Bus Power Delivery Firmware Update Specification, *https://www.usb.org/documents*.
[USBTypeCAuthentication 1.0]	Universal Serial Bus Type-C Authentication Specification, *https://www.usb.org/documents*.
[USBTypeCBridge 1.1]	Universal Serial Bus Type-C Bridge Specification, *https://www.usb.org/documents*.

1.6 Terms and Abbreviations

This section defines terms used throughout this document. For additional terms that pertain to the Universal Serial Bus, see Chapter 2, “Terms and Abbreviations,” in ***[USB 2.0]***, ***[USB 3.2]***, ***[USB Type-C 2.4]*** and ***[USBBC 1.2]***.

Table 1.4 Terms and Abbreviations

Term	Description
(A)PDO	Refers to both the *PDO* and *APDO* collectively.
AC Supply *AC Supplied*	Refers to the main AC power source typically provided to the wall AKA “mains”.
Active Cable	A cable with a *USB Type-C* plug on each end that incorporates data bus signal conditioning circuits. The cable supports the Structured VDM ***Discover Identity*** *Command* to expose its characteristics in addition to other Structured VDM *Commands* (Electronically Marked Cable see ***[USB Type-C 2.4]***).
Active Cable VDO	VDO defining the Capabilities of an Active Cable.
Active Mode	A *Mode* which has been through the *Mode Entry* process but not the *Mode Exit* process.
Adjustable Voltage Supply	A power supply whose output voltage can be adjusted to an operating voltage within its Advertised range. These *Capabilities* are exposed by the *Adjustable Voltage Supply* (*AVS*) *APDO* (see *Section 6.4.1.2.4, "Augmented Power Data Object (APDO)"*). **Note:** Unlike the *SPR PPS*, the *SPR AVS* and *EPR AVS* do not support current limit.
Advertise	An offer made by a *Source* in the ***Source_Capabilities***/***EPR_Source_Capabilities*** *Message* (e.g., an *APDO* or *PDO*).
Alternate Mode	Operation defined by a Vendor or Standard’s organization, which is associated with a *SVID*. The definition of *Alternate Modes* is outside the scope of USB-IF specifications. Entry to and exit from the *Alternate Mode* uses the *Mode Entry* and *Mode Exit* processes. As defined in ***[USB Type-C 2.4]***.
Alternate Mode Adapter	A *PDUSB Device* which supports *Alternate Modes* as defined in ***[USB Type-C 2.4]***. **Note:** Since an *AMA* is a *PDUSB Device*, it has a single *UFP* that is only addressable by *SOP Packets*.
Alternate Mode Controller	A *DFP* that supports connection to *AMAs* as defined in ***[USB Type-C 2.4]***. A *DFP* that is an *AMC* can also be a *PDUSB Host*.
AMA	See *Alternate Mode Adapter*.
AMC	See *Alternate Mode Controller*.
AMS	See *Atomic Message Sequence*.
APDO	See *Augmented Power Data Object*.
Assured Capacity Charger	As defined in ***[USB Type-C 2.4]***. This maps to a *Charger* with one or more *Guaranteed Capability Ports*.
Assured Capacity Group	As defined in ***[USB Type-C 2.4]***. This maps to a group of *Guaranteed Capability Ports*.
Atomic Message Sequence	A fixed sequence of *Messages* as defined in *Section 8.3.2, "Atomic Message Sequence Diagrams"* typically starting and ending in one of the following states: ***PE_SRC_Ready***, ***PE_SNK_Ready*** or ***PE_CBL_Ready***. An *AMS* is *Non-interruptible*.
Attach	Mechanical joining of the *Port Pair* by a cable.
Attached	USB Power Delivery *Ports* which are mechanically joined with USB cable.
Attachment	See *Attach*.
Augmented Power Data Object	*Data Object* used to expose a *Source Port*'s or *Sink Port*'s power *Capabilities* as part of a ***Source_Capabilities***/***EPR_Source_Capabilities*** or ***Sink_Capabilities***/***EPR_Sink_Capabilities*** *Message* respectively. An *SPR PPS Data Object*, *SPR AVS Data Object* and *EPR AVS Data Object* are defined.
AVS	See *Adjustable Voltage Supply*.
AVS Mode	A power supply, currently operating as an *AVS*, is said to be operating in *AVS Mode*.
Battery	A power storage device residing behind a *Port* that can either be a *Source* or *Sink* of power.

Table 1.4 Terms and Abbreviations (Continued)

Term	Description
Battery Slot	A physical location where a *Hot Swappable Battery* can be installed. A *Battery Slot* might or might not have a *Hot Swappable Battery* present in a *Battery Slot* at any given time.
Battery Supply	A power supply that directly applies the output of a *Battery* to *VBUS*. This is exposed by the *Battery Supply PDO* (see Section 6.4.1.2.3, "Battery Supply Power Data Object").
BDO	See *BIST Data Object*.
BFSK	See *Binary Frequency Shift Keying*.
Bi-phase Mark Coding	Modification of Manchester coding where each zero has one transition and a one has two transitions (see ***[IEC 60958-1]***).
Binary Frequency Shift Keying	A *Signaling Scheme* now ***Deprecated*** in this specification. *BFSK* used a pair of discrete frequencies to transmit binary (0s and 1s) information over *VBUS*. See ***[USBPD 2.0]*** for further details.
BIST	Built-In Self-Test - Power Delivery testing mechanism for the *PHY Layer*.
BIST Data Object	*Data Object* used by *BIST Message*s.
BIST Mode	A *BIST* receiver or transmitter test mode enabled by a *BIST Message*.
BIST Carrier Mode	A *BIST Mode* in which the *PHY Layer* sends out a *BMC* encoded continuous string of alternating "1"s and "0"s.
BIST Test Data Mode	A *BIST Mode* in which the *PHY Layer* sends out a ***GoodCRC*** *Message* and then enters a test mode where it sends no further *Message*s, except ***GoodCRC*** *Message*s, in response to received *Message*s.
BIST Shared Capacity Test Mode	A *BIST Mode* applicable only to a *Shared Capacity Group* of *Port*s where the maximum *Source Capabilities* are always offered on every *Port*, regardless of the availability of shared power i.e., all shared power management is disabled.
BMC	See *Bi-phase Mark Coding*.
Cable Capabilities	*Capabilities* offered by a *Cable Plug*.
Cable Discovered	USB Power Delivery *Port*s that have exchanged a *Message* and a ***GoodCRC*** *Message* response with a *Cable Plug* or a *VPD* using the USB Power Delivery protocol so that both the *Port* and the *Cable Plug* know that each is *PD Capable* and which *Revision* they each support.
Cable Discovery	See *Cable Discovered*.
Cable Plug	Term used to describe a *PD Capable* element in a *Multi-Drop* system addressed by *SOP’ Packets*/ *SOP’’ Packet*s. Logically the *Cable Plug* is associated with a *USB Type-C* plug at one end of the cable. In a practical implementation, the electronics might reside anywhere in the cable.
Cable Reset	This is initiated by ***Cable Reset*** *Signaling* from the *DFP*. It restores the *Cable Plug*s to their default, power up condition and resets the *PD* communications engine in the cable to its default state. It does not reset the *Port Partner*s but does restore *VCONN* to its *Attachment* state.
Cable VDO	*VDO* returned by the *Cable Plug* containing *Cable Capabilities*.
Capabilities	Features supported by a product. These can include, for example, power levels supplied/ needed, cable type, *Battery* support or ***[USB4]*** support.
Capabilities Mismatch	Indication from the *Sink* that the *Source*’s *Advertised Capabilities* don’t match the *Sink*’s needs.
CC	See *Configuration Channel*.
Cert Stat VDO	The *Cert Stat VDO* contains the XID assigned by USB-IF to the product before certification in binary format.
Charge Through	A mechanism for a *VCONN Powered USB Device* (*VPD*) to pass power and *CC* communication from one *Port* to the other without any interference or re-regulation.
Charge Through Port	The *USB Type-C* receptacle on a *USB Device* that is designed to allow a *Source* to be connected through the *USB Device* to charge a system to which it is *Attached*. Most common use is to allow a single *Port USB Host* to support a *USB Device* while being charged.
Charger	*Provider* whose primary purpose is to supply power to a *Consumer* or *Consumers* in order to charge their *Battery*.
Chunk	A ***MaxExtendedMsgChunkLen*** (26 byte) or less portion of a *Data Block*. *Data Block*s can be sent either as a single *Message* or as a series of *Chunk*s.

Table 1.4 Terms and Abbreviations (Continued)

Term	Description
Chunked	See *Chunking*.
Chunked Extended Message	*Extended Message* which has been broken up into *Chunks*.
Chunking	The process of breaking up a *Data Block* larger than ***MaxExtendedMsgLegacyLen*** (26-bytes) into two or more *Chunks*.
Chunking Layer	Part of the *Protocol Layer* responsible for *Chunking*.
CL	See *Current Limit*.
Cold Socket	A *Port* that does not apply ***vSafe5V*** on *VBUS* until a *Sink* is *Attached*.
Collision Avoidance	Mechanisms to prevent simultaneous communication by the *Source*, *Sink* and *Cable Plug* on *CC*.
Command	Request and response pair defined as part of a *Structured Vendor Defined Message* (see *Section 6.4.4.2, "Structured VDM"*).
Configuration Channel	Single wire used by the *BMC PHY Layer Signaling Scheme* (see ***[USB Type-C 2.4]***).
Connect	See *Connected*.
Connected	USB Power Delivery ports that have exchanged a *Message* and a ***GoodCRC*** *Message* response using the USB Power Delivery protocol so that both *Port Partners* know that each is *PD Capable*.
Constant Voltage	A constant voltage feature of an *SPR PPS Source*. The *SPR PPS Source* output voltage remains constant as the load changes up to its *Current Limit*.
Consumer	The capability of a *PD Port* (typically a *Device*'s *UFP*) to sink power from the power conductor (e.g., *VBUS*). This corresponds to a *USB Type-C Port* with R_d asserted on its *CC* wire.
Consumer/Provider	A *Consumer* with the additional capability to function as a *Provider*. This corresponds to a *Dual-Role Power Port* with R_d asserted on its *CC* wire.
Continuous BIST Mode	The *BIST Mode* where the *Port* or *Cable Plug* being tested sends a continuous stream of test data.
Contract	An agreement on both power level and direction is reached between a *Port Pair*. A *Contract* could be explicitly *Negotiated* between the *Port Pair* or could be an implicit power level defined by the current *State*. While operating in Power Delivery mode there will always be either an *Explicit Contract* or *Implicit Contract* in place. The *Contract* can only be altered in the case of a *Negotiation*/*Re-negotiation*, *Power Role Swap*, *Fast Role Swap*, *Hard Reset*, *Error Recovery* or failure of the *Source*.
Control Message	A *Control Message* is defined as a *Message* with the ***Number of Data Objects*** field in the *Message Header* is set to zero. The *Control Message* consists only of a *Message Header* and a *CRC*.
CRC	*CRC* stands for Cyclic Redundancy Check. It is an error-detecting code used to determine if a block of data has been corrupted.
CT-VPD	See *VCONN Powered USB Charge Through Device*.
Current Limit	A current limiting feature of an *SPR PPS Source*. When a *Sink* operating in *SPR PPS* mode attempts to draw more current from the *Source* than the requested *Current Limit* value, the *Source* reduces its output voltage so the current it supplies remains at or below the requested value. **Note:** *Current Limit* is not supported by *SPR AVS* and *EPR AVS Sources*.
CV	See *Constant Voltage*.
Data Block	An *Extended Message Payload* data unit. The size of each type of *Data Block* is specified as a series of bytes up to ***MaxExtendedMsgLen*** bytes in length. This is distinct from a *Data Object* used by a *Data Message* which is always a 32-bit object.
Data Message	A *Data Message* consists of a *Message Header* followed by one or more *Data Objects*. *Data Messages* are easily identifiable because the ***Number of Data Objects*** field in the *Message Header* is always a non-zero value.
Data Object	A *Data Message Payload* data unit. This 32-bit object contains information specific to different types of *Data Message*. For example Power, Request, *BIST*, and Vendor *Data Objects* are defined.
Data Reset	Process which resets USB Communication.
Data Role	A *Port Partner* will be in one of two *Data Roles*; either *DFP* (*USB Host*) or *UFP* (*USB Device*).
Data Role Swap	Process of exchanging the *Data Roles* between *Port Partners*.
Dead Battery	A device has a *Dead Battery* when the *Battery* in a device is unable to power its functions.

Table 1.4 Terms and Abbreviations (Continued)

Term	Description
Default Contract	An agreement on current at 5V is reached between a *Port Pair* based on *USB Type-C* current (***[USB Type-C 2.4]***).
Detach	Mechanical unjoining of the *Port Pair* by removal of the cable.
Detached	USB Power Delivery *Port*s which are no longer mechanically joined with USB cable.
Detaches	See *Detach*.
Device	When lower cased (device), it refers to any USB product, either *USB Device* or *USB Host*. When in upper case refers to a *USB Device* (*Peripheral* or *Hub*).
Device Policy	Policy applied across multiple *Ports* in a *Source* or *Sink*.
Device Policy Manager	Module running in a *Source* or *Sink* that applies *Device Policy* to each *Port* in the device, as *Local Policy*, via the *Policy Engine*.
DFP	See *Downstream Facing Port*.
DFP VDO	*VDO* returned by the *DFP* containing *Capabilities*.
Differential Non-Linearity	The difference between an ideal *LSB* step, and the real observable *LSB* step when the Power *Source* is operating in either *PPS* or *AVS* mode. A ***DNL*** of 0 indicates that the step is ideal. If ***DNL*** is positive the step is larger than the ideal *LSB*, and if it is negative then the step is smaller than ideal.
Discovery Process	*Command* sequence using *Structured Vendor Defined Messages* resulting in identification of the *Port Partner* and *Cable Plug*, and their supported *SVIDs* and *Alternate Mode*s.
DNL	See *Differential Non-Linearity*.
Downstream Facing Port	Indicates the *Port*'s position in the USB topology which typically corresponds to a *USB Host* root *Port* or *Hub* downstream *Port* as defined in ***[USB Type-C 2.4]***. At connection, the *Port* defaults to operation as the *Source* and as a *USB Host* (when *USB Communication* is supported).
DPM	See *Device Policy Manager*.
DRD	See *Dual-Role Data*.
DRP	See *Dual-Role Power*.
Dual-Role Data	Capability of operating as either a *DFP* or *UFP*.
Dual-Role Data Port	A *Port* capable of operating as *DRD*.
Dual-Role Power	Capability of operating as either a *Source* or *Sink*.
Dual-Role Power Device	A product containing one or more *Dual-Role Power Ports* that can operate as either a *Source* or a *Sink*.
Dual-Role Power Port	A *Port* capable of operating as a *DRP*.
EM	See *Extended Message*.
End of Packet	*K-code* marker used to delineate the end of a *Packet*.
EOP	See *End of Packet*.
EPR	See *Extended Power Range*.
EPR AVS	A power supply operating in *EPR Mode* whose output voltage can be adjusted to an operating voltage within its *Advertise*d range. Unlike *SPR PPS* it does not support current limit. The *AVS Capabilities* are exposed by the *Adjustable Voltage Supply APDO* (see Section 6.4.1.2.4, *"Augmented Power Data Object (APDO)"*).
EPR AVS Mode	A *EPR Source*, currently operating in an *EPR AVS Contract*, is said to be operating in *EPR AVS Mode*.
EPR Cable	A cable which is rated to operate in both *SPR Mode* and *EPR Mode*.
EPR Capabilities	The *EPR Capabilities Messages* (***EPR_Source_Capabilities*** and ***EPR_Sink_Capabilities***) are *Extended Messages* with the first seven positions filled with the same *SPR (A)PDO*s returned by the *SPR Capabilities Messages* (***Source_Capabilities*** and ***Sink_Capabilities***) followed by the *EPR (A)PDO*s starting in the eighth position.
EPR Capable	A product which has the ability to operate in *EPR Mode*.

Table 1.4 Terms and Abbreviations (Continued)

Term	Description
EPR Mode	A Power Delivery mode of operation where maximum allowable voltage is 48V. The *Sink* complies to the requirements of ***[IEC 62368-1]*** for operation with a PS3 *Source*. The *Source* complies to the requirements of ***[IEC 62368-1]*** for operation with a PS3 *Sink*. The cable complies with ***[IEC 62368-1]***. Entry into the *EPR Mode* requires that an *EPR Source* is *Attached* to an *EPR Sink* with an *EPR Cable*. The *EPR Source* will only enter the *EPR Mode* when requested to do so by the *Sink* and it has determined it is *Attached* to an *EPR Sink* with an *EPR Capable* cable. Only the ***EPR_Source_Capabilities*** and the ***EPR_Request*** *Message*s are allowed to *Negotiate EPR Explicit Contract*s. The *SPR Mode Messages* (***Source_Capabilities*** and ***Request***) are not allowed to be used while in *EPR Mode*.
EPR (A)PDO	*Fixed Supply PDO* that offers either 28V, 36V or 48V. *Adjustable Voltage Supply* (*AVS*) *APDO* whose Maximum voltage is the highest *Fixed Supply PDO* voltage in the ***EPR_Source_Capabilities*** *Message* and no more than 240W.
EPR Sink	A *Sink* that supports both *SPR Mode* and *EPR Mode*.
EPR Sink Port	A *Port* exposed on an *EPR Sink*.
EPR Source	A *Source* that supports both *SPR Mode* and *EPR Mode*.
EPR Source Port	A *Port* exposed on an *EPR Source*.
Error Recovery	*Port* enters the ***ErrorRecovery*** *State* as defined in ***[USB Type-C 2.4]***.
Explicit Contract	An agreement reached between a *Port Pair* as a result of the Power Delivery *Negotiation* process. An *Explicit Contract* is established (or continued) when a *Source* sends an ***Accept*** *Message* in response to a ***Request*** *Message* sent by a *Sink* followed by a ***PS_RDY*** *Message* sent by the *Source* to indicate that the power supply is ready. This corresponds to the ***PE_SRC_Ready*** *State* for a *Source Policy Engine* and the ***PE_SNK_Ready*** *State* for a *Source Policy Engine*. The *Explicit Contract* can be altered through the *Re-negotiation* process.
Extended Capabilities	An *Extended Message* containing *Capabilities* information.
Extended Control Message	An *Extended Message* containing control information only.
Extended Message	A *Message* containing *Data Block*s. The *Extended Message* is defined by the ***Extended*** field in the *Message Header* being set to one and contains an *Extended Message Header* immediately following the *Message Header*.
Extended Message Header	Every *Extended Message* contains a 16-bit *Extended Message Header* immediately following the *Message Header* containing information about the *Data Block* and any *Chunking* being applied.
Extended Power Range	Extends the power range from a maximum of 100W (*SPR*) to a maximum of 240W (*EPR*). When operating in the *EPR Mode*, only *EPR* specific *Messages* (the ***EPR_Source_Capabilities*** *Message* and the ***EPR_Request*** *Message*) are used to *Negotiate Explicit Contract*s.
External Supply	Power supply external to the device. This could be powered from the wall or from any other power source.
Fast Role Swap	Process of exchanging the *Source* and *Sink Power Role*s between *Port Partner*s rapidly due to the disconnection of an external power supply.
Fast Role Swap Request	An indication from an *Initial Source* to the *Initial Sink* that a *Fast Role Swap* is needed. The *Fast Role Swap Request* is indicated by driving the *CC* line to ground for a short period; it is not a *Message* or *Signaling*.
First Explicit Contract	The *Explicit Contract* that immediately follows an *Attach*, power on *Hard Reset*, *Power Role Swap* or *Fast Role Swap* event.
Fixed Battery *Fixed Batteries*	A *Battery* that is not easily removed or replaced by an end user e.g., requires a special tool to access or is soldered in.
Fixed Supply	A well-regulated fixed voltage power supply. This is exposed by the *Fixed Supply PDO* (see *Section 6.4.1.2.1, "Fixed Supply Power Data Object"*)
Frame	Generic term referring to an atomic communication transmitted by *PD* such as a *Packet*, *Test Frame* or *Signaling*.
FRS	See *Fast Role Swap*.

Table 1.4 Terms and Abbreviations (Continued)

Term	Description
Guaranteed Capability Port	A *Guaranteed Capability Port* is always capable of delivering its ***Port Maximum PDP*** and indicates this by setting its ***Port Present PDP*** to be the same as its ***Port Maximum PDP*** except when limited by the cable's *Capabilities*. This is a ***Static*** capability.
Hard Reset	This is initiated by ***Hard Reset*** *Signaling* from either *Port Partner*. It restores *VBUS* to *USB Default Operation* and resets the *PD* communications engine to its default *State* in both *Port Partner*s as well as in any *Attached Cable Plug*s. It restores both *Port Partner*s to their default *Data Roles* and returns the *VCONN Source* to the *Source Port*. A *DRP Source Port* operating as a *Source* will continue to operate as a *Source*.
Host	See *USB Host*.
Hot Swappable Battery	A *Battery* that is easily accessible for a user to remove or change for another *Battery*.
Hub	A *USB Device* that provides additional connections to the USB.
ID Header VDO	The *VDO* in a ***Discover Identity*** *Command* immediately following the *VDM Header*. The *ID Header VDO* contains information corresponding to the Power Delivery Product.
Idle	Condition on *CC* where there are no signal transitions within a given time window. See *Section 5.8.6.1, "Definition of Idle"*.
Implicit Contract	An agreement on power levels between a *Port Pair* which occurs, not because of the Power Delivery *Negotiation* process, but because of a *Power Role Swap* or *Fast Role Swap*. *Implicit Contract*s are transitory since the *Port Pair* is required to immediately *Negotiate* an *Explicit Contract* after the *Power Role Swap*. An *Implicit Contract* ***Shall*** be limited to *USB Type-C* current (see ***[USB Type-C 2.4]***).
Initial Sink	*Sink* at the start of a *Power Role Swap* or *Fast Role Swap* which transitions to being the *New Source*.
Initial Source	*Source* at the start of a *Power Role Swap* or *Fast Role Swap* which transitions to being the *New Sink*.
Initiator	The initial sender of a *Command* request in the form of a query.
Invariant PDOs	A *Source Port* that offers *Invariant PDOs* will always Advertise the same *PDO*s except when limited by the cable.
IoC	The *Negotiated* current value as defined in ***[IEC 63002]***.
IR Drop	The voltage drop across the cable and connectors between the *Source* and the *Sink* as defined in ***[USB Type-C 2.4]***. It is a function of the resistance of the ground and power wire in the cable plus the contact resistance in the connectors times the current flowing over the path.
K-code	Special symbols provided by the 4b5b coding scheme. *K-codes* are used to signal *Hard Reset* and *Cable Reset* and delineate *Packet* boundaries.
Local Policy	Every *PD Capable* device has its own *Policy*, called the *Local Policy* that is executed by its *Policy Engine* to control its power delivery behavior. The *Local Policy* at any given time might be the default policy, hard coded or modified by changes in operating parameters or one provided by the system *USB Host* or some combination of these. The *Local Policy* ***Optionally*** can be changed by a *System Policy Manager*.
LPS	Limited Power Supply as defined in ***[IEC 62368-1]***.
LSB	An abbreviation for Least Significant Bit.
Managed Capability Port	A *Managed Capability Port* can have its ***Port Present PDP*** set to a different value than its ***Port Maximum PDP***. Its ***Port Present PDP*** value can be dynamic and change during normal operation.
Message	The *Packet Payload* consisting of a *Message Header* for *Control Messages* and a *Message Header* and data for *Data Messages* and *Extended Messages* as defined in *Section 6.2, "Messages"*.
Message Header	Every *Message* starts with a 16-bit *Message Header* containing basic information about the *Message* and the *PD Port's Capabilities*.
Messaging	Communication in the form of *Messages* as defined in *Section 6, "Protocol Layer"*.
Modal Operation	Operation where there are one or more *Active Modes*. *Modal Operation* ends when there are no longer any *Active Modes*.
Mode	*Mode* is a general term used to describe a particular type of operation of a given device. Examples of modes are: *Alternate Mode*, *EPR Mode*, *SPR Mode*.

Table 1.4 Terms and Abbreviations (Continued)

Term	Description
Mode Entry	Process to start operation in a particular *Mode*.
Mode Exit	Process to end operation in a particular *Mode*.
Multi-Drop	PD is a *Multi-Drop* system sharing the Power Delivery communication channel between the *Port Partners* and the cable.
Negotiate	See *Negotiation*.
Negotiated	See *Negotiation*.
Negotiation	This is the PD process whereby: 1) The *Source Advertises* its *Capabilities*. 2) The *Sink* requests one of the *Advertise*d *Capabilities*. 3) The *Source* acknowledges the request, alters its output to satisfy the request and informs the *Sink*. The result of the *Negotiation* is a *Contract* for power delivery/consumption between the *Port Pair*.
New Sink	*Sink* at the end of a *Power Role Swap* or *Fast Role Swap* which has transition from being the *Initial Source*.
New Source	*Source* at the end of a *Power Role Swap* or *Fast Role Swap* which has transition from being the *Initial Sink*.
Non-interruptible	There cannot be any unexpected *Messages* during an *AMS*; it is therefore *Non-interruptible*. An *AMS* starts when the first *Message* in the *AMS* has been sent (i.e., a ***GoodCRC*** *Message* has been received acknowledging the *Message*). See *Section 8.3.2.1.3, "Atomic Message Sequences"*.
OCP	Over-Current Protection.
OTP	Over-Temperature Protection.
OVP	Over-Voltage Protection.
Packet	One entire unit of PD communication including a *Preamble*, *SOP**, *Payload*, *CRC* and *EOP* as defined in *Section 5.6, "Packet Format"*.
Passive Cable	Cable with a USB plug on each end at least one of which is a *Cable Plug* supporting *SOP'* that does not incorporate data bus signal conditioning circuits. Supports the *Structured VDM* ***Discover Identity*** to determine its characteristics (Electronically Marked Cable see ***[USB Type-C 2.4]***). **Note:** This specification does not discuss *Passive Cables* that are not Electronically Marked.
Passive Cable VDO	VDO defining the Capabilities of a Passive Cable.
Payload	Data content of a *Packet*, provided to/from the *Protocol Layer*.
PD	USB Power Delivery
PD Capable	A *Port* that supports USB Power Delivery.
PD Connection	See *Connected*.
PD Power	The output power, in Watts, of a *Source*, as specified by the manufacturer and expressed in *Fixed Supply PDOs* as defined in *Section 10, "Power Rules"*.
PD SID	See *USB-IF PD SID*.
PDO	See *Power Data Object*.
PDP	See *PD Power*.
PDP Rating	The *PDP Rating* is the same as the Manufacturer declared *PDP* for a *Source Port* except where there is a fractional value, in which case the *PDP Rating* corresponds to the integer part of the Manufacturer declared *PDP Rating* (see *Section 6.4.11.2, "Port Maximum PDP Field"*).
PDUSB	*USB Device Port* or *USB Host Port* that is both *PD Capable* and capable of *USB Communication*. See also *PDUSB Host*, *PDUSB Device* and *PDUSB Hub*.
PDUSB Device	A *USB Device* with a *PD Capable UFP*. A *PDUSB Device* is only addressed by *SOP Packets*.
PDUSB Host	A *USB Host* which is *PD Capable* on at least one of its *DFPs*. A *PDUSB Host* is only addressed by *SOP Packets*.

Table 1.4 Terms and Abbreviations (Continued)

Term	Description
PDUSB Hub	A port expander *USB Device* with a *UFP* and one or more *DFP*s which is *PD Capable* on at least one of its *Ports*. A *PDUSB Hub* is only addressed by *SOP Packet*s. A self-powered *PDUSB Hub* is treated as a *USB Type-C Multi-Port Charger*.
PDUSB Peripheral	A *USB Device* with a *PD Capable UFP* which is not a *PDUSB Hub*. A *PDUSB Peripheral* is only addressed by *SOP Packet*s.
PE	See *Policy Engine*.
Peripheral	A physical entity that is *Attached* to a USB cable and is currently operating as a *USB Device*.
PHY Layer	The Physical Layer responsible for sending and receiving *Message*s across the *USB Type-C CC* wire between a *Port Pair*.
Policy	*Policy* defines the behavior of *PD Capable* parts of the system and defines the *Capabilities* it *Advertises*, requests made to (re)*Negotiate* power and the responses made to requests received.
Policy Engine	The *Policy Engine* interprets the *Device Policy Manager*'s input to implement *Policy* for a given *Port* and directs the *Protocol Layer* to send appropriate *Message*s.
Port	An interface typically exposed through a receptacle, or via a plug on the end of a hard-wired captive cable. USB Power Delivery defines the interaction between a *Port Pair*.
Port Pair	Two *Attached PD Capable Ports*.
Port Partner	A *Contract* is *Negotiated* between a *Port Pair* connected by a USB cable. These ports are known as *Port Partners*.
Power Conductor	The wire that delivers power from the *Source* to *Sink*. For example, USB's *VBUS*.
Power Consumer	See *Consumer*.
Power Data Object	*Data Object* used to expose a *Source Port*'s or *Sink Port*'s power *Capabilities* as part of a ***Source_Capabilities*** / ***EPR_Source_Capabilities*** or ***Sink_Capabilities*** / ***EPR_Sink_Capabilities*** *Message* respectively. *Fixed Supply*, *Variable Supply* and *Battery Supply Power Data Object*s are defined; *SPR Mode* uses all four while *EPR Mode* uses only *Fixed Supply* and *AVS PDO*s.
Power Delivery Mode	Operation after a *Contract* has initially been established between a *Port Pair*. This *Mode* persists during normal Power Delivery operation, including after a *Power Delivery Mode*. *Power Delivery Mode* can only be exited by *Detach*ing the *Ports*, applying a *Hard Reset* or by the *Source* removing power (except when the *Initial Source* removes power from *VBUS* during the *Power Role Swap* procedure).
Power Provider	See *Provider*.
Power Role	A *Port Partner* will be in one of two *Power Roles*; either *Source* or *Sink*.
Power Role Swap	Process of exchanging the *Source* and *Sink Power Role*s between *Port Partner*s.
Power Rules	Define voltages and current ranges that are offered by compliant USB Power Delivery *Sources* and used by a USB Power Delivery *Sink* for a given value of PDP Rating. See *Section 10, "Power Rules"*.
PPS	See *Programmable Power Supply*.
PPS Mode	An *SPR Source*, currently operating as an *PPS*, is said to be operating in *PPS Mode*.
Preamble	Start of a transmission which is used to enable the receiver to lock onto the carrier. The *Preamble* consists of a 64-bit sequence of alternating 0s and 1s starting with a "0" and ending with a "1" which is not 4b5b encoded.
Product Type	Product categorization returned as part of the ***Discover Identity*** *Command*.
Product Type VDO	*VDO* identifying a certain *Product Type* in the *ID Header VDO* of a ***Discover Identity*** *Command*.
Product VDO	The *Product VDO* contains identity information relating to the product.
Programmable Power Supply	A power supply, operating in *SPR Mode*, whose output voltage can be programmatically adjusted in small increments over its *Advertise*d range and has a programmable output current fold back (note that the *SPR AVS* and *EPR AVS* does not).The *Capabilities* are exposed by the *SPR Programmable Power Supply APDO* (see *Section 6.4.1.2.4, "Augmented Power Data Object (APDO)"*).
Protocol Error	An unexpected *Message* during an *Atomic Message Sequence*. A *Protocol Error* during an *AMS* will result in either a *Soft Reset* or a *Hard Reset*.

Table 1.4 Terms and Abbreviations (Continued)

Term	Description
Protocol Layer	The entity that forms the *Messages* used to communicate information between *Port Partners*.
Provider	A *PD Port* (typically a *USB Host*, *Hub*, or *Charger DFP*) that can source power over the power conductor (e.g., *VBUS*). This corresponds to a *USB Type-C Port* with R_p asserted on its *CC* wire.
Provider/Consumer	A *Provider* with the additional capability to act as a *Consumer*. This corresponds to a *Dual-Role Power Port* with R_p asserted on its *CC* wire.
PS1 *PS2* *PS3*	Classification of electrical power as defined in ***[IEC 62368-1]***.
PSD	*Sink* which draws power but has no other USB or *Alternate Mode* communication function e.g., a power bank.
R_a	Prior to application of *VCONN*, a powered cable applies a pull-down resistor R_a on its *VCONN* pin.
R_d	Pull-down resistor on the *USB Type-C CC* wire used to indicate that the *Port* is a *Sink* (see ***[USB Type-C 2.4]***).
RDO	See *Request Data Object*.
Re-attach	*Attach* of the *Port Pair* by a cable after a previous *Detach*.
Re-negotiate	See *Re-negotiation*.
Re-negotiated	See *Re-negotiation*.
Re-negotiation	A process wherein one of the *Port Partners* wants to alter the *Negotiated Contract*.
Request	*Message* used by a *Sink Port* to *Negotiate* a *Contract*; refers to either a ***Request***/***EPR_Request*** *Message*.
Request Data Object	*Data Object* used by a *Sink Port* to *Negotiate* a *Contract* as a part of a ***Request***/***EPR_Request*** *Message*.
Responder	The receiver of a *Command* request sent by an *Initiator* that replies with a *Command* response.
Revision	Major release of the USB Power Delivery specification. Each *Revision* will have various*Versions* associated with it.
Revision 1.0	***Deprecated*** major *Revision* of the USB Power Delivery Specification.
Revision 2.0	Superseded major *Revision* of the USB Power Delivery Specification as defined in ***[USBPD 2.0]***, with which this specification is compatible.
Revision 3.x	Current major *Revisions* of the USB Power Delivery Specification.
R_p	Pull-up resistor on the *USB Type-C CC* wire used to indicate that the *Port* is a *Source* (see *[USB Type-C 2.4]*).
Safe Operation	*Sources* must have the ability to tolerate ***vSafe5V*** applied by both *Port Partners*.
Shared Capacity Charger	As defined in ***[USB Type-C 2.4]***. This maps to a *Charger* with multiple *Managed Capability Ports*.
Shared Capacity Group	As defined in ***[USB Type-C 2.4]***. This maps to a group with *Managed Capability Ports*.
SID	See *Standard ID*.
Signaling	A Preamble followed by an ordered set of four *K-codes* used to indicate a particular line symbol e.g., *Hard Reset* as defined in *Section 5.4, "Ordered Sets"*.
Signaling Scheme	Physical mechanism used to transmit bits. Only the *BMC Signaling Scheme* is defined in this specification. **Note:** The *BFSK Signaling Scheme* supported in *Revision 1.0* of this specification has been ***Deprecated***.
Single-Role Port	A *Port* that is only capable of operating either as a *Source* or *Sink*, but not both. E.g., the port is not a *DRP*.
Sink	The *Port* consuming power from *VBUS*; most commonly a *USB Device*.
Sink Capabilities	*Capabilities* wanted by a *Sink*.
Sink Directed Charge	A charging scheme whereby the *Sink* connects the *Source* to its *Battery* through safety and other circuitry. When the *SPR PPS Current Limit* feature is activated, the *Source* automatically controls its output current by adjusting its output voltage.

Table 1.4 Terms and Abbreviations (Continued)

Term	Description
Sink Port	*Port* operating as a *Sink*.
Sink Standby	During *Sink Standby* the Sink reduces its current draw to ***iSnkStdby***
Soft Reset	A process that resets the *PD* communications engine to its default state.
SOP	*K-code* marker used for communication between *Port Partners*. See also *Start of Packet*.
SOP Communication	Communication using *SOP Packets* also implies that an *AMS* is being followed.
SOP Packet	Any Power Delivery *Packet* which starts with an *SOP*.
SOP' Communication	Communication with a *Cable Plug* using *SOP' Packets*, also implies that an *AMS* is being followed.
SOP' Packet	Any Power Delivery *Packet* which starts with an *SOP'* used to communicate with a *Cable Plug*.
SOP'' Communication	Communication with a *Cable Plug* using *SOP'' Packets*, also implies that an *AMS* is being followed.
SOP'' Packet	Any Power Delivery *Packet* which starts with an *SOP''* used to communicate with a *Cable Plug* when *SOP' Packets* are being used to communicate with the other *Cable Plug*.
SOP' *SOP''*	*K-code* marker used for communication between a *Port* and a *Cable Plug*. See also *Start of Packet*.
*SOP**	Used to generically refer to *K-code* markers: *SOP*, *SOP'* and *SOP''*. See also *Start of Packet*.
SOP Communication*	Communication using *SOP* Packets*, also implies an *AMS* is being followed.
SOP Packet*	A term referring to any Power Delivery *Packet* starting with either *SOP*, *SOP'*, or *SOP''*.
Source	The *Power Role* a *Port* is operating in to supply power over *VBUS*; most commonly a *USB Host* or *Hub* downstream port.
Source Capabilities	*Capabilities* offered by a *Source*.
Source Port	*Port* operating as a *Source*.
Specification Revision	See *Revision*.
SPM	See *System Policy Manager*.
SPR	See *Standard Power Range*.
SPR AVS	An *SPR Source* whose output voltage can be adjusted to an operating voltage within its *Advertised* range. Unlike *SPR PPS*, it does not support current limit. The *SPR AVS Capabilities* are exposed by the *SPR AVS APDO* (see Section 6.4.1.2.4.2, "SPR Adjustable Voltage Supply APDO").
SPR AVS Mode	A *SPR Source*, currently operating in an *SPR AVS Contract*, is said to be operating in *SPR AVS Mode*.
SPR Capabilities	An *SPR Capabilities Message* (***Source_Capabilities*** *Message* or ***Sink_Capabilities*** *Message*) has at least one *Power Data Object* for ***vSafe5V*** followed by up to 6 additional *Power Data Objects*.
SPR Contract	*Explicit Contract Negotiated*, in *SPR Mode*, based on *SPR (A)PDOs*.
SPR Mode	The classic mode of PD operation where *Explicit Contracts* are *Negotiated* using *SPR (A)PDOs*.
SPR (A)PDO	*Fixed Supply PDO* that offers up to 20V and no more than 100W. *Variable Supply PDO* whose Maximum voltage offers up to 21V and no more than 100W. *Battery Supply PDO* whose Maximum voltage offers up to 21V and no more than 100W. *Adjustable Voltage Supply* (*AVS*) *APDO* whose Maximum voltage is up to 20V and no more than 100W. *Programmable Power Supply* (*PPS*) *APDO* whose Maximum voltage is up to 21V and no more than 100W.
SPR PPS	A power supply whose output voltage and output current can be programmatically adjusted in small increments over its *Advertised* range. It supports current limit unlike *SPR AVS* and *EPR AVS*. The *Capabilities* are exposed by the *Programmable Power Supply APDOs* (see Section 6.4.1.2.4, "Augmented Power Data Object (APDO)").
SPR PPS Mode	A power supply, currently operating in an *SPR PPS Contract*, is said to be operating in *SPR PPS Mode*.
SPR Sink	A *Sink* which only supports *SPR Mode* and does not support *EPR Mode*.
SPR Sink Port	A *Port* exposed on an *SPR Sink*.
SPR Source	A *Source* which only supports *SPR Mode* and does not support *EPR Mode*.

Table 1.4 Terms and Abbreviations (Continued)

Term	Description
SPR Source Port	A *Port* exposed on an *SPR Source*.
Standard ID	16-bit unsigned value assigned by the USB-IF to a given industry standards organization's specification.
Standard or Vendor ID	Generic term referring to either a *VID* or a *SID*. *SVID* is used in place of the phrase "Standard or Vendor ID."
Standard Power Range	Only the ***Source_Capabilities*** and the ***Request*** *Messages* are allowed to *Negotiate SPR Explicit Contracts*. The *EPR Messages* (the ***EPR_Source_Capabilities*** *Message* and the ***EPR_Request*** *Message*) are not allowed to be used while in *SPR Mode*.
Start of Packet	*K-code* marker used to delineate the start of a *Packet*.
State	*PD* state machine state as defined in *Section 6.12, "State behavior"* and *Section 8.3.3, "State Diagrams"* state machines.
Structured VDM	See *Structured Vendor Defined Message*.
Structured VDM Header	The *VDM Header* for a *Structured Vendor Defined Message*.
Structured Vendor Defined Message	A *Vendor Defined Message* where the contents and usage of bits 14...0 of the *VDM Header* are defined by this specification.
SVDM	See *Structured Vendor Defined Message*.
SVID	See *Standard or Vendor ID*.
Swap Standby	During *Swap Standby* the *Source* does not drive *VBUS* and the Sink's current draw does not exceed ***iSnkSwapStdby***.
System Policy	Overall system *Policy* generated by the system, broken up into the policies required by each *Port Pair* to affect the *System Policy*. It is programmatically fed to the individual devices for consumption by their *Policy Engine*s.
System Policy Manager	Module running on the *USB Host*. It applies the *System Policy* through communication with *PD Capable Consumer*s and *Provider*s that are also connected to the *USB Host* via USB.
Test Frame	*Frame* consisting of a *Preamble*, *SOP**, followed by test data (See *Section 5.9, "Built in Self-Test (BIST)"*).
Test Pattern	Continuous stream of test data in a given sequence (See *Section 5.9, "Built in Self-Test (BIST)"*).
Tester	The *Tester* is assumed to be a piece of test equipment that manages the *BIST* testing process of a *PD UUT*.
UFP	See *Upstream Facing Port*.
UFP VDO	*VDO* returned by the *UFP* containing *Capabilities*.
UI	See *Unit Interval*.
Unchunked	See *Unchunked Extended Message*.
Unchunked Extended Message	*Extended Message* that has been transmitted whole without using *Chunking*.
Unexpected Message	*Message* that a *Port* supports but has been received in an incorrect *State*.
Unit Interval	The time to transmit a single data bit on the wire.
Unit Under Test	The *PD* device that is being tested by the *Tester* and responds to the initiation of a particular *BIST* test sequence.
Unrecognized Message	*Message* that a *Port* does not understand e.g., a *Message* using a ***Reserved*** *Message* type, a *Message* defined by a higher specification *Revision* than the *Revision* this *Port* supports, or an *Unstructured Vendor Defined Message* for which the *VID* is not recognized.
Unstructured VDM	See *Unstructured Vendor Defined Message*.
Unstructured VDM Header	The *VDM Header* for an *Unstructured Vendor Defined Message*.
Unstructured Vendor Defined Message	A *Vendor Defined Message* where the contents of bits 14...0 of the *VDM Header* are undefined.
Unsupported Message	*Message* that a *Port* recognizes but does not support. This is a *Message* defined by the specification, but which is not supported by this *Port*.

Table 1.4 Terms and Abbreviations (Continued)

Term	Description
Upstream Facing Port	Indicates the *Port*'s position in the USB topology typically a *Port* on a *Device* as defined in ***[USB Type-C 2.4]***. At connection, the *Port* defaults to operation as a *USB Device* (when *USB Communication* is supported) and *Sink*.
USB Attached State	Synonymous with the ***[USB 2.0]*** and ***[USB 3.2]*** definition of the *Attached* state
USB Communication	Transfer of USB data *Packets* as defined in ***[USB 2.0]*** and ***[USB 3.2]***.
USB Default Operation	Operation of a *Port* at *Attach* or after a *Hard Reset* where the *DFP Source* applies ***vSafe5V*** on *VBUS* and the *UFP Sink* is operating at ***vSafe5V*** as defined in ***[USB 2.0]***, ***[USB 3.2]***, ***[USB Type-C 2.4]*** or ***[USBBC 1.2]***.
USB Device	Either a *Hub* or a *Peripheral* device as defined in ***[USB 2.0]***, ***[USB 3.2]*** and ***[USB4]***.
USB Host	The computer system where the *USB Host* controller is installed as defined in ***[USB 2.0]***, ***[USB 3.2]*** and ***[USB4]***.
USB Hub	See *Hub*.
USB Powered State	Synonymous with the ***[USB 2.0]*** and ***[USB 3.2]*** definition of the powered state.
USB Safe State	State of the *USB Type-C* connector when there are pins to be re-purposed (see ***[USB Type-C 2.4]***) so they are not damaged by and do not cause damage to their *Port Partner*.
USB Type-A	Term used to refer to any A plug or receptacle including USB Micro-A plugs and USB Standard-A plugs and receptacles. USB Micro-AB receptacles are assumed to be a combination of *USB Type-A* and *USB Type-B*.
USB Type-B	Terms used to refer to any B-plug or receptacle including USB Micro-B plugs and USB Standard-B plugs and receptacles, including the PD and non-PD versions. USB Micro-AB receptacles are assumed to be a combination of *USB Type-A* and *USB Type-B*.
USB Type-C	Term used to refer to the *USB Type-C* connector plug, or receptacle as defined in ***[USB Type-C 2.4]***.
USB Type-C Multi-Port Charger	A product that exposes multiple *USB Type-C Source Ports* for the purpose of charging multiple connected *USB Devices* as defined in ***[USB Type-C 2.4]***.
USB-C® Port Control	Module in a *PD Capable* device which controls *Attach*/*Detach* and either detects or sets the R_p value.
USB-IF PD SID	Standard ID allocated to this specification by the USB Implementer's Forum.
USB4® Mode	Device is operating in a *Mode* as defined in ***[USB4]***.
UUT	See *Unit Under Test*.
Variable Supply	A poorly regulated power supply that is not a *Battery*. This is exposed by the *Variable Supply PDO* (see *Section 6.4.2, "Request Message")*.
VBUS	The *VBUS* wire delivers power from a *Source* to a *Sink*.
VCONN	Once the connection between *USB Host* and device is established, the *CC* pin (CC1 or CC2) in the receptacle that is not connected via the *CC* wire through the standard cable is re-purposed to source *VCONN* to power circuits in a *Cable Plug*, *VCONN Powered Accessory* or *VCONN Powered USB Device* (see ***[USB Type-C 2.4]***).
VCONN Powered Accessory	An accessory that is powered from *VCONN* to operate in an *Alternate Mode* (see ***[USB Type-C 2.4]***).
VCONN Powered USB Charge Through Device	A *CT-VPD* is a *VPD* with an additional port for connecting a *Source* (e.g., a *Charger*) as defined in ***[USB Type-C 2.4]***. When no *Charger* is connected, a *CT-VPD* behaves as a *VPD*. When a *Charger* is connected, no *PD* communication to the *CT-VPD* itself is possible as *CC* is connected to the *Charger* port. Hence all PD communication then is with the *Charger* and the cable with which it is connected.

Table 1.4 Terms and Abbreviations (Continued)

Term	Description
VCONN Powered USB Device	A captive cable *USB Device* that can be powered by either *VCONN* or *VBUS* as defined in ***[USB Type-C 2.4]***. A *VPD* is a captive cable *USB Device* that can be powered by either *VCONN* or *VBUS* and only responds to *SOP' Communication* as defined in the Tables in *Section 6.12, "State behavior")*. It only responds to *Messages* sent with a *Specification Revision* of at least *Revision 3.x*. A *VPD* is not allowed to support *Alternate Modes*. The term *VPD* refers to either a *VPD* or a *CT-VPD* with no *Charger* connected.
VCONN Source	The *USB Type-C Port* responsible for sourcing *VCONN*.
VCONN Swap	Process of exchanging the *VCONN Source* between *Port Partners*.
VDEM	See *Vendor Defined Extended Message*.
VDM	See *Vendor Defined Message*.
VDM Header	The first *Data Object* following the *Message Header* in a *Vendor Defined Message*. The *VDM Header* contains the *SVID* relating to the *VDM* being sent and provides information relating to the *Command* in the case of a *Structured VDM* (see *Section 6.4.4, "Vendor Defined Message")*.
VDO	See *Vendor Data Object*.
Vendor Data Object	*Data Object* used to send Vendor specific information as part of a *Message*.
Vendor Defined Extended Message	*PD Extended Message* defined for vendor/standards usage. A *VDEM* does not define any structure and *Messages* can be created in any manner that the vendor chooses.
Vendor Defined Message	*PD Data Message* defined for vendor/standards usage. These are further partitioned into *Structured Vendor Defined Messages*, where *Commands* are defined in this specification, and *Unstructured Vendor Defined Messages* which are entirely vendor defined (see *Section 6.4.4, "Vendor Defined Message")*.
Vendor ID	16-bit unsigned value assigned by the USB-IF to a given Vendor.
Version	A minor release of the USB Power Delivery specification associated with a particular *Revision*. *Version* numbers are also defined in *VDMs*.
VI	Same as power (i.e., voltage * current = power)
VID	See *Vendor ID*.
VPD	See *VCONN Powered USB Device*.

1.7 Parameter Values

The parameters in this specification are expressed in terms of absolute values. For details of how each parameter is measured in compliance please see ***[USBPDCompliance]***.

1.8 Changes from Revision 3.0

Extended Power Range (EPR) including Adjustable Voltage Supply (AVS) has been added.

1.9 Compatibility with Revision 2.0

This Revision of the USB Power Delivery specification is designed to be fully inter-operable with ***[USBPD 2.0]*** systems using BMC Signaling over the ***[USB Type-C 2.4]*** connector and to be compatible with Revision 2.0 hardware.

Please see *Section 2.3, "USB Power Delivery Capable Devices"* for more details of the mechanisms defined to enable compatibility.

2 Overview

This section contains no ***Normative*** requirements.

2.1 Introduction

USB Power Delivery (*PD*) defines the mechanisms for pairs of directly *Attached Ports* (also referred to as *Port Partner*s or *Port Pairs*) to *Negotiate* voltage, current and/or direction of power flow over the USB cable. It uses the *USB Type-C*® connector's *CC* wire as the communications channel. The *PD* mechanisms operate independently of and supersede other USB methods defined in ***[USB 2.0]***, ***[USB 3.2]***, ***[USBBC 1.2]*** and ***[USB Type-C 2.4]***.

USB Power Delivery also defines sideband mechanisms used for configuration management of *USB Type-C* devices and cables. Using *Structured Vendor Defined Message*s (*Structured VDM*s), *PD* facilitates discovery of device and cables features and performance. *Structured VDM*s are also used to enter/exit some *Active Mode*s, either USB-based (e.g., *USB4*® *Mode*) or *USB Type-C Alternate Mode*s. *Alternate Mode*s are associated with *Standard or Vendor ID*s (*SVID*s) and can be either standard (e.g., DisplayPort *Alternate Mode*) or proprietary (e.g., Intel Thunderbolt™ 3).

2.1.1 Power Delivery Source Operational Contracts

A *PD Source* will be in one of three *Contract*s:

- *Default Contract* which it enters immediately following a *Connect* where the *Source* provides 5V and *Advertise*s the amount of current it can deliver using the R_p value as defined in ***[USB Type-C 2.4]***. A *Source* in a *Default Contract* will remain in this *Contract* until the *Sink* is *Detached* or the *Source* and *Sink* *Negotiate* and enter an *Explicit Contract*.

- *Implicit Contract* which immediately follows a *Power Role Swap* or *Fast Role Swap* and is transitory. The *PD Source* provides 5V and *Advertise*s the amount of current it can deliver using the R_p value as defined in ***[USB Type-C 2.4]***. A *Source* in an *Implicit Contract* will immediately *Negotiate* with the *Sink* and enter an *Explicit Contract*.

- *Explicit Contract* is the state of the *Source* after any *PD* power *Negotiation* consisting of the *Source* sending a ***Source_Capabilities*** *Message*, the *Sink* responding with a ***Request*** *Message*, the *Source* acknowledging the request with an ***Accept*** *Message* and finally the *Source* sends a ***PS_RDY*** *Message* when the *Source* is ready to deliver the requested power. This is the normal operational state for *PD*. A *Source* in an *Explicit Contract* will remain in an *Explicit Contract* during and after a *Re-negotiation* of its *Contract* and will exit the *Explicit Contract* when:

    - Disconnected from the *Sink* where it will restart in a *Default Contract* when reconnected to the *Sink*.

    - Following a *Hard Reset* where it will restart as if it were *Detached* then *Attached* to the *Sink*.

    - Following a *Power Role Swap* or *Fast Role Swap* where it will enter an *Implicit Contract*.

    - Following *USB Type-C Error Recovery* which is an electrical *Detach*/*Re-attach* (remove and assert R_p).

2.1.2 Power Delivery Contract Negotiation

*Contract*s *Negotiate*d using the USB Power Delivery Specification supersede any and all previous power contracts established whether from standard ***[USB 2.0]***, ***[USB 3.2]***, ***[USBBC 1.2]*** or ***[USB Type-C 2.4]*** mechanisms. While operating in *Power Delivery Mode* there will be a *Contract* in place (either *Explicit Contract* or *Implicit Contract*) that determines the power level available and the direction of that power. The *Port Pair* will remain in *Power Delivery Mode* until the *Port Pair* is *Detached*, there is a *Hard Reset*, or *USB Type-C Error Recovery*, or the *Source* removes power except as part of the *Power Role Swap* or *Fast Role Swap* processes.

Note: ***[USB4]*** does not define a default power, rather relies on a *PD* power *Contract*. When first *Attached* the ***[USB4]*** device operates in ***[USB 3.2]*** *Mode* which is its *USB Default Operation*.

An *Explicit Contract* is *Negotiate*d by the process of the *Source* sending a set of *Capabilities*, from which the *Sink* is required to request a particular capability and then the *Source* accepting this request.

An *Implicit Contract* is the specified level of power allowed in particular states (i.e., during and after a *Power Role Swap* or *Fast Role Swap*). *Implicit Contract*s are temporary; *Port Pair*s are required to immediately *Negotiate* an *Explicit Contract*.

Each *Provider* has a *Local Policy*, governing power allocation to its *Port*s. *Consumer*s also have their own *Local Policy* governing how they draw power. A *System Policy* can be enacted over USB that allows modification to this *Local Policy* and hence management of overall power allocation in the system.

When *PD Capable* devices are *Attached* to each other, the *DFP*s and *UFP*s initially default to standard *USB Default Operation*. The *DFP* supplies ***vSafe5V*** and the *UFP* draws current in accordance with the rules defined by ***[USB 2.0]***, ***[USB 3.2]***, ***[USB Type-C 2.4]*** or ***[USBBC 1.2]*** specifications. After Power Delivery *Negotiation* has taken place, power can be supplied at higher, or lower, voltages and higher currents than defined in these specifications. It is also possible to:

- Do a *Power Role Swap* or *Fast Role Swap* to exchange the *Power Role*s such that the *DFP* receives power and the *UFP* supplies power.
- Do a *Data Role Swap* such that the *DFP* becomes the *UFP* and vice-versa.
- Do a *VCONN Swap* to change the *Port* supplying *VCONN* to the cable.
- Enter into *EPR Mode*.
- Enter into *USB4® Mode*.
- Enter into *Alternate Mode*s.
- Send *Vendor Defined Message*s.

Prior to the *First Explicit Contract* only the *Source Port*, which is also the *VCONN Source*, can communicate with the *Attached* cable assembly. This is important where 5A and *EPR* capability are marked as well as other details of the cable assembly such as the supported speed.

Cable Discovery, determining whether the cable can communicate, can occur on initial *Attachment* of a *Port Pair* before an *Explicit Contract* has been established. It is also possible to carry out *Cable Discovery* after a *Power Role Swap* or *Fast Role Swap* prior to re-establishing an *Explicit Contract*, where the *UFP* is the *Source*, and an *Implicit Contract* is in place. *Cable Discovery* can be carried out after an *Explicit Contract* has been established, if the cable has not yet been discovered.

2.1.3 Other Uses for Power Delivery

Once an *Explicit Contract* is in place, *PD* can be used to manage the *Port*s and cables for non-power related functionality.

PD is used to enter the *USB4® Mode* of operation. *Port*s and cables can support functionality beyond power. For example, a cable can have active components that require *VCONN* power or a *Port*/cable can support a video display *Alternate Mode* such as DisplayPort. *PD* defines an infrastructure to discover these additional *Capabilities* and *Mode*s that include:

- Discovering a *Port* or *Cable Plug*'s *Capabilities*.
- Discovery of the *SVIDs* a *Port* or *Cable Plug* supports.
- Discovery of the *Modes* a *Port* or *Cable Plug* supports.
- Entry into a *Mode* supported by the *Port* and/or *Cable Plug*.
- Exiting *Mode*s supported by the *Port* and/or *Cable Plug*.

2.2 Compatibility with Revision 2.0

Revision 3.x of the USB Power Delivery specification is designed to be fully inter-operable with ***[USBPD 2.0]*** systems using *BMC Signaling* over the ***[USB Type-C 2.4]*** connector and to be compatible with *Revision 2.0* hardware.

This specification mandates that all *Revision 3.x* systems fully support *Revision 2.0* operation. They must discover the supported *Revision* used by their *Port Partner* and any connected *Cable Plugs* and revert to operation using the lowest common *Revision* number (see *Section 6.2.1.1.5, "Specification Revision"*).

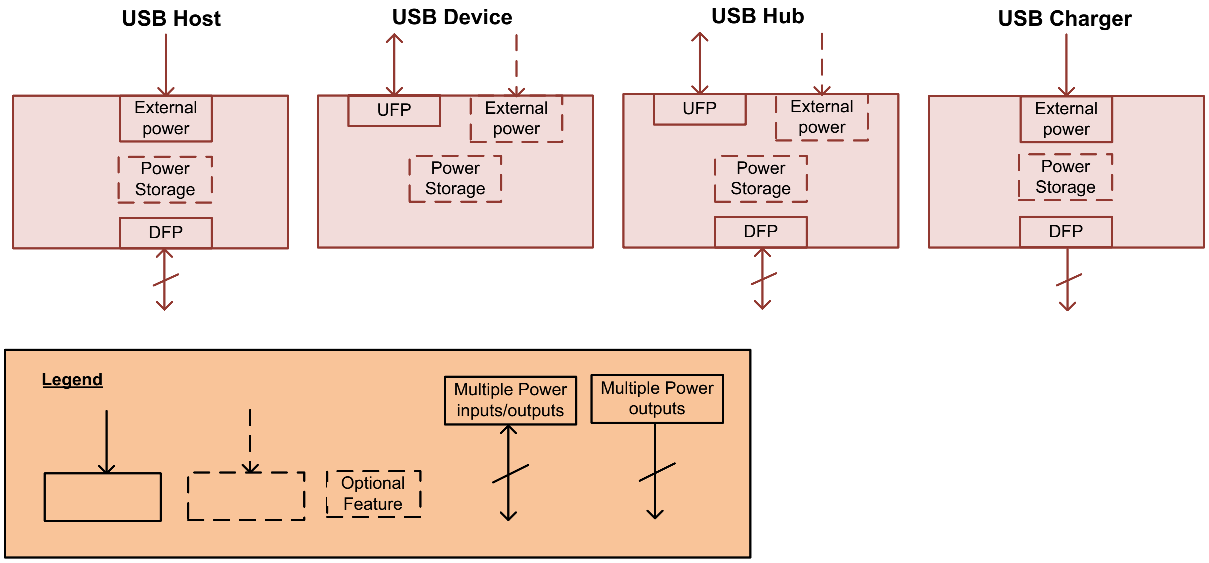
This specification defines *Extended Messages* containing data of up to 260 bytes (see *Section 6.2.1.2, "Extended Message Header"*). These *Messages* can be larger than expected by existing PHY HW. To accommodate *Revision 2.0* based systems a *Chunking* mechanism is mandated such that *Messages* are limited to *Revision 2.0* sizes unless it is discovered that both systems support the longer *Message* lengths.

This specification includes changes to the *Vendor Data Objects* (*VDO*) used in the discovery of passive/active marked cables and *Alternate Mode Adapters* (*AMA*) (see *Section 6.4.4.2, "Structured VDM"*). To enable systems to determine which *VDO* format is being used the *Structured Vendor Defined Message* (*SVDM*) *Version* number has been incremented to 2.x. *Version* numbers have also been incorporated into the *VDOs* themselves to facilitate future changes if these become necessary.

2.3 USB Power Delivery Capable Devices

Some examples of USB Power Delivery capable devices can be seen in *Figure 2.1, "Logical Structure of USB Power Delivery Capable Devices"* (a *USB Host*, a *USB Device*, a *Hub*, and a *Charger*). These are given for reference only and are not intended to limit the possible configurations of products that can be built using this specification.

Figure 2.1 Logical Structure of USB Power Delivery Capable Devices



Each USB Power Delivery capable device is assumed to be made up of at least one *Port*. *Providers* are assumed to have a *Source* and *Consumers* a *Sink*. Each device contains one, or more, of the following components:

- *UFPs* that:
  - Sink Power.
  - Communicate using *SOP Packets*.
  - ***Optionally*** Communicate using *SOP' Packets*/*SOP" Packets*.
  - ***Optionally*** source power (a *Dual-Role Power Device*).
  - ***Optionally*** communicate via USB.
  - ***Optionally*** support *Alternate Modes*.
- *DFPs* that:

  - Source Power
  - Communicate using *SOP Packet*s.
  - ***Optionally*** Communicate using *SOP* Packet*s.
  - ***Optionally*** Sink power (a *Dual-Role Power Device*).
  - ***Optionally*** communicate via USB.
  - ***Optionally*** support *Alternate Mode*s.
- A *Source* that can be:
  - An externally powered source (e.g., AC powered).
  - Power Storage (e.g., *Battery*/Power Bank).
  - Derived from another *Port* (e.g., bus-powered *Hub*).
- A *Sink* that can be:
  - Power Storage (e.g., a *Battery*/Power Bank).
  - Used to power internal functions.
  - Used to power devices *Attached* to other devices (e.g., a bus-powered *Hub*).
- A *VCONN Source* that:
  - Can be either *Port Partner*, either the *DFP*/*UFP* or *Source*/*Sink*.
  - Powers the *Cable Plug*(s).
  - Powers *VPD*s (*VCONN Powered USB Devices*).
  - Is the only *Port* allowed to talk to the *Cable Plug*(s) at any given time.

2.4 SOP* Communication

2.4.1 Introduction

The *Start of Packet* (or *SOP*) is used as an addressing scheme to identify whether the communications were intended for one of the *Port Partners* (*SOP Communication*) or one of the *Cable Plugs* (*SOP' Communication*/*SOP'' Communication*). *SOP*/*SOP'* and *SOP''* are collectively referred to as *SOP**. All *SOP* Communications* take place over a single wire (*CC*). The term *Cable Plug* in the *SOP' Communication*/*SOP'' Communication* case is used to represent a logical entity in the cable which is capable of *PD* Communication, and which might or might not be physically located in the plug.

Note: There are there are other *SOP*s defined for special operation such as debug which are not discussed here.

The following sections describe how this addressing scheme operates for *Port*-to-*Port* and *Port* to *Cable Plug* communication.

2.4.2 SOP* Collision Avoidance

For all *SOP** the *Source* co-ordinates communication to avoid bus collisions by allowing the *Sink* to initiate messaging when it does not need to communicate itself. Once an *Explicit Contract* is in place, the *Source* manipulates its R_p value (3A) to indicate to the *Sink* that it can initiate an *Atomic Message Sequence* (*AMS*). This *AMS* can be communication with the *Source* or with one of the *Cable Plugs*. As soon as the *Source* itself needs to initiate an *AMS*, it will manipulate its R_p value (1.5A) to indicate this to the *Sink*. The *Source* then waits for any outstanding *Sink SOP* Communication* to complete before initiating an *AMS* itself. In all cases, the *Port* initiating an *AMS* waits for *CC* to be *Idle* before putting the *Message* on *CC*.

2.4.3 SOP Communication

SOP Communication is used for *Port*-to-*Port* communication between the *Source* and the *Sink*. *SOP Communication* is recognized by both *Port Partners* but not by any intervening *Cable Plugs*. *SOP Communication* takes priority over other *SOP* Communications* since it is critical to complete power related operations as soon as possible.

2.4.4 SOP'/SOP'' Communication with Cable Plugs

SOP' Communication is recognized by electronics in one *Cable Plug* (see ***[USB Type-C 2.4]***). *SOP'' Communication* can also be supported when *SOP' Communication* is also supported. *SOP'* and *SOP''* assignment in the cable assembly is fixed and does not change dynamically.

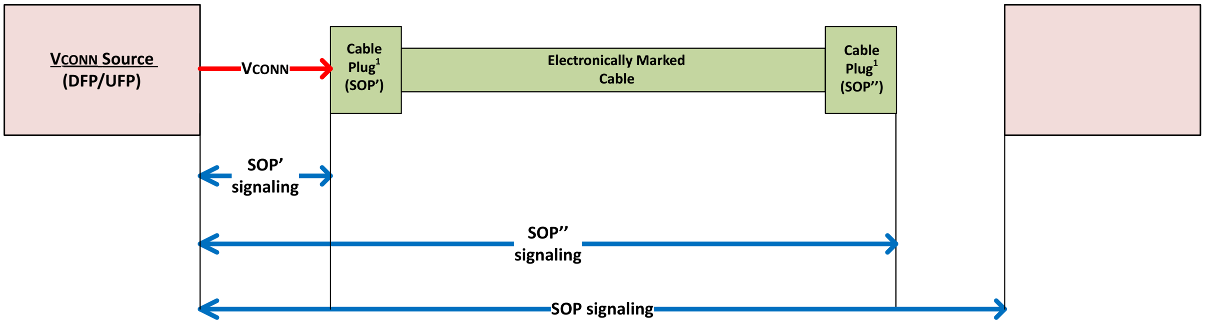
SOP Communication between the *Port Partners* is not recognized by the *Cable Plug*. *Figure 2.2, "Example SOP' Communication between VCONN Source and Cable Plug(s)"* outlines the usage of *SOP* Communications* between a *VCONN Source* (*DFP*/*UFP*) and the *Cable Plugs*.

Since all *SOP* Communications* take place over a single wire (*CC*), the *SOP* Communication* periods must be coordinated to prevent important communication from being blocked. For a product which does not recognize *SOP*/*SOP'* or *SOP'' Packets*, this will look like a non-*Idle* channel, leading to missed *Packets* and retries. Communications between the *Port Partners* take precedence meaning that communications with the *Cable Plug* can be interrupted but will not lead to a *Soft Reset* or *Hard Reset*.

When a *Default Contract* or *Implicit Contract* is in place (e.g., at startup, after a *Power Role Swap* or *Fast Role Swap*) only the *Source Port* that is supplying *VCONN* is allowed to send *Packets* to a *Cable Plug* (*SOP'*) and is allowed to respond to *Packets* from the *Cable Plug* (*SOP'*) with a ***GoodCRC*** *Message* in order to discover the *Cable Plug*'s characteristics (see *Figure 2.2, "Example SOP' Communication between VCONN Source and Cable Plug(s)"*). During this phase, all communication with the *Cable Plug* is initiated and controlled by the *VCONN Source* which acts to prevent conflicts between *SOP Packets* and *SOP' Packets*. The *Sink* does not communicate with the *Cable Plug* and ***Discards*** any *SOP' Packets* received.

When an *Explicit Contract* is in place, only the *VCONN Source* (either the *DFP* or the *UFP*) can communicate with the *Cable Plug*(s) using *SOP' Packets*/*SOP'' Packets* (see *Figure 2.2, "Example SOP' Communication between VCONN Source and Cable Plug(s)"*). During this phase, all communication with the *Cable Plug* is initiated and controlled by the *VCONN Source* which acts to prevent conflicts between *SOP* Packets*. The Port that is not the *VCONN Source* is not allowed to communicate with the *Cable Plug* and does not recognize any *SOP' Packets*/*SOP'' Packets* received. Only the *DFP*, when acting as a *VCONN Source*, is allowed to send *SOP* Packets* to control the entry and exiting of *Modes* and to manage *Modal Operation*.

Figure 2.2 Example SOP' Communication between VCONN Source and Cable Plug(s)



2.5 Operational Overview

A USB Power Delivery *Port* supplying power is known as a *Source* and a *Port* consuming power is known as a *Sink*. There is only one *Source Port* and one *Sink Port* in each *PD Connection* between the *Port Partner*s. At *Attach* the *Source Port* (the *Port* with R_p asserted see ***[USB Type-C 2.4]***) is also the *DFP* and *VCONN Source*. At *Attach* the *Sink Port* (the *Port* with R_d asserted) is also the *UFP* and is not the *VCONN Source*.

The original USB *PD* specification allowed *Source*s to deliver up to 100W. This classic *Mode* of operation is referred to as the *Standard Power Range* (*SPR*). The *First Explicit Contract*, the first *Contract* after a *Default Contract* or *Implicit Contract*, is always an *SPR Contract*. There is an ***Optional*** higher power *Mode* referred to as the *Extended Power Range* (*EPR*) where the *Source* is allowed to deliver up to 240W. The *EPR Mode* can only be entered from the *SPR Mode*. The entry process is designed to prevent accidental entry into this higher power *Mode*. It can be entered only when an *SPR Explicit Contract* is in place and both the *Source Port* and *Sink Port* as well as the cable support *EPR*.

The *Source*/*Sink Power Role*s, *DFP*/*UFP Data Role*s and *VCONN Source* role can all subsequently be swapped orthogonally to each other. A *Port* that supports both *Source* and *Sink Power Role*s is called a *Dual-Role Power Port* (*DRP*). A *Port* that supports both *DFP* and *UFP Data Role*s is called a *Dual-Role Data Port* (*DRD*).

When *USB Communication*s capability is supported in the *DFP Data Role* then the *Port* will also be able to act as a *USB Host*. Similarly, when *USB Communication*s capability is supported in the *UFP Data Role* then the *Port* will also be able to act as a *USB Device*.

The following sections describe the high-level operation of ports taking on the roles of *DFP*, *UFP*, *Source* and *Sink*.

For details of how *PD* maps to USB states in a *PDUSB Device* see *Section 9.1.2, "Mapping to USB Device States"*.

2.5.1 Source Operation

The *Source* operates differently depending on its *Attachment* status:

- At *Attach* (no *PD Connection* or *Contract*):
    - For a *Source*-only *Port* the *Source* detects *Sink Attachment*.
    - For a *DRP* that toggles between *Source* and *Sink* operation, the *Port* becomes a *Source Port* on *Attachment* of a *Sink*
    - The *Source* then supplies ***vSafe5V***.
- Before *PD Connection* (no *PD Connection* or *Contract*):
    - Prior to sending ***Source_Capabilities*** *Message*s the *Source* can detect the *Cable Capabilities* and *Advertises* its *Capabilities* depending on the *Cable Capabilities* detected:
        - The default current carrying capability of a *USB Type-C* cable is 3A.
        - The *Source* can attempt to communicate with one of the *Cable Plug*s using *SOP' Packet*s. If the *Cable Plug* responds, then communication takes place to discover the cable's *Capabilities* (e.g., 5A capable).
    - The *Source* periodically *Advertise*s its *Capabilities* by sending ***Source_Capabilities*** *Message*s every ***tTypeCSendSourceCap***.
- Establishing *PD Connection* (no *PD Connection* or *Contract*):
    - Presence of a *PD Capable Port Partner* is detected either:
        - By receiving a ***GoodCRC*** *Message* in response to a ***Source_Capabilities*** *Message*.
        - By receiving ***Hard Reset*** *Signaling*.
- Establishing the *First Explicit Contract* after an *Attach*, *Hard Reset*, *USB Type-C Error Recovery* or *Implicit Contract* as a result of a *Power Role Swap* or *Fast Role Swap*:

    - The *Source* receives a ***Request*** *Message* from the *Sink* and, if this is a ***Valid*** request, responds with an ***Accept*** *Message* followed by a ***PS_RDY*** *Message* when its power supply is ready to source power at the agreed level. At this point an *Explicit Contract* has been agreed.

    - A *DFP* that does not generate *SOP' Packet*s or *SOP'' Packet*s, is not required to detect *SOP' Packet*s or *SOP'' Packet*s and ***Discards*** them.

- When in an *Explicit Contract* (***PE_SRC_Ready*** State):

    - The *Source* processes and responds (if a response is required) to all *Message*s received and sends appropriate *Message*s whenever its *Local Policy* requires:

        - The *Source* informs the *Sink* whenever its *Capabilities* change, by sending a ***Source_Capabilities*** *Message*.

        - The *Source* responds to a *Sink* ***Request*** *Message* with the *Capabilities* mismatch bit set, by sending a ***Source_Capabilities*** *Message* with its maximum available power.

        - The *Source* will always have an R_p value asserted on its *CC* wire used for *Collision Avoidance*.

        - When this *Port* is a *DRP* the *Source* can initiate or receive a request for the exchange of *Power Role*s. After the *Power Role Swap* this *Port* will be a *Sink* and in an *Implicit Contract* until an *Explicit Contract* is *Negotiate*d immediately afterwards.

        - When this *Port* is a *DRD* the *Source* can initiate or receive a request for an exchange of *Data Role*s. After a *Data Role Swap* the *DFP* (*USB Host*) becomes a *UFP* (*USB Device*). The *Port* remains a *Source* and the *VCONN Source* role remains unchanged.

        - The *Source* can initiate or receive a request for an exchange of *VCONN Source* role. During a *VCONN Swap VCONN* is applied by both *Port*s (make before break). The *Port* remains a *Source* and *DFP*/*UFP Data Role*s remain unchanged.

    - The *Source* when it is the *VCONN Source* can communicate with a *Cable Plug* using *SOP' Communication* or *SOP'' Communication* at any time it is not engaged in any other *SOP Communication*:

        - If *SOP Packet*s are received by the *Source*, during *SOP' Communication* or *SOP'' Communication*, the *SOP' Communication* or *SOP'' Communication* is immediately terminated (the *Cable Plug* times out and does not retry).

        - If the *Source* needs to initiate an *SOP Communication* during an ongoing *SOP' Communication* or *SOP'' Communication* (e.g., for a *Capabilities* change) then the *SOP' Communication* or *SOP'' Communication*s will be interrupted.

    - When the *Source Port* is also a *DFP*:

        - The *Source* can control the entry and exiting of *Mode*s in the *Cable Plug*(s) and control *Modal Operation*.

        - The *Source* can initiate *Unstructured VDM*s or *Structured VDM*s.

        - The *Source* can control the entry and exiting of *Mode*s in the *Sink* and control *Modal Operation* using *Structured VDM*s.

- *Detach* or communications failure:

    - A *Source* detects plug *Detach* and takes *VBUS* down to ***vSafe5V*** within ***tSafe5V*** and ***vSafe0V*** within ***tSafe0V*** (i.e. using *USB Type-C Detach* detection via *CC*).

    - When the *Source* detects the failure to receive a ***GoodCRC*** *Message* in response to a *Message* within ***tReceive***:

        - Leads to a *Soft Reset*, within ***tSoftReset*** of the ***CRCReceiveTimer*** expiring.

        - If the *Soft Reset* process cannot be completed a *Hard Reset* will be issued within ***tHardReset*** of the ***CRCReceiveTimer*** to restore *VBUS* to *USB Default Operation* within ~1-1.5s:
            - When the *Source* is also the *VCONN Source*, *VCONN* will also be power cycled during the *Hard Reset*.
    - When the *Source* operating in *SPR PPS Mode* fails to receive periodic communication (e.g., a ***Request*** *Message*) from the *Sink* within ***tPPSTimeout***:
        - *Source* issues a *Hard Reset* and takes *VBUS* to ***vSafe5V***.
    - When the *Source* operating in the *EPR Mode* fails to receive periodic communication (i.e., an ***EPR_KeepAlive*** *Message* or any other *Message*) from the *Sink* within ***tSourceEPRKeepAlive***:
        - *Source* issues a *Hard Reset* and takes *VBUS* to ***vSafe5V***.
    - Receiving no response to further attempts at communication is interpreted by the *Source* as an error (see Error handling).
    - Errors during power transitions will automatically lead to a *Hard Reset* to restore power to default levels.
- Error handling:
    - *Protocol Error*s are handled by a ***Soft_Reset*** *Message* issued by either *Port Partner*, that resets counters, timers and states, but does not change the *Negotiate*d voltage and current or the *Port*'s role (e.g., *Source*, *DFP*/*UFP*, *VCONN Source*) and does not cause an exit from *Modal Operation*.
    - Serious errors are handled by ***Hard Reset*** *Signaling* issued by either *Port Partner*. A *Hard Reset*:
        - Resets protocol as for a *Soft Reset* but also returns the power supply to *USB Default Operation* (***vSafe0V*** or ***vSafe5V*** output) in order to protect the *Sink*.
        - Restores the *Port*'s *Data Role* to *DFP*.
        - Restores the *Port*'s power to its USB default state.
        - When the *Sink* is the *VCONN Source* it removes *VCONN* then the *Source Port* is restored as the *VCONN Source*.
        - Causes all *Active Mode*s to be exited such that the *Source* is no longer in *Modal Operation*.
    - After a *Hard Reset* it is expected that the *Port Partner* will respond within ***tNoResponse***. If this does not occur then ***nHardResetCount*** further *Hard Reset*s are carried out before the *Source* performs additional *Error Recovery* steps, as defined in ***[USB Type-C 2.4]***, by entering the ***ErrorRecovery*** state.

2.5.2 Sink Operation

- At *Attach* (no *PD Connection* or *Contract*):
    - *Sink* detects *Source Attachment* through the presence of ***vSafe5V***.
    - For a *DRP* that toggles between *Source* and *Sink* operation, the *Port* becomes a *Sink Port* on *Attachment* of a *Source*.
    - Once the *Sink* detects the presence of ***vSafe5V*** on *VBUS* it waits for a ***Source_Capabilities*** *Message* indicating the presence of a *PD Capable Source*.
    - If the *Sink* does not receive a ***Source_Capabilities*** *Message* within ***tTypeCSinkWaitCap*** then it can issue ***Hard Reset*** *Signaling* in order to cause the *Source Port* to send a ***Source_Capabilities*** *Message* if the *Source Port* is *PD Capable*.
    - The *Sink* does not generate *SOP’ Packet*s or *SOP’’ Packet*s, is not required to detect *SOP’ Packet*s or *SOP’’ Packet*s and ***Discards*** them.
- Establishing *PD Connection* (no *PD Connection* or *Contract*):
    - The *Sink* receives a ***Source_Capabilities*** *Message* and responds with a ***GoodCRC*** *Message*.
    - The *Sink* does not generate *SOP’ Packet*s or *SOP’’ Packet*s, is not required to detect *SOP’ Packet*s or *SOP’’ Packet*s and ***Discards*** them.
- Establishing the *First Explicit Contract* after an *Attach*, *Hard Reset* or *Implicit Contract* as a result of a *Power Role Swap* or *Fast Role Swap*:
    - The *Sink* receives a ***Source_Capabilities*** *Message* from the *Source* and responds with a ***Request*** *Message*. If this is a ***Valid*** request the *Sink* receives an ***Accept*** *Message* followed by a ***PS_RDY*** *Message* when the *Source*'s power supply is ready to source power at the agreed level. At this point the *Source* and *Sink* have entered into an *Explicit Contract*:
        - The *Sink Port* can request one of the *Capabilities* offered by the *Source*, even if this is the ***vSafe5V*** output offered by ***[USB 2.0]***, ***[USB 3.2]***, ***[USB Type-C 2.4]*** or ***[USBBC 1.2]***, in order to enable future power *Negotiation*:
            - A *Sink* not requesting any ***Valid*** capability with a ***Request*** *Message* results in an error.
            - A *Sink* unable to fully operate at the offered *Capabilities* requests the default capability but indicates that it would prefer another power level by setting the ***Capability Mismatch*** bit in the ***Request*** *Message* and also providing a physical indication of the failure to the end user (e.g., using an LED).
    - The *Sink* does not generate *SOP’ Packet*s or *SOP’’ Packet*s, is not required to detect *SOP’ Packet*s or *SOP’’ Packet*s and ***Discards*** them.
- During *PD Connection* (*Explicit Contract* - ***PE_SNK_Ready*** state):
    - The *Sink* processes and responds (if a response is required) to all *Message*s received and sends appropriate *Message*s whenever its *Local Policy* requires.
    - A *Sink* whose power needs have changed indicates this to the *Source* with a new ***Request*** *Message*. The *Sink Port* can request one of the *Capabilities* previously offered by the *Source*, even if this is the ***vSafe5V*** output offered by ***[USB 2.0]***, ***[USB 3.2]***, ***[USB Type-C 2.4]*** or ***[USBBC 1.2]***, in order to enable future power *Negotiation*:
        - Not requesting any capability with a ***Request*** *Message* results in an error.
        - A *Sink* unable to fully operate at the offered *Capabilities* requests an offered capability but indicates a *Capabilities Mismatch* i.e., that it would prefer another power level also providing a physical indication of the failure to the end user (e.g., using an LED).

  - A *Sink* operating in the *SPR PPS Mode* periodically sends ***Request*** *Message* within ***tPPSRequest*** even if its request is unchanged.

  - A *Sink* operating in the *EPR Mode* periodically communicates with the *Source* (i.e., sends an ***EPR_KeepAlive*** *Message* or any other *Message*) within ***tSourceEPRKeepAlive***.

  - The *Sink* will always have R_d asserted on its *CC* wire.

  - When this *Port* is a *DRP*, the *Sink* can initiate or receive a request for the exchange of *Power Role*s. After the *Power Role Swap* this *Port* will be a *Source* and an *Implicit Contract* will be in place until an *Explicit Contract* is *Negotiated* immediately afterwards.

  - When this *Port* is a *DRD* the *Sink* can initiate or receive a request for an exchange of *Data Role*s. After a *Data Role Swap* the *UFP* (*USB Device*) becomes a *DFP* (*USB Host*). The *Port* remains a *Sink* and *VCONN Source* role (or not) remains unchanged.

  - The *Sink* can initiate or receive a request for an exchange of *VCONN Source*. During a *VCONN Swap* *VCONN* is applied by both ends (make before break). The *Port* remains a *Sink* and *DFP*/*UFP Data Roles* remain unchanged.

  - The *Sink* when it is the *VCONN Source* can communicate with a *Cable Plug* using *SOP' Communication* or *SOP'' Communication* at any time it is not engaged in any other *SOP Communication*:

    - If *SOP Packet*s are received by the *Sink*, during *SOP' Communication* or *SOP'' Communication*, the *SOP' Communication* or *SOP'' Communication* is immediately terminated (the *Cable Plug* times out and does not retry)

    - If the *Sink* needs to initiate an *SOP Communication* during an ongoing *SOP' Communication* or *SOP'' Communication* (e.g., for a *Capabilities* change) then the *SOP' Communication* or *SOP'' Communication*s will be interrupted.

  - When the *Sink Port* is also a *DFP*:

    - The *Sink* can initiate *Unstructured VDM*s or *Structured VDM*s.

    - The *Sink* can control the *Mode Entry* and *Mode Exit* of *Mode*s in the *Source* and control *Modal Operation* (e.g. ***[USB4]***).

- *Detach* or Communications Failure:

  - A *Sink* detects the removal of *VBUS* and interprets this as the end of the *PD Connection*:

    - This is unless the ***vSafe0V*** is due to either a *Hard Reset*, *Power Role Swap* or *Fast Role Swap*.

  - A *Sink* detects plug removal (i.e., absence of R_p or *VBUS*) and discharges *VBUS*.

  - When the *Sink* detects the failure to receive a ***GoodCRC*** *Message* in response to a *Message* within ***tReceive***:

    - Leads to a *Soft Reset*, within ***tSoftReset*** of the ***CRCReceiveTimer*** expiring.

    - If the *Soft Reset* process cannot be completed a *Hard Reset* will be issued within ***tHardReset*** of the ***CRCReceiveTimer*** to restore *VBUS* to *USB Default Operation* within ~1-1.5s.

    - Receiving no response to further attempts at communication is interpreted by the *Sink* as an error (see Error handling).

  - When the *Sink* operating in the *SPR PPS Mode* fails to send periodic communication (i.e. a ***Request*** *Message*) to the *Source* within ***tPPSRequest***, the *Source* will issue a *Hard Reset* that results in *VBUS* going to ***vSafe5V***.

  - When the *Sink* operating in the *EPR Mode* fails to send periodic communication (i.e. an ***EPR_KeepAlive*** *Message* or any other *Message*) to the *Source* within ***tSourceEPRKeepAlive*** the *Source* will issue a *Hard Reset* that results in *VBUS* going to ***vSafe5V***.

  - Errors during power transitions will automatically lead to a *Hard Reset* to restore power to default levels.

- Error handling:
  - *Protocol Error*s are handled by a ***Soft_Reset*** *Message* issued by either *Port Partner*, that resets counters, timers and states, but does not change the *Negotiate* voltage and current or the *Port*'s role (e.g., *Sink*, *DFP*/*UFP*, *VCONN Source*) and does not cause an exit from *Modal Operation*.
  - Serious errors are handled by ***Hard Reset*** *Signaling* issued by either *Port Partner*. A *Hard Reset*:
    - resets protocol as for a *Soft Reset* but also returns the power supply to *USB Default Operation* (***vSafe0V*** or ***vSafe5V*** output) in order to protect the *Sink*.
    - restores the *Port*'s *Data Role* to *UFP*.
    - when the *Sink* is the *VCONN Source* it removes *VCONN* then the *Source Port* is restored as the *VCONN Source*.
    - causes all *Active Mode*s to be exited such that the *Source* is no longer in *Modal Operation*.
- After a *Hard Reset* it is expected that the *Port Partner* will respond within ***tTypeCSinkWaitCap***. If this does not occur, then two further *Hard Reset*s are carried out before the *UFP* stays in the *PE_SNK_Wait_for_Capabilities* state.

2.5.3 Cable Plugs

- *Cable Plug*s are powered when *VCONN* is present but are not aware of the status of the *Contract* between the ports the cable assembly is connecting.
- *Cable Plug*s do not initiate *AMS*s and only respond to *Message*s sent to them.
- *Detach* or Communications Failure:
  - Communications can be interrupted at any time.
  - There is no communication timeout scheme between the *DFP*/*UFP* and *Cable Plug*.
  - The *Cable Plug* is ready to respond to potentially repeated requests.
- Error handling:
  - The *Cable Plug* detects ***Hard Reset*** *Signaling* to determine that the *Source* and *Sink* have been reset and will need to reset itself (equivalent to a power cycle).
    - The *Cable Plug* cannot generate ***Hard Reset*** *Signaling* itself.
    - The *Hard Reset* process power cycles both *VBUS* and *VCONN* so this is expected to reset the *Cable Plug*s by itself.
- A *Cable Plug* detects ***Cable Reset*** *Signaling* to determine that it will need to reset itself (equivalent to a power cycle).

2.6 Architectural Overview

This logical architecture is not intended to be taken as an implementation architecture. An implementation architecture is, by definition, a part of product definition and is therefore outside of the scope of this specification.

This section outlines the high-level logical architecture of USB Power Delivery referenced throughout this specification. In practice various implementation options are possible based on many different possible types of *PD* devices. *PD* devices can have many different configurations e.g., *USB Communication* or non-*USB Communication*, single versus multiple *Port*s, dedicated power supplies versus supplies shared on multiple ports, hardware versus software-based implementations etc. The architecture outlined in this section is therefore provided only for reference to indicate the high-level logical model used by the *PD* specification. This architecture is used to identify the key concepts and to indicate logical blocks and possible links between them.

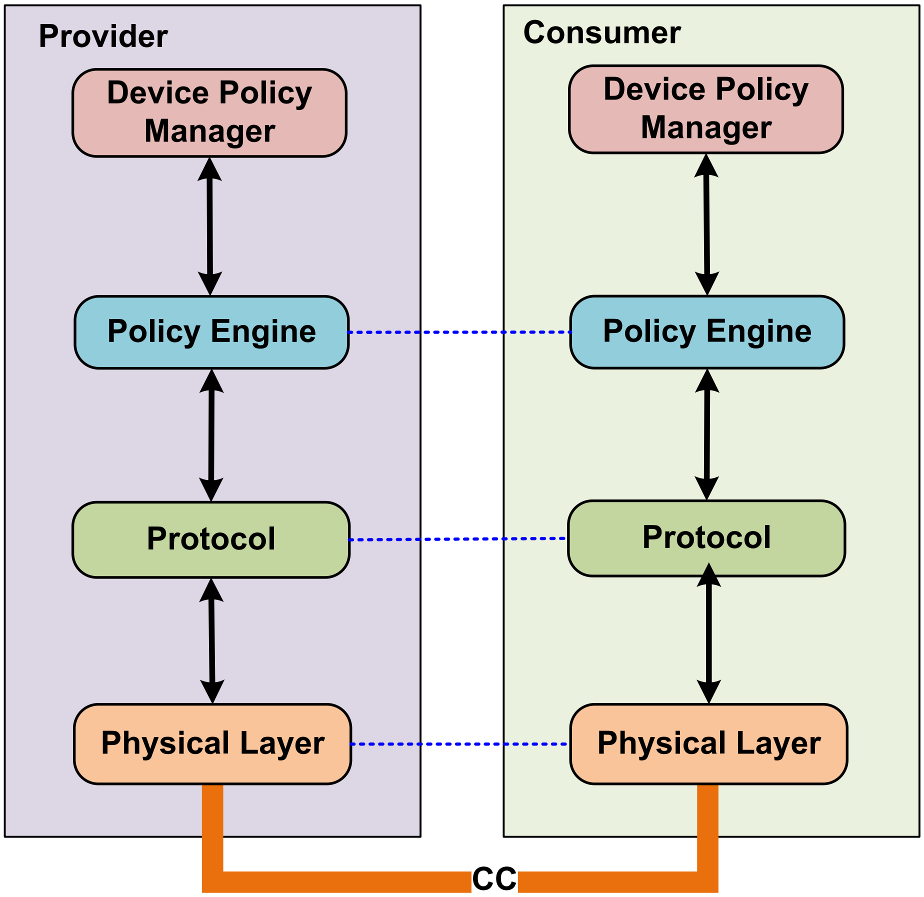
The USB Power Delivery is a *Port* to *Port* architecture in which each *PD Capable* device is made up of several major components.

- *Figure 2.3, "USB Power Delivery Communications Stack"* illustrates the relationship of the layers of the communications stack between a *Port Pair*.

The communications stack consists of:

- A *Device Policy Manager* (see *Section 8.2, "Device Policy Manager"*) that exists in all devices and manages USB Power Delivery resources within the device across one or more *Port*s based on the device's *Local Policy*.
- A *Policy Engine* (see *Section 8.3, "Policy Engine"*) that exists in each USB Power Delivery *Port* implements the *Local Policy* for that *Port*.
- A *Protocol Layer* (see *Section 6, "Protocol Layer"*) that enables *Message*s to be exchanged between a *Source Port* and a *Sink Port*.
- A *PHY Layer* (see *Section 5, "Physical Layer"*) that handles transmission and reception of bits on the wire and handles data transmission

Figure 2.3 USB Power Delivery Communications Stack



Additionally, USB Power Delivery devices which can operate as USB devices can communicate over USB (see *Figure 2.4, "USB Power Delivery Communication Over USB"*). An ***Optional*** *System Policy Manager* (see *Chapter 9* and ***[UCSI]***) that resides in the *USB Host* communicates with the *PDUSB Device* over USB, via the root *Port* and potentially manages the individual *Port* to *Port* connections over a tree of *USB Hub*s. The *Device Policy Manager* interacts with the USB interface in each device to provide and update *PD* related information in the USB domain.

Note: A *PD* device is not required to have a USB device interface.

Figure 2.4 USB Power Delivery Communication Over USB

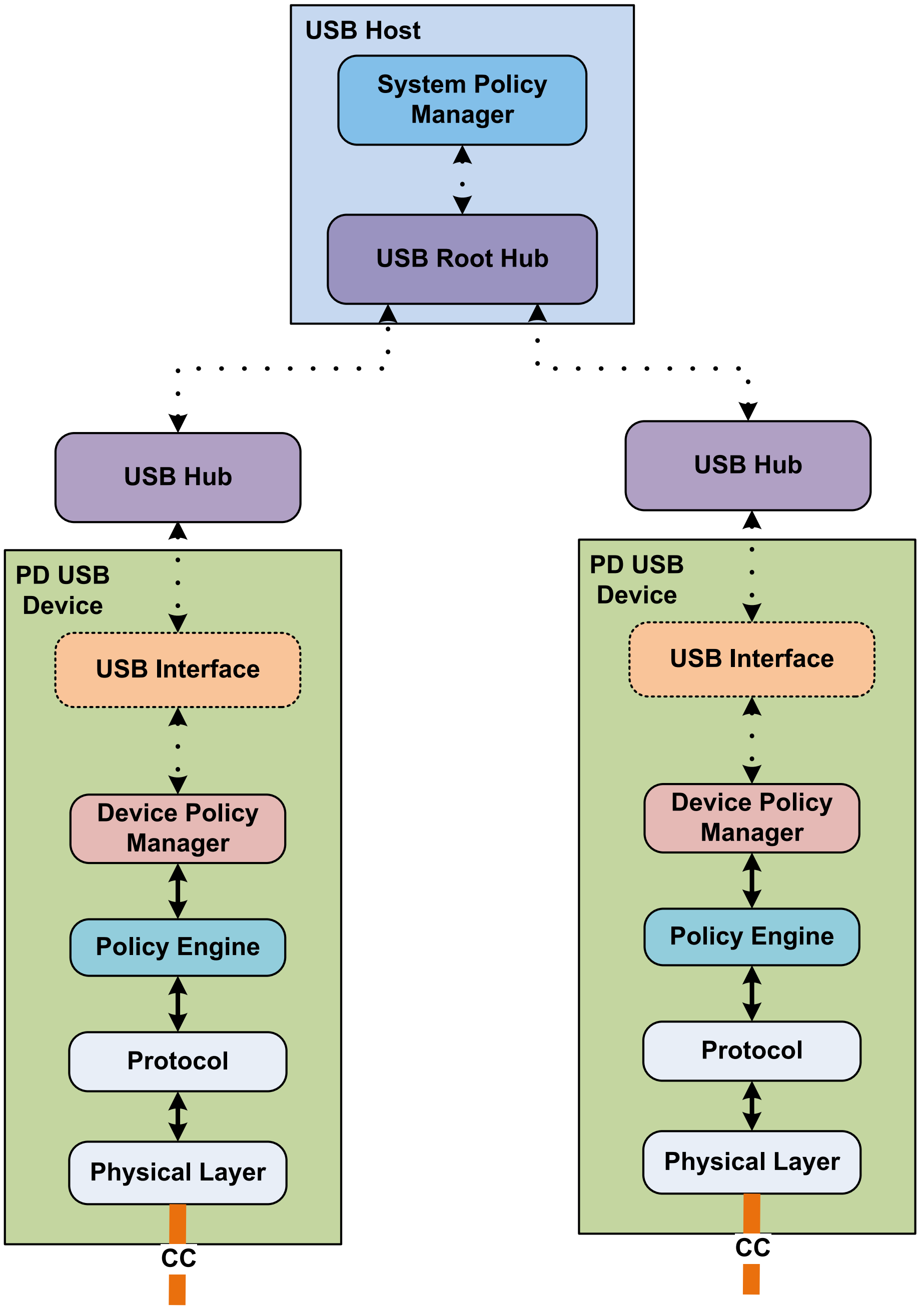


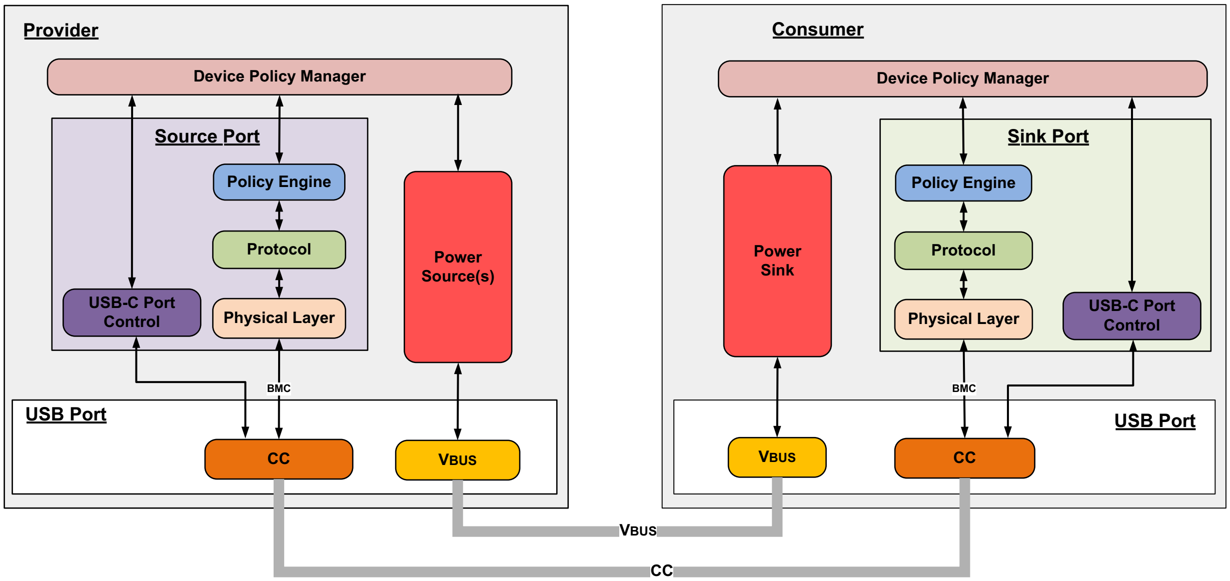
Figure 2.5, "High Level Architecture View" shows the logical blocks between two *Attached PD Ports* (*Port Pair*). In addition to the communication stack described above there are also:

- For a *Provider* or *Dual-Role Power Device*: one or more *Sources* providing power to one or more *Ports*.
- For a *Consumer* or *Dual-Role Power Device*: A *Sink* consuming power.
- A *USB-C*® *Port Control* module (see *Section4.4 "Cable Type Detection"*) that detects cable *Attach*/*Detach* as defined in ***[USB Type-C 2.4]***.
- USB Power Delivery uses standard cabling as defined in ***[USB Type-C 2.4]***.

The *Device Policy Manager* talks to the communication stack, *Source/Sink*, and the *USB-C*® *Port Control* block to manage the resources in the *Provider* or *Consumer*.

[Figure 2.5, "High Level Architecture View"](#) illustrates a *Provider* and a *Consumer*. *Dual-Role Power Devices* can be constructed by combining the elements of both *Provider* and *Consumer* into a single device. *Provider*s can also contain multiple *Source Port*s each with their own communications stack and *USB-C*® *Port Control*.

Figure 2.5 High Level Architecture View



2.6.1 Policy

There are two levels of Policy:

1) *System Policy* applied system wide by the *System Policy Manager* across multiple *Provider*s or *Consumer*s.

3) *Local Policy* enforced on a *Provider* or *Consumer* by the *Device Policy Manager* for a device.

Policy comprises several logical blocks:

- *System Policy Manager* (system wide).
- *Device Policy Manager* (one per *Provider* or *Consumer*).
- *Policy Engine* (one per *Source Port* or *Sink Port*).

2.6.1.1 System Policy Manager

Since the USB Power Delivery protocol is *Port* to *Port*, implementation of a *System Policy* requires communication by an additional data communication mechanism i.e., USB. ***[UCSI]***has been created to define an interface for the *System Policy Manager* to communicate with the *Device Policy Manager*. When present, the *System Policy Manager* monitors and controls *System Policy* between various *Provider*s and *Consumer*s connected via USB. The *System Policy Manager* resides in the *USB Host* and communicates via USB with the *Device Policy Manager* in each connected *Device*. *Device*s without *USB Communication* capability or are not data connected, will not be able to participate in *System Policy*.

The *System Policy Manager* is ***Optional*** so USB Power Delivery *Provider*s and *Consumer*s will operate without it being present. This includes systems where the *USB Host* does not provide a *System Policy Manager* and can also include "headless" systems without any *USB Host*. In those cases where a *USB Host* is not present, USB Power Delivery is useful for charging purposes, or the powering of devices since useful USB functionality is not possible. Where there is a *USB Host*, but no *System Policy Manager*, *Provider*s and *Consumer*s can *Negotiate* power between themselves, independently of USB power rules, but are more limited in terms of the options available for managing power.

2.6.1.2 Device Policy Manager

The *Device Policy Manager* provides mechanisms to monitor and control the USB Power Delivery system within a particular *Consumer* or *Provider*. The *Device Policy Manager* enables *Local Policy* to be enforced across the system by communication with the *System Policy Manager*. *Local Policy* is enacted on a per *Port* basis by the *Device Policy Manager*'s control of the *Source Port*s/*Sink Ports* and by communication with the *Policy Engine* and *USB-C*® *Port Control* for that *Port*. The *Device Policy Manager* is responsible for the sharing algorithm used in *Shared Capacity Charger*s (see ***[USB Type-C 2.4]***)

2.6.1.3 Policy Engine

*Provider*s and *Consumer*s are free to implement their own *Local Policy* on their directly connected *Source Port*s or *Sink Port*s. These will be supported by *Negotiation* and status mechanisms implemented by the *Policy Engine* for that *Port*. The *Policy Engine* interacts directly with the *Device Policy Manager* to determine the present *Local Policy* to be enforced. The *Device Policy Manager* will also inform the *Policy Engine* whenever there is a change in *Local Policy* (e.g., *Capabilities* change).

2.6.2 Message Formation and Transmission

2.6.2.1 Protocol Layer

The *Protocol Layer* forms the *Message*s used to communicate information between a *Port Pair*. It is responsible for forming *Capabilities Message*s, requests and acknowledgments. Additionally, it forms *Message*s used to swap roles and maintain presence. It receives inputs from the *Policy Engine* indicating which *Message*s to send and indicates the responses back to the *Policy Engine*.

The basic protocol uses a push model where the *Provider* pushes its *Capabilities* to the *Consumer* that in turn responds with a request based on the offering. However, the *Consumer* can asynchronously request the *Provider*'s present *Capabilities* and can select another voltage/current.

*Extended Message*s of up to a ***Data Size*** of ***MaxExtendedMsgLen*** can be sent and received provided the *Protocol Layer* determines that both *Port Partner*s support this capability. When one of both *Port Partner*s do not support *Extended Messages* of ***Data Size*** greater than ***MaxExtendedMsgLegacyLen*** then the *Protocol Layer* supports a *Chunking* mechanism to break larger *Message*s into smaller *Chunk*s of size ***MaxExtendedMsgChunkLen***. All *Ports* that support *Extended Message*s longer than ***MaxExtendedMsgLegacyLen*** are required to support *Chunking*.

2.6.2.2 PHY Layer

The *PHY Layer* is responsible for sending and receiving *Message*s across the *USB Type-C CC* wire and for managing data. *PD* is a *Multi-Drop* system, sharing *CC* between the *Port Partner*s and the *Cable Plug*(s) that implements *Collision Avoidance* and recovery mechanisms. The *PHY Layer* detects errors in the *Message*s using a *CRC*.

2.6.3 Collision Avoidance

2.6.3.1 Policy Engine

The *Policy Engine* in a *Source* will indicate to the *Protocol Layer* the start and end of each *Atomic Message Sequence* (*AMS*) that the *Source* initiates. The *Policy Engine* in a *Sink* will indicate to the *Protocol Layer* the start of each *AMS* the *Sink* initiates. This enables co-ordination of *AMS* initiation between the *Port Partner*s.

2.6.3.2 Protocol Layer

The *Protocol Layer* in the *Source* will request the PHY to set the R_p value to ***SinkTxOK*** when it is not actively sending *Message*s. This indicates to the *Sink* that it can initiate an *AMS* by sending the first *Message* in the sequence. The *Protocol Layer* in the *Source* will request the *PHY Layer* to set the R_p value to ***SinkTxNG*** to indicate that the *Sink* cannot initiate an *AMS* since the *Source* is about to initiate an *AMS*.

The *Protocol Layer* in the *Sink*, when the *Policy Engine* indicates that an *AMS* is being initiated, will wait for the R_p value to be set to ***SinkTxOK*** before initiating the *AMS* by sending the first *Message* in the sequence.

2.6.3.3 PHY Layer

The *PHY Layer* in the *Source* will set the R_p value to either ***SinkTxOK*** or ***SinkTxNG*** as directed by the *Protocol Layer*. The *PHY Layer* in the *Sink* will detect the present R_p value and inform the *Protocol Layer*.

2.6.4 Power supply

2.6.4.1 Source

Each *Provider* will contain one or more power sources that are shared between one or more *Port*s. These power sources are controlled by the *Local Policy*. *Source Port*s start up in *USB Type-C* Operation where the *Port* applies ***vSafe0V*** on *VBUS* and returns to this state on *Detach* or after a *Hard Reset*. When the *Source* detects *Attach* events it transitions its output to ***vSafe5V***.

2.6.4.2 Sink

*Consumer*s are assumed to have one *Sink* connected to a *Port*. This *Sink* is controlled by *Local Policy*. *Sink*s start up in *USB Default Operation* where the *Port* can operate at ***vSafe5V*** with USB default specified current levels and return to this state on *Detach* or after a *Hard Reset*.

2.6.4.3 Dual-Role Power Ports

Dual-Role Power Ports have the ability to operate as either a *Source* or a *Sink* and to swap between the two *Power Role*s using *Power Role Swap* or *Fast Role Swap*.

2.6.4.4 Dead Battery or Lost Power Detection

[USB Type-C 2.4] defines mechanisms intended to communicate with and to charge a *Sink* or *DRP* with a *Dead Battery*.

2.6.4.5 VCONN Source

The *Source Port* at *Attach*, is also the *VCONN Source*. The responsibility for sourcing *VCONN* can be swapped between the *Source Port*s and *Sink Port*s in a make before break fashion to ensure that the *Cable Plug*s are continuously powered. To ensure reliable communication with the *Cable Plug*s only the *Port* that is the *VCONN Source* is permitted to communicate with the *Cable Plug*s.

Note: Prior to a *Power Role Swap*, *Data Role Swap* or *Fast Role Swap* each new *Source Port* needs to ensure that it is the *VCONN Source* if it needs to communicate with the *Cable Plugs* after the swap.

2.6.5 DFP/UFP

2.6.5.1 Downstream Facing Port (DFP)

The *Downstream Facing Port* or *DFP* is equivalent in the USB topology to the *Port* a *USB Device* is *Attached* to. The *DFP* will also correspond to the *USB Host* but only if *USB Communication* is supported while acting as a *DFP*. Products such as *Charger*s can be a *DFP* while not having *USB Communication* capability. Only the *DFP* is allowed to control *Alternate Mode* operation.

2.6.5.2 Upstream Facing Port (UFP)

The *Upstream Facing Port* or *UFP* is equivalent in the USB topology to the *Port* on a *USB Device* that is connected to the *USB Host* or *USB Hub*'s *DFP*. The *UFP* will also correspond to the *USB Device* but only if *USB Communication* is supported while acting as a *UFP*. Products which charge can be a *UFP* while not having *USB Communication* capability.

2.6.5.3 Dual-Role Data Ports

Dual-Role Data Ports have the ability to operate as either a *DFP* or a *UFP* and to swap between the two *Data Roles* using *Data Role Swap*.

Note: Products can be *Dual-Role Data Ports* without being *Dual-Role Power Ports* that is they can switch logically between *DFP* and *UFP Data Roles* even if they are *Source*-only or *Sink*-only Ports.

2.6.6 Cable and Connectors

The USB Power Delivery specification assumes certified USB cables and associated detection mechanisms as defined in the ***[USB Type-C 2.4]*** specification.

2.6.6.1 USB-C Port Control

The *USB-C® Port Control* block provides mechanisms to:

- Inform the *Device Policy Manager* of cable *Attach*/*Detach* events.
- Inform *Sink*'s *Device Policy Manager* of the R_p value.
- Allow *Source*'s *Device Policy Manager* to set the R_p value.

2.6.7 Interactions between Non-PD, BC, and PD devices

USB Power Delivery only operates when two USB Power Delivery devices are directly connected. When a device finds itself a mixed environment, where the other device does not support the USB Power Delivery Specification, the existing rules on supplying ***vSafe5V*** as defined in the ***[USB 2.0]***, ***[USB 3.2]***, ***[USBBC 1.2]*** or ***[USB Type-C 2.4]*** specifications are applied.

There are two primary cases to consider:

- The *USB Host* (*DFP*/*Source*) is non-*PD* and as such will not send any *Advertise*ments. An *Attached PD Capable* device will not see any *Advertise*ments and operates using the rules defined in the ***[USB 2.0]***, ***[USB 3.2]***, ***[USBBC 1.2]*** or ***[USB Type-C 2.4]*** specifications.
- The *Device* (*UFP*/*Sink*) is non-*PD* and as such will not see any *Advertise*ments and therefore will not respond. The *USB Host* (*DFP*/*Source*) will continue to supply ***vSafe5V*** to *VBUS* as specified in the ***[USB 2.0]***, ***[USB 3.2]***, ***[USBBC 1.2]*** or ***[USB Type-C 2.4]*** specifications.

2.6.8 Power Rules

Power Rules define voltages and current ranges that are offered by compliant USB Power Delivery *Sources* and used by a USB Power Delivery *Sink* for a given value of *PDP Rating*. See *Chapter 10 "Power Rules"* for further details.

2.7 Extended Power Range (EPR) Operation

Extended Power Range is a *Mode* that provides for up to 240W which is considerably more power than the 100W the original *PD* specification (*SPR Mode*) offered. It is a *Mode* of operation that can be entered only when an *Explicit Contract* is in place and both the *Port*s and the *Cable Plug*(s) support *EPR*.

Entry into *EPR Mode* follows a strict process; this assures that the higher voltages, at power levels above 100W, are only transferred between known *EPR Capable Source*s and *EPR Capable Sink*s over *EPR Capable* cables. *EPR Source*s are capable of both *Fixed Supply* and *Adjustable Voltage Supply* (*AVS*) operation. Maintaining *EPR Mode* operation also requires maintaining a regular cadence of USB *PD* communications; loss of communications between the *EPR Source* and *EPR Sink* will cause a *Hard Reset* to be initiated resulting in a return to *SPR* operation.

The *EPR Mode* entry, operational and exit process is summarized by the following steps:

1) *Negotiate* and enter into an *Explicit Contract* in the *Standard Power Range*. During this step, *EPR Capable Source*s and *Sink*s will declare their supported *EPR Capabilities* through *PDO*/*APDO* and *RDO* exchanges.

2) An *EPR Sink*, having discovered an *EPR Source*, can request *EPR Mode* entry.

3) The *EPR Source*, having already confirmed that the *Attached* cable assembly is *EPR Capable* during the *First Explicit Contract Negotiation*, will respond to the *EPR Sink* with an acknowledgment of the *EPR Mode* entry request.

4) While in *EPR Mode*:

    a) The *EPR Source* sends EPR *Capabilities* (*Fixed Supply PDO*s and an *AVS APDO*) to the *EPR Sink* which requires the *Sink* to evaluate and respond as appropriate to adjust the *Explicit Contract*.

    b) The *EPR Sink* maintains a regular cadence of communications with the *EPR Source* to allow *EPR Mode* to continue.

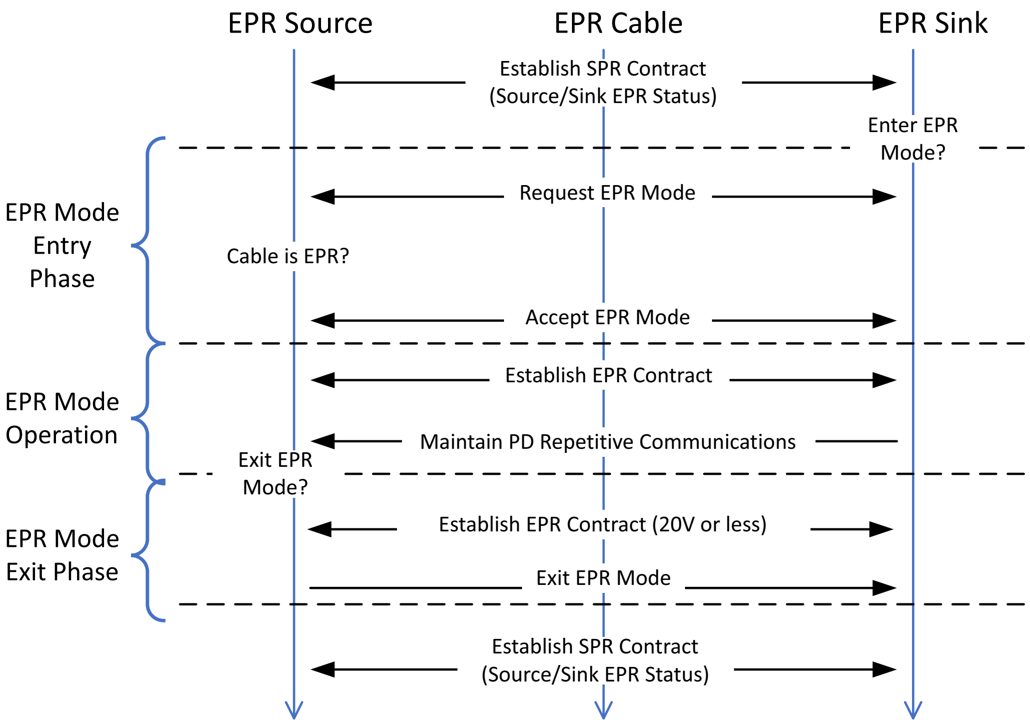
5) When either the *EPR Source* or *EPR Sink* no longer wants to remain in *EPR Mode* operation, a normal exit from *EPR Mode* will first require adjusting the *Explicit Contract* to a voltage of 20V or lower (*SPR (A)PDO*) followed by an explicit *EPR Mode* exit request.

    a) *Source* initiated: *EPR Source* sends an ***EPR_Source_Capabilities*** *Message* that only includes *SPR* voltages to force the *EPR Sink* to drop to 20V or below followed by the *EPR Mode* exit. Once *EPR Mode* is exited, a new *SPR Contract* is *Negotiate*d to return to *SPR Mode* operation.

    b) *Sink* initiated; *EPR Sink* requests a drop to 20V or below followed by the *EPR Mode* exit. Once *EPR Mode* is exited, a new *SPR Contract* is *Negotiate*d to return to *SPR Mode* operation.

Figure 2.6, "Example of a Normal EPR Mode Operational Flow" illustrates an example of a normal *EPR Mode* operational flow. In this example, at some time during the *EPR Mode* operation, the *Source* decides that it needs to exit *EPR Mode*, so it resends the *EPR Capabilities* to the *Sink* with only *SPR (A)PDO*s to cause the *Sink* to *Negotiate* an *SPR Contract* of 20V or lower and then the *Source* follows with an *EPR Mode* ***exit*** *Message*. Once *EPR Mode* is exited, a new *SPR Contract* is *Negotiate*d to return to *SPR Mode* operation.

Figure 2.6 Example of a Normal EPR Mode Operational Flow



Not illustrated in *Figure 2.6, "Example of a Normal EPR Mode Operational Flow"*, while in *EPR Mode* operation, the *Sink* might decide it wants to exit *EPR Mode*. In this case, the *Sink* must initiate the exit process by revising its *Explicit Contract* with the *Source* at 20V or less followed with an ***EPR_Mode exit*** *Message*. Once *EPR Mode* is exited, a new *SPR Contract* is *Negotiate*d to formalize the return to *SPR Mode* operation. Failure to revise the *Explicit Contract* to one at 20V or less before attempting to exit *EPR Mode* will result in a *Hard Reset*.

2.8 Charging Models

This section provides a charging model overview for each of the primary power delivery methods: *Fixed Supply*, *Programmable Power Supply* and *Adjustable Voltage Supply*.

2.8.1 Fixed Supply Charging Models

USB Power Delivery supports *Fixed Supply* charging using a set of defined standard voltages with current available up to the limit of the *Source*'s and cable's *Advertised Capabilities*. As summarized in *Table 2.1, "Fixed Supply Power Ranges"*, the standard voltages are available in either the *Standard Power Range* (*SPR*) and/or the *Extended Power Range* (*EPR*).

Table 2.1 Fixed Supply Power Ranges

Power Range	Available Current and Voltages		PDP Range	Notes
Standard Power Range (*SPR*)	3A:	5V, 9V, 15V, 20V	15 – 60W	
	5A[1]:	20V	>60 – 100W	
Extended Power Range (*EPR*)	3A[2]:	5V, 9V, 15V, 20V	15 – 60W	Requires entry into *EPR Mode*.
	5A[2]:	20V	>60 – 100W	
	5A[2]:	28V, 36V, 48V	>100 – 240W	
1) Requires 5A cable.				
2) Requires *EPR* cable.				

2.8.2 Programmable Power Supply (PPS) Charging Models

USB Power Delivery includes support for *Programmable Power Supply* (*PPS*) charging using a set of defined standard voltage ranges. With current up to the limit of the *Source*'s and cable's *Advertised Capabilities*. Additionally, when operating in *SPR Mode* the current is also limited by the ***Operating Current*** field value in the ***Request*** *Message*.

Note: *PPS* operation is not available in *EPR Mode*.

The standard voltage ranges available in the *Standard Power Range* (*SPR*) for *PPS* are summarized in *Table 2.2, "PPS Voltage Power Ranges"*.

Table 2.2 PPS Voltage Power Ranges

Available Current	Prog	Min Voltage (V)	Max Voltage (V)	PDP Range
3A	9V Prog	5	11	16 – 60W
	15V Prog	5	16	
	20V Prog	5	21	
5A[1]	20V Prog	5	21	61 – 100W
1) Requires 5A cable.				

2.8.3 Adjustable Voltage Supply (AVS) Charging Models

USB Power Delivery operating in *SPR Mode* (when *PDP* is higher than 27W) and *EPR Mode* includes support for *Adjustable Voltage Supply* (*AVS*) charging using a set of defined standard voltage ranges based on the *Source*'s *PDP Rating*.

The standard voltage ranges available for *AVS* are summarized in *Table 2.3, "AVS Voltage Power Ranges"*.

Table 2.3 AVS Voltage Power Ranges

PDP						
	Minimum Voltage (V)	Maximum Voltage (V)	Maximum Available Current[3]	Minimum Voltage (V)	Maximum Voltage (V)	Maximum Available Current
>27…45W	9	15	3A	***N/A***		
>45…60W	9	20	3A			
>60…100W	9	20	5A[1]			
100…140W	9	20	5A[2]	15	28	5A[2]
>140…180W	9	20	5A[2]	15	36	5A[2]
>180…240W	9	20	5A[2]	15	48	5A[2]

1) Requires 5A cable.

2) Requires an *EPR* Cable.

3) The maximum available *SPR AVS* current is determined by the maximum available current in the *Fixed Supply* 15V *PDO* in the 9 - 15V range and *Fixed Supply* 20V *PDO* in the 15 - 20V range.

3 USB Type-A and USB Type-B Cable Assemblies and Connectors

This section has been ***Deprecated***. Please refer to ***[USBPD 2.0]*** for details of cables and connectors used in scenarios utilizing the *BFSK Signaling Scheme* in conjunction with *USB Type-A* or *USB Type-B* connectors.

4 Electrical Requirements

This chapter covers the platform's electrical requirements for implementing USB Power Delivery.

4.1 Interoperability with other USB Specifications

USB Power Delivery ***May*** be implemented alongside the ***[USB 2.0]***, ***[USB 3.2]***, ***[USB4]***, ***[USBBC 1.2]*** and ***[USB Type-C 2.4]*** (*USB Type-C*) specifications. In the case where a *Device* requests power via ***[USBBC 1.2]*** and then the USB Power Delivery Specification, it ***Shall*** follow the USB Power Delivery Specification until the *Port Pair* is *Detached* or there is a *Hard Reset*. If the USB Power Delivery connection is lost, the *Port* ***Shall*** return to its default state, see *Section 6.8.3, "Hard Reset"*.

4.2 Dead Battery Detection / Unpowered Port Detection

Dead Battery/unpowered operation is when a *USB Device* needs to provide power to a *USB Host* under the circumstances where the *USB Host*:

- Has a *Dead Battery* that requires charging or
- Has lost its power source or
- Does not have a power source or
- Does not want to provide power.

Dead Battery charging operation for connections between *USB Type-C* connectors is defined in ***[USB Type-C 2.4]***.

4.3 Cable IR Ground Drop (IR Drop)

Every *PD Sink Port* capable of *USB Communication* can be susceptible to unreliable *USB Communication* if the voltage drop across ground falls outside of the acceptable common mode range for the USB Hi-Speed transceivers data lines due to excessive current draw. Certified USB cabling is specified such that such errors don't typically occur (See ***[USB Type-C 2.4]***).

4.4 Cable Type Detection

Standard *USB Type-C*® cable assemblies are rated for *PD* voltages higher than ***vSafe5V*** and current levels of at least 3A (See ***[USB Type-C 2.4]***). The *Source* ***Shall*** limit maximum *Capabilities* it offers so as not to exceed the *Capabilities* of the type of cabling detected.

*Source*s capable of offering more than 3A ***Shall*** detect the type of *Attached* cable and limit the *Capabilities* they offer based on the current carrying capability of the cable determined by the *Cable Capabilities* determined using the ***Discover Identity*** *Command* (see *Section 6.4.4.3.1, "Discover Identity"*) sent using *SOP' Communication* (see *Section 2.4, "SOP* Communication"*) to the *Cable Plug*. The *Cable VDO* returned as part of the ***Discover Identity*** *Command* details the maximum current and voltage values that ***Shall*** be *Negotiate*d for a given cable as part of an *Explicit Contract*.

The *Cable Discovery* process is usually run when the *Source* is powered up, after a *Power Role Swap* or *Fast Role Swap* or when power is applied to a *Sink*. The method used to detect these events ***Shall*** meet the following requirements:

- *Sources* ***Shall*** run the *Cable Discovery* process prior to the *Source* sending ***Source_Capabilities*** *Messages* offering currents in excess of 3A and/or voltages in excess of 20V.
- *Sink*s with *USB Type-C* connectors ***Shall*** select *Capabilities* from the offered *Source Capabilities* assuming that the *Source* has already determined the *Capabilities* of the cable.
- *Sink*s with the ***Dual-Role Power*** bit set, ***Shall*** respond to a ***Get_Source_Cap*** *Message* by declaring their full *Source Capabilities*, without limiting them based on the cable's *Capabilities*.

5 Physical Layer

5.1 Physical Layer Overview

The Physical Layer (*PHY Layer*) defines the *Signaling* technology for USB Power Delivery. This chapter defines the electrical requirements and parameters of the *PHY Layer* required for interoperability between *PDUSB Devices*.

5.2 Physical Layer Functions

The USB PD *PHY Layer* consists of a pair of transmitters and receivers that communicate across a single signal wire (*CC*). All communication is half duplex. The *PHY Layer* practices *Collision Avoidance* to minimize communication errors on the channel.

The transmitter performs the following functions:

- Receive *Packet* data from the *Protocol Layer*.
- Calculate and append a *CRC*.
- Encode the *Packet* data including the *CRC* (i.e., the *Payload*).
- Transmit the *Packet* (*Preamble*, *SOP**, *Payload*, *CRC* and *EOP*) across the channel using *Bi-phase Mark Coding* (*BMC*) over *CC*.

The receiver performs the following functions:

- Recover the clock and lock onto the *Packet* from the *Preamble*.
- Detect the *SOP**.
- Decode the received data including the *CRC*.
- Detect the *EOP* and validate the *CRC*:
  - If the *CRC* is ***Valid***, deliver the *Packet* data to the *Protocol Layer*.
  - If the *CRC* is ***Invalid***, flush the received data.

5.3 Symbol Encoding

Except for the *Preamble*, all communications on the line ***Shall*** be encoded with a line code to ensure a reasonable level of DC-balance and a suitable number of transitions. This encoding makes receiver design less complicated and allows for more variations in the receiver design.

4b5b line code ***Shall*** be used. This encodes 4-bit data to 5-bit symbols for transmission and decodes 5-bit symbols to 4-bit data for consumption by the receiver.

The 4b5b code provides data encoding along with special symbols. Special symbols are used to signal *Hard Reset*, and delineate *Packet* boundaries (see *Table 5.1, "4b5b Symbol Encoding"*).

Table 5.1 4b5b Symbol Encoding

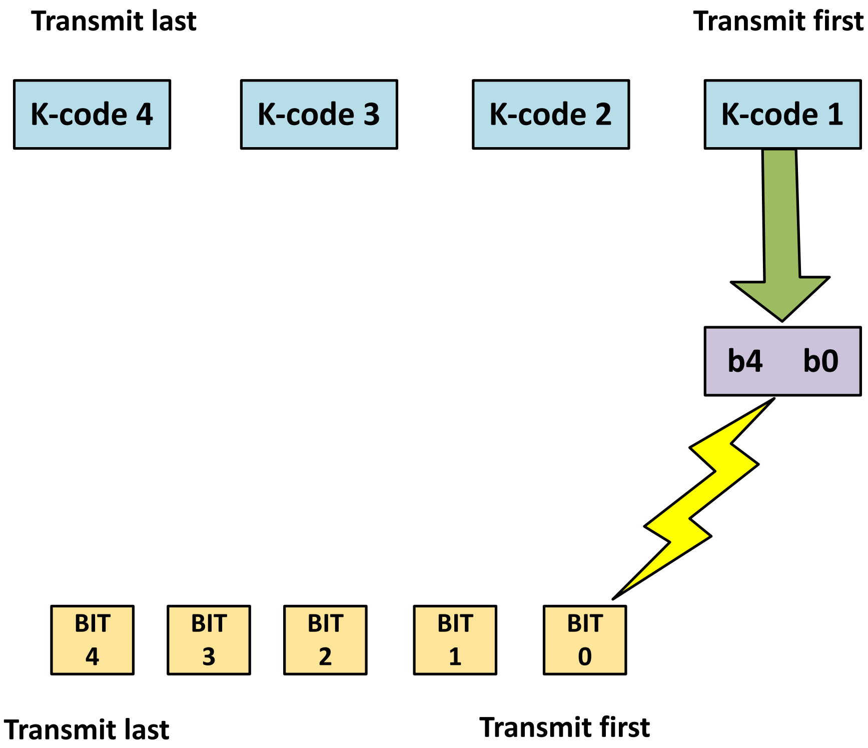
Name	4b	5b Symbol	Description
0	0000	11110	hex data 0
1	0001	01001	hex data 1
2	0010	10100	hex data 2
3	0011	10101	hex data 3
4	0100	01010	hex data 4
5	0101	01011	hex data 5
6	0110	01110	hex data 6
7	0111	01111	hex data 7
8	1000	10010	hex data 8
9	1001	10011	hex data 9
A	1010	10110	hex data A
B	1011	10111	hex data B
C	1100	11010	hex data C
D	1101	11011	hex data D
E	1110	11100	hex data E
F	1111	11101	hex data F
Sync-1	*K-code*	11000	Startsynch #1
Sync-2	*K-code*	10001	Startsynch #2
RST-1	*K-code*	00111	*Hard Reset* #1
RST-2	*K-code*	11001	*Hard Reset* #2
EOP	*K-code*	01101	*EOP* End of *Packet*
	Error	00000	***Shall Not*** be used
	Error	00001	***Shall Not*** be used
	Error	00010	***Shall Not*** be used
	Error	00011	***Shall Not*** be used
	Error	00100	***Shall Not*** be used
	Error	00101	***Shall Not*** be used
Sync-3	*K-code*	00110	Startsynch #3
	Error	01000	***Shall Not*** be used
	Error	01100	***Shall Not*** be used
	Error	10000	***Shall Not*** be used
	Error	11111	***Shall Not*** be used

5.4 Ordered Sets

Ordered sets ***Shall*** be interpreted according to *Figure 5.1, "Interpretation of ordered sets"*.

An ordered set consists of 4 *K-code*s sent as shown in *Figure 5.1, "Interpretation of ordered sets"*.

Figure 5.1 Interpretation of ordered sets



A list of the ordered sets used by USB Power Delivery can be seen in *Table 5.2, "Ordered Sets"*. *SOP** is a generic term used in place of *SOP*/*SOP'*/*SOP"*.

Table 5.2 Ordered Sets

Ordered Set	Reference
Cable Reset	*Section 5.6.5, "Cable Reset"*
Hard Reset	*Section 5.6.4, "Hard Reset"*
SOP	*Section 5.6.1.2.1, "Start of Packet Sequence (SOP)"*
SOP'	*Section 5.6.1.2.2, "Start of Packet Sequence Prime (SOP')"*
SOP'_Debug	*Section 5.6.1.2.4, "Start of Packet Sequence Prime Debug (SOP'_Debug)"*
SOP"	*Section 5.6.1.2.3, "Start of Packet Sequence Double Prime (SOP'')"*
SOP"_Debug	*Section 5.6.1.2.5, "Start of Packet Sequence Double Prime Debug (SOP''_Debug)"*

The receiver ***Shall*** search for all four *K-code*s. When the receiver finds all four *K-code*s in the correct place, it ***Shall*** interpret this as a ***Valid*** ordered set. When the receiver finds three out of four *K-code*s in the correct place, it ***May*** interpret this as a ***Valid*** ordered set. The receiver ***Should*** ensure that all four *K-code*s are ***Valid*** to avoid ambiguity in detection (see *Table 5.3, "Validation of Ordered Sets"*).

Table 5.3 Validation of Ordered Sets

	1st code	2nd code	3rd code	4th code
Valid[1]	Corrupt	*K-code*	*K-code*	*K-code*
Valid[1]	*K-code*	Corrupt	*K-code*	*K-code*
Valid[1]	*K-code*	*K-code*	Corrupt	*K-code*
Valid[1]	*K-code*	*K-code*	*K-code*	Corrupt
Valid[2] (perfect)	*K-code*	*K-code*	*K-code*	*K-code*
Invalid (example)	*K-code*	Corrupt	*K-code*	Corrupt

1) ***May*** be interpreted as a ***Valid*** ordered set.

2) ***Shall*** be interpreted as a ***Valid***ordered set.

5.5 Transmitted Bit Ordering

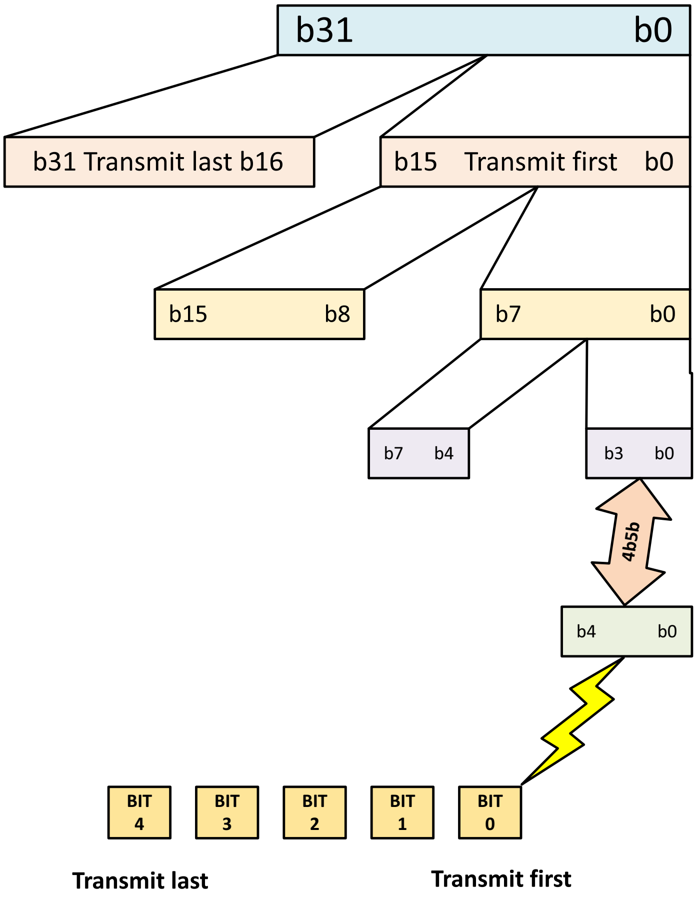
This section describes the order of bits on the wire that ***Shall*** be used when transmitting data of varying sizes. *Table 5.4, "Data Size"* shows the different data sizes that are possible.

Figure 5.2, "Transmit Order for Various Sizes of Data" shows the transmission order that ***Shall*** be followed.

Table 5.4 Data Size

	Unencoded	Encoded
Byte	8-bits	10-bits
Word	16-bits	20- bits
DWord	32-bits	40-bits

Figure 5.2 Transmit Order for Various Sizes of Data



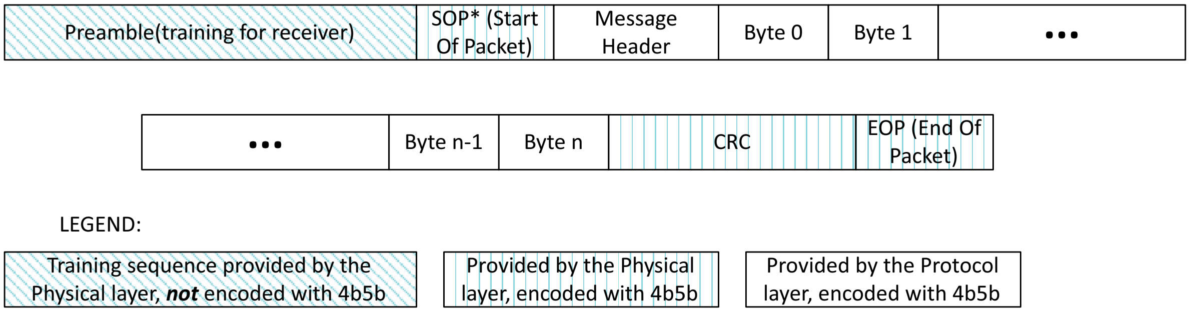
5.6 Packet Format

The *Packet* format ***Shall*** consist of a *Preamble*, an *SOP**, (see *Section 5.6.1.2, "Start of Packet Sequences"*), *Packet* data including the *Message Header*, a *CRC* and an *EOP* (see *Section 5.6.1.5, "End of Packet (EOP)"*). The *Packet* format is shown in *Figure 5.3, "USB Power Delivery Packet Format"* and indicates which parts of the *Packet* ***Shall*** be 4b/5b encoded. Once 4b/5b encoded, the entire *Packet* ***Shall*** be transmitted using *BMC* over *CC*.

Note: All the bits in the *Packet*, including the *Preamble*, are *BMC* encoded.

See *Section 6.2.1, "Message Construction"* for more details of the *Packet* construction for *Control Messages*, *Data Messages* and *Extended Messages*.

Figure 5.3 USB Power Delivery Packet Format


Preamble(training for receiver)
SOP* (Start Of Packet)
Message Header
Byte 0
Byte 1
•••
•••
Byte n-1
Byte n
CRC
EOP (End Of Packet)
LEGEND:
Training sequence provided by the Physical layer, *not* encoded with 4b5b
Provided by the Physical layer, encoded with 4b5b
Provided by the Protocol layer, encoded with 4b5b

5.6.1 Packet Framing

The transmission starts with a *Preamble* that is used to allow the receiver to lock onto the carrier. It is followed by a *SOP** (*Start of Packet*). The *Packet* is terminated with an ***EOP*** (*End of Packet*) *K-code*.

5.6.1.1 Preamble

The *Preamble* is used to achieve lock in the receiver by presenting an alternating series of "0s" and "1s", so the average frequency is the carrier frequency. Unlike the rest of the *Packet*, the *Preamble* ***Shall*** Not be 4b/5b encoded.

The *Preamble* ***Shall*** consist of a 64-bit sequence of alternating 0s and 1s. The *Preamble* ***Shall*** start with a "0" and ***Shall*** end with a "1".

5.6.1.2 Start of Packet Sequences

5.6.1.2.1 Start of Packet Sequence (SOP)

SOP is an ordered set. The ***SOP*** ordered set is defined as: three ***Sync-1*** *K-codes* followed by one ***Sync-2*** *K-code* (see *Table 5.5, "SOP Ordered Set"*).

Table 5.5 SOP Ordered Set

K-Code Number	K-Code in Code Table
1	***Sync-1***
2	***Sync-1***
3	***Sync-1***
4	***Sync-2***

A Power Delivery Capable *Source* or *Sink* ***Shall*** be able to detect and communicate with *Packets* using *SOP*. If a ***Valid*** *SOP* is not detected (see *Table 5.3, "Validation of Ordered Sets"*) then the whole transmission ***Shall*** be ***Discarded***.

Sending and receiving of *SOP Packets* ***Shall*** be limited to *PD Capable Ports* on *PDUSB Hosts* and *PDUSB Devices*. *Cable Plugs* and *VPDs* ***Shall*** neither send nor receive *SOP Packets*.

Note: *PDUSB Devices*, even if they have the physical form of a cable (e.g., *AMAs*), are still required to respond to *SOP Packets*.

5.6.1.2.2 Start of Packet Sequence Prime (SOP')

The ***SOP'*** ordered set is defined as: two ***Sync-1*** *K-codes* followed by two ***Sync-3*** *K-codes* (see *Table 5.6, "SOP' Ordered Set"*).

Table 5.6 SOP' Ordered Set

K-Code Number	K-Code in Code Table
1	***Sync-1***
2	***Sync-1***
3	***Sync-3***
4	***Sync-3***

A *VPD* ***Shall*** have *SOP' Communication* capability. A *VPD* and a *Cable Plug* capable of *SOP' Communications* ***Shall*** only detect and communicate with *Packets* starting with ***SOP'***.

A *Port* needing to communicate with a *Cable Plug* capable of *SOP' Communications*, *Attached* between a *Port Pair* will be able to communicate using both *Packets* starting with ***SOP'*** to communicate with the *Cable Plug* and starting with ***SOP*** to communicate with its *Port Partner*.

For a *VPD* or a *Cable Plug* supporting *SOP' Communications*, if a ***Valid SOP'*** is not detected (see *Table 5.3, "Validation of Ordered Sets"*) then the whole transmission ***Shall*** be ***Discarded***. For a *Port* supporting *SOP' Communications* if a ***Valid SOP*** or ***SOP'*** is not detected (see *Table 5.3, "Validation of Ordered Sets"*) then the whole transmission ***Shall*** be ***Discarded***. When there is no *Explicit Contract* or an *Implicit Contract* in place a *Sink* ***Shall Not*** send *SOP' Packets* and ***Shall Discard*** all *Packets* starting with ***SOP'***.

5.6.1.2.3 Start of Packet Sequence Double Prime (SOP")

The ***SOP''*** ordered set is defined as the following sequence of *K-codes*: ***Sync-1***, ***Sync-3***, ***Sync-1***, ***Sync-3*** (see *Table 5.7, "SOP'' Ordered Set"*).

Table 5.7 SOP'' Ordered Set

K-Code Number	K-Code in Code Table
1	***Sync-1***
2	***Sync-3***
3	***Sync-1***
4	***Sync-3***

A *VPD* ***Shall Not*** have *SOP'' Communication* capability. A *Cable Plug* capable of *SOP'' Communication*, ***Shall*** have a *SOP' Communication* capability in the other *Cable Plug*. No cable ***Shall*** only support *SOP'' Communication*. A *Cable Plug* to which *SOP'' Communication* is assigned ***Shall*** only detect and communicate with *Packets* starting with ***SOP''*** and ***Shall Discard*** any other *Packets*.

A *Port* needing to communicate with such a *Cable Plug*, *Attached* between a *Port Pair* will be able to communicate using *Packets* starting with ***SOP'*** and ***SOP''*** to communicate with the *Cable Plugs* and *Packets* starting with ***SOP*** to communicate with its *Port Partner*. A *Port* which supports *SOP'' Communication* ***Shall*** also support *SOP' Communication* and ***Shall*** co-ordinate *SOP* Communication* so as to avoid collisions.

For the *Cable Plug* supporting *SOP'' Communication*, if a ***Valid SOP''*** is not detected (see *Table 5.3, "Validation of Ordered Sets"*) then the whole transmission ***Shall*** be ***Discarded***. For the *Port* if a ***Valid*** *SOP** is not detected (see *Table 5.3, "Validation of Ordered Sets"*) then the whole transmission ***Shall*** be ***Discarded***.

5.6.1.2.4 Start of Packet Sequence Prime Debug (SOP'_Debug)

The ***SOP'_Debug*** ordered set is defined as the following sequence of *K-codes*: ***Sync-1***, ***RST-2***, ***RST-2***, ***Sync-3*** (see *Table 5.8, "SOP'_Debug Ordered Set"*). The usage of this Ordered Set is presently undefined.

Table 5.8 SOP'_Debug Ordered Set

K-Code Number	K-Code in Code Table
1	***Sync-1***
2	***RST-2***
3	***RST-2***
4	***Sync-3***

5.6.1.2.5 Start of Packet Sequence Double Prime Debug (SOP"_Debug)

The ***SOP"_Debug*** ordered set is defined as the following sequence of *K-codes*: ***Sync-1***, ***RST-2***, ***Sync-3***, ***Sync-2*** (see *Table 5.9, "SOP"_Debug Ordered Set"*). The usage of this Ordered Set is presently undefined.

Table 5.9 SOP"_Debug Ordered Set

K-Code Number	K-Code in Code Table
1	***Sync-1***
2	***RST-2***
3	***Sync-3***
4	***Sync-2***

5.6.1.3 Packet Payload

The *Packet* data is delivered from the *Protocol Layer* (see *Section 6.2, "Messages"*) and ***Shall*** be encoded with the hex data codes from *Table 5.1, "4b5b Symbol Encoding"*.

5.6.1.4 CRC

The *CRC* ***Shall*** be inserted just after the *Payload*. It is described in *Section 5.6.2, "CRC"*.

5.6.1.5 End of Packet (EOP)

The end of *Packet* marker ***Shall*** be a single ***EOP*** *K-code* as defined in *Figure 5.1, "Interpretation of ordered sets"*. This ***Shall*** mark the end of the *CRC*. After the *EOP*, the *CRC*-residual ***Shall*** be checked. If the *CRC* is not good, the whole transmission ***Shall*** be ***Discarded***, if it is good, the *Packet* ***Shall*** be delivered to the *Protocol Layer*.

Note: An *EOP* ***May*** be used to prematurely terminate a *Packet* e.g., before sending ***Hard Reset*** *Signaling*.

5.6.2 CRC

The *Message Header* and data ***Shall*** be protected by a 32-bit *CRC*.

- *CRC*-32 protects the data integrity of the data *Payload*. *CRC*-32 is defined as follows:
- The *CRC*-32 polynomial ***Shall*** be = 04C1_1DB7h.
- The *CRC*-32 Initial value ***Shall*** be = FFFF_FFFFh.
- *CRC*-32 ***Shall*** be calculated for all bytes of the *Payload* not inclusive of any *Packet* framing symbols (i.e., excludes the *Preamble*, *SOP**, *EOP*).
- *CRC*-32 calculation ***Shall*** begin at byte 0, bit 0 and continue to bit 7 of each of the bytes of the *Packet*.
- The remainder of *CRC*-32 ***Shall*** be complemented.
- The residual of *CRC*-32 ***Shall*** be C704 DD7Bh.

This inversion of the *CRC*-32 remainder adds an offset of FFFF_FFFFh that will create a constant *CRC*-32 residual of C704_DD7Bh at the receiver side.

Note: The *CRC* implementation is identical to the one used in ***[USB 3.2]***.

Figure 5.4, "CRC-32 Generation" is an illustration of *CRC*-32 generation. The output bit ordering ***Shall*** be as detailed in *Table 5.10, "CRC-32 Mapping"*.

Figure 5.4 CRC-32 Generation

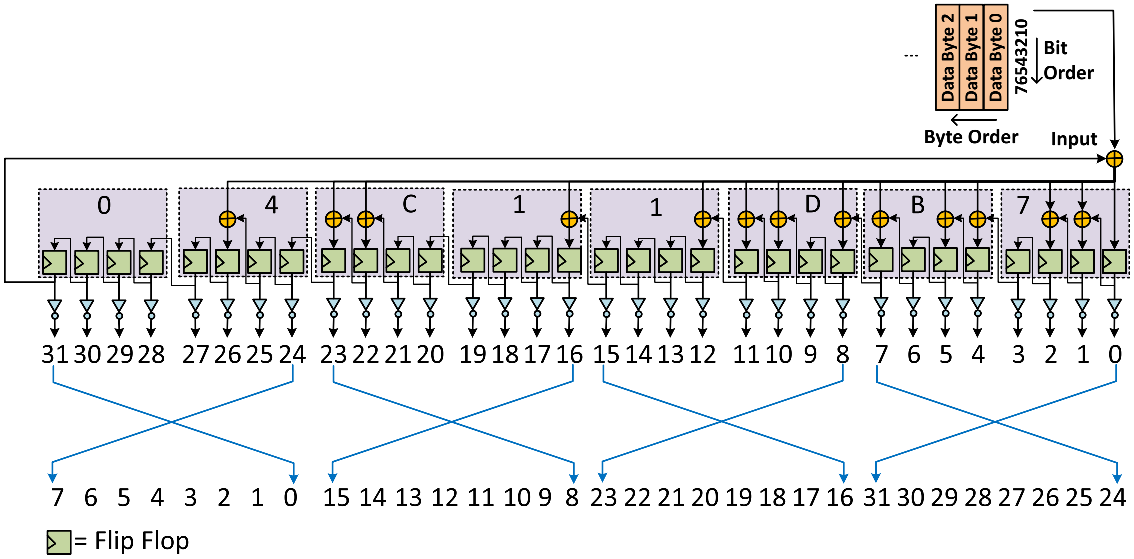


Table 5.10 CRC-32 Mapping

CRC-32	Result Bit Position in CRC-32 Field
0	31
1	30
2	29
3	28
4	27
5	26
6	25
7	24
8	23
9	22
10	21
11	20
12	19
13	18
14	17
15	16
16	15
17	14
18	13
19	12
20	11
21	10
22	9
23	8
24	7
25	6
26	5
27	4
28	3
29	2
30	1
31	0

The *CRC*-32 ***Shall*** be encoded before transmission.

5.6.3 Packet Detection Errors

CRC errors, or errors detected while decoding encoded symbols using the code table, ***Shall*** be treated the same way; the *Message* ***Shall*** be ***Discarded*** and a ***GoodCRC*** *Message* ***Shall Not*** be returned.

While the receiver is processing a *Packet*, if at any time the *CC*-line becomes Idle the receiver ***Shall*** stop processing the *Packet* and ***Discard*** it (no ***GoodCRC*** *Message* is returned). See *Section 5.8.6.1, "Definition of Idle"* for the definition of *BMC Idle*.

5.6.4 Hard Reset

Hard Reset *Signaling* is an ordered set of bytes sent with the purpose to be recognized by the *PHY Layer*. The ***Hard Reset*** *Signaling* ordered set is defined as: three ***RST-1*** *K-codes* followed by one ***RST-2*** *K-code* (see *Table 5.11, "Hard Reset Ordered Set"*).

Table 5.11 Hard Reset Ordered Set

K-Code Number	K-Code in Code Table
1	***RST-1***
2	***RST-1***
3	***RST-1***
4	***RST-2***

A device ***Shall*** perform a *Hard Reset* when it receives ***Hard Reset*** *Signaling*. After receiving the ***Hard Reset*** *Signaling*, the device ***Shall*** reset as described in *Section 6.8.3, "Hard Reset"*. If a ***Valid*** *Hard Reset* is not detected (see *Table 5.3, "Validation of Ordered Sets"*) then the whole transmission ***Shall*** be ***Discarded***.

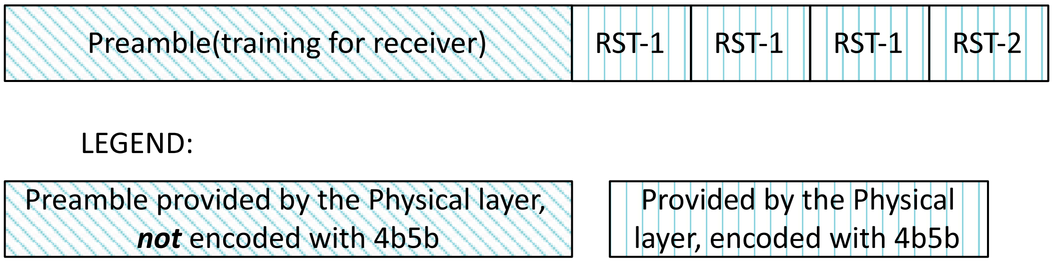
A *Cable Plug* ***Shall*** perform a *Hard Reset* when it detects ***Hard Reset*** *Signaling* being sent between the *Port Partners*. After receiving the ***Hard Reset*** *Signaling*, the device ***Shall*** reset as described in *Section 6.8.3, "Hard Reset"*.

The procedure for sending ***Hard Reset*** *Signaling* ***Shall*** be as follows:

- If the *PHY Layer* is currently sending a *Message*, the *Message* ***Shall*** be interrupted by sending an ***EOP*** *K-code* and the rest of the *Message* ***Discarded***.
- If *CC* is not *Idle*, wait for it to become *Idle* (see *Section 5.8.6.1, "Definition of Idle"*).
- Wait ***tInterFrameGap***.
- If *CC* is still *Idle* send the *Preamble* followed by the 4 *K-codes* for ***Hard Reset*** *Signaling*.
- Disable the channel (i.e., stop sending and receiving), reset the *PHY Layer* and inform the *Protocol Layer* that the *PHY Layer* has been reset.
- Re-enable the channel when requested by the *Protocol Layer*.

Figure 5.5, "Line format of Hard Reset" shows the line format of ***Hard Reset*** *Signaling* which is a *Preamble* followed by the ***Hard Reset*** Ordered Set.

Figure 5.5 Line format of Hard Reset


Preamble(training for receiver)
RST-1
RST-1
RST-1
RST-2
LEGEND:
Preamble provided by the Physical layer, ***not*** encoded with 4b5b
Provided by the Physical layer, encoded with 4b5b

5.6.5 Cable Reset

Cable Reset *Signaling* is an ordered set of bytes sent with the purpose to be recognized by the *PHY Layer*. The ***Cable Reset*** *Signaling* ordered set is defined as the following sequence of *K-codes*: ***RST-1***, ***Sync-1***, ***RST-1***, ***Sync-3*** (see *Table 5.12, "Cable Reset Ordered Set"*).

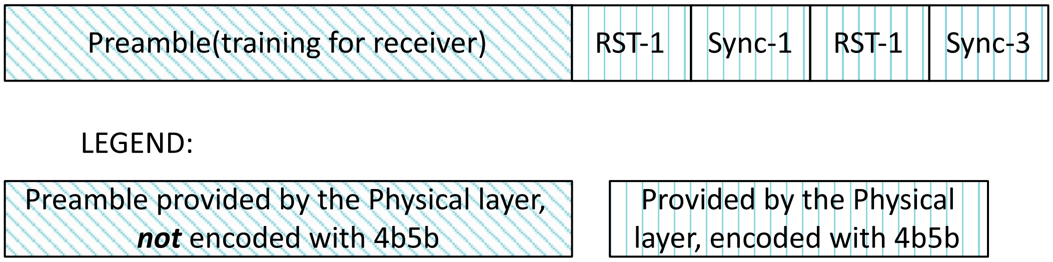
Table 5.12 Cable Reset Ordered Set

K-Code Number	K-Code in Code Table
1	***RST-1***
2	***Sync-1***
3	***RST-1***
4	***Sync-3***

Cable Reset *Signaling* ***Shall*** only be sent by the *DFP*. The ***Cable Reset*** Ordered Set is used to reset the *Cable Plug*s without the need to *Hard Reset* the *Port Partner*s. The state of the *Cable Plug* after the ***Cable Reset*** *Signaling* ***Shall*** be equivalent to power cycling the *Cable Plug*.

Figure 5.6, "Line format of Cable Reset" shows the line format of ***Cable Reset*** *Signaling* which is a *Preamble* followed by the ***Cable Reset*** Ordered Set.

Figure 5.6 Line format of Cable Reset


Preamble(training for receiver)
RST-1
Sync-1
RST-1
Sync-3
LEGEND:
Preamble provided by the Physical layer, *not* encoded with 4b5b
Provided by the Physical layer, encoded with 4b5b

5.7 Collision Avoidance

The *PHY Layer* ***Shall*** monitor the channel for data transmission and only initiate transmissions when *CC* is *Idle*. If the bus *Idle* condition is present, it ***Shall*** be considered safe to start a transmission provided the conditions detailed in *Section 5.8.5.4, "Inter-Frame Gap"* are met. The bus *Idle* condition ***Shall*** be checked immediately prior to transmission. If transmission cannot be initiated, then the *Packet* ***Shall*** be ***Discarded***. If the *Packet* is ***Discarded*** because *CC* is not *Idle*, the *PHY Layer* ***Shall*** signal to the *Protocol Layer* that it has ***Discarded*** the *Message* as soon as *CC* becomes *Idle*. See *Section 5.8.6.1, "Definition of Idle"* for the definition of *Idle CC*.

In addition, during an *Explicit Contract*, the *PHY Layer* ***Shall*** control the R_p resistor value to avoid collisions between *Source* and *Sink* transmissions. The *Source* ***Shall*** set an R_p value corresponding to a current of 3A (***SinkTxOK***) to indicate to the *Sink* that it ***May*** initiate an *AMS*. The *Source* ***Shall*** set an R_p value corresponding to a current of 1.5A (***SinkTxNG***) this ***Shall*** indicate to the *Sink* that it ***Shall Not*** initiate an *AMS* and ***Shall*** only respond to *Messages* as part of an *AMS*. See ***[USB Type-C 2.4]*** (*USB Type-C*) for details of the corresponding R_p values. During the *Implicit Contract* that precedes an *Explicit Contract* (including *Power Role Swap* and *Fast Role Swap*) the R_p resistor value is used to specify *USB Type-C* current and is not used for *Collision Avoidance*.

Table 5.13, "R_p values used for Collision Avoidance" details the R_p values that ***Shall*** be used by the *Source* to control *Sink* initiation of an *AMS*.

Table 5.13 R_p values used for Collision Avoidance

Source R_p	Parameter	Description	Sink Operation	Source Operation
1.5A@5V	***SinkTxNG***	*Sink* Transmit "No Go,"	The *Sink* ***Shall Not*** initiate an *AMS* once ***tSinkDelay*** has elapsed after ***SinkTxNG*** is asserted.	*Source* can initiate an *AMS* ***tSinkTx*** after setting R_p to this value.
3A@5V	***SinkTxOK***	*Sink* Transmit "Ok"	*Sink* can initiate an *AMS*.	*Source* cannot initiate an *AMS* while it has this value set.

See also *Section 6.6.16, "Collision Avoidance Timers"* and *Section 6.10, "Collision Avoidance"*.

5.8 Bi-phase Mark Coding (BMC) Signaling Scheme

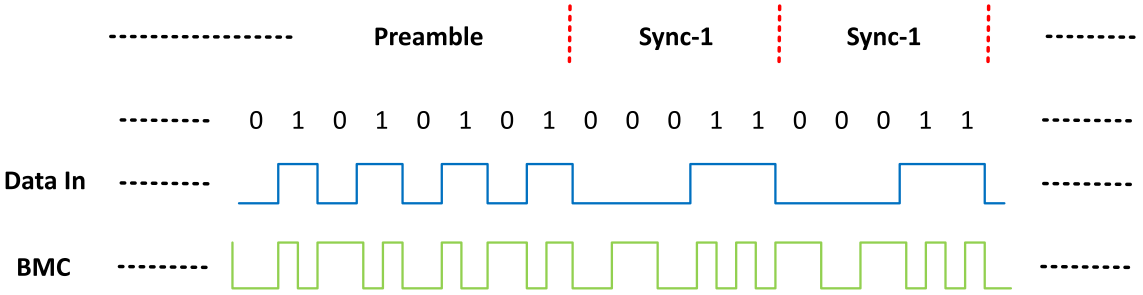
Bi-phase Mark Coding (*BMC*) is the *PHY Layer Signaling Scheme* for carrying USB Power Delivery *Messages*. This encoding assumes a dedicated DC connection, over the *CC* wire, which is used for sending PD *Messages*.

Bi-phase Mark Coding is a version of Manchester coding (see ***[IEC 60958-1]***). In *BMC*, there is a transition at the start of every bit time (*UI*) and there is a second transition in the middle of the *UI* when a 1 is transmitted. *BMC* is effectively DC balanced, (each 1 is DC balanced and two successive zeros are DC balanced, regardless of the number of intervening 1's). It has bounded disparity (limited to 1 bit over an arbitrary *Packet*, so a very low DC level).

Figure 5.7, "BMC Example" illustrates *Bi-phase Mark Coding*. This example shows the transition from a *Preamble* to the ***Sync-1*** *K-codes* of the ***SOP*** Ordered Set at the start of a *Message*.

Note: Other *K-codes* can occur after the *Preamble* for *Signaling* such as ***Hard Reset*** and ***Cable Reset***.

Figure 5.7 BMC Example



5.8.1 Encoding and signaling

BMC uses DC coupled baseband *Signaling* on *CC*. *Figure 5.8, "BMC Transmitter Block Diagram"* shows a block diagram for a Transmitter and *Figure 5.9, "BMC Receiver Block Diagram"* shows a block diagram for the corresponding Receiver.

Figure 5.8 BMC Transmitter Block Diagram

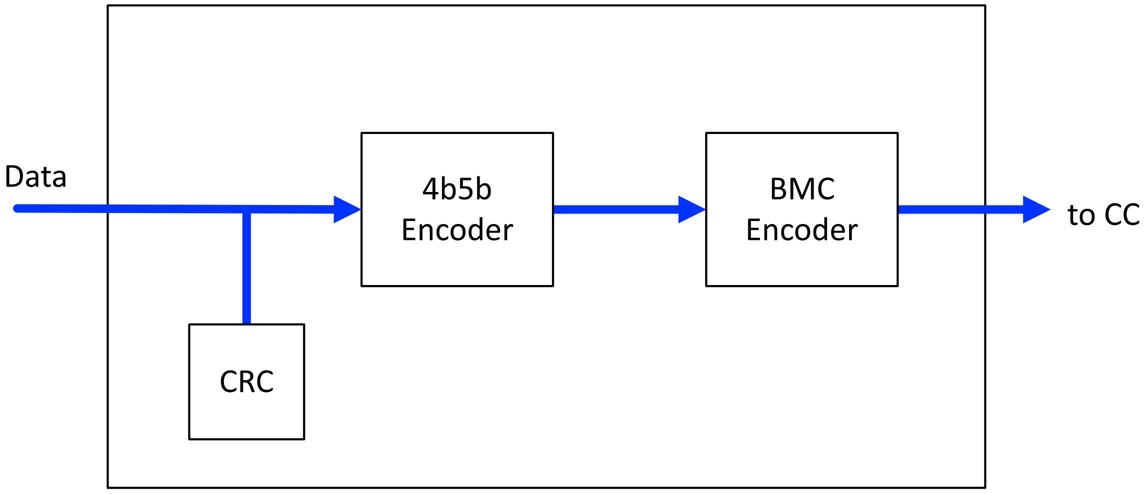
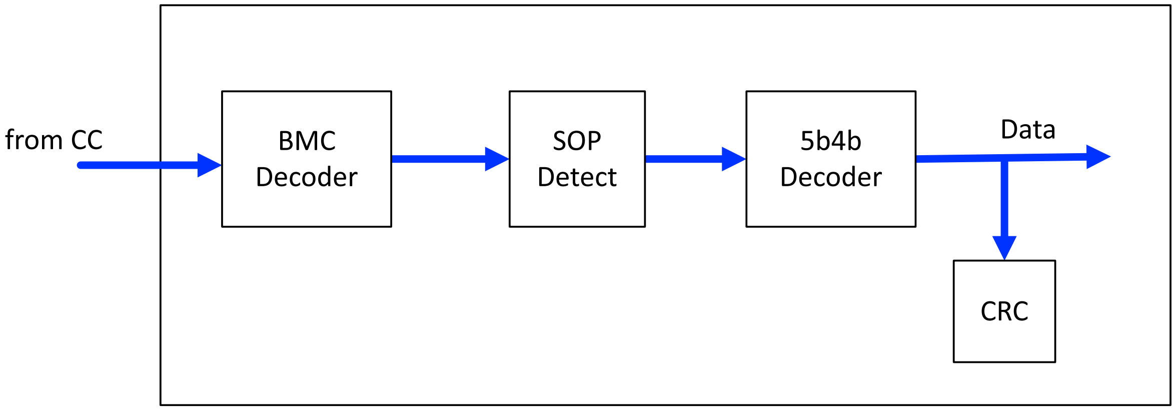


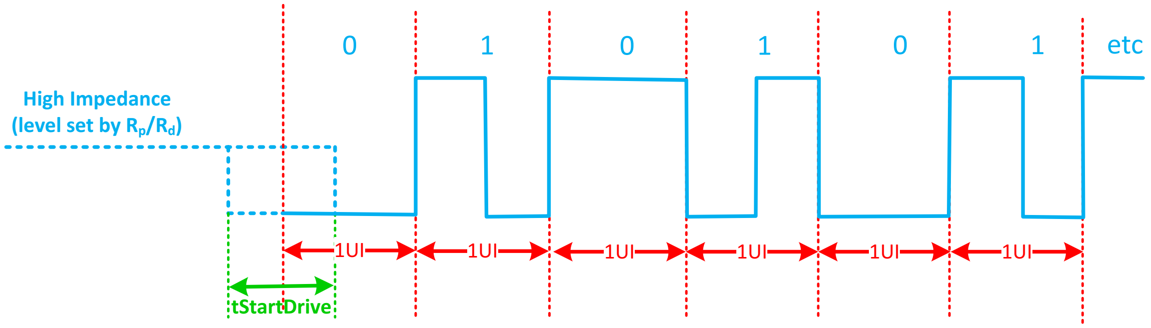
Figure 5.9 BMC Receiver Block Diagram



The USB PD baseband signal ***Shall*** be driven on the *CC* wire with a tristate driver that ***Shall*** cause a ***vSwing*** swing on *CC*. The tristate driver is slew rate limited (see min rise/fall time in *Section 5.8.5, "BMC Transmitter Specifications"*) to limit coupling to D+/D- and to other signal lines in the *USB Type-C* fully featured cables (see ***[USB Type-C 2.4]***). This slew rate limiting can be performed either with driver design or an RC filter on the driver output.

When sending the *Preamble*, the transmitter ***Shall*** start by transmitting a low level. The receiver ***Shall*** tolerate the loss of the first edge. The transmitter ***May*** vary the start of the *Preamble* by ***tStartDrive*** min (see *Figure 5.10, "BMC Encoded Start of Preamble"*).

Figure 5.10 BMC Encoded Start of Preamble



The transmitter ***Shall*** terminate the final bit of the *Frame* by an edge (the “trailing edge”) to help ensure that the receiver clocks the final bit. If the trailing edge results in the transmitter driving *CC* low (i.e., the final half-*UI* of the *Frame* is high, see *Figure 5.11, "Transmitting or Receiving BMC Encoded Frame Terminated by Zero with High-to-Low Last Transition"* and *Figure 5.12, "Transmitting or Receiving BMC Encoded Frame Terminated by One with High-to-Low Last Transition"*), then the transmitter:

- ***Shall*** continue to drive *CC* low for ***tHoldLowBMC***.
- ***Should*** release *CC* to high impedance as soon as possible after min ***tHoldLowBMC*** and ***Shall*** release *CC* by max ***tEndDriveBMC***.

Figure 5.11, "Transmitting or Receiving BMC Encoded Frame Terminated by Zero with High-to-Low Last Transition" illustrates the end of a *BMC* encoded *Frame* with an encoded zero for which the final bit of the *Frame* is terminated by a high to low transition. *Figure 5.12, "Transmitting or Receiving BMC Encoded Frame Terminated by One with High-to-Low Last Transition"* illustrates the end of a *BMC* Encoded *Frame* with an encoded one for which the final bit of the *Frame* is terminated by a high to low transition. Both figures also illustrate the ***tInterFrameGap*** timing requirement before the start of the next *Frame* when the *Port* has either been transmitting or receiving the previous *Frame* (see *Section 5.8.5.4, "Inter-Frame Gap"*).

Figure 5.11 Transmitting or Receiving BMC Encoded Frame Terminated by Zero with High-to-Low Last Transition

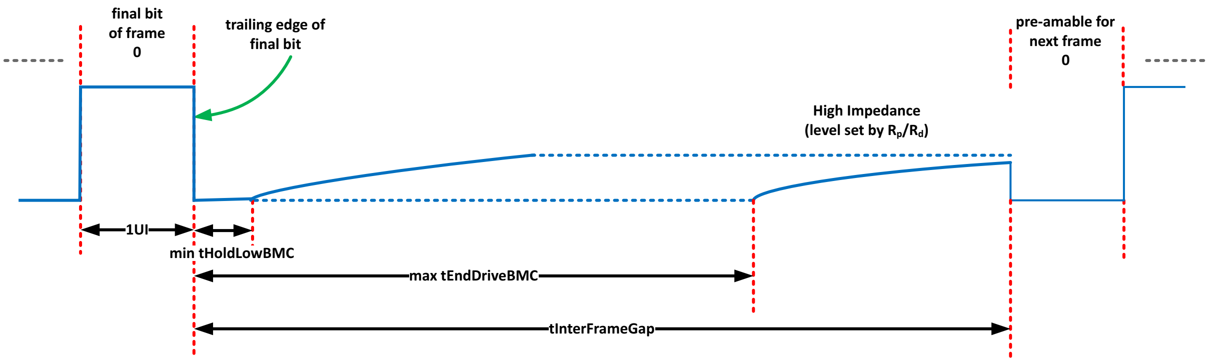
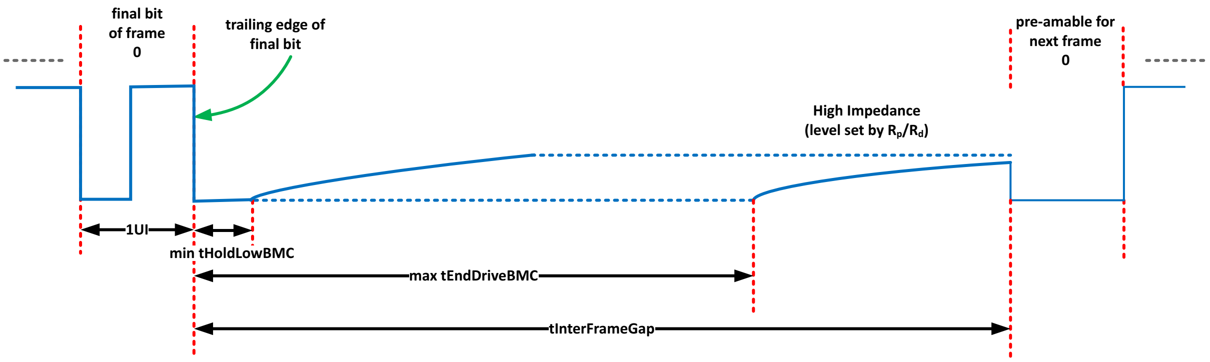


Figure 5.12 Transmitting or Receiving BMC Encoded Frame Terminated by One with High-to-Low Last Transition



If the trailing edge results in the transmitter driving *CC* high (i.e., the final half-*UI* of the *Frame* is low, see *Figure 5.13, "Transmitting or Receiving BMC Encoded Frame Terminated by Zero with Low to High Last Transition"* and *Figure 5.14, "Transmitting or Receiving BMC Encoded Frame Terminated by One with Low to High Last Transition"*), then the transmitter:

- ***Shall*** continue to drive *CC* high for 1 *UI*.
  - Then ***Shall*** drive *CC* low for ***tHoldLowBMC***.
- ***Should*** release *CC* to high impedance as soon as possible after min ***tHoldLowBMC*** and ***Shall*** release *CC* by max ***tEndDriveBMC***.

Figure 5.13, "Transmitting or Receiving BMC Encoded Frame Terminated by Zero with Low to High Last Transition" illustrates the ending of a *BMC* encoded *Frame* that ends with an encoded zero for which the final bit of the *Frame* is terminated by a low to high transition. *Figure 5.14, "Transmitting or Receiving BMC Encoded Frame Terminated by One with Low to High Last Transition"* illustrates the ending of a *BMC* encoded *Frame* that ends with an encoded one for which the final bit of the *Frame* is terminated by a low to high transition. Both figures also illustrate the ***tInterFrameGap*** timing requirement before the start of the next *Frame* when the *Port* has either been transmitting or receiving the previous *Frame* (see *Section 5.8.5.4, "Inter-Frame Gap"*).

Figure 5.13 Transmitting or Receiving BMC Encoded Frame Terminated by Zero with Low to High Last Transition

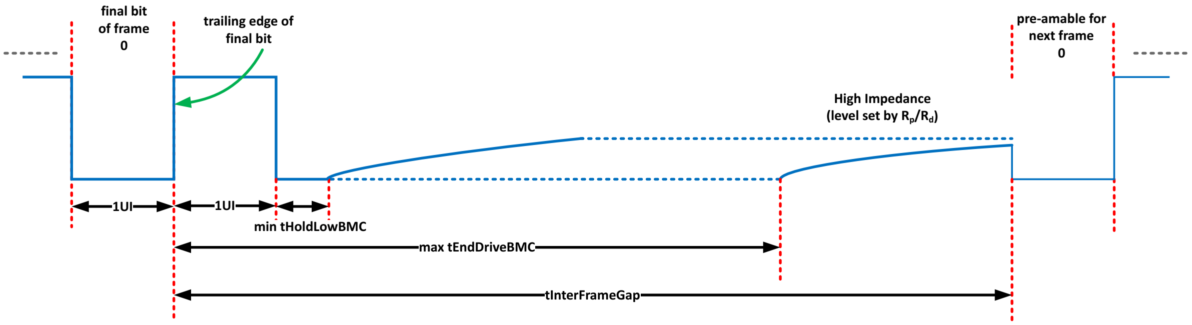
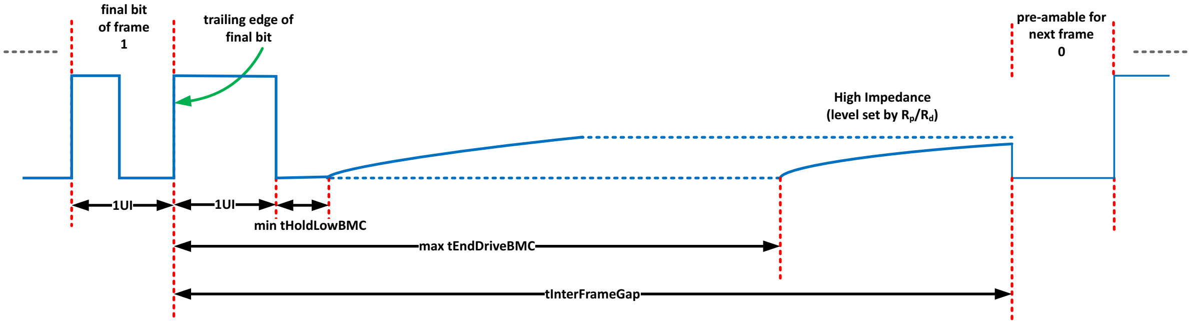


Figure 5.14 Transmitting or Receiving BMC Encoded Frame Terminated by One with Low to High Last Transition



Note: There is no requirement to maintain a timing phase relationship between back-to-back *Packets*.

5.8.2 Transmit and Receive Masks

5.8.2.1 Transmit Masks

The transmitted signal ***Shall Not*** violate the masks defined in *Figure 5.15, "BMC Tx 'ONE' Mask"*, *Figure 5.16, "BMC Tx 'ZERO' Mask"*, *Table 5.14, "BMC Tx Mask Definition, X Values"* and *Table 5.15, "BMC Tx Mask Definition, Y Values"* at the output of a load equivalent to the cable model and receiver load model described in *Section 5.8.3, "Transmitter Load Model"*. The masks apply to the full range of R_p/R_d values as defined in ***[USB Type-C 2.4]***.

Note: The measurement of the transmitter does not need to accommodate a change in signal offset due to the ground offset when current is flowing in the cable.

The transmitted signal ***Shall*** have a rise time no faster than ***tRise***. The transmitted signal ***Shall*** have a fall time no faster than ***tFall***. The maximum limits on the rise and fall times are enforced by the Tx inner masks.

Figure 5.15 BMC Tx 'ONE' Mask

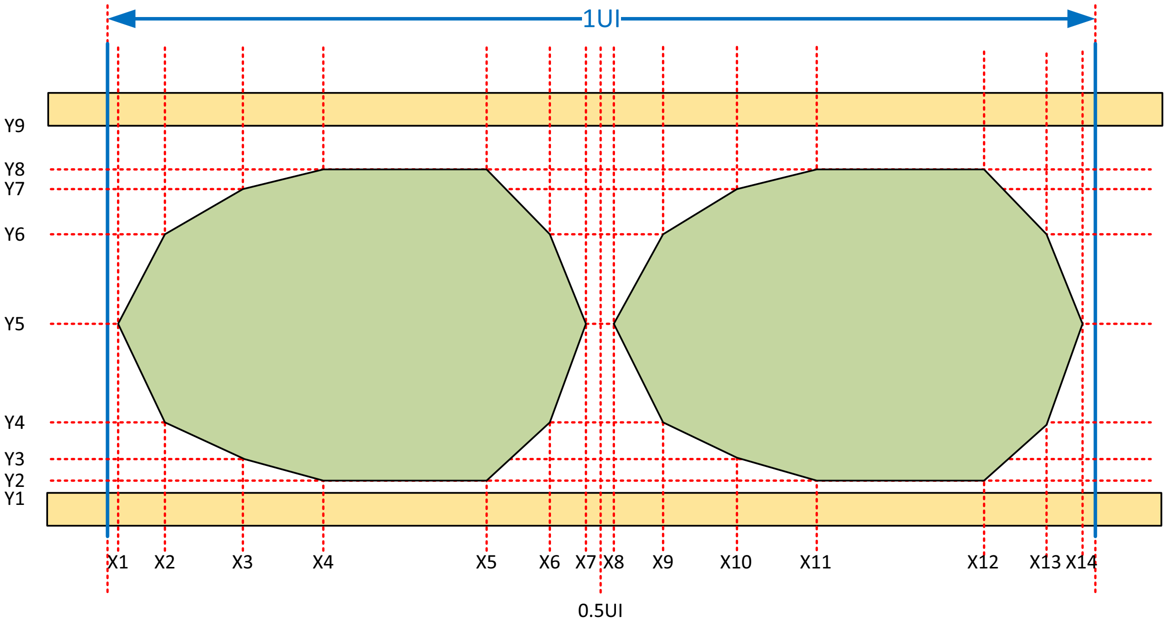


Figure 5.16 BMC Tx 'ZERO' Mask

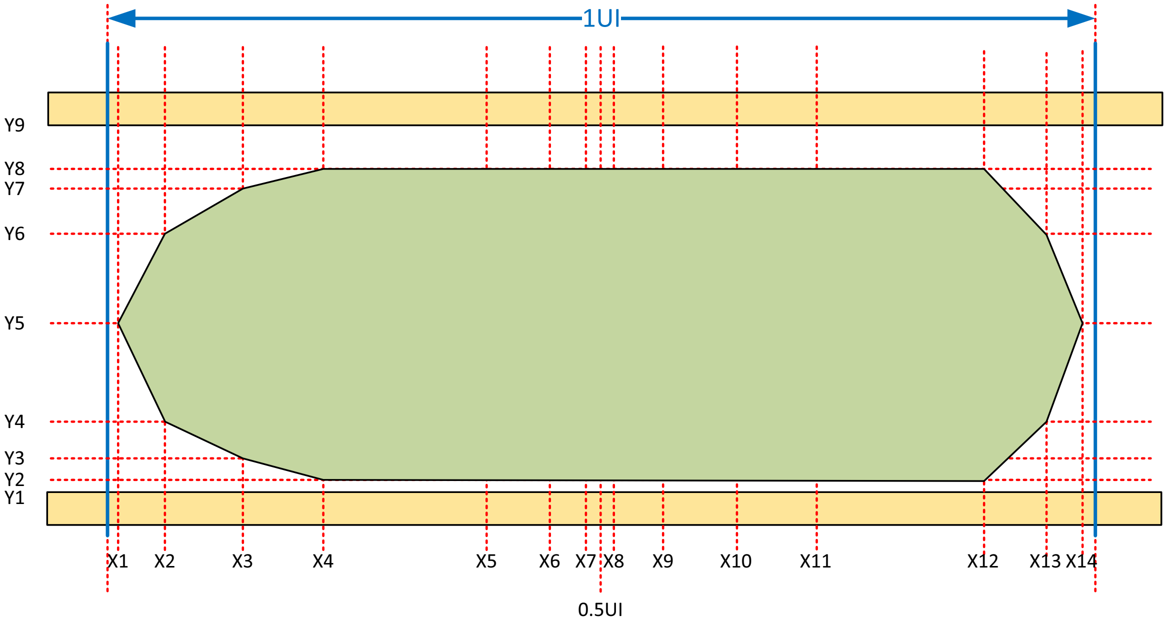


Table 5.14 BMC Tx Mask Definition, X Values

Name	Description	Value	Units
X1Tx	Left Edge of Mask	0.015	*UI*
X2Tx	see figure	0.07	*UI*
X3Tx	see figure	0.15	*UI*
X4Tx	see figure	0.25	*UI*
X5Tx	see figure	0.35	*UI*
X6Tx	see figure	0.43	*UI*
X7Tx	see figure	0.485	*UI*
X8Tx	see figure	0.515	*UI*
X9Tx	see figure	0.57	*UI*
X10Tx	see figure	0.65	*UI*
X11Tx	see figure	0.75	*UI*
X12Tx	see figure	0.85	*UI*
X13Tx	see figure	0.93	*UI*
X14Tx	Right Edge of Mask	0.985	*UI*

Table 5.15 BMC Tx Mask Definition, Y Values

Name	Description	Value	Units
Y1Tx	Lower bound of Outer mask	-0.075	V
Y2Tx	Lower bound of inner mask	0.075	V
Y3Tx	see figure	0.15	V
Y4Tx	see figure	0.325	V
Y5Tx	Inner mask vertical midpoint	0.5625	V
Y6Tx	see figure	0.8	V
Y7Tx	see figure	0.975	V
Y8Tx	see figure	1.04	V
Y9Tx	Upper Bound of Outer mask	1.2	V

5.8.2.2 Receive Masks

A *Source* using the *BMC Signaling Scheme* ***Shall*** be capable of receiving a signal that complies with the mask when sourcing power as defined in *Figure 5.17, "BMC Rx 'ONE' Mask when Sourcing Power"*, *Figure 5.18, "BMC Rx 'ZERO' Mask when Sourcing Power"* and *Table 5.16, "BMC Rx Mask Definition"*. The *Source* Rx mask is bounded by sweeping a Tx mask compliant signal, with added ***vNoiseActive*** between power neutral and *Source* offsets.

A *Consumer* using the *BMC Signaling Scheme* ***Shall*** be capable of receiving a signal that complies with the mask when sinking power as defined in *Figure 5.21, "BMC Rx 'ONE' Mask when Sinking Power"*, *Figure 5.22, "BMC Rx 'ZERO' Mask when Sinking Power"* and *Table 5.16, "BMC Rx Mask Definition"*. The *Consumer* Rx mask is bounded by sweeping a Tx mask compliant signal, with added ***vNoiseActive*** between power neutral and *Consumer* offsets.

Every product using the *BMC Signaling Scheme* ***Shall*** be capable of receiving a signal that complies with the mask when power neutral as defined in *Figure 5.19, "BMC Rx 'ONE' Mask when Power neutral"*, F*Figure 5.20, "BMC Rx 'ZERO' Mask when Power neutral"* and *Table 5.16, "BMC Rx Mask Definition"*.

Dual-Role Power Devices ***Shall*** meet the receiver requirements for a *Source* when providing power during any transmission using the *BMC Signaling Scheme* or a *Sink* when consuming power during any transmission using the *BMC Signaling Scheme*.

Cable Plugs ***Shall*** meet the receiver requirements for both a *Source* and a *Sink* during any transmission using the *BMC Signaling Scheme*.

The parameters used in the masks are specified to be appropriate to either edge triggered or oversampling receiver implementations.

The masks are defined for 'ONE' and 'ZERO' separately as *BMC* enforces a transition at the midpoint of the unit interval while a 'ONE' is transmitted.

The Rx masks are defined to bound the Rx noise after the Rx bandwidth limiting filter with the time constant ***tRxFilter*** has been applied.

The boundaries of Rx outer mask, ***Y1Rx*** and ***Y5Rx***, are specified according to ***vSwing*** max and accommodate half of ***vNoiseActive*** from cable noise coupling and the signal offset ***vIRDropGNDC*** due to the ground offset when current is flowing in the cable.

The vertical dimension of the Rx inner mask, ***Y4Rx*** - ***Y2Rx***, for power neutral is derived by reducing the vertical dimension of the Tx inner mask, ***Y7Tx*** - ***Y3Tx***, at time location ***X3Tx*** by ***vNoiseActive*** to account for cable noise coupling. The received signal is composed of a waveform compliant to the Tx mask plus ***vNoiseActive***.

The vertical dimension of the Rx inner mask for sourcing power is derived by reducing the vertical dimension of the Tx inner mask by ***vNoiseActive*** and ***vIRDropGNDC*** to account for both cable noise coupling and signal DC offset.

The received signal is composed of a waveform compliant to the Tx mask plus the maximum value of ***vNoiseActive*** plus ***vIRDropGNDC*** where the ***vIRDropGNDC*** value transitions between the minimum and the maximum values as allowed in this spec.

The vertical dimension of the Rx inner mask for sinking power is derived by reducing the vertical dimension of the Tx inner mask by ***vNoiseActive*** max and ***vIRDropGNDC*** max for account for both cable noise coupling and signal DC offset. The received signal is composed of a waveform compliant to the Tx mask plus the maximum value of ***vNoiseActive*** plus ***vIRDropGNDC*** where the ***vIRDropGNDC*** value transitions between the minimum and the maximum values as allowed in this spec.

The center line of the Rx inner mask, ***Y3Rx***, is at half of the nominal ***vSwing*** for power neutral, and is shifted up by half of ***vIRDropGNDC*** max for sourcing power and is shifted down by half of ***vIRDropGNDC*** max for sinking power.

The receiver sensitivity ***Shall*** be set such that the receiver does not treat noise on an undriven signal path as an incoming signal. Signal amplitudes below ***vNoiseIdle*** max ***Shall*** be treated as noise when *BMC* is *Idle*.

Figure 5.17 BMC Rx 'ONE' Mask when Sourcing Power

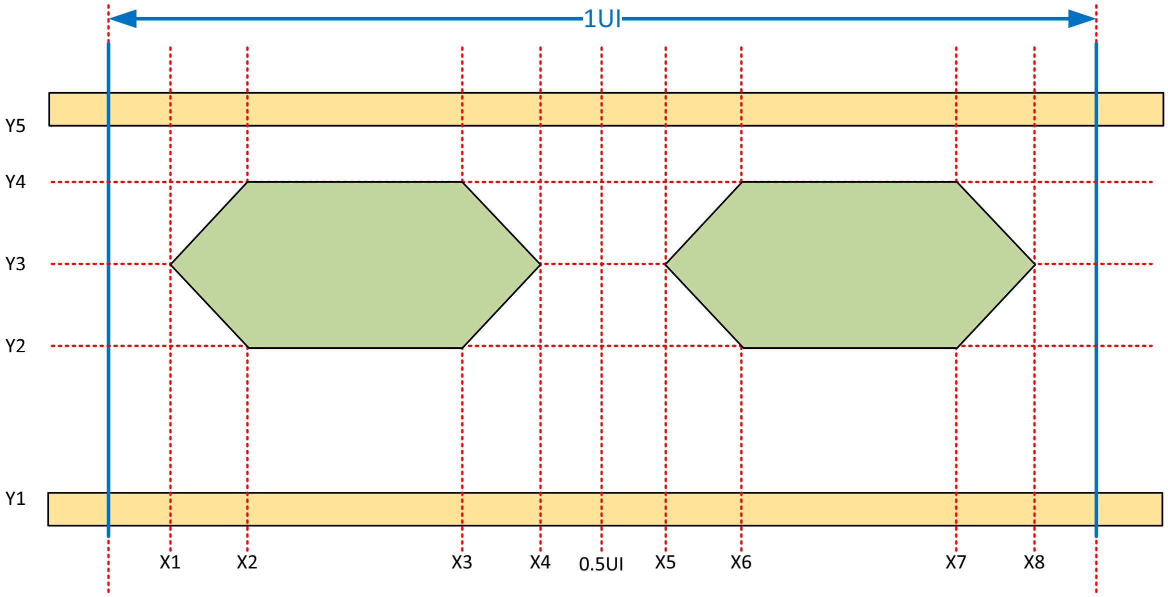


Figure 5.18 BMC Rx 'ZERO' Mask when Sourcing Power

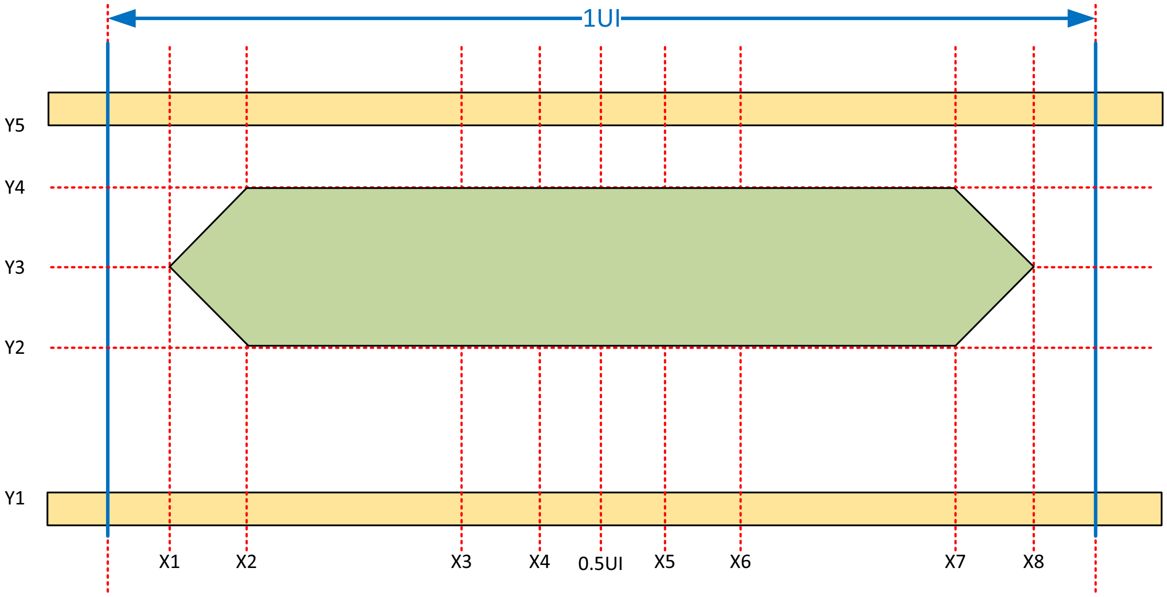


Figure 5.19 BMC Rx 'ONE' Mask when Power neutral

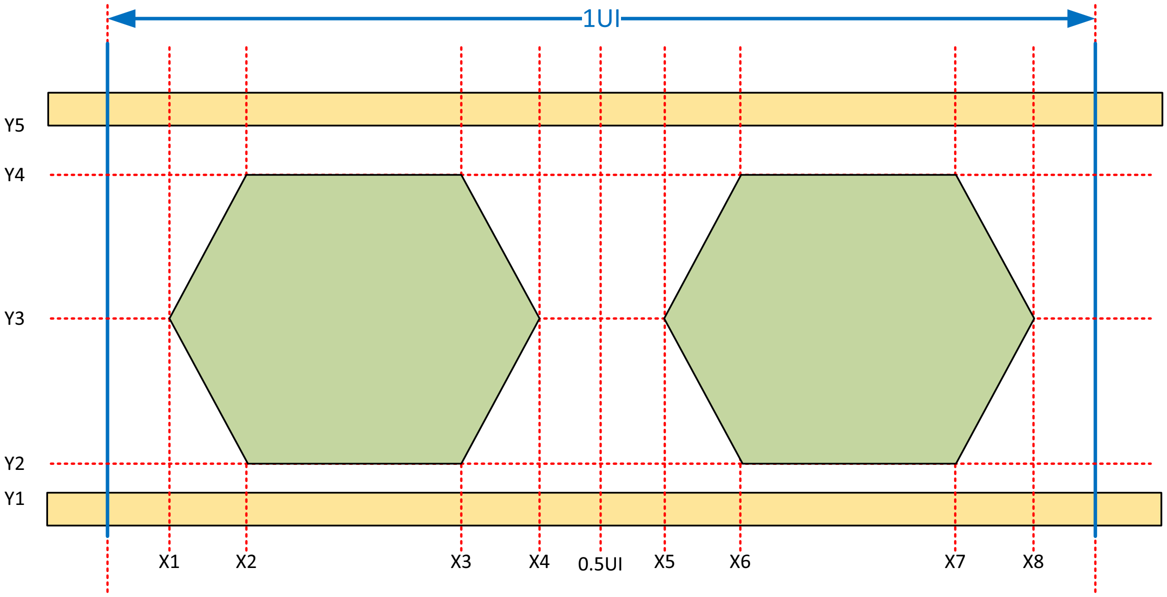


Figure 5.20 BMC Rx 'ZERO' Mask when Power neutral

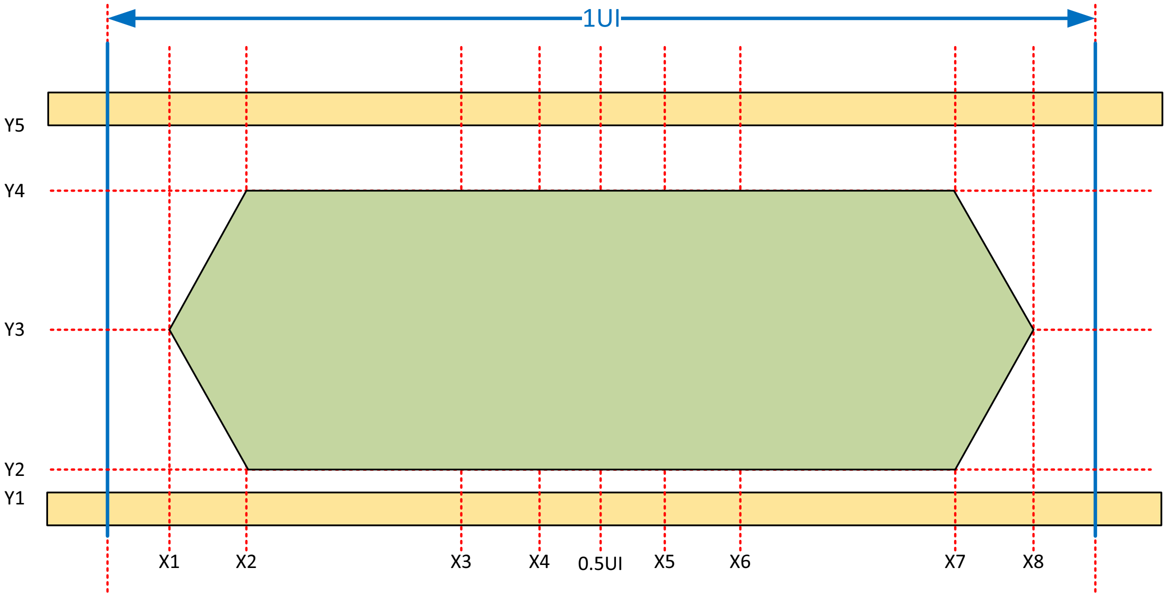


Figure 5.21 BMC Rx 'ONE' Mask when Sinking Power

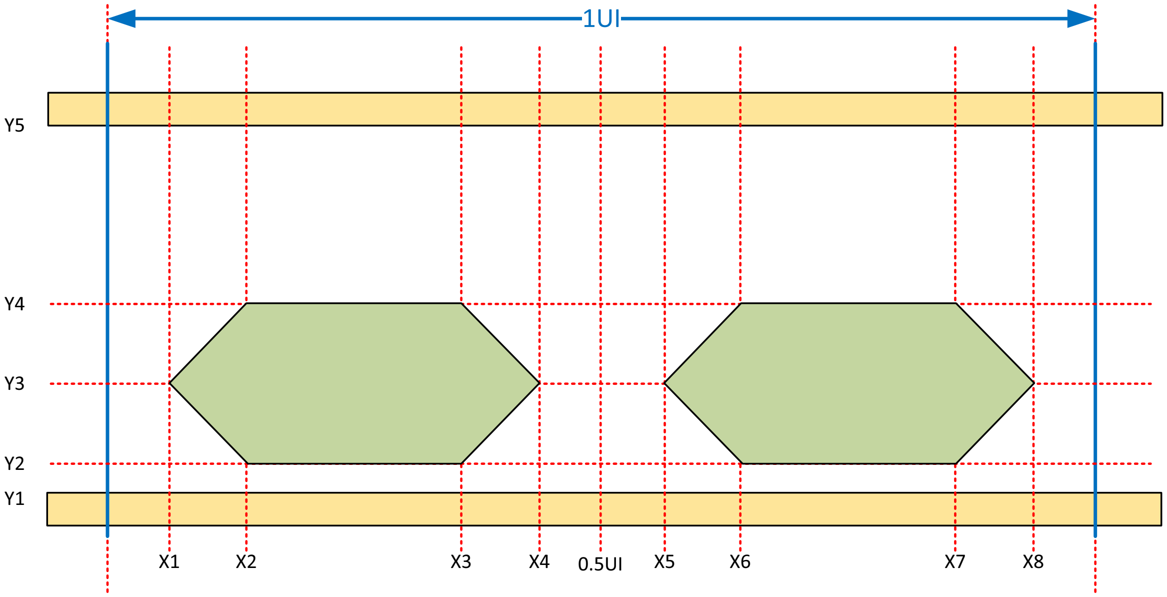


Figure 5.22 BMC Rx 'ZERO' Mask when Sinking Power

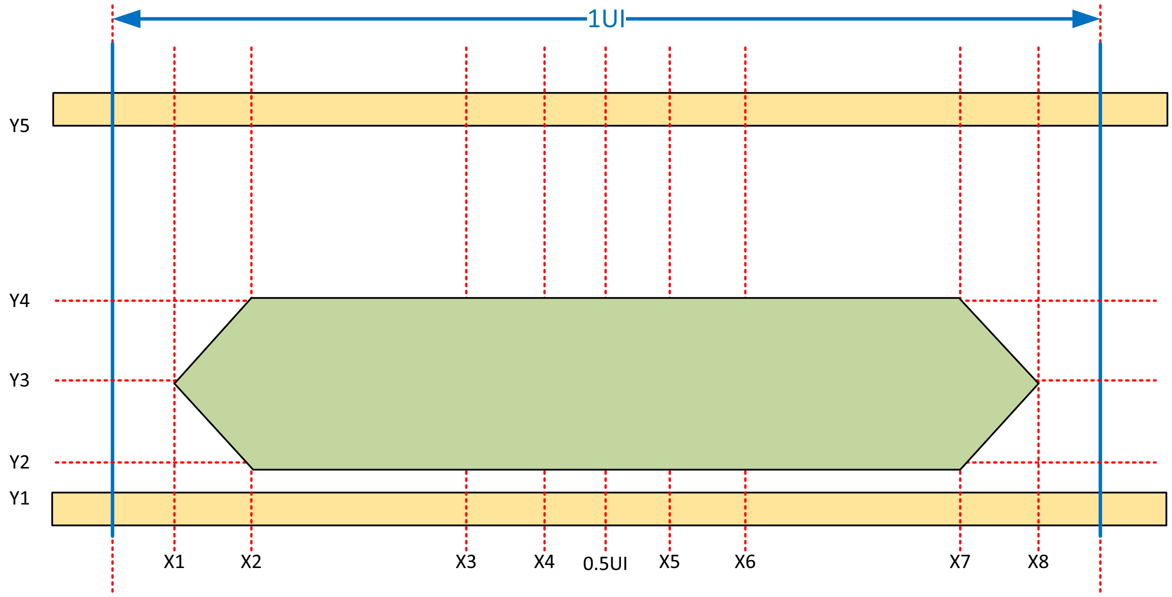


Table 5.16 BMC Rx Mask Definition

Name	Description	Value	Units
X1Rx	Left Edge of Mask	0.07	*UI*
X2Rx	Top Edge of Mask	0.15	*UI*
X3Rx	See figure	0.35	*UI*
X4Rx	See figure	0.43	*UI*
X5Rx	See figure	0.57	*UI*
X6Rx	See figure	0.65	*UI*
X7Rx	See figure	0.85	*UI*
X8Rx	See figure	0.93	*UI*
Y1Rx	Lower bound of Outer Mask	-0.3325	V
Y2Rx	Lower Bound of Inner Mask	*Y3Rx* – 0.205 when sourcing power[1] or sinking power[1]. *Y3Rx* – 0.33 when power neutral[1].	V
Y3Rx	Center line of Inner Mask	0.6875 Sourcing Power[1]. 0.5625 Power Neutral[1]. 0.4375 Sinking Power[1].	V
Y4Rx	Upper bound of Inner mask	*Y3Rx* + 0.205 when sourcing power[1] or sinking power[1]. *Y3Rx* + 0.33 when power neutral[1].	V
Y5Rx	Upper bound of the Outer mask	1.5325	V
1) The position of the center line of the Inner Mask is dependent on whether the receiver is Sourcing or Sinking power or is Power Neutral (see earlier in this section).			

5.8.3 Transmitter Load Model

The transmitter load model ***Shall*** be equivalent to the circuit outlined in *Figure 5.23, "Transmitter Load Model for BMC Tx from a Source"* for a *Source* and *Figure 5.24, "Transmitter Load Model for BMC Tx from a Sink"* for a *Sink*. It is formed by the concatenation of a cable load model and a receiver load model. See ***[USB Type-C 2.4]*** for details of the R_p and R_d resistors.

Note: The parameters zCable_CC, tCableDelay_CC and cCablePlug_CC are defined in ***[USB Type-C 2.4]***.

Figure 5.23 Transmitter Load Model for BMC Tx from a Source

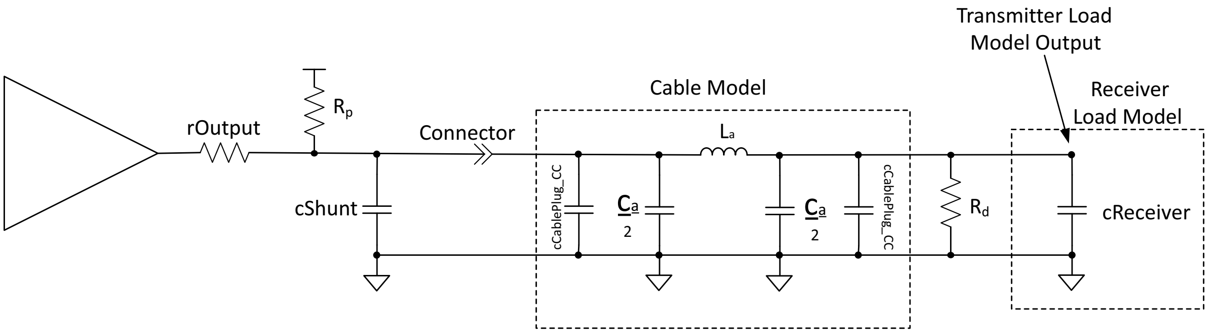
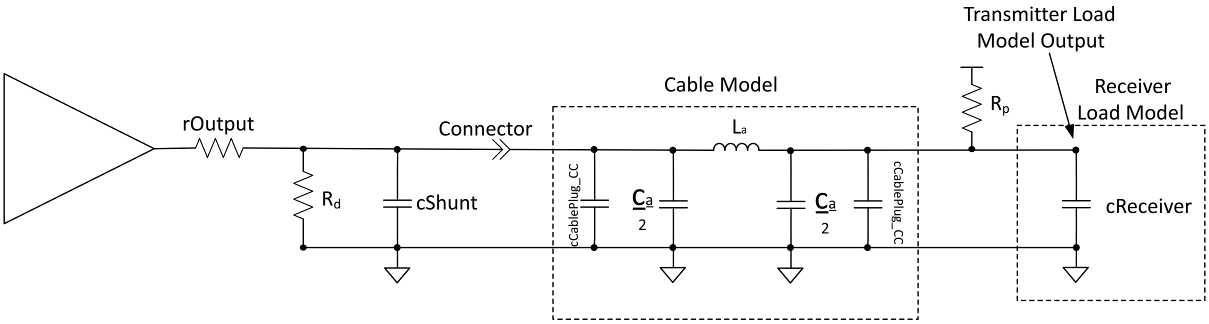


Figure 5.24 Transmitter Load Model for BMC Tx from a Sink



The transmitter system components rOutput and cShunt are illustrated for ***Informative*** purposes, and do not form part of the transmitter load model. See *Section 5.8.5, "BMC Transmitter Specifications"* for a description of the transmitter system design.

The value of the modeled cable inductance, La, (in nH) ***Shall*** be calculated from the following formula:

$$La= tCableDelay\_CC_{max}* zCable\_CC_{min}$$

tCableDelay_CC is the modeled signal propagation delay through the cable, and zCable_CC is the modeled cable impedance.

The modeled cable inductance is 640nH for a cable with zCable_CC$_{min}$ = 32Ω and tCableDelay_CCmax = 20ns.

The value of the modeled cable capacitance, Ca, (in pF) ***Shall*** be calculated from the following formula:

$$Ca=tCableDelay\_CC_{max}/zCable\_CC_{min}$$

The modeled cable capacitance is Ca = 625pF for a cable with zCable_CCmin = 32Ω and tCableDelay_CCmax = 20ns. Therefore, Ca/2 = 312.5pF.

cCablePlug_CC models the capacitance of the plug at each end of the cable. ***cReceiver*** models the capacitance of the receiver. The maximum values ***Shall*** be used in each case.

Note: The transmitter load model assumes that there are no other return currents on the ground path.

5.8.4 BMC Common specifications

This section defines the common receiver and transmitter requirements.

5.8.4.1 BMC Common Parameters

The electrical requirements specified in *Table 5.17, "BMC Common Normative Requirements"* ***Shall*** apply to both the transmitter and receiver.

Table 5.17 BMC Common Normative Requirements

Name	Description	Min	Nom	Max	Units	Comment
fBitRate	Bit rate	270	300	330	Kbps	
tUnitInterval	Unit Interval[1]	3.03		3.70	µs	1/***fBitRate***
1) Denotes the time to transmit an unencoded data bit, not the shortest high or low times on the wire after encoding with *BMC*. A single data bit cell has duration of 1*UI*, but a data bit cell with value 1 will contain a centrally placed 01 or 10 transition in addition to the transition at the start of the cell.						

5.8.5 BMC Transmitter Specifications

The transmitter ***Shall*** meet the specifications defined in *Table 5.18, "BMC Transmitter Normative Requirements"*.

Table 5.18 BMC Transmitter Normative Requirements

Name	Description	Min	Nom	Max	Units	Comment
pBitRate	Maximum difference between the bit-rate during the part of the *Packet* following the *Preamble* and the reference bit-rate.			0.25	%	The reference bit rate is the average bit rate of the last 32 bits of the *Preamble*.
rFRSwapTx	*Fast Role Swap Request* transmit driver resistance (excluding cable resistance)			5	Ω	Maximum driver resistance of a *Fast Role Swap Request* transmitter. Assumes a worst case cable resistance of 15Ω as defined in ***[USB Type-C 2.4]***. **Note:** Based on this value the maximum combined driver and cable resistance of a *Fast Role Swap Request* transmitter is 20Ω.
tEndDriveBMC	Time to cease driving the line after the end of the last bit of the *Frame*.			23	µs	Min value is limited by ***tHoldLowBMC***.
tFall	Fall Time	300			ns	10% and 90% amplitude points, minimum is under an unloaded condition.
tHoldLowBMC	Time to cease driving the line after the final high-to-low transition.	1			µs	Max value is limited by ***tEndDriveBMC***.
tInterFrameGap	Time from the end of last bit of a *Frame* until the start of the first bit of the next *Preamble*.	25			µs	
tFRSwapTx	*Fast Role Swap Request* transmit duration	60		120	µs	*Fast Role Swap Request* is indicated from the *Initial Source* to the *Initial Sink* by driving *CC* low for this time.
tRise	Rise time	300			ns	10% and 90% amplitude points, minimum is under an unloaded condition.
tStartDrive	Time before the start of the first bit of the *Preamble* when the transmitter ***Shall*** start driving the line.	-1		1	µs	
vSwing	Voltage Swing	1.05	1.125	1.2	V	Applies to both no load condition and under the load condition specified in *Section 5.8.3, "Transmitter Load Model"*.
zDriver	Transmitter output impedance	33		75	Ω	*Source* output impedance at the Nyquist frequency of ***[USB 2.0]*** low speed (750 kHz) while the *Source* is driving the *CC* line.

5.8.5.1 Capacitance when not transmitting

cReceiver is the capacitance that a *DFP* or *UFP* ***Shall*** present on the *CC* line when the *DFP* or *UFP*'s receiver is not transmitting on the line. The transmitter ***May*** have more capacitance than ***cReceiver*** while driving the *CC* line, but ***Shall*** meet the waveform mask requirements. Once transmission is complete, the transmitter ***Shall*** disengage capacitance in excess of ***cReceiver*** from the *CC* wire within ***tInterFrameGap***.

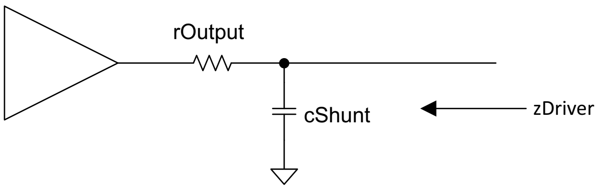
5.8.5.2 Source Output Impedance

Source output impedance ***zDriver*** is determined by the driver resistance and the shunt capacitance of the *Source* and is hence a frequency dependent term. ***zDriver*** impacts the noise ingression in the cable. It is specified such that the noise at the Receiver is bounded.

zDriver is defined by the following equation:

*zDriver=rOutput/(1+s*rOutput*cShunt)*

Figure 5.25 Transmitter diagram illustrating zDriver



cShunt ***Shall*** Not cause a violation of ***cReceiver*** when not transmitting.

5.8.5.3 Bit Rate Drift

Limits on the drift in ***fBitRate*** are set to help low-complexity receiver implementations.

fBitRate is the reciprocal of the average bit duration from the previous 32 bits at a given portion of the *Packet*. The change in ***fBitRate*** during a *Packet* ***Shall*** be less than ***pBitRate***. The reference bit rate (refBitRate) is the average ***fBitRate*** over the last 32 bits of the *Preamble*. ***fBitRate*** throughout the *Packet*, including the *EOP*, ***Shall*** be within ***pBitRate*** of refBitRate. ***pBitRate*** is expressed as a percentage:

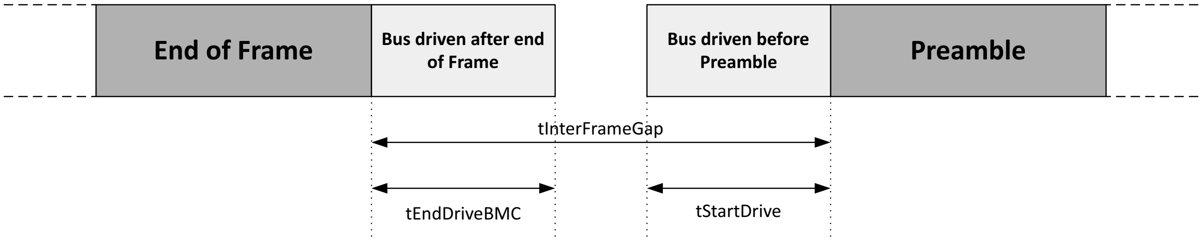
pBitRate = | ***fBitRate*** - *refBitRate* | / *refBitRate x 100%*

The transmitter ***Shall*** have the same ***pBitRate*** for all *Packet* types. The *BIST Carrier Mode* and Bit Stream signals are continuous signals without a *Payload*. When checking ***pBitRate*** any set of 1044 bits (20 bit ***SOP*** followed by 1024 PRBS bits) within a continuous signal ***May*** be considered as the part of the *Packet* following the *Preamble* and the 32 preceding bits considered to be the last 32 bits of the *Preamble* used to compute refBitRate.

5.8.5.4 Inter-Frame Gap

Figure 5.26, "Inter-Frame Gap Timings" illustrates the inter-*Frame* gap timings.

Figure 5.26 Inter-Frame Gap Timings



The transmitter ***Shall*** drive the bus for no longer than ***tEndDriveBMC*** after transmitting the final bit of the *Frame*.

Before starting to transmit the next *Frame*'s *Preamble* the transmitter of the next *Frame* ***Shall*** ensure that it waits for ***tInterFrameGap*** after either:

- Transmitting the previous *Frame*, for example sending the next *Message* in an *AMS* immediately after having sent a ***GoodCRC*** *Message*, or
- Receiving the previous *Frame*, for example when responding to a received *Message* with a ***GoodCRC*** *Message*, or
- Observing an *Idle* condition on *CC* (see *Section 5.7, "Collision Avoidance"*). In this case the *Port* is waiting to initiate an *AMS* observes *Idle* (see *Section 5.8.6.1, "Definition of Idle"*) and then waits ***tInterFrameGap*** before transmitting the *Frame*. See also *Section 5.7, "Collision Avoidance"* for details on when an *AMS* can be initiated.

Note: The transmitter is also required to verify a bus *Idle* condition immediately prior to starting transmission of the next *Frame* (see *Section 5.8.6.1, "Definition of Idle"*).

The transmitter of the next *Frame* **May** vary the start of the *Preamble* by ***tStartDrive*** (see *Section 5.8.1, "Encoding and signaling"*).

See also *Section 5.8.1, "Encoding and signaling"* for figures detailing the timings relating to transmitting, receiving, and observing *Idle* in relating to *Frames*.

5.8.5.5 Shorting of Transmitter Output

A Transmitter in a *Port* or *Cable Plug* ***Shall*** tolerate having its output be shorted to ground for ***tFRSwapTx*** max. This is due to the potential for *Fast Role Swap* to be signaled while the Transmitter is in the process of transmitting (see *Section 5.8.5.6, "Fast Role Swap Transmission"*).

5.8.5.6 Fast Role Swap Transmission

The *Fast Role Swap* process is intended for use by a *PDUSB Hub* that presently has an external supply and is providing power both through its downstream *Port*s to *USB Device*s and upstream to a *USB Host* such as a laptop. On removal of the external wall supply *Fast Role Swap* enables a *VBUS* supply to be maintained by allowing the *USB Host* to apply ***vSafe5V*** when it sees *VBUS* droop below ***vSafe5V*** after having detected *Fast Role Swap Signaling*. The *Fast Role Swap AMS* is then used to correctly assign *Source*/*Sink Power Role*s and configure the R_p/R_d resistors (see *Section 8.3.2.8, "Fast Role Swap"*).

The *Initial Source* ***Shall*** signal a *Fast Role Swap Request* by driving *CC* to ground with a resistance of less than ***rFRSwapTx*** for ***tFRSwapTx***. The *Initial Source* ***Shall*** only send a *Fast Role Swap Request* when it has an *Explicit Contract*. The *Initial Source* ***May*** send a *Fast Role Swap Request* even if it has not yet had its *Sink Capabilities* queried by the *Initial Sink*. On transmission of the *Fast Role Swap Request* any pending *Messages* ***Shall*** be ***Discarded*** (see *Section 6.12.2.2.1, "Common Protocol Layer Message Transmission State Diagram"*).

The *Fast Role Swap Signaling* ***May*** override any active transmissions.

Since the *Initial Sink*'s response to the *Fast Role Swap* signal is to send an ***FR_Swap*** *Message*, the *Initial Source* ***Shall*** ensure R_p is set to ***SinkTxOK*** once the *Fast Role Swap Signaling* is complete.

5.8.6 BMC Receiver Specifications

The receiver ***Shall*** meet the specifications defined in *Table 5.19, "BMC Receiver Normative Requirements"*.

Table 5.19 BMC Receiver Normative Requirements

Name	Description	Min	Nom	Max	Units	Comment
cReceiver	*CC* receiver capacitance	200		600	pF	The *DFP* or *UFP* system ***Shall*** have capacitance within this range when not transmitting on the line.
nBER	Bit error rate, S/N = 25 dB			10^{-6}		
nTransitionCount	Transitions for signal detect	3				Number of transitions to be detected to declare bus non-*Idle*.
tFRSwapRx	*Fast Role Swap Request* detection time	30		50	µs	A *Fast Role Swap Request* results in the receiver detecting a signal low for at least this amount of time.
tRxFilter	Rx bandwidth limiting filter (digital or analog)	100			ns	Time constant of a single pole filter to limit broad-band noise ingression1.
tTransitionWindow	Time window for detecting non-*Idle*	12		20	µs	
vFRSwapCableTx	*Fast Role Swap Request* voltage detection threshold	490	520	550	mV	The *Fast Role Swap Request* must be below this voltage threshold to be detected.
vIRDropGNDC	Cable Ground *IR Drop*			250	mV	As specified in ***[USB Type-C 2.4]***.
vNoiseActive	Noise amplitude when *BMC* is active.			165	mV	Peak-to-peak noise from *VBUS*, ***[USB 2.0]*** and SBU lines after the Rx bandwidth limiting filter with the time constant ***tRxFilter*** has been applied.
vNoiseIdle	Noise amplitude when *BMC* is *Idle*.			300	mV	Peak-to-peak noise from *VBUS*, ***[USB 2.0]*** and SBU lines after the Rx bandwidth limiting filter with the time constant ***tRxFilter*** has been applied.
zBmcRx	Receiver Input Impedance	1			MΩ	
1) Broad-band noise ingression is due to coupling in the cable interconnect.						

5.8.6.1 Definition of Idle

BMC Collision Avoidance is performed by the detection of signal transitions at the receiver. Detection is active when ***nTransitionCount*** transitions occur at the receiver within a time window of ***tTransitionWindow***. After waiting ***tTransitionWindow*** without detecting ***nTransitionCount*** transitions the bus ***Shall*** be declared *Idle*.

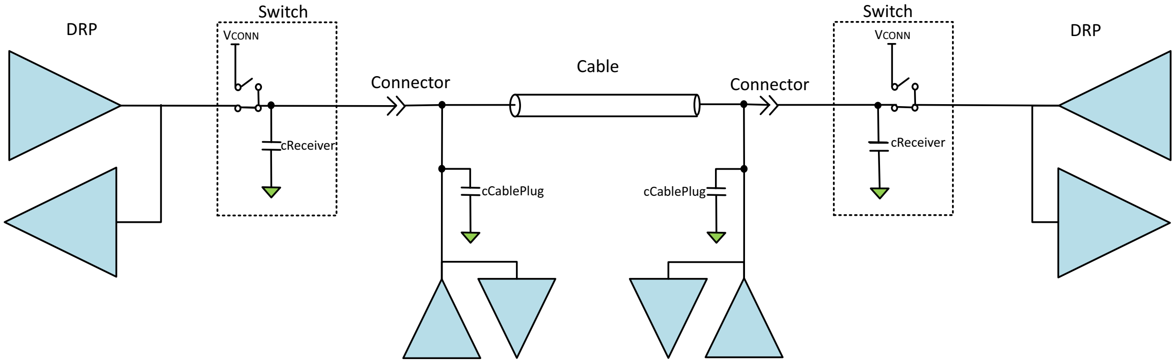
Refer to *Section 5.8.5.4, "Inter-Frame Gap"* for details of when transmissions ***May*** start.

5.8.6.2 Multi-Drop

The *BMC Signaling Scheme* is suitable for use in *Multi-Drop* configurations containing one or two *BMC Multi-Drop* transceivers connected to the *CC* wire, where one or both ends of a cable contains a *Multi-Drop* transceiver. In this specification the location of the *Multi-Drop* transceiver is referred to as the *Cable Plug*.

Figure 5.27, "Example Multi-Drop Configuration showing two DRPs" below illustrates a typical *Multi-Drop* configuration with two *DRP*s.

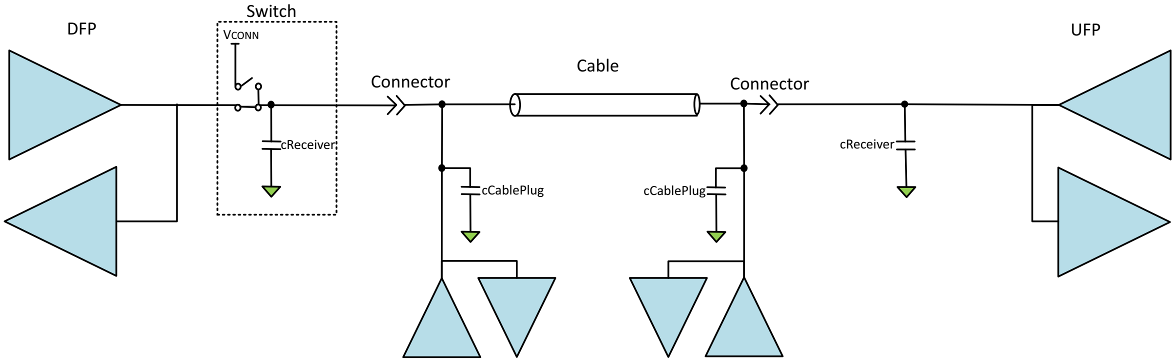
Figure 5.27 Example Multi-Drop Configuration showing two DRPs



The *Multi-Drop* transceiver ***Shall*** obey all the electrical characteristics specified in this section except for those relating to capacitance. The maximum capacitance allowed for the *Multi-Drop* node when not driving the line is cCablePlug_CC defined in ***[USB Type-C 2.4]***. There are no constraints as to the distance of the *Multi-Drop* transceiver from the end of the plug. The *Multi-Drop* transceiver(s) ***May*** be located anywhere along the cable including the plugs. The *Multi-Drop* transceiver suffers less from ground offset compared to the transceivers in the *USB Host* or *USB Device* and contributes no significant reflections.

It is possible to have a configuration at *Attach* where one *Port* can be a *VCONN Source* and the other *Port* is not able to be a *VCONN Source*, such that there is no switch in the second *Port*. An example of a *DFP* with a switch *Attached* to a *UFP* without a switch is outlined in *Figure 5.28, "Example Multi-Drop Configuration showing a DFP and UFP"*. The capacitance on the *CC* line for a *Port* not able to be a *VCONN Source* ***Shall*** still be within ***cReceiver*** except when transmitting.

Figure 5.28 Example Multi-Drop Configuration showing a DFP and UFP



5.8.6.3 Fast Role Swap Detection

An *Initial Sink* prepares for a *Fast Role Swap* by ensuring that once it has detected the *Fast Role Swap Request* its power supply is ready to respond by applying ***vSafe5V*** according to the timing detailed in *Section 7.1.13, "Fast Role Swap"*. The *Initial Sink* ***Shall*** only respond to the *Fast Role Swap Request* when all the following conditions have been met:

- An *Explicit Contract* has been established and the *Sink Capabilities* of the *Initial Source* have been received by, and at the request of, the *Initial Sink*.
- The ***Sink_Capabilities*** *Message* received from the *Initial Source* has at least one of the *Fast Role Swap* bits set in its 5V *Fixed Supply PDO*.
- The *Initial Sink* is able and willing to source the current requested by the *Initial Source* in the *Fast Role Swap* bits of its ***Sink_Capabilities*** *Message*.

On detection of the *Fast Role Swap Request* any pending *Messages* ***Shall*** be ***Discarded*** (see *Section 6.12.2.2.1, "Common Protocol Layer Message Transmission State Diagram"*).

When the *Initial Sink* is prepared for a *Fast Role Swap* and the bus is idle the *CC* voltage averaged over ***tFRSwapRx*** min remains above 0.7V (see ***[USB Type-C 2.4]***) since the *Source* R_p is either 1.5A or 3.0A. However, ***vNoiseIdle*** noise ***May*** cause the *CC* line voltage to reach 0.7V-***vNoiseIdle***/2 for short durations. When the *Initial Sink* is prepared for a *Fast Role Swap* while it is transmitting and the *Initial Source* is sending a *Fast Role Swap Request*, the transmission will be attenuated such that the peak *CC* voltage will not exceed ***vFRSwapCableTx*** min. Therefore, when the *Initial Sink* is prepared for a *Fast Role Swap*, it ***Shall Not*** detect a *Fast Role Swap Request* when the *CC* voltage, averaged over ***tFRSwapRx*** min, is above 0.7V. When the *Initial Sink* is prepared for a *Fast Role Swap*, it ***Shall*** detect a *CC* voltage lower than ***vFRSwapCableTx*** min for ***tFRSwapRx*** as a *Fast Role Swap Request*.

Note: The *Initial Sink* is not required to average the *CC* voltage to meet these requirements.

The *Initial Sink* ***Shall*** initiate the *Fast Role Swap AMS* within ***tFRSwapInit*** of detecting the *Fast Role Swap* Request in order to assign the R_p/R_d resistors to the correct *Ports* and to re-synchronize the state machines (see *Section 6.3.19, "FR_Swap Message"*).

The *Initial Sink* ***Shall*** become the *New Source* and ***Shall*** start supplying ***vSafe5V*** at *USB Type-C* current (see ***[USB Type-C 2.4]***) no later than ***tSrcFRSwap*** after *VBUS* has dropped below ***vSafe5V***. An *Initial Sink* ***Shall*** disable its *VBUS* Disconnect Threshold detection circuitry while *Fast Role Swap* detection is active.

Note: While power is transitioning the *VCONN Source* to the *Cable Plug*(s) cannot be guaranteed.

5.9 Built in Self-Test (BIST)

The following sections define *BIST* functionality which ***Shall*** be supported.

5.9.1 BIST Carrier Mode

In *BIST Carrier Mode*, the *PHY Layer* ***Shall*** send out a *BMC* encoded continuous string of alternating "1"s and "0"s. This enables the measurement of power supply noise and frequency drift.

Note: This transmission is a purely a sequence of alternating bits and ***Shall Not*** be formatted as a *Packet*.

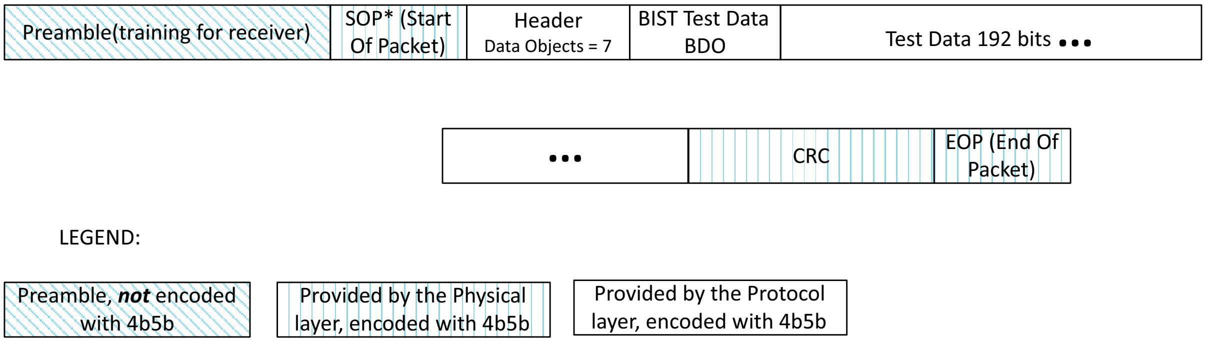
See also *Section 6.4.3, "BIST Message"*.

5.9.2 BIST Test Data Mode

A ***BIST Test Data*** *Message* is used by the *Tester* to send various *Tester* generated *Test Patterns* to the *UUT* in order to test the *UUT*'s receiver. See also *Section 6.4.3, "BIST Message"*.

Figure 5.29, "Test Frame" shows the *Test Frame* which ***Shall*** be sent by the *Tester* to the *UUT*. The ***BIST*** *Message*, with a ***BIST Test Data*** *BIST Data Object* consists of a *Preamble*, followed by *SOP**, followed by the *Message Header* with a data length of 7 *Data Objects*, followed a ***BIST Test Data*** *BIST Data Object*, followed by 6 *Data Objects* containing test data, followed by the *CRC* and then an ***EOP***.

Figure 5.29 Test Frame


Preamble(training for receiver)
SOP* (Start Of Packet)
Header
Data Objects = 7
BIST Test Data BDO
Test Data 192 bits •••
•••
CRC
EOP (End Of Packet)
LEGEND:
Preamble, not encoded with 4b5b
Provided by the Physical layer, encoded with 4b5b
Provided by the Protocol layer, encoded with 4b5b

6 Protocol Layer

6.1 Overview

This chapter describes the requirements of the USB Power Delivery Specification's *Protocol Layer* including:

- Details of how *Message*s are constructed and used.
- Use of timers and timeout values.
- Use of *Message* and retry counters.
- Reset operation.
- Error handling.
- *State* behavior.

Refer to *Section 2.6, "Architectural Overview"* for an overview of the theory of operation of USB Power Delivery.

6.2 Messages

This specification defines three types of *Messages*:

- *Control Messages* that are short and used to manage the *Message* flow between *Port Partners* or to exchange *Messages* that require no additional data. *Control Messages* are 16 bits in length.
- *Data Messages* that are used to exchange information between a pair of *Port Partners*. *Data Messages* range from 48 to 240 bits in length.
    - Some examples of *Data Messages* are:
        - Those used to expose *Capabilities* and *Negotiate* power.
        - Those used for the *BIST*.
        - Those that are *Vendor Defined Messages*.
- *Extended Messages* that are used to exchange information between a pair of *Port Partners*. *Extended Messages* are up to ***MaxExtendedMsgLen*** bytes.
    - Some examples of *Extended Messages* are:
        - Those used for *Source* and *Battery* information.
        - Those used for Security.
        - Those used for Firmware Update.
        - Those that are *Vendor Defined Extended Messages*.

6.2.1 Message Construction

All *Messages* ***Shall*** be composed of a *Message Header* and a variable length (including zero) data portion. A *Message* either originates in the *Protocol Layer* and is passed to the *PHY Layer*, or it is received by the *PHY Layer* and is passed to the *Protocol Layer*.

Figure 6.1, "USB Power Delivery Packet Format for a Control Message" illustrates a *Control Message* as part of a *Packet* showing the parts are provided by the *Protocol Layer* and *PHY Layer*.

Figure 6.1 USB Power Delivery Packet Format for a Control Message

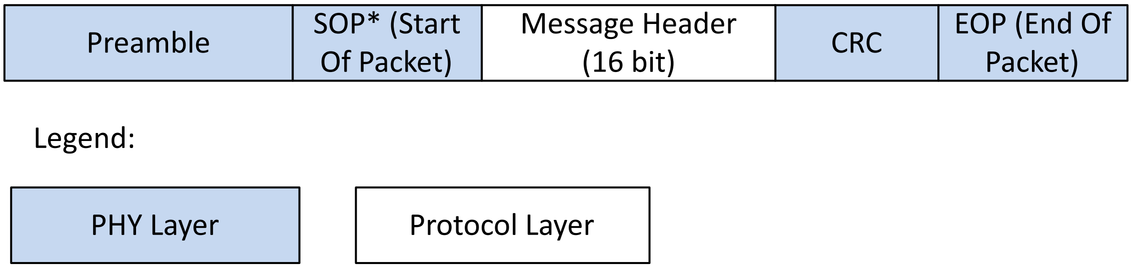


Figure 6.2, "USB Power Delivery Packet Format including Data Message Payload" illustrates a *Data Message* as part of a *Packet* showing the parts are provided by the *Protocol Layer* and *PHY Layer*.

Figure 6.2 USB Power Delivery Packet Format including Data Message Payload

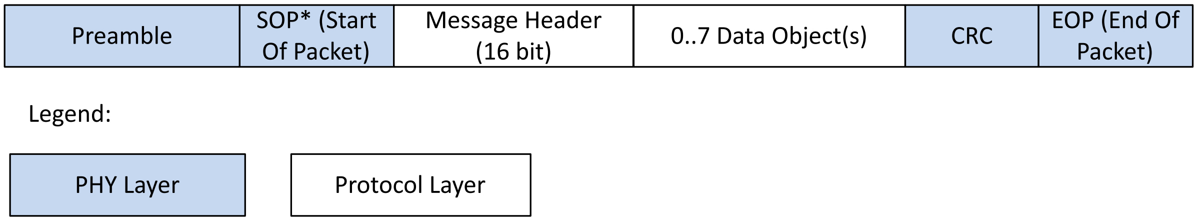
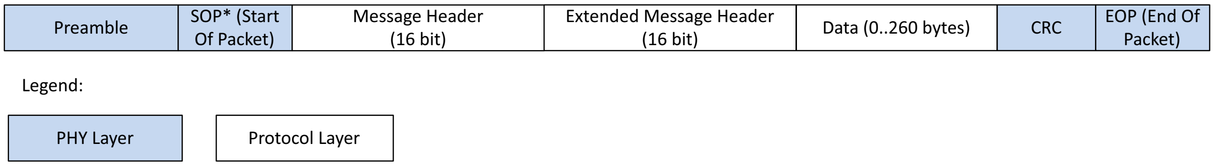


Figure 6.3, "USB Power Delivery Packet Format including an Extended Message Header and Payload" illustrates an *Extended Message* as part of a *Packet* showing the parts are provided by the *Protocol Layer* and *PHY Layer*.

Figure 6.3 USB Power Delivery Packet Format including an Extended Message Header and Payload



6.2.1.1 Message Header

Every *Message* ***Shall*** start with a *Message Header* as shown in:

- *Figure 6.1, "USB Power Delivery Packet Format for a Control Message"*
- *Figure 6.2, "USB Power Delivery Packet Format including Data Message Payload"*
- *Figure 6.3, "USB Power Delivery Packet Format including an Extended Message Header and Payload"*

and as defined in *Table 6.1, "Message Header"*. The *Message Header* contains basic information about the *Message* and the PD *Port Capabilities*.

The *Message Header* ***May*** be used standalone as a *Control Message* when the ***Number of Data Objects*** field is zero or as the first part of a *Data Message* when the ***Number of Data Objects*** field is non-zero.

Table 6.1 Message Header

Bit(s)	Start of Packet	Field Name	Reference
15	*SOP**	***Extended***	*Section 6.2.1.1.1*
14…12	*SOP**	***Number of Data Objects***	*Section 6.2.1.1.2*
11…9	*SOP**	***MessageID***	*Section 6.2.1.1.3*
8	*SOP* only	***Port Power Role***	*Section 6.2.1.1.4*
	SOP'/SOP''	***Cable Plug***	*Section 6.2.1.1.7*
7…6	*SOP**	***Specification Revision***	*Section 6.2.1.1.5*
5	*SOP* only	***Port Data Role***	*Section 6.2.1.1.6*
	SOP'/SOP''	***Reserved***	*Section 1.4.2*
4…0	*SOP**	***Message Type***	*Section 6.2.1.1.8*

6.2.1.1.1 Extended

The 1-bit ***Extended*** field ***Shall*** be set to zero to indicate a *Control Message* or *Data Message* and set to one to indicate an *Extended Message*.

The ***Extended*** field ***Shall*** apply to all *SOP* Packet* types.

6.2.1.1.2 Number of Data Objects

When the ***Extended*** field is set to zero the 3-bit ***Number of Data Objects*** field ***Shall*** indicate the number of 32-bit *Data Objects* that follow the *Message Header*. When this field is zero the *Message* is a *Control Message* and when it is non-zero, the *Message* is a *Data Message*.

The ***Number of Data Objects*** field ***Shall*** apply to all *SOP* Packet* types.

When both the ***Extended*** bit and ***Chunked*** bit are set to one, the ***Number of Data Objects*** field ***Shall*** indicate the number of *Data Objects* in the *Message* padded to the 4-byte boundary including the *Extended Message Header* as part of the first *Data Object*.

When the ***Extended*** bit is set to one and ***Chunked*** bit is set to zero, the ***Number of Data Objects*** field ***Shall*** be ***Reserved***.

Note: In this case, the *Message* length is determined solely by the ***Data Size*** field in the *Extended Message Header*.

6.2.1.1.3 MessageID

The 3-bit ***MessageID*** field is the value generated by a rolling counter maintained by the originator of the *Message*. The ***MessageIDCounter*** ***Shall*** be initialized to zero at power-on as a result of a *Soft Reset*, or a *Hard Reset*. The ***MessageIDCounter*** ***Shall*** be incremented when a *Message* is successfully received as indicated by receipt of a ***GoodCRC*** *Message*.

Note: The usage of ***MessageID*** during testing with *BIST Messages* is defined in ***[USBPDCompliance]***.

The ***MessageID*** field ***Shall*** apply to all *SOP* Packet* types.

6.2.1.1.4 Port Power Role

The 1-bit ***Port Power Role*** field ***Shall*** indicate the *Port*'s present *Power Role*:

- 0b *Sink*
- 1b *Source*

Messages, such as ***Get_Sink_Cap_Extended***, that are only ever sent by a *Source*, ***Shall*** always have the ***Port Power Role*** field set to *Source*. Similarly, *Messages* such as the ***Request*** *Message* that are only ever sent by a *Sink* ***Shall*** always have the ***Port Power Role*** field set to *Sink*.

During the *Power Role Swap AMS*, for the *Initial Source Port*, the ***Port Power Role*** field ***Shall*** be set to *Sink* in the ***PS_RDY*** *Message* indicating that the *Initial Source*'s power supply is turned off (see *Table 8.60, "Steps for a Successful Source Initiated Power Role Swap Sequence"* and *Table 8.63, "Steps for a Successful Sink Initiated Power Role Swap Sequence"*).

During the *Power Role Swap AMS*, for the *Initial Sink*, the ***Port Power Role*** field ***Shall*** be set to *Source* for *Messages* initiated by the *Policy Engine* after receiving the ***PS_RDY*** *Message* from the *Initial Source* (see *Table 8.60, "Steps for a Successful Source Initiated Power Role Swap Sequence"* and *Table 8.63, "Steps for a Successful Sink Initiated Power Role Swap Sequence"*).

During the *Fast Role Swap AMS*, for the *Initial Source Port*, the ***Port Power Role*** field ***Shall*** be set to *Sink* in the ***PS_RDY*** *Message* indicating that *VBUS* is not being driven by the *Initial Source* and is within ***vSafe5V*** (see *Figure 8.39, "Successful Fast Role Swap Sequence"*).

During the *Fast Role Swap AMS*, for the *Initial Sink Port*, the ***Port Power Role*** field ***Shall*** be set to *Source* for *Messages* initiated by the *Policy Engine* after receiving the ***PS_RDY*** *Message* from the *Initial Source* (see *Figure 8.39, "Successful Fast Role Swap Sequence"*).

Note: The ***GoodCRC*** *Message* sent by the *Initial Sink* in response to the ***PS_RDY*** *Message* from the *Initial Source* will have its ***Port Power Role*** field set to *Sink* since this is initiated by the *Protocol Layer*. Subsequent

Messages initiated by the *Policy Engine*, such as the ***PS_RDY*** *Message* sent to indicate that *VBUS* is ready, will have the ***Port Power Role*** field set to *Source*.

The ***Port Power Role*** field of a received *Message* ***Shall Not*** be verified by the receiver and ***Shall Not*** lead to *Soft Reset*, *Hard Reset* or *Error Recovery* if it is incorrect.

The ***Port Power Role*** field ***Shall*** only be defined for *SOP Packet*s.

6.2.1.1.5 Specification Revision

The ***Specification Revision*** field ***Shall*** be one of the following values (except 11b):

- 00b - *Revision 1.0* (***Deprecated***)
- 01b - *Revision 2.0*
- 10b - *Revision 3.x*
- 11b - ***Reserved***, ***Shall Not*** be used.

To ensure interoperability with existing *PDUSB* products, *PDUSB* products ***Shall*** support every PD *Specification Revision* starting from ***[USB 2.0]*** for *SOP**; the only exception to this is a *VPD* which ***Shall Ignore*** *Message*s sent with PD *Specification Revision* 2.0 and earlier.

After a physical or logical (*USB Type-C*® *Error Recovery*) *Attach*, a *Port* discovers the common *Specification Revision* level between itself and its *Port Partner* and/or the *Cable Plug*(s), and uses this *Specification Revision* level until a *Detach*, *Hard Reset* or *Error Recovery* happens.

After detection of the *Specification Revision* to be used, all PD communications ***Shall*** comply completely with the relevant *Revision* of the PD specification.

The 2-bit ***Specification Revision*** field of a ***GoodCRC*** *Message* does not carry any meaning and ***Shall*** be considered as don't care by the recipient of the *Message*. The sender of a ***GoodCRC*** *Message* ***Shall*** set the ***Specification Revision*** field to 01b (*Revision 2.0*) when responding to a *Message* that contains 01b in the ***Specification Revision*** field of the *Message Header*. The sender of a ***GoodCRC*** *Message* ***May*** set the ***Specification Revision*** field to 01b or 10b when responding to a *Message* that contains 10b (*Revision 3.x*) in the ***Specification Revision*** field of the *Message Header*.

The ***Specification Revision*** field ***Shall*** apply to all *SOP* Packet* types.

An *Attach* event or a *Hard Reset* ***Shall*** cause the detection of the applicable *Specification Revision* to be performed for both *Ports* and *Cable Plugs* according to the rules stated below:

When the *Source Port* first communicates with the *Sink Port* the ***Specification Revision*** field ***Shall*** be used as described by the following steps:

1) The *Source Port* sends a ***Source_Capabilities*** *Message* to the *Sink Port* setting the ***Specification Revision*** field to the highest *Revision* of the Power Delivery Specification the *Source Port* supports.
2) The *Sink Port* responds with a ***Request*** *Message* setting the ***Specification Revision*** field to the highest *Revision* of the Power Delivery Specification the *Sink Port* supports that is equal to or lower than the *Specification Revision* received from the *Source Port*.
3) The *Source* and *Sink Ports* ***Shall*** use the *Specification Revision* in the ***Request*** *Message* from the *Sink* in step 2 in all subsequent communications until a *Detach*, *Hard Reset*, or *Error Recovery* happens.

Prior to entering the *First Explicit Contract*, the *VCONN Source* ***Shall*** use the following steps to establish a *Specification Revision* level:

1) The *VCONN Source* sends a ***Discover Identity REQ*** to the *Cable Plug* (*SOP'*) setting the ***Specification Revision*** field in the *Message* to the highest *Revision* of the Power Delivery Specification the *VCONN Source* supports. After a *VCONN Swap* the required ***Soft_Reset*** / ***Accept*** *Message* exchange is used for the same purpose (see [Section 6.3.13, "Soft Reset Message"]).

2) The *Cable Plug* responds with a ***Discover Identity ACK*** setting the ***Specification Revision*** field in the *Message* to the highest *Revision* of the Power Delivery Specification the *VCONN Source* supports that is equal to or lower than the *Specification Revision* it received from the *Source Port*.

3) The *Cable Plug* and *VCONN Source* ***Shall*** communicate using the lower of the two revisions until an *Explicit Contract* has been established.

4) *Table 6.2, "Revision Interoperability during an Explicit Contract"* shows the *Specification Revision* that ***Shall*** be used between the *Port Partner*s and the *Cable Plug*s when the *Specification Revision* has been discovered and an *Explicit Contract* is in place.

Notes:

- A *VCONN Source* that does not communicate with the *Cable Plug*(s) ***May*** skip the above procedure.
- When a *Cable Plug* does not respond to a *Revision 3.x* ***Discover Identity REQ*** with a ***Discover Identity ACK*** or ***BUSY*** the *VCONN Source* ***May*** repeat steps 1-4 using a *Revision 2.0* ***Discover Identity REQ*** in step 1 before establishing that there is no *Cable Plug* to communicate with.

A *VCONN Source* that supports *Revision 3.x* of the Power Delivery Specification ***May*** communicate with a *Cable Plug* also supporting *Revision 3.x* using *Revision 3.x* Compliant Communications regardless of the *Specification Revision* of its *Port Partner* while no *Explicit Contract* exists. After an *Explicit Contract* has been established the *Port Partner*s and *Cable Plug*(s) ***Shall*** use *Table 6.2, "Revision Interoperability during an Explicit Contract"* to determine the *Revision* to be used.

All data in all *Messages* ***Shall*** be consistent with the ***Specification Revision*** field in the *Message Header* for that particular *Message*.

A *Cable Plug* ***Shall Not*** save the state of the agreed *Specification Revision*. A *Cable Plug* ***Shall*** respond with the highest *Specification Revision* it supports that is equal to or lower than the *Specification Revision* contained in the *Message* received from the *VCONN Source*.

Cable Plugs ***Shall*** operate using the same *Specification Revision* for both *SOP'* and *SOP''*. Cable assemblies with two *Cable Plugs* ***Shall*** operate using the same *Specification Revision* for both *Cable Plugs*.

See *Table 6.2, "Revision Interoperability during an Explicit Contract"* for details of how various Revisions ***Shall*** inter-operate.

Table 6.2 Revision Interoperability during an Explicit Contract

Port 1 Revision	Cable Plug Revision	Port 2 Revision	Port to Port Operating Revision	Port to Cable Plug Operating Revision
2	2	2	2	2
2	2	3	2	2
2	3	2	2	2
2	3	3	2	2
3	2	2	2	2
3	2	3	3	2
3	3	2	2	2
3	3	3	3	3

6.2.1.1.6 Port Data Role

The 1-bit ***Port Data Role*** field ***Shall*** indicate the *Port*'s present *Data Role*:

- 0b *UFP*
- 1b *DFP*

The ***Port Data Role*** field ***Shall*** only be defined for *SOP Packet*s. For all other *SOP* Packet*s the ***Port Data Role*** field is ***Reserved*** and ***Shall*** be set to zero.

If a *USB Type-C Port* receives a *Message* with the ***Port Data Role*** field set to the same *Data Role* as its current *Data Role*, except for the ***GoodCRC*** *Message*, *USB Type-C Error Recovery* actions as defined in ***[USB Type-C 2.4]*** ***Shall*** be performed.

For a *USB Type-C Port* the ***Port Data Role*** field ***Shall*** be set to the default value at *Attachment* after a *Hard Reset*: 0b for a *Port* with R_d asserted and 1b for a *Port* with R_p asserted.

In the case that a *Port* is not *USB Communication*s capable, at *Attachment* a *Source Port* ***Shall*** default to *DFP* and a *Sink Port* ***Shall*** default to *UFP*.

6.2.1.1.7 Cable Plug

The 1-bit ***Cable Plug*** field ***Shall*** indicate whether this *Message* originated from a *Cable Plug* or *VPD*:

- 0b *Message* originated from a *DFP* or *UFP*.
- 1b *Message* originated from a *Cable Plug* or *VPD*

The ***Cable Plug*** field ***Shall*** only apply to *SOP' Packet* and *SOP'' Packet* types.

6.2.1.1.8 Message Type

The 5-bit ***Message Type*** field ***Shall*** indicate the type of *Message* being sent. To fully decode the ***Message Type***, the ***Number of Data Objects*** field is first examined to determine whether the *Message* is a *Control Message* or a *Data Message*. Then the specific ***Message Type*** can be found in *Table 6.5, "Control Message Types"* or *Table 6.6, "Data Message Types"*.

The ***Message Type*** field ***Shall*** apply to all *SOP* Packet* types.

6.2.1.2 Extended Message Header

Extended Messages (indicated by the ***Extended*** field being set in the *Message Header*) ***Shall*** contain an *Extended Message Header* following the *Message Header* as shown in *Figure 6.3, "USB Power Delivery Packet Format including an Extended Message Header and Payload"* and defined in "*Table 6.3, "Extended Message Header"*.

Extended Messages contain *Data Block*s of ***Data Size***, defined in the *Extended Message*, that are either sent in a single *Message* or as a series of *Chunk*s. When the *Data Block* is sent as a series of *Chunk*s, each *Chunk* in the series, except for the last *Chunk*, ***Shall*** contain ***MaxExtendedMsgChunkLen*** bytes. The last *Chunk* in the series ***Shall*** contain the remainder of the *Data Block* and so could be less than ***MaxExtendedMsgChunkLen*** bytes and ***Shall*** be padded to the next 4-byte *Data Object* boundary.

6.2.1.2.1 Chunked

Table 6.3 Extended Message Header

Bit(s)	Start of Packet	Field Name	Reference
15	*SOP**	***Chunked***	*Section 6.2.1.2.1*
14…11	*SOP**	***Chunk Number***	*Section 6.2.1.2.2*
10	*SOP**	***Request Chunk***	*Section 6.2.1.2.3*
9	*SOP**	***Reserved***	
8…0	*SOP**	***Data Size***	*Section 6.2.1.2.4*

The *Port Partners* ***Shall*** use the ***Unchunked Extended Messages Supported*** field in the ***Source_Capabilities*** *Message* and ***Unchunked Extended Messages Supported*** field in the ***Request*** *Message* to determine whether to send *Messages* of ***Data Size*** > ***MaxExtendedMsgLegacyLen*** bytes in a single *Unchunked Extended Message* (see *Section 6.4.1.2.1.6, "Unchunked Extended Messages Supported"* and *Section 6.4.2.6, "Unchunked Extended Messages Supported"*).

When either *Port Partner* only supports *Chunked Extended Messages*:

- The ***Chunked*** bit in every *Extended Message* ***Shall*** be set to one.
- Every *Extended Message* of ***Data Size*** > ***MaxExtendedMsgLegacyLen*** ***Shall*** be transmitted between the *Port Partners* in *Chunks*
- The ***Number of Data Objects*** in the *Message Header* ***Shall*** indicate the number of *Data Objects* in the *Message* padded to the 4-byte boundary including the *Extended Message Header* as part of the first *Data Object*.

The conditions listed above ***Shall*** apply until the *Port Pair* is *Detached*, there is a *Hard Reset*, there is *Error Recovery* or the *Source* removes power (except during a *Power Role Swap* or *Fast Role Swap* when the *Initial Source* removes power in order to for the *New Source* to apply power).

When both *Port Partners* support *Unchunked Extended Messages*:

- The ***Chunked*** bit in every *Extended Message* ***Shall*** be set to zero.
- Every *Extended Message* ***Shall*** be transmitted between the *Port Partners Unchunked*.
- The ***Number of Data Objects*** in the *Message Header* is ***Reserved***.

The conditions listed above ***Shall*** apply until the *Port Pair* is *Detached*, there is a *Hard Reset*, there is *Error Recovery* or the *Source* removes power (except during a *Power Role Swap* or *Fast Role Swap* when the *Initial Source* removes power in order to for the *New Source* to apply power).

When sending *Extended Messages* to the *Cable Plug* the *VCONN Source* ***Shall*** only send *Chunked Extended Messages*. *Cable Plugs* ***Shall*** always send *Extended Messages* of ***Data Size*** > ***MaxExtendedMsgLegacyLen*** *Chunked* and ***Shall*** set the ***Chunked*** bit in every *Extended Message* to one.

When *Extended Messages* are supported *Chunking* ***Shall*** be supported.

6.2.1.2.2 Chunk Number

The ***Chunk Number*** field ***Shall*** only be ***Valid*** in a *Message* if the ***Chunked*** flag is set to one. If the ***Chunked*** flag is set to zero the ***Chunk Number*** field ***Shall*** also be set to zero.

The ***Chunk Number*** field is used differently depending on whether the *Message* is a request for Data, or a requested *Data Block* being returned:

- In a request for data the ***Chunk Number*** field indicates the number of the *Chunk* being requested. The requester ***Shall*** only set this field to the number of the next *Chunk* in the series (the next *Chunk* after the last received *Chunk*).
- In the requested *Data Block* the ***Chunk Number*** field indicates the number of the *Chunk* being returned. The ***Chunk Number*** for each *Chunk* in the series ***Shall*** start at zero and ***Shall*** increment for each *Chunk* by one up to a maximum of 9 corresponding to 10 *Chunks* in total.

6.2.1.2.3 Request Chunk

The ***Request Chunk*** bit ***Shall*** only be used for the *Chunked* transfer of an *Extended Message* when the ***Chunked*** bit is set to 1 (see *Figure 6.7, "Example Security_Request sequence Chunked (Chunked bit = 1)"*). For *Unchunked Extended Message* transfers, *Messages* ***Shall*** be sent and received without the request/response mechanism (see *Figure 6.4, "Example Security_Request sequence Unchunked (Chunked bit = 0)"*).

The ***Request Chunk*** bit ***Shall*** be set to one to indicate that this is a request for a *Chunk* of a *Data Block* and ***Shall*** be set to zero to indicate that this is a *Chunk* response containing a *Chunk*. Except for *Chunk* zero, a requested *Chunk* of a *Data Block* ***Shall*** only be returned as a *Chunk* response to a corresponding request for that *Chunk*. Both the *Chunk* request and the *Chunk* response ***Shall*** contain the same value in the ***Message Type*** field. When the ***Request Chunk*** bit is set to one the ***Data Size*** field ***Shall*** be zero.

6.2.1.2.4 Data Size

The ***Data Size*** field ***Shall*** indicate how many bytes of data in total are in *Data Block* being returned. The total number of data bytes in the *Message* ***Shall Not*** exceed ***MaxExtendedMsgLen***.

If the ***Data Size*** field is less than ***MaxExtendedMsgLegacyLen*** and the ***Chunked*** bit is set then the *Packet Payload* ***Shall*** be padded to the next 4-byte *Data Object* boundary with zeros (0x00).

If the ***Data Size*** field is greater than expected for a given *Extended Message* but less than or equal to ***MaxExtendedMsgLen*** then the expected fields in the *Message* ***Shall*** be processed appropriately and the additional fields ***Shall*** be ***Ignored***.

6.2.1.2.5 Extended Message Examples

The following examples illustrate the transmission of *Extended Message*s both *Chunked* (***Chunked*** bit is one) and *Unchunked* (***Chunked*** bit is zero). The examples use a ***Security_Request*** *Message* of ***Data Size*** 7 bytes which is responded to by a ***Security_Response*** *Message* of ***Data Size*** 30 bytes. The sizes of these *Message*s are arbitrary and are used to illustrate *Message* transmission; they are not intended to correspond to genuine security related *Message*s.

During *Negotiation* of the *Explicit Contract* after connection, the *Port Partner*s use the ***Unchunked Extended Messages Supported*** field in the ***Source_Capabilities*** *Message* and ***Unchunked Extended Messages Supported*** field in the ***Request*** *Message* to determine the value of the ***Chunked*** bit (see *Table 6.4, "Use of Unchunked Message Supported bit"*). When both *Port Partner*s support *Unchunked Extended Message*s then the ***Chunked*** bit is zero otherwise the ***Chunked*** bit is one.

The ***Chunked*** bit is used to determine whether:

- The *Chunk* request/response mechanism is used.
- *Extended Messages* are *Chunked*.
- Padding is applied.
- The ***Number of Data Objects*** field is used.

The following examples illustrate the expected usage in each case.

Table 6.4 Use of Unchunked Message Supported bit

		Source: ***Source_Capabilities*** *Message*	
		Unchunked Message Supported bit = 0	*Unchunked Message* Supported bit = 1
Sink: ***Request*** *Message*	*Unchunked Message* Supported bit = 0	***Chunked*** bit = 1	***Chunked*** bit = 1
	Unchunked Message Supported bit = 1	***Chunked*** bit = 1	***Chunked*** bit = 0

6.2.1.2.5.1 Security_Request/Security_Response Unchunked Example

Figure 6.4, "Example Security_Request sequence Unchunked (Chunked bit = 0)" illustrates a typical sequence for a ***Security_Request*** *Message* responded to by a ***Security_Response*** *Message* using *Unchunked Extended Messages* (***Chunked*** bit is zero) between a *USB Host* and a *Charger*. The entire *Data Block* is returned in one *Message*. The *Chunk* request/response mechanism is not used.

Figure 6.4 Example Security_Request sequence Unchunked (Chunked bit = 0)

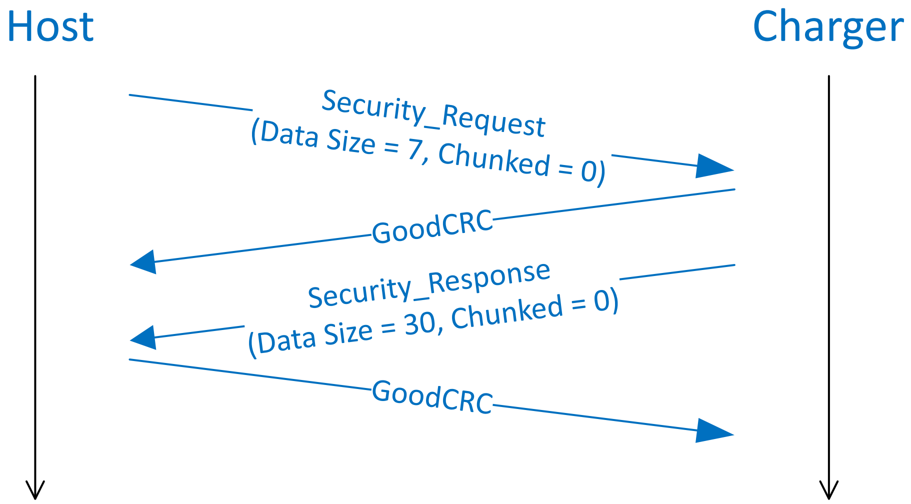


Figure 6.5, "Example byte transmission for Security_Request Message of Data Size 7 (Chunked bit is set to zero)" details the ***Security_Request*** *Message* shown in *Figure 6.4, "Example Security_Request sequence Unchunked (Chunked bit = 0)"*. The figure shows the byte ordering on the bus as well as the fact that there is no padding in this case. The ***Number of Data Objects*** field has a value of 0 since it is ***Reserved*** when the ***Chunked*** bit is zero. The ***Data Size*** field indicates the length of the *Extended Message* when the ***Chunked*** bit is set to 0, which in this case is 7 bytes.

Figure 6.5 Example byte transmission for Security_Request Message of Data Size 7 (Chunked bit is set to zero)

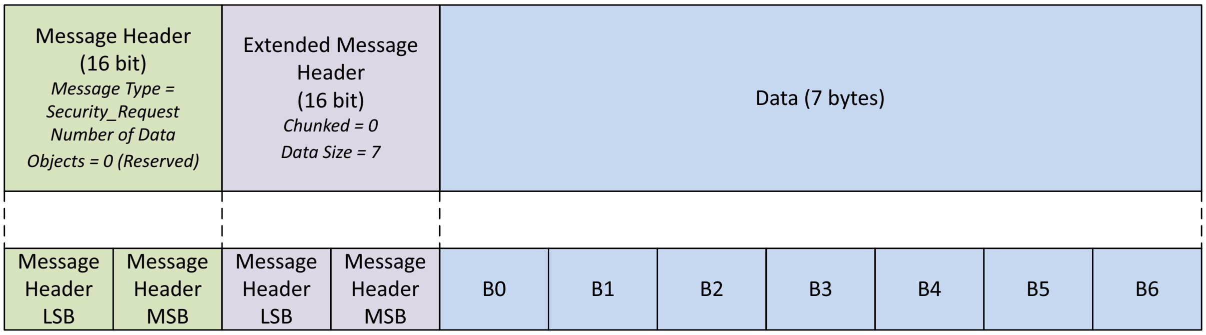
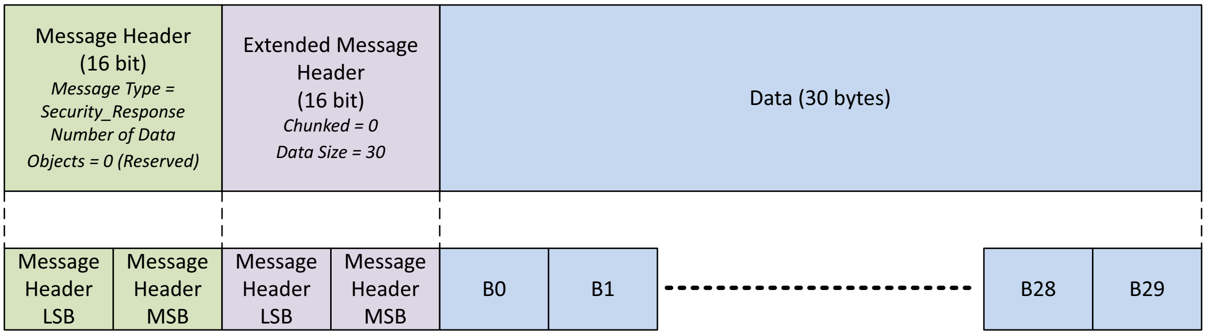


Figure 6.6, "Example byte transmission for Security_Response Message of Data Size 30 (Chunked bit is set to zero)" details the ***Security_Response*** *Message* shown in *Figure 6.4, "Example Security_Request sequence Unchunked (Chunked bit = 0)"*. The figure shows the byte ordering on the bus as well as the fact that there is no padding in this case. The ***Number of Data Objects*** field has a value of 0 since it is ***Reserved*** when the ***Chunked*** bit is zero. The ***Data Size*** field indicates the length of the *Extended Message* when the ***Chunked*** bit is set to zero, which in this case is 30 bytes.

Figure 6.6 Example byte transmission for Security_Response Message of Data Size 30 (Chunked bit is set to zero)



6.2.1.2.5.2 Security_Request/Security_Response Chunked Example

Figure 6.7, "Example Security_Request sequence Chunked (Chunked bit = 1)" illustrates a typical sequence for a ***Security_Request*** *Message* responded to by a ***Security_Response*** *Message* using *Chunked Extended Message*s (***Chunked*** bit is one) between a *USB Host* and a *Charger*.

Note: ***Chunk Number*** zero in every *Extended Message* is sent without the need for a *Chunk* Request, but ***Chunk Number*** one and following need to be requested with a *Chunk* request.

Figure 6.7 Example Security_Request sequence Chunked (Chunked bit = 1)

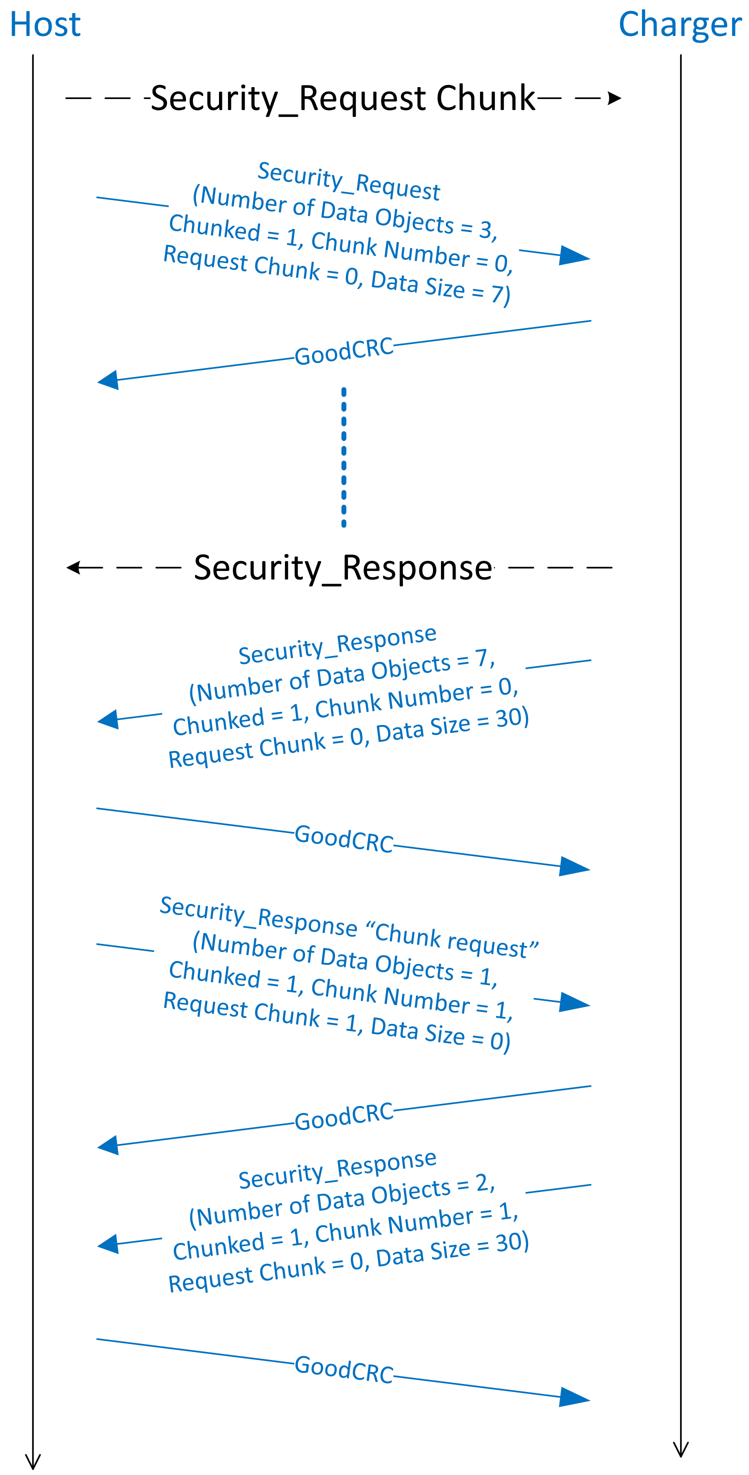

Host
Charger
Security_Request Chunk
Security_Request
(Number of Data Objects = 3,
Chunked = 1, Chunk Number = 0,
Request Chunk = 0, Data Size = 7)
GoodCRC
Security_Response
Security_Response
(Number of Data Objects = 7,
Chunked = 1, Chunk Number = 0,
Request Chunk = 0, Data Size = 30)
GoodCRC
Security_Response “Chunk request”
(Number of Data Objects = 1,
Chunked = 1, Chunk Number = 1,
Request Chunk = 1, Data Size = 0)
GoodCRC
Security_Response
(Number of Data Objects = 2,
Chunked = 1, Chunk Number = 1,
Request Chunk = 0, Data Size = 30)
GoodCRC

Figure 6.8, "Example Security_Request Message of Data Size 7 (Chunked bit set to 1)" shows the ***Security_Request*** *Message* shown in *Figure 6.7, "Example Security_Request sequence Chunked (Chunked bit = 1)"* in more detail including the byte ordering on the bus and padding. Three bytes of padding have been added to the *Message* so that the total number of bytes is a multiple of 32-bits, corresponding to 3 *Data Object*s. The ***Number of Data Objects*** field is set to 3 to indicate the length of this *Chunk*. The ***Chunk Number*** is set to zero and the ***Data Size*** field is set to 7 to indicate the length of the whole *Extended Message*.

Figure 6.8 Example Security_Request Message of Data Size 7 (Chunked bit set to 1)

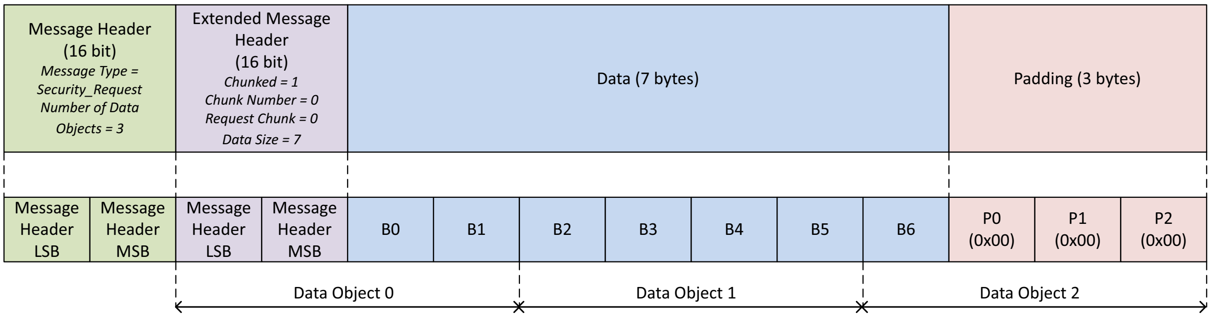


Figure 6.9, "Example Chunk 0 of Security_Response Message of Data Size 30 (Chunked bit set to 1)" shows ***Chunk Number*** zero of the ***Security_Response*** *Message* shown in *Figure 6.7, "Example Security_Request sequence Chunked (Chunked bit = 1)"* in more detail including the byte ordering on the bus and padding. No padding is need for this *Chunk* since the full 26-byte *Payload* plus 2-byte *Extended Message Header* is a multiple of 32-bits, corresponding to 7 *Data Object*s. The ***Number of Data Objects*** field is set to 7 to indicate the length of this *Chunk* and the ***Data Size*** field is set to 30 to indicate the length of the whole *Extended Message*.

Figure 6.9 Example Chunk 0 of Security_Response Message of Data Size 30 (Chunked bit set to 1)

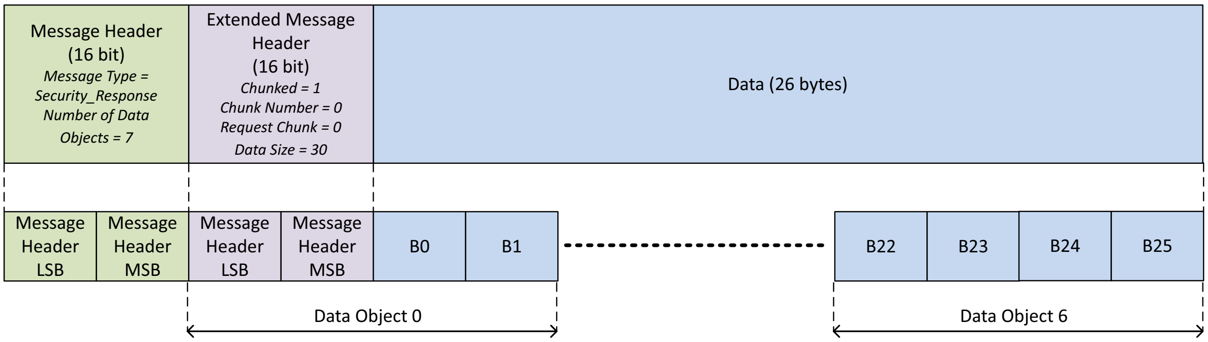
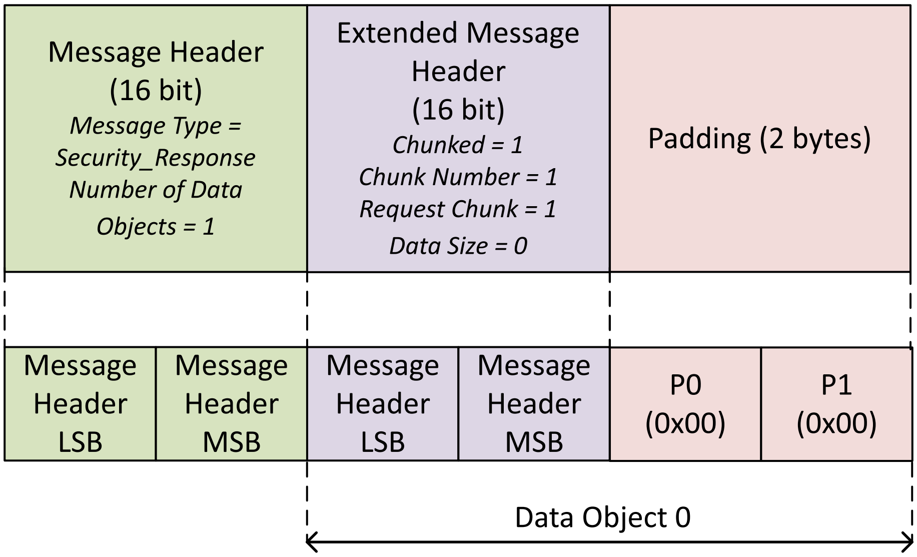


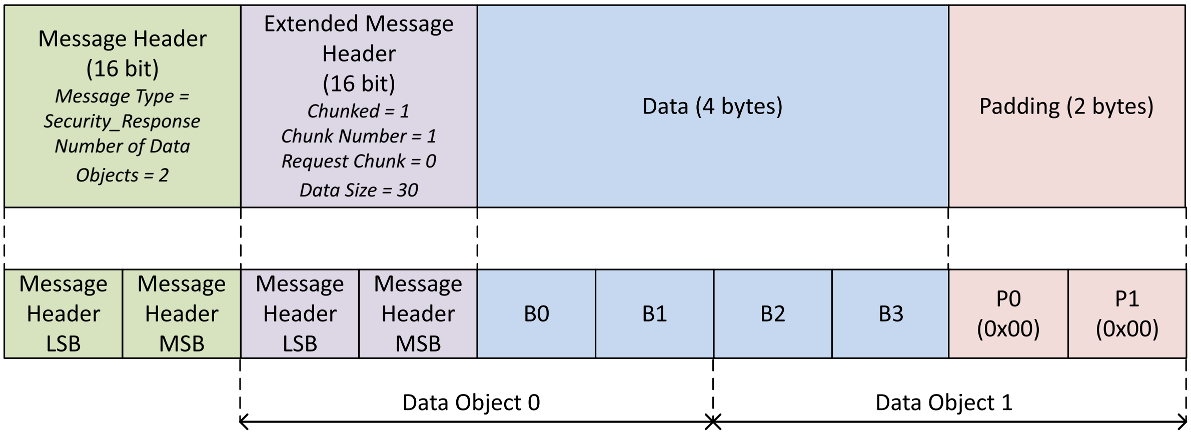
Figure 6.7, "Example Security_Request sequence Chunked (Chunked bit = 1)" shows an example of the *Message* format, byte ordering and padding for the ***Security_Response*** *Message Chunk* request for ***Chunk Number*** one shown in *Figure 6.7, "Example Security_Request sequence Chunked (Chunked bit = 1)"*. In the *Chunk* request the ***Number of Data Objects*** field in the *Message* is set to 1 to indicate that the *Payload* is 32 bits equivalent to 1 data object (see *Figure 6.10, "Example byte transmission for a Security_Response Message Chunk request (Chunked bit is set to 1)"*). Since the ***Chunked*** bit is set to 1 the *Chunk* request/*Chunk* response mechanism is used. The *Message* is a *Chunk* request so the ***Request Chunk*** bit is set to one, and in this case *Chunk* one is being requested so ***Chunk Number*** is set to one. ***Data Size*** is set to zero indicating the length of the *Data Block* being transferred. Two bytes of padding are added to ensure that the *Payload* is a multiple of 32 bits.

Figure 6.10 Example byte transmission for a Security_Response Message Chunk request (Chunked bit is set to 1)



[Figure 6.11, "Example Chunk 1 of Security_Response Message of Data Size 30 (Chunked bit set to 1)"]() shows ***Chunk Number*** one of the ***Security_Response*** *Message* shown in [Figure 6.7, "Example Security_Request sequence Chunked (Chunked bit = 1)"]() in more detail including the byte ordering on the bus and padding. Two bytes of padding are added to ensure that the *Payload* is a multiple of 32 bits, corresponding to 2 *Data Object*s. The ***Number of Data Objects*** field is set to 2 to indicate the length of this *Chunk* and the ***Data Size*** field is set to 30 to indicate the length of the whole *Extended Message*.

Figure 6.11 Example Chunk 1 of Security_Response Message of Data Size 30 (Chunked bit set to 1)



6.3 Control Message

A *Message* is defined as a *Control Message* when the ***Number of Data Objects*** field in the *Message Header* is set to zero. The *Control Message* consists only of a *Message Header* and a *CRC*. The *Protocol Layer* originates the *Control Messages* (i.e., ***Accept*** Message, ***Reject*** *Message* etc.).

The *Control Message* types are specified in the *Message Header*'s ***Message Type*** field (bits 4…0) and are summarized in *Table 6.5, "Control Message Types"*. The Sent by column indicates entities which ***May*** send the given *Message* (*Source*, *Sink* or *Cable Plug*); entities not listed ***Shall Not*** issue the corresponding *Message*. The "Valid Start of Packet" column indicates the *Messages* which ***Shall*** only be issued in *SOP Packets* and the *Messages* which ***May*** be issued in *SOP* Packets*.

Table 6.5 Control Message Types

Bits 4…0	Message Type	Sent by	Description	Valid Start of Packet
0_0000	***Reserved***	***N/A***	All values not explicitly defined are ***Reserved*** and ***Shall Not*** be used.	
0_0001	***GoodCRC***	*Source*, *Sink* or *Cable Plug*	See *Section 6.3.1*.	*SOP**
0_0010	***GotoMin (Deprecated)***	***Deprecated***	See *Section 6.3.2*.	***N/A***
0_0011	***Accept***	*Source*, *Sink* or *Cable Plug*	See *Section 6.3.3*.	*SOP**
0_0100	***Reject***	*Source*, *Sink* or *Cable Plug*	See *Section 6.3.4*.	*SOP**
0_0101	***Ping (Deprecated)***	***Deprecated***	See *Section 6.3.5*.	*SOP* only
0_0110	***PS_RDY***	*Source* or *Sink*	See *Section 6.3.6*.	*SOP* only
0_0111	***Get_Source_Cap***	*Sink* or *DRP*	See *Section 6.3.7*.	*SOP* only
0_1000	***Get_Sink_Cap***	*Source* or *DRP*	See *Section 6.3.8*.	*SOP* only
0_1001	***DR_Swap***	*Source* or *Sink*	See *Section 6.3.9*.	*SOP* only
0_1010	***PR_Swap***	*Source* or *Sink*	See *Section 6.3.10*.	*SOP* only
0_1011	***VCONN_Swap***	*Source* or *Sink*	See *Section 6.3.11*.	*SOP* only
0_1100	***Wait***	*Source* or *Sink*	See *Section 6.3.12*.	*SOP* only
0_1101	***Soft_Reset***	*Source* or *Sink*	See *Section 6.3.13*.	*SOP**
0_1110	***Data_Reset***	*Source* or *Sink*	See *Section 6.3.14*.	*SOP* only
0_1111	***Data_Reset_Complete***	*Source* or *Sink*	See *Section 6.3.15*.	*SOP* only
1_0000	***Not_Supported***	*Source*, *Sink* or *Cable Plug*	See *Section 6.3.16*.	*SOP**
1_0001	***Get_Source_Cap_Extended***	*Sink* or *DRP*	See *Section 6.3.17*.	*SOP* only
1_0010	***Get_Status***	*Source* or *Sink*	See *Section 6.3.18*.	*SOP**
1_0011	***FR_Swap***	*Sink*[1]	See *Section 6.3.19*.	*SOP* only
1_0100	***Get_PPS_Status***	*Sink*	See *Section 6.3.20*.	*SOP* only
1_0101	***Get_Country_Codes***	*Source* or *Sink*	See *Section 6.3.21*.	*SOP* only
1_0110	***Get_Sink_Cap_Extended***	*Source* or *DRP*	See *Section 6.3.22*.	*SOP* only
1_0111	***Get_Source_Info***	*Sink* or *DRP*	See *Section 6.3.23*.	*SOP* Only
1_1000	***Get_Revision***	*Source* or *Sink*	See *Section 6.3.24*.	*SOP**
1_1001… 1_1111	***Reserved***	***N/A***	All values not explicitly defined are ***Reserved*** and ***Shall Not*** be used.	

1) In this case the *Port* is providing ***vSafe5V*** however it will have R_d asserted rather than R_p and sets the ***Port Power Role*** field to *Sink*, until the *Fast Role Swap AMS* has completed.

6.3.1 GoodCRC Message

The ***GoodCRC*** *Message* ***Shall*** be sent by the receiver to acknowledge that the previous *Message* was correctly received (i.e., had a ***GoodCRC*** *Message*). The ***GoodCRC*** *Message* ***Shall*** return the *Message*'s ***MessageID*** so the sender can determine that the correct *Message* is being acknowledged. The first bit of the ***GoodCRC*** *Message* ***Shall*** be returned within ***tTransmit*** after receipt of the last bit of the previous *Message*.

BIST does not send the ***GoodCRC*** *Message* while in a *Continuous BIST Mode* (see Section 6.4.3, "BIST Message").

The retry mechanism is triggered when the *Message* sender fails to receive a ***GoodCRC*** *Message* before the ***CRCReceiveTimer*** expires. It is used by the *Message* sender to detect that the *Message* was not correctly received by the *Message* recipient due to noise or other disturbance on the *Configuration Channel* (*CC*). The retry mechanism ***Shall Not*** be used for any other purpose such as a means of gaining time for processing the required response to the received *Message*.

6.3.2 GotoMin Message (Deprecated)

The ***GotoMin (Deprecated)*** *Message* has been ***Deprecated***. The 0_0010 ***Message Type*** is no longer ***Valid*** and ***Shall*** be responded to by a ***Not_Supported*** *Message*.

6.3.3 Accept Message

The ***Accept*** *Message* is a ***Valid*** response in the following cases:

- It ***Shall*** be sent by the *Source*, in *SPR Mode*, to signal the *Sink* that the *Source* is willing to meet the ***Request*** *Message*.
- It ***Shall*** be sent by the *Source*, in *EPR Mode*, to signal the *Sink* that the *Source* is willing to meet the ***EPR_Request*** *Message*.
- It ***Shall*** be sent by the recipient of the ***PR_Swap*** *Message* to signal that it is willing to do a *Power Role Swap* and has begun the *Power Role Swap AMS*.
- It ***Shall*** be sent by the recipient of the ***DR_Swap*** *Message* to signal that it is willing to do a *Data Role Swap* and has begun the *Data Role Swap AMS*.
- It ***Shall*** be sent by the recipient of the ***VCONN_Swap*** *Message* to signal that it is willing to do a *VCONN Swap* and has begun the *VCONN Swap AMS*.
- It ***Shall*** be sent by the recipient of the ***FR_Swap*** *Message* to indicate that it has begun the *Fast Role Swap AMS*.
- It ***Shall*** be sent by the recipient of the ***Soft_Reset*** *Message* to indicate that it has completed its *Soft Reset*.
- It ***Shall*** be sent by the recipient of the ***Enter_USB*** *Message* to indicate that it has begun the Enter USB *AMS*.
- It ***Shall*** be sent by the recipient of the ***Data_Reset*** *Message* to indicate that it has begun the *Data Reset AMS*.

The ***Accept*** *Message* ***Shall*** be sent within ***tReceiverResponse*** of the receipt of the last bit of the *Message* (see Section 6.6.2, "SenderResponseTimer").

6.3.4 Reject Message

The ***Reject*** *Message* is a ***Valid*** response in the following cases:

- It ***Shall*** be sent to signal the *Sink*, in *SPR Mode*, that the *Source* is unable to meet the ***Request*** *Message*. This ***May*** be due an ***Invalid*** request or because the *Source* can no longer provide what it previously *Advertise*d.

- It ***Shall*** be sent to signal the *Sink*, in *EPR Mode*, that the *Source* is unable to meet the ***EPR_Request*** *Message*. This ***May*** be due an ***Invalid*** request or because the *Source* can no longer provide what it previously *Advertise*d.
- It ***Shall*** be sent by the recipient of a ***PR_Swap*** *Message* to indicate it is unable to do a *Power Role Swap*.
- It ***Shall*** be sent by the recipient of a ***PR_Swap*** *Message* while in *EPR Mode*.
- It ***Shall*** be sent by the recipient of a ***DR_Swap*** *Message* to indicate it is unable to do a *Data Role Swap*.
- It ***Shall*** be sent by the recipient of a ***VCONN_Swap*** *Message* that is not presently the *VCONN Source*, to indicate it is unable to do a *VCONN Swap*.
- It ***Shall*** be sent by *UFP* on receiving an ***Enter_USB*** *Message* to indicate it is unable to enter the requested USB *Mode*.

The sender of a ***Request***, ***EPR_Request***, ***PR_Swap***, ***DR_Swap***, ***VCONN_Swap***, or ***Enter_USB*** *Message*, on receiving a ***Reject*** *Message* response, ***Shall Not*** send this same *Message* to the recipient until one of the following has occurred:

- A New *Explicit Contract Negotiation* as a result of the *Source* sending a ***Source_Capabilities*** *Message* or ***EPR_Source_Capabilities*** *Message*. This can be triggered by:
  - The *Source*'s *Device Policy Manager*.
  - A ***Get_Source_Cap*** *Message* sent from the *Sink* to the *Source* in *SPR Mode*.
  - An ***EPR_Get_Source_Cap*** *Message* sent from the *Sink* to the *Source* in *EPR Mode*.
  - A *Power Role Swap*.
  - A *Soft Reset*.
  - A *Hard Reset*.
  - A Disconnect/Re-connect.
- A *Data Role Swap*.
- A *Data Reset*.

The *Sink* ***May*** send a different ***Request*** *Message* to the one which was rejected but ***Shall Not*** repeat the same ***Request*** *Message*, using the same *RDO*, unless there has been a New *Explicit Contract Negotiation*, *Data Role Swap* or *Data Reset* as described above.

The ***Reject*** *Message* ***Shall*** be sent within ***tReceiverResponse*** of the receipt of the last bit of *Message* (see *Section 6.6.2, "SenderResponseTimer"*).

Note: The ***Reject*** *Message* is not a ***Valid*** response when a *Message* is not supported. In this case the ***Not_Supported*** *Message* is returned (see *Section 6.3.16, "Not_Supported Message"*).

6.3.5 Ping Message

The ***Ping (Deprecated)*** *Message* has been deprecated. The 0_0101 ***Message Type*** is no longer ***Valid***.

A *Port* that receives a ***Ping (Deprecated)*** *Message* ***May*** respond with a ***Not_Supported*** *Message* or ***Ignore*** the ***Ping (Deprecated)*** *Message*. A *Cable Plug* that receives a ***Ping (Deprecated)*** *Message* ***Shall Ignore*** the ***Ping (Deprecated)*** *Message*.

6.3.6 PS_RDY Message

The ***PS_RDY*** *Message* ***Shall*** be sent by the *Source* (or by both the *New Sink* and *New Source* during the *Power Role Swap AMS* or *Fast Role Swap AMS*) to indicate its power supply has reached the desired operating condition (see *Section 8.3.2.2, "Power Negotiation"*).

6.3.7 Get_Source_Cap Message

The ***Get_Source_Cap*** (Get *Source Capabilities*) *Message* ***May*** be sent by a *Port* to request the *Source Capabilities* and *Dual-Role Power* capability of its *Port Partner* (e.g., *Dual-Role Power* capable). The *Port* ***Shall*** respond by returning a ***Source_Capabilities*** *Message* (see *Section 6.4.1.5, "SPR Source Capabilities Message"*).

6.3.8 Get_Sink_Cap Message

The ***Get_Sink_Cap*** (Get *Sink Capabilities*) *Message* ***May*** be sent by a *Port* to request the *Sink Capabilities* and *Dual-Role Power* capability of its *Port Partner* (e.g., *Dual-Role Power* capable). The *Port* ***Shall*** respond by returning a ***Sink_Capabilities*** *Message* (see *Section 6.4.1.6, "SPR Sink Capabilities Message"*).

6.3.9 DR_Swap Message

The ***DR_Swap*** *Message* is used to exchange *DFP* and *UFP* operation between *Port Partner*s while maintaining the direction of power flow over *VBUS*. The *Data Role Swap* process can be used by *Port Partner*s whether or not they support *USB Communications* capability. A *DFP* that supports *USB Communication* capability starts as the *USB Host* on *Attachment*. A *UFP* that supports *USB Communication* capability starts as the *USB Device* on *Attachment*.

[USB Type-C 2.4] *Dual-Role Data* (*DRD*) *Ports* ***Shall*** have the capability to perform a *Data Role Swap* from the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** states. *DFP*s and *UFP*s ***May*** have the capability to perform a *Data Role Swap* from the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** states. A *Data Role Swap* ***Shall*** be regarded in the same way as a cable *Detach*/*Re-attach* in relation to any *USB Communication* which is ongoing between the *Port Partner*s. If there are any *Active Mode*s between the *Port Partner*s when a ***DR_Swap*** *Message* is a received, then a *Hard Reset* ***Shall*** be performed (see *Section 6.4.4.3.4, "Enter Mode Command"*). If the *Cable Plug* has any *Active Modes* then the *DFP* ***Shall Not*** issue a ***DR_Swap*** *Message* and ***Shall*** cause all *Active Modes* in the *Cable Plug* to be exited before accepting a *Data Role Swap* request.

The source of *VBUS* and *VCONN Source* ***Shall*** remain unchanged as well as the R_p/R_d resistors on the *CC* wire during the *Data Role Swap* process.

The ***DR_Swap*** *Message* ***May*** be sent by either *Port Partner*. The recipient of the ***DR_Swap*** *Message* ***Shall*** respond by sending an ***Accept*** *Message*, a ***Wait*** *Message* or a ***Reject*** *Message* (see *Section 6.9, "Accept, Reject and Wait"*).

- If an ***Accept*** *Message* is sent, the *Source* and *Sink* ***Shall*** exchange *Data Role*s.
- If a ***Reject*** *Message* is sent, the requester is informed that the recipient is unable, or unwilling, to do a *Data Role Swap* and no action ***Shall*** be taken.
- If a ***Wait*** *Message* is sent, the requester is informed that a *Data Role Swap* might be possible in the future but that no immediate action ***Shall*** be taken.

Before a *Data Role Swap* the initial *DFP* ***Shall*** have its ***Port Data Role*** bit set to *DFP*, and the initial *UFP* ***Shall*** have its ***Port Data Role*** bit set to *UFP*.

After a successful *Data Role Swap* the *DFP*/*Host* ***Shall*** become the *UFP*/*Device* and vice-versa; the new *DFP* ***Shall*** have its ***Port Data Role*** bit set to *DFP*, and the new *UFP* ***Shall*** have its ***Port Data Role*** bit set to *UFP*. Where *USB Communication* is supported by both *Port Partner*s a USB data connection ***Should*** be established according to the new *Data Role*s.

If the *Data Role Swap*, after having been accepted by the *Port Partner*, is subsequently not successful, in order to attempt a re-establishment of the connection, *USB Type-C Error Recovery* actions, such as disconnect, as defined in ***[USB Type-C 2.4]*** will be necessary.

See *Section 8.3.2.9, "Data Role Swap"*.

6.3.10 PR_Swap Message

The ***PR_Swap*** *Message* ***May*** be sent by either *Port Partner* to request an exchange of *Power Role*s. The recipient of the *Message* ***Shall*** respond by sending an ***Accept*** *Message*, a ***Wait*** *Message* or a ***Reject*** *Message* (see *Section 6.9, "Accept, Reject and Wait"*).

- If an ***Accept*** *Message* is sent, the *Source* and *Sink* ***Shall*** do a *Power Role Swap*.

- If a ***Reject*** *Message* is sent, the requester is informed that the recipient is unable, or unwilling, to do a *Power Role Swap* and no action ***Shall*** be taken.

- If a ***Wait*** *Message* is sent, the requester is informed that a *Power Role Swap* might be possible in the future but that no immediate action ***Shall*** be taken.

The ***PR_Swap*** *Message* ***Shall Not*** be sent while in *EPR Mode*. While in *EPR Mode* if a *Power Role Swap* is required, an *EPR Mode* exit ***Shall*** be done first.

After a successful *Power Role Swap* the *Port Partners* ***Shall*** reset their respective *Protocol Layer*s (equivalent to a *Soft Reset*): resetting their ***MessageIDCounter***, ***RetryCounter*** and *Protocol Layer* state machines before attempting to establish the *First Explicit Contract*. At this point the *New Source* ***Shall*** also reset its ***CapsCounter***.

The *New Source* ***Shall*** have R_p asserted on the *CC* wire and the *New Sink* ***Shall*** have R_d asserted on the *CC* wire as defined in ***[USB Type-C 2.4]***. When performing a *Power Role Swap* from *Source* to *Sink*, the *Port* ***Shall*** change its *CC* wire resistor from R_p to R_d. When performing a *Power Role Swap* from *Sink* to *Source*, the *Port* ***Shall*** change its *CC* wire resistor from R_d to R_p. The *DFP* (*Host*), *UFP* (*Device*) *Data Roles* and *VCONN Source* ***Shall*** remain unchanged by the *Power Role Swap* process.

Note: During the *Power Role Swap* process the *Initial Sink* does not disconnect even though *VBUS* drops below ***vSafe5V***.

For more information regarding the *Power Role Swap*, refer to:

- *Section 7.3.2, "Transitions Caused by Power Role Swap"*

- *Section 8.3.2.5, "Data Reset"*.

- *Section 8.3.3.19.3, "Policy Engine in Source to Sink Power Role Swap State Diagram"*.

- *Section 8.3.3.19.4, "Policy Engine in Sink to Source Power Role Swap State Diagram"*.

- *Section 9.1.2, "Mapping to USB Device States"*.

6.3.11 VCONN_Swap Message

The ***VCONN_Swap*** *Message* ***Shall*** be supported by any *Port* that can operate as a *VCONN Source*.

The ***VCONN_Swap*** *Message* ***May*** be sent by either *Port Partner* to request an exchange of *VCONN Source*. The recipient of the *Message* ***Shall*** respond by sending an ***Accept*** *Message*, ***Reject*** *Message*, ***Wait*** *Message* (see *Section 6.9, "Accept, Reject and Wait"*) or ***Not_Supported*** *Message*.

- If an ***Accept*** *Message* is sent, the *Port Partners* ***Shall*** perform a *VCONN Swap*. The new *VCONN Source* ***Shall*** send a ***PS_RDY*** *Message* within ***tVCONNSourceOn*** to indicate that it is now sourcing *VCONN*. The initial *VCONN Source* ***Shall*** cease sourcing *VCONN* within ***tVCONNSourceOff*** of receipt of the last bit of the ***EOP*** of the ***PS_RDY*** *Message*.

- If a ***Reject*** *Message* is sent, the requester is informed that the recipient is unable, or unwilling, to do a *VCONN Swap* and no action ***Shall*** be taken. A ***Reject*** *Message* ***Shall*** only be sent by the *Port* that is not presently the *VCONN Source* in response to a ***VCONN_Swap*** *Message*. The *Port* that is presently the *VCONN Source* ***Shall Not*** send a ***Reject*** *Message* in response to ***VCONN_Swap*** *Message*.

- If a ***Wait*** *Message* is sent, the requester is informed that a *VCONN Swap* might be possible in the future but that no immediate action ***Shall*** be taken. A *Port* after losing the *VCONN Source* role due to incoming *VCONN Swap* request ***Shall Not*** initiate a *VCONN Swap* until at least ***tVCONNSwapDelayDFP***/ ***tVCONNSwapDelayUFP*** after completing the previous *VCONN Swap AMS*.

- If a ***Not_Supported*** *Message* is sent, the requester is informed that *VCONN Swap* is not supported. The *Port* that is not presently the *VCONN Source* ***May*** turn on *VCONN* when a ***Not_Supported*** *Message* is received in response to a ***VCONN_Swap*** *Message*.

The *DFP* (*Host*), *UFP* (*Device*) *Data Role*s and *Source* of *VBUS* ***Shall*** remain unchanged as well as the R_p/R_d resistors on the *CC* wire during the *VCONN Swap* process.

VCONN ***Shall*** be continually sourced during the *VCONN Swap* process to maintain power to the *Cable Plug*(s) i.e., make before break.

Before communicating with a *Cable Plug* a *Port* ***Shall*** ensure that it is the *VCONN Source* and that the *Cable Plug*s are powered, by performing a *VCONN Swap* if necessary. Since it cannot be guaranteed that the present *VCONN Source* is supplying *VCONN*, the only means to ensure that the *Cable Plug*s are powered is for a *Port* wishing to communicate with a *Cable Plug* to become the *VCONN Source*. If a ***Not_Supported*** *Message* is returned in response to the ***VCONN_Swap*** *Message*, then the *Port* is allowed to become the *VCONN Source* until a *Hard Reset* or *Detach*.

A *VCONN Source* that is also a *Source* can attempt to send a ***Discover Identity*** *Command* using *SOP'* to a *Cable Plug* prior to the establishment of the *First Explicit Contract*.

Note: Even when it is presently the *VCONN Source*, the *Sink* is not permitted to initiate an *AMS* with a *Cable Plug* unless R_p is set to ***SinkTxOK*** (see Section 6.9, "Accept, Reject and Wait").

6.3.12 Wait Message

The ***Wait*** *Message* is a ***Valid*** response to one of the following *Messages*:

- It ***Shall*** be sent to signal the *Sink*, in response to a ***Request*** *Message* in *SPR Mode* during *Negotiation*, to indicate that the *Source* is currently unable to meet the request.
- It ***Shall*** be sent to signal the *Sink*, in response to a ***EPR_Request*** *Message* in *EPR Mode* during *Negotiation*, to indicate that the *Source* is currently unable to meet the request.
- It ***Shall*** be sent by the recipient of a ***PR_Swap*** *Message* to indicate it is currently unable to do a *Power Role Swap*.
- It ***Shall*** be sent by the recipient of a ***DR_Swap*** *Message* to indicate it is currently unable to do a *Data Role Swap*.
- It ***Shall*** be sent by the recipient of a ***VCONN_Swap*** *Message* that is not presently the *VCONN Source* to indicate it is currently unable to do a *VCONN Swap*.
- It ***Shall*** be sent by the recipient of an ***Enter_USB*** *Message* to indicate it is currently unable to enter the requested USB *Mode*.

The ***Wait*** *Message* ***Shall*** be sent within ***tReceiverResponse*** of the receipt of the last bit of the *Message* (see Section 6.9, "Accept, Reject and Wait").

6.3.12.1 Wait in response to a Request Message

The ***Wait*** *Message* allows the *Source* time to recover the power it requires to meet the request, e.g., through *Re-negotiation* with other *Sinks* or an upstream *Source*. A *Source* ***Should*** only send a ***Wait*** *Message* in response to a *Request Message* when an *Explicit Contract* exists between the *Port Partner*s.

The *Sink* is allowed to repeat the *Request Message* using the ***SinkRequestTimer*** and ***Shall*** ensure that there is ***tSinkRequest*** after receiving the ***Wait*** *Message* before sending another *Request Message*.

6.3.12.2 Wait in response to a PR_Swap Message

The ***Wait*** *Message* is used when responding to a ***PR_Swap*** *Message* to indicate that a *Power Role Swap* might be possible in the future. This can occur in any case where the device receiving the ***PR_Swap*** *Message* needs to evaluate the request further e.g., by requesting *Sink Capabilities* from the originator of the ***PR_Swap*** *Message*. Once it has completed this evaluation one of the *Port Partners* ***Should*** initiate the *Power Role Swap* process again by sending a ***PR_Swap*** *Message*.

The ***Wait*** *Message* is also used where a *Hub* is operating in hybrid mode when a request cannot be satisfied (see ***[UCSI]***).

A *Port* that receives a ***Wait*** *Message* in response to a ***PR_Swap*** *Message* ***Shall*** wait ***tPRSwapWait*** after receiving the ***Wait*** *Message* before sending another ***PR_Swap*** *Message*.

6.3.12.3 Wait in response to a DR_Swap Message

The ***Wait*** *Message* is used when responding to a ***DR_Swap*** *Message* to indicate that a *Data Role Swap* might be possible in the future. This can occur in any case where the device receiving the ***DR_Swap*** *Message* needs to evaluate the request further. Once it has completed this evaluation one of the *Port Partners* ***Should*** initiate the *Data Role Swap* process again by sending a ***DR_Swap*** *Message*.

A *Port* that receives a ***Wait*** *Message* in response to a ***DR_Swap*** *Message* ***Shall*** wait ***tDRSwapWait*** after receiving the ***Wait*** *Message* before sending another ***DR_Swap*** *Message*.

6.3.12.4 Wait in response to a VCONN_Swap Message

The ***Wait*** *Message* is used when responding to a ***VCONN_Swap*** *Message* to indicate that a ***VCONN_Swap*** might be possible in the future. This can occur in any case where the device receiving the ***VCONN_Swap*** *Message* needs to evaluate the request further. Once it has completed this evaluation one of the *Port Partners* ***Should*** initiate the *VCONN Swap* process again by sending a ***VCONN_Swap*** *Message*.

A *Port* that receives a ***Wait*** *Message* in response to a ***VCONN_Swap*** *Message* ***Shall*** wait ***tVCONNSwapWait*** after receiving the ***Wait*** *Message* before sending another ***VCONN_Swap*** *Message*.

A *Port* that is currently the *VCONN Source* ***Shall*** respond with an ***Accept*** *Message* (rather than a ***Wait*** *Message*) if the *Port Partner*'s *Revision* and *Version*, as reported in the ***Revision*** *Message*, is earlier than R3.2 V1.1. A *Port Partner* supporting an earlier *Revision* and *Version* will not expect a ***Wait*** *Message* and will generate a *Soft Reset* in response.

6.3.12.5 Wait in response to an Enter_USB Message

The ***Wait*** *Message* is used, by the *UFP*, when responding to an ***Enter_USB*** *Message* to indicate that entering the requested USB *Mode* might be possible in the future. This can occur, for example, in any case where the *UFP* needs to *Negotiate* more power to enter the mode. Once the *UFP* has completed this the *DFP* ***Should*** initiate the Enter USB process again by sending an ***Enter_USB*** *Message*.

A *DFP* that receives a ***Wait*** *Message* in response to an ***Enter_USB*** *Message* ***Shall*** wait ***tEnterUSBWait*** after receiving the ***Wait*** *Message* before sending another ***Enter_USB*** *Message*.

6.3.13 Soft Reset Message

A ***Soft_Reset*** *Message* ***May*** be initiated by either the *Source* or *Sink* to its *Port Partner* requesting a *Soft Reset*. The ***Soft_Reset*** *Message* ***Shall*** cause a *Soft Reset* of the connected *Port Pair* (see *Section 6.8.1, "Soft Reset and Protocol Error"*). If the ***Soft_Reset*** *Message* fails a *Hard Reset* ***Shall*** be initiated within ***tHardReset*** of the last ***CRCReceiveTimer*** expiring after ***nRetryCount*** retries have been completed.

A ***Soft_Reset*** *Message* is used to recover from *Protocol Layer* errors; putting the *Message* counters to a known state to regain *Message* synchronization. The ***Soft_Reset*** *Message* has no effect on the *Source* or *Sink*; that is the previously *Negotiated* direction. Voltage and current remain unchanged. *Modal Operation* is unaffected by *Soft Reset*. However after a *Soft Reset* has completed, an *Explicit Contract Negotiation* occurs, in order to re-establish PD Communication and to bring state operation for both *Port Partners* back to either the ***PE_SNK_Ready*** or ***PE_SRC_Ready*** states as appropriate (see *Section 8.3.3.4, "SOP Soft Reset and Protocol Error State Diagrams"*).

A ***Soft_Reset*** *Message* ***May*** be sent by either the *Source* or *Sink* when there is a *Message* synchronization error. If the error is not corrected by the *Soft Reset*, *Hard Reset Signaling* ***Shall*** be issued (see *Section 6.8.3, "Hard Reset"*).

A ***Soft_Reset*** *Message* ***Shall*** be targeted at a specific entity depending on the type of *SOP* Packet* used. ***Soft_Reset*** *Messages* sent using *SOP Packets* ***Shall*** *Soft Reset* the *Port Partner* only. ***Soft_Reset*** *Messages* sent using *SOP' Packet/ SOP'' Packets* ***Shall*** *Soft Reset* the corresponding *Cable Plug* only.

After a *VCONN Swap* the *VCONN Source* needs to reset the *Cable Plug*'s *Protocol Layer* to ensure ***MessageID*** synchronization. If after a *VCONN Swap* the *VCONN Source* wants to communicate with a *Cable Plug* using *SOP' Packets*, it ***Shall*** issue a ***Soft_Reset*** *Message* using a *SOP' Packet* in order to reset the *Cable Plug*'s *Protocol Layer*. If the *VCONN Source* wants to communicate with a *Cable Plug* using *SOP'' Packets*, it ***Shall*** issue a ***Soft_Reset*** *Message* using a *SOP'' Packet* in order to reset the *Cable Plug*'s *Protocol Layer*.

6.3.14 Data_Reset Message

The ***Data_Reset*** *Message* ***May*** be sent by either the *DFP* or *UFP* and ***Shall*** reset the USB data connection and exit all *Alternate Modes* with its *Port Partner* while preserving the power on *VBUS*. *USB4® Mode* capable ports ***Shall*** support the ***Data_Reset*** *Message* and other ports ***May*** support the ***Data_Reset*** *Message*.

The ***Data_Reset*** *Message* ***Shall Not*** change the existing:

- Power *Contract*
- *Data Roles* (i.e., which *Port* is the *DFP* or *UFP*)

The receiver of the ***Data_Reset*** *Message* ***Shall*** respond by sending an ***Accept*** *Message* and then follow the process outlined in the following steps. Neither the sender nor receiver ***Shall*** initiate a *VCONN Swap* until the *Data Reset* process is complete, and the ***Data_Reset_Complete*** *Message* has been sent. Following receipt of the ***Accept*** *Message*, or ***GoodCRC*** following the ***Accept***, depending which *Port* sends the ***Data_Reset*** *Message*:

1) The *DFP* ***Shall***:
   - Disconnect the *Port*'s ***[USB 2.0]*** D+/D- signals.
   - If operating in ***[USB 3.2]*** remove the *Port*'s Rx Terminations (see ***[USB 3.2]***).
   - If operating in ***[USB4]*** drive the *Port*'s SBTX to a logic low (see ***[USB4]***).
2) Both the *DFP* and *UFP* ***Shall*** exit all *Alternate Modes* if any.
3) Reset the cable:
   - If the *VCONN Source Port* is also the *UFP*, then it ***Shall*** run the *UFP VCONN* Power Cycle process described in [Section 7.1.15.1, "UFP VCONN Power Cycle"](#).
   - If the *VCONN Source Port* is also the *DFP*, then it ***Shall*** run the *DFP VCONN* Power Cycle process described in [Section 7.1.15.2, "DFP VCONN Power Cycle"](#).
   - The *DFP* ***Shall*** exit the *VCONN* Power Cycle process as the *VCONN Source* and be sourcing *VCONN*.
4) After ***tDataReset*** the *DFP* ***Shall***:
   - Reconnect the ***[USB 2.0]*** D+/D- signals.
   - If the *Port* was operating in ***[USB 3.2]*** or ***[USB4]*** reapply the *Port*'s Rx Terminations (see ***[USB 3.2]***).
5) The *Data Reset* process is complete; the *DFP* ***Shall*** send a ***Data_Reset_Complete*** *Message* and enter the USB4® Discovery and Entry Flow (See ***[USB Type-C 2.4]***).

If the *Initiator* of the ***Data_Reset*** *Message* does not receive a ***Valid*** response within ***tSenderResponse*** it ***Shall*** enter the ***ErrorRecovery*** State.

6.3.15 Data_Reset_Complete Message

The ***Data_Reset_Complete*** *Message* ***Shall*** be sent by the *DFP* to the *UFP* to indicate the completion of the *Data Reset* process (see [Section 6.3.14, "Data_Reset Message"](#)).

6.3.16 Not_Supported Message

The ***Not_Supported*** *Message* ***Shall*** be sent by a *Port* or *Cable Plug* in response to any *Message* it does not support. Returning a ***Not_Supported*** *Message* is assumed in this specification and has not been called out explicitly except in [Section 6.13, "Message Applicability"](#) which defines cases where the ***Not_Supported*** *Message* is returned.

6.3.17 Get_Source_Cap_Extended Message

The ***Get_Source_Cap_Extended*** *Message* is sent by a *Port* to request additional information about a *Port*'s *Source Capabilities*. The *Port* ***Shall*** respond by returning a ***Source_Capabilities_Extended*** *Message* (see *Section 6.5.1, "Source_Capabilities_Extended Message"*).

6.3.18 Get_Status Message

The ***Get_Status*** *Message* is sent by a *Port* using *SOP* to request the *Port Partner*'s present status.

The *Port Partner* ***Shall*** respond by returning a ***Status*** *Message* (see *Section 6.5.2, "Status Message"*). A *Port* that receives an ***Alert*** *Message* (see *Section 6.4.6, "Alert Message"*) indicates that the *Source* or *Sink*'s Status has changed and ***Should*** be re-read using a ***Get_Status*** *Message*.

The ***Get_Status*** *Message* ***May*** also be sent to an *Active Cable* to get its present status using *SOP'*/*SOP''*.

The *Active Cable* ***Shall*** respond by returning a ***Status*** *Message* (see *Section 6.5.2, "Status Message"*).

6.3.19 FR_Swap Message

The ***FR_Swap*** *Message* ***Shall*** be sent by the *New Source* within ***tFRSwapInit*** after it has detected a *Fast Role Swap* signal (see *Section 5.8.6.3, "Fast Role Swap Detection"* and *Section 6.6.17.3, "tFRSwapInit"*). The *Fast Role Swap AMS* is necessary to apply R_p to the *New Source* and R_d to the *New Sink* and to re-synchronize the state machines. The ***tFRSwapInit*** time ***Shall*** be measured from the time the *Fast Role Swap Request* has been sent for ***tFRSwapRx*** (max) until the last bit of the ***EOP*** of the ***FR_Swap*** *Message* has been transmitted by the *PHY Layer*.

The recipient of the ***FR_Swap*** *Message* ***Shall*** respond by sending an ***Accept*** *Message*.

After a successful *Fast Role Swap* the *Port Partners* ***Shall*** reset their respective *Protocol Layer*s (equivalent to a *Soft Reset*): resetting their ***MessageIDCounter***, ***RetryCounter*** and *Protocol Layer* state machines before attempting to establish the *First Explicit Contract*. At this point the *Source* ***Shall*** also reset its ***CapsCounter***.

This ensures that only the *Cable Plug* responds with a ***GoodCRC*** *Message* to the ***Discover Identity*** *Command*.

Prior to the *Fast Role Swap AMS*, the *New Source* ***Shall*** have R_d asserted on the *CC* wire and the *New Sink* ***Shall*** have R_p asserted on the *CC* wire.

Note: This is an incorrect assignment of R_p/R_d (since R_p follows the *Source* and R_d follows the *Sink* as defined in ***[USB Type-C 2.4]***) that is corrected by the *Fast Role Swap AMS*.

During the *Fast Role Swap AMS*, the *New Source* ***Shall*** change its *CC* wire resistor from R_d to R_p and the *New Sink* ***Shall*** change its *CC* wire resistor from R_p to R_d. The *DFP* (*Host*), *UFP* (*Device*) *Data Roles* and *VCONN Source* ***Shall*** remain unchanged during the *Fast Role Swap* process.

The *Initial Source* ***Should*** avoid being the *VCONN Source* (by using the *VCONN Swap* process) whenever not actively communicating with the cable, since it is difficult for the *Initial Source* to maintain *VCONN* power during the *Fast Role Swap* process.

Note: A *Fast Role Swap* is a "best effort" solution to a situation where a *PDUSB Device* has lost its external power. This process can occur at any time, even during an *AMS* in which case error handling such as *Hard Reset* or ***[USB Type-C 2.4]*** *Error Recovery* will be triggered.

Note: During the *Fast Role Swap* process the *Initial Sink* does not disconnect even though *VBUS* drops below ***vSafe5V***.

For more information regarding the *Fast Role Swap* process, refer to:

- *Section 7.1.13, "Fast Role Swap"*
- *Section 7.2.10, "Fast Role Swap"*
- *Section 8.3.3.19.5, "Policy Engine in Source to Sink Fast Role Swap State Diagram"*
- *Section 8.3.3.19.6, "Policy Engine in Sink to Source Fast Role Swap State Diagram"*

- *Section 9.1.2, "Mapping to USB Device States"* for *VBUS* mapping to USB states.

6.3.20 Get_PPS_Status

The ***Get_PPS_Status*** *Message* is sent by the *Sink* to request additional information about a *Source*'s status. The *Port* ***Shall*** respond by returning a ***PPS_Status*** *Message* (see *Section 6.5.10, "PPS_Status Message"*).

6.3.21 Get_Country_Codes

The ***Get_Country_Codes*** *Message* is sent by a *Port* to request the alpha-2 country codes its *Port Partner* supports as defined in ***[ISO 3166]***. The *Port Partner* ***Shall*** respond by returning a ***Country_Codes*** *Message* (see *Section 6.5.11, "Country_Codes Message"*).

6.3.22 Get_Sink_Cap_Extended Message

The ***Get_Sink_Cap_Extended*** (Get *Sink Capabilities* Extended) *Message* is sent by a *Port* to request additional information about a *Port*'s *Sink Capabilities*. The *Port* ***Shall*** respond by returning a ***Sink_Capabilities_Extended*** *Message* (see *Section 6.5.13, "Sink_Capabilities_Extended Message"*).

6.3.23 Get_Source_Info Message

The ***Get_Source_Info*** *Message* is sent by a *Port* to request the type, maximum *Capabilities* and present *Capabilities* of the *Port* when it is operating as a *Source*. The *Port* ***Shall*** respond by returning the ***Source_Info*** *Message* (See *Section 6.4.11, "Source_Info Message"*).

6.3.24 Get_Revision Message

The ***Get_Revision*** *Message* is sent by a *Port* using *SOP* to request the *Revision* and *Version* of the Power Delivery Specification its *Port Partner* supports.

The *Port Partner* ***Shall*** respond by returning a Revision *Message* (See *Section 6.4.12, "Revision Message"*).

The ***Get_Revision*** *Message* ***May*** also be sent to a *Cable Plug* to request the *Revision* and *Version* of the Power Delivery Specification it supports using *SOP'/SOP''*.

The *Active Cable* ***Shall*** respond by returning a Revision *Message* (see *Section 6.4.12, "Revision Message"*).

6.4 Data Message

A *Data Message* ***Shall*** consist of a *Message Header* and be followed by one or more *Data Object*s. *Data Message*s are easily identifiable because the ***Number of Data Objects*** field in the *Message Header* is a non-zero value.

There are many types of *Data Object*s used to compose *Data Message*s. Some examples are:

- *Power Data Object* (*PDO*) used to expose a *Source Port*'s power *Capabilities* or a *Sink*'s power requirements.
- *Request Data Object* (*RDO*) used by a *Sink Port* to *Negotiate* an *Explicit Contract*.
- *Vendor Data Object* (*VDO*) used to convey vendor specific information.
- *BIST Data Object* (*BDO*) used for *PHY Layer* compliance testing.
- Battery Status Data Object (BSDO) used to convey *Battery* status information.
- Alert Data Object (ADO) used to indicate events occurring on the *Source* or *Sink*.

The type of *Data Object* being used in a *Data Message* is defined by the *Message Header*'s ***Message Type*** field and is summarized in [*Table 6.6, "Data Message Types"*]. The Sent by column indicates entities which ***May*** send the given *Message* (*Source*, *Sink* or *Cable Plug*); entities not listed ***Shall Not*** issue the corresponding *Message*. The "Valid Start of Packet" column indicates the *Message*s which ***Shall*** only be issued in *SOP Packet*s and the *Message*s which ***May*** be issued in *SOP* Packet*s.

Table 6.6 Data Message Types

Bits 4…0	Type	Sent by	Description	Valid Start of Packet
0_0000	***Reserved***	***N/A***	All values not explicitly defined are ***Reserved*** and ***Shall Not*** be used.	***N/A***
0_0001	***Source_Capabilities***	*Source* or *Dual-Role Power*	See *Section 6.4.1.5*	*SOP* only
0_0010	***Request***	*Sink* only	See *Section 6.4.2*	*SOP* only
0_0011	***BIST***	*Tester*, *Source* or *Sink*	See *Section 6.4.3*	*SOP**
0_0100	***Sink_Capabilities***	*Sink* or *Dual-Role Power*	See *Section 6.4.2*	*SOP* only
0_0101	***Battery_Status***	*Source* or *Sink*	See *Section 6.4.5*	*SOP* only
0_0110	***Alert***	*Source* or *Sink*	See *Section 6.4.6*	*SOP* only
0_0111	***Get_Country_Info***	*Source* or *Sink*	See *Section 6.4.7*	*SOP* only
0_1000	***Enter_USB***	*DFP*	See *Section 6.4.8*	*SOP**
0_1001	***EPR_Request***	*Sink*	See *Section 6.4.9*	*SOP* only
0_1010	***EPR_Mode***	*Source* or *Sink*	See *Section 6.4.10*	*SOP* only
0_1011	***Source_Info***	*Source*	See *Section 6.4.11*	*SOP* only
0_1100	***Revision***	*Source*, *Sink* or *Cable Plug*	See *Section 6.4.12*	*SOP**
0_1101…0_1110	***Reserved***	***N/A***	All values not explicitly defined are ***Reserved*** and ***Shall Not*** be used.	***N/A***
0 1111	***Vendor_Defined***	*Source*, *Sink* or *Cable Plug*	See *Section 6.4.4*	*SOP**
1_0000…1_1111	***Reserved***	***N/A***	All values not explicitly defined are ***Reserved*** and ***Shall Not*** be used.	***N/A***

6.4.1 Capabilities Message

There are two distinct *Capabilities Messages*: one used while in *SPR Mode* and another while in *EPR Mode*. This section defines the *Capabilities Messages* specific to the *SPR Mode* and *Section 6.5.15, "EPR Capabilities Message"* defines the *Capabilities Messages* specific to the *EPR Mode*.

6.4.1.1 Power Data Objects

Sections *Section 6.4.1.5, "SPR Source Capabilities Message"* and *Section 7.1.3, "Types of Sources"* describes the *Power Data Objects* (*PDOs*) used in the construction of a *Capabilities Message* for both *SPR Mode* and *EPR Mode*.

There are three types of *Power Data Objects*. They contain additional information beyond that encoded in the *Message Header* to identify each of the three types of *Power Data Objects*:

- *Fixed Supply* is used to expose well-regulated fixed voltage power supplies.
- *Variable Supply* is used to expose very poorly regulated power supplies.
- *Battery Supply* is used to expose batteries that can be directly connected to *VBUS*.

There are three types of *Augmented Power Data Objects*:

- *SPR PPS* is used to expose a power supply whose output voltage can be programmatically adjusted over the *Advertised* voltage range and limited by the *Source* to a programmable current limit.
- *SPR AVS* and *EPR AVS* are used to expose a power supply whose output voltage can be adjusted over the *Advertised* voltage range but otherwise is equivalent to a *Fixed Supply* (*AVS* does not support a programmable current limit).

Power Data Objects are also used to expose additional *Capabilities* that ***May*** be utilized, such as in the case of a *Power Role Swap*.

A list of one or more *Power Data Objects* ***Shall*** be sent by the *Source* to convey its *Capabilities*. The *Sink* ***May*** then request one of these *Capabilities* by returning a *Request Data Object* that contains an index to a *Power Data Object*, to *Negotiate* a mutually agreeable *Explicit Contract*.

Where Maximum and Minimum voltage and current values are given in *PDOs* these ***Shall*** be taken to be absolute values.

The *Source* and *Sink* ***Shall Not*** *Negotiate* a power level that would allow the current to exceed the maximum current supported by their receptacles or the *Attached* plug (see ***[USB Type-C 2.4]***). The *Source* ***Shall*** limit its offered *Capabilities* to the maximum current supported by its receptacle and *Attached* plug. A *Sink* ***Shall*** only make a request from any of the *Capabilities* offered by the *Source*. For further details see *Section 4.4, "Cable Type Detection"*.

Sources expose their power *Capabilities* by sending a ***Source_Capabilities*** *Message*. *Sinks* expose their power requirements by sending a ***Sink_Capabilities*** *Message*. Both are composed of several 32-bit *Power Data Objects* (see *Table 6.7, "Power Data Object"*).

Table 6.7 Power Data Object

Bit(s)	Description	
	Value	**Parameter**
B31…30	00b	*Fixed Supply* (Vmin = Vmax)
	01b	*Battery*
	10b	*Variable Supply* (non-*Battery*)
	11b	*Augmented Power Data Object* (*APDO*)
B29…0	Specific Power *Capabilities* are described by the *PDOs* in the following sections.	

The *Augmented Power Data Object* (*APDO*) is defined to allow support for more than the four *PDO* types by extending the *Power Data Object* field from 2 to 4 bits when the B31…B30 are 11b. The generic *APDO* structure is shown in *Table 6.8, "Augmented Power Data Object"*.

Table 6.8 Augmented Power Data Object

Bit(s)	Description	
	Value	**Parameter**
B31…30	11b	*Augmented Power Data Object* (*APDO*)
B29…28	00b	*SPR PPS*
	01b	*EPR AVS*
	10b	*SPR AVS*
	11b	***Reserved***
B27…0	Specific Power *Capabilities* are described by the *APDO*s in the following sections.	

6.4.1.2 Source Power Data Objects

This section lists the types of *PDO*s a *Source* can use in an *SPR Capabilities* or *EPR Capabilities Message*.

6.4.1.2.1 Fixed Supply Power Data Object

Table 6.9, "Fixed Supply PDO – Source" describes the *Fixed Supply* (00b) *PDO*. See *Section 7.1.3, "Types of Sources"*for the electrical requirements of the power supply.

Since all USB *Provider*s support ***vSafe5V***, the required ***vSafe5V*** *Fixed Supply Power Data Object* is also used to convey additional information that is returned in bits 29…23. All other *Fixed Supply Power Data Object*s ***Shall*** set bits 29…23 to zero.

For a *Source* offering no *Capabilities*, the ***Voltage*** field (B19…10) ***Shall*** be set to 5V and the***Maximum Current*** field ***Shall*** be set to 0mA. This is used in cases such as a *Dual-Role Power* device which offers no *Capabilities* in its default *Power Role* or when external power is required to offer power.

When a *Source* wants a *Sink*, consuming power from *VBUS*, to go to its lowest power state, the ***Voltage*** field (B19…10) ***Shall*** be set to 5V and the ***Maximum Current*** field ***Shall*** be set to 0mA. This is used in cases where the *Source* wants the *Sink* to draw ***pSnkSusp***.

Table 6.9 Fixed Supply PDO – Source

Bit(s)	Field	Description
B31…30	*Fixed Supply*	00b - *Fixed Supply PDO*
B29	***Dual-Role Power***	Set to '1' for *Dual-Role Power* device.
B28	***USB Suspend Supported***	Set to '1' if USB suspend is supported.
B27	***Unconstrained Power***	Set to '1' if unconstrained power is available.
B26	***USB Communications Capable***	Set to '1' if capable of *USB Communications* capable
B25	***Dual-Role Data***	Set to '1' for a *Dual-Role Data* device.
B24	***Unchunked Extended Messages Supported***	Set to '1 if *Unchunked Extended Messages* are supported.
B23	***EPR Capable***	Set to '1 if *EPR Capable*.
B22	***Reserved***	***Reserved*** – ***Shall*** be set to zero.
B21…20	***Peak Current***	Peak Current value.
B19…10	***Voltage***	Voltage in 50mV units
B9…0	***Maximum Current***	Maximum current in 10mA units

6.4.1.2.1.1 Dual-Role Power

The ***Dual-Role Power*** bit ***Shall*** be set when the *Port* is *Dual-Role Power* capable i.e., supports the ***PR_Swap*** *Message*.

This is a ***Static*** capability which ***Shall*** remain fixed for a given device regardless of the device's present *Power Role*. If the ***Dual-Role Power*** bit is set to one in the ***Source_Capabilities*** *Message* the ***Dual-Role Power*** bit in the ***Sink_Capabilities*** *Message* ***Shall*** also be set to one. If the ***Dual-Role Power*** bit is set to zero in the ***Source_Capabilities*** *Message* the ***Dual-Role Power*** bit in the ***Sink_Capabilities*** *Message* ***Shall*** also be set to zero.

6.4.1.2.1.2 USB Suspend Supported

Prior to an *Explicit Contract* or when the ***USB Communications Capable*** bit is set to zero, the ***USB Suspend Supported*** flag is undefined and *Sinks* ***Shall*** follow the rules for suspend as defined in ***[USB 2.0]***, ***[USB 3.2]***, ***[USB4]***, ***[USB Type-C 2.4]*** or ***[USBBC 1.2]***. After an *Explicit Contract* has been *Negotiated*:

- If the ***USB Suspend Supported*** flag is set, then the *Sink* ***Shall*** follow the ***[USB 2.0]***, ***[USB 3.2]*** or ***[USB4]*** rules for suspend and resume. A PDUSB Peripheral ***May*** draw up to ***pSnkSusp*** during suspend; a *PDUSB Hub* ***May*** draw up to ***pHubSusp*** during suspend (see *Section 7.2.3, "Sink Standby"*).

- If the ***USB Suspend Supported*** flag is cleared, then the *Sink* ***Shall Not*** apply the ***[USB 2.0]***, ***[USB 3.2]*** or ***[USB4]*** rules for suspend and ***May*** continue to draw the *Negotiated* power.

Note: When USB is suspended, the USB device state is also suspended.

Sinks ***May*** indicate to the *Source* that they would prefer to have the ***USB Suspend Supported*** flag cleared by setting the No USB Suspend flag in a ***Request*** *Message* (see *Section 6.4.2.5, "No USB Suspend"*).

6.4.1.2.1.3 Unconstrained Power

The ***Unconstrained Power*** bit ***Shall*** be set when an external source of power is available that is sufficient to adequately power the system while charging external devices, or when the device's primary function is to charge external devices.

To set the ***Unconstrained Power*** bit because of an external source, the external source of power ***Should*** be either:

- An *AC Supply*, e.g., a *Charger*, directly connected to the *Sink*.
- Or, in the case of a *PDUSB Hub*:
  - A PD *Source* with its ***Unconstrained Power*** bit set.
  - Multiple PD *Sources* all with their ***Unconstrained Power*** bits set.

6.4.1.2.1.4 USB Communications Capable

The ***USB Communications Capable*** bit ***Shall*** only be set for *Sources* capable of communication over the USB data lines (e.g., D+/- or SS Tx/Rx).

6.4.1.2.1.5 Dual-Role Data

The ***Dual-Role Data*** bit ***Shall*** be set when the *Port* is *Dual-Role Data* capable i.e., it supports the ***DR_Swap*** *Message*. This is a ***Static*** capability which ***Shall*** remain fixed for a given device regardless of the device's present *Power Role* or *Data Role*. If the ***Dual-Role Data*** bit is set to one in the ***Source_Capabilities*** *Message* the ***Dual-Role Data*** bit in the ***Sink_Capabilities*** *Message* ***Shall*** also be set to one. If the ***Dual-Role Data*** bit is set to zero in the ***Source_Capabilities*** *Message* the ***Dual-Role Data*** bit in the ***Sink_Capabilities*** *Message* ***Shall*** also be set to zero.

6.4.1.2.1.6 Unchunked Extended Messages Supported

The ***Unchunked Extended Messages Supported*** bit ***Shall*** be set when the *Port* can send and receive *Extended Messages* with ***Data Size*** > ***MaxExtendedMsgLegacyLen*** bytes in a single, *Unchunked Extended Message*.

6.4.1.2.1.7 EPR Mode Capable

The ***EPR Capable*** bit is a ***Static*** bit that ***Shall*** be set if the *Source* is designed to supply more than 100W and operate in *EPR Mode*.

When this bit is set, an *EPR Source*:

- Operating in *SPR Mode* ***Shall*** only send an ***EPR_Source_Capabilities*** *Message* in response to an ***EPR_Get_Source_Cap*** *Message*
- ***May*** only enter *EPR Mode* when the Cable and the *Sink* also report that they are *EPR Capable*.

6.4.1.2.1.8 Peak Current

The USB Power Delivery *Fixed Supply* is only required to deliver the amount of current requested in the ***Operating Current*** field (*IoC*) of an *RDO*. In some usages however, for example computer systems, where there are short bursts of activity, it might be desirable to overload the *Source* for short periods.

For example, when a computer system tries to maintain average power consumption, the higher the peak current, the longer the low current (see *Section 7.2.8, "Sink Peak Current Operation"*) period needed to maintain such average power. The ***Peak Current*** field allows a *Source* to *Advertise* this additional capability. This capability is intended for direct *Port* to *Port* connections only and ***Shall Not*** be offered to downstream *Sinks* via a *Hub*.

Every *Fixed Supply PDO* ***Shall*** contain a ***Peak Current*** field. Supplies that want to offer a set of overload *Capabilities* ***Shall*** *Advertise* this through the ***Peak Current*** field in the corresponding *Fixed Supply PDO* (see Table 6.10, "Fixed Power Source Peak Current Capability"). Supplies that do not support an overload capability ***Shall*** set these bits to 00b in the corresponding *Fixed Supply PDO*. Supplies that support an extended overload capability specified in the PeakCurrent1…3 fields of the ***Source_Capabilities_Extended*** *Message* (see Section 6.5.1, "Source_Capabilities_Extended Message") ***Shall*** also set these bits to 00b. *Sinks* wishing to utilize these *Extended Capabilities* ***Shall*** first send the ***Get_Source_Cap_Extended*** *Message* to determine what *Capabilities*, if any are supported by the *Source*.

Table 6.10 Fixed Power Source Peak Current Capability

Bits 21…20	Description
00	Peak current equals *IoC* (default) or look at the ***Source_Capabilities_Extended*** *Message* (send ***Get_Source_Cap_Extended*** *Message*)
01	Overload *Capabilities*: 1. Peak current equals 150% *IoC* for 1ms @ 5% duty cycle (low current equals 97% *IoC* for 19ms) 2. Peak current equals 125% *IoC* for 2ms @ 10% duty cycle (low current equals 97% *IoC* for 18ms) 3. Peak current equals 110% *IoC* for 10ms @ 50% duty cycle (low current equals 90% *IoC* for 10ms)
10	Overload *Capabilities*: 1. Peak current equals 200% *IoC* for 1ms @ 5% duty cycle (low current equals 95% *IoC* for 19ms) 2. Peak current equals 150% *IoC* for 2ms @ 10% duty cycle (low current equals 94% *IoC* for 18ms) 3. Peak current equals 125% *IoC* for 10ms @ 50% duty cycle (low current equals 75% *IoC* for 10ms)
11	Overload *Capabilities*: 1. Peak current equals 200% *IoC* for 1ms @ 5% duty cycle (low current equals 95% *IoC* for 19ms) 2. Peak current equals 175% *IoC* for 2ms @ 10% duty cycle (low current equals 92% *IoC* for 18ms) 3. Peak current equals 150% *IoC* for 10ms @ 50% duty cycle (low current equals 50% *IoC* for 10ms)

6.4.1.2.2 Variable Supply (non-Battery) Power Data Object

Table 6.11, "Variable Supply (non-Battery) PDO – Source" describes a *Variable Supply* (non-*Battery*) (10b) *PDO* for a *Source*. See Section 7.1.3, "Types of Sources" for the electrical requirements of the power supply.

The voltage fields ***Shall*** define the range that output voltage ***Shall*** fall within. This does not indicate the voltage that will be supplied, except it ***Shall*** fall within that range. The absolute voltage, including any voltage variation, ***Shall Not*** fall below the ***Minimum Voltage*** field value and ***Shall Not*** exceed the ***Maximum Voltage*** field value. The ***Minimum Voltage*** field value ***Shall Not*** be less than 80% of the ***Maximum Voltage*** field value.

Table 6.11 Variable Supply (non-Battery) PDO – Source

Bit(s)	Field	Description
B31…30	*Variable Supply*	01b - *Variable Supply* (non-*Battery*) *PDO*
B29…20	***Maximum Voltage***	Maximum voltage in 50mV units
B19…10	***Minimum Voltage***	Minimum voltage in 50mV units
B9…0	***Maximum Current***	Maximum current in 10mA units

6.4.1.2.3 Battery Supply Power Data Object

Table 6.12, "Battery Supply PDO – Source" describes a *Battery Supply* (01b) *PDO* for a *Source*. See Section 7.1.3, "Types of Sources" for the electrical requirements of the power supply.

The voltage fields ***Shall*** represent the *Battery*'s voltage range. The *Battery* ***Shall*** be capable of supplying the Power value over the entire voltage range. The absolute voltage, including any voltage variation, ***Shall Not*** fall below the ***Minimum Voltage*** field value and ***Shall Not*** exceed the ***Maximum Voltage*** field value.

Note: The *Battery Supply PDO* uses power instead of current.

The *Sink* ***May*** monitor the *Battery* voltage.

Table 6.12 Battery Supply PDO – Source

Bit(s)	Field	Description
B31…30	*Battery Supply*	10b - *Battery Supply PDO*
B29…20	***Maximum Voltage***	Maximum voltage in 50mV units
B19…10	***Minimum Voltage***	Minimum voltage in 50mV units
B9…0	***Maximum Allowable Power***	Maximum allowable power in 250mW units

6.4.1.2.4 Augmented Power Data Object (APDO)

The voltage fields define the output voltage range over which the power supply ***Shall*** be adjustable in 20mV steps in *SPR PPS Mode* and 100mV steps in both *SPR AVS Mode* and *EPR AVS Mode*. The ***Maximum Current*** field contains the current the Programmable Power Supply ***Shall*** be capable of delivering over the *Advertise*d voltage range. See *Section 7.1.3, "Types of Sources"* for the electrical requirements of the power supply.

6.4.1.2.4.1 SPR Programmable Power Supply APDO

Table 6.13, "SPR Programmable Power Supply APDO – Source" below describes the *SPR PPS* (1100b) *APDO* for a *Source* operating in *SPR Mode* and supplying 5V up to 21V.

Table 6.13 SPR Programmable Power Supply APDO – Source

Bit(s)	Field	Description
B31…30	*APDO*	11b – *Augmented Power Data Object* (*APDO*)
B29…28	*SPR PPS*	00b – *SPR PPS*
B27	***PPS Power Limited***	Set to '1' when *PPS* Power Limited
B26…25	***Reserved***	***Reserved*** – ***Shall*** be set to zero.
B24…17	***Maximum Voltage***	Maximum voltage in 100mV increments
B16	***Reserved***	***Reserved*** – ***Shall*** be set to zero.
B15…8	***Minimum Voltage***	Minimum voltage in 100mV increments
B7	***Reserved***	***Reserved*** – ***Shall*** be set to zero.
B6…0	***Maximum Current***	Maximum current in 50mA increments

The *PPS APDO* is used primarily for *Sink Directed Charge* Directed Charge of a *Battery* in the *Sink*. When applying a current to the *Battery* greater than the cable supports, a high efficiency fixed voltage scaler ***May*** be used in the *Sink* to reduce the cable current.

6.4.1.2.4.1.1 PPS Power Limited

When the ***PPS Power Limited*** bit is set, the *SPR PPS Source* ***Shall*** operate in the same way as if the ***PPS Power Limited*** bit is clear (see *Section 7.1.4.2, "SPR Programmable Power Supply (PPS)"* with the below exception:

- ***May*** supply power that exceeds the *Source*'s rated *PDP* within the ***Optional*** operating area in *Figure 7.7, "SPR PPS Constant Power"*.

When the ***PPS Power Limited*** bit is cleared, the *SPR PPS Source* ***Shall*** deliver the ***Maximum Current*** field value up to the ***Maximum Voltage*** as *Advertise*d in its *APDO*.

The *SPR PPS Source* ***Shall Not*** reject an *RDO* with an ***Operating Current*** field value that is less than or equal to the ***Maximum Current*** field value in the *APDO* even if the requested ***Operating Current*** field value is greater than the *Source*'s *PDP*/requested Output voltage.

6.4.1.2.4.2 SPR Adjustable Voltage Supply APDO

Table 6.14, "SPR Adjustable Voltage Supply APDO – Source" below describes the *SPR AVS* (1110b) *APDO* for a *Source* operating in *SPR Mode* and supplying 9V up to 20V.

Table 6.14 SPR Adjustable Voltage Supply APDO – Source

Bit(s)	Field	Description
B31…30	*APDO*	11b – *Augmented Power Data Object* (*APDO*)
B29…28	SPR AVS	10b – *SPR AVS*
B27…26	***Peak Current***	Peak Current (see *Table 6.10, "Fixed Power Source Peak Current Capability"*))
B25…20	***Reserved***	***Reserved*** – ***Shall*** be set to zero.
B19…10	***Maximum Current 15V***	For 9V – 15V range: Maximum current in 10mA units equal to the ***Maximum Current*** field of the 15V *Fixed Supply PDO*
B9…0	***Maximum Current 20V***	For 15V – 20V range: Maximum current in 10mA units equal to the ***Maximum Current*** field of the 20V *Fixed Supply PDO*, set to 0 if the maximum voltage in the *SPR AVS* range is 15V.

6.4.1.2.4.2.1 Peak Current

The ***Peak Current*** field follows the same definition as for the ***Peak Current*** field (see *Section 6.4.1.2.1.8, "Peak Current"* and *Table 6.10, "Fixed Power Source Peak Current Capability"*.

6.4.1.2.4.3 EPR Adjustable Voltage Supply APDO

Table 6.15, "EPR Adjustable Voltage Supply APDO – Source" below describes the *EPR AVS* (1101b) *APDO* for a *Source* operating in *EPR Mode* and supplying 15V up to 48V.

Table 6.15 EPR Adjustable Voltage Supply APDO – Source

Bit(s)	Field	Description
B31…30	*APDO*	11b – *Augmented Power Data Object* (*APDO*)
B29…28	EPR AVS	01b – *EPR AVS*
B27…26	***Peak Current (Source EPR AVS)***	Peak Current (see *Table 6.16, "EPR AVS Power Source Peak Current Capability"*)
B25…17	***Maximum Voltage***	Maximum voltage in 100mV increments
B16	***Reserved***	***Reserved*** – ***Shall*** be set to zero.
B15…8	***Minimum Voltage***	Minimum voltage in 100mV increments
B7…0	***PDP***	*PDP* in 1W increments

6.4.1.2.4.3.1 PDP

The ***PDP*** field ***Shall*** contain the *AVS Port*'s *PDP*.

See *Section 10.2.3.3, "Optional Normative Extended Power Range (EPR)"* and *Figure 10.6, "Valid EPR AVS Operating Region"* for more information regarding how *PDP* in the *AVS APDO* relates to maximum available current.

6.4.1.2.4.3.2 Peak Current

The USB Power Delivery *EPR AVS* is only required to deliver the amount of current requested in the ***Operating Current*** field (*IoC*) of an *AVS RDO*. In some usages however, for example computer systems, where there are short bursts of activity, it might be desirable to overload the *Source* for short periods.

For example, when a computer system tries to maintain average power consumption, the higher the peak current, the longer the low current period needed to maintain such average power (see *Section 7.2.8, "Sink Peak Current Operation"*). The ***Peak Current (Source EPR AVS)*** field allows a *Source* to *Advertise* this additional capability. This capability is intended for direct *Port* to *Charger* connections only and ***Shall Not*** be offered to downstream *Sink*s via a *Hub*.

Every *EPR AVS APDO* ***Shall*** contain a ***Peak Current (Source EPR AVS)*** field. Supplies that want to offer a set of overload *Capabilities* ***Shall*** *Advertise* this through the ***Peak Current (Source EPR AVS)*** field in the corresponding *EPR AVS APDO* (see *Table 6.16, "EPR AVS Power Source Peak Current Capability"*. Supplies that do not support an overload capability ***Shall*** set these bits to 00b in the corresponding *EPR AVS APDO*. Supplies that support an extended overload capability specified in the PeakCurrent1…3 fields of the ***Source_Capabilities_Extended*** *Message* (see *Section 6.5.1, "Source_Capabilities_Extended Message"*) ***Shall*** set these bits to 00b. *Sink*s wishing to utilize these *Extended Capabilities* ***Shall*** first send a ***Get_Source_Cap_Extended*** *Message* to determine what *Capabilities*, if any are supported by the *Source*.

Table 6.16 EPR AVS Power Source Peak Current Capability

Bits 21…20	Description
00	Peak current equals *IoC* (default) or look at the ***Source_Capabilities_Extended*** *Message* (send ***Get_Source_Cap_Extended*** *Message*)
01	Overload *Capabilities*: 1. Peak current equals 150% *IoC* for 1ms @ 5% duty cycle (low current equals 97% *IoC* for 19ms) 2. Peak current equals 125% *IoC* for 2ms @ 10% duty cycle (low current equals 97% *IoC* for 18ms) 3. Peak current equals 110% *IoC* for 10ms @ 50% duty cycle (low current equals 90% *IoC* for 10ms)
10	Overload *Capabilities*: 1. Peak current equals 200% *IoC* for 1ms @ 5% duty cycle (low current equals 95% *IoC* for 19ms) 2. Peak current equals 150% *IoC* for 2ms @ 10% duty cycle (low current equals 94% *IoC* for 18ms) 3. Peak current equals 125% *IoC* for 10ms @ 50% duty cycle (low current equals 75% *IoC* for 10ms)
11	Overload *Capabilities*: 1. Peak current equals 200% *IoC* for 1ms @ 5% duty cycle (low current equals 95% *IoC* for 19ms) 2. Peak current equals 175% *IoC* for 2ms @ 10% duty cycle (low current equals 92% *IoC* for 18ms) 3. Peak current equals 150% *IoC* for 10ms @ 50% duty cycle (low current equals 50% *IoC* for 10ms)

6.4.1.3 Sink Power Data Objects

This section lists the types of *PDO*s a *Sink* can use in an *SPR* or *EPR Capabilities Message*.

6.4.1.3.1 Sink Fixed Supply Power Data Object

Table 6.17, "Fixed Supply PDO – Sink" describes the *Sink Fixed Supply* (00b) *PDO*. See *Section 7.1.3, "Types of Sources"* for the electrical requirements of the power supply. The *Sink* ***Shall*** set the ***Voltage*** field to its required voltage and the ***Operational Current*** field to its required operating current. Required operating current is defined as the amount of current a given device needs to be functional. This value could be the maximum current the *Sink* will ever require or could be sufficient to operate the *Sink* in one of its modes of operation.

Since all USB *Consumer*s support ***vSafe5V***, the required ***vSafe5V*** *Fixed Supply Power Data Object* is also used to convey additional information that is returned in bits 29 through 20. All other *Fixed Supply Power Data Objects* ***Shall*** set bits 29…20 to zero.

For a *Sink* requiring no power from the *Source*, the ***Voltage*** field ***Shall*** be set to 5V and the ***Operational Current*** field ***Shall*** be set to 0mA.

Table 6.17 Fixed Supply PDO – Sink

<table>
<tr><th>Bit(s)</th><th>Field</th><th colspan="2">Description</th></tr>
<tr><td>B31…30</td><td>*Fixed Supply*</td><td colspan="2">00b - *Fixed Supply PDO*</td></tr>
<tr><td>B29</td><td>***Dual-Role Power***</td><td colspan="2">Set to ‘1’ if *Dual-Role Power* supported</td></tr>
<tr><td>B28</td><td>***Higher Capability***</td><td colspan="2">Set to ‘1’ if Higher Capability supported</td></tr>
<tr><td>B27</td><td>***Unconstrained Power***</td><td colspan="2">Set to ‘1’ if Unconstrained Power supported</td></tr>
<tr><td>B26</td><td>***USB Communications Capable***</td><td colspan="2">Set to ‘1’ if *USB Communications* Capable</td></tr>
<tr><td>B25</td><td>***Dual-Role Data***</td><td colspan="2">*Dual-Role Data*</td></tr>
<tr><td rowspan="6">B24…23</td><td rowspan="6">***Fast Role Swap required USB Type-C Current***</td><td colspan="2">*Fast Role Swap* required *USB Type-C* current (see also ***[USB Type-C 2.4]***):</td></tr>
<tr><th>Value</th><th>Description</th></tr>
<tr><td>00b</td><td>*Fast Role Swap* not supported (default)</td></tr>
<tr><td>01b</td><td>Default USB *Port*</td></tr>
<tr><td>10b</td><td>1.5A@5V</td></tr>
<tr><td>11b</td><td>3.0A@5V</td></tr>
<tr><td>B22…20</td><td>***Reserved***</td><td colspan="2">***Reserved*** – ***Shall*** be set to zero.</td></tr>
<tr><td>B19…10</td><td>***Voltage***</td><td colspan="2">Voltage in 50mV units</td></tr>
<tr><td>B9…0</td><td>***Operational Current***</td><td colspan="2">Operational current in 10mA units</td></tr>
</table>

6.4.1.3.1.1 Dual-Role Power

The ***Dual-Role Power*** bit ***Shall*** be set when the *Port* is *Dual-Role Power* capable i.e., supports the ***PR_Swap*** *Message*. This is a ***Static*** capability which ***Shall*** remain fixed for a given device regardless of the device's present *Power Role*. If the ***Dual-Role Power*** bit is set to one in the ***Source_Capabilities*** *Message* the ***Dual-Role Power*** bit in the ***Sink_Capabilities*** *Message* ***Shall*** also be set to one. If the ***Dual-Role Power*** bit is set to zero in the ***Source_Capabilities*** *Message* the ***Dual-Role Power*** bit in the ***Sink_Capabilities*** *Message* ***Shall*** also be set to zero.

6.4.1.3.1.2 Higher Capability

In the case that the *Sink* needs more than ***vSafe5V*** (e.g., 15V) to provide full functionality, then the ***Higher Capability*** bit ***Shall*** be set.

6.4.1.3.1.3 Unconstrained Power

The ***Unconstrained Power*** bit ***Shall*** be set when an external source of power is available that is sufficient to adequately power the system while charging external devices, or when the device's primary function is to charge external devices.

To set the ***Unconstrained Power*** bit because of an external source, the external source of power ***Should*** be either:

- An *AC Supply*, e.g., a *Charger*, directly connected to the *Sink*.
- Or, in the case of a *PDUSB Hub*:
    - A PD *Source* with its ***Unconstrained Power*** bit set.
    - Multiple PD *Sources* all with their ***Unconstrained Power*** bits set.

6.4.1.3.1.4 USB Communications Capable

The ***USB Communications Capable*** bit ***Shall*** only be set for *Sink*s capable of communication over the USB data lines (e.g., D+/- or SS Tx/Rx).

6.4.1.3.1.5 Dual-Role Data

The ***Dual-Role Data*** bit ***Shall*** be set when the *Port* is *Dual-Role Data* capable i.e., it supports the ***DR_Swap*** *Message*. This is a ***Static*** capability which ***Shall*** remain fixed for a given device regardless of the device's present *Power Role* or *Data Role*. If the ***Dual-Role Data*** bit is set to one in the ***Source_Capabilities*** *Message* the ***Dual-Role Data*** bit in the ***Sink_Capabilities*** *Message* ***Shall*** also be set to one. If the ***Dual-Role Data***a bit is set to zero in the ***Source_Capabilities*** *Message* the ***Dual-Role Data*** bit in the ***Sink_Capabilities*** *Message* ***Shall*** also be set to zero.

6.4.1.3.1.6 Fast Role Swap USB Type-C Current

The ***Fast Role Swap required USB Type-C Current*** field ***Shall*** indicate the current level the *Sink* will require after a *Fast Role Swap* has been performed.

The *Initial Source* ***Shall Not*** transmit a *Fast Role Swap Request* if the ***Fast Role Swap required USB Type-C Current*** field is set to zero.

Initially when the *New Source* applies ***vSafe5V*** it will have R_d asserted but ***Shall*** provide the *USB Type-C* current indicated by the *New Sink* in this field. If the *New Source* is not able to supply this level of current, it ***Shall Not*** perform a *Fast Role Swap*. When R_p is asserted by the *New Source* during the *Fast Role Swap AMS* (see Section 6.3.19, "FR_Swap Message"), the value of *USB Type-C* current indicated by R_p ***Shall*** be the same or greater than that indicated in the ***Fast Role Swap required USB Type-C Current*** field.

6.4.1.3.2 Variable Supply (non-Battery) Power Data Object

Table 6.18, "Variable Supply (non-Battery) PDO – Sink" describes a *Variable Supply* (non-*Battery*) (10b) *PDO* used by a *Sink*. See Section 7.1.3, "Types of Sources" for the electrical requirements of the power supply.

The voltage fields ***Shall*** be set to the output voltage range that the *Sink* requires to operate. The ***Operational Current*** field ***Shall*** be set to the operational current that the *Sink* requires at the given voltage range. The absolute voltage, including any voltage variation, ***Shall Not*** fall below the ***Minimum Voltage*** field value and ***Shall Not*** exceed the ***Maximum Voltage*** field value. Required operating current is defined as the amount of current a given device needs to be functional. This value could be the maximum current the *Sink* will ever require or could be sufficient to operate the *Sink* in one of its modes of operation.

Table 6.18 Variable Supply (non-Battery) PDO – Sink

Bit(s)	Field	Description
B31…30	*Variable Supply*	01b - *Variable Supply* (non-*Battery*) *PDO*
B29…20	***Maximum Voltage***	Maximum voltage in 50mV units
B19…10	***Minimum Voltage***	Minimum voltage in 50mV units
B9…0	***Operational Current***	Operational current in 10mA units

6.4.1.3.3 Battery Supply Power Data Object

Table 6.19, "Battery Supply PDO – Sink" describes a *Battery Supply* (01b) *PDO* used by a *Sink*. See Section 7.1.3, "Types of Sources" for the electrical requirements of the power supply.

The voltage fields ***Shall*** be set to the output voltage range that the *Sink* requires to operate. The ***Operational Power*** field ***Shall*** be set to the operational power that the *Sink* requires at the given voltage range. The absolute voltage, including any voltage variation, ***Shall Not*** fall below the ***Minimum Voltage*** field value and ***Shall Not*** exceed the ***Maximum Voltage*** field value.

Note: Only the *Battery Supply PDO* uses power instead of current.

Required operating power is defined as the amount of power a given device needs to be functional. This value could be the maximum power the *Sink* will ever require or could be sufficient to operate the *Sink* in one of its modes of operation.

Table 6.19 Battery Supply PDO – Sink

Bit(s)	Field	Description
B31…30	*Battery Supply*	10b - *Battery Supply PDO*
B29…20	***Maximum Voltage***	Maximum voltage in 50mV units
B19…10	***Minimum Voltage***	Minimum voltage in 50mV units
B9…0	***Operational Power***	Operational Power in 250mW units

6.4.1.3.4 Augmented Power Data Objects

See *Section 7.1.3, "Types of Sources"* for the electrical requirements of the power supply.

The Maximum and Minimum voltage fields ***Shall*** be set to the output voltage range that the *Sink* requires to operate.

6.4.1.3.4.1 SPR Programmable Power Supply APDO

Table 6.20, "SPR Programmable Power Supply APDO – Sink" below describes a *SPR PPS APDO* for a *Sink* operating in *SPR Mode* and consuming 21V or less. The ***Maximum Current*** field ***Shall*** be set to the maximum current the *Sink* requires over the voltage range. The maximum current is defined as the maximum amount of current the device needs to fully support its function (e.g., *Sink Directed Charge*).

Table 6.20 SPR Programmable Power Supply APDO – Sink

Bit(s)	Field	Description
B31…30	*APDO*	11b – *Augmented Power Data Object* (*APDO*)
B29…28	*SPR PPS*	00b – *SPR PPS*
B27…25	***Reserved***	***Reserved*** – ***Shall*** be set to zero.
B24…17	***Maximum Voltage***	Maximum voltage in 100mV increments
B16	***Reserved***	***Reserved*** – ***Shall*** be set to zero.
B15…8	***Minimum Voltage***	Minimum voltage in 100mV increments
B7	***Reserved***	***Reserved*** – ***Shall*** be set to zero.
B6…0	***Maximum Current***	Maximum current in 50mA increments

6.4.1.3.4.2 SPR Adjustable Voltage Supply APDO

Table 6.21, "SPR Adjustable Voltage Supply APDO – Sink" below describes the *SPR AVS* (1110b) *APDO* for a *Sink* operating in *SPR AVS Mode*. The ***Maximum Current 15V***/***Maximum Current 20V*** fields in the *SPR AVS APDO* for the *Sink* is defined as the maximum current the device needs to fully support its function.

Table 6.21 SPR Adjustable Voltage Supply APDO – Sink

Bit(s)	Field	Description
B31…30	*APDO*	11b – *Augmented Power Data Object* (*APDO*)
B29…28	SPR AVS	10b – *SPR AVS*
B27…20	***Reserved***	***Reserved*** – ***Shall*** be set to zero.
B19…10	***Maximum Current 15V***	For 9V – 15V range: Maximum current in 10mA units equal to the ***Maximum Current*** field of the 15V *Fixed Supply PDO*
B9…0	***Maximum Current 20V***	For 15V – 20V range: Maximum Current in 10mA units equal to the ***Maximum Current*** field of the 20V *Fixed Supply PDO*, set to 0 if the Maximum voltage in the *SPR AVS* range is 15V.

6.4.1.3.4.3 EPR Adjustable Voltage Supply APDO

Table 6.22, "EPR Adjustable Voltage Supply APDO – Sink" below describes a *EPR AVS APDO* for a *Sink* operating in *EPR AVS Mode*. The ***PDP*** field in the *EPR AVS APDO* for the *Sink* is defined as the *PDP* the device needs to fully support its function.

Table 6.22 EPR Adjustable Voltage Supply APDO – Sink

Bit(s)	Field	Description
B31…30	*APDO*	11b – *Augmented Power Data Object* (*APDO*)
B29…28	EPR AVS	01b – *EPR AVS*
B27…26	***Reserved***	***Reserved*** – ***Shall*** be set to zero.
B25…17	***Maximum Voltage***	Maximum voltage in 100mV increments
B16	***Reserved***	***Reserved*** – ***Shall*** be set to zero.
B15…8	***Minimum Voltage***	Minimum voltage in 100mV increments
B7…0	***PDP***	*PDP* in 1W increments

6.4.1.4 SPR Capabilities Message Construction

An *SPR Capabilities Message* (***Source_Capabilities*** *Message* or ***Sink_Capabilities*** *Message*) ***Shall*** have at least one *Power Data Object* for ***vSafe5V***. The *SPR Capabilities Message* ***Shall*** also contain the sending *Port*'s information followed by up to 6 additional *Power Data Objects*. *Power Data Objects* in an *SPR Capabilities Message* ***Shall*** be sent in the following order:

1) The ***vSafe5V*** *Fixed Supply PDO* ***Shall*** always be the first *(A)PDO*.

2) The remaining *Fixed Supply PDOs*, if present, ***Shall*** be sent in voltage order; lowest to highest.

3) The *Battery Supply PDOs* if present ***Shall*** be sent in Minimum voltage order; lowest to highest.

4) The *Variable Supply* (non-*Battery*) *PDOs*, if present, ***Shall*** be sent in Minimum voltage order; lowest to highest.

5) The *SPR AVS APDO*, if present, ***Shall*** be sent.

6) The Programmable Power Supply *APDOs*, if present, ***Shall*** be sent in Maximum voltage order, lowest to highest.

Note: The *EPR Capabilities Message* construction is defined in Section 6.5.15.1, "EPR Capabilities Message Construction".

Figure 6.12, "SPR Capabilities Message Construction" describes the construction of an *SPR Capabilities Message*. The *Message* will always have at least one *Fixed Supply* 5V *PDO* and may have up to six more *PDO*s depending on the *Source Capabilities*.

Figure 6.12 SPR Capabilities Message Construction

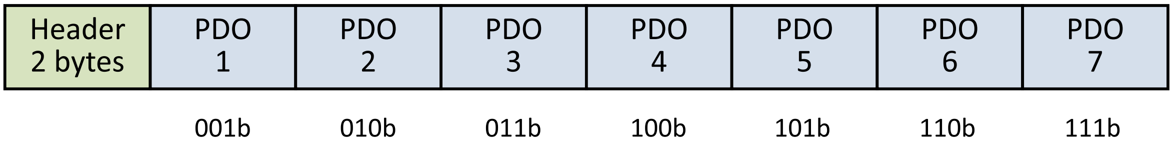
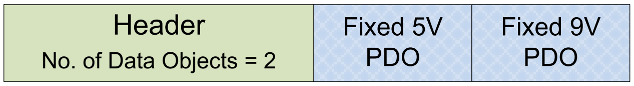


Figure 6.13 Example Capabilities Message with 2 Power Data Objects



In the 27W *Source* as shown in *Figure 6.13, "Example Capabilities Message with 2 Power Data Objects"*, the ***Number of Data Objects*** field is 2: ***vSafe5V*** plus one other voltage.

Power Data Objects (*PDO*) and *Augmented Power Data Objects* (*APDO*) are identified by the *Message Header*'s ***Message Type*** field. They are used to form *SPR Capabilities Message*s.

6.4.1.5 SPR Source Capabilities Message

*Source*s send a ***Source_Capabilities*** *Message* either as part of advertising *Port Capabilities*, or in response to a ***Get_Source_Cap*** *Message*. See *Section 6.5.15.2, "EPR_Source_Capabilities Message"* for information about *EPR Source Capabilities Message*s.

Following a *Hard Reset*, a power-on event or plug insertion event, a *Source Port* ***Shall*** send a ***Source_Capabilities*** *Message* after every ***SourceCapabilityTimer*** timeout as an *Advertise*ments that ***Shall*** be interpreted by the *Sink Port* on *Attachment*. The *Source* ***Shall*** continue sending a minimum of ***nCapsCount Source_Capabilities*** *Messages* until a ***GoodCRC*** *Message* is received.

Additionally, a ***Source_Capabilities*** *Message* ***Shall*** only be sent by a *Port* in the following cases:

- By the *Source Port* from the ***PE_SRC_Ready*** state upon a change in its ability to supply power to this *Port*.
- By a *Source Port* or *Dual-Role Power Port* in response to a ***Get_Source_Cap*** *Message*.
- ***Optionally*** by a *Source Port* from the ***PE_SRC_Ready*** state when available power in a multi-*Port* system changes, even if the *Source Capabilities* for this *Port* have not changed.

A *Source Port* ***Shall*** report its *Capabilities* in a series of 32-bit *Power Data Objects* (see *Table 6.7, "Power Data Object"*) as part of a ***Source_Capabilities*** *Message* (see *Figure 6.13, "Example Capabilities Message with 2 Power Data Objects"*). *Power Data Object*s are used to convey a *Source Port*'s *Capabilities* to provide power including *Dual-Role Power* ports presently operating as a *Sink*.

Each *Power Data Object* ***Shall*** describe a specific *Source* capability such as a *Battery* (e.g., 2.8-4.1V) or a *Fixed Supply* (e.g., 15V) at a maximum allowable current. The ***Number of Data Objects*** field in the *Message Header* ***Shall*** define the number of *Power Data Object*s that follow the *Message Header* in a *Data Message*. All *Sources* ***Shall*** minimally offer one *Power Data Object* that reports ***vSafe5V***. A *Source* ***Shall Not*** offer multiple *Power Data Object*s of the same type (*Fixed Supply*, *Variable Supply*, *Battery Supply*) and the same voltage but ***Shall*** instead offer one *Power Data Object* with the highest available current for that *Source* capability and voltage.

Sinks with Accessory Support do not source *VBUS* (see ***[USB Type-C 2.4]***). *Sinks* with Accessory Support are still considered *Sources* when sourcing *VCONN* to an Accessory even though *VBUS* is not applied; in this case they ***Shall*** *Advertise* ***vSafe5V*** with the ***Maximum Current*** field set to 0mA in the first *Power Data Object*. The main purpose of this is to enable the *Sink* with Accessory Support to get into the ***PE_SRC_Ready*** State to enter an *Alternate Mode*.

A *Sink* in *SPR Mode* ***Shall*** evaluate every ***Source_Capabilities*** *Message* it receives and ***Shall*** respond with a ***Request*** *Message*. If its power consumption exceeds the *Source Capabilities* it ***Shall*** *Re-negotiate* so as not to exceed the *Source*'s most recently *Advertised Capabilities*.

A *Sink*, in *SPR Mode*, in an *Explicit Contract* with a *PPS APDO*, ***Shall*** periodically re-request the *PPS APDO* at least every ***tPPSRequest*** until either:

- The *Sink* requests something other than *PPS APDO*.
- There is a *Power Role Swap*.
- There is a *Hard Reset*.
- There is *Error Recovery*.

A *Sink* in *EPR Mode* that receives a ***Source_Capabilities*** *Message* in response to a ***Get_Source_Cap*** *Message* ***Shall Not*** respond with a ***Request*** *Message*. If a *Sink* in *EPR Mode* receives a ***Source_Capabilities*** *Message*, not in response to a ***Get_Source_Cap*** *Message*, the *Sink* ***Shall*** initiate a *Hard Reset*.

A *Source* that has accepted a ***Request*** *Message* with a Programmable *RDO* ***Shall*** issue ***Hard Reset*** *Signaling* if it has not received a ***Request*** *Message* with a Programmable *RDO* within ***tPPSTimeout***. The *Source* ***Shall*** discontinue this behavior after:

- Receiving a ***Request*** *Message* with a *Fixed Supply*, *Variable Supply* or *Battery Supply RDO*.
- There is a *Power Role Swap*.
- There is a *Hard Reset*.
- There is *Error Recovery*.

6.4.1.6 SPR Sink Capabilities Message

Sinks send a ***Sink_Capabilities*** *Message* (see *Section 6.4.2, "Request Message"*) in response to a ***Get_Sink_Cap*** *Message*. See *Section 6.5.15.3, "EPR_Sink_Capabilities Message"* for more information about the *Capabilities Message*.

A USB Power Delivery capable *Sink*, upon detecting ***vSafe5V*** on *VBUS* and after a ***SinkWaitCapTimer*** timeout without seeing a ***Source_Capabilities*** *Message*, ***Shall*** send a *Hard Reset*. If the *Attached Source* is USB Power Delivery capable, it responds by sending ***Source_Capabilities*** *Messages* thus allowing power *Negotiations* to begin.

A *Sink Port* ***Shall*** report power levels it is able to operate at in a series of 32-bit *Power Data Objects* (see *Section Table 6.7, "Power Data Object"*). These are returned as part of a ***Sink_Capabilities*** *Message* in response to a ***Get_Sink_Cap*** *Message* (see *Figure 6.13, "Example Capabilities Message with 2 Power Data Objects"*). This is similar to that used for *Source Port Capabilities* with equivalent *Power Data Objects* for *Fixed Supply*, *Variable Supply* and *Battery Supply* as defined in this section. *Power Data Objects* are used to convey the *Sink Port*'s operational power requirements including *Dual-Role Power Ports* presently operating as a *Source*.

Each *Power Data Object* ***Shall*** describe a specific *Sink* operational power level, such as a *Battery Supply* (e.g., 2.8-4.1V) or a *Fixed Supply* (e.g., 15V). The ***Number of Data Objects*** field in the *Message Header* ***Shall*** define the number of *Power Data Objects* that follow the *Message Header* in a *Data Message*.

All *Sinks* ***Shall*** minimally offer one *Power Data Object* with a power level at which the *Sink* can operate. A *Sink* ***Shall Not*** offer multiple *Power Data Objects* of the same type (*Fixed Supply*, *Variable Supply*, *Battery Supply*) and the same voltage but ***Shall*** instead offer one *Power Data Object* with the highest available current for that *Sink* capability and voltage.

All *Sinks* ***Shall*** include one *Power Data Object* that reports ***vSafe5V*** even if they require additional power to operate fully. In the case where additional power is required for full operation the Higher Capability bit ***Shall*** be set.

6.4.1.6.1 Use by Dual-Role Power devices

Dual-Role Power devices send a ***Source_Capabilities*** *Message* (see *Section 6.4.1.5, "SPR Source Capabilities Message"*) as part of advertising *Port Capabilities* when operating in *Source* role. *Dual-Role Power* devices send a ***Source_Capabilities*** *Message* in response to a ***Get_Source_Cap*** *Message* regardless of their present operating role. Similarly *Dual-Role Power* devices send a ***Sink_Capabilities*** *Message* (see *Section 6.4.1.6, "SPR Sink Capabilities Message"*) in response to a ***Get_Sink_Cap*** *Message* regardless of their present operating role.

6.4.1.6.2 Management of the Power Reserve

This section has been removed. Refer to *Section 8.2.5, "Managing Power Requirements"*.

6.4.2 Request Message

A ***Request*** *Message* ***Shall*** be sent by a *Sink* to request power during the request phase of an SPR power *Negotiation*. The *Request Data Object* ***Shall*** be returned by the *Sink* making a request for power. It ***Shall*** be sent in response to the most recent ***Source_Capabilities*** *Message* (see *Section 8.3.2.2, "Power Negotiation"*) when in *SPR Mode*. A ***Request*** *Message* ***Shall*** return one and only one *Sink Request Data Object* that ***Shall*** identify the *Power Data Object* being requested.

The *Source* ***Shall*** respond to a ***Request*** *Message* with an ***Accept*** *Message*, a ***Wait*** *Message* or a ***Reject*** *Message* (see *Section 6.9, "Accept, Reject and Wait"*).

The ***Request*** *Message* includes the requested power level. For example, if the ***Source_Capabilities*** *Message* includes a *Fixed Supply PDO* that offers 9V @ 1.5A and if the *Sink* only wants 9V @ 0.5A, it will set the ***Operating Current*** field to 50 (i.e., 10mA * 50 = 0.5A).

The request uses a different format depending on the kind of power requested.

- The *Fixed Supply Power Data Object* and *Variable Supply Power Data Object* share a common format shown in *Table 6.23, "Fixed and Variable Request Data Object"*.
- The *Battery Supply Power Data Object* uses the format shown in *Table 6.24, "Battery Request Data Object"*.
- The *PPS Request Data Object*'s format is shown in *Table 6.25, "PPS Request Data Object"*.
- The *AVS Request Data Object*'s format is shown in *Table 6.26, "AVS Request Data Object"*.

The *Request Data Objects* are also used by the ***EPR_Request*** *Message* when operating in *EPR Mode*. See *Section 6.4.9, "EPR_Request Message"* for information about the use of the ***EPR_Request*** *Message*.

A *Source* operating in *EPR Mode* that receives a ***Request*** *Message* ***Shall*** initiate a *Hard Reset*.

Table 6.23 Fixed and Variable Request Data Object

Bit(s)	Field	Description
B31…28	***Object Position***	Object position (0000b and 1110b…1111b are ***Reserved*** and ***Shall Not*** be used)
B27	***Giveback***	GiveBack flag = 0 - ***Deprecated*** and ***Shall*** be set to zero.
B26	***Capability Mismatch***	Set to ‘1’ for a *Capabilities Mismatch*
B25	***USB Communications Capable***	Set to ‘1’ if *USB Communications* Capable
B24	***No USB Suspend***	Set to ‘1’ if requesting No USB Suspend
B23	***Unchunked Extended Messages Supported***	Set to ‘1’ if *Unchunked Extended Messages* Supported
B22	***EPR Capable***	Set to ‘1’ if *EPR Capable*
B21…20	***Reserved***	***Reserved*** – ***Shall*** be set to zero.
B19…10	***Operating Current***	Operating current in 10mA units
B9…0	***Maximum Operating Current***	Maximum Operating current 10mA units

Table 6.24 Battery Request Data Object

Bit(s)	Field	Description
B31…28	*Object Position*	Object position (0000b and 1110b…1111b are ***Reserved*** and ***Shall Not*** be used)
B27	*Giveback*	GiveBack flag = 0- ***Deprecated*** and ***Shall*** be set to zero.
B26	*Capability Mismatch*	Set to '1' for a *Capabilities Mismatch*
B25	*USB Communications Capable*	Set to '1' if *USB Communications* Capable
B24	*No USB Suspend*	Set to '1' if requesting No USB Suspend
B23	*Unchunked Extended Messages Supported*	Set to '1' if *Unchunked Extended Messages* Supported
B22	*EPR Capable*	Set to '1' if *EPR Capable*
B21…20	***Reserved***	***Reserved*** – ***Shall*** be set to zero.
B19…10	*Operating Power*	Operating Power in 250mW units
B9…0	*Maximum Operating Power*	Maximum Operating Power in 250mW units

Table 6.25 PPS Request Data Object

Bit(s)	Field	Description
B31…28	*Object Position*	Object position (0000b and 1110b…1111b are ***Reserved*** and ***Shall Not*** be used)
B27	***Reserved***	***Reserved*** – ***Shall*** be set to zero.
B26	*Capability Mismatch*	Set to '1' for a *Capabilities Mismatch*
B25	*USB Communications Capable*	Set to '1' if *USB Communications* Capable
B24	*No USB Suspend*	Set to '1' if requesting No USB Suspend
B23	*Unchunked Extended Messages Supported*	Set to '1' if *Unchunked Extended Messages* Supported
B22	*EPR Capable*	Set to '1' if *EPR Capable*
B21	***Reserved***	***Reserved*** – ***Shall*** be set to zero.
B20…9	*Output Voltage*	Output voltage in 20mV units.
B8…7	***Reserved***	***Reserved*** – ***Shall*** be set to zero.
B6…0	*Operating Current*	Operating current 50mA units.

Table 6.26 AVS Request Data Object

Bit(s)	Field	Description
B31…28	*Object Position*	Object position (0000b and 1110b…1111b are ***Reserved*** and ***Shall Not*** be used)
B27	***Reserved***	***Reserved*** – ***Shall*** be set to zero.
B26	*Capability Mismatch*	Set to '1' for a *Capabilities Mismatch*
B25	*USB Communications Capable*	Set to '1' if *USB Communications* Capable
B24	*No USB Suspend*	Set to '1' if requesting No USB Suspend
B23	*Unchunked Extended Messages Supported*	Set to '1' if *Unchunked Extended Messages* Supported
B22	*EPR Capable*	Set to '1' if *EPR Capable*
B21	***Reserved***	***Reserved*** – ***Shall*** be set to zero.
B20…9	*Output Voltage*	Output voltage in 25mV units, the least two significant bits ***Shall*** be set to zero making the effective voltage step size 100mV.
B8…7	***Reserved***	***Reserved*** – ***Shall*** be set to zero.
B6…0	*Operating Current*	Operating current 50mA units.

6.4.2.1 Object Position

The value in the ***Object Position*** field ***Shall*** indicate which object in the ***Source_Capabilities*** *Message* or ***EPR_Source_Capabilities*** *Message* the *RDO* refers to. The value 0001b always indicates the 5V *Fixed Supply PDO* as it is the first object following the ***Source_Capabilities*** *Message*'s *Message Header* or ***EPR_Source_Capabilities*** *Message*'s *Extended Message Header*. The number 0010b refers to the next *PDO* and so forth.

The ***Object Position*** field values 0001b…0111b ***Shall*** only be used to refer to *SPR (A)PDO*s. *SPR (A)PDO*s ***May*** be requested by either a ***Request*** or an ***EPR_Request*** *Message*. Object positions 1000b…1011b ***Shall*** only be used to refer to *EPR (A)PDO*s. *EPR (A)PDO*s ***Shall*** only be requested by an ***EPR_Request*** *Message*. If the ***Object Position*** field in a ***Request*** *Message* contains a value greater than 0111b, the *Source* ***Shall*** send ***Hard Reset*** *Signaling*.

6.4.2.2 GiveBack Flag (Deprecated)

The ***Giveback*** flag has been ***Deprecated*** and ***Shall*** be set to zero.

6.4.2.3 Capability Mismatch

A *Capabilities Mismatch* occurs when the *Source* cannot satisfy the *Sink*'s power requirements based on the *Source Capabilities* it has offered. In this case the *Sink* ***Shall*** make a ***Valid*** request from the offered *Source Capabilities* and ***Shall*** set the ***Capability Mismatch*** bit (see Section 8.2.5.2, "Power Capability Mismatch"). When a *Capabilities Mismatch* condition does not exist, the *Sink* ***Shall Not*** set the ***Capability Mismatch*** bit.

When a *Sink* returns a *Request Data Object* with the ***Capability Mismatch*** bit set in response to a *Source Capabilities Message*, it indicates that it wants more power than the *Source* is currently offering. This can be due to either a specific voltage that is not being offered or there is not sufficient current for the voltages that are being offered.

*Source*s whose ***Port Reported PDP*** is less than their ***Port Present PDP*** (see Section 6.4.11, "Source_Info Message") ***Shall*** respond to the Requests with the ***Capability Mismatch*** bit set as follows. The *Source* within ***tCapabilitiesMismatchResponse*** of the ***PS_RDY*** *Message* ***Shall*** send a new *Source Capabilities Message* that offers either:

1) The set of *Source Capabilities* to minimally satisfy the *Sink*'s requirements based on what it actually requires for full operation by evaluating the:

   a) ***Sink_Capabilities_Extended*** *Message*(if supported by the *Sink*) and/or

   b) ***Sink_Capabilities*** or ***EPR_Sink_Capabilities*** *Message*.

2) The set of *Source Capabilities* the *Source* can supply at this time based on the ***Port Present PDP***.

To prevent looping, *Sources* ***Should Not*** send a new *Source Capabilities Message* in response to subsequent *Request Message* with the ***Capability Mismatch*** flag set until its ***Port Present PDP*** changes.

Once a Guaranteed Capability *Source* that has responded to a ***Capability Mismatch***, it ***Shall Not*** subsequently send out another *Source Capabilities Message* at a lower *PDP* unless the power required by the *Sink* (as indicated in its *Sink Capabilities Message* or ***Sink_Capabilities_Extended*** *Message*) has also been reduced. *Source*s wishing to manage their power ***May*** periodically check the *Sink Capabilities Message* or ***Sink_Capabilities_Extended*** *Message* to determine whether these have changed.

Note: A *Source Capabilities Message* refers to a ***Source_Capabilities*** *Message* or an ***EPR_Source_Capabilities*** *Message*, and a *Sink Capabilities Message* refers to a ***Sink_Capabilities*** *Message* or ***EPR_Sink_Capabilities*** *Message*, *Request* refers to a ***Request*** *Message* or ***EPR_Request*** depending on operating mode.

In this context a ***Valid*** *Request Message* means the following:

- The ***Object Position*** field ***Shall*** contain a reference to an object that was present in the last received *Source Capabilities Message*.
- The ***Operating Current***/***Operating Power*** field ***Shall*** contain a value which is less than or equal to the maximum current/power offered by the selected *(A)PDO* the *Source Capabilities Message*.

6.4.2.4 USB Communications Capable

The ***USB Communications Capable*** flag ***Shall*** be set to one when the *Sink* has USB data lines and is capable of communicating using either ***[USB 2.0]***, ***[USB 3.2]*** or ***[USB4]*** protocols. The ***USB Communications Capable*** flag ***Shall*** be set to zero when the *Sink* does not have USB data lines or is otherwise incapable of communicating using either ***[USB 2.0]***, ***[USB 3.2]*** or ***[USB4]*** protocols. This is used by the *Source* to determine operation in certain cases such as USB suspend. If the ***USB Communications Capable*** flag has been set to zero by a *Sink*, then the *Source* needs to be aware that USB Suspend rules cannot be observed by the *Sink*.

6.4.2.5 No USB Suspend

The ***No USB Suspend*** flag ***May*** be set by the *Sink* to indicate to the *Source* that this device is requesting to continue its *Explicit Contract* during USB Suspend. *Sink*s setting this flag typically have functionality that can use power for purposes other than *USB Communication* e.g., for charging a *Battery*.

The *Source* uses this flag to evaluate whether it ***Should*** re-issue the ***Source_Capabilities*** *Message* with the ***USB Suspend Supported*** flag cleared.

6.4.2.6 Unchunked Extended Messages Supported

The ***Unchunked Extended Messages Supported*** bit ***Shall*** be set when the *Port* can send and receive *Extended Messages* with ***Data Size*** > ***MaxExtendedMsgLegacyLen*** bytes in a single, *Unchunked Extended Message*.

6.4.2.7 EPR Mode Capable

The ***EPR Capable*** bit ***Shall*** indicate whether or not the *Sink* is capable of operating in *EPR Mode*. When the *Sink*'s ability to operate in *EPR Mode* changes, it ***Shall*** send a new ***Request*** *Message* with the updated ***EPR Capable*** bit set in the *RDO*.

6.4.2.8 Operating Current

The ***Operating Current*** field in the *Request Data Object* ***Shall*** be set to the highest current the *Sink* will draw during the *Explicit Contract*. A new ***Request*** *Message* or ***EPR_Request*** *Message*, with an updated ***Operating Current*** value, ***Shall*** be issued whenever the *Sink*'s power needs change.

The ***Operating Current*** field in the SPR Programmable *Request Data Object* is used in addition by the *Sink* to request the *Source* for the *Current Limit* level it needs. When the request is accepted the *Source*'s output current supplied into any load ***Shall*** be less than or equal to the ***Operating Current*** value. When the *Sink* attempts to consume more current, the *Source* ***Shall*** reduce the output voltage so as not to exceed the ***Operating Current*** value.

The ***Operating Current*** field in the *AVS Request Data Object* ***Shall*** be set to the highest current the *Sink* will draw during the *Explicit Contract*.

Note: A *Source* in *AVS Mode*, unlike the *SPR Source* in *PPS Mode*, does not support current limit; the *Sink* is responsible not to take more current than it requested.

A new ***Request*** / ***EPR_Request*** *Message*, with an updated ***Operating Current*** value, ***Shall*** be issued whenever the *Sink*'s power needs change.

The value in the ***Operating Current*** field ***Shall Not*** exceed the value in the Maximum Current field of the ***Source_Capabilities*** *Message*. For *EPR AVS*, the ***Operating Current*** field ***Shall Not*** exceed the ***PDP*** / Output voltage rounded down to the nearest 50 mA.

This field ***Shall*** apply to the *Fixed Supply*, *Variable Supply*, Programmable and *AVS RDO*s.

6.4.2.9 Maximum Operating Current

The Maximum Operating Current field has been functionally ***Deprecated***. In order to maintain backward compatibility with *Source*s that may try to interpret the ***Maximum Operating Current*** field in the ***Request*** *Message* or ***EPR_Request*** *Message*, the field ***Shall*** be set equal to the value of the ***Operating Current*** field. To ensure backward compatibility, the *Source* ***Should Ignore*** this field.

This field ***Shall*** apply to the *Fixed Supply* and *Variable Supply RDO* in *SPR Mode* and the *Fixed Supply RDO* in ***EPR Capable***.

6.4.2.10 Operating Power

The ***Operating Power*** field in the *Request Data Object* ***Shall*** be set to the highest power the *Sink* will draw throughout the *Explicit Contract*.

This field ***Shall*** apply to the *Battery Supply RDO*.

6.4.2.11 Maximum Operating Power

The ***Maximum Operating Power*** field has been functionally ***Deprecated***. In order to maintain backward compatibility with *Source*s that may try to interpret the ***Maximum Operating Power*** field in the ***Request*** *Message*, the field ***Shall*** be set equal to the value of the ***Operating Power*** field. To ensure backward compatibility, the *Source* ***Should Ignore*** this field.

This field ***Shall*** apply to the *Battery Supply RDO*.

6.4.2.12 Output Voltage

The Output Voltage field in the Programmable and *AVS Request Data Object*s ***Shall*** be set by the *Sink* to the voltage the *Sink* requires as measured at the *Source*'s output connector. The Output Voltage field ***Shall*** be greater than or equal to the Minimum Voltage field and less than or equal to the Maximum Voltage field in the Programmable Power Supply and *AVS APDO*s, respectively.

This field ***Shall*** apply to the Programmable *RDO* and *AVS RDO*.

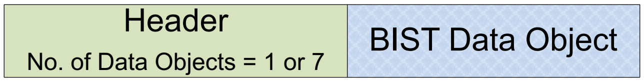
6.4.3 BIST Message

The ***BIST*** *Message* is sent to request the *Port* to enter a *PHY Layer* test mode (see *Section 5.9, "Built in Self-Test (BIST)"*) that performs one of the following functions:

- Enter a *Continuous BIST Mode* to send a continuous stream of test data to the *Tester*.
- Enter and leave a *Shared Capacity Group* test mode.

The *Message* format is as shown in *Figure 6.14, "BIST Message"*.

Figure 6.14 BIST Message



All Ports ***Shall*** be able to be a *Unit Under Test* (*UUT*) only when operating at ***vSafe5V***. All of the following *BIST Modes* ***Shall*** be supported:

- Process reception of a ***BIST Carrier Mode*** *BIST Data Object* that ***Shall*** result in the generation of the appropriate carrier signal.
- Process reception of a ***BIST Test Data*** *BIST Data Object* that ***Shall*** result in the *Message* being ***Ignored***.

*UUT*s with Ports constituting a *Shared Capacity Group* (see ***[USB Type-C 2.4]***) ***Shall*** support the following *BIST Mode*:

- Process reception of a ***BIST Shared Test Mode Entry*** *BIST Data Object* that ***Shall*** cause the *UUT* to enter *BIST Shared Capacity Test Mode*; a mode in which the *UUT* offers its full *Source Capabilities* on every *Port* in the *Shared Capacity Group*.

- Process reception of a ***BIST Shared Test Mode Exit*** *BIST Data Object* that ***Shall*** cause the *UUT* to exit the *BIST Shared Capacity Test Mode*.

When a *Port* receives a ***BIST*** *Message BIST Data Object* for a *BIST Mode* when not operating at ***vSafe5V***, the ***BIST*** *Message* ***Shall*** be ***Ignored***.

When a *Port* receives a ***BIST*** *Message BIST Data Object* for a *BIST Mode* it does not support the ***BIST*** *Message* ***Shall*** be ***Ignored***.

When a *Port* or *Cable Plug* receives a ***BIST*** *Message BIST Data Object* for a *Continuous BIST Mode* the *Port* or *Cable Plug* enters the requested *BIST Mode* and ***Shall*** remain in that *BIST Mode* for ***tBISTContMode*** and then ***Shall*** return to normal operation (see *Section 6.6.7.2, "BISTContModeTimer"*).

The usage model of the *PHY Layer BIST Mode*s generally assumes that some controlling agent will request a test of its *Port Partner*.

In *Section 8.3.2.15, "Built in Self-Test (BIST)"* there is a sequence description of the test sequences used for compliance testing.

The fields in the *BIST Data Object* are defined in the *Table 6.27, "BIST Data Object"*.

Table 6.27 BIST Data Object

Bit(s)	Value	Parameter	Description	Reference	Applicability
B31…28	0000b…0100b	***Reserved***	***Shall Not*** be used	*Section 1.4.2*	-
	0101b	***BIST Carrier Mode***	Request Transmitter to enter *BIST Carrier Mode*	*Section 6.4.3.1*	Mandatory
	0110b…0111b	***Reserved***	***Shall Not*** be used	*Section 1.4.2*	-
	1000b	***BIST Test Data***	Sends a *Test Frame*.	*Section 6.4.3.2*	Mandatory
	1001b	***BIST Shared Test Mode Entry***	Requests *UUT* to enter *BIST Shared Capacity Test Mode*.	*Section 6.4.3.3.1*	Mandatory for *UUTs* with shared capacity
	1010b	***BIST Shared Test Mode Exit***	Requests *UUT* to exit *BIST Shared Capacity Test Mode*.	*Section 6.4.3.3.2*	Mandatory for *UUTs* with shared capacity
	1011b…1111b	***Reserved***	***Shall Not*** be used	*Section 1.4.2*	-
B27…0		***Reserved***	***Shall*** be set to zero.	*Section 1.4.2*	-

6.4.3.1 BIST Carrier Mode

Upon receipt of a ***BIST*** *Message*, with a ***BIST Carrier Mode*** *BIST Data Object*, the *UUT* ***Shall*** send out a continuous string of *BMC* encoded alternating "1"s and "0"s.

The *UUT* ***Shall*** exit the *Continuous BIST Mode* within ***tBISTContMode*** of this *Continuous BIST Mode* being enabled (see *Section 6.6.7.2, "BISTContModeTimer"*).

6.4.3.2 BIST Test Data Mode

Upon receipt of a ***BIST*** *Message*, with a ***BIST Test Data*** *BIST Data Object*, the *UUT* ***Shall*** return a ***GoodCRC*** *Message* and ***Shall*** enter *BIST Test Data Mode* in which it sends no further *Messages* except for ***GoodCRC*** *Messages* in response to received *Messages*. See *Section 5.9.2, "BIST Test Data Mode"* for the definition of the *Test Frame*.

The test ***Shall*** be ended by sending ***Hard Reset*** *Signaling* to reset the *UUT*.

6.4.3.3 BIST Shared Capacity Test Mode

A *Shared Capacity Group* of Ports share a common power source that is not capable of simultaneously powering all the ports to their full *Source Capabilities* (see ***[USB Type-C 2.4]***). The *BIST Shared Capacity Test Mode* ***Shall*** only be implemented by ports in a *Shared Capacity Group*.

The *UUT Shared Capacity Group* of Ports ***Shall*** contain one or more Ports, designated as Master Ports, that recognize both the ***BIST Shared Test Mode Entry*** *BIST Data Object* and the ***BIST Shared Test Mode Exit*** *BIST Data Object*.

6.4.3.3.1 BIST Shared Test Mode Entry

When any master *Port* in a *Shared Capacity Group* receives a ***BIST*** *Message* with a ***BIST Shared Test Mode Entry*** *BIST Data Object*, while in the ***PE_SRC_Ready*** State, the *UUT* ***Shall*** enter a compliance test mode where the maximum *Source Capabilities* are always offered on every *Port*, regardless of the availability of shared power i.e., all shared power management is disabled.

Ports in the *Shared Capacity Group* that are not Master Ports ***Shall Not*** enter compliance mode on receiving the ***BIST Shared Test Mode Entry*** *BIST Data Object*.

Upon receipt of a ***BIST*** *Message*, with a ***BIST Shared Test Mode Entry*** *BIST Data Object*, the *UUT* ***Shall*** return a ***GoodCRC*** *Message* and ***Shall*** enter the *BIST Shared Capacity Test Mode*.

On entering this mode, the *UUT* ***Shall*** send a new ***Source_Capabilities*** *Message* from each *Port* in the *Shared Capacity Group* within ***tBISTSharedTestMode***. The *Tester* will not exceed the shared capacity during this mode.

6.4.3.3.2 BIST Shared Test Mode Exit

Upon receipt of a ***BIST*** *Message*, with a ***BIST Shared Test Mode Exit*** *BIST Data Object*, the *UUT* ***Shall*** return a ***GoodCRC*** *Message* and ***Shall*** exit the *BIST Shared Capacity Test Mode*. If any other *Message*, aside from a ***BIST*** *Message*, with a ***BIST Shared Test Mode Exit*** *BIST Data Object*, is received while in *BIST Shared Capacity Test Mode* this ***Shall Not*** cause the *UUT* to exit the *BIST Shared Capacity Test Mode*

On exiting the mode, the *UUT* ***May*** send a new ***Source_Capabilities*** *Message* to each *Port* in the *Shared Capacity Group* or the *UUT* ***May*** perform ***ErrorRecovery*** on each *Port*.

Ports in the *Shared Capacity Group* that are not Master Ports ***Shall Not*** exit compliance mode on receiving the ***BIST Shared Test Mode Entry*** *BIST Data Object*.

Ports in the *Shared Capacity Group* that are not Master Ports ***Should Not*** exit compliance mode on receiving the ***BIST Shared Test Mode Exit*** *BIST Data Object*.

- The *UUT* ***Shall*** exit *BIST Shared Capacity Test Mode* when It is powered off.
- The *UUT* ***Shall*** remain in *BIST Shared Capacity Test Mode* for any PD event (except when a ***BIST Shared Test Mode Exit*** *BIST Data Object*, is received); specifically the *UUT* ***Shall*** remain in *BIST Shared Capacity Test Mode* when any of the following PD events occurs:
    - *Hard Reset*
    - *Cable Reset*
    - *Soft Reset*
    - *Data Role Swap*
    - *Power Role Swap*
    - *Fast Role Swap*
    - *VCONN Swap*.
- The *UUT* ***May*** leave *BIST Shared Capacity Test Mode* if the *Tester* makes a request that exceeds the *Capabilities* of the *UUT*.

6.4.4 Vendor Defined Message

The ***Vendor_Defined*** *Message* (*VDM*) is provided to allow vendors to exchange information outside of that defined by this specification.

A ***Vendor_Defined*** *Message* ***Shall*** consist of at least one *Vendor Data Object* (*VDO*), the *VDM Header*, and ***May*** contain up to a maximum of six additional *VDO*s.

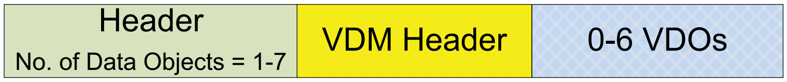
To ensure vendor uniqueness of ***Vendor_Defined*** *Message*s, all ***Vendor_Defined*** *Messages* ***Shall*** contain a ***Valid*** USB *Standard or Vendor ID* (*SVID*) allocated by USB-IF in the *VDM Header*.

Two types of ***Vendor_Defined*** *Message*s are defined: *Structured VDM*s and *Unstructured VDM*s. A *Structured VDM* defines an extensible structure designed to support *Modal Operation*. An *Unstructured VDM* does not define any structure and *Messages* ***May*** be created in any manner that the vendor chooses.

Vendor_Defined *Messages* ***Shall Not*** be used for direct power *Negotiation*. They ***May*** however be used to alter *Local Policy*, affecting what is offered or consumed via the normal PD *Message*s.

The *Message* format ***Shall*** be as shown in *Figure 6.15, "Vendor Defined Message"*.

Figure 6.15 Vendor Defined Message



The *VDM Header* ***Shall*** be the first 4-byte object in a Vendor Defined *Message*. The *VDM Header* provides *Command* space to allow vendors to customize *Message*s for their own purposes. Additionally, vendors ***May*** make use of the *Commands* in a *Structured VDM*.

The fields in the *VDM Header* for an *Unstructured VDM*, when the ***VDM Type*** Bit is set to zero, ***Shall*** be as defined in *Table 6.28, "Unstructured VDM Header"*. The fields in the *VDM Header* for a *Structured VDM*, when the ***VDM Type*** Bit is set to one ***Shall*** be as defined in *Table 6.29, "Structured VDM Header"*.

Both *Unstructured VDM*s and *Structured VDM*s ***Shall*** only be sent and received after an *Explicit Contract* has been established. The only exception to this is the ***Discover Identity*** *Command* which ***May*** be sent by *Source* when a *Default Contract* or an *Implicit Contract* (in place after *Attach*, a *Power Role Swap* or *Fast Role Swap*) is in place in order to discover *Cable Capabilities* (see S*Section 8.3.3.25.3, "Source Startup Structured VDM Discover Identity of a Cable Plug State Diagram"*).

6.4.4.1 Unstructured VDM

The *Unstructured VDM* does not define the contents of bits B14…0 in the *VDM Header*. Their definition and use are the sole responsibility of the vendor indicated by the *VID*. The *Port Partner*s and *Cable Plugs* ***Shall*** exit any states entered using an *Unstructured VDM* when a *Hard Reset* appears on PD.

The following rules apply to the use of *Unstructured VDM Messages*:

- *Unstructured VDM*s ***Shall*** only be used when an *Explicit Contract* is in place.
- Prior to establishing an *Explicit Contract Unstructured VDM*s ***Shall Not*** be sent and ***Shall*** be ***Ignored*** if received.
- Only the *DFP* ***Shall*** be an *Initiator* of *Unstructured VDM*s.
- Only the *UFP* or a *Cable Plug* ***Shall*** be a *Responder* to *Unstructured VDM*.
- *Unstructured VDM*s ***Shall Not*** be initiated or responded to under any other circumstances.

- *Unstructured VDMs* ***Shall*** only be used during *Modal Operation* in the context of an *Active Mode* i.e., only after the *UFP* has Ack'ed the ***Enter Mode*** *Command* can *Unstructured VDMs* be sent or received. The *Active Mode* and the associated *Unstructured VDMs* ***Shall*** use the same *SVID*.
- *Unstructured VDMs* ***May*** be used with *SOP* Packets*.
- When a *DFP* or *UFP* does not support *Unstructured VDMs* or does not recognize the *VID* it ***Shall*** return a ***Not_Supported*** *Message*.

Table 6.28, "Unstructured VDM Header" illustrates the *VDM Header* bits.

Table 6.28 Unstructured VDM Header

Bit(s)	Parameter	Description
B31…16	***Vendor ID (VID)***	Unique 16-bit unsigned integer. Assigned by the USB-IF to the Vendor.
B15	***VDM Type***	0 = *Unstructured VDM*
B14…0	Available for Vendor Use	Content of this field is defined by the vendor.

6.4.4.1.1 USB Vendor ID

The ***Vendor ID (VID)*** field ***Shall*** contain the 16-bit *Vendor ID* value assigned to the vendor by the USB-IF (*VID*). No other value ***Shall*** be present in this field.

6.4.4.1.2 VDM Type

The ***VDM Type*** field ***Shall*** be set to zero indicating that this is an *Unstructured VDM*.

6.4.4.2 Structured VDM

Setting the ***VDM Type*** field to 1 (*Structured VDM*) defines the use of bits B14…0 in the *Structured VDM Header*. The fields in the *Structured VDM Header* are defined in *Table 6.29, "Structured VDM Header"*.

The following rules apply to the use of *Structured VDM Messages*:

- *Structured VDMs* ***Shall*** only be used when an *Explicit Contract* is in place with the following exception:
  - Prior to establishing the *First Explicit Contract*, a *Source* ***May*** issue ***Discover Identity*** *Messages*, to a *Cable Plug* using *SOP' Packets*, as an *Initiator* (see *Section 8.3.3.25.3, "Source Startup Structured VDM Discover Identity of a Cable Plug State Diagram"*).
- Either *Port* ***May*** be an *Initiator* of *Structured VDMs* except for the ***Enter Mode*** and ***Exit Mode*** *Commands* which ***Shall*** only be initiated by the *DFP*.
- A *Cable Plug* ***Shall*** only be a *Responder* to *Structured VDMs*.
- *Structured VDMs* ***Shall Not*** be initiated or responded to under any other circumstances.
- When a *DFP* or *UFP* does not support *Structured VDMs* any *Structured VDMs* received ***Shall*** return a ***Not_Supported*** *Message*.
- When using any of the *SVID* Specific *Commands* in the *Structured VDM Header* (*VDM Header* b4…0 - value 16 - 31) the *Responder* ***Shall*** **NAK** *Messages* where the *SVID* in the *VDM Header* is not recognized as an *SVID* that uses *SVID* Specific *Commands* or the use of *SVID* Specific *Commands* is not supported for the *SVID*.
- When a *Cable Plug* does not support *Structured VDMs* any *Structured VDMs* received ***Shall*** be ***Ignored***.

A *DFP*, *UFP* or *Cable Plug* which supports *Structured VDM*s and receiving a *Structured VDM* for a *SVID* that it does not recognize ***Shall*** reply with a ***NAK*** *Command*.

Table 6.29 Structured VDM Header

Bit(s)	Field	Description		
B31…16	***Standard or Vendor ID (SVID)***	Unique 16-bit unsigned integer, assigned by the USB-IF		
B15	***VDM Type***	1 = *Structured VDM*		
B14…13	***Structured VDM Version (Major)***	*Version* Number (Major) of the *Structured VDM* (not this specification *Version*): • Version 1.0 = 00b (***Deprecated*** and ***Shall Not*** be used) • Version 2.x = 01b • Values 2-3 are ***Reserved*** and ***Shall Not*** be used		
B12…11	***Structured VDM Version (Minor)***	For *Commands* 0…15 *Version* Number (Minor) of the *Structured VDM* • Version 2.0 = 00b (Used for ports implemented prior to USB PD Revision 3.1, Version 1.6) • Version 2.1 = 01b (Used for ports implemented starting with USB PD Revision 3.1, Version 1.6) • All other Values are ***Reserved*** and ***Shall Not*** be used • *SVID* Specific *Commands* (16…31) defined by the *SVID*.		
B10…8	***Object Position***	For the ***Enter Mode***, ***Exit Mode***, and ***Attention*** *Commands* (Requests/ Responses): • 000b = ***Reserved*** and ***Shall Not*** be used. • 001b…110b = Index into the list of *VDO*s to identify the desired *Alternate Mode VDO* • 111b = Exit all *Active Modes* (equivalent of a power on reset). ***Shall*** • only be used with the *Command*. *Commands* 0…3, 7…15: • 000b • 001b…111b = ***Reserved*** and ***Shall Not*** be used. *SVID* Specific *Commands* (16…31) defined by the *SVID*.		
B7…6	***Command Type***	00b =	***REQ***	(Request from *Initiator Port*)
		01b =	***ACK***	(Acknowledge Response from *Responder Port*)
		10b =	***NAK***	(Negative Acknowledge Response from *Responder Port*)
		11b =	***BUSY***	(Busy Response from *Responder Port*)
B5	***Reserved***	***Shall*** be set to zero and ***Shall*** be ***Ignored***		
B4…0[1]	***Command***	0 =	***Reserved*** and ***Shall Not*** be used.	
		1 =	***Discover Identity***	
		2 =	***Discover SVIDs***	
		3 =	***Discover Modes***	
		4 =	***Enter Mode***	
		5 =	***Exit Mode***	
		6 =	***Attention***	
		7-15 =	***Reserved*** and ***Shall Not*** be used.	
		16…31 =	*SVID* Specific *Commands*	

1) In the case where a SID is used the modes are defined by a standard. When a *VID* is used the modes are defined by the Vendor.

Section Table 6.30, "Structured VDM Commands" shows the *Commands*, which *SVID* to use with each *Command* and the *SOP** values which ***Shall*** be used.

Table 6.30 Structured VDM Commands

Command	VDM Header SVID Field	SOP* used
Discover Identity	***Shall*** only use the ***PD SID***.	***Shall*** only use *SOP*/*SOP'*.
Discover SVIDs	***Shall*** only use the ***PD SID***.	***Shall*** only use *SOP*/*SOP'*.
Discover Modes	***Valid*** with any *SVID*.	***Shall*** only use *SOP*/*SOP'*.
Enter Mode	***Valid*** with any *SVID*.	***Valid*** with *SOP**.
Exit Mode	***Valid*** with any *SVID*.	***Valid*** with *SOP**.
Attention	***Valid*** with any *SVID*.	***Valid*** with *SOP**.
SVID Specific *Commands*	***Valid*** with any *SVID*.	***Valid*** with *SOP** (defined by *SVID*).

6.4.4.2.1 SVID

The ***Standard or Vendor ID (SVID)*** field ***Shall*** contain either a 16-bit USB Standard ID value (SID) or the 16-bit assigned to the vendor by the USB-IF (*VID*). No other value ***Shall*** be present in this field.

Section Table 6.31, "SVID Values" lists specific *SVID* values referenced by this specification.

Table 6.31 SVID Values

Parameter	Value	Description
PD SID	0xFF00	Standard ID allocated to this specification by USB-IF.
DPTC SID	0xFF01	Standard ID allocated to ***[DPTC2.1]*** by USB-IF.

6.4.4.2.2 VDM Type

The ***VDM Type*** field ***Shall*** be set to one indicating that this is a *Structured VDM*.

6.4.4.2.3 Structured VDM Version

The ***Structured VDM Version (Major)***/***Structured VDM Version (Minor)*** fields indicate the level of functionality supported in the *Structured VDM* part of the specification. This is not the same *Version* as the *Version* of this specification. The ***Structured VDM Version (Major)*** ***Shall*** be set to 01b to indicate Version 2.x with the ***Structured VDM Version (Minor)*** field set as appropriate based on whether the *Port* is implemented to USB PD Revision 3.1, Version 1.6 (or newer) or a prior *Version*.

To ensure interoperability with existing *PDUSB* products, *PDUSB* products ***Shall*** support every *Structured VDM Version* number starting from Version 1.0.

On receipt of a *VDM Header* with a higher *Version* number than it supports, a *Port* or *Cable Plug* ***Shall*** respond using the highest *Version* number it supports. On receipt of a *VDM Header* with a lower *Version* number than it supports, a *Port* or *Cable Plug* ***Shall*** respond using the same *Version* number it received.

The ***Structured VDM Version (Major)***/***Structured VDM Version (Minor)*** fields of the ***Discover Identity*** *Command* sent and received during the *Discovery Process* ***Shall*** be used to determine the lowest common *Structured VDM Version* supported by the *Port Partners* or *Cable Plug* and ***Shall*** continue to operate using this *Specification Revision* until they are *Detached*. After discovering the *Structured VDM Version*, the ***Structured VDM Version (Major)***/***Structured VDM Version (Minor)*** fields ***Shall*** match the agreed common *Structured VDM Version*.

6.4.4.2.4 Object Position

The ***Object Position*** field ***Shall*** be used by the ***Enter Mode*** and ***Exit Mode*** *Command*s. The ***Discover Modes*** *Command* returns a list of zero to six *VDO*s, each of which describes an *Alternate Mode*. The value in ***Object Position*** field is an index into that list that indicates which *VDO* (e.g., *Alternate Mode*) in the list the ***Enter Mode*** and ***Exit Mode*** *Command* refers to. The ***Object Position*** ***Shall*** start with one for the first *Alternate Mode* in the list. If the *SVID* is a *VID*, the content of the *VDO* for the *Alternate Mode* ***Shall*** be defined by the vendor. If the ***Standard or Vendor ID (SVID)*** is a SID, the value ***Shall*** be assigned, by the USB-IF, to the given Standard. The *VDO*'s content ***May*** be as simple as a numeric value or as complex as bit mapped description of *Capabilities* of the *Alternate Mode*. In all cases, the *Responder* is responsible for deciphering the contents to know whether or not it supports the *Alternate Mode* at the Object Position.

This field ***Shall*** be set to zero in the Request or Response (***REQ***, ***ACK***, ***NAK*** or ***BUSY***) when not required by the specification of the individual *Command*.

6.4.4.2.5 Command Type

6.4.4.2.5.1 Commands other than Attention

This ***Command Type*** field ***Shall*** be used to indicate the type of *Command* request/response being sent.

An *Initiator* ***Shall*** set the ***Command Type*** field to ***REQ*** to indicate that this is a *Command* request from an *Initiator*.

If *Structured VDM*s are supported, then the responses are as follows:

- "*Responder* ***ACK***" is the normal return and ***Shall*** be sent to indicate that the *Command* request was received and handled normally.
- "*Responder* ***NAK***" ***Shall*** be returned when the *Command* request:
  - Has an ***Invalid*** parameter (e.g., ***Invalid*** *SVID* or *Alternate Mode*).
  - Cannot be acted upon because the configuration is not correct (e.g., an *Alternate Mode* which has a dependency on another *Alternate Mode* or a request to exit an *Alternate Mode* which is not an*Active Mode*).
  - Is an Unrecognized *Message*.
  - The handling of "*Responder* ***NAK***" is left up to the *Initiator*.
- "*Responder* ***BUSY***" ***Shall*** be sent in the response to a *VDM* when the *Responder* is unable to respond to the *Command* request immediately, but the *Command* request ***May*** be retried. The *Initiator* ***Shall*** wait ***tVDMBusy*** after a "*Responder* ***BUSY***" response is received before retrying the *Command* request.

6.4.4.2.5.2 Attention Command

This ***Command Type*** field ***Shall*** be used to indicate the type of *Command* request being sent. An *Initiator* ***Shall*** set the field to ***REQ*** to indicate that this is a *Command* request from an *Initiator*. If *Structured VDM*s are supported, then no response ***Shall*** be made to an ***Attention*** *Command*.

6.4.4.2.6 Command

6.4.4.2.6.1 Commands other than Attention

The ***Command*** field contains the value for the *VDM Command* being sent. The *Command*s explicitly listed in the ***Command*** field are used to identify devices and manage their operational Modes. There is a further range of *Command* values left for the vendor to use to manage additional extensions.

A *Structured VDM Command* consists of a *Command* request and a *Command* response (***ACK***, ***NAK*** or ***BUSY***). A *Structured VDM Command* is deemed to be completed (and if applicable, the transition to the requested functionality is made) when the ***GoodCRC*** *Message* has been successfully received by the *Responder* in reply to its *Command* response.

If *Structured VDM*s are supported, but the *Structured VDM Command* request is an Unrecognized *Message*, it ***Shall*** be NAKed (see *Table 6.32, "Commands and Responses"*).

6.4.4.2.6.2 Attention Command

The ***Command*** field contains the value for the *VDM Command* being sent (***Attention***). The ***Attention*** *Command* ***May*** be used by the *Initiator* to notify the *Responder* that it requires service.

A *Structured VDM* ***Attention*** *Command* consists of a *Command* request but no *Command* response. A *Structured VDM* ***Attention*** *Command* is deemed to be completed when the ***GoodCRC*** *Message* has been successfully received by the *Initiator* in reply to its ***Attention*** *Command* request.

If *Structured VDMs* are supported, but the *Structured VDM* ***Attention*** *Command* request is an Unrecognized *Message* it ***Shall*** be ***Ignored*** (see *Table 6.32, "Commands and Responses"*).

6.4.4.3 Use of Commands

The *VDM Header* for a *Structured VDM Message* defines *Command*s used to retrieve a list of *SVID*s the device supports, to discover the Modes associated with each *SVID*, and to enter/exit the Modes. The *Command*s include:

- ***Discover Identity***
- ***Discover SVIDs***
- ***Discover Modes***
- ***Enter Mode***
- ***Exit Mode***
- ***Attention***

Additional *Command* space is also ***Reserved*** for Standard and Vendor use and for future extensions.

The *Command AMS*s use the terms *Initiator* and *Responder* to identify messaging roles the ports are taking on relative to each other. This role is independent of the *Port*'s power capability (*Provider*, *Consumer* etc.) or its present *Power Role* (*Source* or *Sink*). The *Initiator* is the *Port* sending the initial *Command* request and the *Responder* is the *Port* replying with the *Command* response. See *Section 6.4.4.4, "Command Processes"*.

All Ports that support Modes ***Shall*** support the ***Discover Identity***, ***Discover SVIDs***, the ***Discover Modes***, the ***Enter Mode*** and ***Exit Mode*** *Command*s.

Table 6.32, "Commands and Responses" details the responses a *Responder* ***May*** issue to each *Command* request. Responses not listed for a given *Command* ***Shall Not*** be sent by a *Responder*. A *NAK* response ***Should*** be taken as an indication not to retry that particular *Command*.

Table 6.32 Commands and Responses

Command	Allowed Response	Reference
Discover Identity	*ACK*, *NAK*, *BUSY*	*Section 6.4.4.3.1*
Discover SVIDs	*ACK*, *NAK*, *BUSY*	*Section 6.4.4.3.2*
Discover Modes	*ACK*, *NAK*, *BUSY*	*Section 6.4.4.3.3*
Enter Mode	*ACK*, *NAK*	*Section 6.4.4.3.4*
Exit Mode	*ACK*, *NAK*	*Section 6.4.4.3.5*
Attention	None	*Section 6.4.4.3.6*

Examples of *Command* usage can be found in *Appendix C, "VDM Command Examples"*.

6.4.4.3.1 Discover Identity

The ***Discover Identity*** *Command* is provided to enable an *Initiator* to identify its *Port Partner* and for an *Initiator* (*VCONN Source*) to identify the *Responder* (*Cable Plug* or *VPD*). The ***Discover Identity*** *Command* is also used to determine whether a *Cable Plug* or *VPD* is PD-Capable by looking for a ***GoodCRC*** *Message* Response.

The ***Discover Identity*** *Command* ***Shall*** only be sent to *SOP* when there is an *Explicit Contract*.

The ***Discover Identity*** *Command* ***Shall*** be used to determine whether a given *Cable Plug* or *VPD* is PD Capable (see *Section 8.3.3.21.1, "Initiator Structured VDM Discover Identity State Diagram"* and *Section 8.3.3.25.3, "Source Startup Structured VDM Discover Identity of a Cable Plug State Diagram"*). In this case a ***Discover Identity*** *Command* request sent to *SOP'* ***Shall Not*** cause a *Soft Reset* if a ***GoodCRC*** *Message* response is not returned since this can indicate a non-PD Capable cable or *VPD*.

Note: A *Cable Plug* or *VPD* will not be ready for PD Communication until tVCONNStable after *VCONN* has been applied (see ***[USB Type-C 2.4]***).

During *Cable Plug* or *VPD* discovery, when there is an *Explicit Contract*, ***Discover Identity*** *Commands* are sent at a rate defined by the ***DiscoverIdentityTimer*** (see *Section 6.6.15, "DiscoverIdentityTimer"*) up to a maximum of ***nDiscoverIdentityCount*** times (see *Section 6.7.5, "Discover Identity Counter"*).

A PD-Capable *Cable Plug* or *VPD* ***Shall*** return a ***Discover Identity*** *Command* ***ACK*** in response to a ***Discover Identity*** *Command* request sent to *SOP'*.

The ***Discover Identity*** *Command* ***Shall*** be used to determine the identity and/or *Capabilities* of the *Port Partner*. The following products ***Shall*** return a ***Discover Identity*** *Command* ***ACK*** in response to a ***Discover Identity*** *Command* request sent to *SOP*:

- A PD-Capable *UFP* that supports *Modal Operation*.
- A PD-Capable product that has multiple *DFP*s.
- A PD-Capable ***[USB4]*** product.

The *SVID* in the ***Discover Identity*** *Command* request ***Shall*** be set to the PD SID (see *Section Table 6.31, "SVID Values"*).

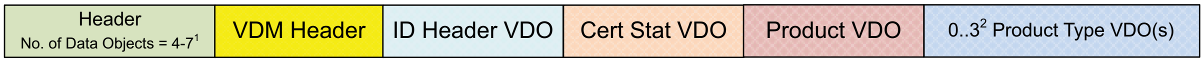
The ***Number of Data Objects*** field in the *Message Header* in the ***Discover Identity*** *Command* request ***Shall*** be set to 1 since the ***Discover Identity*** *Command* request ***Shall Not*** contain any *VDO*s.

The ***Discover Identity*** *Command* ***ACK*** sent back by the *Responder* ***Shall*** contain an *ID Header VDO*, a *Cert Stat VDO*, a *Product VDO* and the *Product Type VDO*s defined by the *Product Type* as shown in *Figure 6.16, "Discover Identity Command response"*. This specification defines the following *Product Type VDO*s:

- *Passive Cable VDO* (see *Section 6.4.4.3.1.6, "Passive Cable VDO"*)
- *Active Cable VDO*s (see *Section 6.4.4.3.1.7, "Active Cable VDOs"*)
- *VCONN Powered USB Device* (*VPD*) *VDO* (see *Section 6.4.4.3.1.9, "VCONN Powered USB Device VDO"*)
- *UFP VDO* (see *Section 6.4.4.3.1.4, "UFP VDO"*)
- *DFP VDO* (see *Section 6.4.4.3.1.5, "DFP VDO"*)

No *VDO*s other than those defined in this specification ***Shall*** be sent as part of the ***Discover Identity*** *Command* response. Where there is no *Product Type VDO* defined for a specific *Product Type*, no *VDO*s ***Shall*** be sent as part of the ***Discover Identity*** *Command* response. Any additional *VDO*s received by the *Initiator* ***Shall*** be ***Ignored***.

Figure 6.16 Discover Identity Command response

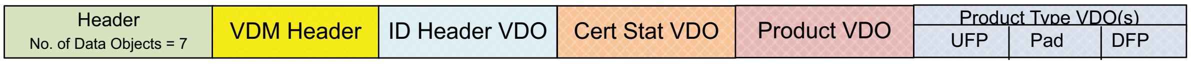


1. Only Data objects defined in this specification can be sent as part of the *Discover Identity* Command.
2. The following sections define the number and content of the VDOs for each Product Type.

The ***Number of Data Objects*** field in the *Message Header* in the ***Discover Identity*** *Command* ***NAK*** and ***BUSY*** responses ***Shall*** be set to 1 since they ***Shall Not*** contain any *VDO*s.

If the product is a DRD both a *Product Type* (*UFP*) and a *Product Type* (*DFP*) are declared in the ID Header. These products ***Shall*** return *Product Type VDO*s for both *UFP* and *DFP* beginning with the *UFP VDO*, then by a 32-bit Pad Object (defined as all '0's), followed by the *DFP VDO* as shown in *Figure 6.17, "Discover Identity Command response for a DRD"*.

Figure 6.17 Discover Identity Command response for a DRD



6.4.4.3.1.1 ID Header VDO

The *ID Header VDO* contains information corresponding to the Power Delivery Product. The fields in the *ID Header VDO* ***Shall*** be as defined in *Section Table 6.33, "ID Header VDO"*.

Table 6.33 ID Header VDO

Bit(s)	Description	Reference
B31	***USB Communications Capable as USB Host*** • ***Shall*** be set to one if the product is capable of enumerating *USB Devices*. • ***Shall*** be set to zero otherwise.	*Section 6.4.4.3.1.1.1*
B30	***USB Communications Capable as a*** *USB Device* • ***Shall*** be set to one if the product is capable of being enumerated as a *USB Device*. • ***Shall*** be set to zero otherwise	*Section 6.4.4.3.1.1.2*
B29…27	***SOP Product Type (UFP)*** • 000b – Not a *UFP* • 001b – *PDUSB Hub* • 010b – PDUSB Peripheral • 011b – PSD • 100b…111b – ***Reserved***, ***Shall Not*** be used.	*Section 6.4.4.3.1.1.3*
	SOP' Product Type (Cable Plug/VPD) • 000b – Not a *Cable Plug/VPD* • 001b…010b – ***Reserved***, ***Shall Not*** be used. • 011b – *Passive Cable* • 100b – *Active Cable* • 101b – ***Reserved***, ***Shall Not*** be used. • 110b – *VCONN Powered USB Device* (*VPD*) • 111b – ***Reserved***, ***Shall Not*** be used.	

Table 6.33 ID Header VDO (Continued)

Bit(s)	Description	Reference
B26	***Modal Operation Supported*** - ***Shall*** be set to one if the product (*UFP*/*Cable Plug*) is capable of supporting *Modal Operation* (*Alternate Modes*). - ***Shall*** be set to zero otherwise.	*Section 6.4.4.3.1.1.4*
B25…23	***SOP - Product Type (DFP)*** - 000b – Not a *DFP* - 001b – *PDUSB Hub* - 010b – *PDUSB Host* - 011b – Power Brick - 100b…111b – ***Reserved***, ***Shall Not*** be used. *SOP'*: ***Reserved***, ***Shall Not*** be used.	*Section 6.4.4.3.1.1.6*
B22…21	***Connector Type*** - 00b – ***Reserved***, for compatibility with legacy systems. - 01b – ***Reserved***, ***Shall Not*** be used. - 10b – *USB Type-C* Receptacle - 11b – *USB Type-C* Plug	*Section 6.4.4.3.1.1.7*
B20…16	***Reserved***, ***Shall Not*** be used.	
B15…0	***USB Vendor ID***	*Section 6.4.4.3.1.1.8* ***[USB 2.0]***/***[USB 3.2]***/***[USB4]***

6.4.4.3.1.1.1 USB Communications Capable as a USB Host

The ***USB Communications Capable as USB Host*** field is used to indicate whether or not the *Port* has a *USB Host* Capability.

6.4.4.3.1.1.2 USB Communications Capable as a USB Device

The ***USB Communications Capable as a*** *USB Device* field is used to indicate whether or not the *Port* has a *USB Device* Capability.

6.4.4.3.1.1.3 Product Type (UFP)

The ***SOP Product Type (UFP)*** field indicates the type of Product when in *UFP Data Role*, whether a *VDO* will be returned and if so the type of *VDO* to be returned. The *Product Type* indicated in the ***SOP Product Type (UFP)*** field ***Shall*** be the closest categorization of the main functionality of the Product in *UFP Data Role* or "Undefined" when there is no suitable category for the product. For DRD Products this field ***Shall*** always indicate the *Product Type* when in *UFP* role regardless of the present *Data Role*. *Table 6.34, "Product Types (UFP)"* defines the *Product Type VDO*s which ***Shall*** be returned.

Table 6.34 Product Types (UFP)

Product Type	Description	Product Type VDO	Reference
Undefined	***Shall*** be used when this is not a *UFP*.	None	
PDUSB Hub	***Shall*** be used when the Product is a *PDUSB Hub*.	*UFP VDO*	*Section 6.4.4.3.1.4*
PDUSB Peripheral	***Shall*** be used when the Product is a *PDUSB Device* other than a *PDUSB Hub*.	*UFP VDO*	*Section 6.4.4.3.1.4*
PSD	***Shall*** be used when the Product is a PSD, e.g., power bank.	None	

6.4.4.3.1.1.4 Product Type (Cable Plug)

The *SOP’ Product Type (Cable Plug/VPD)* field indicates the type of Product when the Product is a *Cable Plug* or *VPD*, whether a *VDO* will be returned and if so the type of *VDO* to be returned. *Table 6.35, "Product Types (Cable Plug/ VPD)"* defines the *Product Type VDO*s which ***Shall*** be returned.

Table 6.35 Product Types (Cable Plug/VPD)

Product Type	Description	Product Type VDO	Reference
Undefined	***Shall*** be used where no other *Product Type* value is appropriate.	None	
Active Cable	***Shall*** be used when the Product is a cable that incorporates signal conditioning circuits.	*Active Cable VDO*	*Section 6.4.4.3.1.7*
Passive Cable	***Shall*** be used when the Product is a cable that does not incorporate signal conditioning circuits.	*Passive Cable VDO*	*Section 6.4.4.3.1.6*
VCONN Powered USB Device	***Shall*** be used when the Product is a PDUSB *VCONN Powered USB Device*.	*VPD* VDO	*Section 6.4.4.3.1.9*

6.4.4.3.1.1.5 Modal Operation Supported

The ***Modal Operation Supported*** bit is used to indicate whether or not the Product (either a *Cable Plug* or a device that can operate in the *UFP* role) is capable of supporting Modes. The ***Modal Operation Supported*** bit does not describe a *DFP*'s *Alternate Mode Controller* functionality.

A product that supports *Modal Operation* ***Shall*** respond to the ***Discover SVIDs*** *Command* with a list of *SVID*s for all of the Modes it is capable of supporting whether or not those Modes can currently be entered.

6.4.4.3.1.1.6 Product Type (DFP)

The ***SOP - Product Type (DFP)*** field indicates the type of Product when in *DFP Data Role*, whether a *VDO* will be returned and if so the type of *VDO* to be returned. The *Product Type* indicated in the ***SOP - Product Type (DFP)*** field ***Shall*** be the closest categorization of the main functionality of the Product in *DFP Data Role* or "Undefined" when there is no suitable category for the product. For DRD Products this field ***Shall*** always indicate the *Product Type* when in *DFP* role regardless of the present *Data Role*. *Table 6.36, "Product Types (DFP)"* defines the *Product Type VDO*s which ***Shall*** be returned.

In *SOP’ Communication* (*Cable Plugs* and *VPDs*) this bit field is ***Reserved*** and ***Shall*** be set to zero.

Table 6.36 Product Types (DFP)

Product Type	Description	Product Type VDO	Reference
Undefined	***Shall*** be used where no other *Product Type* value is appropriate.	None	
PDUSB Hub	***Shall*** be used when the Product is a *PDUSB Hub*.	*DFP VDO*	*Section 6.4.4.3.1.7*
PDUSB Host	***Shall*** be used when the Product is a *PDUSB Host* or a PDUSB host that supports one or more *Alternate Modes* as an AMC.	*DFP VDO*	*Section 6.4.4.3.1.6*
Charger	***Shall*** be used when the Product is a *Charger*.	*DFP VDO*	*Section 6.4.4.3.1.9*

6.4.4.3.1.1.7 Connector Type Field

The ***Connector Type*** field (B22…21) ***Shall*** contain a value identifying it as either a *USB Type-C* receptacle or a *USB Type-C* plug.

6.4.4.3.1.1.8 Vendor ID

Manufacturers ***Shall*** set the ***USB Vendor ID*** field to the value of the *Vendor ID* assigned to them by USB-IF. For *USB Devices* or *Hubs* which support *USB Communications* the ***USB Vendor ID*** field ***Shall*** be identical to the Vendor ID field defined in the product's *USB Device* Descriptor (see ***[USB 2.0]*** and ***[USB 3.2]***).

6.4.4.3.1.2 Cert Stat VDO

The *Cert Stat VDO* ***Shall*** contain the XID assigned by USB-IF to the product before certification in binary format. The fields in the *Cert Stat VDO* ***Shall*** be as defined in *Table 6.37, "Cert Stat VDO"*.

Table 6.37 Cert Stat VDO

Bit(s)	Description	Reference
B31…0	32-bit unsigned integer, XID	Assigned by USB-IF

6.4.4.3.1.3 Product VDO

The *Product VDO* contains identity information relating to the product. The fields in the *Product VDO* ***Shall*** be as defined in *Table 6.38, "Product VDO"*.

Table 6.38 Product VDO

Bit(s)	Description	Reference
B31…16	16-bit unsigned integer, USB Product ID	***[USB 2.0]***/***[USB 3.2]***
B15…0	16-bit unsigned integer, bcdDevice	***[USB 2.0]***/***[USB 3.2]***

Manufacturers ***Should*** set the USB Product ID field to a unique value identifying the product and ***Should*** set the bcdDevice field to a version number relevant to the release version of the product.

6.4.4.3.1.4 UFP VDO

The *UFP VDO* defined in this section ***Shall*** be returned by Ports capable of operating as a *UFP* including traditional USB peripherals, *USB Hub*'s upstream *Port* and DRD capable host Ports. The *UFP VDO* defined in this section ***Shall*** be sent when the *Product Type* (*UFP*) field in the *ID Header VDO* is given as a PDUSB Peripheral or *PDUSB Hub*. *Table 6.39, "UFP VDO"* defines the *UFP VDO* that ***Shall*** be sent based on the *Product Type*.

A ***[USB4]*** *UFP* ***Shall*** support the *Structured VDM* ***Discover Identity*** *Command*.

Table 6.39 UFP VDO

<table>
<tr><th>Bit(s)</th><th>Description</th><th colspan="2">Reference</th></tr>
<tr><td>B31…29</td><td><b><i>UFP VDO Version</i></b></td><td colspan="2"><i>Version</i> Number of the <i>VDO</i> (not this specification <i>Version</i>):
- Version 1.3 = 011b
Values 100b…111b are <b><i>Reserved</i></b>, <b><i>Shall Not</i></b> be used.</td></tr>
<tr><td>B28</td><td><b><i>Reserved</i></b></td><td colspan="2"><b><i>Shall</i></b> be set to zero.</td></tr>
<tr><td rowspan="5">B27…24</td><td rowspan="5"><b><i>Device Capability</i></b></td><td><b>Bit</b></td><td><b>Description</b></td></tr>
<tr><td>0</td><td><b><i>[USB 2.0]</i></b> <i>Device</i> Capable</td></tr>
<tr><td>1</td><td><b><i>[USB 2.0]</i></b> <i>Device</i> Capable (Billboard only)</td></tr>
<tr><td>2</td><td><b><i>[USB 3.2]</i></b> <i>Device</i> Capable</td></tr>
<tr><td>3</td><td><b><i>[USB4]</i></b> <i>Device</i> Capable</td></tr>
<tr><td>B23…22</td><td><b><i>Connector Type (Legacy)</i></b></td><td colspan="2"><b><i>Deprecated</i></b>, <b><i>Shall</i></b> be set to 00b.</td></tr>
<tr><td>B21…11</td><td><b><i>Reserved</i></b></td><td colspan="2"><b><i>Shall</i></b> be set to zero.</td></tr>
</table>

Table 6.39 UFP VDO (Continued)

<table>
<tr><th>Bit(s)</th><th>Description</th><th>Reference</th></tr>
<tr><td>B10…8</td><td><em><strong>VCONN Power</strong></em></td><td>When the <em><strong>VCONN Required</strong></em> field is set to “Yes” the <em><strong>VCONN Power</strong></em> Field indicates the <em>VCONN</em> power needed by the <em>AMA</em> for full functionality:
• 000b = 1W
• 001b = 1.5W
• 010b = 2W
• 011b = 3W
• 100b = 4W
• 101b = 5W
• 110b = 6W
111b = <em><strong>Reserved</strong></em>, <em><strong>Shall Not</strong></em> be used.
When the <em><strong>VCONN Required</strong></em> field is set to “No” the <em><strong>VCONN Power</strong></em> field is <em><strong>Reserved</strong></em> and <em><strong>Shall</strong></em> be set to zero.</td></tr>
<tr><td>B7</td><td><em><strong>VCONN Required</strong></em></td><td>Indicates whether the <em>AMA</em> requires <em>VCONN</em> in order to function.
• 0 = No
• 1 = Yes
When the <em><strong>Alternate Modes</strong></em> field indicates no modes are supported, the <em><strong>VCONN Required</strong></em> field is <em><strong>Reserved</strong></em> and <em><strong>Shall</strong></em> be set to zero.</td></tr>
<tr><td>B6</td><td><em><strong>VBUS Required</strong></em></td><td>Indicates whether the <em>AMA</em> requires <em>VBUS</em> in order to function.
• 0 = Yes
• 1 = No
When the <em><strong>Alternate Modes</strong></em> field indicates no modes are supported, the <em><strong>VBUS Required</strong></em> field is <em><strong>Reserved</strong></em> and <em><strong>Shall</strong></em> be set to zero.</td></tr>
<tr><td>B5…3</td><td><em><strong>Alternate Modes</strong></em></td><td><table>
<tr><th>Bit</th><th>Description</th></tr>
<tr><td>0</td><td>Supports <em><strong>[TBT3]</strong></em> <em>Alternate Mode</em></td></tr>
<tr><td>1</td><td>Supports <em>Alternate Modes</em> that reconfigure the signals on the <em><strong>[USB Type-C 2.4]</strong></em> connector – except for <em><strong>[TBT3]</strong></em>.</td></tr>
<tr><td>2</td><td>Supports <em>Alternate Modes</em> that do not reconfigure the signals on the <em><strong>[USB Type-C 2.4]</strong></em> connector.</td></tr>
</table></td></tr>
<tr><td>B2…0</td><td><em><strong>USB Highest Speed</strong></em></td><td>• 000b = <em><strong>[USB 2.0]</strong></em> only, no SuperSpeed support
• 001b = <em><strong>[USB 3.2]</strong></em> Gen1
• 010b = <em><strong>[USB 3.2]</strong></em>/<em><strong>[USB4]</strong></em> Gen2
• 011b = <em><strong>[USB4]</strong></em> Gen3
• 100b =<em><strong>[USB4]</strong></em> Gen4
• 101b…111b = <em><strong>Reserved</strong></em> and <em><strong>Shall</strong></em> be set to zero.</td></tr>
</table>

6.4.4.3.1.4.1 VDO Version Field

The ***UFP VDO Version*** field contains a *VDO Version* for this *VDM Version* number. This field indicates the expected content for the *UFP VDOs*.

6.4.4.3.1.4.2 Device Capability Field

The ***Device Capability*** bit-field describes the *UFP*'s *Capabilities* when operating as either a *PDUSB Device* or *PDUSB Hub*.

The bits in the bit-field ***Shall*** be non-zero when the corresponding *USB Device* speed is supported and ***Shall*** be set to zero when the corresponding *USB Device* speed is not supported.

[USB 2.0] "Device capable" and "Device capable Billboard only" (bits 0 and 1) ***Shall Not*** be simultaneously set.

6.4.4.3.1.4.3 Connector Type Field

Th ***Connector Type (Legacy)*** field was previously used for the *UFP VDO*'s Connector Type. ***Shall*** be set to 00b by the *Cable Plug* and ***Shall*** be ***Ignored*** by the receiver. The receiver can find this information in the ***Connector Type*** field in the *ID Header VDO* (*Section 6.4.4.3.1.1.7, "Connector Type Field"*).

6.4.4.3.1.4.4 VCONN Power Field

When the ***VCONN Required*** field indicates that *VCONN* is required the ***VCONN Power*** field ***Shall*** indicate how much power an *AMA* needs in order to fully operate. When the ***VCONN Required*** field is set to "No" the ***VCONN Power*** field is ***Reserved*** and ***Shall*** be set to zero.

6.4.4.3.1.4.5 VCONN Required Field

The ***VCONN Required*** field ***Shall*** indicate whether *VCONN* is needed for the *AMA* to operate. The ***VCONN Required*** field ***Shall*** only be used if the ***Alternate Modes*** field indicates that an *Alternate Mode* is supported. If no *Alternate Mode*s are supported, this field is ***Reserved*** and ***Shall*** be set to zero.

6.4.4.3.1.4.6 VBUS Required Field

The ***VBUS Required*** field ***Shall*** indicate whether *VBUS* is needed for the *AMA* to operate. The *VBUS* required field ***Shall*** only be used if the ***Alternate Modes*** field indicates that an *Alternate Mode* is supported. If no *Alternate Mode*s are supported, this field is ***Reserved*** and ***Shall*** be set to zero.

6.4.4.3.1.4.7 Alternate Modes Field

The ***Alternate Modes*** field ***Shall*** be used to identify all the types of *Alternate Mode*s, if any, a device supports.

6.4.4.3.1.4.8 USB Highest Speed Field

The ***USB Highest Speed*** field ***Shall*** indicate the *Port*'s highest speed capability. The *DFP* ***Shall*** consider all values indicated in this field that are higher than the highest value that the *DFP* recognizes as being ***Valid*** and functionally compatible with the highest speed that the *DFP* supports.

6.4.4.3.1.5 DFP VDO

The *DFP VDO* ***Shall*** be returned by Ports capable of operating as a *DFP*; including those implemented by *Hosts*, *Hubs* and Power Bricks. The *DFP VDO* ***Shall*** be returned when the *Product Type* (*DFP*) field in the *ID Header VDO* is given as Power Brick, *PDUSB Host* or *PDUSB Hub*. *Table 6.40, "DFP VDO"* defines the *DFP VDO* that ***Shall*** be sent.

Table 6.40 DFP VDO

Bit(s)	Field	Description	
B31…29	***DFP VDO Version***	*Version* Number of the *VDO* (not this specification *Version*): - Version 1.2 = 010b Values 011b…111b are ***Reserved*** and ***Shall Not*** be used	
B28…27	***Reserved***	***Shall*** be set to zero.	
B26…24	***Host Capability***	**Bit**	**Description**
		0	***[USB 2.0]*** *Host* Capable
		1	***[USB 3.2]*** *Host* Capable
		2	***[USB4]*** *Host* Capable
B23…22	***Connector Type (Legacy)***	***Shall*** be set to 00b.	
B21…5	***Reserved***	***Shall*** be set to zero.	
B4…0	***Port Number***	Unique *Port* number to identify a specific *Port* on a multi-*Port* device.	

6.4.4.3.1.5.1 VDO Version Field

The ***DFP VDO Version*** field ***Shall*** contain a *VDO Version* for this *VDM Version* number. This field indicates the expected content for the *DFP VDO*.

6.4.4.3.1.5.2 Host Capability Field

The ***Host Capability*** bit-field ***Shall*** describe whether the *DFP* can operate as a *PDUSB Host* and the *DFP*'s *Capabilities* when operating as a *PDUSB Host*.

Power Bricks and *PDUSB Hubs* ***Shall*** set the ***Host Capability*** bits to zero.

6.4.4.3.1.5.3 Connector Type Field

The ***Connector Type (Legacy)*** field was previously used for the *UFP VDO*'s Connector Type. ***Shall*** be set to 00b by the *Cable Plug* and ***Shall*** be ***Ignored*** by the receiver. The receiver can find this information in the ***Connector Type*** field in the *ID Header VDO* (*Section 6.4.4.3.1.1.7, "Connector Type Field"*).

6.4.4.3.1.5.4 Port Number Field

The ***Port Number*** field ***Shall*** be a ***Static*** unique number that unambiguously identifies each ***[USB Type-C 2.4]*** *DFP*, including *DRP*s, on the device.

Note: This number is independent of the USB *Port* number.

6.4.4.3.1.6 Passive Cable VDO

The *Passive Cable VDO* defined in this section ***Shall*** be sent when the *Product Type* is given as *Passive Cable*. *Table 6.41, "Passive Cable VDO"* defines the *Cable VDO* which ***Shall*** be sent.

A *Passive Cable* has a USB Plug on each end at least one of which is a *Cable Plug* supporting *SOP' Communication*. A *Passive Cable* ***Shall Not*** incorporate data bus signal conditioning circuits and hence has no concept of Super Speed Directionality. A *Passive Cable* ***Shall*** include a *VBUS* wire and ***Shall*** only respond to *SOP' Communication*. *Passive Cables* ***Shall*** support the *Structured VDM* ***Discover Identity*** *Command* and ***Shall*** return the *Passive Cable VDO* in a ***Discover Identity*** *Command* ***ACK*** as shown in *Table 6.41, "Passive Cable VDO"*.

Table 6.41 Passive Cable VDO

Bit(s)	Field	Description
B31…28	***HW Version***	0000b…1111b assigned by the *VID* owner
B27…24	***Firmware Version***	0000b…1111b assigned by the *VID* owner
B23…21	***VDO Version***	*Version* Number of the *VDO* (not this specification *Version*): - Version 1.0 = 000b Values 001b…111b are ***Reserved*** and ***Shall Not*** be used.
B20	***Reserved***	***Shall*** be set to zero.
B19…18	***USB Type-C plug to USB Type-C/Captive (Passive Cable)***	- 00b = ***Reserved*** and ***Shall Not*** be used - 01b = ***Reserved*** and ***Shall Not*** be used - 10b = *USB Type-C* - 11b = Captive
B17	***EPR Capable (Passive Cable)***	- 0b – Cable is not *EPR Capable* - 1b = Cable is *EPR Capable*
B16…13	***Cable Latency (Passive Cable)***	- 0000b – ***Reserved*** and ***Shall Not*** be used - 0001b – <10ns (~1m) - 0010b – 10ns to 20ns (~2m) - 0011b – 20ns to 30ns (~3m) - 0100b – 30ns to 40ns (~4m) - 0101b – 40ns to 50ns (~5m) - 0110b – 50ns to 60ns (~6m) - 0111b – 60ns to 70ns (~7m) - 1000b – > 70ns (>~7m) **Note:** 1001b ….1111b ***Reserved*** and ***Shall Not*** be used
B12…11	***Cable Termination Type (Passive Cable)***	- 00b = *VCONN* not required. *Cable Plugs* that only support ***Discover Identity*** *Commands* ***Shall*** set these bits to 00b. - 01b = *VCONN* required - 10b…11b = ***Reserved*** and ***Shall Not*** be used
B10…9	***Maximum VBUS Voltage (Passive Cable)***	Maximum Cable *VBUS* Voltage[2]: - 00b – 20V - 01b – 30V[1] (***Deprecated***) - 10b – 40V[1] (***Deprecated***) - 11b – 50V
B8…7	***Reserved***	***Shall*** be set to zero.
1)	Values no longer allowed. When present the field ***Shall*** be interpreted as if it was 00b.	
2)	*EPR Sinks* with a captive cable ***Shall*** report 50V.	

Table 6.41 Passive Cable VDO (Continued)

Bit(s)	Field	Description
B6…5	*VBUS Current Handling Capability (Passive Cable)*	• 00b = ***Reserved*** and ***Shall Not*** be used • 01b = 3A • 10b = 5A • 11b = ***Reserved*** and ***Shall Not*** be used
B4…3	***Reserved***	***Shall*** be set to zero.
B2…0	*USB Highest Speed (Passive Cable)*	• 000b = *[USB 2.0]* only, no SuperSpeed support • 001b = *[USB 3.2]* Gen1 • 010b = *[USB 3.2]*/*[USB4]* Gen2 • 011b = *[USB4]* Gen3 • 100b = *[USB4]* Gen4 • 101b…111b = ***Reserved*** and ***Shall Not*** be used
1)	Values no longer allowed. When present the field ***Shall*** be interpreted as if it was 00b.	
2)	*EPR Sinks* with a captive cable ***Shall*** report 50V.	

6.4.4.3.1.6.1 HW Version Field

The ***HW Version*** (B31…28) contains a HW version assigned by the *VID* owner.

6.4.4.3.1.6.2 FW Version Field

The ***Firmware Version*** field (B27…24) contains a FW version assigned by the *VID* owner.

6.4.4.3.1.6.3 VDO Version Field

The ***VDO Version*** field (B23…20) contains a *VDO Version* for this *VDM Version* number. This field indicates the expected content for this *VDO*.

6.4.4.3.1.6.4 USB Type-C plug to USB Type-C/Captive Field

The ***USB Type-C plug to USB Type-C/Captive (Passive Cable)*** field (B19…18) ***Shall*** contain a value indicating whether the opposite end from the *USB Type-C* plug is another *USB Type-C* plug (i.e., a detachable Standard *USB Type-C* Cable Assembly) or is a Captive Cable Assembly.

6.4.4.3.1.6.5 EPR Mode Capable

The ***EPR Capable (Passive Cable)*** bit is a ***Static*** bit which ***Shall*** only be set when the cable is specifically designed for safe operation when carrying up to 48 volts at 5 amps.

6.4.4.3.1.6.6 Cable Latency Field

The ***Cable Latency (Passive Cable)*** field (B16…13) ***Shall*** contain a value corresponding to the signal latency through the cable which can be used as an approximation for its length.

6.4.4.3.1.6.7 Cable Termination Type Field

The ***Cable Termination Type (Passive Cable)*** field (B12…11) ***Shall*** contain a value indicating whether the *Passive Cable* needs *VCONN* only initially in order to support the ***Discover Identity*** *Command*, after which it can be removed, or the *Passive Cable* needs *VCONN* to be continuously applied in order to power some feature of the *Cable Plug*.

6.4.4.3.1.6.8 Maximum VBUS Voltage Field

The ***Maximum VBUS Voltage (Passive Cable)*** field (B10…9) ***Shall*** contain the maximum voltage that ***Shall*** be *Negotiated* using a *Fixed Supply* over the cable as part of an *Explicit Contract* where the maximum voltage that ***Shall*** be applied to the cable is ***vSrcNew*** max + ***vSrcValid*** max. For example, when the ***Maximum VBUS Voltage (Passive Cable)*** field is 20V, a *Fixed Supply* of 20V can be *Negotiated* as part of an *Explicit Contract* where the absolute maximum voltage that can be applied to the cable is 21.55V. Similarly, when the ***Maximum VBUS Voltage (Passive***

Cable) field is 50V, a *Fixed Supply* of 48V can be *Negotiated* as part of an *Explicit Contract* where the absolute maximum voltage that can be applied to the cable is 50.9V. ***Maximum VBUS Voltage (Passive Cable)*** field values of 01b and 10b (formerly 30V and 40V) ***Shall*** be treated if they were 00b (20V).

6.4.4.3.1.6.9 VBUS Current Handling Capability Field

The ***VBUS Current Handling Capability (Passive Cable)*** field (B6…5) ***Shall*** indicate whether the cable is capable of carrying 3A or 5A.

6.4.4.3.1.6.10 USB Highest Speed Field

The ***USB Highest Speed (Passive Cable)*** field (B2…0) ***Shall*** indicate the highest rate the cable supports. The *DFP* ***Shall*** consider all values indicated in this field that are higher than the highest value that the *DFP* recognizes as being ***Valid*** and functionally compatible with the highest speed that the *DFP* supports.

6.4.4.3.1.7 Active Cable VDOs

An *Active Cable* has a USB Plug on each end at least one of which is a *Cable Plug* supporting *SOP’ Communication*. An *Active Cable* ***Shall*** incorporate data bus signal conditioning circuits and ***May*** have a concept of Super Speed Directionality on its Super Speed wires. An *Active Cable* ***May*** include a *VBUS* wire.

An *Active Cable*:

- ***Shall*** respond to *SOP’ Communication*.
- ***May*** respond to *SOP’’ Communication*.
- ***Shall*** support the *Structured VDM* ***Discover Identity*** *Command*.
- In the ***Discover Identity*** *Command* ***ACK***:
  - ***Shall*** set the *Product Type* in the *ID Header VDO* to *Active Cable*.
  - ***Shall*** return the *Active Cable VDOs* defined in *Table 6.42, "Active Cable VDO1"* and *Table 6.43, "Active Cable VDO2"*..

Table 6.42 Active Cable VDO1

Bit(s)	Field	Description
B31…28	***HW Version***	0000b…1111b assigned by the *VID* owner
B27…24	***Firmware Version***	0000b…1111b assigned by the *VID* owner
B23…21	***VDO Version***	*Version* Number of the *VDO* (not this specification *Version*): • Version 1.0 = 000b Values 001b…111b are ***Reserved*** and ***Shall Not*** be used.
B20	***Reserved***	***Shall*** be set to zero.
B19…18	***USB Type-C plug to USB Type-C/Captive***	• 00b = ***Reserved*** and ***Shall Not*** be used • 01b = ***Reserved*** and ***Shall Not*** be used • 10b = *USB Type-C* • 11b = Captive
B17	***EPR Capable (Active Cable)***	• 0b – Cable is not *EPR Capable* • 1b = Cable is *EPR Capable*
B16…13	***Cable Latency***	• 0000b – ***Reserved*** and ***Shall Not*** be used • 0001b – <10ns (~1m) • 0010b – 10ns to 20ns (~2m) • 0011b – 20ns to 30ns (~3m) • 0100b – 30ns to 40ns (~4m) • 0101b – 40ns to 50ns (~5m) • 0110b – 50ns to 60ns (~6m) • 0111b – 60ns to 70ns (~7m) • 1000b –1000ns (~100m) • 1001b –2000ns (~200m) • 1010b – 3000ns (~300m) • 1001b ….1111b ***Reserved*** and ***Shall Not*** be used **Note:** Includes latency of electronics in *Active Cable*.
B12…11	***Cable Termination Type (Active Cable)***	• 00b…01b = ***Reserved*** and ***Shall Not*** be used • 10b = One end Active, one end passive, *VCONN* required • 11b = Both ends Active, *VCONN* required
1) Values no longer allowed. When present the field ***Shall*** be interpreted as if it was 00b.		
2) *EPR Sinks* with a captive cable ***Shall*** report 50V.		

Table 6.42 Active Cable VDO1 (Continued)

Bit(s)	Field	Description
B10…9	*Maximum VBUS Voltage (Active Cable)*	Maximum Cable *VBUS* voltage[2]: - 00b – 20V - 01b – 30V[1] (***Deprecated***) - 10b – 40V[1] (***Deprecated***) - 11b – 50V
B8…7	***Reserved***	***Shall*** be set to zero.
B8	*SBU Supported*	- 0 = SBU connections supported - 1 = SBU connections are not supported
B7	*SBU Type*	When SBU Supported = 1 this bit ***Shall*** be ***Ignored*** When SBU Supported = 0: - 0 = SBU is passive - 1 = SBU is active
B6…5	*VBUS Current Handling Capability (Active Cable)*	When *VBUS Through Cable* is "No", this field ***Shall*** be ***Ignored***. When *VBUS Through Cable* is "Yes": - 00b = ***Reserved*** and ***Shall Not*** be used - 01b = 3A - 10b = 5A - 11b = ***Reserved*** and ***Shall Not*** be used
B4	*VBUS Through Cable*	- 0 = No - 1 = Yes
B3	*SOP'' Controller Present*	- 0 = No *SOP''* controller present - 1 = *SOP''* controller present
B2…0	*USB Highest Speed (Active Cable)*	- 000b = *[USB 2.0]* only, no SuperSpeed support - 001b = *[USB 3.2]* Gen1 - 010b = *[USB 3.2]*/*[USB4]* Gen2 - 011b = *[USB4]* Gen3 - 100b = *[USB4]* Gen4 - 101b…111b = ***Reserved*** and ***Shall Not*** be used
1)	Values no longer allowed. When present the field ***Shall*** be interpreted as if it was 00b.	
2)	*EPR Sinks* with a captive cable ***Shall*** report 50V.	

Table 6.43 Active Cable VDO2

Bit(s)	Field	Description
B31…24	*Maximum Operating Temperature*	The maximum internal operating temperature in °C. It might or might not reflect the plug's skin temperature.
B23…16	*Shutdown Temperature*	The temperature, in °C, at which the cable will go into thermal shutdown so as not to exceed the allowable plug skin temperature.
B15	***Reserved***	***Shall*** be set to zero.
B14…12	*U3/CLd Power*	- 000b: >10mW - 001b: 5-10mW - 010b: 1-5mW - 011b: 0.5-1mW - 100b: 0.2-0.5mW - 101b: 50-200µW - 110b: <50µW - 111b: ***Reserved*** and ***Shall Not*** be used

Table 6.43 Active Cable VDO2 (Continued)

Bit(s)	Field	Description
B11	*U3 to U0 transition mode*	- 0b: U3 to U0 direct - 1b: U3 to U0 through U3S
B10	*Physical connection*	- 0b = Copper - 1b = Optical
B9	*Active element*	- 0b = Active Re-driver - 1b = Active Re-timer
B8	*USB4 Supported*	- 0b = *[USB4]* supported - 1b = *[USB4]*not supported
B7…6	*USB 2.0 Hub Hops Consumed*	Number of *[USB 2.0]* 'hub hops' cable consumes. ***Shall*** be set to zero if USB 2.0 not supported.
B5	*USB 2.0 Supported*	- 0b = *[USB 2.0]* supported - 1b = *[USB 2.0]* not supported
B4	*USB 3.2 Supported*	- 0b = *[USB 3.2]* SuperSpeed supported - 1b = *[USB 3.2]* SuperSpeed not supported
B3	*USB Lanes Supported*	- 0b = One lane - 1b = Two lanes
B2	*Optically Isolated Active Cable*	- 0b = No - 1b = Yes
B1	*USB4 Asymmetric Mode Supported*	- 0b = No - 1b = Yes ***Shall*** be set to zero if asymmetry is not supported.
B0	*USB Gen*	- 0b = Gen 1 - 1b = Gen 2 or higher **Note:** See VDO1 USB Highest Speed for details of Gen supported.

6.4.4.3.1.7.1 HW Version Field

The ***HW Version*** field (B31…28) contains a HW version assigned by the *VID* owner.

6.4.4.3.1.7.2 FW Version Field

The ***Firmware Version*** field (B27…24) contains a FW version assigned by the *VID* owner.

6.4.4.3.1.7.3 VDO Version Field

The ***VDO Version*** field (B23…20) contains a *VDO Version* for this *VDM Version* number. This field indicates the expected content for the *Active Cable VDO*s.

6.4.4.3.1.7.4 Connector Type Field

The ***USB Type-C plug to USB Type-C/Captive*** field (B19…18) ***Shall*** contain a value indicating whether the opposite end from the *USB Type-C* plug is another *USB Type-C* plug (i.e., a detachable Standard *USB Type-C* Cable Assembly) or is a Captive Cable Assembly.

6.4.4.3.1.7.5 EPR Mode Capable

The ***EPR Capable (Active Cable)*** is a ***Static*** bit which ***Shall*** only be set when the cable is specifically designed for safe operation when carrying up to 48 volts at 5 amps.

6.4.4.3.1.7.6 Cable Latency Field

The ***Cable Latency*** field (B16…13) ***Shall*** contain a value corresponding to the signal latency through the cable which can be used as an approximation for its length.

6.4.4.3.1.7.7 Cable Termination Type Field

The ***Cable Termination Type (Active Cable)*** field (B12…11) ***Shall*** contain a value corresponding to whether the *Active Cable* has one or two *Cable Plugs* requiring power from *VCONN*.

6.4.4.3.1.7.8 Maximum VBUS Voltage Field

The ***Maximum VBUS Voltage (Active Cable)*** field (B10…9) ***Shall*** contain the maximum voltage that ***Shall*** be *Negotiated* as part of an *Explicit Contract* where the maximum voltage that ***Shall*** be applied to the cable is ***vSrcNew*** max + ***vSrcValid*** max. When this field is set to 20V, the cable will safely carry a Programmable Power Supply *APDO* of 20V where the absolute maximum voltage that can be applied to the cable is 21.55V. Similarly, when the ***Maximum VBUS Voltage (Active Cable)*** field is 50V, a *Fixed Supply* of 48V can be *Negotiated* as part of an *Explicit Contract* where the absolute maximum voltage that can be applied to the cable is 50.9V. ***Maximum VBUS Voltage (Active Cable)*** field values of 01b and 10b (formerly 30V and 40V) ***Shall*** be treated if they were 00b (20V).

6.4.4.3.1.7.9 SBU Supported Field

The ***SBU Supported*** field (B8) ***Shall*** indicate whether the cable supports the SBUs in the cable.

6.4.4.3.1.7.10 SBU Type Field

The ***SBU Type*** field (B7) ***Shall*** indicate whether the SBUs are passive or active (e.g., digital).

6.4.4.3.1.7.11 VBUS Current Handling Capability Field

The ***VBUS Current Handling Capability (Active Cable)*** field (B6…5) ***Shall*** indicate whether the cable is capable of carrying 3A or 5A. The ***VBUS Current Handling Capability (Active Cable)*** field ***Shall*** only be ***Valid*** when the ***VBUS Current Handling Capability (Active Cable)*** field indicates an end-to-end *VBUS* wire.

6.4.4.3.1.7.12 VBUS Through Cable Field

The ***VBUS Through Cable*** field (B4) ***Shall*** indicate whether the cable contains an end-to-end *VBUS* wire.

6.4.4.3.1.7.13 SOP'' Controller Present Field

The ***SOP" Controller Present*** field (B3) ***Shall*** indicate whether one of the *Cable Plugs* is capable of *SOP" Communication* in addition to the **Normative** *SOP' Communication*.

6.4.4.3.1.7.14 USB Highest Speed Field

The ***USB Highest Speed (Active Cable)*** field (B2…0) ***Shall*** indicate the highest rate the cable supports. The *DFP* ***Shall*** consider all values indicated in this field that are higher than the highest value that the *DFP* recognizes as being ***Valid*** and functionally compatible with the highest speed that the *DFP* supports.

6.4.4.3.1.7.15 Maximum Operating Temperature Field

Maximum Operating Temperature field (B31…24) ***Shall*** report the maximum allowable operating temperature inside the plug in °C.

6.4.4.3.1.7.16 Shutdown Temperature Field

Shutdown Temperature field (B23…16) ***Shall*** indicate the temperature inside the plug, in °C, at which the plug will shut down its active signaling components. When this temperature is reached, it will be reported in the *Active Cable* ***Status*** *Message* through the Thermal Shutdown bit.

6.4.4.3.1.7.17 U3/CLd Power Field

The ***U3/CLd Power*** field (B14…12) ***Shall*** indicate the power the cable consumes while in ***[USB 3.2]*** U3 or ***[USB4]*** CLd.

6.4.4.3.1.7.18 U3 to U0 Transition Mode Field

The ***U3 to U0 transition mode*** field (B11) ***Shall*** indicate which U3 to U0 mode the cable supports. This does not include the power in U3S if supported.

6.4.4.3.1.7.19 Physical Connection Field

The ***Physical connection*** field (B10) ***Shall*** indicate the cable's construction, whether the connection between the active elements is copper or optical.

6.4.4.3.1.7.20 Active element Field

The ***Active element*** field (B9) ***Shall*** indicate the cable's active element, whether the active element is a re-timer or a re-driver.

6.4.4.3.1.7.21 USB4 Supported Field

The ***USB4 Supported*** field (B8) ***Shall*** indicate whether or not the cable supports ***[USB4]*** operation.

6.4.4.3.1.7.22 USB 2.0 Hub Hops Consumed field

The ***USB 2.0 Hub Hops Consumed*** field (B7…6) ***Shall*** indicate the number of USB 2.0 'hub hops' that are lost due to the transmission time of the cable.

6.4.4.3.1.7.23 USB 2.0 Supported Field

The ***USB 2.0 Supported*** field (B5) ***Shall*** indicate whether or not the cable supports ***[USB 2.0]*** only signaling.

6.4.4.3.1.7.24 USB 3.2 Supported Field

The ***USB 3.2 Supported*** field (B4) ***Shall***, indicate whether or not the cable supports ***[USB 3.2]*** SuperSpeed signaling.

6.4.4.3.1.7.25 USB Lanes Supported Field

The ***USB Lanes Supported*** field (B3) ***Shall*** indicate whether the cable supports one or two lanes of ***[USB 3.2]*** SuperSpeed signaling.

6.4.4.3.1.7.26 Optically Isolated Active Cable Field

The ***Optically Isolated Active Cable*** field (B2) ***Shall*** indicate whether this cable is an optically isolated *Active Cable* or not (as defined in ***[USB Type-C 2.4]***). Optically Isolated *Active Cables* ***Shall*** have a re-timer or linear re-driver (LRD) as the active element and do not support ***[USB 2.0]*** or carry *VBUS*.

6.4.4.3.1.7.27 USB4 Asymmetric Mode Supported Field

The ***USB4 Asymmetric Mode Supported*** field (B1) ***Shall*** indicate that the *Active Cable* supports asymmetric mode as defined in ***[USB4]*** and ***[USB Type-C 2.4]***.

6.4.4.3.1.7.28 USB Gen Field

The ***USB Gen*** field (B0) ***Shall*** indicate the signaling Gen the cable supports. Gen 1 ***Shall*** only be used by ***[USB 3.2]*** cables as indicated by the USB 3.2 Supported field. Gen 2 or higher ***May*** be used by either ***[USB 3.2]*** or ***[USB4]*** cables as indicated by their respective supported fields. When Gen 2 or higher is indicated the ***USB Highest Speed (Active Cable)*** field in VDO1 ***Shall*** indicate the actual Gen supported.

6.4.4.3.1.8 Alternate Mode Adapter VDO

The *Alternate Mode Adapter* (*AMA*) *VDO* has been ***Deprecated***. *PDUSB Device*s which support one or more *Alternate Mode*s ***Shall*** set an appropriate *Product Type* (*UFP*), and ***Shall*** set the ***Modal Operation Supported*** bit to '1'.

6.4.4.3.1.9 VCONN Powered USB Device VDO

The *VCONN Powered USB Device* (*VPD*) *VDO* defined in this section ***Shall*** be sent when the *Product Type* is given as *VCONN Powered USB Device*. [Table 6.44, "VPD VDO"](#) defines the *VPD* VDO which ***Shall*** be sent.

Table 6.44 VPD VDO

Bit(s)	Field	Description
B31…28	***HW Version***	0000b…1111b assigned by the *VID* owner
B27…24	***Firmware Version***	0000b…1111b assigned by the *VID* owner
B23…21	***VDO Version***	*Version* Number of the VDO (not this specification *Version*): • Version 1.0 = 000b • Values 001b…111b are ***Reserved*** and ***Shall Not*** be used.
B20…17	***Reserved***	***Shall*** be set to zero.
B16…15	***Maximum VBUS Voltage***	Maximum *VPD VBUS* Voltage: • 00b – 20V • 01b – 30V[1] (***Deprecated***) • 10b – 40V[1] (***Deprecated***) • 11b – 50V[1] (***Deprecated***)
B14	***Charge Through Current Support***	***Charge Through Current Support*** bit=1b: • 0b - 3A capable. • 1b - 5A capable ***Charge Through Current Support*** bit = 0b: • ***Reserved*** and ***Shall*** be set to zero.
B13	***Reserved***	***Shall*** be set to zero.
B12…7	***VBUS Impedance***	***Charge Through Current Support*** bit = 1b: *VBUS* impedance through the *VPD* in 2 mΩ increments. Values less than 10 mΩ are ***Reserved*** and ***Shall Not*** be used. ***Charge Through Current Support*** bit = 0b: ***Reserved*** and ***Shall*** be set to zero.
B6…1	***Ground Impedance***	***Charge Through Current Support*** bit = 1b: Ground impedance through the *VPD* in 1 mΩ increments. Values less than 10 mΩ are ***Reserved*** and ***Shall Not*** be used. ***Charge Through Current Support*** bit = 0b: ***Shall*** be set to zero.
B0	***Charge Through Support***	• 1b – the *VPD* supports *Charge Through* • 0b – the *VPD* does not support *Charge Through*
1) Values no longer allowed. When present the field ***Shall*** be interpreted as if it was 00b.		

6.4.4.3.1.9.1 HW Version Field

The ***HW Version*** field (B31…28) contains a HW version assigned by the *VID* owner.

6.4.4.3.1.9.2 FW Version Field

The ***Firmware Version*** field (B27…24) contains a FW version assigned by the *VID* owner.

6.4.4.3.1.9.3 VDO Version Field

The ***VDO Version*** field (B23…20) contains a VDO *Version* for this *VDM Version* number. This field indicates the expected content for this VDO.

6.4.4.3.1.9.4 Maximum VBUS Voltage Field

The ***Maximum VBUS Voltage*** field (B16…15) ***Shall*** contain the maximum voltage that a *Sink* ***Shall*** *Negotiate* through the *VPD Charge Through Port* as part of an *Explicit Contract*.

Note: The maximum voltage that will be applied to the cable is ***vSrcNew*** max + ***vSrcValid*** max. For example, when the ***Maximum VBUS Voltage*** field is 20V, a *Fixed Supply* of 20V can be *Negotiated* as part of an

Explicit Contract where the absolute maximum voltage that can be applied to the cable is 21.55V. ***Maximum VBUS Voltage*** field values of 01b and 10b (formerly 30V and 40V) ***Shall*** be treated if they were 00b (20V).

6.4.4.3.1.9.5 VBUS Impedance Field

The ***VBUS Impedance*** field (B12…7) ***Shall*** contain the impedance the *VPD* adds in series between the *Source* and the *Sink*. The *Sink* ***Shall*** take this value into account when requesting current so as to not to exceed the *VBUS IR Drop* limit of 0.5V between the *Source* and itself. If the *Sink* can tolerate a larger *IR Drop* on *VBUS* it ***May*** do so.

6.4.4.3.1.9.6 Ground Impedance Field

The ***Ground Impedance*** field (B6…1) ***Shall*** contain the impedance the *VPD* adds in series between the *Source* and the *Sink*. The *Sink* ***Shall*** take this value into account when requesting current so as to not to exceed the Ground *IR Drop* limit of 0.25V between the *Source* and itself.

6.4.4.3.1.9.7 Charge Through Field

The ***Firmware Version*** field (B0) ***Shall*** be set to 1b when the *VPD* supports *Charge Through* and 0b otherwise.

6.4.4.3.2 Discover SVIDs

The ***Discover SVIDs*** *Command* is used by an *Initiator* to determine the *SVID*s for which a *Responder* has Modes. The ***Discover SVIDs*** *Command* is used in conjunction with the ***Discover Modes*** *Command* in the *Discovery Process* to determine which Modes a device supports. The list of *SVID*s is always terminated with one or two 0x0000 *SVID*s.

The *SVID* in the ***Discover SVIDs*** *Command* ***Shall*** be set to the PD SID (see "*Table 6.31, "SVID Values"*") by both the *Initiator* and the *Responder* for this *Command*.

The ***Number of Data Objects*** field in the *Message Header* in the ***Discover SVIDs*** *Command* request ***Shall*** be set to 1 since the ***Discover SVIDs*** *Command* request ***Shall Not*** contain any VDOs.

The ***Discover SVIDs*** *Command* ***ACK*** sent back by the *Responder* ***Shall*** contain one or more *SVID*s. The *SVID*s are returned 2 per VDO (see *Table 6.45, "Discover SVIDs Responder VDO"*). If there are an odd number of supported *SVID*s, the ***Discover SVIDs*** *Command* is returned ending with a *SVID* value of 0x0000 in the last part of the last VDO. If there are an even number of supported *SVID*s, the ***Discover SVIDs*** *Command* is returned ending with an additional VDO containing two *SVID*s with values of 0x0000. A *Responder* ***Shall*** only return *SVID*s for which a ***Discover Modes*** *Command* request for that *SVID* will return at least one *Alternate Mode*.

A *Responder* that does not support any *SVID*s ***Shall*** return a ***NAK***.

The ***Number of Data Objects*** field in the *Message Header* in the ***Discover SVIDs*** *Command* ***NAK*** and ***BUSY*** responses ***Shall*** be set to 1 since they ***Shall Not*** contain any VDOs.

If the *Responder* supports 12 or more *SVID*s then the ***Discover SVIDs*** *Command* ***Shall*** be executed multiple times until a ***Discover SVIDs*** VDO is returned ending either with a *SVID* value of 0x0000 in the last part of the last VDO or with a VDO containing two *SVID*s with values of 0x0000. Each Discover *SVID* ***ACK*** *Message*, other than the one containing the terminating 0x0000 *SVID*, ***Shall*** convey 12 *SVID*s. The *Responder* ***Shall*** restart the list of *SVID*s each time a ***Discover Identity*** *Command* request is received from the *Initiator*.

Note: Since a *Cable Plug* does not retry *Messages* if the ***GoodCRC*** *Message* from the *Initiator* becomes corrupted the *Cable Plug* will consider the ***Discover SVIDs*** *Command* ***ACK*** unsent and will send the same list of *SVID*s again.

Figure 6.18, "Example Discover SVIDs response with 3 SVIDs" shows an example response to the ***Discover SVIDs*** *Command* request with two VDOs containing three *SVID*s. *Figure 6.19, "Example Discover SVIDs response with 4 SVIDs"* shows an example response with two VDOs containing four *SVID*s followed by an empty VDO to terminate the response. *Figure 6.20, "Example Discover SVIDs response with 12 SVIDs followed by an empty response"* shows an example response with six VDOs containing twelve *SVID*s followed by an additional request that returns an empty VDO indicating there are no more *SVID*s to return.

Table 6.45 Discover SVIDs Responder VDO

Bit(s)	Field	Description
B31…16	*SVID* n	16-bit unsigned integer, assigned by the USB-IF or 0x0000 if this is the last VDO and the *Responder* supports an even number of *SVIDs*.
B15…0	*SVID* n+1	16-bit unsigned integer, assigned by the USB-IF or 0x0000 if this is the last VDO and the *Responder* supports an odd or even number of *SVIDs*.

Figure 6.18 Example Discover SVIDs response with 3 SVIDs

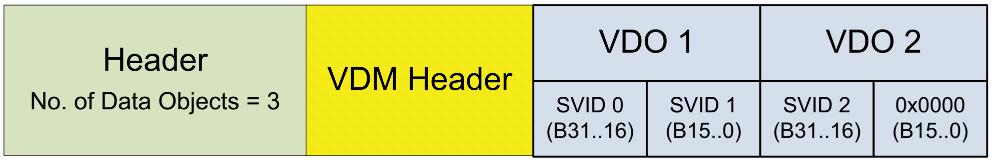


Figure 6.19 Example Discover SVIDs response with 4 SVIDs

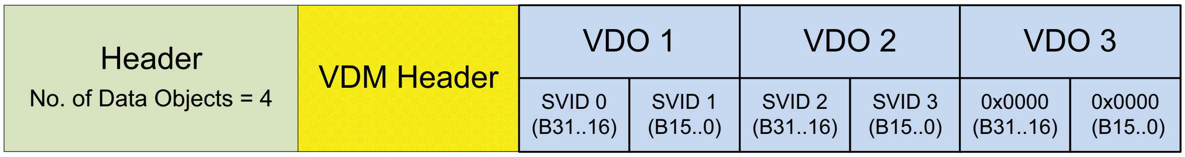
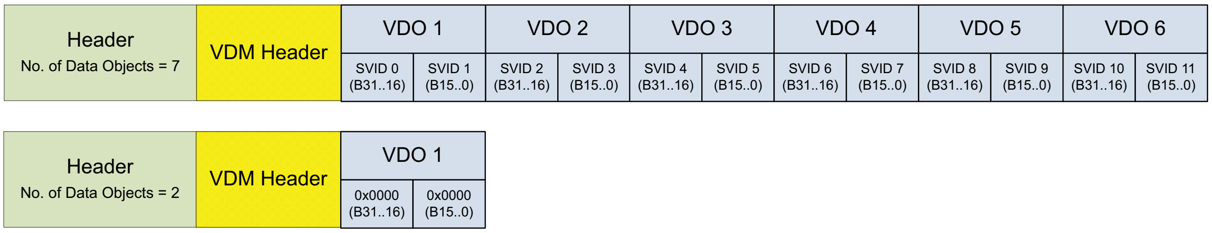


Figure 6.20 Example Discover SVIDs response with 12 SVIDs followed by an empty response



6.4.4.3.3 Discover Modes

The ***Discover Modes*** *Command* is used by an *Initiator* to determine the Modes a *Responder* supports for a given *SVID*.

The *SVID* in the ***Discover Modes*** *Command* ***Shall*** be set to the *SVID* for which Modes are being requested by both the *Initiator* and the *Responder* for this *Command*.

The ***Number of Data Objects*** field in the *Message Header* in the ***Discover Modes*** *Command* request ***Shall*** be set to 1 since the ***Discover Modes*** *Command* request ***Shall Not*** contain any VDOs.

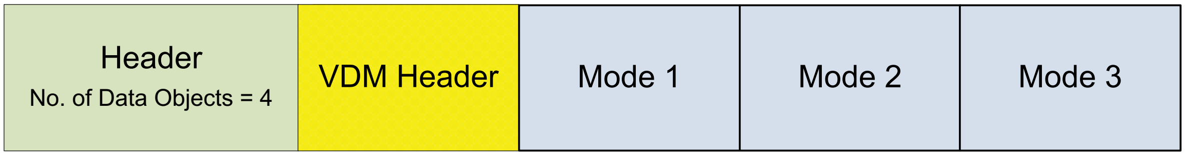
The ***Discover Modes*** *Command* ***ACK*** sent back by the *Responder* ***Shall*** contain one or more Modes. The ***Discover Modes*** *Command* ***ACK*** ***Shall*** contain a *Message Header* with the ***Number of Data Objects*** field set to a value of 2 to 7 (the actual value is the number of *Alternate Mode* objects plus one). If the ID is a *VID*, the structure and content of the VDO is left to the Vendor. If the ID is a SID, the structure and content of the VDO is defined by the relevant standard's body.

A *Responder* that does not support any Modes ***Shall*** return a ***NAK***.

The ***Number of Data Objects*** field in the *Message Header* in the ***Discover Modes*** *Command* ***NAK*** and ***BUSY*** responses ***Shall*** be set to 1 since they ***Shall Not*** contain any VDOs.

Figure 6.21, "Example Discover Modes response for a given SVID with 3 Modes" shows an example of a ***Discover Modes*** *Command* response from a *Responder* which supports three Modes for a given *SVID*.

Figure 6.21 Example Discover Modes response for a given SVID with 3 Modes



6.4.4.3.4 Enter Mode Command

The ***Enter Mode*** *Command* is used by an *Initiator* (*DFP*) to command a *Responder* (*UFP* or *Cable Plug*) to enter a specified *Alternate Mode* of operation. Only a *DFP* ***Shall*** initiate the ***Enter Mode*** Process which it starts after it has successfully completed the *Discovery Process*.

The value in the Object Position field in the *VDM Header* ***Shall*** indicate to which *Alternate Mode* in the ***Discover Modes*** *Command* the VDO refers (see *Figure 6.21, "Example Discover Modes response for a given SVID with 3 Modes"*). The value 1 always indicates the first *Alternate Mode* as it is the first object following the *VDM Header*. The value 2 refers to the next *Alternate Mode* and so forth.

The ***Number of Data Objects*** field in the *Message Header* in the *Command* request ***Shall*** be set to either 1 or 2 since the ***Enter Mode*** *Command* request ***Shall Not*** contain more than 1 VDO. When a VDO is included in an ***Enter Mode*** *Command* request the contents of the 32-bit VDO is defined by the *Alternate Mode*.

The ***Number of Data Objects*** field in the *Command* response ***Shall*** be set to 1 since an ***Enter Mode*** *Command* response (***ACK***, ***NAK***) ***Shall Not*** contain any VDOs.

Before entering a *Alternate Mode*, by sending the ***Enter Mode*** *Command* request that requires the reconfiguring of any pins on entry to that *Alternate Mode*, the *Initiator* ***Shall*** ensure that those pins being reconfigured are placed into the *USB Safe State*. Before entering an *Alternate Mode* that requires the reconfiguring of any pins, the *Responder* ***Shall*** ensure that those pins being reconfigured are placed into either USB operation or the *USB Safe State*.

A device ***May*** support multiple Modes with one or more active at any point in time. Any interactions between them are the responsibility of the Standard or Vendor. Where there are multiple *Active Mode*s at the same time *Modal Operation* ***Shall*** start on entry to the first *Alternate Mode*.

On receiving an ***Enter Mode*** *Command* requests the *Responder* ***Shall*** respond with either an ***ACK*** or a ***NAK*** response. The *Responder* is not allowed to return a ***BUSY*** response. The value in the Object Position field of the ***Enter Mode*** *Command* response ***Shall*** contain the same value as the received ***Enter Mode*** *Command* request.

If the *Responder* responds to the ***Enter Mode*** *Command* request with an ***ACK***, the *Responder* ***Shall*** enter the *Alternate Mode* before sending the ***ACK***. The *Initiator* ***Shall*** enter the *Alternate Mode* on reception of the ***ACK***. Successful transmission of the *Message* confirms to the *Responder* that the *Initiator* will enter an *Active Mode*.

See *Figure 8.111, "DFP to UFP Enter Mode"* for more details.

If the *Responder* responds to the ***Enter Mode*** *Command* request with a ***NAK***, the *Alternate Mode* is not entered. If not presently in *Modal Operation* the *Initiator* ***Shall*** return to USB operation. If not presently in *Modal Operation* the *Responder* ***Shall*** remain in either USB operation or the *USB Safe State*.

If the *Initiator* fails to receive a response within ***tVDMWaitModeEntry*** it ***Shall Not*** enter the *Alternate Mode* but return to USB operation.

Figure 6.22, "Successful Enter Mode sequence" shows the sequence of events during the transition between USB operation and entering an *Alternate Mode*. It illustrates when the *Responder*'s *Alternate Mode* changes and when the *Initiator*'s *Alternate Mode* changes. *Figure 6.23, "Unsuccessful Enter Mode sequence due to NAK"* illustrates that when the *Responder* returns a ***NAK*** the transition to an *Alternate Mode* do not take place and the *Responder* and *Initiator* remain in their default USB roles.

Figure 6.22 Successful Enter Mode sequence

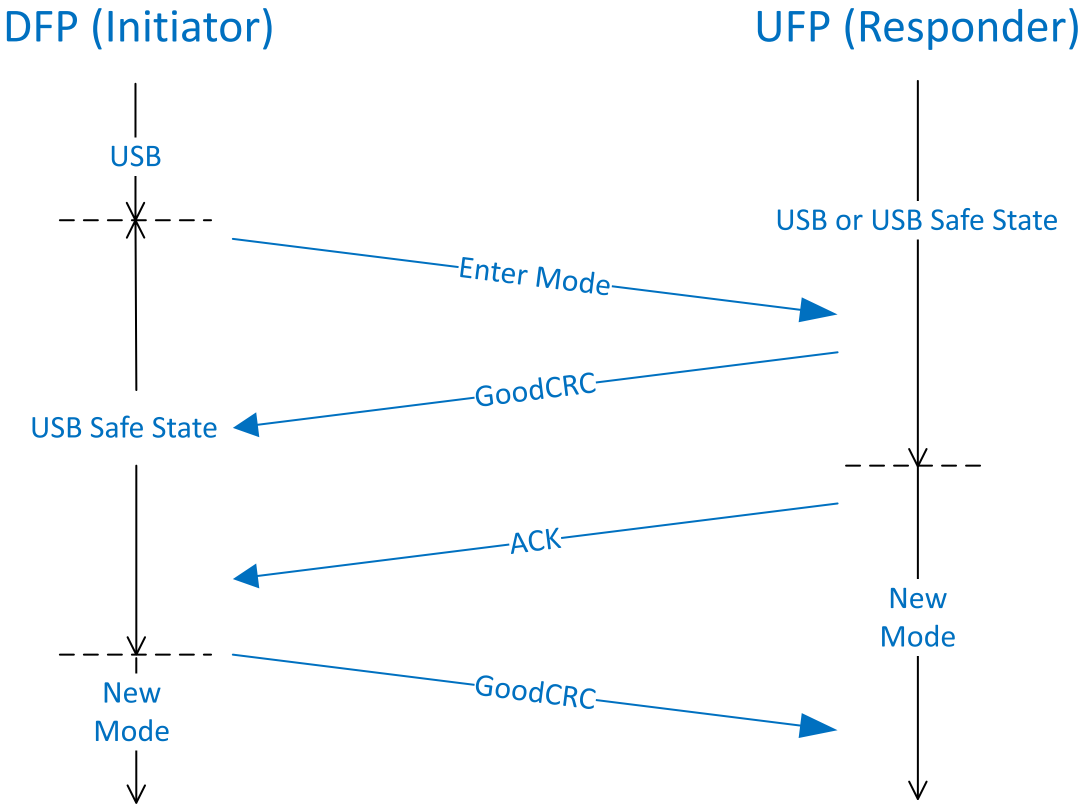
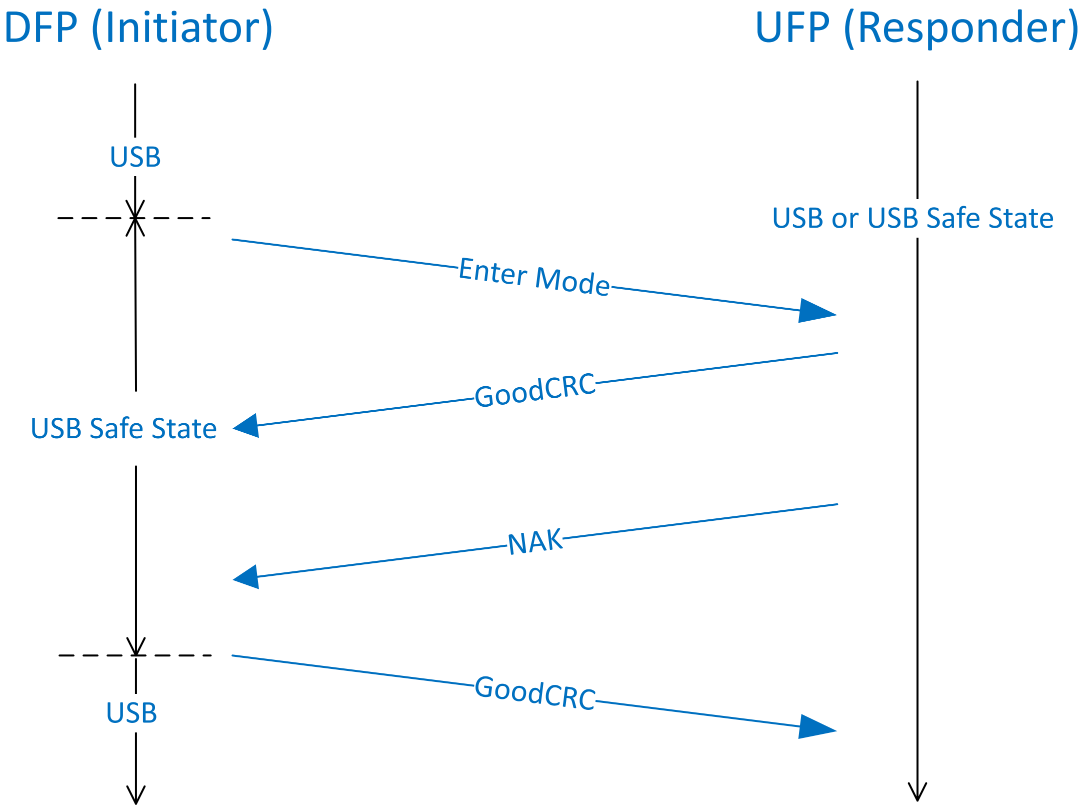


Figure 6.23 Unsuccessful Enter Mode sequence due to NAK



Once the *Alternate Mode* is entered, the device ***Shall*** remain in that *Active Mode* until the ***Exit Mode*** *Command* is successful (see [Section 6.4.4.3.5, "Exit Mode Command"](#)).

The following events ***Shall*** also cause the *Port Partner*s and *Cable Plug*(s) to exit all *Active Mode*s:

- A PD *Hard Reset*.
- *Error Recovery*.
- The *Port Partners* or *Cable Plug*(s) are *Detached*.
- A *Cable Reset* (only exits the *Cable Plug*'s *Active Modes*).
- A *Data Reset* (removing power briefly resets all the *Active Mode*s in the *Cable Plug*).

The *Initiator* ***Shall*** return to USB Operation within ***tVDMExitMode*** of a disconnect, of ***Hard Reset*** *Signaling* being detected or *Error Recovery*.

The *Responder* ***Shall*** return to either USB operation or *USB Safe State* within ***tVDMExitMode*** of a disconnect, of ***Hard Reset*** *Signaling* being detected or *Error Recovery*.

A ***DR_Swap*** *Message* ***Shall Not*** be sent during *Modal Operation* between the *Port Partner*s (see [Section 6.3.9, "DR_Swap Message"](#)).

6.4.4.3.5 Exit Mode Command

The ***Exit Mode*** *Command* is used by an *Initiator* (*DFP*) to command a *Responder* (*UFP* or *Cable Plug*) to exit its *Active Mode* and return to normal USB operation. Only the *DFP* ***Shall*** initiate the ***Exit Mode*** Process.

The value in the Object Position field ***Shall*** indicate to which *Alternate Mode* in the ***Discover Modes*** *Command* the VDO refers (see [Figure 6.21, "Example Discover Modes response for a given SVID with 3 Modes"](#)) and ***Shall*** have been used previously in an ***Enter Mode*** *Command* request for an *Active Mode*. The value 1 always indicates the first

Alternate Mode as it is the first object following the *VDM Header*. The value 2 refers to the next *Alternate Mode* and so forth. A value of 111b in the Object Position field ***Shall*** indicate that all *Active Modes* ***Shall*** be exited.

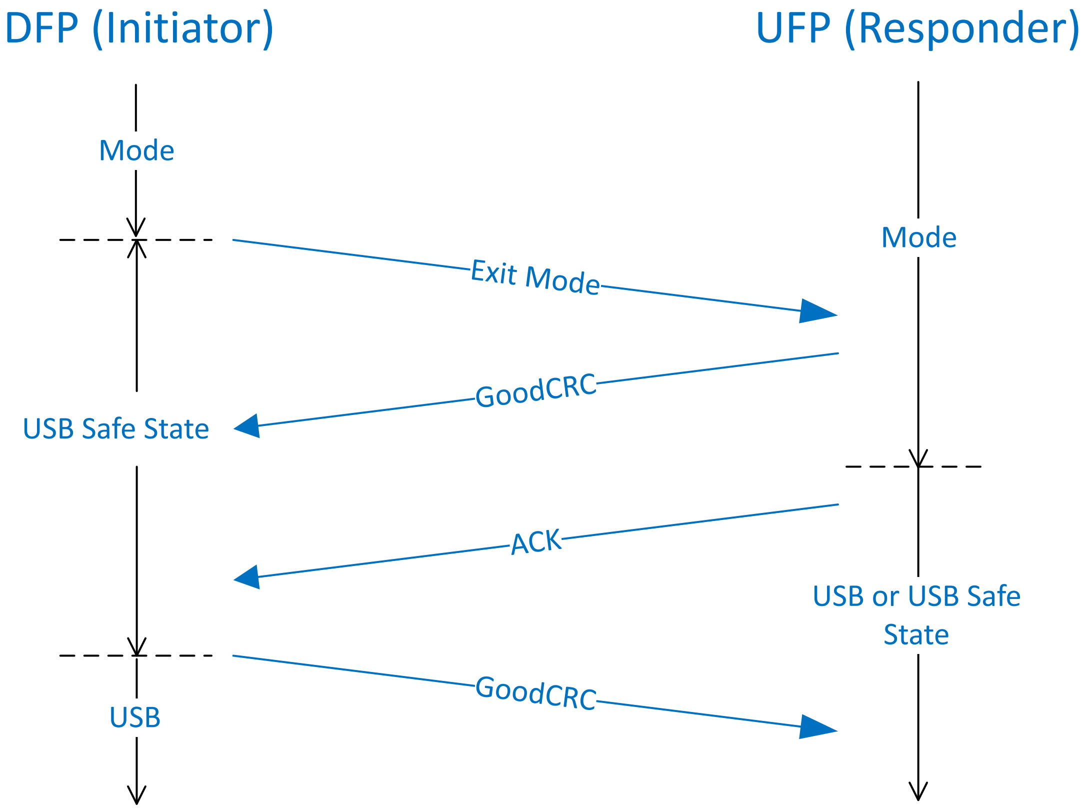
The ***Number of Data Objects*** field in both the *Command* request and *Command* response (***ACK***, ***NAK***) ***Shall*** be set to 1 since an ***Exit Mode*** *Command* ***Shall Not*** contain any VDOs.

The *Responder* ***Shall*** exit its *Active Mode* before sending the response *Message*. The *Initiator* ***Shall*** exit its *Active Mode* when it receives the ***ACK***. The *Responder* ***Shall Not*** return a ***BUSY*** acknowledgment and ***Shall*** only return a ***NAK*** acknowledgment to a request not containing an *Active Mode* (i.e., ***Invalid*** object position). An *Initiator* which fails to receive an ***ACK*** within ***tVDMWaitModeExit*** or receives a ***NAK*** or ***BUSY*** response ***Shall*** exit its *Active Mode*.

See *Figure 8.112, "DFP to UFP Exit Mode"* for more details.

Figure 6.24, "Exit Mode sequence" shows the sequence of events during the transition between exiting an *Active Mode* and USB operation. It illustrates when the *Responder*'s *Alternate Mode* changes and when the *Initiator*'s *Alternate Mode* changes.

Figure 6.24 Exit Mode sequence



6.4.4.3.6 Attention

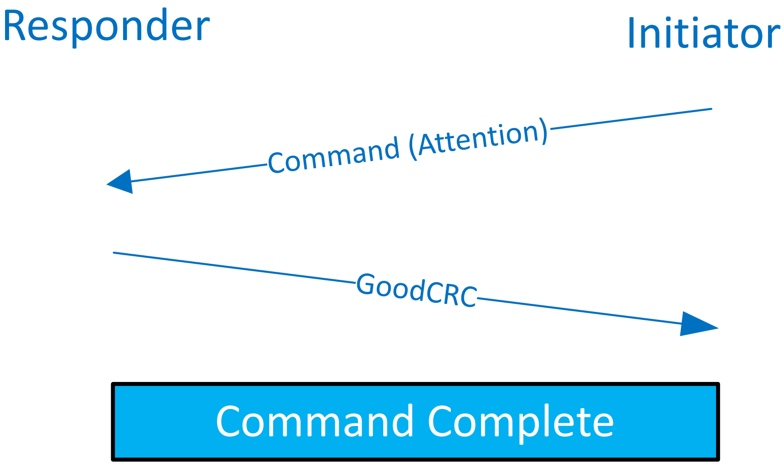
The ***Attention*** *Command* ***May*** be used by the *Initiator* to notify the *Responder* that it requires service.

The value in the Object Position field ***Shall*** indicate to which *Alternate Mode* in the ***Discover Modes*** *Command* the VDO refers (see *Figure 6.21, "Example Discover Modes response for a given SVID with 3 Modes"*) and ***Shall*** have been used previously in an ***Enter Mode*** *Command* request for an *Active Mode*. The value 1 always indicates the first *Alternate Mode* as it is the first object following the *VDM Header*. The value 2 refers to the next *Alternate Mode* and so forth. A value of 000b or 111b in the Object Position field ***Shall Not*** be used by the ***Attention*** *Command*.

The ***Number of Data Objects*** field in the *Message Header* ***Shall*** be set to 1 or 2 since the ***Attention*** *Command* ***Shall Not*** contain more than 1 VDO. When a VDO is included in an ***Attention*** *Command* the contents of the 32-bit VDO is defined by the *Alternate Mode*.

Figure 6.24, "Exit Mode sequence" shows the sequence of events when an ***Attention*** *Command* is received.

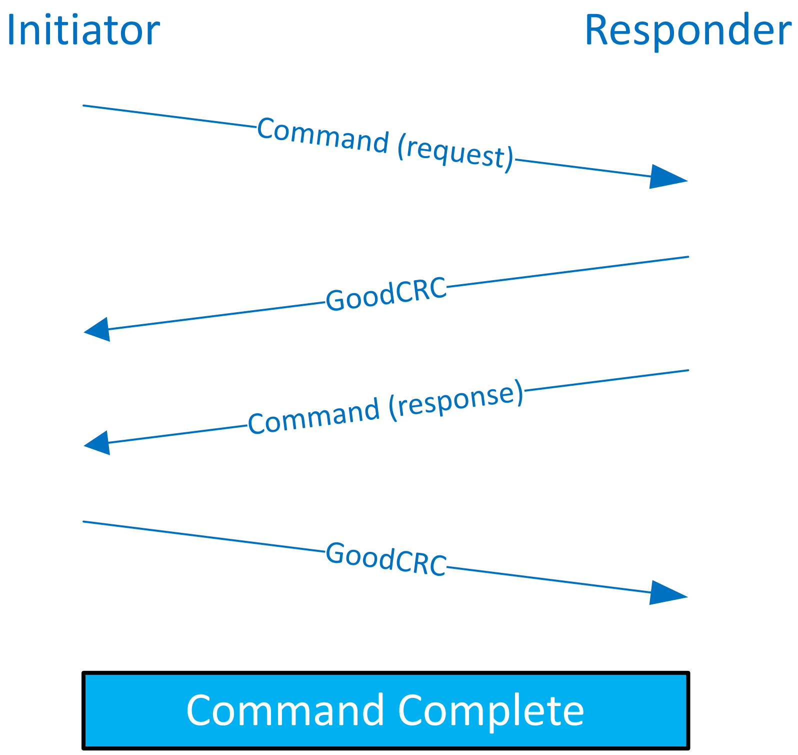
Figure 6.25 Attention Command request/response sequence



6.4.4.4 Command Processes

The *Message* flow of *Command*s during a Process is a query followed by a response. Every *Command* request sent has to be responded to with a ***GoodCRC*** *Message*. The ***GoodCRC*** *Message* only indicates the *Command* request was received correctly; it does not mean that the *Responder* understood or even supports a particular *SVID*. *Figure 6.26, "Command request/response sequence"* shows the request/response sequence including the ***GoodCRC*** *Message*s.

Figure 6.26 Command request/response sequence



In order for the *Initiator* to know that the *Command* request was actually consumed, it needs an acknowledgment from the *Responder*. There are three responses that indicate the *Responder* received and processed the *Command* request:

- ***ACK***
- ***NAK***
- ***BUSY***

The *Responder **Shall*** complete:

- ***Enter Mode*** requests within ***tVDMEnterMode***.
- ***Exit Mode*** requests within ***tVDMExitMode***.
- Other requests within ***tVDMReceiverResponse***.

An *Initiator* not receiving a response within the following times ***Shall*** timeout and return to either the *PE_SRC_Ready* or *PE_SNK_Ready* state (as appropriate):

- ***Enter Mode*** requests within ***tVDMWaitModeEntry***.
- ***Exit Mode*** requests within ***tVDMWaitModeExit***.
- Other requests within ***tVDMSenderResponse***.

The *Responder **Shall*** respond with:

- ***ACK*** if it recognizes the *SVID* and can process it at this time.
- ***NAK***:
  - if it recognizes the *SVID* but cannot process the *Command* request

    - or if it does not recognize the *SVID*
    - or if it does not support the *Command*
    - or if a VDO contains a field which is ***Invalid***.
- ***BUSY*** if it recognizes the *SVID* and the *Command* but cannot process the *Command* request at this time.

The ***ACK***, ***NAK*** or ***BUSY*** response ***Shall*** contain the same *SVID* as the *Command* request.

6.4.4.4.1 Discovery Process

The *Initiator* (usually the *DFP*) always begins the *Discovery Process*. The *Discovery Process* has two phases. In the first phase, the ***Discover SVIDs*** *Command* request is sent by the *Initiator* to get the list of *SVIDs* the *Responder* supports. In the second phase, the *Initiator* sends a ***Discover Modes*** *Command* request for each *SVID* supported by both the *Initiator* and *Responder*.

6.4.4.4.2 Enter Vendor Mode / Exit Vendor Mode Processes

The result of the *Discovery Process* is that both the *Initiator* and *Responder* identify the Modes they mutually support. The *Initiator* (*DFP*), upon finding a suitable *Alternate Mode*, uses the ***Enter Mode*** *Command* to enable the *Alternate Mode*.

The *Responder* (*UFP* or *Cable Plug*) and *Initiator* continue using the *Active Mode* until the *Active Mode* is exited.

In a managed termination, using the ***Exit Mode*** *Command*, the *Active Mode* ***Shall*** be exited in a controlled manner as described in *Section 6.4.4.3.5, "Exit Mode Command"*.

In an unmanaged termination, triggered by:

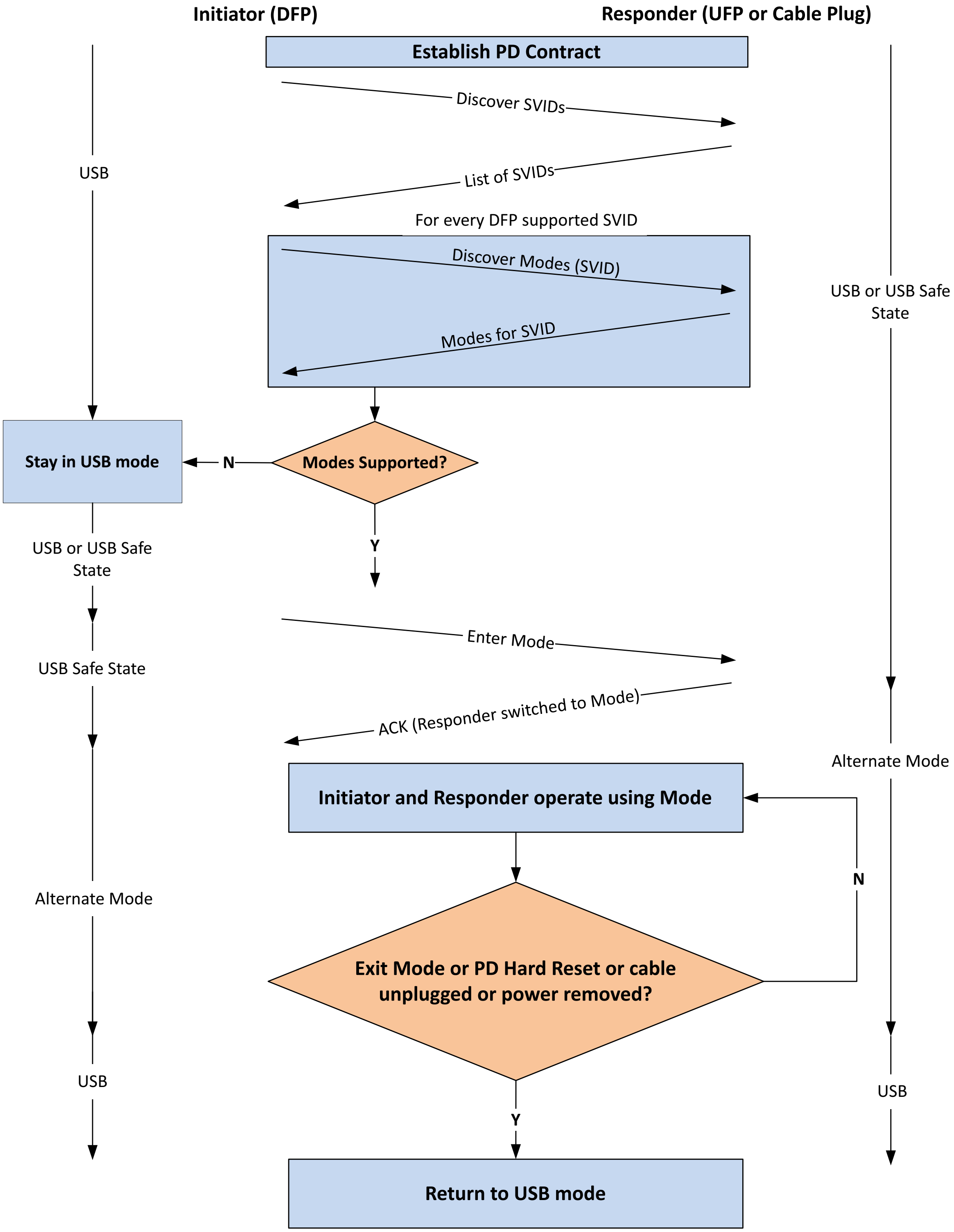
- A Power Delivery *Hard Reset* (i.e. ***Hard Reset*** *Signaling* sent by either *Port Partner*) or
- By cable *Detach* (device unplugged) or
- By ***Error Recovery***

the *Active Mode* ***Shall*** still be exited but there ***Shall Not*** be a transition through the *USB Safe State*.

In both the managed and unmanaged terminations, the *Initiator* and *Responder* return to USB operation as defined in ***[USB Type-C 2.4]*** following an exit from an *Alternate Mode*.

The overall *Message* flow is illustrated in *Figure 6.27, "Enter/Exit Mode Process"*.

Figure 6.27 Enter/Exit Mode Process



6.4.4.5 VDM Message Timing and Normal PD Messages

The timing and interspersing of *VDMs* between regular PD *Messages* ***Shall*** be done without perturbing the PD *AMSs*. This requirement ***Shall*** apply to both *Unstructured VDMs* and *Structured VDMs*.

The use of *Structured VDMs* by an *Initiator* ***Shall Not*** interfere with the normal PD *Message* timing requirements nor ***Shall*** either the *Initiator* or *Responder* interrupt a PD *AMS* (e.g., *Negotiation*, *Power Role Swap*, *Data Role Swap* etc.). The use of *Unstructured VDMs* ***Shall Not*** interfere with normal PD *Message* timing.

6.4.5 Battery_Status Message

The ***Battery_Status*** *Message* ***Shall*** be sent in response to a ***Get_Battery_Status*** *Message*. The ***Battery_Status*** *Message* contains one Battery Status Data Object (BSDO) for one of the Batteries it supports as reported by ***Number of Batteries/Battery Slots*** field in the ***Source_Capabilities_Extended*** *Message*. The returned BSDO ***Shall*** correspond to the *Battery* requested in the ***Battery Status Ref*** field contained in the ***Get_Battery_Status*** *Message*.

The ***Battery_Status*** *Message* returns a BSDO whose format ***Shall*** be as shown in *Figure 6.28, "Battery_Status Message"* and *Table 6.46, "Battery Status Data Object (BSDO)"*. The ***Number of Data Objects*** field in the ***Battery_Status*** *Message* ***Shall*** be set to 1.

Figure 6.28 Battery_Status Message

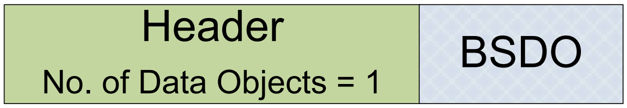


Table 6.46 Battery Status Data Object (BSDO)

<table>
<tr><th>Bit(s)</th><th>Field</th><th colspan="2">Description</th></tr>
<tr><td>B31…16</td><td><b><i>Battery Present Capacity</i></b></td><td colspan="2"><i>Battery</i>’s State of Charge (SoC) in 0.1 WH increments
<b>Note:</b> 0xFFFF = <i>Battery</i>’s SOC unknown</td></tr>
<tr><td rowspan="5">B15…8</td><td rowspan="5"><b><i>Battery Info</i></b></td><th>Bit</th><th>Description</th></tr>
<tr><td>0</td><td><b><i>Invalid Battery Reference</i></b>
<b><i>Invalid</i></b> <i>Battery</i> reference</td></tr>
<tr><td>1</td><td><b><i>Battery Present</i></b>
<i>Battery</i> is present when set</td></tr>
<tr><td>3…2</td><td><b><i>Battery Charging Status</i></b>
When <b><i>Battery Present</i></b> is ‘1’ <b><i>Shall</i></b> contain the <i>Battery</i> charging status:
• 00b: <i>Battery</i> is Charging.
• 01b: <i>Battery</i> is Discharging.
• 10b: <i>Battery</i> is Idle.
• 11b: <b><i>Reserved, Shall Not</i></b> be used.
When <b><i>Battery Present</i></b> is ‘0’:
• 11b…00b: <b><i>Reserved, Shall Not</i></b> be used.</td></tr>
<tr><td>7…4</td><td><b><i>Reserved, Shall Not</i></b> be used.</td></tr>
<tr><td>B7…0</td><td><b><i>Reserved</i></b></td><td colspan="2"><b><i>Shall</i></b> be set to zero</td></tr>
</table>

6.4.5.1 Battery Present Capacity

The ***Battery Present Capacity*** field ***Shall*** return either the *Battery*'s State of Charge (SoC) in tenths of WH or indicate that the *Battery*'s present State of Charge (SOC) is unknown.

6.4.5.2 Battery Info

The ***Battery Info*** field ***Shall*** be used to report additional information about the *Battery*'s present status. The ***Battery Info*** field's bits ***Shall*** reflect the present conditions under which the *Battery* is operating in the systems.

6.4.5.2.1 Invalid Battery Reference

The ***Invalid Battery Reference*** bit ***Shall*** be set when the ***Get_Battery_Status*** *Message* contains a reference to a *Battery* or *Battery Slot* (see *Section 6.5.1.13, "Number of Batteries/Battery Slots Field"*) that does not exist.

6.4.5.2.2 Battery Present

The ***Battery Present*** bit ***Shall*** be set whenever the *Battery* is present. It ***Shall*** always be set for Batteries that are not Hot Swappable Batteries. For Hot Swappable Batteries, the ***Battery Present*** bit ***Shall*** indicate whether the *Battery* is *Attached* or *Detached*.

6.4.5.2.3 Battery Charging Status

The ***Battery Charging Status*** bits indicate whether the *Battery* is being charged, discharged or is idle (neither charging nor discharging). These bits ***Shall*** be set when the ***Battery Present*** bit is set. Otherwise, when the ***Battery Present*** bit is zero the ***Battery Charging Status*** bits ***Shall*** also be zero.

6.4.6 Alert Message

The ***Alert*** *Message* is provided to allow *Port Partners* to inform each other when there is a status change event. Some of the events are critical such as *OCP*, *OVP* and *OTP*, while others are informational such as change in a *Battery*'s status from charging to neither charging nor discharging.

The ***Alert*** *Message* ***Shall*** only be sent when the *Source* or *Sink* detects a status change.

The ***Alert*** *Message* ***Shall*** contain exactly one Alert Data Object (ADO) and the format ***Shall*** be as shown in *Figure 6.29, "Alert Message"* and *Table 6.47, "Alert Data Object (ADO)"*.

Figure 6.29 Alert Message

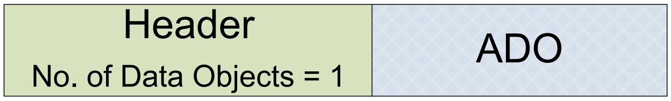


Table 6.47 Alert Data Object (ADO)

Bit(s)	Field	Description	
		Bit	Description
B31…24	***Type of Alert***	0	***Reserved*** and ***Shall*** be set to zero.
		1	***Battery Status Change Event*** *Battery* Status Change Event (*Attach*/*Detach*/charging/discharging/idle)
		2	***OCP Event*** *OCP* event when set (*Source* only, for *Sink* ***Reserved*** and ***Shall*** be set to zero).
		3	***OTP Event*** *OTP* event when set
		4	***Operating Condition Change*** Operating Condition Change when set
		5	***Source Input Change Event*** *Source* Input Change Event when set
		6	***OVP Event*** *OVP* event when set
		7	***Extended Alert Event*** Extended Alert Event when set
B23…20	***Fixed Batteries***	When ***Battery Status Change Event*** bit set indicates which *Fixed Batteries* have had a status change. B20 corresponds to *Battery* 0 and B23 corresponds to *Battery* 3.	
B19…16	***Hot Swappable Batteries***	When ***Battery Status Change Event*** bit set indicates which Hot Swappable Batteries have had a status change. B16 corresponds to *Battery* 4 and B19 corresponds to *Battery* 7.	

Table 6.47 Alert Data Object (ADO) (Continued)

Bit(s)	Field	Description
B15…4	***Reserved***	***Shall*** be set to zero
B3…0	***Extended Alert Event Type***	When the ***Extended Alert Event*** bit in the ***Type of Alert*** field equals '1', then the ***Extended Alert Event Type*** field indicates the event which has occurred: • 0 = ***Reserved***. • 1 = Power state change (*DFP* only) • 2 = Power button press (*UFP* only) • 3 = Power button release (*UFP* only) • 4 = Controller initiated wake e.g., Wake on LAN (*UFP* only) • 5-15 = ***Reserved*** When the ***Extended Alert Event*** bit in the ***Type of Alert*** field equals '0', then the ***Extended Alert Event Type*** field is ***Reserved*** and ***Shall*** be set to zero.

6.4.6.1 Type of Alert

The ***Type of Alert*** field ***Shall*** be used to report *Source* or *Sink* status changes. Only one ***Alert*** *Message* ***Shall*** be generated for each Event or Change; however multiple Type of Alert bits ***May*** be set in one ***Alert*** *Message*. Once the ***Alert*** *Message* has been sent the ***Type of Alert*** field ***Shall*** be cleared.

A ***Get_Battery_Status*** *Message* ***Should*** be sent in response to a *Battery* status change in an ***Alert*** *Message* to get the details of the change.

A ***Get_Status*** *Message* ***Should*** be sent in response to a non-*Battery* status change in an ***Alert*** *Message* from to get the details of the change.

6.4.6.1.1 Battery Status Change

The ***Battery Status Change Event*** bit ***Shall*** be set when any *Battery*'s power state changes between charging, discharging, neither. For Hot Swappable Batteries, it ***Shall*** also be set when a *Battery* is *Attached* or *Detached*.

6.4.6.1.2 Over-Current Protection Event

The ***OCP Event*** bit ***Shall*** be set when a *Source* detects its output current exceeds its limits triggering its protection circuitry. This bit is ***Reserved*** for a *Sink*.

6.4.6.1.3 Over-Temperature Protection Event

The ***OTP Event*** bit ***Shall*** be set when a *Source* or *Sink* shuts down due to over-temperature triggering its protection circuitry.

6.4.6.1.4 Operating Condition Change

The ***Operating Condition Change*** bit ***Shall*** be set when a *Source* or *Sink* detects its Operating Condition enters or exits either the 'warning' or 'over temperature' temperature states.

The ***Operating Condition Change*** bit ***Shall*** be set when the *Source* operating in the Programmable Power Supply mode detects it has changed its operating condition between *Constant Voltage* (*CV*) and *Current Limit* (*CL*).

6.4.6.1.5 Source Input Change Event

The ***Source Input Change Event*** bit ***Shall*** be set when the *Source*/*Sink*'s input changes. For example, when the AC input is removed, and the *Source*/*Sink* continues to be powered from one or more of its batteries or when AC returns and the *Source*/*Sink* transitions from *Battery* to AC operation or when the *Source*/*Sink* changes operation from one (or more) *Battery* to another (or more) *Battery*.

6.4.6.1.6 Over-Voltage Protection Event

The ***OVP Event*** bit ***Shall*** be set when the *Sink* detects its output voltage exceeds its limits triggering its protection circuitry.

The ***OVP Event*** bit ***May*** be set when the *Source* detects its output voltage exceeds its limits triggering its protection circuitry.

6.4.6.1.7 Extended Alert Event

The ***Extended Alert Event*** bit ***Shall*** be set when the event is defined as an Extended Alert Type.

6.4.6.2 Fixed Batteries

The ***Fixed Batteries*** field indicates which *Fixed Batteries* have had a status change. B20 corresponds to *Battery* 0 and B23 corresponds to *Battery* 3.

Once the ***Alert*** *Message* has been sent the ***Fixed Batteries*** field ***Shall*** be cleared.

6.4.6.3 Hot Swappable Batteries

The ***Hot Swappable Batteries*** field indicates which Hot Swappable Batteries have had a status change. B16 corresponds to *Battery* 0 and B19 corresponds to *Battery* 3.

Once the ***Alert*** *Message* has been sent the ***Hot Swappable Batteries*** field ***Shall*** be cleared.

6.4.6.4 Extended Alert Event Types

The ***Extended Alert Event Type*** field provides extensions to the available types for the ***Alert*** *Message*. If the ***Extended Alert Event Type*** bit is not set, then the Extended Alert Event Type is ***Reserved*** and ***Shall*** be set to zero.

6.4.6.4.1 Power State Change

The Power state change event value ***May*** be set when the *DFP* transitions into a new power state. The new power state ***Shall*** be communicated via the Power state change byte in the ***Status*** *Message*. This *Message* ***Should*** be sent by the host in response to any system power state change.

6.4.6.4.2 Power Button Press

The Power button press event value ***May*** be set when the power button on the *UFP* is pressed. The press and release events are separated into two different events so that devices that respond differently to a long button press will see a long button press. On the host-side, the power button press event typically initiates the same behavior as a power button press of the host's power button.

6.4.6.4.3 Power Button Release

If a Power button press event was sent, then the Power button release event value ***Shall*** be sent by the *UFP* following the Power button press event. If a physical power button press initiated the Power button press event, then the Power button release event ***Should*** be sent when the physical button is released.

6.4.6.4.4 Controller Initiated Wake

The Controller initiated wake is used to communicate a wake event from the *UFP* to the DPF such as Wake on LAN from a NIC or another controller. This event doesn't need the press/release form of the Power button press, because it only needs to communicate the presence of the event, and not the timing.

6.4.7 Get_Country_Info Message

The ***Get_Country_Info*** *Message* ***Shall*** be sent by a *Port* to get country specific information from its *Port Partner* using the country's Alpha-2 Country Code defined by ***[ISO 3166]***. The *Port Partner* responds with a ***Country_Info*** *Message* that contains the country specific information. The ***Get_Country_Info*** *Message* ***Shall*** be as shown in *Figure 6.30, "Get_Country_Info Message"* and *Table 6.48, "Country Code Data Object (CCDO)"*.

For example, if the request is for China information, then the Country Code Data Object (CCDO) would be CCDO [31:0] = 434E0000h for "CN" country code.

Figure 6.30 Get_Country_Info Message

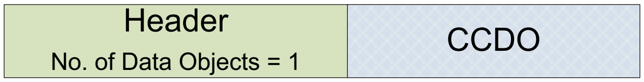


Table 6.48 Country Code Data Object (CCDO)

Bit(s)	Description
B31…24	First character of the Alpha-2 Country Code defined by ***[ISO 3166]***
B23…16	Second character of the Alpha-2 Country Code defined by ***[ISO 3166]***
B15…0	***Reserved***, ***Shall*** be set to zero.

6.4.8 Enter_USB Message

The ***Enter_USB*** *Message* ***Shall*** be sent by the *DFP* to its *UFP Port Partner* and to the *Cable Plug*(s) of an *Active Cable*, when in an *Explicit Contract*, to enter a specified USB *Mode* of operation. The recipient of the *Message* ***Shall*** respond by sending an ***Accept*** *Message*, a ***Wait*** *Message* or a ***Reject*** *Message* (see *Section 6.9, "Accept, Reject and Wait"*).

When entering ***[USB4]*** operation, the ***Enter_USB*** *Message* ***Shall*** be sent by a ***[USB4]*** *PDUSB Hub*'s *DFP*(s) or ***[USB4]*** *PDUSB Host*'s *DFP*(s) within ***tEnterUSB***:

- following a PD Connection.
- after a *Data Reset* to enter ***[USB4]*** operation is completed.
- after a *Data Role Swap* is completed.

The ***Enter_USB*** *Message* ***May*** be sent by a *PDUSB Hub*'s *DFP*(s) or *PDUSB Host*'s *DFP*(s) within ***tEnterUSB*** following a PD Connection or after a *Data Reset* to enter ***[USB 3.2]*** or ***[USB 2.0]*** operation.

The ***Enter_USB*** *Message* ***Shall*** be used by a *PDUSB Hub*'s *DFP*(s) to speculatively train the USB links or enter ***[DPTC2.1]*** or ***[TBT3]*** *Alternate Mode*s prior to the presence of a host. In this case, the ***Host Present*** bit ***Shall*** be cleared. When the Host is *Connected* the ***Enter_USB*** *Message* ***Shall*** be resent with the ***Host Present*** bit set. The ***Enter_USB*** *Message*'s Enter USB Data Object (EUDO), received from the Root Hub when the *USB Host* is connected, ***Shall*** be propagated down through the *Hub* tree.

See ***[USB Type-C 2.4]*** USB4® *Hub* Connection Requirements.

The ***Enter_USB*** *Message* ***Shall*** be as shown in *Figure 6.31, "Enter_USB Message"* and *Table 6.49, "Enter_USB Data Object (EUDO)"*.

Figure 6.31 Enter_USB Message

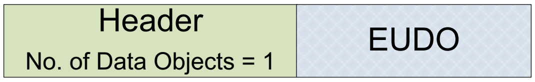


Table 6.49 Enter_USB Data Object (EUDO)

Bit(s)	Field	Description
B31	***Reserved***	***Shall*** be set to zero.
B30…28	*USB Mode* [1]	- 000b: - 001b: - 010b: - 111b…011b: ***Reserved, Shall Not*** be used.
B27	***Reserved***	***Shall*** be set to zero.
B26	*USB4 DRD* [2]	- 0b: Not capable of operating as a *[USB4] Device* - 1b: Capable of operating as a *[USB4] Device*
B25	*USB3 DRD* [2]	- 0b: Not capable of operating as a *[USB 3.2] Device* - 1b: Capable of operating as a *[USB 3.2] Device*
B24	***Reserved***	***Shall*** be set to zero.
B23…21	*Cable Speed* [2,3]	- 000b: *[USB 2.0]*only, no SuperSpeed support - 001b: *[USB 3.2]* Gen1 - 010b: *[USB 3.2]*Gen2 and *[USB4]* Gen2 - 011b: *[USB4]* Gen3 - 100b: *[USB4]* Gen4 - 101b…111b: ***Reserved, Shall Not*** be used.
B20…19	*Cable Type* [2,3]	- 00b: Passive - 01b: Active Re-timer - 10b: Active Re-driver - 11b: Optically Isolated
B18…17	*Cable Current* [2]	- 00b = *VBUS* is not supported - 01b = ***Reserved*** - 10b = 3A - 11b = 5A
B16	*PCIe Support* [2]	*[USB4]* PCIe tunneling supported by the host
B15	*DP Support* [2]	*[USB4]* DP tunneling supported by the host
B14	*TBT Support* [2]	*[TBT3]* is supported by the host's USB4® Connection Manager
B13	*Host Present* [2]	A *Host* is present at the top of the USB tree. When this bit is set *PCIe Support*, *DP Support* and *TBT Support* represent the *Host*'s *Capabilities* that ***Shall*** be propagated down the *Hub* tree.
B12…0	***Reserved***	***Shall*** be set to zero.

1) Entry into *[USB 3.2]* and *[USB4]* include entry into *[USB 2.0]*.

2) ***Shall*** be ***Ignored*** when received by a *Cable Plug* (e.g., *SOP'* or *SOP''*).

3) The *DFP* ***Shall*** interpret the *Cable Plug*'s reported capability as defined in *[USB Type-C 2.4]* in the USB4 Discovery and Entry Section.

6.4.8.1 USB Mode Field

The ***USB Mode*** field ***Shall*** be used by the *DFP* to direct the USB *Mode* the *Port Partner* is to enter.

6.4.8.2 USB4® DRD Field

The ***USB4 DRD*** field ***Shall*** be set when the *Host DFP* is capable of operating as a ***[USB4]*** *Device*. A ***[USB4]*** *Host DFP* that sets the ***USB4 DRD*** field ***Shall*** also be capable of operating as a ***[USB 2.0]*** *Device*.

6.4.8.3 USB3 DRD Field

The ***USB3 DRD*** field ***Shall*** be set when the *Host DFP* is capable of operating as a ***[USB 3.2]*** *Device*. A ***[USB 3.2]*** *Host DFP* that sets the ***USB3 DRD*** field ***Shall*** also be capable of operating as a ***[USB 2.0]*** *Device*.

6.4.8.4 Cable Speed Field

The ***Cable Speed*** field ***Shall*** be used to indicate the cable's maximum speed. The value is read from the *Cable Plug* and interpreted by the *DFP* as defined by ***[USB Type-C 2.4]*** in the USB4 Discovery and Entry Section.

6.4.8.5 Cable Type Field

The ***Cable Type*** field ***Shall*** be used to indicate whether the cable is passive or active. Further if the cable is active, it indicates the type of active circuits in the cable and if the cable is optically isolated. The value is read from the *Cable Plug* and interpreted by the *DFP* as defined by ***[USB Type-C 2.4]*** in the USB4 Discovery and Entry Section.

6.4.8.6 Cable Current Field

The ***Cable Current*** field ***Shall*** be used to indicate the cable's current carrying capability. The value is reported by the *Cable Plug* in the ***VBUS Current Handling Capability (Passive Cable)***/***VBUS Current Handling Capability (Active Cable)*** field.

6.4.8.7 PCIe Support Field

The ***PCIe Support*** field ***Shall*** be set when the *Host DFP* is capable of tunneling PCIe over ***[USB4]***.

The ***PCIe Support*** field ***May*** be set speculatively when the *Hub*'s *DFP* is capable of tunneling PCIe over ***[USB4]***.

6.4.8.8 DP Support Field

The ***DP Support*** field ***Shall*** be set when the *Host DFP* is capable of tunneling DP over ***[USB4]***.

The ***DP Support*** field ***May*** be set speculatively when the *Hub*'s *DFP* is capable of tunneling DP over ***[USB4]***.

6.4.8.9 TBT Support Field

The ***TBT Support*** field ***Shall*** be set when the *Host DFP* is capable of tunneling Thunderbolt™ over ***[USB4]*** and that the Connection Manager (CM) supports discovery and configuration of Thunderbolt 3 devices connected to the *DFP* of ***[USB4]*** *Hubs*.

The ***TBT Support*** field ***May*** be set speculatively when the *Hub*'s *DFP* is capable of tunneling Thunderbolt over ***[USB4]***.

6.4.8.10 Host Present Field

The ***Host Present*** field ***Shall*** be set to indicate that a *Host* is present upstream.

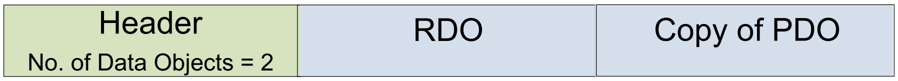
6.4.9 EPR_Request Message

An ***EPR_Request*** *Message* ***Shall*** be sent by a *Sink*, operating in *EPR Mode*, to request power, typically during the request phase of a power *Negotiation*. The ***EPR_Request*** *Message* ***Shall*** be sent in response to the most recent ***EPR_Source_Capabilities*** *Message*. The ***EPR_Request*** *Message* ***Shall*** return a *Sink Request Data Object* (*RDO*) that ***Shall*** identify the *Power Data Object* being requested followed by a copy of the *Power Data Object* being requested.

Note: The requested *Power Data Object* ***May*** be either an EPR *(A)PDO* or SPR *(A)PDO*.

The ***EPR_Request*** *Message* ***Shall*** be as shown in *Figure 6.32, "EPR_Request Message"*.

Figure 6.32 EPR_Request Message



The *Source* ***Shall*** verify the *PDO* in the ***EPR_Request*** *Message* exactly matches the *PDO* in the latest ***EPR_Source_Capabilities*** *Message* pointed to by the Object Position field in the *RDO*.

The *Source* ***Shall*** respond to an ***EPR_Request*** *Message* in the same manner as it responds to a ***Request*** *Message* with an ***Accept*** *Message*, or a ***Reject*** *Message* (see *Section 6.9, "Accept, Reject and Wait"*). The *Explicit Contract Negotiation* process for EPR is the same as the process for *SPR Mode* except that the ***Source_Capabilities*** *Message* is replaced by the ***EPR_Source_Capabilities*** and the ***Request*** *Message* is replaced by the ***EPR_Request*** *Message*.

An *EPR Source* operating in *SPR Mode* that receives a ***EPR_Request*** *Message* ***Shall*** initiate a *Hard Reset*.

The *RDO* takes a different form depending on the kind of power requested. The *PDO* and *APDO* formats are detailed in *Section 6.4.2, "Request Message"*.

6.4.10 EPR_Mode Message

The ***EPR_Mode*** *Message* is used to enter, acknowledge, and exit the *EPR Mode*. The Action field is used to describe the action that is to be taken by the recipient of the ***EPR_Mode*** *Message*. The Data field provides additional information for the *Message* recipient in the *EPR Mode* Data Object (ERMDO).

The ***EPR_Mode*** *Message* ***Shall*** be as shown in *Figure 6.33, "EPR Mode DO Message"* and *Table 6.50, "EPR Mode Data Object (EPRMDO)"*.

Figure 6.33 EPR Mode DO Message

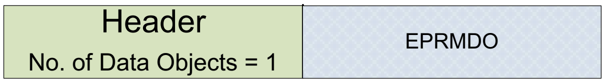


Table 6.50 EPR Mode Data Object (EPRMDO)

Bit(s)	Field	Description		
		Value	Action	Sent By
B31…24	***Action***	0x00	***Reserved*** and ***Shall Not*** be used.	
		0x01	***Enter***	*Sink* only
		0x02	***Enter Acknowledged***	*Source* only
		0x03	***Enter Succeeded***	*Source* only
		0x04	***Enter Failed***	*Source* only
		0x05	***Exit***	*Sink* or *Source*
		0x06…0xFF	***Reserved*** and ***Shall Not*** be used.	
B23…16	***Data***	Action Field	Data Field Value	
		Enter	***Shall*** be set to the *EPR Sink* Operational *PDP*	
		Enter Acknowledged	***Shall*** be set to zero	
		Enter Succeeded	***Shall*** be set to zero	
		Enter Failed	***Shall*** be one of the following values: • 0x00 - Unknown cause • 0x01 - Cable not *EPR Capable* • 0x02 –*Source* failed to become *VCONN Source*. • 0x03 – ***EPR Capable*** bit not set in *RDO*. • 0x04 – *Source* unable to enter *EPR Mode*[1]. • 0x05 - ***EPR Capable*** bit not set in *PDO*. All other values are ***Reserved*** and ***Shall Not*** be used	
		Exit	***Shall*** be set to zero	
B15…0	***Reserved***	***Shall*** be set to zero		
1) The Sink ***May*** retry entering *EPR Mode* after receiving this ***Enter Failed*** response.				

6.4.10.1 Process to enter EPR Mode

An *EPR Source* ***Shall*** enter *EPR Mode* upon request by an *EPR Sink* connected with an *EPR Cable* when able to offer the *Source Capabilities* as defined in the *Power Rules* (See *Table 10.12, "EPR Source Capabilities based on the Port Maximum PDP and using an EPR Capable Cable"* and *Table 10.13, "EPR Source Capabilities when Port Present PDP is less than Port Maximum PDP and using an EPR-capable cable"*).

For *Port Partners* to successfully enter *EPR Mode*, the following conditions must be met:

- The *Sink* ***Shall*** request entry into the *EPR Mode*.

- The *Source* ***Shall*** verify the cable is *EPR Capable*.
- A *Sink* ***Shall Not*** be *Connected* to the *Source* through a *Charge Through VPD* (*CT-VPD*).
- The *Source* and *Sink* ***Shall*** already be in an SPR *Explicit Contract*.
- The ***EPR Capable*** bit ***Shall*** be set in the *Fixed Supply* 5V *PDO*.
- The ***EPR Capable*** bit ***Shall*** have been set in the *RDO* in the last ***Request*** *Message* received by the *Source*.

To verify the cable is *EPR Capable*, the *EPR Source* ***Shall*** have already done the following (see *Section 6.6.21.4, "tEPRSourceCableDiscovery"*):

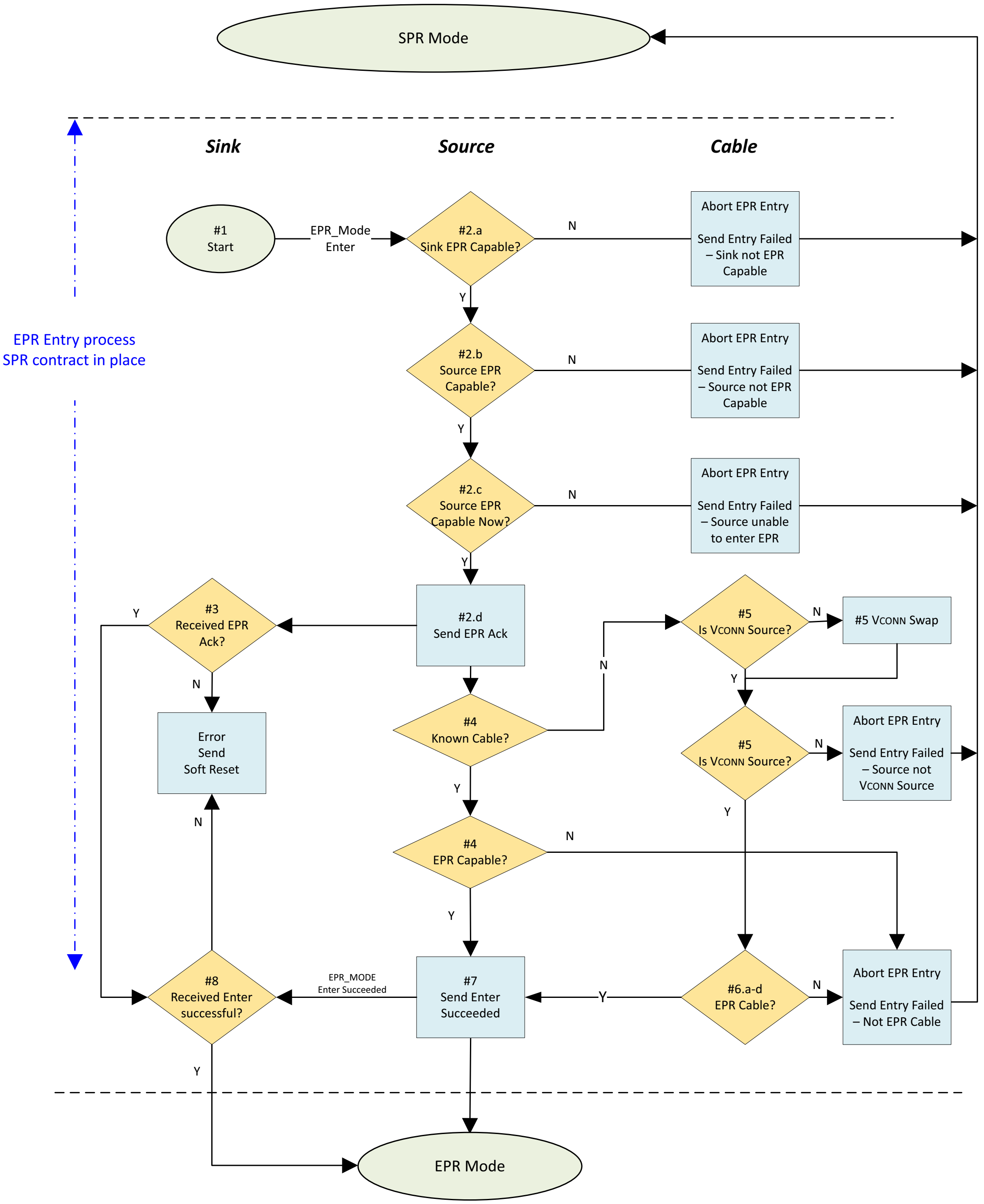
- Discover the cable prior to entering its *First Explicit Contract*
- Alternatively, within ***tEPRSourceCableDiscovery*** of entry into the *First Explicit Contract*
  - If it is the *VCONN Source*, discover the cable.
  - If not the *VCONN Source*, do a *VCONN Swap* then discover the cable.

and can verify the cable is *EPR Capable* by completing steps *5* and *6* in the entry process in *Figure 6.34, "Illustration of process to enter EPR Mode"*.

The *EPR Mode* entry process is a *Non-interruptible* multi-*Message AMS*. An illustration of this *AMS* is shown in *Figure 6.34, "Illustration of process to enter EPR Mode"*.

Note: *Figure 6.34, "Illustration of process to enter EPR Mode"* is not ***Normative*** but is ***Informative*** only.

Figure 6.34 Illustration of process to enter EPR Mode



The entry process ***Shall*** follow these steps in order:

1) The *Sink* ***Shall*** send the ***EPR_Mode*** *Message* with the Action field set to 1 (***Enter***) and the Data field set to its Operational *PDP*. If the *EPR Source* receives an ***EPR_Mode*** *Message* with the Action field not set to ***Enter*** it ***Shall*** initiate a *Soft Reset*.

2) The *Source* ***Shall*** do the following:

a) Verify the ***EPR Capable*** bit was set in the most recent *RDO*. If not set, the *Source* ***Shall*** do the following:

   i) Send an ***EPR_Mode*** *Message* with the Action field set to 4 (***Enter Failed***) and the Data field set to 3 ("EPR Mode Capable bit not set in the RDO").

   ii) Abort the *EPR Mode* entry process and remain in the existing SPR *Explicit Contract*.

b) Verify the ***EPR Capable*** bit was set in the most recent 5V *Fixed Supply PDO*. If not set, the *Source* ***Shall*** do the following:

   i) Send an ***EPR_Mode*** *Message* with the Action field set to 4 (***Enter Failed***) and the Data field set to 5 ("EPR Mode Capable bit not set in the *Fixed Supply* 5V *PDO*").

   ii) Abort the *EPR Mode* entry process and remain in the existing SPR *Explicit Contract*.

c) Verify the *Source* is still able to support *EPR Mode*. If not, the *Source* ***Shall*** do the following:

   i) Send an ***EPR_Mode*** *Message* with the Action field set to 4 (***Enter Failed***) and Data field set to 4 ("Unable at this time").

   ii) Abort the *EPR Mode* entry process and remain in the existing SPR *Explicit Contract*. The *Sink* ***May*** at some time in the future send another request to enter *EPR Mode*.

d) Send an ***EPR_Mode*** *Message* with the Action field set to 2 (***Enter Acknowledged***).

3) If the *Sink* receives any *Message*, other than an ***EPR_Mode*** *Message* with the Action Field set to 2, the *Sink* ***Shall*** initiate a *Soft Reset*.

4) When the *EPR Source* has used the ***Discover Identity*** *Command* to determine and remembers the *Cable Capabilities* or the *EPR Source* is connected with a captive cable:

a) If the cable is *EPR Capable* it ***Should*** go directly to Step 7, but ***May*** continue to Step 5.

b) If the cable is not *EPR Capable* it ***Shall*** do the following:

c) Send an ***EPR_Mode*** *Message* with the Action field set to 4 (***Enter Failed***) and the Data field set to 1 ("Cable not EPR capable").

d) Abort the *EPR Mode* entry process and remain in the existing SPR *Explicit Contract*.

5) If the *Source* is not the *VCONN Source*, it ***Shall*** send a ***VCONN_Swap*** *Message*

a) If the *Source* fails to become the *VCONN Source*, it ***Shall***:

   i) Send an ***EPR_Mode*** *Message* with the Action field set to 4 (***Enter Failed***) and the Data field set to 2 (not *VCONN Source*).

   ii) Abort the *EPR Mode* entry process and remain in the existing SPR *Explicit Contract*.

6) The *Source* ***Shall*** use the ***Discover Identity*** *Command* to read the cable's e-Marker and verify the following:

a) *Cable VDO* - ***Maximum VBUS Voltage (Passive Cable)***/***Maximum VBUS Voltage (Active Cable)*** field is 11b (50V)

b) *Cable VDO* - ***VBUS Current Handling Capability (Passive Cable)***/***VBUS Current Handling Capability (Active Cable)*** field is 10b (5A)

c) *Cable VDO* - ***EPR Capable (Passive Cable)***/***EPR Capable (Active Cable)*** field is 1b (*EPR Capable*)

d) If the cable fails to respond to the ***Discover Identity*** *Command* or is not *EPR Capable*, the *Source* ***Shall*** do the following:

   i) Send an ***EPR_Mode*** *Message* with the Action field set to 4 (***Enter Failed***) and the Data field to1 ("Cable not EPR capable").

    ii) Abort the *EPR Mode* entry process and remain in the existing SPR *Explicit Contract*.

7) The *Source* ***Shall*** send the ***EPR_Mode*** *Message* with the Action field set to 3 (***Enter Succeeded***) and ***Shall*** enter *EPR Mode*.

8) If the *Sink* receives an ***EPR_Mode*** *Message* with the Action field set to 3 (***Enter Succeeded***) it ***Shall*** enter *EPR Mode*, otherwise it ***Shall*** initiate a *Soft Reset*.

If the *EPR Mode* entry process successfully completes within ***tEnterEPR*** of the last bit of the ***GoodCRC*** *Message* sent in response to the ***EPR_Mode*** *Message* with the Action field set to 1 (***Enter***), the *Source* ***Shall*** send an ***EPR_Source_Capabilities*** *Message* within ***tFirstSourceCap***.

If the *EPR Mode* entry process has not been aborted or does not complete within ***tEnterEPR*** of the last bit of the ***GoodCRC*** *Message* sent in response to the ***EPR_Mode*** *Message* with the Action field set to 1 (***Enter***), the *Sink* ***Shall*** initiate a *Soft Reset*.

6.4.10.2 Operation in EPR Mode

While operating in *EPR Mode*, the *Source* ***Shall*** only send ***EPR_Source_Capabilities*** *Message*s to *Advertise* its power *Capabilities* and the *Sink* ***Shall*** only respond with ***EPR_Request*** *Message*s to *Negotiate Explicit Contract*s. The ***EPR_Request*** *Message* ***May*** be for either an SPR or EPR *(A)PDO*.

If the *Source* sends a ***Source_Capabilities*** *Message*, that is not in response to a *Sink* ***Get_Source_Cap*** *Message*, the *Sink* ***Shall*** initiate a *Hard Reset*. If the *Sink* sends a ***Request*** *Message*, the *Source* ***Shall*** initiate a *Hard Reset*.

The *Source* ***Shall*** monitor the *CC* communications path to ensure that there is periodic traffic. The *Sink* ***Shall*** send an ***EPR_KeepAlive*** *Message* when it has not sent any *Message*s for more than ***tSinkEPRKeepAlive*** to ensure there is timely periodic traffic. If there is no traffic for more than ***tSourceEPRKeepAlive***, the *Source* ***Shall*** initiate a *Hard Reset*.

6.4.10.3 Exiting EPR Mode

6.4.10.3.1 Commanded Exit

While in *EPR Mode*, either the *Source* or *Sink* ***May*** exit *EPR Mode* by sending an ***EPR_Mode*** *Message* with the Action field set to 5 (***Exit***).

The ports ***Shall*** be in an *Explicit Contract* with an SPR *(A)PDO* prior to the *EPR Mode* exit process by either:

- The *Source* sending an ***EPR_Source_Capabilities*** *Message* with no *EPR (A)PDO* s (e.g., only *SPR (A)PDO* s) or
- The *Sink* negotiating a new *Explicit Contract* with bit 31 in the *RDO* set to zero (e.g., only *SPR (A)PDO* s)).

The process to exit *EPR Mode* is a *Non-interruptible* multi-*Message AMS* and ***Shall*** follow these steps in order:

1) The *Port Partners* ***Shall*** be in an *Explicit Contract* with an SPR *(A)PDO*.

2) Either the *Source* or *Sink* ***Shall*** send an ***EPR_Mode*** *Message* with the Action field set to 5 (***Exit***) to exit the *EPR Mode*

3) The *Source* ***Shall*** send a ***Source_Capabilities*** *Message* within ***tFirstSourceCap*** of the ***GoodCRC*** *Message* in response to the ***EPR_Mode*** *Message* with the Action field set to 5 (***Exit***).

4) If the *Sink* does not receive a ***Source_Capabilities*** *Message* within ***tTypeCSinkWaitCap*** of the last bit of the ***GoodCRC*** *Message* in response to the ***EPR_Mode*** *Message* with the Action field set to 5 (***Exit***), *Sink* ***Shall*** initiate a *Hard Reset*.

6.4.10.3.2 Implicit Exit

EPR Mode ***Shall*** be exited as the side-effect of the *Power Role Swap* and *Fast Role Swap* processes. This is because at the end of these processes *VBUS* will be at ***vSafe5V*** and the Ports will be in an *Implicit Contract*. The *New Source* will then send a ***Source_Capabilities*** *Message* (not an ***EPR_Source_Capabilities*** *Message*) to begin the process of negotiating an SPR *Explicit Contract*. Once an SPR *Explicit Contract* is entered, the *Source* and *Sink* can then enter *EPR Mode* if needed.

6.4.10.3.3 Exits due to errors

Other critical errors can occur while in *EPR Mode*; these errors ***Shall*** result in *Hard Reset* being initiated by the *Port* that detects the error. Some of these errors include:

- An ***EPR_Mode*** *Message* with the Action field set to 5 (***Exit***) to exit *EPR Mode* is received by a *Port* in an *Explicit Contract* with an EPR *(A)PDO*.
- The *Sink* receives an ***EPR_Source_Capabilities*** *Message* with an EPR *(A)PDO* in any of the first seven object positions.
- The *(A)PDO* in the ***EPR_Request*** *Message* does not match the *(A)PDO* in the latest ***EPR_Source_Capabilities*** *Message* pointed to by the Object Position field in the *RDO*.
- The *Source* receives a ***Request*** *Message*.
- The *Sink* receives a ***Source_Capabilities*** *Message* not in response to a ***Get_Source_Cap*** *Message*.

6.4.11 Source_Info Message

The ***Source_Info*** *Message* ***Shall*** be sent in response to a ***Get_Source_Info*** *Message*. The ***Source_Info*** *Message* contains one Source Information Data Object (SIDO).

The ***Source_Info*** *Message* returns a SIDO whose format ***Shall*** be as shown in *Figure 6.35, "Source_Info Message"* and *Table 6.51, "Source_Info Data Object (SIDO)"*. The ***Number of Data Objects*** field in the ***Source_Info*** *Message* ***Shall*** be set to 1.

The ***Port Maximum PDP***, ***Port Present PDP***, ***Port Reported PDP*** and the ***Port Type*** are used to identify *Capabilities* of a *Source Port*.

Figure 6.35 Source_Info Message

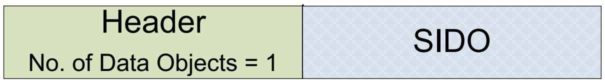


Table 6.51 Source_Info Data Object (SIDO)

Bit(s)	Field	Description
B31	***Port Type***	• 0 = *Managed Capability Port* • 1 = *Guaranteed Capability Port*
B30…24	***Reserved***	***Shall*** be set to zero
B23…16	***Port Maximum PDP***	Power the *Port* is designed to supply
B15…8	***Port Present PDP***	Power the *Port* is presently capable of supplying
B7…0	***Port Reported PDP***	Power the *Port* is actually advertising

6.4.11.1 Port Type Field

Port Type is a ***Static*** field that ***Shall*** be used to indicate whether the amount of power the *Port* can provide is fixed or can change dynamically.

For *Ports* that are part of a *Shared Capacity Group*, the ***Port Type*** field ***Shall*** be set to *Managed Capability Port*.

For *Ports* not part of a *Shared Capacity Group*, the ***Port Type*** field ***May*** be set to either *Managed Capability Port* or *Guaranteed Capability Port*.

6.4.11.2 Port Maximum PDP Field

Port Maximum PDP is a ***Static*** field that ***Shall*** report the integer portion of the *PDP Rating* of the *Port*. A *Guaranteed Capability Port* (as indicated by the ***Port Type*** field being set to '1') ***Shall*** always be capable of supplying this amount of power. A *Managed Capability Port* (as indicated by the ***Port Type*** field being set to '0') ***Shall*** be able to offer this amount of power at some time.

The ***Port Maximum PDP*** ***Shall*** be the same as the larger of the *SPR Source PDP Rating* and the *EPR Source PDP Rating* in the ***Source_Capabilities_Extended*** *Message*.

6.4.11.3 Port Present PDP Field

The ***Port Present PDP*** field ***Shall*** indicate the integer part of the amount of power the *Port* is presently capable of supplying including limitations due to *Cable Capabilities* or abnormal operating conditions (e.g., elevated temperature, low input voltage, etc.).

A *Guaranteed Capability Port* ***Shall*** always set its ***Port Present PDP*** to be the same as its ***Port Maximum PDP*** or the highest possible value when limited.

A *Managed Capability Port* that is part of a *Shared Capacity Group* ***Shall*** set its ***Port Present PDP*** to Shared Port Power Available as defined in ***[USB Type-C 2.4]*** or to a lower value when limited.

A *Managed Capability Port* that is part of an *Assured Capacity Group* ***Shall*** set its ***Port Present PDP*** to the ***Port Maximum PDP*** or the highest value possible when limited.

6.4.11.4 Port Reported PDP Field

The ***Port Reported PDP*** field ***Shall*** track the amount of power the *Port* is offering in its ***Source_Capabilities*** *Message* or ***EPR_Source_Capabilities*** *Message*. The ***Port Reported PDP*** field ***May*** be dynamic or ***Static*** depending on the *Port*'s other characteristics such as Managed/Guaranteed Capability, SPR/*EPR Mode*, its power policy etc.

Note: The ***Port Reported PDP*** field is computed as the integer part of, the largest of the products of the voltage times current of the *Fixed Supply PDO*s returned in the ***Source_Capabilities*** *Message* or ***EPR_Source_Capabilities*** *Message*s.

6.4.12 Revision Message

The ***Revision*** *Message* ***Shall*** be sent in response to the ***Get_Revision*** *Message* sent by the *Port Partner*. This *Message* is used to identify the highest *Revision* the *Port* is capable of operating at. The ***Revision*** *Message* contains one ***Revision*** *Message* Data Object (RMDO).

The ***Revision*** *Message* returns an RMDO whose format ***Shall*** be as shown in *Figure 6.36, "Revision Message Data Object"*and *Table 6.52, "Revision Message Data Object (RMDO)"*. The ***Number of Data Objects*** field in the ***Revision*** *Message* ***Shall*** be set to 1.

Figure 6.36 Revision Message Data Object

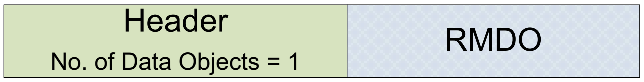


Table 6.52 Revision Message Data Object (RMDO)

Bit(s)	Description
B31…28	*Revision*.major
B27…24	*Revision*.minor
B23...20	*Version*.major
B19...16	*Version*.minor
B15...0	***Reserved***, ***Shall*** be set to zero.

E.g., for Revision 3.2, Version 1.1 the fields would be the following:

- *Revision*.major = 0011b
- *Revision*.minor = 0010b
- *Version*.major = 0001b
- *Version*.minor = 0001b

6.5 Extended Message

An *Extended Message* ***Shall*** contain an *Extended Message Header* (indicated by the ***Extended*** field in the *Message Header* being set) and be followed by zero or more data bytes. Additional bytes that might be added to existing *Messages* in future *Revision* of this specification ***Shall*** be ***Ignored***.

The format of the *Extended Message* is defined by the *Message Header*'s ***Message Type*** field and is summarized in *Table 6.53, "Extended Message Types"*. The Sent by column indicates entities which ***May*** send the given *Message* (*Source*, *Sink* or *Cable Plug*); entities not listed ***Shall Not*** issue the corresponding *Message*. The "Valid Start of Packet" column indicates the *Messages* which ***Shall*** only be issued in *SOP Packets* and the *Messages* which ***May*** be issued in *SOP* Packets*.

Table 6.53 Extended Message Types

Bits 4…0	Type	Sent by	Description	Valid Start of Packet
0 0000	***Reserved***		All values not explicitly defined are ***Reserved*** and ***Shall Not*** be used.	
0 0001	***Source_Capabilities_Extended***	*Source* or *Dual-Role Power*	See Section 6.5.1	*SOP* only
0 0010	***Status***	*Source*, *Sink* or *Cable Plug*	See Section 6.5.2	*SOP**
0 0011	***Get_Battery_Cap***	*Source* or *Sink*	See Section 6.5.3	*SOP* only
0 0100	***Get_Battery_Status***	*Source* or *Sink*	See Section 6.5.4	
0 0101	***Battery_Capabilities***	*Source* or *Sink*	See Section 6.5.5	*SOP* only
0 0110	***Get_Manufacturer_Info***	*Source* or *Sink*	See Section 6.5.6	*SOP**
0 0111	***Manufacturer_Info***	*Source*, *Sink* or *Cable Plug*	See Section 6.5.7	*SOP**
0 1000	***Security_Request***	*Source* or *Sink*	See Section 6.5.8.1	*SOP**
0 1001	***Security_Response***	*Source*, *Sink* or *Cable Plug*	See Section 6.5.8.2	*SOP**
0 1010	***Firmware_Update_Request***	*Source* or *Sink*	See Section 6.5.9.1	*SOP**
0 1011	***Firmware_Update_Response***	*Source*, *Sink* or *Cable Plug*	See Section 6.5.9.2	*SOP**
0 1100	***PPS_Status***	*Source*	See Section 6.5.10	*SOP* only
0 1101	***Country_Info***	*Source* or *Sink*	See Section 6.5.12	*SOP* only
0 1110	***Country_Codes***	*Source* or *Sink*	See Section 6.5.11	*SOP* only
0 1111	***Sink_Capabilities_Extended***	*Sink* or *Dual-Role Power*	See Section 6.5.13	*SOP* only
1 0000	***Extended_Control***	*Source* or *Sink*	See Section 6.5.14	*SOP* only
1 0001	***EPR_Source_Capabilities***	*Source* or *Dual-Role Power*	See Section 6.5.15.2	*SOP* only
1 0010	***EPR_Sink_Capabilities***	*Sink* or *Dual-Role Power*	See Section 6.5.15.3	*SOP* only
1 0011… 1 1101	***Reserved***		All values not explicitly defined are ***Reserved*** and ***Shall Not*** be used.	
1 1110	***Vendor_Defined_Extended***	*Source*, *Sink* or *Cable Plug*	See Section 6.5.16	*SOP**
1 1111	***Reserved***		All values not explicitly defined are ***Reserved*** and ***Shall Not*** be used.	

6.5.1 Source_Capabilities_Extended Message

The ***Source_Capabilities_Extended*** *Message* ***Should*** be sent in response to a ***Get_Source_Cap_Extended*** *Message*. The ***Source_Capabilities_Extended*** *Message* enables a *Source* or a *DRP* to inform the *Sink* about its *Capabilities* as a *Source*.

The ***Source_Capabilities_Extended*** *Message* ***Shall*** return a 25-byte Source Capabilities Extended Data Block (SCEDB) whose format ***Shall*** be as shown in *Figure 6.37, "Source_Capabilities_Extended Message"* and*Table 6.54, "Source Capabilities Extended Data Block (SCEDB)"*.

Figure 6.37 Source_Capabilities_Extended Message

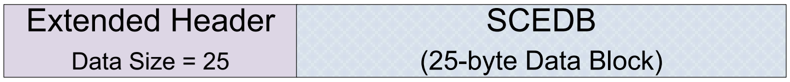


Table 6.54 Source Capabilities Extended Data Block (SCEDB)

<table>
<tr><th>Offset</th><th>Field</th><th colspan="2">Description</th></tr>
<tr><td>0</td><td><b><i>VID</i></b></td><td colspan="2"><i>Vendor ID</i> (assigned by the USB-IF)</td></tr>
<tr><td>2</td><td><b><i>PID</i></b></td><td colspan="2">Product ID (assigned by the manufacturer)</td></tr>
<tr><td>4</td><td><b><i>XID</i></b></td><td colspan="2">Value provided by the USB-IF assigned to the product</td></tr>
<tr><td>8</td><td><b><i>FW Version</i></b></td><td colspan="2">Firmware version number</td></tr>
<tr><td>9</td><td><b><i>HW Version</i></b></td><td colspan="2">Hardware version number</td></tr>
<tr><td rowspan="4">10</td><td rowspan="4"><b><i>Voltage Regulation</i></b></td><th>Bit</th><th>Description</th></tr>
<tr><td>1...0</td><td>• 00b: 150mA/µs Load Step (default)
• 01b: 500mA/µs Load Step
• 11b...10b: <b><i>Reserved</i></b> and <b><i>Shall Not</i></b> be used.</td></tr>
<tr><td>2</td><td>• 0b: 25% <i>IoC</i> (default)
• 1b: 90% <i>IoC</i></td></tr>
<tr><td>3...7</td><td><b><i>Reserved</i></b> and <b><i>Shall Not</i></b> be used</td></tr>
<tr><td>11</td><td><b><i>Holdup Time</i></b></td><td colspan="2">Output will stay with regulated limits for this number of milliseconds after removal of the AC from the input.
• 0x00 = feature not supported
<b>Note:</b> A value of at least 3ms <b><i>Should</i></b> be used (see <i>Section 7.1.12.2, "Holdup Time Field"</i>).</td></tr>
<tr><td rowspan="6">12</td><td rowspan="6"><b><i>Compliance</i></b></td><td colspan="2">Compliance in <i>SPR Mode</i>:</td></tr>
<tr><th>Bit</th><th>Description</th></tr>
<tr><td>0</td><td><i>LPS</i> compliant when set</td></tr>
<tr><td>1</td><td>PS1 compliant when set</td></tr>
<tr><td>2</td><td>PS2 compliant when set</td></tr>
<tr><td>3...7</td><td><b><i>Reserved</i></b> and <b><i>Shall Not</i></b> be used</td></tr>
<tr><td rowspan="5">13</td><td rowspan="5"><b><i>Touch Current</i></b></td><th>Bit</th><th>Description</th></tr>
<tr><td>0</td><td>Low touch current EPS when set</td></tr>
<tr><td>1</td><td>Ground pin supported when set</td></tr>
<tr><td>2</td><td>Ground pin intended for protective earth when set</td></tr>
<tr><td>3...7</td><td><b><i>Reserved</i></b> and <b><i>Shall Not</i></b> be used</td></tr>
</table>

Table 6.54 Source Capabilities Extended Data Block (SCEDB) (Continued)

Offset	Field	Description	
14	***Peak Current1***	**Bit**	**Description**
		0…4	Percent overload in 10% increments Values higher than 25 (11001b) are clipped to 250%.
		5…10	Overload period in 20ms
		11…14	Duty cycle in 5% increments
		15	*VBUS* voltage droop
16	***Peak Current2***	**Bit**	**Description**
		0…4	Percent overload in 10% increments Values higher than 25 (11001b) are clipped to 250%.
		5…10	Overload period in 20ms
		11…14	Duty cycle in 5% increments
		15	*VBUS* voltage droop
18	***Peak Current3***	**Bit**	**Description**
		0…4	Percent overload in 10% increments Values higher than 25 (11001b) are clipped to 250%.
		5…10	Overload period in 20ms
		11…14	Duty cycle in 5% increments
		15	*VBUS* voltage droop
20	***Touch Temp***	Temperature conforms to: • 0 = ***[IEC 60950-1]*** (default) • 1 = ***[IEC 62368-1]*** TS1 • 2 = ***[IEC 62368-1]*** TS2 **Note:** All other values ***Reserved*** and ***Shall Not*** be used.	
21	***Source Inputs***	**Bit**	**Description**
		0	• 0b: No external supply • 1b: External supply present
		1	If bit 0 is set: • 0b: External supply is constrained. • 1b: External supply is unconstrained. If bit 0 is not set ***Reserved*** and ***Shall*** be set to zero
		2	• 0b: No internal *Battery* • 1b: Internal *Battery* present
		3…7	***Reserved*** and ***Shall*** be set to zero
22	***Number of Batteries/ Battery Slots***	Upper Nibble = Number of Hot Swappable *Battery Slots* (0…4) Lower Nibble = Number of *Fixed Batteries* (0…4)	
23	***SPR Source PDP Rating***	0…6: *Source PDP Rating* (*EPR Source*'s *PDP Rating* when operating in *SPR Mode*. 7: ***Reserved*** and ***Shall*** be set to zero	
24	***EPR Source PDP Rating***	0…7: *EPR Source PDP Rating*	

6.5.1.1 Vendor ID (VID) Field

The ***VID*** field ***Shall*** contain the 16-bit *Vendor ID* (*VID*) assigned to the *Source*'s vendor by the USB-IF. If the vendor does not have a *VID*, the ***VID*** field ***Shall*** be set to 0xFFFF. *Device*s that have a USB data interface ***Shall*** report the same *VID* as the idVendor in the Standard Device Descriptor (see ***[USB 2.0]*** and ***[USB 3.2]***).

6.5.1.2 Product ID (PID) Field

The ***PID*** field ***Shall*** contain the 16-bit Product ID (PID) assigned by the *Source*'s vendor. *Device*s that have a USB data interface ***Shall*** report the same PID as the idProduct in the Standard Device Descriptor (see ***[USB 2.0]*** and ***[USB 3.2]***).

6.5.1.3 XID Field

The ***XID*** field ***Shall*** contain the 32-bit XID provided by the USB-IF to the vendor who in turns assigns it to a product. If the vendor does not have an XID, then it ***Shall*** return zero in this field (see ***[USB 2.0]*** and ***[USB 3.2]***).

6.5.1.4 Firmware Version Field

The ***FW Version*** field ***Shall*** contain an 8-bit firmware version number assigned to the device by the vendor.

6.5.1.5 Hardware Version Field

The ***HW Version*** field ***Shall*** contain an 8-bit hardware version number assigned to the device by the vendor.

6.5.1.6 Voltage Regulation Field

The ***Voltage Regulation*** field contains bits covering Load Step Slew Rate and Magnitude.

See *Section 7.1.12.1, "Voltage Regulation Field"* for further details.

6.5.1.6.1 Load Step Slew Rate

The *Source* ***Shall*** report its load step response capability in bits 0…1 of the ***Voltage Regulation*** bit field.

6.5.1.6.2 Load Step Magnitude

The *Source* ***Shall*** report its load step magnitude rate as a percentage of *IoC* in bit 2 of the ***Voltage Regulation*** field.

6.5.1.7 Holdup Time Field

The ***Holdup Time*** field ***Shall*** contain the *Source*'s holdup time (see *Section 7.1.12.2, "Holdup Time Field"*).

6.5.1.8 Compliance Field

The ***Compliance*** is ***Static*** and ***Shall*** contain the standards the *Source* is compliant with in SPR (see *Section 7.1.12.3, "Compliance Field"*).

6.5.1.9 Touch Current Field

The ***Touch Current*** field reports whether the *Source* meets certain leakage current levels and if it has a ground pin.

A *Source* ***Shall*** set the ***Touch Current*** bit (bit 0) when their leakage current is less than 65μA rms when *Source*'s maximum capability is less than or equal to 30W, or when their leakage current is less than 100 μA rms when its power capability is between 30W and 100W. The total combined leakage current ***Shall*** be measured in accordance with ***[IEC 60950-1]*** when tested at 250VAC rms at 50 Hz.

A *Source* with a ground pin ***Shall*** set the Ground pin bit (bit 1).

A *Source* whose Ground pin is intended to be connected to a protective earth ***Shall*** set both bit1 and bit 2.

6.5.1.10 Peak Current Field

The ***Peak Current1***/***Peak Current2***/***Peak Current3*** fields ***Shall*** contain the combinations of Peak Current that the *Source* supports (see *Section 7.1.12.4, "Peak Current"*).

Peak Current provides a means for *Source* report its ability to provide current in excess of the *Negotiated* amount for short periods. The Peak Current descriptor defines up to three combinations of% overload, duration and duty cycle defined as ***Peak Current1***, ***Peak Current2*** and ***Peak Current3*** that the *Source* supports. A *Source* ***May*** offer no Peak Current capability. A *Source* ***Shall*** populate unused Peak Current bit fields with zero.

The Bit Fields within ***Peak Current1***, ***Peak Current2*** and ***Peak Current3*** contain the following subfields:

- Percentage Overload
  - ***Shall*** be the maximum peak current reported in 10% increments as a percentage of the *Negotiated* operating current (*IoC*) offered by the *Source*. Values higher than 25 (11001b) are clipped to 250%.
- Overload Period
  - ***Shall*** be the minimum rolling average time window in 20ms increments, where a value of 20ms is recommended.
- Duty Cycle
  - ***Shall*** be the maximum percentage of overload period reported in 5% increments. The values ***Should*** be 5%, 10% and 50% for PeakCurrent1, PeakCurrent2, and PeakCurrent3, respectively.
- *VBUS* Droop
  - ***Shall*** be set to one to indicate there is an additional 5% voltage droop on *VBUS* when the overload conditions occur as defined by ***vSrcPeak***. However, it is recommended that the *Source* ***Should*** provide *VBUS* in the range of ***vSrcNew*** when overload conditions occur and set this bit to zero.

6.5.1.11 Touch Temp Field

The ***Touch Temp*** field ***Shall*** report the IEC standard used to determine the surface temperature of the *Source*'s enclosure. Safety limits for the *Source*'s touch temperature are set in applicable product safety standards (e.g., ***[IEC 60950-1]*** or ***[IEC 62368-1]***). The *Source* ***May*** report when its touch temperature performance conforms to the TS1 or TS2 limits described in ***[IEC 62368-1]***.

6.5.1.12 Source Inputs Field

The ***Source Inputs*** field ***Shall*** identify the possible inputs that provide power to the *Source*:

- When bit 0 is set, the *Source* can be sourced by an external power supply.
- When bits 0 and 1 are set, the *Source* can be sourced by an external power supply which is assumed to be effectively "infinite" i.e., it won't run down over time.
- When bit 2 is set the *Source* can be sourced by an internal *Battery*.

Note: Some *Sources* are only powered by a *Battery* (e.g., an automobile) rather than the more common *AC Supply*.

Note: Bit 2 ***May*** be set independently of bits 0 and 1.

6.5.1.13 Number of Batteries/Battery Slots Field

The ***Number of Batteries/Battery Slots*** field ***Shall*** report the number of *Fixed Batteries* and Hot Swappable *Battery Slots* the *Source* supports. This field ***Shall*** independently report the number of *Battery Slots* and the number of *Fixed Batteries*.

A *Source* ***Shall*** have no more than 4 *Fixed Batteries* and no more than 4 *Battery Slots*.

Fixed Batteries ***Shall*** be numbered consecutively from 0 to 3. The number assigned to a given *Fixed Battery* ***Shall Not*** change between *Attach* and *Detach*.

Battery Slots ***Shall*** be numbered consecutively from 4 to 7. The number assigned to a given *Battery Slot* ***Shall Not*** change between *Attach* and *Detach*.

6.5.1.14 SPR Source PDP Rating Field

For an *SPR Source* the ***SPR Source PDP Rating*** field ***Shall*** report the integer portion of the *PDP Rating* of the *Port*.

For an *EPR Source*, the *SPR Source PDP Rating* field ***Shall*** report the integer portion of the maximum amount of power that the *Port* is designed to deliver in SPR Mode.

The ***SPR Source PDP Rating*** field that is reported ***Shall*** be ***Static***.

6.5.1.15 EPR Source PDP Rating Field

For an *EPR Source* the ***EPR Source PDP Rating*** field ***Shall*** report the integer portion of the *PDP Rating* of the *Port*.

For an *SPR Source* this field ***Shall*** be set to zero.

The ***EPR Source PDP Rating*** field that is reported ***Shall*** be ***Static***.

6.5.2 Status Message

The ***Status*** *Message* ***Shall*** be sent in response to a ***Get_Status*** *Message*. The content of the ***Status*** *Message* depends on the target of the ***Get_Status*** *Message*. When sent to *SOP* the ***Status*** *Message* returns the status of the *Port*'s *Port Partner*. When sent to *SOP’* or *SOP’’* the ***Status*** *Message* returns the status of one of the *Active Cable*'s *Cable Plugs*.

6.5.2.1 SOP Status Message

A ***Status*** *Message*, sent in response to ***Get_Status*** *Message* to *SOP*, enables a *Port* to inform its *Port Partner* about the present status of the *Source* or *Sink*. Typically, a ***Get_Status*** *Message* will be sent by the *Port* after receipt of an ***Alert*** *Message*. Some of the reported events are critical such as *OCP*, *OVP* and *OTP*, while others are informational such as change in a *Battery*'s status from charging to neither charging nor discharging.

The ***Status*** *Message* returns a 7-byte Status Data Block (SDB) whose format ***Shall*** be as shown in *Figure 6.38, "SOP Status Message"* and *Table 6.55, "SOP Status Data Block (SDB)"*.

Figure 6.38 SOP Status Message

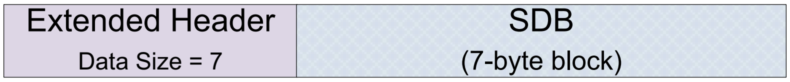


Table 6.55 SOP Status Data Block (SDB)

Offset (Byte)	Field	Description	
0	***Internal Temp***		*Source* or *Sink*’s internal temperature in °C • 0 = feature not supported • 1 = temperature is less than 2°C. • 2-255 = temperature in °C.
1	***Present Input***	Bit	Description
		0	***Reserved*** and ***Shall*** be set to zero
		1	External Power when set
		2	External Power AC/DC (***Valid*** when Bit 1 set) • 0: DC • 1: AC ***Reserved*** when Bit 1 is zero
		3	Internal Power from *Battery* when set
		4	Internal Power from non-*Battery* power source when set
		5…7	***Reserved*** and ***Shall*** be set to zero
2	***Present Battery Input***	When ***Present Input*** field bit 3 set ***Shall*** contain the bit corresponding to the *Battery* or Batteries providing power: • Upper nibble = Hot Swappable Battery (b7…4) • Lower nibble = *Fixed Battery* (b3…0) When ***Present Input*** field bit 3 is not set this field is ***Reserved*** and ***Shall*** be set to zero.	

Table 6.55 SOP Status Data Block (SDB) (Continued)

Offset (Byte)	Field	Description		
		Bit	Flag	Description
3	***Event Flags***	0		***Reserved*** and ***Shall*** be set to zero
		1	***OCP Event***	*OCP* event when set
		2	***OTP Event***	*OTP* event when set
		3	***OVP Event***	*OVP* event when set
		4	***CL/CV Mode***	In *PPS Mode* only: *CL* mode when set, *CV* mode when cleared
		5…7		***Reserved*** and ***Shall*** be set to zero
4	***Temperature Status***	Bit	Description	
		0	***Reserved*** and ***Shall*** be set to zero	
		1…2	• 00 – Not Supported. • 01 – Normal • 10 – Warning • 11 – Over temperature	
		3…7	***Reserved*** and ***Shall*** be set to zero	
5	***Power Status***	Bit	Description	
		0	***Reserved*** and ***Shall*** be set to zero	
		1	*Source* power limited due to cable supported current	
		2	*Source* power limited due to insufficient power available while sourcing other ports	
		3	*Source* power limited due to insufficient external power	
		4	*Source* power limited due to Event Flags in place (Event Flags must also be set)	
		5	*Source* power limited due to temperature	
		6…7	***Reserved*** and ***Shall*** be set to zero	

Table 6.55 SOP Status Data Block (SDB) (Continued)

Offset (Byte)	Field	Description		
		Bit	Description	
6	***Power State Change***	0…2	***New Power State***	
			Value	Description
			0	Status not supported
			1	S0
			2	Modern Standby
			3	S3
			4	S4
			5	S5 (Off with battery, wake events supported)
			6	G3 (Off with no battery, wake events not supported)
			7	***Reserved*** and ***Shall*** be set to zero
		3…5	***New Power State indicator***	
			Value	Description
			0	Off LED
			1	On LED
			2	Blinking LED
			3	Breathing LED
			4…7	***Reserved*** and ***Shall*** be set to zero
		6…7	***Reserved*** and ***Shall*** be set to zero	

6.5.2.1.1 Internal Temp Field

The ***Internal Temp*** field reports the instantaneous temperature of a portion of the *Source* or *Sink*.

6.5.2.1.2 Present Input Field

The ***Present Input*** field indicates which supplies are presently powering the *Source* or *Sink*.

The following bits are defined:

- Bit 1: indicates that an external power source is present.
- Bit 2: indicates whether the external unconstrained power source is AC or DC.
- Bit 3: indicates that power is being provided from *Battery*.
- Bit4: indicates an alternative internal source of power that is not a *Battery*.

6.5.2.1.3 Present Battery Input Field

The ***Present Battery Input*** field indicates which *Battery* or Batteries are presently supplying power to the *Source* or *Sink*. The ***Present Battery Input*** field is only ***Valid*** when the ***Present Input*** field indicates that there is Internal Power from *Battery*.

The upper nibble of the field indicates which Hot Swappable *Battery*/Batteries are supplying power with bit 4 in upper nibble corresponding to *Battery* 4 and bit 7 in the upper nibble corresponding to *Battery* 7 (see *Section 6.5.3, "Get_Battery_Cap Message"* and *Section 6.5.4, "Get_Battery_Status Message"*).

The lower nibble of the field indicates which *Fixed Battery*/Batteries are supplying power with bit 0 in lower nibble corresponding to *Battery* 0 and bit 3 in the lower nibble corresponding to *Battery* 3 (see *Section 6.5.3, "Get_Battery_Cap Message"* and *Section 6.5.4, "Get_Battery_Status Message"*).

6.5.2.1.4 Event Flags Field

The ***Event Flags*** field returns event flags. The *OTP*, *OVP* and *OCP* event flags ***Shall*** be set when there is an event and ***Shall*** only be cleared when read with the ***Get_Status*** *Message*.

When the ***OTP Event*** flag is set the ***Temperature Status*** field ***Shall*** also be set to over temperature.

The ***CL/CV Mode*** flag is only ***Valid*** when operating as a Programmable Power Supply and ***Shall*** be ***Ignored*** otherwise. When the *Source* is operating as a Programmable Power Supply the ***CL/CV Mode*** flag ***Shall*** be set when operating in ***Current Limit*** mode (***CL***) and ***Shall*** be cleared when operating in ***Constant Voltage*** mode (***CV***).

6.5.2.1.5 Temperature Status Field

The ***Temperature Status*** field returns the current temperature status of the device either: normal, warning or over temperature. When the ***Temperature Status*** field is set to over temperature the ***OTP Event*** flag ***Shall*** also be set.

6.5.2.1.6 Power Status Field

The ***Power Status*** field indicates the current status of a *Source*. A non-zero return of the field indicates *Advertise*d *Source* power is being reduced for either:

- The cable does not support the full *Source* current.
- The *Source* is supplying power to other ports and is unable to provide its full power.
- The external power to the *Source* is insufficient to support full power.
- An Event has occurred that is causing the *Source* to reduce its *Advertise*d power.

A *Sink* ***Shall*** set this field to zero.

6.5.2.1.7 Power state change

The ***Power State Change*** field contains two status bytes; the *New Power State* and *New Power State indicator* status bytes.

6.5.2.1.7.1 New power state

The *New Power State* status byte indicates a power state change to one of the specified power states. Any device that supports the ACPI standard system power states ***Shall*** use the ACPI states. For devices that do not support the ACPI power states, the following mapping ***Should*** be used:

High power (on) state	-> S0
Sleep state	-> S3
Low power (off) state	-> S5 or G3

6.5.2.1.7.2 New power state indicator

The ***New Power State indicator*** status byte defines the host's desired indicator for the specified power state. This indicator allows several possibilities for predefined behaviors that the host can specify to indicate its system power state to the user via the downstream device. The ***New Power State indicator*** is a "best effort" indicator. If the device cannot provide the requested indicator, then it provides the best indicator that it can. If a Breathing indicator cannot be provided, then a Blinking indicator ***Should*** be provided. If a Blinking indicator cannot be provided, then a constant on indicator ***Should*** be provided.

New Power State indicators in decreasing precedence:

- Breathing
- Blinking
- Constant on
- No indicator

6.5.2.2 SOP'/SOP'' Status Message

A ***Status*** *Message*, sent in response to a ***Get_Status*** *Message* to *SOP'* or *SOP''*, enables a *Source* or *Sink* to get the present status of the Cable's *Cable Plug*(s). Typically, a ***Get_Status*** *Message* will be used by the *USB Host* and/or *USB Device* to manage the Cable's *Cable Plug*(s) temperature. The ***Status*** *Message* returns a 2-byte Status Data Block (SDB) whose format ***Shall*** be as shown in *Figure 6.39, "SOP'/SOP'' Status Message"* and *Table 6.56, ""SOP'/SOP" Status Data Block (SPDB)""*.

Passive *Cable Plugs* ***Shall Not*** indicate Thermal Shutdown.

Figure 6.39 SOP'/SOP'' Status Message

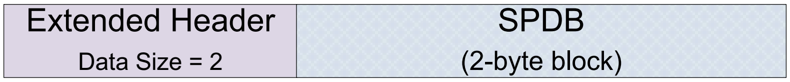


Table 6.56 "SOP'/SOP" Status Data Block (SPDB)"

<table>
<tr><th>Offset (Byte)</th><th>Field</th><th>Value</th><th colspan="2">Description</th></tr>
<tr><td>0</td><td><em><strong>Internal Temp</strong></em></td><td>Unsigned Int</td><td colspan="2"><em>Cable Plug</em>'s internal temperature in °C.
• 0 = feature not supported
• 1 = temperature is less than 2°C.
• 2…255 = temperature in °C.</td></tr>
<tr><td rowspan="3">1</td><td rowspan="3"><em><strong>Flags</strong></em></td><td rowspan="3">Bit Field</td><th>Bit</th><th>Description</th></tr>
<tr><td>0</td><td>Thermal Shutdown</td></tr>
<tr><td>1…7</td><td><em><strong>Reserved</strong></em> and <em><strong>Shall</strong></em> be set to zero</td></tr>
</table>

6.5.2.2.1 Internal Temp Field

The ***Internal Temp*** field reports the instantaneous temperature of the plug in °C. The internal temperature ***Shall*** be monotonic. The *Cable Plug* ***Shall*** report its internal temperature every ***tACTempUpdate***.

6.5.2.2.2 Thermal Shutdown Field

The ***Flags*** flag ***Shall*** also be set when the plug's internal temperature exceeds the Internal Maximum Temperature reported in the *Active Cable* VDO. Once this bit has been set, it ***Shall*** remain set and the plug ***Shall*** remain in Thermal Shutdown until there is a *Hard Reset* or the *Active Cable*'s power is removed. The Thermal Shutdown flag ***Shall Not*** be cleared by a *Cable Reset*.

6.5.3 Get_Battery_Cap Message

The ***Get_Battery_Cap*** (Get *Battery Capabilities*) *Message* is used to request the capability of a *Battery* present in its *Port Partner*. The *Port* ***Shall*** respond by returning a ***Battery_Capabilities*** *Message* (see *Section 6.5.5, "Battery_Capabilities Message"*) containing a Battery Capabilities Data Block (BCDB) for the targeted *Battery*.

The ***Get_Battery_Cap*** *Message* contains a 1-byte Get Battery Cap Data Block (GBCDB), whose format ***Shall*** be as shown in *Figure 6.40, "Get_Battery_Cap Message"* and *Table 6.57, "Get Battery Cap Data Block (GBCDB)"*. This block defines for which *Battery* the request is being made.

The ***Data Size*** field in the ***Get_Battery_Cap*** *Message* ***Shall*** be set to 1.

Figure 6.40 Get_Battery_Cap Message

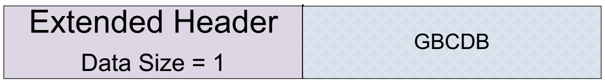


Table 6.57 Get Battery Cap Data Block (GBCDB)

Offset	Field	Description
0	***Battery Cap Ref***	Number of the *Battery* indexed from zero: • Values 0…3 represent the *Fixed Batteries*. • Values 4…7 represent the Hot Swappable Batteries. • Values 8…255 are ***Reserved*** and ***Shall Not*** be used.

6.5.4 Get_Battery_Status Message

The ***Get_Battery_Status*** (Get *Battery* Status) *Message* is used to request the status of a *Battery* present in its *Port Partner*. The *Port* ***Shall*** respond by returning a ***Battery_Status*** *Message* (see *Section 6.4.5, "Battery_Status Message"*) containing a Battery Status Data Object (BSDO) for the targeted *Battery*.

The ***Get_Battery_Status*** *Message* contains a 1-byte Get Battery Status Data Block (GBSDB) whose format ***Shall*** be as shown in *Figure 6.41, "Get_Battery_Status Message"* and *Table 6.58, "Get Battery Status Data Block (GBSDB)"*. This block contains details of the requested *Battery*. The ***Data Size*** field in the ***Get_Battery_Status*** *Message* ***Shall*** be set to 1.

Figure 6.41 Get_Battery_Status Message

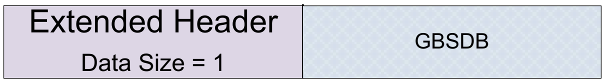


Table 6.58 Get Battery Status Data Block (GBSDB)

Offset	Field	Description
0	***Battery Status Ref***	Number of the *Battery* indexed from zero: • Values 0…3 represent the *Fixed Batteries*. • Values 4…7 represent the Hot Swappable Batteries. • Values 8…255 are ***Reserved*** and ***Shall Not*** be used.

6.5.5 Battery_Capabilities Message

The ***Battery_Capabilities*** *Message* is sent in response to a ***Get_Battery_Cap*** *Message*. The ***Battery_Capabilities*** *Message* contains one Battery Capability Data Block (BCDB) for one of the Batteries its supports as reported by ***Number of Batteries/Battery Slots*** field in the ***Source_Capabilities_Extended*** *Message*. The returned BCDB ***Shall*** correspond to the *Battery* requested in the ***Battery Cap Ref*** field contained in the ***Get_Battery_Cap*** *Message*.

The ***Battery_Capabilities*** *Message* returns a 9-byte BCDB whose format ***Shall*** be as shown in *Figure 6.42, "Battery_Capabilities Message"* and *Table 6.59, "Battery Capability Data Block (BCDB)""*.

Figure 6.42 Battery_Capabilities Message

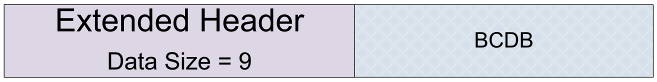


Table 6.59 Battery Capability Data Block (BCDB)"

<table>
<tr><th>Offset (Byte)</th><th>Field</th><th colspan="3">Description</th></tr>
<tr><td>0</td><td><b><i>VID</i></b></td><td colspan="3"><i>Vendor ID</i> (assigned by the USB-IF)</td></tr>
<tr><td>2</td><td><b><i>PID</i></b></td><td colspan="3">Product ID (assigned by the manufacturer)</td></tr>
<tr><td>4</td><td><b><i>Battery Design Capacity</i></b></td><td colspan="3"><i>Battery</i>'s design capacity in 0.1 WH
<b>Note:</b>
• 0x0000 = <i>Battery</i> not present
• 0xFFFF = design capacity unknown</td></tr>
<tr><td>6</td><td><b><i>Battery Last Full Charge Capacity</i></b></td><td colspan="3"><i>Battery</i>'s last full charge capacity in 0.1 WH
<b>Note:</b>
• 0x0000 = <i>Battery</i> not present
• 0xFFFF = last full charge capacity unknown</td></tr>
<tr><td rowspan="3">8</td><td rowspan="3"><b><i>Battery Type</i></b></td><th>Bit</th><th>Field</th><th>Description</th></tr>
<tr><td>0</td><td><b><i>Invalid Battery Reference</i></b></td><td><b><i>Invalid</i></b> <i>Battery</i> reference when set.</td></tr>
<tr><td>1…7</td><td>---</td><td><b><i>Reserved</i></b></td></tr>
</table>

6.5.5.1 Vendor ID (VID)

The ***VID*** field ***Shall*** contain the manufacturer *VID* associated with the *Battery*, as assigned by the USB-IF, or 0xFFFF in the case that no such *VID* exists.

If the ***Battery Cap Ref*** field in the ***Get_Battery_Cap*** *Message* is ***Invalid***, the ***VID*** field ***Shall*** be 0xFFFF.

6.5.5.2 Product ID (PID)

The following rules apply to the ***PID*** field. When the ***VID***:

- Belongs to the *Battery* vendor the ***PID*** field ***Shall*** contain the *Battery*'s 16-bit product identifier designated by the *Battery* vendor.
- Belongs to the *Device* vendor the ***PID*** field ***Shall*** contain the *Battery*'s 16-bit product identifier designated by the *Device* vendor.
- Is 0xFFFF the ***PID*** field ***Shall*** be set to 0x0000.

6.5.5.3 Battery Design Capacity Field

The ***Battery Design Capacity*** field ***Shall*** return the *Battery*'s design capacity in tenths of WH. If the *Battery* is Hot Swappable and is not present, the ***Battery Design Capacity*** field ***Shall*** be set to zero. If the *Battery* is unable to report its Design Capacity, the ***Battery Design Capacity*** field ***Shall*** be set to 0xFFFF.

6.5.5.4 Battery Last Full Charge Capacity Field

The ***Battery Last Full Charge Capacity*** field ***Shall*** contain the *Battery*'s last full charge capacity in tenths of WH. If the *Battery* is Hot Swappable and is not present, the ***Battery Last Full Charge Capacity*** field ***Shall*** be set to zero. If the *Battery* is unable to report its Design Capacity, the ***Battery Last Full Charge Capacity*** field ***Shall*** be set to 0xFFFF.

6.5.5.5 Battery Type Field

The ***Battery Type*** field is used to report additional information about the *Battery*'s *Capabilities*.

6.5.5.5.1 Invalid Battery Reference

The ***Invalid Battery Reference*** bit ***Shall*** be set when the ***Get_Battery_Cap*** *Message* contains a reference to a *Battery* that does not exist.

6.5.6 Get_Manufacturer_Info Message

The ***Get_Manufacturer_Info*** (Get Manufacturer Info) *Message* is sent by a *Port* to request manufacturer specific information relating to its *Port Partner*, *Cable Plug* or of a *Battery* behind a *Port*. The *Port* ***Shall*** respond by returning a ***Manufacturer_Info*** *Message* (*Section 6.5.7, "Manufacturer_Info Message"*) containing a Manufacturer Info Data Block (MIDB). Support for this feature by the *Cable Plug* is ***Optional Normative***.

The ***Get_Manufacturer_Info*** *Message* contains a 2-byte Get Manufacturer Info Data Block (GMIDB). This block defines whether it is the *Device* or *Battery* manufacturer information being requested and for which *Battery* the request is being made.

The ***Get_Manufacturer_Info*** *Message* returns a GMIDB whose format ***Shall*** be as shown in *Figure 6.43, "Get_Manufacturer_Info Message"* and *Table 6.60, "Get Manufacturer Info Data Block (GMIDB)"*.

Figure 6.43 Get_Manufacturer_Info Message

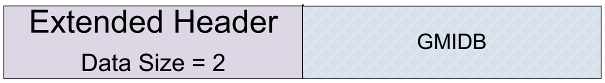


Table 6.60 Get Manufacturer Info Data Block (GMIDB)

Offset	Field	Description
0	***Manufacturer Info Target***	• 0: *Port/Cable Plug* • 1: *Battery* • 255…2: ***Reserved*** and ***Shall Not*** be used.
1	***Manufacturer Info Ref***	If the ***Manufacturer Info Target*** field is *Battery* (01b) the ***Manufacturer Info Ref*** field ***Shall*** contain the *Battery* number reference which is the number of the *Battery* indexed from zero: • Values 0…3 represent the *Fixed Batteries*. • Values 4…7 represent the Hot Swappable Batteries. Otherwise, this field is ***Reserved*** and ***Shall*** be set to zero.

6.5.7 Manufacturer_Info Message

The ***Manufacturer_Info*** *Message* ***Shall*** be sent in response to a ***Get_Manufacturer_Info*** *Message*. The ***Manufacturer_Info*** *Message* contains the USB *VID* and the Vendor's PID to identify the device or *Battery* and the device or *Battery*'s manufacturer byte array in a variable length Data Block of up to ***MaxExtendedMsgLegacyLen***.

The ***Manufacturer_Info*** *Message* returns a Manufacturer Info Data Block (MIDB) whose format ***Shall*** be as shown in *Figure 6.44, "Manufacturer_Info Message"* and *Table 6.61, "Manufacturer Info Data Block (MIDB)"*.

Figure 6.44 Manufacturer_Info Message

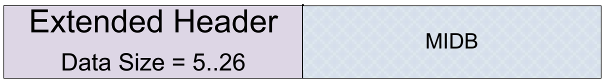


Table 6.61 Manufacturer Info Data Block (MIDB)

Offset	Field	Description
0	***VID***	*Vendor ID* (assigned by the USB-IF)
2	***PID***	Product ID (assigned by the manufacturer)
4	***Manufacturer String***	Vendor defined null terminated string of 0…21 characters. If the ***Manufacturer Info Target*** field or ***Manufacturer Info Ref*** field in the ***Get_Manufacturer_Info*** *Message* is unrecognized the field ***Shall*** return a null terminated ASCII text string "Not Supported".

6.5.7.1 Vendor ID (VID)

If the in ***Manufacturer Info Target*** field in the ***Get_Manufacturer_Info*** *Message* is associated with this *Port*/*Cable Plug*, the ***VID*** field ***Shall*** contain:

- The manufacturer's *VID* associated with the *Port*/*Cable Plug*, as defined by the USB-IF, or
- 0xFFFF in the case that the vendor does not have a *VID*.

If the in ***Manufacturer Info Target*** field in the ***Get_Manufacturer_Info*** *Message* is associated with a *Device* that has a USB data interface, the *Device* ***Shall*** report the same *VID* as the idVendor in the Standard Device Descriptor (see ***[USB 2.0]*** and ***[USB 3.2]***).

If the in ***Manufacturer Info Target*** field in the ***Get_Manufacturer_Info*** *Message* is associated with a *Battery*, the ***VID*** field ***Shall*** contain:

- The manufacturer *VID* associated with the *Battery* specified, as defined by the USB-IF, or
- 0xFFFF in the case that the vendor does not have a *VID*.

If the in ***Manufacturer Info Target*** field in the ***Get_Manufacturer_Info*** *Message*:

- Is ***Invalid***, this ***VID*** field ***Shall*** be 0xFFFF.
- Is *Battery* (01b) and the ***Manufacturer Info Ref*** field is ***Invalid***, the ***VID*** field ***Shall*** be 0xFFFF.

6.5.7.2 Product ID (PID)

If the ***VID*** is 0xFFFF, the ***PID*** field ***Shall*** contain 0x0000.

Otherwise:

- If the in ***Manufacturer Info Target*** field in the ***Get_Manufacturer_Info*** *Message* is associated with this *Port*/*Cable Plug*, the PID field ***Shall*** contain the device's 16-bit product identifier designated by the device vendor.
- If the in ***Manufacturer Info Target*** field in the ***Get_Manufacturer_Info*** *Message* is associated with a *Battery*:
  - And the *VID* belongs to the *Battery* vendor, the ***PID*** field ***Shall*** contain the *Battery*'s 16-bit product identifier designated by the *Battery* vendor.
  - And the *VID* belongs to the *Device* vendor, the ***PID*** field ***Shall*** contain the *Battery*'s 16-bit product identifier designated by the *Device* vendor.

6.5.7.3 Manufacturer String

The ***Manufacturer String*** field ***Shall*** contain the device’s or *Battery*'s manufacturer string as defined by the vendor.

If the ***Manufacturer Info Target*** field or ***Manufacturer Info Ref*** field in the ***Get_Manufacturer_Info*** *Message* is unrecognized the field ***Shall*** return a null terminated ASCII text string "Not Supported".

6.5.8 Security Messages

The authentication process between *Port Partners* or a *Port* and *Cable Plug* is fully described in ***[USBTypeCAuthentication 1.0]***. This specification describes two *Extended Messages* used by the authentication process when applied to PD.

In the authentication process described in ***[USBTypeCAuthentication 1.0]*** there are three basic exchanges that serve to:

- Get the *Port* or *Cable Plug*'s certificates.
- Get the *Port* or *Cable Plug*'s digest.
- Challenge the *Port Partner* or *Cable Plug*.

Certificates are used to convey information, attested to by a signer, which attests to the *Port Partner*'s or *Cable Plug*'s authenticity. The *Port*'s or *Cable Plug*'s certificates are needed when a *Port* encounters a *Port Partner* or *Cable Plug* it has not been *Attached* to before. To minimize calculations after the initial *Attachment*, a *Port* can also use a digest consisting of hashes of the certificates rather than the certificates themselves. Once the *Port* has the certificates and has calculated the hashes, it stores the hashes and uses the digest in future exchanges. After the *Port* gets the certificates or digest, it challenges its *Port Partner* or the *Cable Plug* to detect replay attacks.

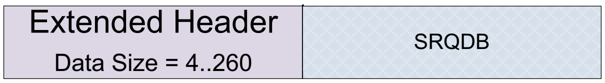
For further details refer to ***[USBTypeCAuthentication 1.0]***.

6.5.8.1 Security_Request

The ***Security_Request*** *Message* is used by a *Port* to pass a security data structure to its *Port Partner* or a *Cable Plug*.

The ***Security_Request*** *Message* contains a Security Request Data Block (SRQDB) whose format ***Shall*** be as shown in *Figure 6.45, "Security_Request Message"*. The contents of the SRQDB and its use are defined in ***[USBTypeCAuthentication 1.0]***.

Figure 6.45 Security_Request Message

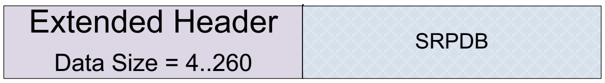


6.5.8.2 Security_Response

The ***Security_Response*** *Message* is used by a *Port* or *Cable Plug* to pass a security data structure to the *Port* that sent the ***Security_Request*** *Message*.

The ***Security_Response*** *Message* contains a Security Response Data Block (SRPDB) whose format ***Shall*** be as shown in *Figure 6.46, "Security_Response Message"*. The contents of the SRPDB and its use are defined in ***[USBTypeCAuthentication 1.0]***.

Figure 6.46 Security_Response Message



6.5.9 Firmware Update Messages

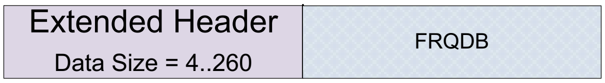
The firmware update process between *Port Partner*s or a *Port* and *Cable Plug* is fully described in ***[USBPDFirmwareUpdate 1.0]***. This specification describes two *Extended Message*s used by the firmware update process when applied to PD.

6.5.9.1 Firmware_Update_Request

The ***Firmware_Update_Request*** *Message* is used by a *Port* to pass a firmware update data structure to its *Port Partner* or a *Cable Plug*.

The ***Firmware_Update_Request*** *Message* contains a Firmware Update Request Data Block (FRQDB) whose format ***Shall*** be as shown in *Figure 6.47, "Firmware_Update_Request Message"*. The contents of the FRQDB and its use are defined in ***[USBPDFirmwareUpdate 1.0]***.

Figure 6.47 Firmware_Update_Request Message

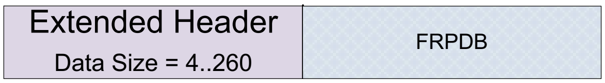


6.5.9.2 Firmware_Update_Response

The ***Firmware_Update_Response*** *Message* is used by a *Port* or *Cable Plug* to pass a firmware update data structure to the *Port* that sent the ***Firmware_Update_Request*** *Message*.

The ***Firmware_Update_Response*** *Message* contains a Firmware Update Response Data Block (FRPDB) whose format ***Shall*** be as shown in *Figure 6.48, "Firmware_Update_Response Message"*. The contents of the FRPDB and its use are defined in ***[USBPDFirmwareUpdate 1.0]***.

Figure 6.48 Firmware_Update_Response Message



6.5.10 PPS_Status Message

The ***PPS_Status*** *Message* ***Shall*** be sent in response to a ***Get_PPS_Status*** *Message*. The ***PPS_Status*** *Message* enables a *Sink* to query the *Source* to get additional information about its operational state. The ***Get_PPS_Status*** *Message* and the ***PPS_Status*** *Message* ***Shall*** only be supported when the ***Alert*** *Message* is also supported.

The ***PPS_Status*** *Message* ***Shall*** return a 4-byte PPS Status Data Block (PPSSDB) whose format ***Shall*** be as shown in *Figure 6.49, "PPS_Status Message"* and *Table 6.62, "PPS Status Data Block (PPSSDB)"*.

Figure 6.49 PPS_Status Message

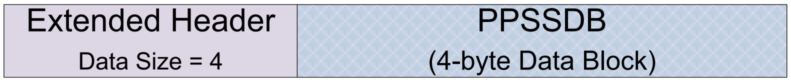


Table 6.62 PPS Status Data Block (PPSSDB)

Offset (Byte)	Field	Description	
0	***Output Voltage***	2	*Source*'s output voltage in 20mV units. When set to 0xFFFF, the *Source* does not support this field.
2	***Output Current***	1	*Source*'s output current in 50mA units. When set to 0xFF, the *Source* does not support this field.
3	***Real Time Flags***	**Bit**	**Description**
		0	***Reserved*** and ***Shall*** be set to zero
		1…2	***PTF*** • PTF: 00 – Not Supported • PTF: 01 – Normal • PTF: 10 – Warning • PTF: 11 – Over temperature
		3	***OMF*** OMF (Operating Mode Flag) is set when operating in ***Current Limit*** mode and cleared when operating in ***Constant Voltage*** mode.
		4…7	***Reserved*** and ***Shall*** be set to zero

6.5.10.1 Output Voltage Field

The ***Output Voltage*** field ***Shall*** return the *Source*'s output voltage at the time of the request. The output voltage is measured either at the *Source*'s receptacle or, if the *Source* has a captive cable, where the voltage is applied to the cable.

The measurement accuracy ***Shall*** be +/-3% rounded to the nearest 20mV in *SPR PPS Mode*.

If the *Source* does not support the ***Output Voltage*** field, the field ***Shall*** be set to 0xFFFF.

6.5.10.2 Output Current Field

The ***Output Current*** field ***Shall*** return the *Source*'s output current at the time of the request measured at the *Source*'s receptacle.

The measurement accuracy ***Shall*** be +/-150mA.

If the *Source* does not support the ***Output Current*** field, the field ***Shall*** be set to 0xFF.

6.5.10.3 Real Time Flags Field

Real Time flags provide a real-time indication of the *Source*'s operating state:

- The ***PTF*** (Present Temperature Flag) ***Shall*** provide a real-time indication of the *Source*'s internal thermal status. If the PTF is not supported, it will be set to zero:
  - Normal indicates that the *Source* is operating within its normal thermal envelope.
  - Warning indicates that the *Source* is over-heating but is not in imminent danger of shutting down.
  - Over Temperature indicates that the *Source* is over heated and will shut down soon or has already shutdown and has sent the ***OTP Event*** flag in an ***Alert*** *Message*.
- The ***OMF*** (Operating Mode Flag) ***Shall*** provide a real-time indication of the *SPR PPS Source*'s operating mode. When set, the *Source* is operating in ***Current Limit*** mode; when cleared it is operating ***Constant Voltage*** mode. This bit ***Shall*** be set to zero when not in *SPR PPS Mode*.

6.5.11 Country_Codes Message

The ***Country_Codes*** *Message* ***Shall*** be sent in response to a ***Get_Country_Codes*** *Message*. The ***Country_Codes*** *Message* enables a *Port* to query its *Port Partner* to get a list of alpha-2 country codes as defined in ***[ISO 3166]*** for which the *Port Partner* has country specific information.

The ***Country_Codes*** *Message* ***Shall*** contain a 4…26-byte Country Code Data Block (CCDB) whose format ***Shall*** be as shown in *Figure 6.50, "Country_Codes Message"* and *Table 6.63, "Country Codes Data Block (CCDB)"*.

Figure 6.50 Country_Codes Message

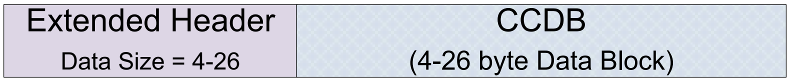


Table 6.63 Country Codes Data Block (CCDB)

<table>
<tr><th>Offset</th><th>Field</th><th colspan="3">Description</th></tr>
<tr><td>0</td><td><em><strong>Length</strong></em></td><td colspan="3">Number of country codes in the <em>Message</em></td></tr>
<tr><td>1</td><td><em><strong>Reserved</strong></em></td><td colspan="3"><em><strong>Shall</strong></em> be set to zero.</td></tr>
<tr><td rowspan="7">2…
Length * 2n</td><td rowspan="7"><em><strong>Country Code</strong></em></td><th>Offset</th><th>Field</th><th>Description</th></tr>
<tr><td>2</td><td>1st Country Code</td><td>First character of the Alpha-2 Country Code defined by <em><strong>[ISO 3166]</strong></em></td></tr>
<tr><td>3</td><td></td><td>Second character of the Alpha-2 Country Code defined by <em><strong>[ISO 3166]</strong></em></td></tr>
<tr><td>4</td><td>2nd Country Code</td><td>First character of the Alpha-2 Country Code defined by <em><strong>[ISO 3166]</strong></em></td></tr>
<tr><td>5</td><td></td><td>Second character of the Alpha-2 Country Code defined by <em><strong>[ISO 3166]</strong></em></td></tr>
<tr><td></td><td>…</td><td></td></tr>
<tr><td>Length * 2n</td><td>nth Country Code</td><td></td></tr>
</table>

6.5.11.1 Country Code Field

The ***Country Code*** field ***Shall*** contain ***Length*** Country Codes in the Alpha-2 Country Code defined by ***[ISO 3166]***.

6.5.12 Country_Info Message

The *Country_Info Message* ***Shall*** be sent in response to a *Get_Country_Info Message*. The *Country_Info Message* enables a *Port* to get additional country specific information from its *Port Partner*.

The *Country_Info Message* ***Shall*** contain a 4…26-byte Country Info Data Block (CIDB) whose format ***Shall*** be as shown in *Figure 6.51, "Country_Info Message"* and *Table 6.64, "Country Info Data Block (CIDB)"*.

Figure 6.51 Country_Info Message

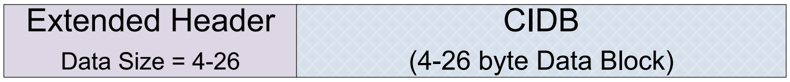


Table 6.64 Country Info Data Block (CIDB)

Offset	Field	Size
0	*Country Code*	First character of the Alpha-2 Country Code received in the corresponding *Get_Country_Info Message*.
1		Second character of the Alpha-2 Country Code received in the corresponding *Get_Country_Info Message*
2…3	***Reserved***	***Shall*** be set to zero.
4	*Country Specific Data*	1…22 bytes of content defined by the country’s authority.

6.5.12.1 Country Code Field

The *Country Code* field ***Shall*** contain the Alpha-2 Country Code received in the corresponding *Get_Country_Info Message*.

6.5.12.2 Country Specific Data Field

The *Country Specific Data* field ***Shall*** contain content defined by and formatted in a manner determined by an official agency of the country indicated in the Country Code field.

If the Country Code field in the *Get_Country_Info Message* is unrecognized then Country Specific Data field ***Shall*** return the null terminated ASCII text string "Unsupported Code".

6.5.13 Sink_Capabilities_Extended Message

The ***Sink_Capabilities_Extended*** *Message* ***Shall*** be sent in response to a ***Get_Sink_Cap_Extended*** *Message*. The ***Sink_Capabilities_Extended*** *Message* enables a *Sink* or a *DRP* to inform the *Source* about its *Capabilities* as a *Sink*.

The ***Sink_Capabilities_Extended*** *Message* ***Shall*** return a 24-byte Sink Capabilities Extended Data Block (SKEDB) whose format ***Shall*** be as shown in *Figure 6.52, "Sink_Capabilities_Extended Message"* and *Table 6.65, "Sink Capabilities Extended Data Block (SKEDB)"*.

Figure 6.52 Sink_Capabilities_Extended Message

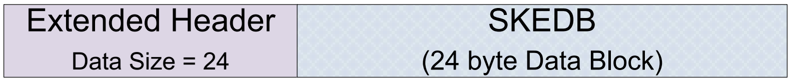


Table 6.65 Sink Capabilities Extended Data Block (SKEDB)

<table>
<tr><th>Offset (Byte)</th><th>Field</th><th>Size (Bytes)</th><th>Type</th><th colspan="2">Description</th></tr>
<tr><td>0</td><td><i>VID</i></td><td>2</td><td>Numeric</td><td colspan="2"><i>Vendor ID</i> (assigned by the USB-IF)</td></tr>
<tr><td>2</td><td><i>PID</i></td><td>2</td><td>Numeric</td><td colspan="2">Product ID (assigned by the manufacturer)</td></tr>
<tr><td>4</td><td><i>XID</i></td><td>4</td><td>Numeric</td><td colspan="2">Value provided by the USB-IF assigned to the product</td></tr>
<tr><td>8</td><td><i>FW Version</i></td><td>1</td><td>Numeric</td><td colspan="2">Firmware version number</td></tr>
<tr><td>9</td><td><i>HW Version</i></td><td>1</td><td>Numeric</td><td colspan="2">Hardware version number</td></tr>
<tr><td>10</td><td><i>SKEDB Version</i></td><td>1</td><td>Numeric</td><td colspan="2">SKEDB Version (not the specification Version):
• Version 1.0 = 1
Values 0 and 2-255 are <b><i>Reserved</i></b> and <b><i>Shall Not</i></b> be used.</td></tr>
<tr><td rowspan="3">11</td><td rowspan="3"><i>Load Step</i></td><td rowspan="3">1</td><td rowspan="3">Bit Field</td><td><b>Bit</b></td><td><b>Description</b></td></tr>
<tr><td>0…1</td><td>• 00b: 150mA/µs Load Step (default)
• 01b: 500mA/µs Load Step
11b…10b: <b><i>Reserved</i></b> and <b><i>Shall Not</i></b> be used.</td></tr>
<tr><td>2…7</td><td><b><i>Reserved</i></b> and <b><i>Shall</i></b> be set to zero</td></tr>
<tr><td rowspan="5">12</td><td rowspan="5"><i>Sink Load Characteristics</i></td><td rowspan="5">2</td><td rowspan="5">Bit Field</td><td><b>Bit</b></td><td><b>Description</b></td></tr>
<tr><td>0…4</td><td>Percent overload in 10% increments.
Values higher than 25 (11001b) are clipped to 250%. 00000b is the default.</td></tr>
<tr><td>5…10</td><td>Overload period in 20ms when bits 0…4 non-zero.</td></tr>
<tr><td>1…14</td><td>Duty cycle in 5% increments when bits 0…4 are non-zero.</td></tr>
<tr><td>15</td><td>Can tolerate <i>VBUS</i> voltage droop</td></tr>
<tr><td rowspan="5">14</td><td rowspan="5"><i>Compliance</i></td><td rowspan="5">1</td><td rowspan="5">Bit Field</td><td><b>Bit</b></td><td><b>Description</b></td></tr>
<tr><td>0</td><td>Requires <i>LPS Source</i> when set</td></tr>
<tr><td>1</td><td>Requires PS1 <i>Source</i> when set</td></tr>
<tr><td>2</td><td>Requires PS2 <i>Source</i> when set</td></tr>
<tr><td>3…7</td><td><b><i>Reserved</i></b> and <b><i>Shall</i></b> be set to zero</td></tr>
</table>

Table 6.65 Sink Capabilities Extended Data Block (SKEDB) (Continued)

<table>
<tr><th>Offset (Byte)</th><th>Field</th><th>Size (Bytes)</th><th>Type</th><th colspan="2">Description</th></tr>
<tr><td>15</td><td>*Touch Temp*</td><td>1</td><td>Value</td><td colspan="2">Temperature conforms to:
• 0 = Not applicable
• 1 = *[IEC 60950-1]* (default)
• 2 = *[IEC 62368-1]* TS1
• 3 = *[IEC 62368-1]* TS2
Note: All other values ***Reserved***</td></tr>
<tr><td>16</td><td>*Battery Info*</td><td>1</td><td>Byte</td><td colspan="2">Upper Nibble = Number of Hot Swappable *Battery Slots* (0…4)
Lower Nibble = Number of *Fixed Batteries* (0…4)</td></tr>
<tr><td rowspan="8">17</td><td rowspan="8">*Sink Modes*</td><td rowspan="8">1</td><td rowspan="8">Bit Field</td><th>Bit</th><th>Description</th></tr>
<tr><td>0</td><td>*PPS* charging supported</td></tr>
<tr><td>1</td><td>*VBUS* powered</td></tr>
<tr><td>2</td><td>*AC Supply* powered</td></tr>
<tr><td>3</td><td>*Battery* powered</td></tr>
<tr><td>4</td><td>*Battery* essentially unlimited</td></tr>
<tr><td>5</td><td>*AVS* Support</td></tr>
<tr><td>6…7</td><td>***Reserved*** and ***Shall*** be set to zero</td></tr>
<tr><td rowspan="3">18</td><td rowspan="3">*SPR Sink Minimum PDP*</td><td rowspan="3">1</td><td rowspan="3">Byte</td><th>Bit</th><th>Description</th></tr>
<tr><td>0…6</td><td>The *PDP* of the *Source* that the *Sink* requires to operate at its lowest functionality without consuming power from its *Battery* if it has one.</td></tr>
<tr><td>7</td><td>***Reserved*** and ***Shall*** be set to zero</td></tr>
<tr><td rowspan="3">19</td><td rowspan="3">*SPR Sink Operational PDP*</td><td rowspan="3">1</td><td rowspan="3">Byte</td><th>Bit</th><th>Description</th></tr>
<tr><td>0…6</td><td>The *PDP* of the *Source* that the *Sink* requires to operate at its normal functionality.</td></tr>
<tr><td>7</td><td>***Reserved*** and ***Shall*** be set to zero</td></tr>
<tr><td rowspan="3">20</td><td rowspan="3">*SPR Sink Maximum PDP*</td><td rowspan="3">1</td><td rowspan="3">Byte</td><th>Bit</th><th>Description</th></tr>
<tr><td>0…6</td><td>The maximum *PDP* the *Sink* will ever request.</td></tr>
<tr><td>7</td><td>***Reserved*** and ***Shall*** be set to zero</td></tr>
<tr><td>21</td><td>*EPR Sink Minimum PDP*</td><td>1</td><td>Byte</td><td colspan="2">The *PDP* of the *Source* that the *EPR Sink* requires to operate at its lowest functionality without consuming power from its *Battery* if it has one.</td></tr>
<tr><td>22</td><td>*EPR Sink Operational PDP*</td><td>1</td><td>Byte</td><td colspan="2">The *PDP* of the *Source* that the *EPR Sink* requires to operate at its normal functionality.</td></tr>
<tr><td>23</td><td>*EPR Sink Maximum PDP*</td><td>1</td><td>Byte</td><td colspan="2">The maximum *PDP* that the *EPR Sink* will ever request.</td></tr>
</table>

6.5.13.1 Vendor ID (VID) Field

The *VID* field ***Shall*** contain the 16-bit *Vendor ID* (*VID*) assigned to the *Sink*'s vendor by the USB-IF. If the vendor does not have a *VID*, the *VID* field ***Shall*** be set to 0xFFFF. *Devices* that have a USB data interface ***Shall*** report the same *VID* as the idVendor in the Standard Device Descriptor (see *[USB 2.0]* and *[USB 3.2]*).

6.5.13.2 Product ID (PID) Field

The *PID* field ***Shall*** contain the 16-bit Product ID (PID) assigned by the *Sink*'s vendor. *Devices* that have a USB data interface ***Shall*** report the same PID as the idProduct in the Standard Device Descriptor (see *[USB 2.0]* and *[USB 3.2]*).

6.5.13.3 XID Field

The ***XID*** field ***Shall*** contain the 32-bit XID provided by the USB-IF to the vendor who in turns assigns it to a product. If the vendor does not have an XID, then it ***Shall*** return zero in this field (see ***[USB 2.0]*** and ***[USB 3.2]***).

6.5.13.4 Firmware Version Field

The ***FW Version*** field ***Shall*** contain an 8-bit firmware version number assigned to the device by the vendor.

6.5.13.5 Hardware Version Field

The ***HW Version*** field ***Shall*** contain an 8-bit hardware version number assigned to the device by the vendor.

6.5.13.6 SKEDB Version Field

The ***SKEDB Version*** field contains the version level of the SKEDB. Currently only Version 1 is defined.

6.5.13.7 Load Step Field

The ***Load Step*** field contains bits indicating the Load Step Slew Rate and Magnitude that this *Sink* prefers. See *Section 7.1.12.1, "Voltage Regulation Field"* for further details.

6.5.13.8 Sink Load Characteristics Field

The *Sink* ***Shall*** report its preferred load characteristics in the ***Sink Load Characteristics*** field. Regardless of this value, in operation its load ***Shall Not*** exceed the *Capabilities* reported in the ***Source_Capabilities_Extended*** *Message*.

6.5.13.9 Compliance Field

The ***Compliance*** field ***Shall*** contain the types of *Source*s the *Sink* has been tested and certified with (see *Section 7.1.12.3, "Compliance Field"*).

6.5.13.10 Touch Temp

The ***Touch Temp*** field ***Shall*** report the IEC standard used to determine the surface temperature of the *Sink*'s enclosure. Safety limits for the *Sink*'s touch temperature are set in applicable product safety standards (e.g., ***[IEC 60950-1]*** or ***[IEC 62368-1]***). The *Sink* ***May*** report when its touch temperature performance conforms to the TS1 or TS2 limits described in ***[IEC 62368-1]***.

6.5.13.11 Battery Info

The ***Battery Info*** field ***Shall*** report the number of *Fixed Batteries* and *Hot Swappable Battery* slots the *Sink* supports. This field ***Shall*** independently report the number of *Battery Slot*s and the number of *Fixed Batteries*. The information reported in the ***Battery Info*** field ***Shall*** match that reported in the ***Number of Batteries/Battery Slots*** field of the ***Source_Capabilities_Extended*** *Message*.

A *Sink* ***Shall*** have no more than 4 *Fixed Batteries* and no more than 4 *Battery Slot*s.

Fixed Batteries ***Shall*** be numbered consecutively from 0 to 3. The number assigned to a given *Fixed Battery* ***Shall Not*** change between *Attach* and *Detach*.

Battery Slots ***Shall*** be numbered consecutively from 4 to 7. The number assigned to a given *Battery Slot* ***Shall Not*** change between *Attach* and *Detach*.

6.5.13.12 Sink Modes

The ***Sink Modes*** bit field ***Shall*** identify the charging *Capabilities* and the power sources that can be used by the *Sink*. When bit 0 is set, the *Sink* has the ability to use a *PPS Source* for fast charging.

The source of power a *Sink* can use:

- When bit 1 is set, the *Sink* has the ability to be sourced by *VBUS*.
- When bit 2 is set, the *Sink* has the ability to be sourced by an *AC Supply*.
- When bit 3 is set, the *Sink* has the ability to be sourced by a *Battery*.
- When bit 4 is set, the *Sink* has the ability to be sourced by a *Battery* with essentially infinite energy (e.g., a car battery).

Bits 1-4 ***May*** be set independently of one another. The combination indicates what sources of power the *Sink* can utilize. For example, some *Sink*s are only powered by a *Battery* (e.g., an automobile battery) rather than the more common *AC Supply* and some *Sink*s are only powered from *VBUS* or *VCONN*.

When bit 5 is set, the *Sink* has the ability to support *AVS*.

6.5.13.13 SPR Sink Minimum PDP

The ***SPR Sink Minimum PDP*** field ***Shall*** contain the minimum power *Source PDP* needed by the *Sink*, rounded up to the next integer, to operate at its lowest level of functionality without requiring power from its *Battery* if present. *Battery* charging may be an opportunistic feature, however this *PDP* ***Should*** be designed for basic functionality, not for charging. The ***SPR Sink Minimum PDP*** field ***Shall*** be less than or equal to the ***SPR Sink Operational PDP***. The value is used by the *Source* to determine whether or not it has sufficient power to minimally support the *Attached Sink*. If the *Sink* is *EPR Capable* and is unable to operate at *PDP*s less than 100W, it ***Shall*** set this field to the minimum power to sustain PD communication.

If the *Sink* is self-powered, such that it doesn't need power from a *Source*, then it ***Shall*** set this field to zero.

The ***SPR Sink Minimum PDP*** is used to indicate to *Shared Capacity Charger*s the power that ***Should*** be delivered to the *Sink* to guarantee at least basic functionality for the end user.

Possible examples of ***SPR Sink Minimum PDP*** could be:

- The minimum power a wireless *Charger* would require in order to detect, and deliver the minimum required amount of power to the attached device.
- The power required to have basic functionality by a *Battery*less *Sink*,
- On a device with a *Battery*, it can power the minimum functionality of the device

6.5.13.14 SPR Sink Operational PDP

The ***SPR Sink Operational PDP*** field ***Shall*** contain the *Source PDP* that the manufacturer recommends for the normal functionality of the *Sink*, rounded up to the next integer. This corresponds to the *PDP Rating* of *Source*s that the *Sink* is designed to operate with (See Section 10.3.2, "Normative Sink Rules"). The ***SPR Sink Operational PDP*** field ***Shall*** be sufficient to operate all the *Sink*'s functional modes normally AND charge the *Sink*'s *Battery* if present. For *Sink*s with a *Battery*(s), the ***SPR Sink Operational PDP*** field ***Shall*** correspond to the *PDP Rating* of the *Charger* shipped with the *Sink* or the recommended *Charger*'s *PDP Rating*. If the *Sink* is *EPR Capable* and is unable to operate at *PDP*s less than 100W, it ***Shall*** set the ***SPR Sink Minimum PDP*** field to the minimum power to sustain PD communication.

If the *Sink* is self-powered, such that it doesn't need power from a *Source*, then it ***Shall*** set this field to zero.

The ***SPR Sink Operational PDP*** is used to indicate to *Shared Capacity Charger*s that at this power level the user is not expected to receive any performance warning related to the power being supplied to the *Sink*.

6.5.13.15 SPR Sink Maximum PDP

The ***SPR Sink Maximum PDP*** field ***Shall*** contain the highest *PDP* the *Sink* will ever request under any operating condition, rounded up to the next integer, including charging its *Battery* if present. The ***SPR Sink Maximum PDP*** field ***Shall Not*** be less than the ***SPR Sink Operational PDP*** field, but ***May*** be the same. The value is used by the *Source* to determine the maximum amount of power it has to budget for the *Attached Sink*. If the *Sink* is *EPR Capable* and is unable to operate at *PDP*s less than 100W, it ***Shall*** set this field to the minimum power to sustain PD communication.

If the *Sink* is self-powered, such that it doesn't need power from a *Source*, then it ***Shall*** set this field to zero.

6.5.13.16 EPR Sink Minimum PDP

The ***EPR Sink Minimum PDP*** field ***Shall*** contain the *Source PDP* needed by an *EPR Sink*, rounded up to the next integer, to operate at its lowest level of functionality without requiring power from its *Battery*, if present. *Battery* charging may be an opportunistic feature, however this *PDP* ***Should*** be designed for basic functionality, not for charging. The ***EPR Sink Minimum PDP*** field ***Shall*** be less than or equal to the ***EPR Sink Operational PDP*** field value. The value is used by the *Source* to determine whether or not it has sufficient power to minimally support the *Attached Sink*. If the *Sink* is not *EPR Capable*, or if the *Sink* is self-powered, such that it doesn't need power from a *Source*, this field ***Shall*** be set to zero.

The ***EPR Sink Minimum PDP*** is used to indicate to *Shared Capacity Charger*s the power that ***Should*** be delivered to the *Sink* to guarantee at least basic functionality for the end user.

Possible examples of ***EPR Sink Minimum PDP*** could be:

- The power required to have basic functionality by a *Battery*less *Sink*,
- On a device with a *Battery*, it can power the minimum functionality of the device.

Note: ***EPR Sink Minimum PDP*** can be the same as its ***SPR Sink Minimum PDP***.

6.5.13.17 EPR Sink Operational PDP

The ***EPR Sink Operational PDP*** field ***Shall*** contain the *Source PDP* that the manufacturer recommends for the normal functionality of the *Sink*, rounded up to the next integer. This corresponds to the *PDP Rating* of *EPR Source*s that the *Sink* is designed to operate with (See [Section 10.3.2, "Normative Sink Rules"](#)). The ***EPR Sink Operational PDP*** ***Shall*** be sufficient to operate all the *Sink*'s functional modes normally AND charge the *Sink*'s *Battery* if present. For *Sink*s with a *Battery*(s), it ***Shall*** correspond to the *PDP Rating* of the *Charger* shipped with the *EPR Sink* or the recommended *Charger*'s *PDP Rating*. If the *Sink* is not *EPR Capable*, or if the *Sink* is self-powered, such that it doesn't need power from a *Source*, this field ***Shall*** be set to zero.

The ***EPR Sink Operational PDP*** is used to indicate to *Shared Capacity Charger*s that at this power level the user is not expected to receive any performance warning related to the power being supplied to the *Sink*.

6.5.13.18 EPR Sink Maximum PDP

The ***EPR Sink Maximum PDP*** field ***Shall*** be highest *PDP* the *EPR Sink* will ever request under any operating condition, rounded up to the next integer, including charging its *Battery* if present. The ***EPR Sink Maximum PDP*** field ***Shall Not*** be less than the ***EPR Sink Operational PDP***, but ***May*** be the same. The value is used by the *Source* to determine the maximum amount of power it has to budget for the *Attached Sink*. If the *Sink* is not *EPR Capable*, or if the *Sink* is self-powered, such that it doesn't need power from a *Source*, this field ***Shall*** be set to zero.

6.5.14 Extended_Control Message

The ***Extended_Control*** *Message* extends the *Control Message* space. The ***Extended_Control*** *Message* includes one byte of data. The ***Extended_Control*** *Message* ***Shall*** be as shown in *Figure 6.53, "Extended_Control Message"* and *Table 6.66, "Extended Control Data Block (ECDB)"*.

Figure 6.53 Extended_Control Message

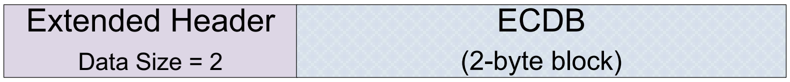


Table 6.66 Extended Control Data Block (ECDB)

Offset	Field	Value	Description
0	Type	Unsigned Int	*Extended Control Message* Type
1	Data	Byte	***Shall*** be set to zero when not used.

The ***Extended_Control*** *Message* types are specified in the Type field of the ECDB and are listed in *Table 6.67, "Extended Control Message Types"*. The Sent by column indicates entities which ***May*** send the given *Message* (*Source*, *Sink* or *Cable Plug*); entities not listed ***Shall Not*** issue the corresponding *Message*. The "Valid Start of Packet" column indicates the *Messages* which ***Shall*** only be issued in *SOP Packet*s.

Table 6.67 Extended Control Message Types

Type	Data	Message Type	Sent by	Description	Valid Start of Packet
0		***Reserved***		All values not explicitly defined are ***Reserved*** and ***Shall Not*** be used.	
1	Not used	***EPR_Get_Source_Cap***	*Sink* or *DRP*	See *Section 6.5.14.1*	*SOP* only
2	Not used	***EPR_Get_Sink_Cap***	*Source* or *DRP*	See *Section 6.5.14.2*	*SOP* only
3	Not used	***EPR_KeepAlive***	*Sink*	See *Section 6.5.14.3*	*SOP* only
4	Not Used	***EPR_KeepAlive_Ack***	*Source*	See *Section 6.5.14.4*	*SOP* only
5…255		***Reserved***		All values not explicitly defined are ***Reserved*** and ***Shall Not*** be used.	

6.5.14.1 EPR_Get_Source_Cap Message

The ***EPR_Get_Source_Cap*** (EPR Get *Source Capabilities*) *Message* ***Shall*** only be sent by a *Port* capable of operating as a *Sink* and that supports *EPR Mode* to request the *Source Capabilities* and *Dual-Role Power* capability of its *Port Partner*. A *Port* that can operate as an *EPR Source* ***Shall*** respond by returning an ***EPR_Source_Capabilities*** *Message* (see *Section 6.5.15.2, "EPR_Source_Capabilities Message"*). A *Port* that does not support *EPR Mode* as a *Source* ***Shall*** return the ***Not_Supported*** *Message*.

An *EPR Capable Sink Port* that is operating in *SPR Mode* ***Shall*** treat the ***EPR_Source_Capabilities*** *Message* as informational only and ***Shall Not*** respond with an ***EPR_Request*** *Message*.

6.5.14.2 EPR_Get_Sink_Cap Message

The ***EPR_Get_Sink_Cap*** (EPR Get *Sink Capabilities*) *Message* ***Shall*** only be sent by a *Port* capable of operating as a *Source* and that supports *EPR Mode* to request the *Sink Capabilities* and *Dual-Role Power* capability of its *Port Partner*. A *Port* that is *EPR Capable* operating as a *Sink* ***Shall*** respond by returning an ***EPR_Sink_Capabilities*** *Message* (see *Section 6.5.15.3, "EPR_Sink_Capabilities Message"*). A *Port* that does not support *EPR Mode* as a *Sink* ***Shall*** return the ***Not_Supported*** *Message*.

6.5.14.3 EPR_KeepAlive Message

The ***EPR_KeepAlive*** *Message* ***May*** be sent by a *Sink* operating in *EPR Mode* to meet the requirement for periodic traffic. The *Source* operating on *EPR Mode* responds by returning an ***EPR_KeepAlive_Ack*** *Message* to the *Sink*. See *Section 6.4.9, "EPR_Request Message"* for additional information.

6.5.14.4 EPR_KeepAlive_Ack Message

The ***EPR_KeepAlive_Ack*** *Message* ***Shall*** be sent by a *Source* operating in *EPR Mode* in response to an ***EPR_KeepAlive*** *Message*. See *Section 6.4.9, "EPR_Request Message"* for additional information.

6.5.15 EPR Capabilities Message

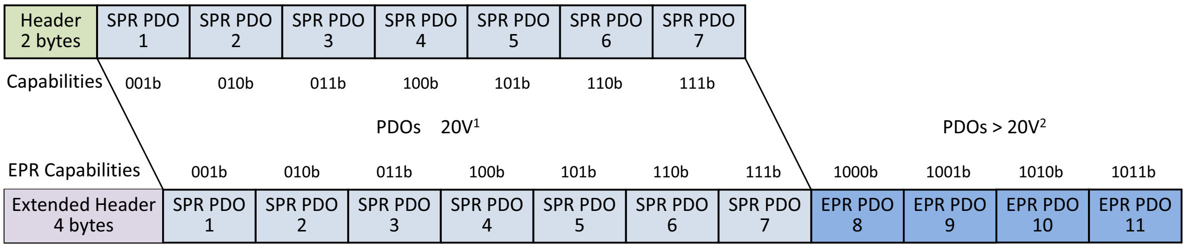
The *EPR Capabilities Message* is an *Extended Capabilities Message* made of *Power Data Objects* (*PDO*) defined in *Section 6.4.1, "Capabilities Message"*. It is used to form ***EPR_Source_Capabilities*** *Messages* and ***EPR_Sink_Capabilities*** *Messages*. *Sources* expose their EPR power *Capabilities* by sending an ***EPR_Source_Capabilities*** *Message*. *Sinks* expose their EPR power requirements by returning an ***EPR_Sink_Capabilities*** *Message* when requested. Both are composed of a number of 32-bit *Power Data Objects* (see *Table 6.7, "Power Data Object"*).

An *EPR Capabilities Message* ***Shall*** have a 5V *Fixed Supply PDO* containing the sending *Port*'s information in the first object position followed by up to 10 additional *PDOs*.

6.5.15.1 EPR Capabilities Message Construction

The *EPR Capabilities Messages* (***EPR_Source_Capabilities*** and ***EPR_Sink_Capabilities***) are *Extended Messages* with the first seven positions filled with the same *SPR (A)PDOs* returned by the *SPR Capabilities Messages* (***Source_Capabilities*** and ***Sink_Capabilities***) followed by the *EPR (A)PDOs* starting in the eighth position. See *Figure 6.54, "Mapping SPR Capabilities to EPR Capabilities"*.

Figure 6.54 Mapping SPR Capabilities to EPR Capabilities



[1] See ***Section 10 "Power Rules"*** for rules, on which SPR (A)PDOs are allowed to be used for a given PDP.

[2] See ***Section 10 "Power Rules"*** for rules, on which EPR (A)PDOs are allowed be used for a given PDP.

Power Data Objects in the *EPR Capabilities Messages* ***Shall*** be sent in the following order:

1) The *SPR (A)PDOs* as reported in the *SPR Capabilities Message*. The ***Number of Data Objects*** field in the *Message Header* of the *EPR Capabilities Message* is the same as the ***Number of Data Objects*** field in the *Message Header* of the *SPR Capabilities Message*.

2) If the *SPR Capabilities Message* contains fewer than 7 *PDOs*, the unused *Data Objects* ***Shall*** be zero filled.

3) The *EPR (A)PDOs* as defined in *Section 6.4.1, "Capabilities Message"* ***Shall*** start at *Data Object* position 8 and ***Shall*** be sent in the following order:

   a) *Fixed Supply PDOs* that offer 28V, 36V or 48V, if present, ***Shall*** be sent in voltage order; lowest to highest.

   b) One *EPR AVS APDO* ***Shall*** be sent.

6.5.15.2 EPR_Source_Capabilities Message

The ***EPR_Source_Capabilities*** is an *EPR Capabilities Message* containing a list of *Power Data Objects* that the *EPR Source* is capable of supplying. It is sent by an *EPR Source* in order to convey its *Capabilities* to a *Sink*. An *EPR Source* ***Shall*** send the ***EPR_Source_Capabilities*** *Message*:

- When entering *EPR Mode*
- While in *EPR Modes* when its *Capabilities* change
- In response to an ***EPR_Get_Source_Cap*** *Message*
- After a *Soft Reset* while in *EPR Mode*

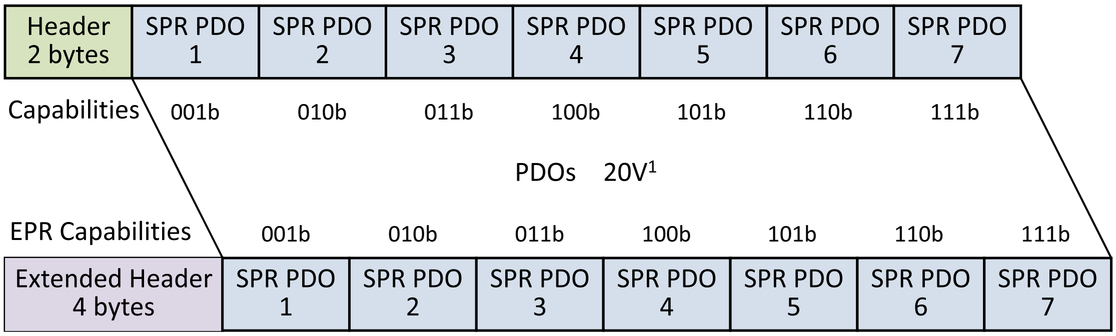
An *EPR Sink* operating in *EPR Mode* ***Shall*** evaluate every ***EPR_Source_Capabilities*** *Message* it receives and ***Shall*** respond with a ***EPR_Request*** *Message*. If its power consumption exceeds the *Source Capabilities*, it ***Shall*** *Re-negotiate* so as not to exceed the *Source*'s most recently *Advertised Source Capabilities*.

While operating in *SPR Mode*, an *EPR Sink* receiving an ***EPR_Source_Capabilities*** *Message* in response to an ***EPR_Get_Source_Cap*** *Messages* ***Shall Not*** respond with an ***EPR_Request*** *Message*.

The *(A)PDOs* in an ***EPR_Source_Capabilities*** *Message* ***Shall*** only be requested using the ***EPR_Request*** *Message* and only when in *EPR Mode*.

When *Source* wants to exit *EPR Mode*, if not already in power contract with an *SPR (A)PDO*, it ***Shall*** send an ***EPR_Source_Capabilities*** *Message* with no *EPR (A)PDOs* (i.e. seven *SPR (A)PDOs* including any zero padded ones). See *Figure 6.55, "EPR_Source_Capabilities message with no EPR PDOs"*.

Figure 6.55 EPR_Source_Capabilities message with no EPR PDOs



[1] See ***Section 10 "Power Rules"*** for rules, on which SPR (A)PDOs are allowed to be used for a given PDP.

6.5.15.3 EPR_Sink_Capabilities Message

The ***EPR_Sink_Capabilities*** is an *EPR Capabilities Message* that contains a list of *Power Data Objects* that the *EPR Sink* requires to operate. It is sent by an *EPR Sink* in order to convey its power requirements to an *EPR Source*. The *EPR Sink* ***Shall*** only send the ***EPR_Sink_Capabilities*** *Message* in response to an ***EPR_Get_Sink_Cap*** *Message*.

6.5.16 Vendor_Defined_Extended Message

The ***Vendor_Defined_Extended*** *Message* (*VDEM*) is provided to allow vendors to exchange information outside of that defined by this specification using the *Extended Message* format.

A ***Vendor_Defined_Extended*** *Message* ***Shall*** consist of at least one *Vendor Data Object*, the *VDM Header*, and ***May*** contain up to a maximum of 256 additional data bytes.

To ensure vendor uniqueness of ***Vendor_Defined_Extended*** *Messages*, all ***Vendor_Defined_Extended*** *Messages* ***Shall*** contain a ***Valid*** USB *Standard or Vendor ID* (*SVID*) allocated by USB-IF in the *VDM Header*.

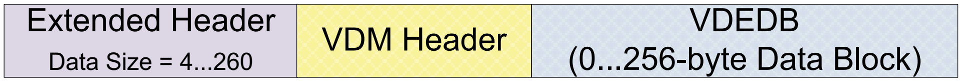
A *VDEM* does not define any structure and *Messages* ***May*** be created in any manner that the vendor chooses.

Vendor_Defined_Extended *Messages* ***Shall Not*** be used for direct power *Negotiation*. They ***May*** however be used to alter *Local Policy*, affecting what is offered or consumed via the normal PD *Message*s. For example, a ***Vendor_Defined_Extended*** *Message* could be used to enable the *Source* to offer additional power via a ***Source_Capabilities*** *Message*.

Vendor_Defined_Extended *Messages* ***Shall Not*** be used where equivalent functionality is contained in the PD Specification e.g., authentication or firmware update.

The *Message* format ***Shall*** be as shown in *Figure 6.56, "Vendor_Defined_Extended Message"*.

Figure 6.56 Vendor_Defined_Extended Message



The *VDM Header* ***Shall*** be the first 4-bytes in a *Vendor Defined Extended Message*. The *VDM Header* provides *Command* space to allow vendors to customize *Message*s for their own purposes.

The *VDM Header* in the *VDEM* ***Shall*** follow the *Unstructured VDM Header* format as defined in *Section 6.4.4.1, "Unstructured VDM"*.

*VDEM*s ***Shall*** only be sent and received after an *Explicit Contract* has been established.

A *VDEM AMS* ***Shall Not*** interrupt any other PD *AMS*.

The *VDEM* does not define the contents of bits B14...0 in the *VDM Header*. Their definition and use are the sole responsibility of the vendor indicated by the *SVID*. The *Port Partner*s and *Cable Plugs* ***Shall*** exit any states entered using a *VDEM* according to the rules defined in *Section 6.4.4.3.4, "Enter Mode Command"*.

The following rules apply to the use of *VDEM Messages*:

- *VDEM*s ***Shall Not*** be initiated or responded to under any other circumstances than the following:
    - *VDEM*s ***Shall*** only be used when an *Explicit Contract* is in place.
    - Prior to establishing an *Explicit Contract VDEM*s ***Shall Not*** be sent and ***Shall*** be ***Ignored*** if received.
    - *Cable Plugs* ***Shall Not*** initiate *VDEM*s.

- *VDEM*s ***Shall*** only be used during *Modal Operation* in the context of an *Active Mode* i.e., only after the *UFP* has Ack'ed the ***Enter Mode*** *Command* can *VDEM*s be sent or received. The *Active Mode* and the associated *VDEM*s ***Shall*** use the same *SVID*.
- *VDEM*s ***May*** be used with *SOP* Packet*s.
- When a *DFP* or *UFP* does not support *VDEM*s or does not recognize the *VID* it ***Shall*** return a ***Not_Supported*** *Message*.

Note: Usage of *VDEM*s with *Chunking* is not recommended since this is less efficient than using *Unstructured VDM*s.

6.6 Timers

All the following timers are defined in terms of bits on the bus regardless of where they are implemented in terms of the logical architecture. This is to ensure a fixed reference for the starting and stopping of timers. It is left to the implementer to ensure that this timing is observed in a real system.

6.6.1 CRCReceiveTimer

The ***CRCReceiveTimer*** ***Shall*** be used by the sender's *Protocol Layer* to ensure that a *Message* has not been lost. Failure to receive an acknowledgment of a *Message* (a ***GoodCRC*** *Message*) whether caused by a bad ***GoodCRC*** *Message* on the receiving end or by a garbled *Message* within ***tReceive*** is detected when the ***CRCReceiveTimer*** expires.

The sender's *Protocol Layer* response when a ***CRCReceiveTimer*** expires ***Shall*** be to retry ***nRetryCount*** times.

Note: *Cable Plugs* do not retry *Messages* and large *Extended Messages* that are not *Chunked* are not retried (see *Section 6.7.2, "Retry Counter"*).

Sending of the Preamble corresponding to the retried *Message* ***Shall*** start within ***tRetry*** of the ***CRCReceiveTimer*** expiring.

The ***CRCReceiveTimer*** ***Shall*** be started when the last bit of the *Message* ***EOP*** has been transmitted by the *PHY Layer*. The ***CRCReceiveTimer*** ***Shall*** be stopped when the last bit of the ***EOP*** corresponding to the ***GoodCRC*** *Message* has been received by the *PHY Layer*.

The *Protocol Layer* receiving a *Message* ***Shall*** respond with a ***GoodCRC*** *Message* within ***tTransmit*** in order to ensure that the sender's ***CRCReceiveTimer*** does not expire. The ***tTransmit*** time ***Shall*** be measured from when the last bit of the *Message* ***EOP*** has been received by the *PHY Layer* until the first bit of the Preamble of the ***GoodCRC*** *Message* has been transmitted by the *PHY Layer*.

6.6.2 SenderResponseTimer

The ***SenderResponseTimer*** ***Shall*** be used by the sender's *Policy Engine* to ensure that a *Message* requesting a response (e.g., ***Get_Source_Cap*** *Message*) is responded to within a bounded time of ***tSenderResponse***. Failure to receive the expected response is detected when the ***SenderResponseTimer*** expires.

For *Extended Messages* received as *Chunks*, the ***SenderResponseTimer*** will also be started and stopped by the *Chunking* Rx State Machine. See *Section 8.3.3.1.1, "SenderResponseTimer State Diagram"* for more details of the ***SenderResponseTimer*** operation.

The *Policy Engine*'s response when the ***SenderResponseTimer*** expires ***Shall*** be dependent on the *Message* sent (see *Section 8.3, "Policy Engine"*).

The ***SenderResponseTimer*** ***Shall*** be started from the time the last bit of the ***GoodCRC*** *Message* ***EOP***, corresponding to the *Message* requesting a response, has been received by the *PHY Layer*.

The ***SenderResponseTimer*** ***Shall*** be stopped when the last bit of the ***EOP*** of the ***GoodCRC*** *Message*, corresponding to the expected response *Message*, has been transmitted by the *PHY Layer*.

The receiver of a *Message* requiring a response ***Shall*** respond within ***tReceiverResponse*** in order to ensure that the sender's ***SenderResponseTimer*** does not expire.

The ***tReceiverResponse*** time ***Shall*** be measured from the time the last bit of the ***GoodCRC*** *Message* ***EOP***, corresponding to the expected request *Message*, has been transmitted by the *PHY Layer* until the first bit of the response *Message* Preamble has been transmitted by the *PHY Layer*.

6.6.3 Capability Timers

Sources and *Sinks* use Capability Timers to determine *Attachment* of a PD Capable device. By periodically sending or requesting *Capabilities*, it is possible to determine PD device *Attachment* when a response is received.

6.6.3.1 SourceCapabilityTimer

Prior to the *First Explicit Contract* a *Source* ***Shall*** use the ***SourceCapabilityTimer*** to periodically send out a ***Source_Capabilities*** *Message* every ***tTypeCSendSourceCap*** while:

- The *Port* is *Attached*.
- The *Source* is not in an active connection with a PD *Sink Port*.

Whenever there is a ***SourceCapabilityTimer*** timeout the *Source* ***Shall*** send a ***Source_Capabilities*** *Message*. It ***Shall*** then re-initialize and restart the ***SourceCapabilityTimer***. The ***SourceCapabilityTimer*** ***Shall*** be stopped when the last bit of the ***EOP*** corresponding to the ***GoodCRC*** *Message* has been received by the *PHY Layer* since a PD connection has been established. At this point, the *Source* waits for a ***Request*** *Message* or a response timeout.

Note: The *Source* can also stop sending ***Source_Capabilities*** *Message* after ***nCapsCount*** *Messages* have been sent without a ***GoodCRC*** *Message* response (see *Section 6.7.4, "Capabilities Counter"*).

See *Section 8.3.3.2, "Policy Engine Source Port State Diagram"* for more details of when ***Source_Capabilities*** *Messages* are transmitted.

6.6.3.2 SinkWaitCapTimer

The *Sink* ***Shall*** support the ***SinkWaitCapTimer***.

While in a *Default Contract* or an *Implicit Contract* when a *Sink* observes an absence of ***Source_Capabilities*** *Messages*, after *VBUS* is present, for a duration of ***tTypeCSinkWaitCap*** the *Sink* ***May*** issue ***Hard Reset*** *Signaling* in order to restart the sending of ***Source_Capabilities*** *Messages* by the *Source* (see *Section 6.7.4, "Capabilities Counter"*) or continue to operate at *USB Type-C* current.

When a *Sink*, entering *EPR Mode*, observes an absence of ***EPR_Source_Capabilities*** *Messages*, after the ***GoodCRC*** *Message* acknowledging the ***EPR_Mode*** *Message* with the Action field set to 3 (***Enter Succeeded***), for a duration of ***tTypeCSinkWaitCap*** the *Sink* ***Shall*** issue ***Hard Reset*** *Signaling* in order to exit *EPR Mode* (see *Section 6.4.10, "EPR_Mode Message"*).

When a *Sink*, exiting *EPR Mode*, observes an absence of ***Source_Capabilities*** *Messages*, after the ***GoodCRC*** *Message* acknowledging the ***EPR_Mode*** *Message* with the Action field set to 5 (***Exit***), for a duration of ***tTypeCSinkWaitCap*** the *Sink* ***Shall*** issue ***Hard Reset*** *Signaling* in order to restart the sending of ***Source_Capabilities*** *Messages* by the *Source* (see *Section 6.7.4, "Capabilities Counter"*).

See *Section 8.3.3.3, "Policy Engine Sink Port State Diagram"* for more details of when the ***SinkWaitCapTimer*** is run.

6.6.3.3 tFirstSourceCap

After *Port Partners* are *Attached* or after a *Hard Reset* or after a *Power Role Swap* or after a *Fast Role Swap* a *Source* ***Shall*** send its first ***Source_Capabilities*** *Message* within ***tFirstSourceCap*** of *VBUS* reaching ***vSafe5V***.

After *Soft Reset*, a *Source* ***Shall*** send its first *Source Capabilities Message* within ***tFirstSourceCap*** after last bit of the ***GoodCRC*** *Message* ***EOP*** corresponding to ***Accept*** *Message*.

This ensures that the *Sink* receives a *Source Capabilities Message* before the *Sink*'s ***SinkWaitCapTimer*** expires.

A *Source* entering *EPR Mode* ***Shall*** send its first ***EPR_Source_Capabilities*** *Message* within ***tFirstSourceCap*** of the ***GoodCRC*** *Message* acknowledging the ***EPR_Mode*** *Message* with the Action field set to 3 (***Enter Succeeded***).

A *Source* exiting *EPR Mode* ***Shall*** send its first ***Source_Capabilities*** *Message* within ***tFirstSourceCap*** of the ***GoodCRC*** *Message* acknowledging the ***EPR_Mode*** *Message* with the Action field set to 5 (***Exit***).

6.6.4 Wait Timers and Times

6.6.4.1 SinkRequestTimer

The ***SinkRequestTimer*** is used to ensure that the time before the next *Sink Request Message*, after a ***Wait*** *Message* has been received from the *Source* in response to a *Sink Request Message*, is a minimum of ***tSinkRequest*** min (see *Section 6.3.12, "Wait Message"*).

The ***SinkRequestTimer*** ***Shall*** be started when the ***EOP*** of a ***Wait*** *Message* has been received and ***Shall*** be stopped if any other *Message* is received or during a *Hard Reset*.

The *Sink* ***Shall*** wait at least ***tSinkRequest***, after receiving the ***EOP*** of a ***Wait*** *Message* sent in response to a *Sink Request Message*, before sending a new *Request Message*. Whenever there is a ***SinkRequestTimer*** timeout the *Sink* ***May*** send a *Request Message*. It ***Shall*** then re-initialize and restart the ***SinkRequestTimer***.

6.6.4.2 tPRSwapWait

The time before the next ***PR_Swap*** *Message*, after a ***Wait*** *Message* has been received in response to a ***PR_Swap*** *Message* is a minimum of ***tPRSwapWait*** min (see *Section 6.3.12, "Wait Message"*). The *Port* ***Shall*** wait at least ***tPRSwapWait*** after receiving the ***EOP*** of a ***Wait*** *Message* sent in response to a ***PR_Swap*** *Message*, before sending a new ***PR_Swap*** *Message*.

6.6.4.3 tDRSwapWait

The time before the next ***DR_Swap*** *Message*, after a ***Wait*** *Message* has been received in response to a ***DR_Swap*** *Message* is a minimum of ***tDRSwapWait*** min (see *Section 6.3.12, "Wait Message"*). The *Port* ***Shall*** wait at least ***tDRSwapWait*** after receiving the ***EOP*** of a ***Wait*** *Message* sent in response to a ***DR_Swap*** *Message*, before sending a new ***DR_Swap*** *Message*.

6.6.4.4 tVCONNSwapWait

The time before the next ***VCONN_Swap*** *Message*, after a ***Wait*** *Message* has been received in response to a ***VCONN_Swap*** *Message* is a minimum of ***tVCONNSwapWait*** min (see *Section 6.3.12, "Wait Message"*). The *Port* ***Shall*** wait at least ***tVCONNSwapWait*** after receiving the ***EOP*** of a ***Wait*** *Message* sent in response to a ***VCONN_Swap*** *Message*, before sending a new ***VCONN_Swap*** *Message*.

6.6.4.5 tVCONNSwapDelayDFP

The time delay for *DFP* after losing *VCONN Source* role due to an incoming *VCONN Swap* request from *UFP* and before sending the next ***VCONN_Swap*** *Message*. The *DFP* ***Shall*** wait at least ***tVCONNSwapDelayDFP*** after sending the ***EOP*** of the ***GoodCRC*** *Message* in response to ***PS_RDY*** *Message* received at the end of the previous *VCONN Swap AMS*.

6.6.4.6 tVCONNSwapDelayUFP

The time delay for *UFP* after losing *VCONN Source* role due to an incoming *VCONN Swap* request from *DFP* and before sending the next ***VCONN_Swap*** *Message*. The *UFP* ***Shall*** wait at least ***tVCONNSwapDelayUFP*** after sending the ***EOP*** of the ***GoodCRC*** *Message* in response to ***PS_RDY*** *Message* received at the end of the previous *VCONN Swap AMS*.

6.6.4.7 tEnterUSBWait

The time before the next ***Enter_USB*** *Message*, after a ***Wait*** *Message* has been received in response to a ***Enter_USB*** *Message* is a minimum of ***tEnterUSBWait*** min (see *Section 6.3.12, "Wait Message"*). The *DFP* ***Shall*** wait at least ***tEnterUSBWait*** after receiving the ***EOP*** of a ***Wait*** *Message* sent in response to an ***Enter_USB*** *Message*, before sending a new ***Enter_USB*** *Message*.

6.6.5 Power Supply Timers

See *Section 7.3, "Transitions"* for diagrams showing the usage of the timers in this section.

6.6.5.1 PSTransitionTimer

The ***PSTransitionTimer*** is used by the *Policy Engine* to timeout on a ***PS_RDY*** *Message*. It is started when a request for new *Source Capabilities* has been accepted and will timeout after ***tPSTransition*** if a ***PS_RDY*** *Message* has not been received. This condition leads to a *Hard Reset* and a return to *USB Default Operation*. The ***PSTransitionTimer*** relates to the time taken for the *Source* to transition from one voltage, or current level, to another (see *Section 7.1, "Source Requirements"*).

The ***PSTransitionTimer*** ***Shall*** be started when the last bit of the ***GoodCRC*** *Message* ***EOP***, corresponding to an ***Accept*** *Message*, has been transmitted by the *PHY Layer*. The ***PSTransitionTimer*** ***Shall*** be stopped when the last bit of the ***GoodCRC*** *Message* ***EOP***, corresponding to the ***PS_RDY*** *Message*, has been transmitted by the *PHY Layer*.

6.6.5.2 PSSourceOffTimer

6.6.5.2.1 Use during Power Role Swap

The ***PSSourceOffTimer*** is used by the *Policy Engine* in *Dual-Role Power Device* that is currently acting as a *Sink* to timeout on a ***PS_RDY*** *Message* during a *Power Role Swap AMS*. This condition leads to *USB Type-C Error Recovery*.

If a ***PR_Swap*** *Message* request has been sent by the *Dual-Role Power Device* currently acting as a *Source* the *Sink* can respond with an ***Accept*** *Message*. When the last bit of the ***GoodCRC*** *Message* ***EOP***, corresponding to this transmitted ***Accept*** *Message*, is received by the *Sink*'s *PHY Layer*, then the ***PSSourceOffTimer*** ***Shall*** be started.

If a ***PR_Swap*** *Message* request has been sent by the *Dual-Role Power Device* currently acting as a *Sink* the *Source* can respond with an ***Accept*** *Message*. When the last bit of the ***GoodCRC*** *Message* ***EOP***, corresponding to this received ***Accept*** *Message*, is transmitted by the *Sink*'s *PHY Layer*, then the ***PSSourceOffTimer*** ***Shall*** be started.

The ***PSSourceOffTimer*** ***Shall*** be stopped when the last bit of the ***GoodCRC*** *Message* ***EOP***, corresponding to the received ***PS_RDY*** *Message*, is transmitted by the *PHY Layer*.

The ***PSSourceOffTimer*** relates to the time taken for the remote *Dual-Role Power Device* to stop supplying power (see also *Section 7.3.2.1, "Sink Requested Power Role Swap"* and *Section 7.3.2.2, "Source Requested Power Role Swap"*). The timer ***Shall*** time out if a ***PS_RDY*** *Message* has not been received from the remote *Dual-Role Power Device* within ***tPSSourceOff*** indicating this has occurred.

6.6.5.2.2 Use during Fast Role Swap

The ***PSSourceOffTimer*** is used by the *Policy Engine* in *Dual-Role Power Device* that is the *Initial Sink* (currently providing ***vSafe5V***) to timeout on a ***PS_RDY*** *Message* during a *Fast Role Swap AMS*. This condition leads to *USB Type-C Error Recovery*.

When the ***FR_Swap*** *Message* request has been sent by the *Initial Sink*, the *Initial Source* ***Shall*** respond with an ***Accept*** *Message*. When the last bit of the ***GoodCRC*** *Message* ***EOP***, corresponding to this ***Accept*** *Message* is received by the *Initial Sink*'s *PHY Layer*, then the ***PSSourceOffTimer*** ***Shall*** be started.

The ***PSSourceOffTimer*** ***Shall*** be stopped when

the last bit of the ***GoodCRC*** *Message* ***EOP***, corresponding to the received ***PS_RDY*** *Message*, is transmitted by the *PHY Layer*.

The ***PSSourceOffTimer*** relates to the time taken for the *Initial Source* to stop supplying power and for *VBUS* to revert to ***vSafe5V*** (see also *Section 7.2.10, "Fast Role Swap"* and *Section 7.3.4, "Transitions Caused by Fast Role Swap"*). The timer ***Shall*** time out if a ***PS_RDY*** *Message* has not been received from the *Initial Source* within ***tPSSourceOff*** indicating this has occurred.

6.6.5.3 PSSourceOnTimer

6.6.5.3.1 Use during Power Role Swap

The ***PSSourceOnTimer*** is used by the *Policy Engine* in *Dual-Role Power Device* that has just stopped sourcing power and is waiting to start sinking power to timeout on a ***PS_RDY*** *Message* during a *Power Role Swap*. This condition leads to *USB Type-C Error Recovery*.

The ***PSSourceOnTimer*** ***Shall*** be started when:

- The last bit of the ***GoodCRC*** *Message* ***EOP***, corresponding to the transmitted ***PS_RDY*** *Message*, is received by the *PHY Layer*.
- The ***PSSourceOnTimer*** ***Shall*** be stopped when:
- The last bit of the ***GoodCRC*** *Message* ***EOP***, corresponding to the received ***PS_RDY*** *Message*, is transmitted by the *PHY Layer*.

The ***PSSourceOnTimer*** relates to the time taken for the remote *Dual-Role Power Device* to start sourcing power (see also *Section 7.3.2.1, "Sink Requested Power Role Swap"* and *Section 7.3.2.2, "Source Requested Power Role Swap"*) and will time out if a ***PS_RDY*** *Message* indicating this has not been received within ***tPSSourceOn***.

6.6.5.3.2 Use during Fast Role Swap

The ***PSSourceOnTimer*** is used by the *Policy Engine* in *Dual-Role Power Device* that has just stopped sourcing power and is waiting to start sinking power to timeout on a ***PS_RDY*** *Message* during a *Fast Role Swap*. This condition leads to *USB Type-C Error Recovery*.

The ***PSSourceOnTimer*** ***Shall*** be started when:

- The last bit of the ***GoodCRC*** *Message* ***EOP***, corresponding to the transmitted ***PS_RDY*** *Message*, is received by the *PHY Layer*.

The ***PSSourceOnTimer*** ***Shall*** be stopped when:

- The last bit of the ***GoodCRC*** *Message* ***EOP***, corresponding to the received ***PS_RDY*** *Message*, is transmitted by the *PHY Layer*.

The ***PSSourceOnTimer*** relates to the time taken for the remote *Dual-Role Power Device* to start sourcing power (see also *Section 7.2.10, "Fast Role Swap"* and *Section 7.3.4, "Transitions Caused by Fast Role Swap"*) and will time out if a ***PS_RDY*** *Message* indicating this has not been received within ***tPSSourceOn***.

6.6.6 NoResponseTimer

The ***NoResponseTimer*** is used by the *Policy Engine* in a *Source* to determine that its *Port Partner* is not responding after a *Hard Reset*. When the ***NoResponseTimer*** times out, the *Policy Engine* ***Shall*** issue up to ***nHardResetCount*** additional *Hard Resets* before determining that the *Port Partner* is non-responsive to USB Power Delivery messaging.

If the *Source* fails to receive a ***GoodCRC*** *Message* in response to a ***Source_Capabilities*** *Message* within ***tNoResponse*** of:

- The last bit of a ***Hard Reset*** *Signaling* being sent by the *PHY Layer* if the ***Hard Reset*** *Signaling* was initiated by the *Sink*.
- The last bit of a ***Hard Reset*** *Signaling* being received by the *PHY Layer* if the ***Hard Reset*** *Signaling* was initiated by the *Source*.

Then the *Source* ***Shall*** issue additional *Hard Resets* up to ***nHardResetCount*** times (see *Section 6.8.3, "Hard Reset"*).

For a non-responsive device, the *Policy Engine* in a *Source* ***May*** either decide to continue sending ***Source_Capabilities*** *Messages* or to go to non-USB Power Delivery operation and cease sending ***Source_Capabilities*** *Messages*.

6.6.7 BIST Timers

6.6.7.1 tBISTCarrierMode

tBISTCarrierMode is used to define the maximum time that a *UUT* has to enter *BIST Carrier Mode* when requested by a *Tester*.

A *UUT* ***Shall*** enter *BIST Carrier Mode* within ***tBISTCarrierMode*** of the last bit of the ***GoodCRC*** *Message* ***EOP***, corresponding to the received the ***BIST*** *Message* used to initiate the test, being transmitted by the *PHY Layer*. In *BIST Carrier Mode* when transmitting a continuous carrier signal transmission ***Shall*** start as soon as the *UUT* enters *BIST Mode*.

6.6.7.2 BISTContModeTimer

The ***BISTContModeTimer*** is used by a *UUT* to ensure that a *Continuous BIST Mode* (i.e., *BIST Carrier Mode*) is exited in a timely fashion. A *UUT* that has been put into a *Continuous BIST Mode* ***Shall*** return to normal operation (either ***PE_SRC_Transition_to_default***, ***PE_SNK_Transition_to_default***, or ***PE_CBL_Ready***) within ***tBISTContMode*** of starting to transmit a continuous carrier signal.

6.6.7.3 tBISTSharedTestMode

tBISTSharedTestMode is used to define the maximum time that a *UUT* has to enter *BIST Shared Capacity Test Mode* when requested by a *Tester*.

A *UUT* ***Shall*** enter *BIST Shared Capacity Test Mode* and send a new ***Source_Capabilities*** *Message* from all Ports within the *Shared Capacity Group* within ***tBISTSharedTestMode*** of the last bit of the ***GoodCRC*** *Message* ***EOP***, corresponding to the received the ***BIST*** *Message* used to initiate the test, being transmitted by the *PHY Layer*.

6.6.8 Power Role Swap Timers

6.6.8.1 SwapSourceStartTimer

The ***SwapSourceStartTimer*** ***Shall*** be used by the *New Source*, after a *Power Role Swap* or *Fast Role Swap*, to ensure that it does not send ***Source_Capabilities*** *Message* before the *New Sink* is ready to receive the ***Source_Capabilities*** *Message*. The *New Source* ***Shall Not*** send the ***Source_Capabilities*** *Message* earlier than ***tSwapSourceStart*** after the last bit of the ***EOP*** of ***GoodCRC*** *Message* sent in response to the ***PS_RDY*** *Message* sent by the *New Source* indicating that its power supply is ready. The *Sink* ***Shall*** be ready to receive a ***Source_Capabilities*** *Message* ***tSwapSinkReady*** after having sent the last bit of the ***EOP*** of ***GoodCRC*** *Message* sent in response to the ***PS_RDY*** *Message* sent by the *New Source* indicating that its power supply is ready.

6.6.9 Soft Reset Timers

6.6.9.1 tSoftReset

A failure to see a ***GoodCRC*** *Message* in response to any *Message* within ***tReceive*** (after ***nRetryCount*** retries), when a *Port Pair* is *Connected*, is indicative of a communications failure. This ***Shall*** cause the *Source* or *Sink* to send a ***Soft_Reset*** *Message*, transmission of which ***Shall*** be completed within ***tSoftReset*** of the ***CRCReceiveTimer*** expiring.

6.6.9.2 tProtErrSoftReset

If the *Protocol Error* occurs that causes the *Source* or *Sink* to send a ***Soft_Reset*** *Message*, the transmission of the ***Soft_Reset*** *Message* ***Shall*** be completed within ***tProtErrSoftReset*** of the ***EOP*** of the ***GoodCRC*** sent in response to the *Message* that caused the *Protocol Error*.

6.6.10 Data Reset Timers

6.6.10.1 VCONNDischargeTimer

The ***VCONNDischargeTimer*** is used by the *Policy Engine* in the *DFP* to ensure the *UFP* actively discharges *VCONN* in a timely manner to ensure the cable will restore Ra. Once the *UFP* has discharged *VCONN* below vRaReconnect (see ***[USB Type-C 2.4]***) it sends a ***PS_RDY*** *Message* (see also *Section 7.1.15, "VCONN Power Cycle"*).

If the *DFP* does not receive a ***PS_RDY*** *Message* from the *UFP* within ***tVCONNSourceDischarge*** of the last bit of the ***GoodCRC*** acknowledging the ***Accept*** *Message* in response to the ***Data_Reset*** *Message*, the ***VCONNDischargeTimer*** will time out and the *Policy Engine* ***Shall*** enter the ***ErrorRecovery*** State.

6.6.10.2 tDataReset

The *DFP* ***Shall*** complete the ***Data_Reset*** process (as defined in *Section 6.3.14, "Data_Reset Message"*) within ***tDataReset*** of the last bit of the ***GoodCRC*** *Message* ***EOP***, corresponding to the ***Accept*** *Message*, being transmitted by the *PHY Layer*.

6.6.10.3 DataResetFailTimer

The ***DataResetFailTimer*** ***Shall*** be used by the *DFP*'s *Policy Engine* to ensure the *Data Reset* process completes within ***tDataResetFail*** of the last bit of the ***GoodCRC*** acknowledging the ***Accept*** *Message* in response to the ***Data_Reset*** *Message*. If the *DFP*'s ***DataResetFailTimer*** expires, the *DFP* ***Shall*** enter the ***ErrorRecovery*** State.

6.6.10.4 DataResetFailUFPTimer

The ***DataResetFailUFPTimer*** ***Shall*** be used by the *UFP*'s *Policy Engine* to ensure the *Data Reset* process completes within ***tDataResetFailUFP*** of the last bit of the ***GoodCRC*** acknowledging the ***Accept*** *Message* in response to the ***Data_Reset*** *Message*. If the *UFP*'s ***DataResetFailUFPTimer*** expires, the *UFP* ***Shall*** enter the ***ErrorRecovery*** State.

6.6.11 Hard Reset Timers

6.6.11.1 HardResetCompleteTimer

The ***HardResetCompleteTimer*** is used by the *Protocol Layer* in the case where it has asked the *PHY Layer* to send ***Hard Reset*** *Signaling* and the *PHY Layer* is unable to send the *Signaling* within a reasonable time due to a non-*Idle* channel. If the *PHY Layer* does not indicate that the ***Hard Reset*** *Signaling* has been sent within ***tHardResetComplete*** of the *Protocol Layer* requesting transmission, then the *Protocol Layer* ***Shall*** inform the *Policy Engine* that the ***Hard Reset*** *Signaling* has been sent in order to ensure the power supply is reset in a timely fashion.

6.6.11.2 PSHardResetTimer

The ***PSHardResetTimer*** is used by the *Policy Engine* in a *Source* to ensure that the *Sink* has had sufficient time to process ***Hard Reset*** *Signaling* before turning off its power supply to *VBUS*.

When a *Hard Reset* occurs the *Source*, stops driving *VCONN*, removes R_p from the *CC* pin and starts to transition the *VBUS* voltage to ***vSafe0V*** either:

- ***tPSHardReset*** after the last bit of the ***Hard Reset*** *Signaling* has been received from the *Sink* or
- ***tPSHardReset*** after the last bit of the ***Hard Reset*** *Signaling* has been sent by the *Source*.

See *Section 7.1.5, "Response to Hard Resets"*.

6.6.11.3 tDRSwapHardReset

If a ***DR_Swap*** *Message* is received during *Modal Operation* then a *Hard Reset* ***Shall*** be initiated by the recipient of the unexpected ***DR_Swap*** *Message*; ***Hard Reset*** *Signaling* ***Shall*** be generated within ***tDRSwapHardReset*** of the ***EOP*** of the ***GoodCRC*** sent in response to the ***DR_Swap*** *Message*.

6.6.11.4 tProtErrHardReset

If a *Protocol Error* occurs that directly leads to a *Hard Reset*, the transmission of the ***Hard Reset*** *Signaling* ***Shall*** be completed within ***tProtErrHardReset*** of the ***EOP*** of the ***GoodCRC*** sent in response to the *Message* that caused the *Protocol Error*.

6.6.12 Structured VDM Timers

6.6.12.1 VDMResponseTimer

The ***VDMResponseTimer*** ***Shall*** be used by the *Initiator*'s *Policy Engine* to ensure that a *Structured VDM Command* request needing a response (e.g. ***Discover Identity*** *Command* request) is responded to within a bounded time of ***tVDMSenderResponse***. The ***VDMResponseTimer*** ***Shall*** be applied to all *Structured VDM Commands* except the

Enter Mode and ***Exit Mode*** *Command*s which have their own timers (***VDMModeEntryTimer*** and ***VDMModeExitTimer*** respectively). Failure to receive the expected response is detected when the ***VDMResponseTimer*** expires.

The *Policy Engine*'s response when the ***VDMResponseTimer*** expires ***Shall*** be dependent on the *Message* sent (see *Section 8.3, "Policy Engine"*).

The ***VDMResponseTimer*** ***Shall*** be started from the time the last bit of the ***GoodCRC*** *Message* ***EOP***, corresponding to the *VDM Command* requesting a response, has been received by the *PHY Layer*. The ***VDMResponseTimer*** ***Shall*** be stopped when the last bit of the ***EOP*** of the ***GoodCRC*** *Message*, corresponding to the expected *VDM Command* response, has been transmitted by the *PHY Layer*.

The receiver of a *Message* requiring a response ***Shall*** respond within ***tVDMReceiverResponse*** in order to ensure that the sender's ***VDMResponseTimer*** does not expire.

The ***tVDMReceiverResponse*** time ***Shall*** be measured from the time the last bit of the *Message* ***EOP*** has been transmitted by the *PHY Layer* until the first bit of the response *Message* Preamble has been transmitted by the *PHY Layer*.

6.6.12.2 VDMModeEntryTimer

The ***VDMModeEntryTimer*** ***Shall*** be used by the *Initiator*'s *Policy Engine* to ensure that the response to a *Structured VDM* ***Enter Mode*** *Command* request (***ACK*** or ***NAK*** with ***ACK*** indicating that the requested *Alternate Mode* has been entered) arrives within a bounded time of ***tVDMWaitModeEntry***. Failure to receive the expected response is detected when the ***VDMModeEntryTimer*** expires.

The *Policy Engine*'s response when the ***VDMModeEntryTimer*** expires is to inform the *Device Policy Manager* (see *Section 8.3.3.23.1, "DFP Structured VDM Mode Entry State Diagram"*).

The ***VDMModeEntryTimer*** ***Shall*** be started from the time the last bit of the ***EOP*** of the ***GoodCRC*** *Message*, corresponding to the *VDM Command* request, has been received by the *PHY Layer*. The ***VDMModeEntryTimer*** ***Shall*** be stopped when the last bit of the ***EOP*** of the ***GoodCRC*** *Message*, corresponding to the expected *Structured VDM Command* response (***ACK***, ***NAK*** or ***BUSY***), has been transmitted by the *PHY Layer*.

The receiver of a *Message* requiring a response ***Shall*** respond within ***tVDMEnterMode*** in order to ensure that the sender's ***VDMModeEntryTimer*** does not expire.

The ***tVDMEnterMode*** time ***Shall*** be measured from the time the last bit of the ***EOP*** of the ***GoodCRC*** *Message*, corresponding to *VDM Command* Request, has been transmitted by the *PHY Layer* until the first bit of the response *Message* Preamble has been transmitted by the *PHY Layer*.

6.6.12.3 VDMModeExitTimer

The ***VDMModeExitTimer*** ***Shall*** be used by the *Initiator*'s *Policy Engine* to ensure that the ***ACK*** response to a *Structured VDM* ***Exit Mode*** *Command*, indicating that the requested *Alternate Mode* has been exited, arrives within a bounded time of ***tVDMWaitModeExit***. Failure to receive the expected response is detected when the ***VDMModeExitTimer*** expires.

The *Policy Engine*'s response when the ***VDMModeExitTimer*** expires is to inform the *Device Policy Manager* (see *Section 8.3.3.23.2, "DFP Structured VDM Mode Exit State Diagram"*).

The ***VDMModeExitTimer*** ***Shall*** be started from the time the last bit of the ***GoodCRC*** *Message* ***EOP***, corresponding to the *VDM Command* requesting a response, has been received by the *PHY Layer*. The ***VDMModeExitTimer*** ***Shall*** be stopped when the last bit of the ***GoodCRC*** *Message* ***EOP***, corresponding to the expected *Structured VDM Command* response ***ACK***, has been transmitted by the *PHY Layer*.

The receiver of a *Message* requiring a response ***Shall*** respond within ***tVDMExitMode*** in order to ensure that the sender's ***VDMModeExitTimer*** does not expire.

The ***tVDMExitMode*** time ***Shall*** be measured from the time the last bit of the *Message* ***EOP*** has been received by the *PHY Layer* until the first bit of the response *Message* Preamble has been transmitted by the *PHY Layer*.

6.6.12.4 tVDMBusy

The *Initiator* ***Shall*** wait at least ***tVDMBusy***, after receiving a ***BUSY*** *Command* response, before repeating the *Structured VDM* request again.

6.6.13 VCONN Timers

6.6.13.1 VCONNOnTimer

The ***VCONNOnTimer*** is used during a *VCONN Swap*.

The ***VCONNOnTimer*** ***Shall*** be started when:

- The last bit of ***GoodCRC*** *Message* ***EOP***, corresponding to the ***Accept*** *Message*, is transmitted or received by the *PHY Layer*.

The ***VCONNOnTimer*** ***Shall*** be stopped when:

- The last bit of the ***GoodCRC*** *Message* ***EOP***, corresponding to the ***PS_RDY*** *Message*, is transmitted by the *PHY Layer*.

Prior to sending the ***PS_RDY*** *Message*, the *Port* ***Shall*** have turned *VCONN* On.

6.6.13.2 tVCONNSourceOff

The ***tVCONNSourceOff*** time applies during a *VCONN Swap*. The initial *VCONN Source* ***Shall*** cease sourcing *VCONN* within ***tVCONNSourceOff*** of the last bit of the ***GoodCRC*** *Message* ***EOP***, corresponding to the ***PS_RDY*** *Message*, being transmitted by the *PHY Layer*.

6.6.14 tCableMessage

Ports compliant with *Revision 3.x* of the specification ***Shall Not*** wait ***tCableMessage*** before sending an *SOP' Packet* or *SOP'' Packet* even when communicating using ***[USBPD 2.0]*** with a *Cable Plug*. This specification defines *Collision Avoidance* mechanisms that obviate the need for this time.

Cable Plugs ***Shall*** only wait ***tCableMessage*** before sending an *SOP' Packet* or *SOP'' Packet* when operating at ***[USBPD 2.0]***. When operating at Revisions higher than ***[USBPD 2.0]*** *Cable Plugs* ***Shall Not*** wait ***tCableMessage*** before sending an *SOP' Packet* or *SOP'' Packet*.

6.6.15 DiscoverIdentityTimer

The ***DiscoverIdentityTimer*** is used prior to or during an *Explicit Contract* when discovering whether a *Cable Plug* is PD Capable using *SOP'*. When performing *Cable Discovery* during an *Explicit Contract* the ***Discover Identity*** *Command* request ***Shall*** be sent every ***tDiscoverIdentity***. No more than ***nDiscoverIdentityCount Discover Identity*** *Messages* without a ***GoodCRC*** *Message* response ***Shall*** be sent. If no ***GoodCRC*** *Message* response is received after ***nDiscoverIdentityCount Discover Identity*** *Command* requests have been sent by a *Port*, the *Port* ***Shall Not*** send any further *SOP'/SOP'' Messages*.

6.6.16 Collision Avoidance Timers

6.6.16.1 SinkTxTimer

The ***SinkTxTimer*** is used by the *Protocol Layer* in a *Source* to allow the *Sink* to complete its transmission before initiating an *AMS*.

The *Source* ***Shall*** wait a minimum of ***tSinkTx*** after changing R_p from ***SinkTxOK*** to ***SinkTxNG*** before initiating an *AMS* by sending a *Message*.

A *Sink* ***Shall*** only initiate an *AMS* when it has determined that R_p is set to ***SinkTxOK***.

6.6.16.2 tSrcHoldsBus

If a transition into the *PE_SRC_Ready* state will result in an immediate transition out of the *PE_SRC_Ready* state within ***tSrcHoldsBus*** e.g. it is due to a *Protocol Error* that has not resulted in a *Soft Reset*, then the notifications of the end of *AMS* and first *Message* in an *AMS* ***May*** Not be sent to avoid changing the R_p value unnecessarily.

6.6.17 Fast Role Swap Timers

6.6.17.1 tFRSwap5V

The ***tFRSwap5V*** time ***Shall*** be measured from:

- The later of:
  - The last bit of the ***GoodCRC*** *Message* ***EOP***, corresponding to the ***Accept*** *Message* or
  - *VBUS* being within ***vSafe5V***.
- Until the first bit of the response ***PS_RDY*** *Message* Preamble has been transmitted by the *PHY Layer*.

During a *Fast Role Swap*, the *Initial Source* ***Shall*** start the ***PS_RDY*** *Message* within ***tFRSwap5V*** after both:

- The *Initial Source* has sent the ***Accept*** *Message*, and
- *VBUS* is at or below ***vSafe5V***.

6.6.17.2 tFRSwapComplete

During a fast-role swap, the *Initial Sink* ***Shall*** respond with a the ***PS_RDY*** *Message* within ***tFRSwapComplete*** after it has received the ***PS_RDY*** *Message* from the *Initial Source*. The ***tFRSwapComplete*** time ***Shall*** be measured from the time the last bit of the ***GoodCRC*** *Message* ***EOP***, corresponding to the ***PS_RDY*** *Message*, has been transmitted by the *PHY Layer* until the first bit of the response ***PS_RDY*** *Message* Preamble has been transmitted by the *PHY Layer*.

6.6.17.3 tFRSwapInit

That last bit of the ***EOP*** of the ***FR_Swap*** *Message* ***Shall*** be transmitted by the *New Source* no later than ***tFRSwapInit*** after the *Fast Role Swap Request* has been detected (see *Section 5.8.6.3, "Fast Role Swap Detection"*).

6.6.18 Chunking Timers

6.6.18.1 ChunkingNotSupportedTimer

The ***ChunkingNotSupportedTimer*** is used by a *Source* or *Sink* which does not support multi-chunk *Chunking* but has received a *Message Chunk*.

The ***ChunkingNotSupportedTimer*** ***Shall*** be started when:

- The last bit of the ***GoodCRC*** *Message* ***EOP***, corresponding to a *Message Chunk* of a multi-chunk *Message*, is transmitted by the *PHY Layer*. The *Policy Engine* ***Shall Not*** send its ***Not_Supported*** *Message* before the ***ChunkingNotSupportedTimer*** expires.

6.6.18.2 ChunkSenderRequestTimer

The ***ChunkSenderRequestTimer*** is used during a *Chunked Message* transmission.

The ***ChunkSenderRequestTimer*** ***Shall*** be used by the sender's *Chunking* state machine to ensure that a *Chunk* Response is responded to within a bounded time of ***tChunkSenderRequest***. Failure to receive the expected response is detected when the ***ChunkSenderRequestTimer*** expires.

The ***ChunkSenderRequestTimer*** ***Shall*** be started when:

- The last bit of the ***GoodCRC*** *Message* ***EOP***, corresponding to the *Chunk* Response *Message*, is received by the *PHY Layer*.

The ***ChunkSenderRequestTimer*** ***Shall*** be stopped when:

- The last bit of the ***EOP*** of the ***GoodCRC*** *Message*, corresponding to the *Chunk* Request *Message*, is transmitted by the *PHY Layer*.
- A *Message* other than a *Chunk* Request is received from the *Protocol Layer* Rx.

The receiver of a *Chunk* Response requiring a *Chunk* Request ***Shall*** respond with a *Chunk* Request within ***tChunkReceiverRequest*** in order to ensure that the sender's ***ChunkSenderRequestTimer*** does not expire.

The ***tChunkReceiverRequest*** time ***Shall*** be measured from the time the last bit of the ***EOP*** of the ***GoodCRC*** *Message*, corresponding to the *Chunk* Response *Message*, has been transmitted by the *PHY Layer* until the first bit of the response *Message* Preamble has been transmitted by the *PHY Layer*.

6.6.18.3 ChunkSenderResponseTimer

The ***ChunkSenderResponseTimer*** is used during a *Chunked Message* transmission.

The ***ChunkSenderResponseTimer*** ***Shall*** be used by the sender's *Chunking* state machine to ensure that a *Chunk* Request is responded to within a bounded time of ***tChunkSenderResponse***. Failure to receive the expected response is detected when the ***ChunkSenderResponseTimer*** expires.

The ***ChunkSenderResponseTimer*** ***Shall*** be started when:

- The last bit of the ***GoodCRC*** *Message* ***EOP***, corresponding to the *Chunk* Request *Message*, is received by the *PHY Layer*.

The ***ChunkSenderResponseTimer*** ***Shall*** be stopped when:

- The last bit of the ***GoodCRC*** *Message* ***EOP***, corresponding to the *Chunk* Response *Message*, is transmitted by the *PHY Layer*.
- A *Message* other than a *Chunk* is received from the *Protocol Layer*.

The receiver of a *Chunk* Request requiring a *Chunk* Response ***Shall*** respond with a *Chunk* Response within ***tChunkReceiverResponse*** in order to ensure that the sender's ***ChunkSenderResponseTimer*** does not expire.

The ***tChunkReceiverResponse*** time ***Shall*** be measured from the time the last bit of the ***EOP*** of the ***GoodCRC*** *Message*, corresponding to the *Chunk* Request *Message*, has been transmitted by the *PHY Layer* until the first bit of the response *Message* Preamble has been transmitted by the *PHY Layer*.

6.6.19 Programmable Power Supply Timers

6.6.19.1 SinkPPSPeriodicTimer

The ***SinkPPSPeriodicTimer*** ***Shall*** be used by the *Sink*'s *Policy Engine* to ensure that communication between the *Sink* and *Source* occurs within a bounded time of ***tPPSRequest*** when in *SPR PPS Mode*. In the absence of any other traffic, a ***Request*** *Message* requesting an *SPR PPS APDO* is sent periodically as a keep alive mechanism.

SinkPPSPeriodicTimer ***Shall*** be re-initialized and restarted on transmission, by the *PHY Layer*, of the last bit of the ***GoodCRC*** *Message* ***EOP***, corresponding to any received *Message*, that causes the *Sink* to enter the ***PE_SNK_Ready*** state.

The *Sink* ***Shall*** stop the ***SinkPPSPeriodicTimer*** on transmission, by the *PHY Layer*, of the last bit of the ***GoodCRC*** *Message* ***EOP***, corresponding to any *Message*, or the last bit of any *Signaling* is received, by the *PHY Layer*, from the *Source* and by the *Sink* that causes the *Sink* to leave the ***PE_SNK_Ready*** state.

6.6.19.2 SourcePPSCommTimer

The ***SourcePPSCommTimer*** ***Shall*** be used by the *Source*'s *Policy Engine* to ensure that communication between the *Sink* and *Source* occurs within a bounded time of ***tPPSTimeout*** when in *SPR PPS Mode*. In the absence of any other traffic, a ***Request*** *Message* requesting an *SPR PPS APDO* is received periodically as a keep alive mechanism.

SourcePPSCommTimer ***Shall*** be re-initialized and restarted when, after receiving any *Message* that causes the *Source* to enter the ***PE_SRC_Ready*** state, the last bit of the corresponding ***GoodCRC*** *Message* ***EOP*** is transmitted by the *PHY Layer*.

The *Source* ***Shall*** stop the ***SourcePPSCommTimer*** when:

- After receiving any *Message* that causes the *Source* to leave the ***PE_SRC_Ready*** state, the last bit of the of the corresponding ***GoodCRC*** *Message* ***EOP*** is sent by the *PHY Layer*, or
- The last bit of any *Signaling* is received by the *PHY Layer* from the *Sink* by the *Source* that causes the *Source* to leave the ***PE_SRC_Ready*** state.

When the ***SourcePPSCommTimer*** times out the *Source* ***Shall*** issue ***Hard Reset*** *Signaling*.

6.6.20 tEnterUSB

The *DFP* ***Shall*** send the ***Enter_USB*** *Message* within ***tEnterUSB*** of either:

- The last bit of the ***GoodCRC*** acknowledging the ***Data_Reset_Complete*** *Message* in response to the ***Data_Reset*** *Message* or
- A PD Connection, specifically the last bit of the ***GoodCRC*** acknowledging the ***Source_Capabilities*** *Message* after the initial entry into the ***PE_SRC_Send_Capabilities*** state or
- The last bit of the ***GoodCRC*** acknowledging the ***Accept*** *Message* in response to the ***DR_Swap*** *Message*

Failure by the *DFP* to meet this timeout parameter can result in the ports not transitioning into ***[USB4]*** operation. Any *AMS* initiated by the *UFP* prior to receiving the ***Enter_USB*** *Message* will delay reception of the ***Enter_USB*** *Message* and ***[USB4]*** operation, therefore a USB4® -capable *UFP* ***Should Not*** initiate any *AMS* until the *DFP* has been given time to send the ***Enter_USB*** *Message*.

6.6.21 EPR Timers

6.6.21.1 SinkEPREnterTimer Timer

The ***SinkEPREnterTimer*** is used to ensure the *EPR Mode* entry process completes within ***tEnterEPR***. The *Sink* ***Shall*** start the timer when it sees the last bit of the ***GoodCRC*** *Message* in response to the ***EPR_Mode*** *Message* with the Action field set to 1 (***Enter***). The *Sink* ***Shall*** stop the timer when the last bit of the corresponding ***GoodCRC*** *Message* ***EOP***, corresponding to the received ***EPR_Mode*** *Message* with the Action field set to 3 (***Enter Succeeded***), has been transmitted by the *PHY Layer*. If the timer expires the *Sink* ***Shall*** send a ***Soft_Reset*** *Message*.

6.6.21.2 SinkEPRKeepAlive Timer

The ***SinkEPRKeepAliveTimer*** ***Shall*** be used by the *Sink*'s *Policy Engine* to ensure that communication between the *Sink* and *Source* occurs within a bounded time of ***tSinkEPRKeepAlive***. The *Sink* ***Shall*** initialize and run this timer upon entry into the ***PE_SNK_Ready*** State when in *EPR Mode* and ***Shall*** stop it upon exit from the ***PE_SNK_Ready*** when in *EPR Mode*.

While operating in *EPR Mode*, the *Sink* ***Shall*** stop the ***SinkEPRKeepAliveTimer*** timer whenever:

- The last bit of the ***GoodCRC*** *Message* ***EOP***, in response any *Message* from the *Source*, is transmitted by the *PHY Layer*.
- The *PHY Layer* receives the last bit of the ***GoodCRC*** *Message* ***EOP*** in response to any *Message* sent to the *Source*.

If the timer expires the *Sink* ***Shall*** send an ***EPR_KeepAlive*** *Message*.

6.6.21.3 SourceEPRKeepAlive Timer

The ***SourceEPRKeepAliveTimer*** ***Shall*** be used by the *Source*'s *Policy Engine* to ensure that communication between the *Sink* and *Source* occurs within a bounded time of ***tSourceEPRKeepAlive***. The *Source* ***Shall*** initialize and run this timer upon entry into the ***PE_SRC_Ready*** State when in *EPR Mode* and ***Shall*** disable it upon exit from the ***PE_SRC_Ready*** State when *EPR Mode*.

While operating in *EPR Mode*, the *Source* ***Shall*** stop the ***SourceEPRKeepAliveTimer*** timer whenever:

- The last bit of the ***GoodCRC*** *Message* ***EOP***, in response any *Message* from the *Sink*, is transmitted by the *PHY Layer*.
- The *PHY Layer* receives the last bit of the ***GoodCRC*** *Message* ***EOP*** in response to any *Message* sent to the *Source*.

If the timer expires the *Source* ***Shall*** send ***Hard Reset*** *Signaling*.

6.6.21.4 tEPRSourceCableDiscovery

After *Port Partners* are *Attached* or after a *Hard Reset* or after a *Power Role Swap* or after a *Fast Role Swap* an *EPR Source* ***Shall*** discover the *Cable Plug* within ***tEPRSourceCableDiscovery*** of entering the *First Explicit Contract*.

The *EPR Source* ***Shall*** send the ***Discover Identity REQ*** *Command*, to the *Cable Plug*, within ***tEPRSourceCableDiscovery*** of receiving the ***GoodCRC*** *Message* acknowledging the ***PS_RDY*** *Message* as part of the *Explicit Contract Negotiation*.

Note: If the *EPR Source* is not the *VCONN Source*, ***tEPRSourceCableDiscovery***, will also include the time needed for the *VCONN Swap*.

6.6.22 Time Values and Timers

Table 6.68, "Time Values" summarizes the values for the timers listed in this section. For each Timer Value, a given implementation ***Shall*** pick a fixed value within the range specified. Table 6.69, "Timers" lists the timers.

Table 6.68 Time Values

Parameter	Value (min)	Value (Nom)	Value (max)	Units	Reference
tACTempUpdate			500	ms	Section 6.5.2.2.1
tBISTContMode	30	45	60	ms	Section 6.6.7.2
tBISTCarrierMode			300	ms	Section 6.6.7.1
tBISTSharedTestMode			1	s	Section 6.6.7.3
tCableMessage	750			µs	Section 6.6.14
tCapabilitiesMismatchResponse			2	s	Section 6.4.2.3
tChunkingNotSupported	40	45	50	ms	Section 6.6.18.1
tChunkReceiverRequest			15	ms	Section 6.6.18.2
tChunkReceiverResponse			15	ms	Section 6.6.18.3
tChunkSenderRequest	24	27	30	ms	Section 6.6.18.2
tChunkSenderResponse	24	27	30	ms	Section 6.6.18.3
tDataReset	200	225	250	ms	Section 6.6.10.2
tDataResetFail	300		400	ms	Section 6.6.10.3
tDataResetFailUFP	450		550	ms	Section 6.6.10.4
tDiscoverIdentity	40		50	ms	Section 6.6.14
tDRSwapHardReset			15	ms	Section 6.6.11.3
tDRSwapWait	100			ms	Section 6.6.4.3
tEnterUSB			500	ms	Section 6.6.20
tEnterUSBWait	100			ms	Section 6.6.4.7
tEnterEPR	450	500	550	ms	Section 6.6.21.1
tEPRSourceCableDiscovery			2	s	Section 6.6.21.4
tFirstSourceCap			250	ms	Section 6.6.3.3
tFRSwap5V			15	ms	Section 6.6.17.1
tFRSwapComplete			15	ms	Section 6.6.17.2
tFRSwapInit			15	ms	Section 6.6.17.3
tHardReset			5	ms	Section 6.3.13
tHardResetComplete	4	4.5	5	ms	Section 6.6.9
tSourceEPRKeepAlive	0.750	0.875	1.000	s	Section 6.6.21.3
tSinkEPRKeepAlive	0.250	0.375	0.500	s	Section 6.6.21.2
tNoResponse	4.5	5.0	5.5	s	Section 6.6.6
tPPSRequest			10	s	Section 6.6.19.1
tPPSTimeout	12.0	13.5	15.0	s	Section 6.6.19.2
tProtErrHardReset			15	ms	Section 6.6.11.4
tProtErrSoftReset			15	ms	Section 6.6.9.2
tPRSwapWait	100			ms	Section 6.6.4.2
tPSHardReset	25	30	35	ms	Section 6.6.11.2

Table 6.68 Time Values (Continued)

Parameter		Value (min)	Value (Nom)	Value (max)	Units	Reference
tPSSourceOff	*SPR Mode*	750	835	920	ms	Section 6.6.5.2
	EPR Mode	1120	1260	1400		
tPSSourceOn	*SPR Mode*	390	435	480	ms	Section 6.6.5.3
tPSTransition	*SPR Mode*	450	500	550	ms	Section 6.6.5.1
	EPR Mode	830	925	1020		
tReceive		0.9	1.0	1.1	ms	Section 6.6.1
tReceiverResponse				15	ms	Section 6.6.2
tRetry				195	µs	Section 6.6.1
tSenderResponse		27	30	33	ms	Section 6.6.2
tSinkDelay				5	ms	Section 5.7
tSinkRequest		100			ms	Section 6.6.4.1
tSinkTx		16	18	20	ms	Section 6.6.16
tSoftReset				15	ms	Section 6.8.1
tSrcHoldsBus				50	ms	Section 8.3.3.2
tSwapSinkReady				15	ms	Section 6.6.8.1
tSwapSourceStart		20			ms	Section 6.6.8.1
tTransmit				195	µs	Section 6.6.1
tTypeCSendSourceCap		100	150	200	ms	Section 6.6.3.1
tTypeCSinkWaitCap		310	465	620	ms	Section 6.6.3.2
tVCONNSourceDischarge		160	200	240	ms	Section 6.6.10.1
tVCONNSourceOff				25	ms	Section 6.6.13
tVCONNSourceOn				50	ms	Section 6.3.11
tVCONNSourceTimeout		100	150	200	ms	Section 6.6.13
tVCONNSwapWait		100			ms	Section 6.6.4.4
tVCONNSwapDelayDFP		100			ms	Section 6.6.4.5
tVCONNSwapDelayUFP		500			ms	Section 6.6.4.6
tVDMBusy		50			ms	Section 6.6.12.4
tVDMEnterMode				25	ms	Section 6.6.12.2
tVDMExitMode				25	ms	Section 6.6.12.3
tVDMReceiverResponse				15	ms	Section 6.6.12.1
tVDMSenderResponse		24	27	30	ms	Section 6.6.12.1
tVDMWaitModeEntry		40	45	50	ms	Section 6.6.12.2
tVDMWaitModeExit		40	45	50	ms	Section 6.6.12.3

Table 6.69 Timers

Timer	Parameter	Used By	Reference
BISTContModeTimer	tBISTContMode	Policy Engine	Section 6.6.7.2
ChunkingNotSupportedTimer	tChunkingNotSupported	Policy Engine	Section 6.6.18.1
ChunkSenderRequestTimer	tChunkSenderRequest	Protocol Layer	Section 6.6.18.2
ChunkSenderResponseTimer	tChunkSenderResponse	Protocol Layer	Section 6.6.18.3
CRCReceiveTimer	tReceive	Protocol Layer	Section 6.6.1
DataResetFailTimer	tDataResetFail	Policy Engine	Section 6.6.10.3
DataResetFailUFPTimer	tDataResetFailUFP	Policy Engine	Section 6.6.10.4
DiscoverIdentityTimer	tDiscoverIdentity	Policy Engine	Section 6.6.15
HardResetCompleteTimer	tHardResetComplete	Protocol Layer	Section 6.6.9
NoResponseTimer	tNoResponse	Policy Engine	Section 6.6.6
PSHardResetTimer	tPSHardReset	Policy Engine	Section 6.6.11.2
PSSourceOffTimer	tPSSourceOff	Policy Engine	Section 6.6.5.2
PSSourceOnTimer	tPSSourceOn	Policy Engine	Section 6.6.5.3
PSTransitionTimer	tPSTransition	Policy Engine	Section 6.6.5.1
SenderResponseTimer	tSenderResponse	Policy Engine	Section 6.6.2
SinkEPREnterTimer	tEnterEPR	Policy Engine	Section 6.6.21.1
SinkEPRKeepAliveTimer	tSinkEPRKeepAlive	Policy Engine	Section 6.6.21.2
SinkPPSPeriodicTimer	tPPSRequest	Policy Engine	Section 6.6.19.1
SinkRequestTimer	tSinkRequest	Policy Engine	Section 6.6.4
SinkWaitCapTimer	tTypeCSinkWaitCap	Policy Engine	Section 6.6.3.2
SourceCapabilityTimer	tTypeCSendSourceCap	Policy Engine	Section 6.6.3.1
SourceEPRKeepAliveTimer	tSourceEPRKeepAlive	Policy Engine	Section 6.6.21.3
SourcePPSCommTimer	tPPSTimeout	Policy Engine	Section 6.6.19.2
SinkTxTimer	tSinkTx	Protocol Layer	Section 6.6.16
SwapSourceStartTimer	tSwapSourceStart	Policy Engine	Section 6.6.8.1
VCONNDischargeTimer	tVCONNSourceDischarge	Policy Engine	Section 6.6.10.1
VCONNOnTimer	tVCONNSourceTimeout	Policy Engine	Section 6.6.13.1
VDMModeEntryTimer	tVDMWaitModeEntry	Policy Engine	Section 6.6.12.2
VDMModeExitTimer	tVDMWaitModeExit	Policy Engine	Section 6.6.12.3
VDMResponseTimer	tVDMSenderResponse	Policy Engine	Section 6.6.12.1

6.7 Counters

6.7.1 MessageID Counter

The ***MessageIDCounter*** is a rolling counter, ranging from 0 to ***nMessageIDCount***, used to detect duplicate *Messages*. This value is used for the ***MessageID*** field in the *Message Header* of each transmitted *Message*.

Each *Port* ***Shall*** maintain a copy of the last ***MessageID*** value received from its *Port Partner*. Devices that support multiple ports, such as *Hubs*, ***Shall*** maintain copies of the last ***MessageID*** on a per *Port* basis. A *Port* which communicates using *SOP* Packets* ***Shall*** maintain copies of the last ***MessageID*** for each type of *SOP** it uses.

The transmitter ***Shall*** use the ***MessageID*** in a ***GoodCRC*** *Message* to verify that a particular *Message* was received correctly. The receiver ***Shall*** use the ***MessageID*** to detect duplicate *Messages*.

6.7.1.1 Transmitter Usage

The Transmitter ***Shall*** use the ***MessageID*** as follows:

- Upon receiving either ***Hard Reset*** *Signaling*, or a ***Soft_Reset*** *Message*, the transmitter ***Shall*** set its ***MessageIDCounter*** to zero and re-initialize its retry mechanism.
- If a ***GoodCRC*** *Message* with a ***MessageID*** matching the ***MessageIDCounter*** is not received before the ***CRCReceiveTimer*** expires, it ***Shall*** retry the same *Packet* up to ***nRetryCount*** times using the same ***MessageID***.
- If a ***GoodCRC*** *Message* is received with a ***MessageID*** matching the current ***MessageIDCounter*** before the ***CRCReceiveTimer*** expires, the transmitter ***Shall*** re-initialize its retry mechanism and increment its ***MessageIDCounter***.
- If the *Message* is aborted by the *Policy Engine*, the transmitter ***Shall*** delete the *Message* from its transmit buffer, re-initialize its retry mechanism and increment its ***MessageIDCounter***.

6.7.1.2 Receiver Usage

The Receiver ***Shall*** use the ***MessageID*** as follows:

- When the first good *Packet* is received after a reset, the receiver ***Shall*** store a copy of the received ***MessageID*** value.
- For subsequent *Messages*, if ***MessageID*** value in a received *Message* is the same as the stored value, the receiver ***Shall*** return a ***GoodCRC*** *Message* with that ***MessageID*** value and drop the *Message* (this is a retry of an already received *Message*).

Note: This ***Shall Not*** apply to the ***Soft_Reset*** *Message* which always has a ***MessageID*** value of zero.

- If ***MessageID*** value in the received *Message* is different than the stored value, the receiver ***Shall*** return a ***GoodCRC*** *Message* with the new ***MessageID*** value, store a copy of the new ***MessageID*** value and process the *Message*.

6.7.2 Retry Counter

The ***RetryCounter*** is used by a *Port* whenever there is a *Message* transmission failure (timeout of ***CRCReceiveTimer***). If the ***nRetryCount*** retry fails, then the link ***Shall*** be reset using the *Soft Reset* mechanism.

The following rules apply to retries when there is a *Message* transmission failure (see also *Section 6.12.2.2, "Protocol Layer Message Transmission"*):

- *Cable Plugs* ***Shall Not*** retry *Messages*.
- *Extended Messages* of ***Data Size*** > ***MaxExtendedMsgLegacyLen*** that are not *Chunked* (***Chunked*** flag set to zero) ***Shall Not*** be retried.

- *Extended Messages* of ***Data Size*** ≤ ***MaxExtendedMsgLegacyLen*** (***Chunked*** flag set to zero or one) ***Shall*** be retried.

- *Extended Messages* of ***Data Size*** > ***MaxExtendedMsgLegacyLen*** that are *Chunked* (***Chunked*** flag set to one) individual Chunks ***Shall*** be retried.

When *Messages* are not retried, then the ***RetryCounter*** is not used. Higher layer protocols are expected to accommodate *Message* delivery failure or failure to receive a ***GoodCRC*** *Message*.

6.7.3 Hard Reset Counter

The ***HardResetCounter*** is used to retry the *Hard Reset* whenever there is no response from the remote device (see *Section 6.6.6, "NoResponseTimer"*). Once the *Hard Reset* has been retried ***nHardResetCount*** times then it ***Shall*** be assumed that the remote device is non-responsive.

6.7.4 Capabilities Counter

The ***CapsCounter*** is used to count the number of ***Source_Capabilities*** *Messages* which have been sent by a *Source* at power up or after a *Hard Reset*. Implementation of the ***CapsCounter*** is ***Optional*** but ***May*** be used by any *Source* which wishes to preserve power by not sending ***Source_Capabilities*** *Messages* after a period of time.

When the ***CapsCounter*** is implemented and the *Source* detects that a *Sink* is *Attached* then after ***nCapsCount*** ***Source_Capabilities*** *Messages* have been sent the *Source* ***Shall*** decide that the *Sink* is non-responsive, stop sending ***Source_Capabilities*** *Messages* and disable PD.

A *Sink* ***Shall*** use the ***SinkWaitCapTimer*** to trigger the resending of ***Source_Capabilities*** *Messages* by a USB Power Delivery capable *Source* which has previously stopped sending ***Source_Capabilities*** *Messages*. Any *Sink* which is *Attached* and does not detect a ***Source_Capabilities*** *Message*, ***Shall*** issue ***Hard Reset*** *Signaling* when the ***SinkWaitCapTimer*** times out in order to reset the *Source*. Resetting the *Source* ***Shall*** also reset the ***CapsCounter*** and restart the sending of ***Source_Capabilities*** *Messages*.

6.7.5 Discover Identity Counter

When sending ***Discover Identity*** *Messages* to a *Cable Plug* a *Port* ***Shall*** maintain a count of *Messages* sent (***DiscoverIdentityCounter***). No more than ***nDiscoverIdentityCount*** ***Discover Identity*** *Messages* ***Shall*** be sent by the *Port* without receiving a ***GoodCRC*** *Message* response. A *VCONN Swap* ***Shall*** reset the ***DiscoverIdentityCounter***.

6.7.6 VDMBusyCounter

When sending *Responder* ***BUSY*** responses to a Structured ***Vendor_Defined*** *Message* a *UFP* or *Cable Plug* ***Shall*** maintain a count of *Messages* sent (***VDMBusyCounter***). No more than ***nBusyCount*** *Responder* ***BUSY*** responses ***Shall*** be sent. The ***VDMBusyCounter*** ***Shall*** be reset on sending a non-***BUSY*** response. Products wishing to meet ***[USB Type-C 2.4]*** requirements for *Alternate Mode* entry ***Should*** use an ***nBusyCount*** of 1.

6.7.7 Counter Values and Counters

Table 6.70, "Counter Parameters" lists the counters used in this section and *Table 6.71, "Counters"* shows the corresponding parameters.

Table 6.70 Counter Parameters

Parameter	Value	Reference
nBusyCount	5	*Section 6.7.6*
nCapsCount	50	*Section 6.7.4*
nDiscoverIdentityCount	20	*Section 6.7.5*
nHardResetCount	2	*Section 6.7.3*
nMessageIDCount	7	*Section 6.7.1*
nRetryCount	2	*Section 6.7.2*

Table 6.71 Counters

Counter	Max	Reference
CapsCounter	***nCapsCount***	*Section 6.7.4*
DiscoverIdentityCounter	***nDiscoverIdentityCount***	*Section 6.7.5*
HardResetCounter	***nHardResetCount***	*Section 6.7.3*
MessageIDCounter	***nMessageIDCount***	*Section 6.7.1*
RetryCounter	***nRetryCount***	*Section 6.7.2*
VDMBusyCounter	***nBusyCount***	*Section 6.7.6*

6.8 Reset

Resets are a necessary response to protocol or other error conditions. USB Power Delivery defines four different types of reset:

- *Soft Reset*, which resets protocol.
- *Data Reset* which resets the *USB Communication*s.
- *Hard Reset* which resets both the power supplies and protocol
- *Cable Reset* which resets the cable.

6.8.1 Soft Reset and Protocol Error

A ***Soft_Reset*** *Message* is used to cause a *Soft Reset* of protocol communication when this has broken down in some way. It ***Shall Not*** have any impact on power supply operation but is used to correct a *Protocol Error* occurring during an *Atomic Message Sequence* (*AMS*). The *Soft Reset* ***May*** be triggered by either *Port Partner* in response to the *Protocol Error*.

*Protocol Error*s are any unexpected *Message* during an *AMS*. If the first *Message* in an *AMS* has been passed to the *Protocol Layer* by the *Policy Engine* but has not yet been sent (i.e., a ***GoodCRC*** *Message* acknowledging the *Message* has not been received) when the *Protocol Error* occurs, the *Policy Engine* ***Shall Not*** issue a *Soft Reset* but ***Shall*** return to the ***PE_SNK_Ready*** or ***PE_SRC_Ready*** state and then process the incoming *Message*. If the incoming *Message* is an *Unexpected Message* received in the ***PE_SNK_Ready*** or ***PE_SRC_Ready*** state, the *Policy Engine* ***Shall*** issue a *Soft Reset*. If the *Protocol Error* occurs during an *AMS* this ***Shall*** lead to a *Soft Reset* in order to re-synchronize the *Policy Engine* state machines (see *Section 8.3.3.4, "SOP Soft Reset and Protocol Error State Diagrams"*) except when the voltage is transition when a *Protocol Error* ***Shall*** lead to a *Hard Reset* (see *Section 6.6.11.4, "tProtErrHardReset"* and *Section 8.3.3.2, "Policy Engine Source Port State Diagram"*). Details of *AMS*'s can be found in *Section 8.3.2.1.3, "Atomic Message Sequences"*.

An *Unrecognized Message* or *Unsupported Message* received in the ***PE_SNK_Ready*** or ***PE_SRC_Ready*** states, ***Shall Not*** cause a ***Soft_Reset*** *Message* to be generated but instead a ***Not_Supported*** *Message* ***Shall*** be generated.

A ***Soft_Reset*** *Message* ***Shall*** be sent regardless of the R_p value either ***SinkTxOK*** or ***SinkTxNG*** if it is the correct response in that state.

Note: This means that a ***Soft_Reset*** *Message* can be sent during an *AMS* regardless of the R_p value either ***SinkTxOK*** or ***SinkTxNG*** when responding to a *Protocol Error*.

Table 6.72, "Response to an incoming Message (except VDM)" and *Table 6.73, "Response to an incoming VDM"* summarize the responses that ***Shall*** be made to an incoming *Message* including *VDMs*.

Table 6.72 Response to an incoming Message (except VDM)

Recipient's Power Role	Recipient's state	Incoming Message			
		Recognized			Unrecognized
		Supported		Unsupported	
		Expected	Unexpected		
Source	***PE_SRC_Ready***	Process *Message*	***Soft_Reset*** *Message*[2]	***Not_Supported*** *Message*[3]	***Not_Supported*** *Message*[3] (except for *VDM*) See Section 6.4.4.1 for UVDM. See Section 6.4.4.1 for SVDM
	During *AMS* (power not transitioning[1])	Process *Message*	***Soft_Reset*** *Message*[2]		
	During *AMS* (power transitioning[1])	Process *Message*	***Hard Reset*** *Signaling*		
Sink	***PE_SNK_Ready***	Process *Message*	***Soft_Reset*** *Message*[2]	***Not_Supported*** *Message*[3]	***Not_Supported*** *Message*[3] (except for *VDM*) See Section 6.4.4.1 for UVDM. See Section 6.4.4.1 for SVDM
	During *AMS* (not power transitioned)	Process *Message*	***Soft_Reset*** *Message*[2]		
	During *AMS* (power transitioned)	Process *Message*	***Hard Reset*** *Signaling*		

1) "Power transitioning" means the *Policy Engine* is in ***PE_SRC_Transition_Supply*** State or ***PE_SNK_Transition_Sink*** State or ***PE_FRS_SNK_SRC_Start_AMS*** State.

2) The ***Soft_Reset*** *Message* ***Shall*** be sent using the *SOP** of the incoming *Message*.

3) The ***Not_Supported*** *Message* ***Shall*** be sent using the *SOP** of the incoming *Message*.

Table 6.73 Response to an incoming VDM

Recipient's Role	*Unstructured VDM*			*Structured VDM*		
	Supported	Unsupported	Unrecognized	Supported	Unsupported	Unrecognized
DFP or *UFP*	Defined by vendor	***Not_Supported*** *Message*	***Not_Supported*** *Message*	See Section 6.13.5	***Not_Supported*** *Message*	***NAK*** *Command*
Cable Plug	Defined by vendor	*Message* ***Ignored***	*Message* ***Ignored***	See Section 6.13.5	*Message* ***Ignored***	***NAK*** *Command*

A failure to see a ***GoodCRC*** *Message* in response to any *Message* within ***tReceive*** (after ***nRetryCount*** retries), when a *Port Pair* is *Connected*, is indicative of a communications failure resulting in a *Soft Reset* (see Section 6.6.9.1, "tSoftReset").

A *Soft Reset* ***Shall*** impact the USB Power Delivery layers in the following ways:

- *PHY Layer*: Reset not required since the *PHY Layer* resets on each *Packet* transmission/reception.
- *Protocol Layer*: Reset ***MessageIDCounter***, ***RetryCounter*** and state machines.

- *Policy Engine*: Reset state dependent behavior by performing an *Explicit Contract Negotiation*.
- Power supply: ***Shall Not*** change.

Note: When in *SPR Mode* the *Source* sends a ***Source_Capabilities*** *Message* and when in *EPR Mode* the *Source* sends an ***EPR_Source_Capabilities*** *Message*.

A *Soft Reset* is performed using an *AMS* (see *Table 8.8, "AMS: Soft Reset"*). *Message* numbers ***Shall*** be set to zero prior to sending the ***Soft_Reset***/***Accept*** *Message* since the issue might be with the counters. The sender of a ***Soft_Reset*** *Message* ***Shall*** reset its ***MessageIDCounter*** and ***RetryCounter***, the receiver of the *Message* ***Shall*** reset its ***MessageIDCounter*** and ***RetryCounter*** before sending the ***Accept*** *Message* response. Any failure in the *Soft Reset* process will trigger a ***Hard Reset*** when *SOP Packet*s are being used or *Cable Reset*, sent by the *DFP* only, for any other *SOP* Packet*s; for example a ***GoodCRC*** *Message* is not received during the *Soft Reset* process (see *Section 6.8.3, "Hard Reset"* and *Section 6.8.4, "Cable Reset"*).

6.8.2 Data Reset

A ***Data_Reset*** *Message* is used by a *Port* to reset its USB data connection and to exit all *Alternate Modes* both with its *Port Partner* and in the *Cable Plug*(s).

- The *Data Reset* process ***May*** be initiated by either *Port Partner* sending a ***Data_Reset*** *Message*.

A *Data Reset* impacts USB Power Delivery in the following ways:

- ***Shall Not*** change the *Port Power Roles* (*Source*/*Sink*) or *Port Data Roles* (*DFP*/*UFP*).
- ***Shall Not*** change the existing *Explicit Contract*.
- ***Shall*** cause all *Active Mode*s to be exited.
- ***Shall*** reset the cable by Power cycling *VCONN*.
- The *DFP* ***Shall*** become the *VCONN Source*.
- If the *Data Reset* process fails, then the *Port* ***Shall*** enter the ***ErrorRecovery*** State as defined in ***[USB Type-C 2.4]***.

See *Section 6.3.14, "Data_Reset Message"* for details of *Data Reset* operation.

6.8.3 Hard Reset

*Hard Reset*s are signaled by an ordered set as defined in *Section 5.6.4, "Hard Reset"*. Both the sender and recipient ***Shall*** cause their power supplies to return to their default states (see *Section 7.3.3.1, "Source Initiated Hard Reset"* and *Section 7.3.3.2, "Sink Initiated Hard Reset"* for details of voltage transitions). In addition, their respective *Protocol Layers* ***Shall*** be reset as for the *Soft Reset*. This allows the *Attached* devices to be in a state where they can re-establish USB PD communication. *Hard Reset* is retried up to ***nHardResetCount*** times (see also *Section 6.6.6, "NoResponseTimer"* and *Section 6.7.3, "Hard Reset Counter"*).

Note: Even though *VBUS* drops to ***vSafe0V*** during a *Hard Reset* a *Sink* will not see this as a disconnect since this is expected behavior.

A *Hard Reset* ***Shall Not*** cause any change to either the R_p/R_d resistor being asserted.

If there has been a *Data Role Swap* the *Hard Reset* ***Shall*** cause the ***Port Data Role*** to be changed back to *DFP* for a *Port* with the R_p resistor asserted and *UFP* for a *Port* with the R_d resistor asserted.

When *VCONN* is supported (see ***[USB Type-C 2.4]***) the *Hard Reset* ***Shall*** cause the *Port* with the R_p resistor asserted to supply *VCONN* and the *Port* with the R_d resistor asserted to turn off *VCONN*.

In effect the *Hard Reset* will revert the Ports to their default state based on their *CC* line resistors. Removing and reapplying *VCONN* from the *Cable Plugs* also ensures that they re-establish their configuration as either *SOP'* or *SOP''* based on the location of *VCONN* (see ***[USB Type-C 2.4]***).

If the *Hard Reset* is insufficient to clear the error condition, then the *Port* ***Shall*** use *USB Type-C* ***ErrorRecovery*** as defined in ***[USB Type-C 2.4]***.

A *Sink* ***Shall*** be able to send ***Hard Reset*** *Signaling* regardless of the value of R_p (see *Section 5.7, "Collision Avoidance"*).

6.8.3.1 Cable Plugs and Hard Reset

Cable Plugs ***Shall Not*** generate ***Hard Reset*** *Signaling* but ***Shall*** monitor for ***Hard Reset*** *Signaling* between the *Port Partners* and ***Shall*** reset when this is detected (see *Section 8.3.3.25.2.2, "Cable Plug Hard Reset State Diagram"*). The *Cable Plugs* ***Shall*** perform the equivalent of a power cycle returning to their initial power up state. This allows the *Port Partners* to be in a state where they can re-establish USB PD communication.

6.8.3.2 Modal Operation and Hard Reset

A *Hard Reset* ***Shall*** cause *EPR Mode* and all *Active Modes* to be exited by both *Port Partners* and any *Cable Plugs* (see *Section 6.4.4.3.4, "Enter Mode Command"*).

6.8.4 Cable Reset

Cable Resets are signaled by an ordered set as defined in *Section 5.6.5, "Cable Reset"*. Both the sender and recipient of ***Cable Reset*** *Signaling* ***Shall*** reset their respective *Protocol Layers*. The *Cable Plugs* ***Shall*** perform the equivalent of a power cycle returning to their initial power up state. This allows the *Port Partners* to be in a state where they can re-establish USB PD communication.

The *DFP* must be supplying *VCONN* prior to a *Cable Reset*. If *VCONN* has been turned off the *DFP* ***Shall*** turn on *VCONN* prior to generating ***Cable Reset*** *Signaling*. If there has been a *VCONN Swap* and the *UFP* is currently supplying *VCONN*, the *DFP* ***Shall*** perform a *VCONN Swap* such that it is supplying *VCONN* prior to generating ***Cable Reset*** *Signaling*.

Only a *DFP* ***Shall*** generate ***Cable Reset*** *Signaling*. A *DFP* ***Shall*** only generate ***Cable Reset*** *Signaling* within an *Explicit Contract*.

A *Cable Reset* ***Shall*** cause all *Active Modes* in the *Cable Plugs* to be exited (see *Section 6.4.4.3.4, "Enter Mode Command"*).

6.9 Accept, Reject and Wait

The recipient of a ***Request***, ***EPR_Request***, ***PR_Swap***, ***DR_Swap***, ***VCONN_Swap***, or ***Enter_USB*** *Message* ***Shall*** respond by sending one of the following responses:

- An ***Accept*** *Message* in response to a ***Valid*** request which can be serviced immediately (see *Section 6.3.3, "Accept Message"*).
- A ***Wait*** *Message* in response to a ***Valid*** request which cannot be serviced immediately but could be serviced at a later time (see *Section 6.3.12, "Wait Message"*).
- A ***Reject*** *Message* in response to an ***Invalid*** request or a request which is outside of the device's design *Capabilities* (see *Section 6.3.4, "Reject Message"*).

6.10 Collision Avoidance

To avoid *Message* collisions due to asynchronous *Messaging* sent from the *Sink*, the *Source* sets R_p to ***SinkTxOK*** to indicate to the *Sink* that it is OK to initiate an *AMS*. When the *Source* wishes to initiate an *AMS*, it sets R_p to ***SinkTxNG***. When the *Sink* detects that R_p is set to ***SinkTxOK*** it ***May*** initiate an *AMS*. When the *Sink* detects that R_p is set to ***SinkTxNG*** it ***Shall Not*** initiate an *AMS* and ***Shall*** only send *Message*s that are part of an *AMS* the *Source* has initiated.

Note: This restriction applies to *SOP* AMS*'s i.e., for both *Port* to *Port* and *Port* to *Cable Plug* communications.

If a transition into the ***PE_SRC_Ready*** state will result in an immediate transition out of the ***PE_SRC_Ready*** state within ***tSrcHoldsBus*** e.g. it is due to a *Protocol Error* that has not resulted in a *Soft Reset*, then the notifications of the end of *AMS* and first *Message* in an *AMS* ***May*** Not be sent to avoid changing the R_p value unnecessarily.

Note: A *Sink* can still send ***Hard Reset*** *Signaling* at any time.

6.11 Message Discarding

On receiving a received *Message* on *SOP*, the *Protocol Layer* ***Shall Discard*** any pending *SOP* Message*s. A received *Message* on *SOP'/SOP''* ***Shall Not*** cause any pending *SOP* Message*s to be ***Discarded***.

It is assumed that *Message*s using *SOP'/SOP"* constitute a simple request/response *AMS*, with the *Cable Plug* providing the response so there is no reason for a pending *SOP* Message* to be ***Discarded***. There can only be one *AMS* between the *Port Partner*s, and these also take priority over *Cable Plug* communications so a *Message* received on *SOP* will always cause a *Message* pending on *SOP** to be ***Discarded***.

Table 6.74, "Message Discarding" for details of the *Message*s that ***Shall***/ ***Shall Not*** be ***Discarded***.

Table 6.74 Message Discarding

Message pending transmission	Message received	Message to be Discarded
SOP	*SOP*	Outgoing *Message*
SOP	*SOP'/SOP''*	Incoming *Message*
SOP'	*SOP*	Outgoing *Message*
SOP'	*SOP'*	Incoming *Message*
SOP'	*SOP''*	Incoming *Message*
SOP''	*SOP*	Outgoing *Message*
SOP''	*SOP'*	Incoming *Message*
SOP''	*SOP''*	Incoming *Message*

6.12 State behavior

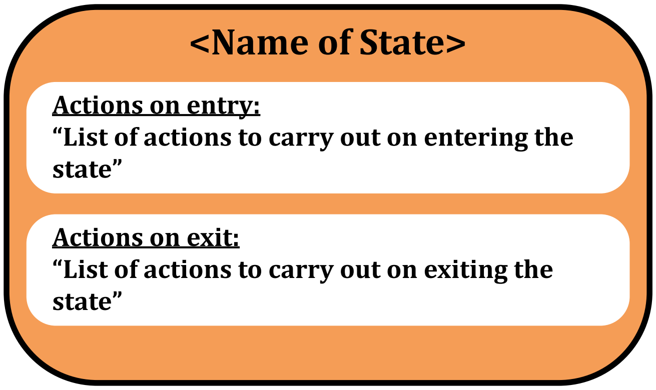
6.12.1 Introduction to state diagrams used in Chapter 6

The state diagrams defined in *Section 6.12, "State behavior"* are ***Normative*** and ***Shall*** define the operation of the Power Delivery *Protocol Layer*.

Note: These state diagrams are not intended to replace a well written and robust design.

Figure 6.57, "Outline of States" shows an outline of the states defined in the following sections. At the top there is the name of the state. This is followed by "Actions on entry" a list of actions carried out on entering the state and in some states "Actions on exit" a list of actions carried out on exiting the state.

Figure 6.57 Outline of States

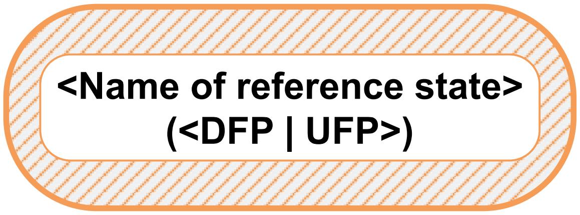

<Name of State>
Actions on entry:
"List of actions to carry out on entering the state"
Actions on exit:
"List of actions to carry out on exiting the state"

Transitions from one state to another are indicated by arrows with the conditions listed on the arrow. Where there are multiple conditions, these are connected using either a logical OR "|" or a logical AND "&." The inverse of a condition is shown with a "NOT" in front of the condition.

In some cases, there are transitions which can occur from any state to a particular state. These are indicated by an arrow which is unconnected to a state at one end, but with the other end (the point) connected to the final state.

In some state diagrams it is necessary to enter or exit from states in other diagrams. *Figure 6.57, "Outline of States"* indicates how such references are made. The reference is indicated with a hatched box. The box contains the name of the referenced state.

Figure 6.58 References to states



Timers are included in many of the states. Timers are initialized (set to their starting condition) and run (timer is counting) in the state it is referenced. As soon as the state is exited then the timer is no longer active. Timeouts of the timers are listed as conditions on state transitions.

Conditions listed on state transitions will come from one of three sources:

- *Messages* received from the *PHY Layer*.
- Events triggered within the *Protocol Layer* e.g., timer timeouts
- *Message* and related indications passed up to the *Policy Engine* from the *Protocol Layer* (*Message* sent; *Message* received etc.)

6.12.2 State Operation

The following section details *Protocol Layer* State Operation when sending and receiving *SOP* Packet*s.

For each *SOP' Communication* being sent and received there ***Shall*** be separate *Protocol Layer* Transmission and *Protocol Layer* Reception and *Hard Reset* State Machine instances, with their own counter and timer instances. When *Chunking* is supported there ***Shall*** be separate *Chunked* Tx, *Chunked* Tx, and *Chunked* Message Router State Machine instances.

Soft Reset ***Shall*** only apply to the State Machine instances it is targeted at based on the type of *SOP* Packet* used to send the ***Soft_Reset*** *Message*. The *Hard Reset* State Machine (including *Cable Reset*) ***Shall*** apply simultaneously to all *Protocol Layer* State Machine instances active in the *DFP*, *UFP* and *Cable Plug* (if present).

6.12.2.1 Protocol Layer Chunking

6.12.2.1.1 Architecture of Device Including Chunking Layer

The *Chunking* component resides in the *Protocol Layer* between the *Policy Engine* and Protocol Tx/Rx. *Figure 6.59, "Chunking architecture Showing Message and Control Flow"* illustrates the relationship between components.

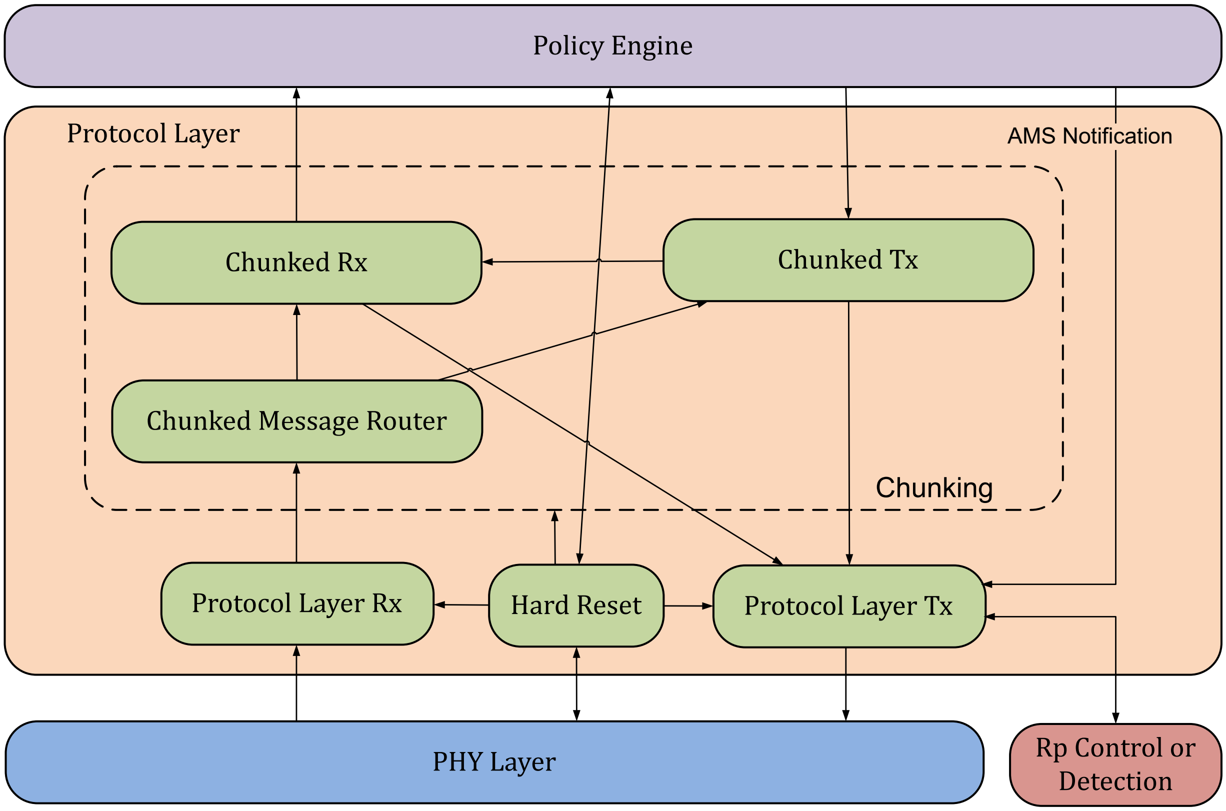
The *Chunking Layer* comprises three related state machines:

- *Chunked* Rx.
- *Chunked* Tx.
- *Chunked* Message Router.

Note: The consequence of this architecture is that the *Policy Engine* deals entirely in *Unchunked Message*s. It will not receive (and might not respond to) a *Message* until all the related chunks have been collated.

If a PD device or *Cable Plug* has no requirement to handle any *Message* requiring more than one *Chunk* of any *Extended Message*, it ***May*** omit the *Chunking Layer*. In this case it ***Shall*** implement the ***ChunkingNotSupportedTimer*** to ensure compatible operation with partners which support *Chunking* (see *Section 6.6.18.1, "ChunkingNotSupportedTimer"* and *Section 8.3.3.6, "Not Supported Message State Diagrams"*).

Figure 6.59 Chunking architecture Showing Message and Control Flow



6.12.2.1.1.1 Optional Abort Mechanism

Long *Chunked Messages* bring with them the potential problem that they could prevent urgent *Messages* from being transmitted in a timely manner. An ***Optional*** Abort mechanism is provided to remedy this problem.

The Abort Flag referred to in the diagrams below ***May*** be set and examined by the *Policy Engine*. The specific means are left to the implementer.

6.12.2.1.1.2 Aborting Sending a Long-Chunked Message

A long-*Chunked Message* being sent ***May*** be aborted by setting the ***Optional*** Abort Flag. The *Message* ***Shall*** be considered aborted when the Abort Flag is again cleared by the *Chunked* Tx state machine.

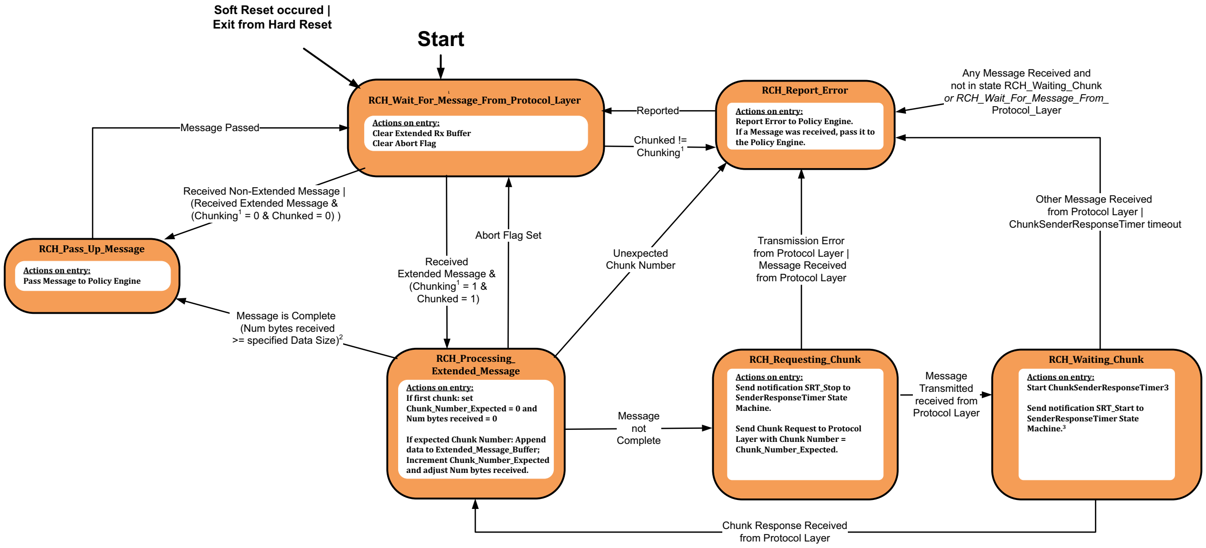
6.12.2.1.1.3 Aborting Receiving a Long-Chunked Message

If the ***Optional*** Abort mechanism has been implemented, any *Message* sent while a *Chunked Message* receive is in progress will result in an error report being received by the *Policy Engine*, to indicate that the *Message* request has been ***Discarded***. If the *Message* was urgent the *Policy Engine* might set the Abort Flag, which will result in the incoming *Chunked Message* being aborted. The Abort Flag being cleared by the *Chunked* Rx state machine indicates that the urgent *Message* can now be sent.

6.12.2.1.2 Chunked Rx State Diagram

Figure 6.60, "Chunked Rx State Diagram" shows the state behavior for the *Chunked* Rx State Machine. This recognizes whether *Chunked* received *Messages* are involved and deals with requesting chunks when they are. It also performs validity checks on all *Messages* related to *Chunking*.

Figure 6.60 Chunked Rx State Diagram


Soft Reset occured |
Exit from Hard Reset
Start
RCH_Wait_For_Message_From_Protocol_Layer
Actions on entry:
Clear Extended Rx Buffer
Clear Abort Flag
Message Passed
Received Non-Extended Message | (Received Extended Message & (Chunking1 = 0 & Chunked = 0))
RCH_Pass_Up_Message
Actions on entry:
Pass Message to Policy Engine
Message is Complete (Num bytes received >= specified Data Size)2
Received Extended Message & (Chunking1 = 1 & Chunked = 1)
Abort Flag Set
RCH_Processing_Extended_Message
Actions on entry:
If first chunk: set Chunk_Number_Expected = 0 and Num bytes received = 0
If expected Chunk Number: Append data to Extended_Message_Buffer; Increment Chunk_Number_Expected and adjust Num bytes received.
Reported
Chunked != Chunking1
RCH_Report_Error
Actions on entry:
Report Error to Policy Engine.
If a Message was received, pass it to the Policy Engine.
Any Message Received and not in state RCH_Waiting_Chunk or RCH_Wait_For_Message_From_Protocol_Layer
Unexpected Chunk Number
Transmission Error from Protocol Layer | Message Received from Protocol Layer
Other Message Received from Protocol Layer | ChunkSenderResponseTimer timeout
Message not Complete
RCH_Requesting_Chunk
Actions on entry:
Send notification SRT_Stop to SenderResponseTimer State Machine.
Send Chunk Request to Protocol Layer with Chunk Number = Chunk_Number_Expected.
Message Transmitted received from Protocol Layer
RCH_Waiting_Chunk
Actions on entry:
Start ChunkSenderResponseTimer3
Send notification SRT_Start to SenderResponseTimer State Machine.3
Chunk Response Received from Protocol Layer

[1] Chunking is an internal state that is set to 1 if the 'Unchunked Extended Messages Supported' bit in either Source Capabilities or Request is 0. It defaults to 1 and is set after the first exchange of Source Capabilities and Request. It is also set to 1 for ***SOP'*** or ***SOP''*** communication.

[2] Additional bytes received over specified ***Data Size*** will be because of padding in the last chunk.

[3] This state is responsible for starting two timers of similar length. The implementor ***Should*** mitigate against more than one of these timers resulting in recovery action.

6.12.2.1.2.1 RCH_Wait_For_Message_From_Protocol_Layer State

The *Chunked* Rx State Machine ***Shall*** enter the ***RCH_Wait_For_Message_From_Protocol_Layer*** state:

- At startup.
- As a result of a *Soft Reset* occurring.
- On exit from a *Hard Reset*.

On entry to the ***RCH_Wait_For_Message_From_Protocol_Layer*** state the *Chunked* Rx state machine clears the Extended Rx Buffer and clears the ***Optional*** Abort Flag.

In the ***RCH_Wait_For_Message_From_Protocol_Layer*** state the *Chunked* Rx state machine waits until the *Chunked* Message Router passes up a received *Message*.

The *Chunked* Rx State Machine ***Shall*** transition to the ***RCH_Pass_Up_Message*** state when:

- A non-*Extended Message* is passed up from the *Chunked* Message Router.
- An *Extended Message* is passed up from the *Chunked* Message Router, and the *Policy Engine* has determined that we are not doing *Chunking*, and the *Message* has its ***Chunked*** bit set to 0b.

The *Chunked* Rx State Machine ***Shall*** transition to the ***RCH_Processing_Extended_Message*** state when:

- An *Extended Message* is passed up from the *Chunked* Message Router, and the *Policy Engine* has determined that we are doing *Chunking*, and the *Message* has its ***Chunked*** bit set to 1b.

6.12.2.1.2.2 RCH_Pass_Up_Message State

On entry to the ***RCH_Pass_Up_Message*** state the *Chunked* Rx state machine ***Shall*** pass the received *Message* to the *Policy Engine*.

The *Chunked* Rx State Machine ***Shall*** transition to the ***RCH_Wait_For_Message_From_Protocol_Layer*** state when:

- The *Message* has been passed.

6.12.2.1.2.3 RCH_Processing_Extended_Message State

On entry to the ***RCH_Processing_Extended_Message*** state the *Chunked* Rx state machine ***Shall***:

- If this is the first chunk:
  - Set Chunk_Number_Expected = 0.
  - Set Num bytes received = 0.
- If chunk contains the expected ***Chunk Number***:
  - Append its data to the Extended_Message_Buffer.
  - Increment Chunk_Number_Expected.
  - Adjust Num bytes received.

The *Chunked* Rx State Machine ***Shall*** transition to the ***RCH_Pass_Up_Message*** state when:

- The *Message* is complete (i.e., Num bytes received >= specified ***Data Size***.

Note: The inequality allows for padding bytes in the last chunk, which are not actually part of the *Extended Message*).

The *Chunked* Rx State Machine ***Shall*** transition to the ***RCH_Requesting_Chunk*** state when:

- The *Message* is not yet complete.

The *Chunked* Rx State Machine ***Shall*** transition to the ***RCH_Report_Error*** state when:

- An unexpected ***Chunk Number*** is received.

The *Chunked* Rx State Machine ***Shall*** transition to the ***RCH_Wait_For_Message_From_Protocol_Layer*** state when:

- The ***Optional*** Abort Flag is set.

6.12.2.1.2.4 RCH_Requesting_Chunk State

On entry to the ***RCH_Requesting_Chunk*** state the *Chunked* Rx state machine ***Shall***:

- Send notification SRT_Stop to ***SenderResponseTimer*** state machine (see *Section 8.3.3.1.1, "SenderResponseTimer State Diagram"*).
- Send *Chunk* Request to *Protocol Layer* with ***Chunk Number*** = Chunk_Number_Expected.

The *Chunked* Rx State Machine ***Shall*** transition to the ***RCH_Waiting_Chunk*** state when:

- *Message* Transmitted is received from the *Protocol Layer*.

The *Chunked* Rx State Machine ***Shall*** transition to the ***RCH_Report_Error*** state when:

- Transmission Error is received from the *Protocol Layer*, or
- A *Message* is received from the *Protocol Layer*.

6.12.2.1.2.5 RCH_Waiting_Chunk State

On entry to the ***RCH_Waiting_Chunk*** state the *Chunked* Rx state machine ***Shall***:

- Start the ***ChunkSenderResponseTimer***.
- Send notification SRT_Start to ***SenderResponseTimer*** state machine (see S*Section 8.3.3.1.1, "SenderResponseTimer State Diagram"*).

The *Chunked* Rx State Machine ***Shall*** transition to the ***RCH_Processing_Extended_Message*** state when:

- A *Chunk* is received from the *Protocol Layer*.

The *Chunked* Rx State Machine ***Shall*** transition to the ***RCH_Report_Error*** state when:

- A *Message*, other than a *Chunk*, is received from the *Protocol Layer*, or
- The ***ChunkSenderResponseTimer*** expires.

6.12.2.1.2.6 RCH_Report_Error State

The *Chunked* Rx State Machine ***Shall*** enter the ***RCH_Report_Error*** state:

- When any *Message* is received and the *Chunked* Rx State Machine is not in one of the states ***RCH_Waiting_Chunk*** or ***RCH_Wait_For_Message_From_Protocol_Layer***.

On entry to the ***RCH_Report_Error*** state the *Chunked* Rx state machine ***Shall***:

- Report the error to the *Policy Engine*.
- If the state was entered because a *Message* was received, this *Message* ***Shall*** be passed to the *Policy Engine*.

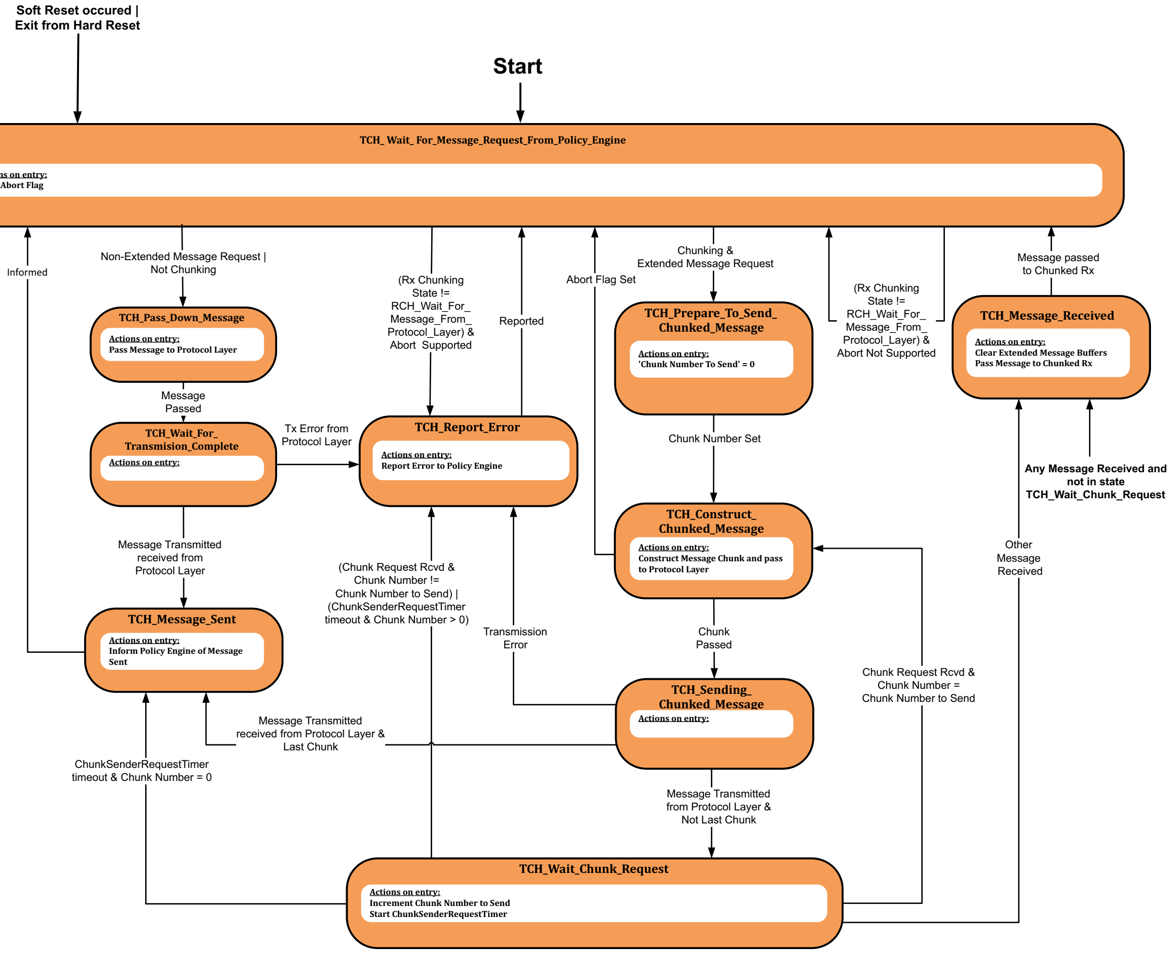
The *Chunked* Rx State Machine ***Shall*** transition to the ***RCH_Wait_For_Message_From_Protocol_Layer*** state when:

- The error has been reported.
- Any *Message* received was passed to the *Policy Engine*.

6.12.2.1.3 Chunked Tx State Diagram

Figure 6.61, "Chunked Tx State Diagram" shows the state behavior for the *Chunked* Tx State Machine. This recognizes whether *Chunked* transmitted *Messages* are involved and deals with sending chunks and waiting for chunk requests when they are. It also performs validity checks on all related *Messages* related to *Chunking*.

Figure 6.61 Chunked Tx State Diagram



6.12.2.1.3.1 TCH_Wait_For_Message_Request_From_Policy_Engine State

The *Chunked* Tx State Machine ***Shall*** enter the *TCH_Wait_For_Message_Request_From_Policy_Engine* state:

- At startup.
- As a result of a *Soft Reset* occurring.
- On exit from a *Hard Reset*.

On entry to the *TCH_Wait_For_Message_Request_From_Policy_Engine* state the *Chunked* Tx state machine clears the ***Optional*** Abort Flag.

In the *TCH_Wait_For_Message_Request_From_Policy_Engine* state the *Chunked* Tx State Machine waits until the *Policy Engine* sends it a *Message* Request.

The *Chunked* Tx State Machine ***Shall*** transition to the *TCH_Pass_Down_Message* state when:

- A non-*Extended Message* Request is received from the *Policy Engine*, or
- A *Message* Request is received from the *Policy Engine* and the link is not *Chunking*.

The *Chunked* Tx State Machine ***Shall*** transition to the ***TCH_Prepare_To_Send_Chunked_Message*** state when:

- An *Extended Message* Request is received from the *Policy Engine*, and the link is *Chunking*.

The *Chunked* Tx State Machine ***Shall Discard*** the *Message* Request and remain in the ***TCH_Wait_For_Message_Request_From_Policy_Engine*** state when:

- The *Chunked* Rx state is any other than ***RCH_Wait_For_Message_From_Protocol_Layer***, and the ***Optional*** Abort Flag has not been implemented.

The *Chunked* Tx State Machine ***Shall Discard*** the *Message* Request and enter the ***TCH_Report_Error*** state when:

- The *Chunked* Rx state is any other than ***RCH_Wait_For_Message_From_Protocol_Layer*** and the ***Optional*** Abort Flag has been implemented.

6.12.2.1.3.2 TCH_Pass_Down_Message State

On entry to the ***TCH_Pass_Down_Message*** state the *Chunked* Tx State Machine ***Shall*** pass the *Message* to the *Protocol Layer*.

The *Chunked* Tx State Machine ***Shall*** transition to the ***TCH_Wait_For_Transmision_Complete*** state when:

- The *Message* has been passed to the *Protocol Layer*.

6.12.2.1.3.3 TCH_Wait_For_Transmision_Complete State

The *Chunked* Tx State Machine ***Shall*** transition to the ***TCH_Message_Sent*** state when:

- *Message* Transmitted has been received from the *Protocol Layer*.

The *Chunked* Tx State Machine ***Shall*** transition to the ***TCH_Report_Error*** state when:

- Transmission Error has been received from the *Protocol Layer*.

6.12.2.1.3.4 TCH_Message_Sent State

On entry to the ***TCH_Message_Sent*** state the *Chunked* Tx State Machine ***Shall***:

- Inform the *Policy Engine* that the *Message* has been sent.

The *Chunked* Tx State Machine ***Shall*** transition to the ***TCH_Wait_For_Message_Request_From_Policy_Engine*** state when:

- The *Policy Engine* has been informed.

6.12.2.1.3.5 TCH_Prepare_To_Send_Chunked_Message State

On entry to the ***TCH_Prepare_To_Send_Chunked_Message*** state the *Chunked* Tx State Machine ***Shall***:

- Set 'Chunk Number To Send' to zero.

The *Chunked* Tx State Machine ***Shall*** transition to the ***TCH_Construct_Chunked_Message*** state when:

- ‘Chunk Number To Send' has been set to zero.

6.12.2.1.3.6 TCH_Construct_Chunked_Message State

On entry to the ***TCH_Construct_Chunked_Message*** state the *Chunked* Tx State Machine ***Shall***:

- Construct a *Message Chunk* and pass it to the *Protocol Layer*.

The *Chunked* Tx State Machine ***Shall*** transition to the ***TCH_Sending_Chunked_Message*** state when:

- The *Message Chunk* has been passed to the *Protocol Layer*.

The *Chunked* Tx State Machine ***Shall*** transition to the ***TCH_Wait_For_Message_Request_From_Policy_Engine*** state when:

- The ***Optional*** Abort Flag is set.

6.12.2.1.3.7 TCH_Sending_Chunked_Message State

The *Chunked* Tx State Machine ***Shall*** transition to the ***TCH_Wait_Chunk_Request*** state when:

- *Message* Transmitted is received from *Protocol Layer* and this was not the last chunk.

The *Chunked* Tx State Machine ***Shall*** transition to the ***TCH_Message_Sent*** state when:

- *Message* Transmitted is received from *Protocol Layer* and this was the last chunk.

The *Chunked* Tx State Machine ***Shall*** transition to the ***TCH_Report_Error*** state when:

- Transmission Error has been received from the *Protocol Layer*.

6.12.2.1.3.8 TCH_Wait_Chunk_Request State

On entry to the ***TCH_Wait_Chunk_Request*** state the *Chunked* Tx State Machine ***Shall***:

- Increment Chunk Number to Send.
- Start ***ChunkSenderRequestTimer***.

The *Chunked* Tx State Machine ***Shall*** transition to the ***TCH_Report_Error*** state when:

- A *Chunk* Request has been received and the ***Chunk Number*** does not equal Chunk Number to Send or
- ***ChunkSenderRequestTimer*** has expired and ***Chunk Number*** is greater than zero.

The *Chunked* Tx State Machine ***Shall*** transition to the ***TCH_Message_Sent*** state when:

- ***ChunkSenderRequestTimer*** has expired and ***Chunk Number*** equals zero.

Note: This is the mechanism which allows the remote *Port Partner* or *Cable Plug* to omit the *Chunking Layer*. The *Policy Engine* will receive a *Message* Sent signal if the remote *Port Partner* or *Cable Plug* is present (***GoodCRC*** *Message* received) but does not send a *Chunk* Request. After this the remote *Port Partner* will send a ***Not_Supported*** *Message*, or the *Cable Plug* will ***Ignore*** the *Chunked Message*.

The *Chunked* Tx State Machine ***Shall*** transition to the ***TCH_Message_Received*** state when:

- Any other *Message* than *Chunk* Request is received.

6.12.2.1.3.9 TCH_Message_Received State

The *Chunked* Tx State Machine ***Shall*** enter the ***TCH_Message_Received*** state:

- When any *Message* is received, and the *Chunked* Tx State Machine is not in the ***TCH_Wait_Chunk_Request*** state.

On entry to the ***TCH_Message_Received*** state the *Chunked* Tx State Machine ***Shall***:

- Clear the *Extended Message* Buffers.
- Pass the received *Message* to *Chunked* Rx Engine.

The *Chunked* Tx State Machine ***Shall*** transition to the ***TCH_Wait_For_Message_Request_From_Policy_Engine*** state when:

- The received *Message* has been passed to the *Chunked* Rx Engine.

6.12.2.1.3.10 TCH_Report_Error State

On entry to the ***TCH_Report_Error*** state the *Chunked* Tx State Machine ***Shall***:

- Report the error to the *Policy Engine*.

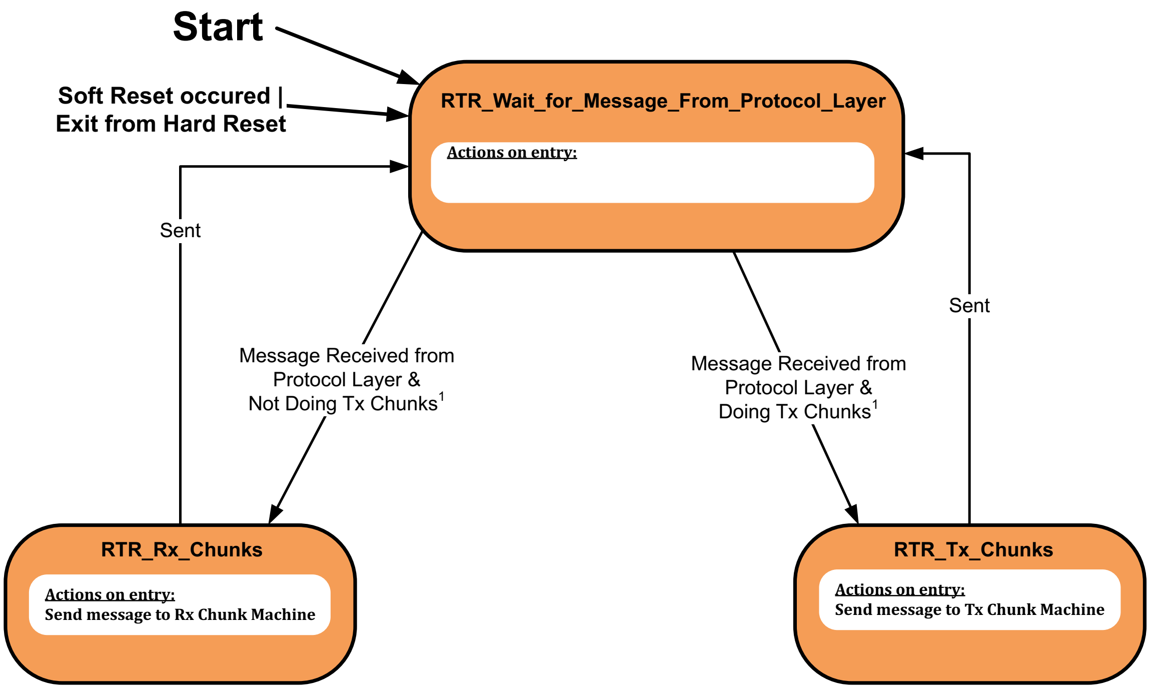
The *Chunked* Tx State Machine ***Shall*** transition to the ***TCH_Wait_For_Message_Request_From_Policy_Engine*** state when:

- The error has been reported.

6.12.2.1.4 Chunked Message Router State Diagram

Figure 6.62, "Chunked Message Router State Diagram" shows the state behavior for the *Chunked* Message Router. This determines to which state machine an incoming *Message* is routed to (*Chunked* Rx, *Chunked* Tx or direct to *Policy Engine*).

Figure 6.62 Chunked Message Router State Diagram


Start
Soft Reset occured | Exit from Hard Reset
RTR_Wait_for_Message_From_Protocol_Layer
Actions on entry:
Sent
Message Received from Protocol Layer & Not Doing Tx Chunks¹
Message Received from Protocol Layer & Doing Tx Chunks¹
Sent
RTR_Rx_Chunks
Actions on entry:
Send message to Rx Chunk Machine
RTR_Tx_Chunks
Actions on entry:
Send message to Tx Chunk Machine

[1] Doing Tx Chunks means that Chunked Tx State Machine is not in the *TCH_Wait_For_Message_Request_From_Policy_Engine* state.

[2] Messages are taken to include notification about transmission success or otherwise of Messages.

6.12.2.1.4.1 RTR_Wait_for_Message_From_Protocol_Layer State

In the ***RTR_Wait_for_Message_From_Protocol_Layer*** state the *Chunked* Message Router waits until the *Protocol Layer* sends it a received *Message*.

The *Chunked* Message Router ***Shall*** transition to the ***RTR_Rx_Chunks*** state when:

- A *Message* is received from the *Protocol Layer*, and the combined *Chunking* is not doing Tx *Chunks*.

The *Chunked* Message Router ***Shall*** transition to the ***RTR_Tx_Chunks*** state when:

- A *Message* is received from the *Protocol Layer*, and the combined *Chunking* is doing Tx *Chunks*.

6.12.2.1.4.2 RTR_Rx_Chunks State

On entry to the ***RTR_Rx_Chunks*** state the *Chunked* Message Router ***Shall***:

- Send the *Message* to the *Chunked* Rx State Machine.
- Transition to the ***RTR_Wait_for_Message_From_Protocol_Layer*** state.

6.12.2.1.4.3 RTR_Tx_Chunks State

On entry to the ***RTR_Tx_Chunks*** state the *Chunked* Message Router ***Shall***:

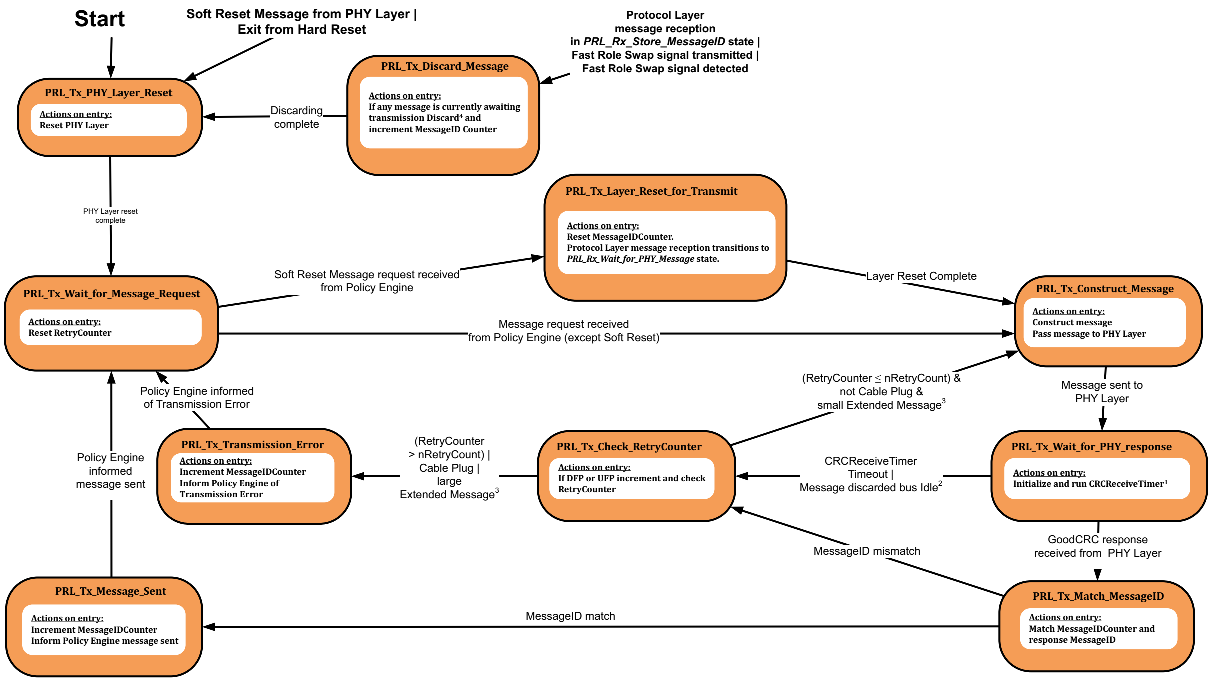
- Send the *Message* to the *Chunked* Tx State Machine.
- Transition to the ***RTR_Wait_for_Message_From_Protocol_Layer*** state.

6.12.2.2 Protocol Layer Message Transmission

6.12.2.2.1 Common Protocol Layer Message Transmission State Diagram

Figure 6.63, "Common Protocol Layer Message Transmission State Diagram" shows the state behavior, common between the *Source* and the *Sink*, for the *Protocol Layer* when transmitting a *Message*.

Figure 6.63 Common Protocol Layer Message Transmission State Diagram


Start
Soft Reset Message from PHY Layer |
Exit from Hard Reset
Protocol Layer
message reception
in PRL_Rx_Store_MessageID state |
Fast Role Swap signal transmitted |
Fast Role Swap signal detected
PRL_Tx_PHY_Layer_Reset
Actions on entry:
Reset PHY Layer
Discarding complete
PRL_Tx_Discard_Message
Actions on entry:
If any message is currently awaiting transmission Discard⁴ and increment MessageID Counter
PHY Layer reset complete
PRL_Tx_Layer_Reset_for_Transmit
Actions on entry:
Reset MessageIDCounter.
Protocol Layer message reception transitions to PRL_Rx_Wait_for_PHY_Message state.
Soft Reset Message request received from Policy Engine
Layer Reset Complete
PRL_Tx_Wait_for_Message_Request
Actions on entry:
Reset RetryCounter
Message request received from Policy Engine (except Soft Reset)
PRL_Tx_Construct_Message
Actions on entry:
Construct message
Pass message to PHY Layer
(RetryCounter ≤ nRetryCount) &
not Cable Plug &
small Extended Message³
Message sent to PHY Layer
Policy Engine informed of Transmission Error
Policy Engine informed message sent
PRL_Tx_Transmission_Error
Actions on entry:
Increment MessageIDCounter
Inform Policy Engine of Transmission Error
(RetryCounter > nRetryCount) |
Cable Plug |
large
Extended Message³
PRL_Tx_Check_RetryCounter
Actions on entry:
If DFP or UFP increment and check RetryCounter
CRCReceiveTimer
Timeout |
Message discarded bus Idle²
PRL_Tx_Wait_for_PHY_response
Actions on entry:
Initialize and run CRCReceiveTimer¹
MessageID mismatch
GoodCRC response received from PHY Layer
PRL_Tx_Message_Sent
Actions on entry:
Increment MessageIDCounter
Inform Policy Engine message sent
MessageID match
PRL_Tx_Match_MessageID
Actions on entry:
Match MessageIDCounter and response MessageID

1) The ***CRCReceiveTimer*** is only started after the PHY has sent the message. If the message is not sent due to a busy channel, then the ***CRCReceiveTimer*** will not be started (see *Section 6.6.1 "CRCReceiveTimer"*).

2) This indication is sent by the PHY Layer when a message has been ***Discarded*** due to CC being busy, and after CC becomes idle again (see *Section 5.7 "Collision Avoidance"*). The ***CRCReceiveTimer*** is not running in this case since no message has been sent.

3) A "small" Extended Message is either an Extended Message with ***Data Size*** ≤ ***MaxExtendedMsgLegacyLen*** bytes or an Extended Message with ***Data Size*** > ***MaxExtendedMsgLegacyLen*** bytes that has been Chunked. A "large" Extended Message is an Extended Message with ***Data Size*** > ***MaxExtendedMsgLegacyLen*** bytes that has not been Chunked.

4) See ***Section 6.11 "Message Discarding"*** for details of when Messages are ***Discarded*** .

6.12.2.2.1.1 PRL_Tx_PHY_Layer_Reset State

The *Protocol Layer* ***Shall*** enter the ***PRL_Tx_PHY_Layer_Reset*** state:

- At startup.
- As a result of a *Soft Reset* request being received by the *PHY Layer*.
- On exit from a *Hard Reset*.

On entry to the ***PRL_Tx_PHY_Layer_Reset*** state the *Protocol Layer* ***Shall*** reset the *PHY Layer* (clear any outstanding *Messages* and enable communications).

The *Protocol Layer* ***Shall*** transition to the ***PRL_Tx_Wait_for_Message_Request*** state when:

- When the *PHY Layer* reset is complete.

6.12.2.2.1.2 PRL_Tx_Wait_for_Message_Request State

In the ***PRL_Tx_Wait_for_Message_Request*** state the *Protocol Layer* waits until the *Policy Engine* directs it to send a *Message*.

- On entry to the ***PRL_Tx_Wait_for_Message_Request*** state the *Protocol Layer* ***Shall*** reset the ***RetryCounter***.

The *Protocol Layer* ***Shall*** transition to the ***PRL_Tx_Construct_Message*** state when:

- A *Message* request is received from the *Policy Engine* which is not a ***Soft_Reset*** *Message*.

The *Protocol Layer* ***Shall*** transition to the ***PRL_Tx_Layer_Reset_for_Transmit*** state when:

- A *Message* request is received from the *Policy Engine* which is a ***Soft_Reset*** *Message*.

6.12.2.2.1.3 PRL_Tx_Layer_Reset_for_Transmit State

On entry to the ***PRL_Tx_Layer_Reset_for_Transmit*** state the *Protocol Layer* ***Shall*** reset the ***MessageIDCounter***. The *Protocol Layer* ***Shall*** transition *Protocol Layer Message* reception to the ***PRL_Rx_Wait_for_PHY_Message*** state (see *Section 6.12.2.3.1, "PRL_Rx_Wait_for_PHY_Message state"*) in order to reset the stored ***MessageID***.

The *Protocol Layer* ***Shall*** transition to the ***PRL_Tx_Construct_Message*** state when:

- The layer reset actions in this state have been completed.

6.12.2.2.1.4 PRL_Tx_Construct_Message State

On entry to the ***PRL_Tx_Construct_Message*** state the *Protocol Layer* ***Shall*** construct the *Message* requested by the *Policy Engine*, or resend a previously constructed *Message*, and then pass this *Message* to the *PHY Layer*.

The *Protocol Layer* ***Shall*** transition to the ***PRL_Tx_Wait_for_PHY_Response*** state when:

- The *Message* has been sent to the *PHY Layer*.

6.12.2.2.1.5 PRL_Tx_Wait_for_PHY_Response State

On entry to the ***PRL_Tx_Wait_for_PHY_Response*** state, once the *Message* has been sent, the *Protocol Layer* ***Shall*** initialize and run the ***CRCReceiveTimer*** (see *Section 6.6.1, "CRCReceiveTimer"*).

The *Protocol Layer* ***Shall*** transition to the ***PRL_Tx_Match_MessageID*** state when:

- A ***GoodCRC*** *Message* response is received from the *PHY Layer*.

The *Protocol Layer* ***Shall*** transition to the ***PRL_Tx_Check_RetryCounter*** state when:

- The ***CRCReceiveTimer*** times out.
- Or the *PHY Layer* indicates that a *Message* has been ***Discarded*** due to the channel being busy but the channel is now *Idle* (see *Section 5.7, "Collision Avoidance"*).

6.12.2.2.1.6 PRL_Tx_Match_MessageID State

On entry to the ***PRL_Tx_Match_MessageID*** state the *Protocol Layer* ***Shall*** compare the ***MessageIDCounter*** and the ***MessageID*** of the received ***GoodCRC*** *Message*.

The *Protocol Layer* ***Shall*** transition to the ***PRL_Tx_Message_Sent*** state when:

- The ***MessageIDCounter*** and the ***MessageID*** of the received ***GoodCRC*** *Message* match.

The *Protocol Layer* ***Shall*** transition to the ***PRL_Tx_Check_RetryCounter*** state when:

- The ***MessageIDCounter*** and the ***MessageID*** of the received ***GoodCRC*** *Message* do not match.

6.12.2.2.1.7 PRL_Tx_Message_Sent State

On entry to the ***PRL_Tx_Message_Sent*** state the *Protocol Layer* ***Shall*** increment the ***MessageIDCounter*** and inform the *Policy Engine* that the *Message* has been sent.

The *Protocol Layer* ***Shall*** transition to the ***PRL_Tx_Wait_for_Message_Request*** state when:

- The *Policy Engine* has been informed that the *Message* has been sent.

6.12.2.2.1.8 PRL_Tx_Check_RetryCounter State

On entry to the ***PRL_Tx_Check_RetryCounter*** state the *Protocol Layer* in a *DFP* or *UFP* ***Shall*** increment the value of the ***RetryCounter*** and then check it in order to determine whether it is necessary to retry sending the *Message*.

Note: *Cable Plugs* do not retry *Messages* and so do not use the ***RetryCounter***.

The *Protocol Layer* ***Shall*** transition to the ***PRL_Tx_Construct_Message*** state in order to retry *Message* sending when:

- ***RetryCounter*** ≤ ***nRetryCount*** and
- This is not a *Cable Plug* and
- This is an *Extended Message* with ***Data Size*** ≤ ***MaxExtendedMsgLegacyLen*** or
- This is an *Extended Message* that has been *Chunked*.

The *Protocol Layer* ***Shall*** transition to the ***PRL_Tx_Transmission_Error*** state when:

- ***RetryCounter*** > ***nRetryCount*** or
- This is a *Cable Plug*, which does not retry.
- This is an *Extended Message* with ***Data Size*** > ***MaxExtendedMsgLegacyLen*** that has not been *Chunked*.

6.12.2.2.1.9 PRL_Tx_Transmission_Error State

On entry to the ***PRL_Tx_Transmission_Error*** state the *Protocol Layer* ***Shall*** increment the ***MessageIDCounter*** and inform the *Policy Engine* of the transmission error.

The *Protocol Layer* ***Shall*** transition to the ***PRL_Tx_Wait_for_Message_Request*** state when:

- The *Policy Engine* has been informed of the transmission error.

6.12.2.2.1.10 PRL_Tx_Discard_Message State

Protocol Layer Message transmission ***Shall*** enter the ***PRL_Tx_Discard_Message*** state whenever:

- *Protocol Layer Message* reception receives an incoming *Message* or
- The *Fast Role Swap Request* is being transmitted (see *Section 5.8.5.6, "Fast Role Swap Transmission"*)
- The *Fast Role Swap Request* is detected (see *Section 5.8.6.3, "Fast Role Swap Detection"*).

On entry to the ***PRL_Tx_Discard_Message*** state, if there is a *Message* queued awaiting transmission, the *Protocol Layer* ***Shall Discard*** the *Message* according to the rules in *Section 6.11, "Message Discarding"* and increment the ***MessageIDCounter***.

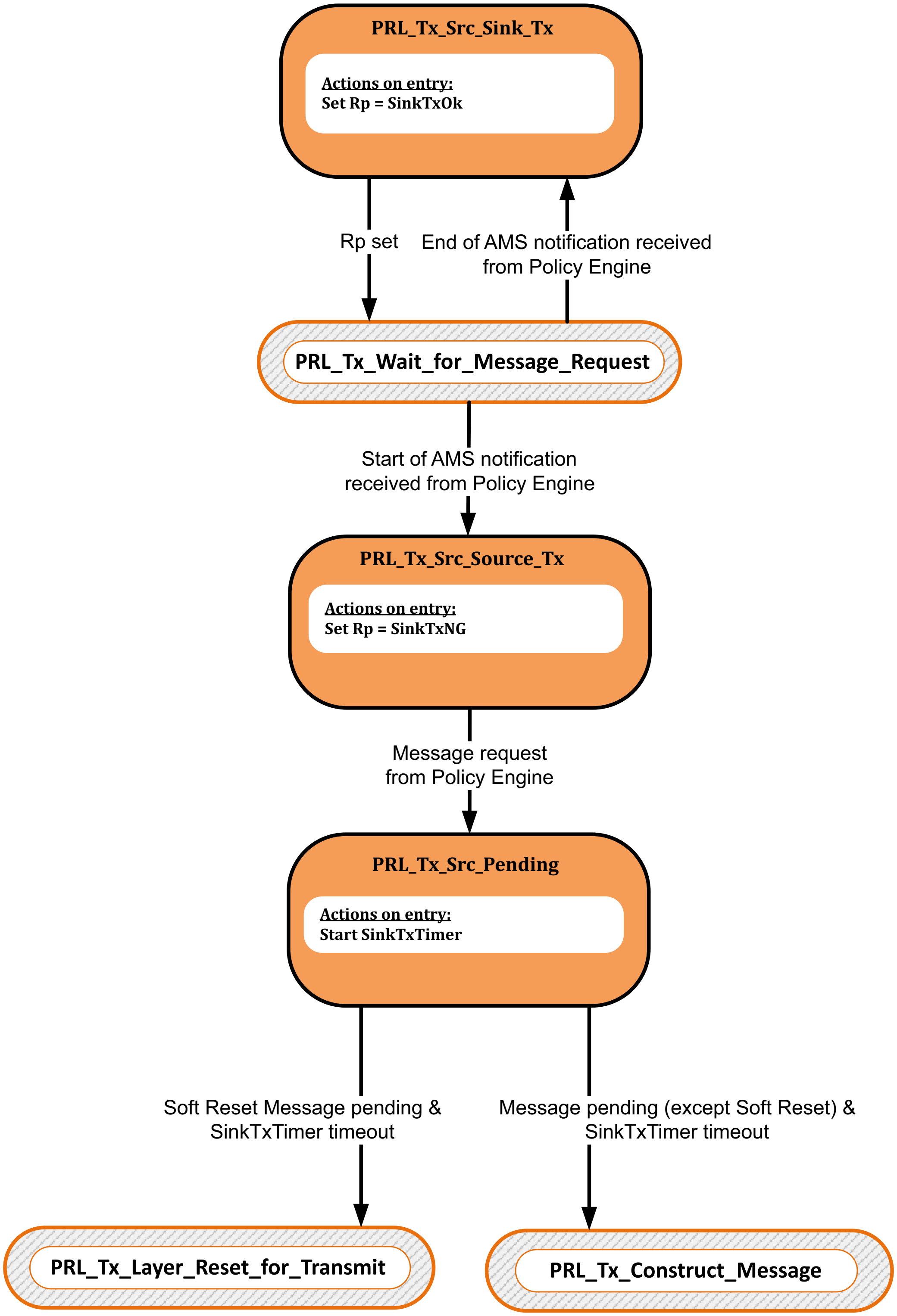
The *Protocol Layer* ***Shall*** transition to the ***PRL_Tx_PHY_Layer_Reset*** state when:

- Discarding is complete i.e., the *Message* queue is empty.

6.12.2.2.2 Source Protocol Layer Message Transmission State Diagram

Figure 6.64, "Source Protocol Layer Message Transmission State Diagram" shows the state behavior for the *Protocol Layer* in a *Source* when transmitting a *Message*.

Figure 6.64 Source Protocol Layer Message Transmission State Diagram


PRL_Tx_Src_Sink_Tx
Actions on entry:
Set Rp = SinkTxOk
Rp set
End of AMS notification received from Policy Engine
PRL_Tx_Wait_for_Message_Request
Start of AMS notification received from Policy Engine
PRL_Tx_Src_Source_Tx
Actions on entry:
Set Rp = SinkTxNG
Message request from Policy Engine
PRL_Tx_Src_Pending
Actions on entry:
Start SinkTxTimer
Soft Reset Message pending & SinkTxTimer timeout
Message pending (except Soft Reset) & SinkTxTimer timeout
PRL_Tx_Layer_Reset_for_Transmit
PRL_Tx_Construct_Message

6.12.2.2.2.1 PRL_Tx_Src_Sink_Tx State

In the ***PRL_Tx_Src_Sink_Tx*** state the *Source* sets R_p to ***SinkTxOK*** allowing the *Sink* to start an *Atomic Message Sequence* (*AMS*).

The *Protocol Layer* in a *Source* ***Shall*** transition from the ***PRL_Tx_Wait_for_Message_Request*** state to the ***PRL_Tx_Src_Sink_Tx*** state when:

- A notification is received from the *Policy Engine* that the end of an *AMS* has been reached.

On entry to the ***PRL_Tx_Src_Sink_Tx*** state the *Protocol Layer* ***Shall*** request the *PHY Layer* to R_p to ***SinkTxOK***.

The *Protocol Layer* ***Shall*** transition to the ***PRL_Tx_Wait_for_Message_Request*** state when:

- R_p has been set.

6.12.2.2.2.2 PRL_Tx_Src_Source_Tx State

In the ***PRL_Tx_Src_Source_Tx*** state the *Source* sets R_p to ***SinkTxNG*** allowing the *Source* to start an *Atomic Message Sequence* (*AMS*).

The *Protocol Layer* in a *Source* ***Shall*** transition from the ***PRL_Tx_Wait_for_Message_Request*** state to the ***PRL_Tx_Src_Source_Tx*** state when:

- A notification is received from the *Policy Engine* that an *AMS* will be starting.

On entry to the ***PRL_Tx_Src_Source_Tx*** state the *Protocol Layer* ***Shall*** set R_p to ***SinkTxNG***.

The *Protocol Layer* ***Shall*** transition to the ***PRL_Tx_Src_Pending*** state when:

- A *Message* request is received from the *Policy Engine*.

6.12.2.2.2.3 PRL_Tx_Src_Pending State

In the ***PRL_Tx_Src_Pending*** state the *Protocol Layer* has a *Message* buffered ready for transmission.

On entry to the ***PRL_Tx_Src_Pending*** state the ***SinkTxTimer*** ***Shall*** be initialized and run.

The *Protocol Layer* ***Shall*** transition to the ***PRL_Tx_Construct_Message*** state when:

- The pending *Message* request from the *Policy Engine* is not a ***Soft_Reset*** *Message* and
- The ***SinkTxTimer*** times out.

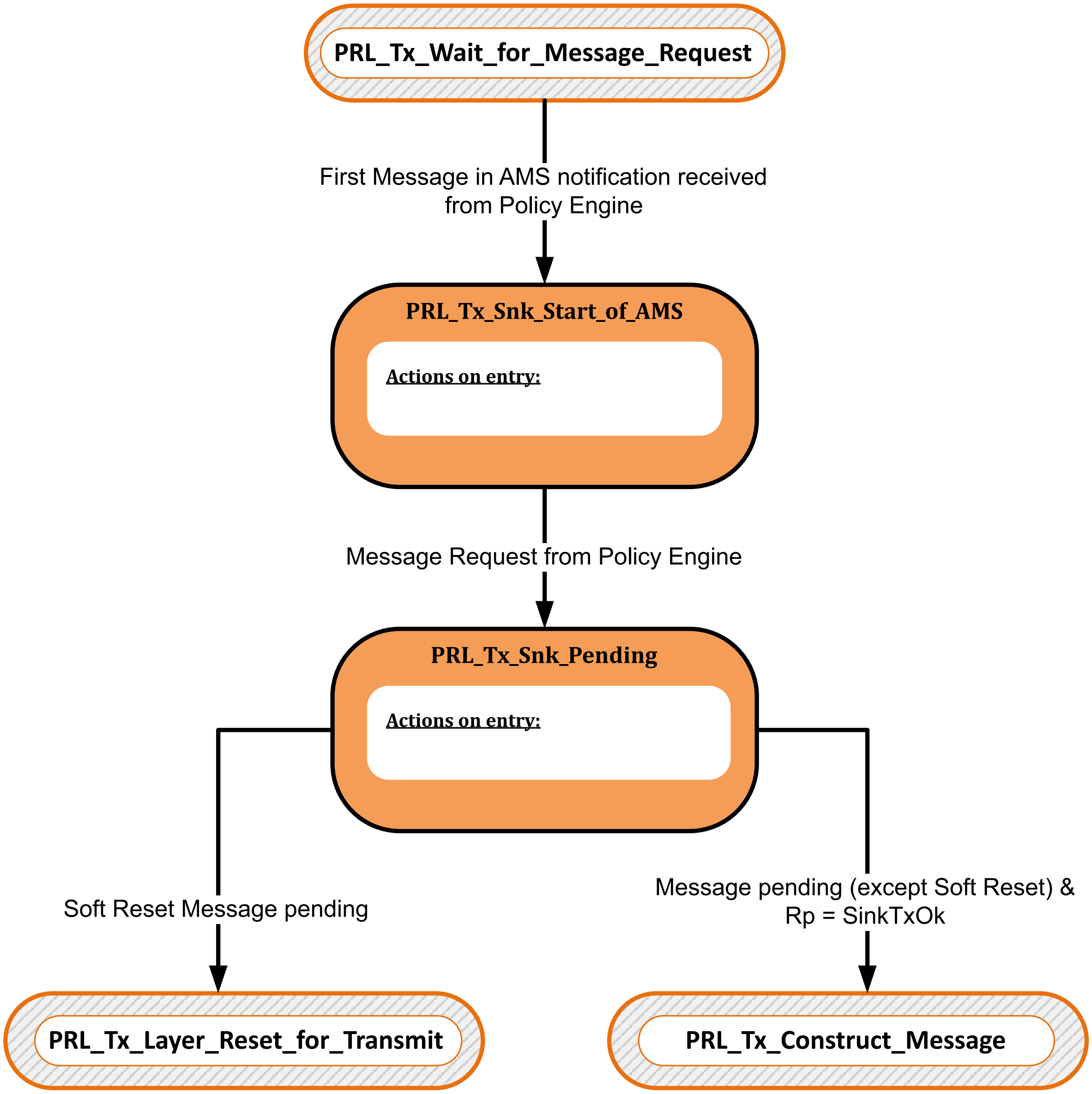
The *Protocol Layer* ***Shall*** transition to the ***PRL_Tx_Layer_Reset_for_Transmit*** state when:

- The pending *Message* request from the *Policy Engine* is a ***Soft_Reset*** *Message* and
- The ***SinkTxTimer*** times out.

6.12.2.2.3 Sink Protocol Layer Message Transmission State Diagram

Figure 6.65, "Sink Protocol Layer Message Transmission State Diagram" shows the state behavior for the *Protocol Layer* in a *Sink* when transmitting a *Message*.

Figure 6.65 Sink Protocol Layer Message Transmission State Diagram


PRL_Tx_Wait_for_Message_Request
First Message in AMS notification received from Policy Engine
PRL_Tx_Snk_Start_of_AMS
Actions on entry:
Message Request from Policy Engine
PRL_Tx_Snk_Pending
Actions on entry:
Soft Reset Message pending
Message pending (except Soft Reset) & Rp = SinkTxOk
PRL_Tx_Layer_Reset_for_Transmit
PRL_Tx_Construct_Message

6.12.2.2.3.1 PRL_Tx_Snk_Start_of_AMS State

In the ***PRL_Tx_Snk_Start_of_AMS*** state the *Protocol Layer* waits for the first *Message* in a *Sink* initiated *AMS*.

The *Protocol Layer* in a *Sink* ***Shall*** transition from the ***PRL_Tx_Wait_for_Message_Request*** state to the ***PRL_Tx_Snk_Start_of_AMS*** state when:

- A notification is received from the *Policy Engine* that the next *Message* the *Sink* will send is the start of an *AMS*.

The *Protocol Layer* ***Shall*** transition to the ***PRL_Tx_Snk_Pending*** state when:

- A *Message* request is received from the *Policy Engine*.

6.12.2.2.3.2 PRL_Tx_Snk_Pending State

In the ***PRL_Tx_Snk_Pending*** state the *Protocol Layer* has the first *Message* in a *Sink* initiated *AMS* ready to send and is waiting for R_p to transition to ***SinkTxOK*** before sending the *Message*.

The *Protocol Layer* ***Shall*** transition to the ***PRL_Tx_Construct_Message*** state when:

- A *Message* is Pending that is not a ***Soft_Reset*** *Message* and
- R_p is set to ***SinkTxOK***.

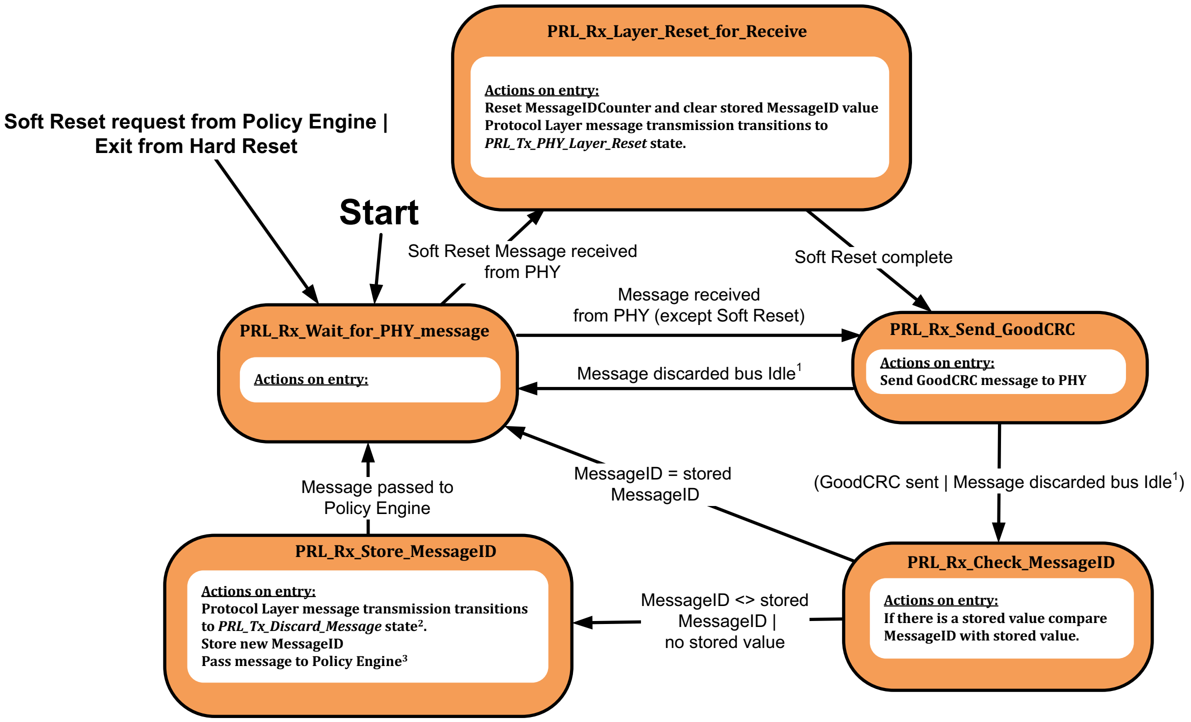
The *Protocol Layer* ***Shall*** transition to the ***PRL_Tx_Layer_Reset_for_Transmit*** state when:

- A ***Soft_Reset*** *Message* is pending.

6.12.2.3 Protocol Layer Message Reception

Figure 6.66, "Protocol layer Message reception" shows the state behavior for the *Protocol Layer* when receiving a *Message*.

Figure 6.66 Protocol layer Message reception


PRL_Rx_Layer_Reset_for_Receive
Actions on entry:
Reset MessageIDCounter and clear stored MessageID value
Protocol Layer message transmission transitions to
PRL_Tx_PHY_Layer_Reset state.
Soft Reset request from Policy Engine |
Exit from Hard Reset
Start
Soft Reset Message received
from PHY
Soft Reset complete
Message received
from PHY (except Soft Reset)
PRL_Rx_Wait_for_PHY_message
Actions on entry:
PRL_Rx_Send_GoodCRC
Actions on entry:
Send GoodCRC message to PHY
Message discarded bus Idle[1]
MessageID = stored
MessageID
(GoodCRC sent | Message discarded bus Idle[1])
Message passed to
Policy Engine
PRL_Rx_Store_MessageID
Actions on entry:
Protocol Layer message transmission transitions
to PRL_Tx_Discard_Message state[2].
Store new MessageID
Pass message to Policy Engine[3]
MessageID <> stored
MessageID |
no stored value
PRL_Rx_Check_MessageID
Actions on entry:
If there is a stored value compare
MessageID with stored value.

[1] This indication is sent by the PHY when a message has been ***Discarded*** due to CC being busy, and after CC becomes idle again (see *Section 5.7 "Collision Avoidance"*). Two alternate allowable transitions are shown.

[2] In the case of a Ping message being received, in order to maintain robust communications in the presence of collisions, the outgoing message ***Should Not*** be ***Discarded***.

[3] See *Section 6.11 "Message Discarding"* for details of when Messages are discarded.

6.12.2.3.1 PRL_Rx_Wait_for_PHY_Message state

The *Protocol Layer* ***Shall*** enter the ***PRL_Rx_Wait_for_PHY_Message*** state:

- At startup.
- As a result of a *Soft Reset* request from the *Policy Engine*.
- On exit from a *Hard Reset*.

In the ***PRL_Rx_Wait_for_PHY_Message*** state the *Protocol Layer* waits until the *PHY Layer* passes up a received *Message*.

The *Protocol Layer* ***Shall*** transition to the ***PRL_Rx_Send_GoodCRC*** state when:

- A *Message* is passed up from the *PHY Layer*.

The *Protocol Layer* ***Shall*** transition to the ***PRL_Rx_Layer_Reset_for_Receive*** state when:

- A ***Soft_Reset*** *Message* is received from the *PHY Layer*.

6.12.2.3.2 PRL_Rx_Layer_Reset_for_Receive state

On entry to the ***PRL_Rx_Layer_Reset_for_Receive*** state the *Protocol Layer* ***Shall*** reset the ***MessageIDCounter*** and clear the stored ***MessageID***. The *Protocol Layer* ***Shall*** transition *Protocol Layer Message* transmission to the ***PRL_Tx_Wait_for_Message_Request*** state (see *Section 6.12.2.2.1.2, "PRL_Tx_Wait_for_Message_Request State"*).

The *Protocol Layer* ***Shall*** transition to the ***PRL_Rx_Send_GoodCRC*** State when:

- The *Soft Reset* actions in this state have been completed.

6.12.2.3.3 PRL_Rx_Send_GoodCRC state

On entry to the ***PRL_Rx_Send_GoodCRC*** state the *Protocol Layer* ***Shall*** construct a ***GoodCRC*** *Message* and request the *PHY Layer* to transmit it.

The *Protocol Layer* ***Shall*** transition to the ***PRL_Rx_Check_MessageID*** state when:

- The ***GoodCRC*** *Message* has been passed to the *PHY Layer*.

When the *PHY Layer* indicates that a *Message* has been ***Discarded*** due to *CC* being busy but *CC* is now *Idle* (see *Section 5.7, "Collision Avoidance"*), the *Protocol Layer* ***Shall*** either:

- Transition to the ***PRL_Rx_Check_MessageID*** state or
- Transition to the ***PRL_Rx_Wait_for_PHY_Message*** state.

6.12.2.3.4 PRL_Rx_Check_MessageID state

On entry to the ***PRL_Rx_Check_MessageID*** state the *Protocol Layer* ***Shall*** compare the ***MessageID*** of the received *Message* with its stored value if a value has previously been stored.

The *Protocol Layer* ***Shall*** transition to the ***PRL_Rx_Wait_for_PHY_Message*** state when:

- The ***MessageID*** of the received *Message* equals the stored ***MessageID*** value since this is a *Message* retry which ***Shall*** be ***Discarded***.

The *Protocol Layer* ***Shall*** transition to the ***PRL_Rx_Store_MessageID*** state when:

- The ***MessageID*** of the received *Message* does not equal the stored ***MessageID*** value since this is a new *Message* or
- This is the first received *Message* and no ***MessageID*** value is currently stored.

6.12.2.3.5 PRL_Rx_Store_MessageID state

On entry to the ***PRL_Rx_Store_MessageID*** state the *Protocol Layer* ***Shall*** transition *Protocol Layer Message* transmission to the ***PRL_Tx_Discard_Message*** state, replace the stored value of ***MessageID*** with the value of ***MessageID*** in the received *Message* and pass the *Message* up to the *Policy Engine*.

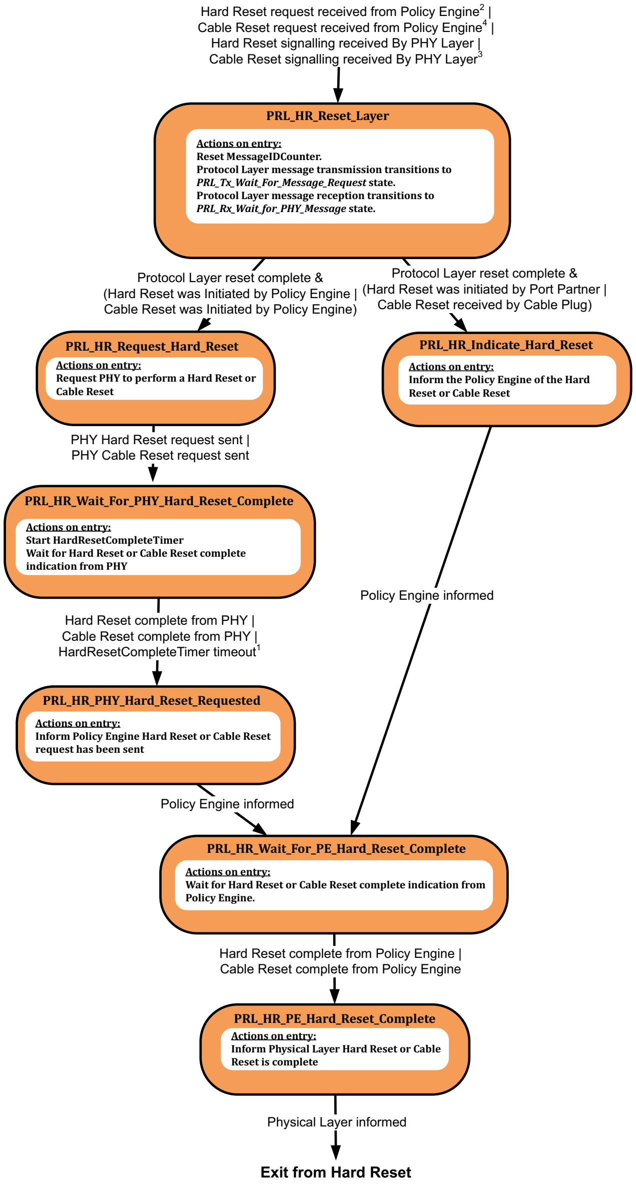
The *Protocol Layer* ***Shall*** transition to the ***PRL_Rx_Wait_for_PHY_Message*** state when:

- The *Message* has been passed up to the *Policy Engine*.

6.12.2.4 Hard Reset operation

Figure 6.57, "Outline of States" shows the state behavior for the *Protocol Layer* when receiving a *Hard Reset* or *Cable Reset* request from the *Policy Engine* or ***Hard Reset*** *Signaling* or ***Cable Reset*** *Signaling* from the *PHY Layer* (see also *Section 6.8.3, "Hard Reset"* and *Section 6.8.4, "Cable Reset"*).

Figure 6.67 Hard/Cable Reset



Hard Reset request received from Policy Engine[2] |
Cable Reset request received from Policy Engine[4] |
Hard Reset signalling received By PHY Layer |
Cable Reset signalling received By PHY Layer[3]
PRL_HR_Reset_Layer
Actions on entry:
Reset MessageIDCounter.
Protocol Layer message transmission transitions to
PRL_Tx_Wait_For_Message_Request state.
Protocol Layer message reception transitions to
PRL_Rx_Wait_for_PHY_Message state.
Protocol Layer reset complete &
(Hard Reset was Initiated by Policy Engine |
Cable Reset was Initiated by Policy Engine)
Protocol Layer reset complete &
(Hard Reset was initiated by Port Partner |
Cable Reset received by Cable Plug)
PRL_HR_Request_Hard_Reset
Actions on entry:
Request PHY to perform a Hard Reset or Cable Reset
PRL_HR_Indicate_Hard_Reset
Actions on entry:
Inform the Policy Engine of the Hard Reset or Cable Reset
PHY Hard Reset request sent |
PHY Cable Reset request sent
PRL_HR_Wait_For_PHY_Hard_Reset_Complete
Actions on entry:
Start HardResetCompleteTimer
Wait for Hard Reset or Cable Reset complete indication from PHY
Policy Engine informed
Hard Reset complete from PHY |
Cable Reset complete from PHY |
HardResetCompleteTimer timeout[1]
PRL_HR_PHY_Hard_Reset_Requested
Actions on entry:
Inform Policy Engine Hard Reset or Cable Reset request has been sent
Policy Engine informed
PRL_HR_Wait_For_PE_Hard_Reset_Complete
Actions on entry:
Wait for Hard Reset or Cable Reset complete indication from Policy Engine.
Hard Reset complete from Policy Engine |
Cable Reset complete from Policy Engine
PRL_HR_PE_Hard_Reset_Complete
Actions on entry:
Inform Physical Layer Hard Reset or Cable Reset is complete
Physical Layer informed
Exit from Hard Reset

[1] If the ***HardResetCompleteTimer*** timeout occurs this means that the PHY is still waiting to send the Hard Reset due to a non-idle channel. This condition will be cleared once the PE Hard Reset is completed.
[2] Cable Plugs do not generate ***Hard Reset*** signaling but are required to monitor for ***Hard Reset*** signaling between the Port Partners and respond by resetting.
[3] Cable Reset signaling is only recognized by a Cable Plug.
[4] Cable Reset signaling cannot be generated by Cable Plugs.

6.12.2.4.1 PRL_HR_Reset_Layer state

The ***PRL_HR_Reset_Layer*** State defines the mode of operation of both the *Protocol Layer* transmission and reception state machines during a *Hard Reset* or *Cable Reset*. During *Hard Reset* no USB Power Delivery Protocol *Messages* are sent or received; only ***Hard Reset*** *Signaling* is present after which the communication channel is assumed to have been disabled by the *PHY Layer* until completion of the *Hard Reset*. During *Cable Reset* no USB Power Delivery Protocol *Messages* are sent to or received by the *Cable Plug* but other USB Power Delivery communication ***May*** continue.

The *Protocol Layer* ***Shall*** enter the ***PRL_HR_Reset_Layer*** state from any other state when:

- A *Hard Reset* Request is received from the *Policy Engine* or
- ***Hard Reset*** *Signaling* is received from the *PHY Layer* or

- A *Cable Reset* Request is received from the *Policy Engine* or
- ***Cable Reset*** *Signaling* is received from the *PHY Layer*.

On entry to the ***PRL_HR_Reset_Layer*** state the *Protocol Layer* ***Shall*** reset the ***MessageIDCounter***. It ***Shall*** also reset the states of the *Protocol Layer* transmission and reception state machines to their starting points. The *Protocol Layer* transmission state machine ***Shall*** transition to the ***PRL_Tx_Wait_for_Message_Request*** state. The *Protocol Layer* reception state machine ***Shall*** transition to the ***PRL_Rx_Wait_for_PHY_Message*** state.

The *Protocol Layer* ***Shall*** transition to the ***PRL_HR_Request_Hard_Reset*** state when:

- The *Protocol Layer*'s reset is complete and
- The *Hard Reset* request has originated from the *Policy Engine* or
- The *Cable Reset* request has originated from the *Policy Engine*.

The *Protocol Layer* ***Shall*** transition to the ***PRL_HR_Indicate_Hard_Reset*** state when:

- The *Protocol Layer*'s reset is complete and
- The *Hard Reset* request has been passed up from the *PHY Layer* or
- A *Cable Reset* request has been passed up from the *PHY Layer* (*Cable Plug* only).

6.12.2.4.2 PRL_HR_Indicate_Hard_Reset state

On entry to the ***PRL_HR_Indicate_Hard_Reset*** state the *Protocol Layer* ***Shall*** indicate to the *Policy Engine* that either ***Hard Reset*** *Signaling* or ***Cable Reset*** *Signaling* has been received.

The *Protocol Layer* ***Shall*** transition to the ***PRL_HR_Wait_for_PE_Hard_Reset_Complete*** state when:

- The indication to the *Policy Engine* has been sent.

6.12.2.4.3 PRL_HR_Request_Hard_Reset state

On entry to the ***PRL_HR_Request_Hard_Reset*** state the *Protocol Layer* ***Shall*** request the *PHY Layer* to send either ***Hard Reset*** *Signaling* or ***Cable Reset*** *Signaling*.

The *Protocol Layer* ***Shall*** transition to the ***PRL_HR_Wait_for_PHY_Hard_Reset_Complete*** state when:

- The *PHY Layer* ***Hard Reset*** *Signaling* request has been sent or
- The *PHY Layer* ***Cable Reset*** *Signaling* request has been sent.

6.12.2.4.4 PRL_HR_Wait_for_PHY_Hard_Reset_Complete state

In the ***PRL_HR_Wait_for_PHY_Hard_Reset_Complete*** state the *Protocol Layer* ***Shall*** start the ***HardResetCompleteTimer*** and wait for the *PHY Layer* to indicate that the *Hard Reset* or *Cable Reset* has been completed.

The *Protocol Layer* ***Shall*** transition to the ***PRL_HR_PHY_Hard_Reset_Requested*** state when:

- A *Hard Reset* complete indication is received from the *PHY Layer* or
- A *Cable Reset* complete indication is received from the *PHY Layer* or
- The ***HardResetCompleteTimer*** times out.

6.12.2.4.5 PRL_HR_PHY_Hard_Reset_Requested state

On entry to the ***PRL_HR_PHY_Hard_Reset_Requested*** state the *Protocol Layer* ***Shall*** inform the *Policy Engine* that the *PHY Layer* has been requested to perform a *Hard Reset* or *Cable Reset*.

The *Protocol Layer* ***Shall*** transition to the ***PRL_HR_Wait_for_PE_Hard_Reset_Complete*** state when:

- The Indication to the *Policy Engine* has been sent.

6.12.2.4.6 PRL_HR_Wait_for_PE_Hard_Reset_Complete state

In the ***PRL_HR_Wait_for_PE_Hard_Reset_Complete*** state the *Protocol Layer* ***Shall*** wait for the *Policy Engine* to indicate that the *Hard Reset* or *Cable Reset* has been completed.

The *Protocol Layer* ***Shall*** transition to the ***PRL_HR_PE_Hard_Reset_Complete*** state when:

- A *Hard Reset* complete indication is received from the *Policy Engine* or
- A *Cable Reset* complete indication is received from the *Policy Engine*.

6.12.2.4.7 PRL_HR_PE_Hard_Reset_Complete

On entry to the ***PRL_HR_PE_Hard_Reset_Complete*** state the *Protocol Layer* ***Shall*** inform the *PHY Layer* that the *Hard Reset* or *Cable Reset* is complete.

The *Protocol Layer* ***Shall*** exit from the *Hard Reset* and return to normal operation when:

- The *PHY Layer* has been informed that the *Hard Reset* is complete so that it will re-enable the communications channel. If ***Hard Reset*** *Signaling* is still pending due to a non-*Idle* channel this ***Shall*** be cleared and not sent or
- The *PHY Layer* has been informed that the *Cable Reset* is complete.

6.12.3 List of Protocol Layer States

Table 6.75, "Protocol Layer States" lists the states used by the various state machines.

Table 6.75 Protocol Layer States

State Name	Section
Protocol Layer Message Transmission	
Common Protocol Layer Message Transmission	
PRL_Tx_PHY_Layer_Reset	Section 6.12.2.2.1.1
PRL_Tx_Wait_for_Message_Request	Section 6.12.2.2.1.2
PRL_Tx_Layer_Reset_for_Transmit	Section 6.12.2.2.1.3
PRL_Tx_Construct_Message	Section 6.12.2.2.1.4
PRL_Tx_Wait_for_PHY_Response	Section 6.12.2.2.1.5
PRL_Tx_Match_MessageID	Section 6.12.2.2.1.6
PRL_Tx_Message_Sent	Section 6.12.2.2.1.7
PRL_Tx_Check_RetryCounter	Section 6.12.2.2.1.8
PRL_Tx_Transmission_Error	Section 6.12.2.2.1.9
PRL_Tx_Discard_Message	Section 6.12.2.2.1.10
Source Protocol Layer Message Transmission	
PRL_Tx_Src_Sink_Tx	Section 6.12.2.2.2.1
PRL_Tx_Src_Source_Tx	Section 6.12.2.2.2.2
PRL_Tx_Src_Pending	Section 6.12.2.2.2.3
Sink Protocol Layer Message Transmission	
PRL_Tx_Snk_Start_of_AMS	Section 6.12.2.2.3.1
PRL_Tx_Snk_Pending	Section 6.12.2.2.3.2
Protocol Layer Message Reception	
PRL_Rx_Wait_for_PHY_Message	Section 6.12.2.3.1
PRL_Rx_Layer_Reset_for_Receive	Section 6.12.2.3.2
PRL_Rx_Send_GoodCRC	Section 6.12.2.3.3
PRL_Rx_Check_MessageID	Section 6.12.2.3.4
PRL_Rx_Store_MessageID	Section 6.12.2.3.5
Hard Reset Operation	
PRL_HR_Reset_Layer	Section 6.12.2.4.1
PRL_HR_Indicate_Hard_Reset	Section 6.12.2.4.2
PRL_HR_Request_Hard_Reset	Section 6.12.2.4.3
PRL_HR_Wait_for_PHY_Hard_Reset_Complete	Section 6.12.2.4.4
PRL_HR_PHY_Hard_Reset_Requested	Section 6.12.2.4.5
PRL_HR_Wait_for_PE_Hard_Reset_Complete	Section 6.12.2.4.6
PRL_HR_PE_Hard_Reset_Complete	Section 6.12.2.4.7

Table 6.75 Protocol Layer States (Continued)

State Name	Section
Chunking	
Chunked Rx	
RCH_Wait_For_Message_From_Protocol_Layer	*Section 6.12.2.2.1.1*
RCH_Pass_Up_Message	*Section 6.12.2.2.1.1*
RCH_Processing_Extended_Message	*Section 6.12.2.2.1.1*
RCH_Requesting_Chunk	*Section 6.12.2.2.1.1*
RCH_Waiting_Chunk	*Section 6.12.2.2.1.1*
RCH_Report_Error	*Section 6.12.2.2.1.1*
Chunked Tx	
TCH_Wait_For_Message_Request_From_Policy_Engine	*Section 6.12.2.1.3.1*
TCH_Pass_Down_Message	*Section 6.12.2.1.3.2*
TCH_Wait_For_Transmision_Complete	*Section 6.12.2.1.3.3*
TCH_Message_Sent	*Section 6.12.2.1.3.4*
TCH_Prepare_To_Send_Chunked_Message	*Section 6.12.2.1.3.5*
TCH_Construct_Chunked_Message	*Section 6.12.2.1.3.6*
TCH_Sending_Chunked_Message	*Section 6.12.2.1.3.7*
TCH_Wait_Chunk_Request	*Section 6.12.2.1.3.8*
TCH_Message_Received	*Section 6.12.2.1.3.9*
TCH_Report_Error	*Section 6.12.2.1.3.10*
Chunked Message Router	
RTR_Wait_for_Message_From_Protocol_Layer	*Section 6.12.2.1.4.1*
RTR_Rx_Chunks	*Section 6.12.2.1.4.2*
RTR_Tx_Chunks	*Section 6.12.2.1.4.3*

6.13 Message Applicability

The following tables outline the *Message*s supported by a given *Port*, depending on its capability.

When a *Message* is supported the feature and the *AMS* implied by the *Message* ***Shall*** also be supported. The abbreviations in *Table 6.76, "Message Applicability Abbreviations"* are used in this section to denote the level of support required.

Table 6.76 Message Applicability Abbreviations

Abbreviation	Meaning	Description
N	***Normative***	***Shall*** be supported by this *Port*/*Cable Plug*.
CN	***Conditional Normative***	***Shall*** supported by a given *Port*/*Cable Plug* based on features.
R	Recommended	***Should*** be supported by this *Port*/*Cable Plug*.
O	***Optional***	***May*** be supported by this *Port*/*Cable Plug*.
NS	Not Supported	***Shall*** result in a ***Not_Supported*** *Message* response by this *Port*/*Cable Plug* when received.
I	***Ignore***	***Shall*** be ***Ignored*** by this *Port*/*Cable Plug* when received.
NK	***NAK***	This *Port*/*Cable Plug* ***Shall*** return *Responder* ***NAK*** to this *Command* when received.
NA	Not allowed	***Shall Not*** be transmitted by this *Port*/*Cable Plug*.
DR	Don't Recognize	There ***Shall*** be no response at all (i.e., not even a ***GoodCRC*** Message) from this *Port*/*Cable Plug* when received.

For the case of ***Conditional Normative*** a note has been added to indicate the condition. "CN/" notation is used to indicate the level of support when the condition is not present.

"R/" and "O/" notation is used to indicate the response when the Recommended or ***Optional*** *Message* is not supported.

Note: Where NS/R/NK is indicated for Received *Message*s this ***Shall*** apply to the ***PE_CBL_Ready***, ***PE_SNK_Ready*** or ***PE_SRC_Ready*** states only since unexpected *Message*s received during an *AMS* are *Protocol Errors* (see *Section 6.8.1, "Soft Reset and Protocol Error"*).

This section covers *Control Message* and *Data Message* support for *Sources*, *Sink* and *Cable Plugs*. It also covers *VDM Command* support for *DFPs*, *UFPs* and *Cable Plugs*.

6.13.1 Applicability of Control Messages

Table 6.77, "Applicability of Control Messages" details *Control Messages* that ***Shall***/***Should***/***Shall Not*** be transmitted and received by a *Source*, *Sink*, *Cable Plug* or *VPD*. Requirements for *Dual-Role Power Ports* and *Dual-Role Data Ports* ***Shall*** override any requirements for *Source*-only or *Sink*-Only Ports.

Table 6.77 Applicability of Control Messages

Message Type	Source	Sink	Dual-Role Power	Dual-Role Data	Cable Plug	VPD[9]
Transmitted Message						
Accept	N	N			N	N
Data_Reset	CN[10]/R	CN[10]/R			NA	NA
DR_Swap	O	O		N	NA	NA
FR_Swap	NA	NA	R		NA	NA
Get_Country_Codes	CN[7]/NA	CN[7]/NA			NA	NA
Get_PPS_Status	NA	CN[6]			NA	NA
Get_Sink_Cap	R	NA	N		NA	NA
Get_Sink_Cap_Extended	R	NA	R		NA	NA
Get_Source_Cap	NA	R	N		NA	NA
Get_Source_Cap_Extended	NA	R	R		NA	NA
Get_Source_Info	NA	R	R		NA	NA
Get_Revision	R	R			NA	NA
Get_Status	R	R			NA	NA
GoodCRC	N	N			N	N
GotoMin (Deprecated)	NA	NA			NA	NA
Not_Supported	N	N			NA	NA
Ping (Deprecated)	NA	NA			NA	NA
PR_Swap	NA	NA	N		NA	NA
PS_RDY	N	CN[1]/NA	N		NA	NA
Reject	N	O	O	O	CN[10]/NA	NA
Soft_Reset	N	N			NA	NA
VCONN_Swap	R	R			NA	NA
Wait	O	NA	O	O	NA	NA

1) ***Shall*** be supported by any *Port* that can supply *VCONN*.

2) ***Shall*** be supported products that support the ***Source_Capabilities_Extended*** Message.

3) ***Shall*** be supported by *Sources* that support the ***Alert*** Message.

4) ***Shall*** be supported when the *Fast Role Swap Request* is supported.

5) ***Shall*** be supported when *VCONN Swap* is supported.

6) ***Shall*** be supported when *SPR PPS Mode* is supported.

7) ***Shall*** be supported when required by a country authority.

8) ***Shall*** be supported by *Active Cables*.

9) *VPD* includes *CT-VPDs* when not *Connected* to a *Charger*. PD communication with a *CT-VPD* ***Shall*** only take place when not *Connected* to a *Charger*.

10) ***Shall*** be supported by products that support ***[USB4]***.

11) ***Shall*** be supported by all *Sources* except single *Port SPR Chargers* with *Invariant PDOs*.

Table 6.77 Applicability of Control Messages (Continued)

Message Type	Source	Sink	Dual-Role Power	Dual-Role Data	Cable Plug	VPD[9]
Received Message						
Accept	N	N	N	N	I	I
Data_Reset	CN[10]/R	CN[10]/R			I	I
DR_Swap	O/NS	O/NS		N	I	I
FR_Swap	NS	NS	CN[4]/NS		I	I
Get_Country_Codes	CN[7]/NS	CN[7]/NS			I	I
Get_PPS_Status	CN[6]/NS	NS			I	I
Get_Sink_Cap	NS	N	N		I	I
Get_Sink_Cap_Extended	NS	N	N		I	I
Get_Source_Cap	N	NS	N		I	I
Get_Source_Cap_Extended	CN[2]/NS	NS	CN[2]/NS		I	I
Get_Source_Info	CN[11]	NS	N		I	I
Get_Revision	N	N			O/I	O/I
Get_Status	CN[3]/NS	CN[3]/NS	CN[3]/NS		CN[8]/I	I
GoodCRC	N	N			N	N
GotoMin **(Deprecated)**	NS	NS			I	I
Not_Supported	N	N			CN[8]/I	I
Ping **(Deprecated)**	NS	NS/I			I	I
PR_Swap	NS	NS	N		I	I
PS_RDY	CN[1]/NS	N	N		I	I
Reject	CN[5]/NS	N	N	N	I	I
Soft_Reset	N	N			N	N
VCONN_Swap	CN[1]/ NS	CN[1]/ NS			I	I
Wait	CN[5]/NS	N	N	N	I	I

1) ***Shall*** be supported by any *Port* that can supply *VCONN*.

2) ***Shall*** be supported products that support the ***Source_Capabilities_Extended*** Message.

3) ***Shall*** be supported by *Source*s that support the ***Alert*** Message.

4) ***Shall*** be supported when the *Fast Role Swap Request* is supported.

5) ***Shall*** be supported when *VCONN Swap* is supported.

6) ***Shall*** be supported when *SPR PPS Mode* is supported.

7) ***Shall*** be supported when required by a country authority.

8) ***Shall*** be supported by *Active Cable*s.

9) *VPD* includes *CT-VPDs* when not *Connected* to a *Charger*. PD communication with a *CT-VPD* ***Shall*** only take place when not *Connected* to a *Charger*.

10) ***Shall*** be supported by products that support *[USB4]*.

11) ***Shall*** be supported by all *Source*s except single *Port SPR Chargers* with *Invariant PDOs*.

6.13.2 Applicability of Data Messages

Table 6.78, "Applicability of Data Messages" details *Data Messages* (except for *VDM Commands*) that ***Shall***/***Should***/***Shall Not*** be transmitted and received by a *Source*, *Sink*, *Cable Plug* or *VPD*. Requirements for *Dual-Role Power Ports* ***Shall*** override any requirements for *Source*-only or *Sink*-Only Ports.

Table 6.78 Applicability of Data Messages

Message Type	Source	Sink	Dual-Role Power	Cable Plug SOP’	Cable Plug SOP’’	VPD[6]
Transmitted Message						
Source_Capabilities	N	NA	N	NA	NA	NA
Request	NA	N		NA	NA	NA
Get_Country_Info	CN[5]/O	CN[5]/O		NA	NA	NA
BIST	N[1]	N[1]		NA	NA	NA
Sink_Capabilities	NA	N	N	NA	NA	NA
Battery_Status	CN[2]	CN[2]		NA	NA	NA
Alert	CN[11]/R	CN[11]/R		NA	NA	NA
Enter_USB	CN[7]/O	CN[7]/O		NA	NA	NA
EPR_Request	NA	CN[9]		NA	NA	NA
EPR_Mode	CN[9]	CN[9]		NA	NA	NA
Source_Info	CN[10]	NA	N	NA	NA	NA
Revision	N	N		CN[12]/O/I	NA	O
Received Message						
Source_Capabilities	NS	N	N	I	I	I
Request	N	NS		I	I	I
Get_Country_Info	CN[5]/NS	CN[5]/NS		I	I	I
BIST	N[1]	N[1]		N[1]	N[1]	N[1]
Sink_Capabilities	CN[4]	NS	CN[4]	I	I	I
Battery_Status	CN[3]/NS	CN[3]/NS		I	I	I
Alert	R/NS	R/NS		I	I	I
Enter_USB	CN[7]/O	CN[7]/O		CN[8]/I	CN[8]/I	I

1) For details of which *BIST Modes* and ***BIST*** Messages ***Shall*** be supported see *Section 5.9* and *Section 6.4.3*.

2) ***Shall*** be supported by products that contain batteries.

3) ***Shall***be supported by products that support the ***Get_Battery_Status*** Message.

4) ***Shall*** be supported by products that support the ***Get_Sink_Cap*** Message.

5) ***Shall*** be supported when required by a country authority.

6) *VPD* includes *CT-VPDs* when not *Connected* to a *Charger*. PD communication with a *CT-VPD* ***Shall*** only take place when not *Connected* to a *Charger*.

7) ***Shall*** be supported by products that support ***[USB4]***.

8) ***Shall*** be supported by *Active Cables* that support ***[USB4]***.

9) ***Shall*** be supported by products that support *Source* operation in *EPR Mode*.

10) ***Shall*** be supported by all *Source Ports* except single*Port SPR Chargers* with *Invariant PDOs*.

11) ***Shall*** be supported when *SPR PPS Mode* is supported.

12) ***Shall*** be supported by *Active Cables*.

Table 6.78 Applicability of Data Messages (Continued)

Message Type	Source	Sink	Dual-Role Power	Cable Plug SOP’	Cable Plug SOP’’	VPD[6]
EPR_Request	CN[9]	NA		I	I	I
EPR_Mode	CN[9]	CN[9]		I	I	I
Source_Info	NA	N	N	I	I	I
Revision	N	N		I	I	I

1) For details of which *BIST Mode*s and ***BIST*** Messages ***Shall*** be supported see *Section 5.9* and *Section 6.4.3*.

2) ***Shall*** be supported by products that contain batteries.

3) ***Shall***be supported by products that support the ***Get_Battery_Status*** Message.

4) ***Shall*** be supported by products that support the ***Get_Sink_Cap*** Message.

5) ***Shall*** be supported when required by a country authority.

6) *VPD* includes *CT-VPD*s when not *Connected* to a *Charger*. PD communication with a *CT-VPD* ***Shall*** only take place when not *Connected* to a *Charger*.

7) ***Shall*** be supported by products that support ***[USB4]***.

8) ***Shall*** be supported by *Active Cable*s that support ***[USB4]***.

9) ***Shall*** be supported by products that support *Source* operation in *EPR Mode*.

10) ***Shall*** be supported by all *Source Ports* except single*Port SPR Charger*s with *Invariant PDOs*.

11) ***Shall*** be supported when *SPR PPS Mode* is supported.

12) ***Shall*** be supported by *Active Cable*s.

6.13.3 Applicability of Extended Messages

Table 6.79, "Applicability of Extended Messages" details *Extended Messages* (except for *VDEM Commands*) that ***Shall***/***Should***/ ***Shall Not*** be transmitted and received by a *Source*, *Sink*, *Cable Plug* or *VPD*. Requirements for *Dual-Role Power Ports* ***Shall*** override any requirements for *Source*-only or *Sink*-Only Ports.

Table 6.79 Applicability of Extended Messages

Message Type	Source	Sink	Dual-Role Power	Cable Plug SOP'	Cable Plug SOP''	VPD[13]
Transmitted Message						
Battery_Capabilities	CN[1]/NA	CN[1]/NA		NA	NA	NA
Country_Codes	CN[10]/NA	CN[10]/NA		NA	NA	NA
Country_Info	CN[10]/NA	CN[10]/NA		NA	NA	NA
EPR_Source_Capabilities	CN[14]/NA	NA	CN[14]/NA	NA	NA	NA
EPR_Sink_Capabilities	NA	CN[14]/NA	CN[14]/NA	NA	NA	NA
Extended_Control	See *Section 6.13.4* for details					
Firmware_Update_Request	CN[7]/NA	CN[7]/NA		NA	NA	NA
Firmware_Update_Response	CN[7]/NA	CN[7]/NA		CN[7]/NA	O	NA
Get_Battery_Cap	R	R		NA	NA	NA
Get_Battery_Status	R	R		NA	NA	NA
Get_Manufacturer_Info	R	R		NA	NA	NA
Manufacturer_Info	R	R		R	NA	NA
PPS_Status	CN[8]/NA	NA		NA	NA	NA
Security_Request	CN[6]/NA	CN[6]/NA		NA	NA	NA
Security_Response	CN[6]/NA	CN[6]/NA		CN[6]/NA	NA	NA
Sink_Capabilities_Extended	NA	N	N	NA	NA	NA
Source_Capabilities_Extended	R	NA	R	NA	NA	NA

1) ***Shall*** be supported by products that contain batteries.

2) ***Shall*** be supported by products that can transmit the ***Get_Source_Cap_Extended*** Message.

3) ***Shall*** be supported by products that can transmit the ***Get_Status*** Message.

4) ***Shall*** be supported by products that can transmit the ***Get_Battery_Cap*** Message.

5) ***Shall*** be supported by products that can transmit the ***Get_Manufacturer_Info*** Message.

6) ***Shall*** be supported by products that support USB security communication as defined in ***[USBTypeCAuthentication 1.0]***.

7) ***Shall*** be supported by products that support USB firmware update communication as defined in ***[USBPDFirmwareUpdate 1.0]***.

8) ***Shall*** be supported when PPS is supported.

9) ***Shall*** be supported by products that can transmit the ***Get_PPS_Status*** Message.

10) ***Shall*** be supported when required by a country authority.

11) ***Shall*** be supported by products that can transmit the ***Get_Sink_Cap_Extended*** Message.

12) ***Shall*** be supported by *Active Cables*.

13) *VPD* includes *CT-VPDs* when not *Connected* to a *Charger*. PD communication with a *CT-VPD* ***Shall*** only take place when not *Connected* to a *Charger*.

14) ***Shall*** be supported by products that support operation in *EPR Mode*.

15) ***Shall*** be supported by *Sources* that support the ***Alert*** Message.

Table 6.79 Applicability of Extended Messages (Continued)

Message Type	Source	Sink	Dual-Role Power	Cable Plug SOP’	Cable Plug SOP’’	VPD[13]
Status	CN[15]/R	CN[15]/R	CN[15]/R	CN[12]/NA	CN[12]/NA	NA
Vendor_Defined_Extended	O	O		O	O	O
Received Message						
Battery_Capabilities	CN[4]/NS	CN[4]/NS		I	I	I
Country_Codes	CN[10]/NS	CN[10]/NS		I	I	I
Country_Info	CN[10]/NS	CN[10]/NS		I	I	I
EPR_Source_Capabilities	NS	CN[14]/NS	CN[14]/NS	I	I	I
EPR_Sink_Capabilities	CN[14]/NS	NS	CN[14]/NS	I	I	I
Extended_Control	See Section 6.13.4 for details					
Firmware_Update_Request	CN[7]/NS	CN[7]/NS		CN[7]/I	O	I
Firmware_Update_Response	CN[7]/NS	CN[7]/NS		I	I	I
Get_Battery_Cap	CN[1]/NS	CN[1]/NS		I	I	I
Get_Battery_Status	CN[1]/NS	CN[1]/NS		I	I	I
Get_Manufacturer_Info	R/NS	R/NS		R/I	I	I
Manufacturer_Info	CN[5]/NS	CN[5]/NS		I	I	I
PPS_Status	NS	CN[9]/NS		I	I	I
Security_Request	CN[6]/NS	CN[6]/NS		CN[6]/I	I	I
Security_Response	CN[6]/NS	CN[6]/NS		I	I	I
Sink_Capabilities_Extended	CN[11]/NS	NS	CN[11]/NS	I	I	I
Source_Capabilities_Extended	NS	CN[2]/NS	CN[2]/NS	I	I	I

1) ***Shall*** be supported by products that contain batteries.

2) ***Shall*** be supported by products that can transmit the ***Get_Source_Cap_Extended*** Message.

3) ***Shall*** be supported by products that can transmit the ***Get_Status*** Message.

4) ***Shall*** be supported by products that can transmit the ***Get_Battery_Cap*** Message.

5) ***Shall*** be supported by products that can transmit the ***Get_Manufacturer_Info*** Message.

6) ***Shall*** be supported by products that support USB security communication as defined in ***[USBTypeCAuthentication 1.0]***.

7) ***Shall*** be supported by products that support USB firmware update communication as defined in ***[USBPDFirmwareUpdate 1.0]***.

8) ***Shall*** be supported when PPS is supported.

9) ***Shall*** be supported by products that can transmit the ***Get_PPS_Status*** Message.

10) ***Shall*** be supported when required by a country authority.

11) ***Shall*** be supported by products that can transmit the ***Get_Sink_Cap_Extended*** Message.

12) ***Shall*** be supported by *Active Cables*.

13) *VPD* includes *CT-VPDs* when not *Connected* to a *Charger*. PD communication with a *CT-VPD* ***Shall*** only take place when not *Connected* to a *Charger*.

14) ***Shall*** be supported by products that support operation in *EPR Mode*.

15) ***Shall*** be supported by *Sources* that support the ***Alert*** Message.

Table 6.79 Applicability of Extended Messages (Continued)

Message Type	Source	Sink	Dual-Role Power	Cable Plug SOP’	Cable Plug SOP”	VPD[13]
Status	CN[33]/NS	CN[3]/NS		I	I	I
Vendor_Defined_Extended	O/NS	O/NS		O/I	O/I	O/I

1) ***Shall*** be supported by products that contain batteries.

2) ***Shall*** be supported by products that can transmit the ***Get_Source_Cap_Extended*** Message.

3) ***Shall*** be supported by products that can transmit the ***Get_Status*** Message.

4) ***Shall*** be supported by products that can transmit the ***Get_Battery_Cap*** Message.

5) ***Shall*** be supported by products that can transmit the ***Get_Manufacturer_Info*** Message.

6) ***Shall*** be supported by products that support USB security communication as defined in ***[USBTypeCAuthentication 1.0]***.

7) ***Shall*** be supported by products that support USB firmware update communication as defined in ***[USBPDFirmwareUpdate 1.0]***.

8) ***Shall*** be supported when PPS is supported.

9) ***Shall*** be supported by products that can transmit the ***Get_PPS_Status*** Message.

10) ***Shall*** be supported when required by a country authority.

11) ***Shall*** be supported by products that can transmit the ***Get_Sink_Cap_Extended*** Message.

12) ***Shall*** be supported by *Active Cables*.

13) *VPD* includes *CT-VPDs* when not *Connected* to a *Charger*. PD communication with a *CT-VPD* ***Shall*** only take place when not *Connected* to a *Charger*.

14) ***Shall*** be supported by products that support operation in *EPR Mode*.

15) ***Shall*** be supported by *Sources* that support the ***Alert*** Message.

6.13.4 Applicability of Extended Control Messages

Table 6.80, "Applicability of Extended Control Messages" details *Extended Control Message*s that ***Shall***/***Should***/ ***Shall Not*** be transmitted and received by a *Source*, *Sink*, *Cable Plug* or *VPD*. Requirements for *Dual-Role Power Port*s and *Dual-Role Data Port*s ***Shall*** override any requirements for *Source*-only or *Sink*-Only Ports.

Table 6.80 Applicability of Extended Control Messages

Message Type	Source	Sink	Dual-Role Power	Dual-Role Data	Cable Plug	VPD[2]
Transmitted Message						
EPR_Get_Source_Cap	NA	CN[1]	CN[1]		NA	NA
EPR_Get_Sink_Cap	CN[1]	NA	CN[1]		NA	NA
EPR_KeepAlive	NA	CN[1]			NA	NA
EPR_KeepAlive_Ack	CN[1]	NA			NA	NA
Received Message						
EPR_Get_Source_Cap	CN[1]	NS	CN[1]		I	I
EPR_Get_Sink_Cap	NS	CN[1]	CN[1]		I	I
EPR_KeepAlive	CN[1]	NS			I	I
EPR_KeepAlive_Ack	NS	CN[1]			I	I

1) ***Shall*** be supported by products that support *EPR Mode*.

2) *VPD* includes *CT-VPD*s when not *Connected* to a *Charger*. PD communication with a *CT-VPD* ***Shall*** only take place when not *Connected* to a *Charger*.

6.13.5 Applicability of Structured VDM Commands

Table 6.81, "Applicability of Structured VDM Commands" details *Structured VDM Commands* that ***Shall***/***Should***/ ***Shall Not*** be transmitted and received by a *DFP*, *UFP*, *Cable Plug* or *VPD*. If *Structured VDMs* are not supported, the *DFP* or *UFP* receiving a *VDM Command* ***Shall*** send a ***Not_Supported*** Message in response.

Table 6.81 Applicability of Structured VDM Commands

Command Type	DFP	UFP	Cable Plug SOP’	Cable Plug SOP’’	VPD[4]
Transmitted Command Request					
Discover Identity	CN[1,6]/R	R[2]	NA	NA	NA
Discover SVIDs	CN[1]/O	O	NA	NA	NA
Discover Modes	CN[1]/O	O	NA	NA	NA
Enter Mode	CN[1]/NA	NA	NA	NA	NA
Exit Mode	CN[1]/NA	NA	NA	NA	NA
Attention	O	O	NA	NA	NA
Received Command Request/Transmitted Command Response					
Discover Identity	CN[5,6]/R/ NK[3]	CN[1,6]/R/ NK[3]	N	I	N
Discover SVIDs	O/NK[3]	CN[1]/NK[3]	CN[1]/NK	I	NK
Discover Modes	O/NK[3]	CN[1]/NK[3]	CN[1]/NK	I	NK
Enter Mode	NK[3]	CN[1]/NK[3]	CN[1]/NK	O	NK
Exit Mode	NK[3]	CN[1]/NK[3]	CN[1]/NK	O	NK
Attention	O/I[3]	O/I[3]	I	I	I

1) ***Shall*** be supported when *Modal Operation* is supported.

2) ***May*** be transmitted by a *UFP*/*Source* during discovery (see *Section 6.4.4.3.1, "Discover Identity"* and *Section 8.3.3.25.3, "Source Startup Structured VDM Discover Identity of a Cable Plug State Diagram"*).

3) If *Structured VDMs* are not supported, the *DFP* or *UFP* receiving a *VDM Command* ***Shall*** send a ***Not_Supported*** Message in response.

4) *VPD* includes *CT-VPDs* when not *Connected* to a *Charger*. PD communication with a *CT-VPD* ***Shall*** only take place when not *Connected* to a *Charger*.

5) ***Shall*** be supported by products with more than one *DFP*.

6) ***Shall*** be supported by products that support ***[USB4]***.

6.13.6 Applicability of Reset Signaling

Table 6.82, "Applicability of Reset Signaling" details the Reset that ***Shall***/***Should***/ ***Shall Not*** be transmitted and received by a *DFP*/*UFP* or *Cable Plug*.

Table 6.82 Applicability of Reset Signaling

Reset Type	DFP	UFP	Cable Plug SOP’	Cable Plug SOP’’	VPD[2]
Transmitted Message/Signaling					
Soft_Reset	N	N	NA	NA	NA
Hard Reset	N	N	NA	NA	NA
Cable Reset	CN[1]	NA	NA	NA	NA
Received Message/Signaling					
Soft_Reset	N	N	N	N	N
Hard Reset	N	N	N	N	N
Cable Reset	DR	DR	N	N	N

1) ***Shall*** be supported when transmission of *SOP’ Packet*s are supported, and the *Port* can supply *VCONN*.

2) *VPD* includes *CT-VPD*s when not *Connected* to a *Charger*. PD communication with a *CT-VPD* ***Shall*** only take place when not *Connected* to a *Charger*.

6.13.7 Applicability of Fast Role Swap Request

Table 6.83, "Applicability of Fast Role Swap Request" details the *Fast Role Swap Request* that ***Shall***/***Should***/ ***Shall Not*** be transmitted and received by a *Source* or *Sink*.

Table 6.83 Applicability of Fast Role Swap Request

Command Type	Source	Sink	Dual-Role Power
Transmitted Message/Signaling			
Fast Role Swap	NA	NA	R
Received Message/Signaling			
Fast Role Swap	NA	NA	R

6.14 Value Parameters

Table 6.84, "Value Parameters" contains value parameters used in this section.

Table 6.84 Value Parameters

Parameter	Description	Value	Unit	Reference
MaxExtendedMsgLen	Maximum length of an *Extended Message* as expressed in the ***Data Size*** field.	260	Byte	*Section 6.2.1.2*
MaxExtendedMsgChunkLen	Maximum length of an *Extended Message Chunk*.	26	Byte	*Section 6.2.1.2*
MaxExtendedMsgLegacyLen	Maximum length of an *Extended Message* that can be sent without *Chunking*.	26	Byte	*Section 6.2.1.2*

7 Power Supply

7.1 Source Requirements

7.1.1 Behavioral Aspects

A *PDUSB Source* exhibits the following behaviors:

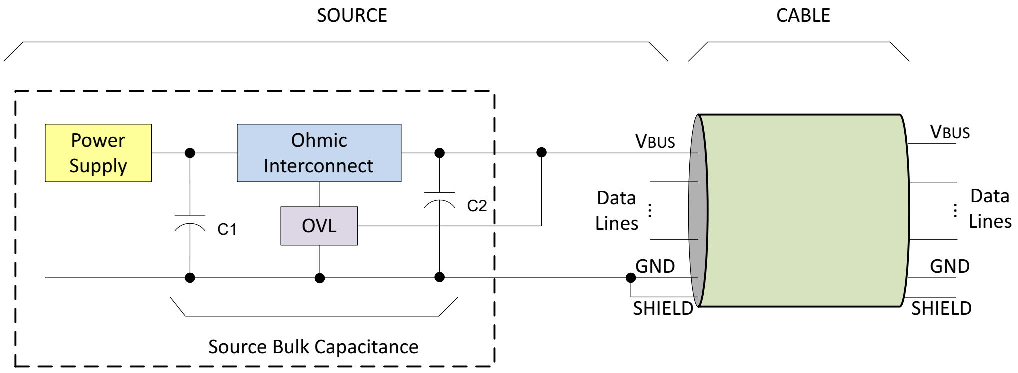
- ***Shall*** supply ***[USB Type-C 2.4]*** *USB Type-C*® current to *VBUS* while in a *Default Contract* or *Implicit Contract*.
- ***Shall*** follow the requirements as specified in *Section 7.1.5, "Response to Hard Resets"* when ***Hard Reset*** *Signaling* is received.
- ***Shall*** control *VBUS* voltage transitions as bound by undershoot, overshoot and transition time requirements.

7.1.2 Source Bulk Capacitance

The *Source* bulk capacitance ***Shall Not*** be placed between the transceiver isolation impedance and the USB receptacle. The *Source* bulk capacitance consists of C1 and C2 as shown in *Figure 7.1, "Placement of Source Bulk Capacitance"*. The Ohmic Interconnect might consist of PCB traces for power distribution or power switching devices. The Ohmic Interconnect might also be part of the circuit implemented by the *Source* to limit its *VBUS* Output Voltage Limit (OVL) as described in *Section 7.1.7.5, "Output Voltage Limit"*. Though a *Source* ***Shall*** limit its output voltage, a *Sink* ***Shall*** implement *Sink OVP* as described in *Section 7.2.9.2, "Input Over Voltage Protection"* to protect against excessive *VBUS* input voltage. The capacitance might be a single capacitor, a capacitor bank or distributed capacitance. If the power supply is shared across multiple ports, the bulk capacitance is defined as ***cSrcBulkShared***. If the power supply is dedicated to a single *Port*, the minimum bulk capacitance is defined as ***cSrcBulk***.

The *Source* bulk capacitance is allowed to change for a newly *Negotiated* power level. The capacitance change ***Shall*** occur before the *Source* is ready to operate at the new power level. During a *Power Role Swap*, the *Initial Source* ***Shall*** transition to *Swap Standby* before operating as the *New Sink*. Any change in bulk capacitance required to complete the *Power Role Swap* ***Shall*** occur during *Swap Standby*.

Figure 7.1 Placement of Source Bulk Capacitance



7.1.3 Types of Sources

Consistent with the *Power Data Objects* discussed in *Section 6.4.1, "Capabilities Message"*, the power supply types that are available as *Sources* in a USB Power Delivery System are:

- The *Fixed Supply PDO* exposes well-regulated fixed voltage power supplies. *Sources* ***Shall*** support at least one *Fixed Supply* capable of supplying ***vSafe5V***. The output voltage of a *Fixed Supply* ***Shall*** remain within the range defined by the relative tolerance ***vSrcNew*** and the absolute band ***vSrcValid*** as listed in *Table 7.23, "Source Electrical Parameters"* and described in *Section 7.1.8, "Output Voltage Tolerance and Range"*.

- The *Variable Supply* (non-*Battery*) *PDO* exposes less well-regulated *Source*s. The output voltage of a *Variable Supply* (non-*Battery*) ***Shall*** remain within the absolute maximum output voltage and the absolute minimum output voltage exposed in the *Variable Supply PDO*.
- The *Battery Supply PDO* exposes Batteries than can be connected directly as a *Source* to *VBUS*. The output voltage of a *Battery Supply* ***Shall*** remain within the absolute maximum output voltage and the absolute minimum output exposed in the *Battery Supply PDO*.
- The Programmable Power Supply (PPS) *Augmented Power Data Object* (*APDO*) exposes a *Source* with an output voltage that can be adjusted programmatically over a defined range. The output voltage of the Programmable Power Supply ***Shall*** remain within a range defined by the relative tolerance ***vPpsNew*** and the absolute band ***vPpsValid***.
- The *Adjustable Voltage Supply* (*AVS*) *Augmented Power Data Object* (*APDO*) exposes a *Source* with an output voltage that can be adjusted programmatically over a defined range. The output voltage of the *AVS* ***Shall*** remain within a range defined by the relative tolerance ***vAvsNew*** and the absolute band ***vAvsValid***.

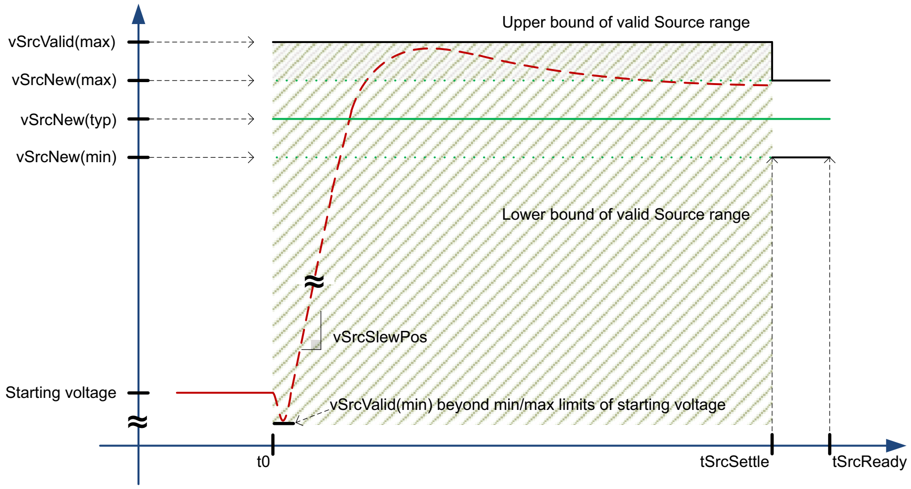
7.1.4 Source Transitions

7.1.4.1 Fixed Supply

7.1.4.1.1 Fixed Supply Positive Voltage Transitions

The *Source* ***Shall*** transition *VBUS* from the starting voltage to the higher new voltage in a controlled manner. The *Negotiated* new voltage (e.g., 5V, 9V, 15V, …) defines the nominal value for ***vSrcNew***. During the positive transition the *Source* ***Should*** be able to supply the *Sink Standby* current and the transient current to charge the total bulk capacitance on *VBUS*. The slew rate of the positive transition ***Shall Not*** exceed ***vSrcSlewPos***. The transitioning *Source* output voltage ***Shall*** settle within ***vSrcNew*** by ***tSrcSettle***. The *Source* ***Shall*** be able to supply the *Negotiated* power level at the new voltage by ***tSrcReady***. The positive voltage transition ***Shall*** remain above ***vSrcValid*** min of the previous *Explicit Contract* and below ***vSrcValid*** max of the new *Explicit Contract* (*Figure 7.2, "Transition Envelope for Positive Voltage Transitions"*). The voltage ***Shall*** settle to ***vSrcNew*** within ***tSrcSettle***. The starting time, t0, in *Figure 7.2, "Transition Envelope for Positive Voltage Transitions"* starts ***tSrcTransition*** after the last bit of the ***EOP*** of the ***GoodCRC*** *Message* has been received by the *Source*.

Figure 7.2 Transition Envelope for Positive Voltage Transitions


Upper bound of valid Source range
vSrcValid(max)
vSrcNew(max)
vSrcNew(typ)
vSrcNew(min)
Lower bound of valid Source range
vSrcSlewPos
Starting voltage
vSrcValid(min) beyond min/max limits of starting voltage
t0
tSrcSettle
tSrcReady

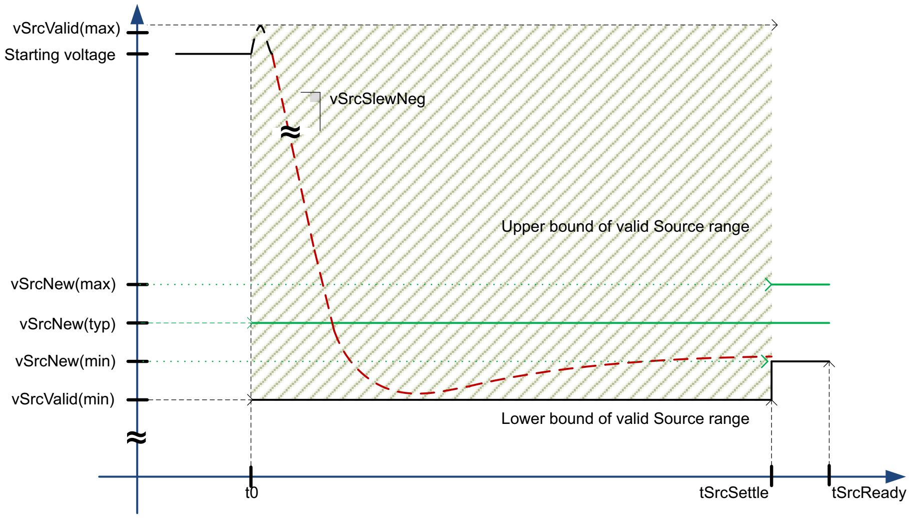
At the start of the positive voltage transition the *VBUS* voltage level ***Shall Not*** droop ***vSrcValid*** min below either ***vSrcNew*** (i.e., if the starting *VBUS* voltage level is not ***vSafe5V***) or ***vSafe5V*** as applicable.

Section 7.1.14, "Non-application of VBUS Slew Rate Limits" lists transitions that are exempt from the ***vSrcSlewPos*** limit.

7.1.4.1.2 Fixed Supply Negative Voltage Transitions

Negative voltage transitions are defined as shown in *Figure 7.3, "Transition Envelope for Negative Voltage Transitions"* and are specified in a similar manner to positive voltage transitions. *Figure 7.3, "Transition Envelope for Negative Voltage Transitions"* does not apply to ***vSafe0V*** transitions. The slew rate of the negative transition ***Shall Not*** exceed ***vSrcSlewNeg***. The negative voltage transition ***Shall*** remain below ***vSrcValid*** max of the previous *Explicit Contract* and above ***vSrcValid*** min of the new *Explicit Contract*, as shown in F*Figure 7.3, "Transition Envelope for Negative Voltage Transitions"*. The transitioning *Source* output voltage ***Shall*** settle to ***vSrcNew*** within ***tSrcSettle***. The starting time, t0, in *Figure 7.3, "Transition Envelope for Negative Voltage Transitions"* starts ***tSrcTransition*** after the last bit of the ***EOP*** of the ***GoodCRC*** *Message* has been received by the *Source*.

Figure 7.3 Transition Envelope for Negative Voltage Transitions



If the newly *Negotiated* voltage is ***vSafe5V***, then the ***vSrcValid*** limits ***Shall*** determine the transition window and the transitioning *Source* ***Shall*** settle within the ***vSafe5V*** limits by ***tSrcSettle***.

Section 7.1.14, "Non-application of VBUS Slew Rate Limits" lists transitions that are exempt from the ***vSrcSlewNeg*** limit.

7.1.4.2 SPR Programmable Power Supply (PPS)

7.1.4.2.1 SPR Programmable Power Supply Voltage Transitions

The Programmable Power Supply (PPS) ***Shall*** transition *VBUS* over the defined voltage range in a controlled manner. The Output Voltage value in the Programmable *RDO* defines the nominal value of the PPS output voltage after completing a voltage change and ***Shall*** settle within the limits defined by ***vPpsNew*** by ***tPpsSrcTransSmall*** for steps smaller than or equal to ***vPpsSmallStep***, or else, within the limits defined by ***vPpsNew*** by ***tPpsSrcTransLarge***, but only in case the Programmable Power Supply is not in *CL* mode. Any overshoot beyond ***vPpsNew Shall Not*** exceed ***vPpsValid*** at any time. Any undershoot beyond ***vPpsNew Shall Not*** exceed ***vPpsValid*** for currents not resulting in *CL* mode. The PPS output voltage ***May*** change in a step-wise or linear manner and the slew rate of either type of change ***Shall Not*** exceed ***vPpsSlewPos*** for voltage increases or ***vPpsSlewNeg*** for voltage decreases. The nominal requested voltage of all linear voltage changes ***Shall*** equate to an integer number of *LSB* changes. An *LSB* change of the PPS output voltage is defined as ***vPpsStep***. A PPS ***Shall*** be able to supply the *Negotiated* current level as it changes its output voltage to the requested level. All PPS voltage increases ***Shall*** result in a voltage that is greater than or equal to the previous PPS output voltage. Likewise, all PPS voltage decreases ***Shall*** result in a voltage that is less than or equal to the previous PPS output voltage.

Since a *Sink* can draw current up to the *Negotiated APDO* current level in case of a voltage step, the voltage might not increase to the requested level due to the power supply operating in *CL* mode. Likewise, since a *Sink* can have a *Battery* connected to *VBUS*, the voltage might not decrease to the requested level due to the *Battery* voltage being higher than the output voltage set point the *Source* is transitioning to. Were the *Source* to rely on checking the voltage on *VBUS*, in either case, to determine when its power supply is ready a ***PS_RDY*** *Message* would never be sent.

When the PPS voltage steps up or down, a ***PS_RDY*** *Message* ***Shall*** be sent within:

- ***tPpsSrcTransLarge*** after the last bit of the ***GoodCRC*** *Message* following the ***Accept*** *Message* for steps larger than ***vPpsSmallStep***.
- ***tPpsSrcTransSmall*** after the last bit of the ***GoodCRC*** *Message* following the ***Accept*** *Message* for steps less than or equal to ***vPpsSmallStep*** provided that either the voltage on *VBUS* has reached ***vPpsNew*** or the power supply is in *CL* mode.

When ***vPpsNew*** is lower than the *Battery* voltage, or the *Source*'s primary power is cut off the *Sink* ***Shall*** immediately disconnect its *Battery* from *VBUS*. In these situations, the output current could reverse polarity and the *Sink* is not allowed to source current (see *Section 7.2.1, "Behavioral Aspects"* and *Section 7.2.9, "Robust Sink Operation"*).

Figure 7.4, "PPS Positive Voltage Transitions" and *Figure 7.5, "PPS Negative Voltage Transitions"* below show the output voltage behavior of a Programmable Power Supply in response to positive and negative voltage change requests. The parameters ***vPpsMinVoltage*** and ***vPpsMaxVoltage*** define the lower and upper limits of the PPS range respectively (see *Table 10.11, "SPR Programmable Power Supply Voltage Ranges"* for required ranges). ***vPpsMinVoltage*** corresponds to the ***Minimum Voltage*** field in the PPS *APDO* and ***vPpsMaxVoltage*** corresponds to ***Maximum Voltage*** field in the PPS *APDO*. If the *Sink* negotiates for a new PPS *APDO*, then the transition between the two PPS *APDO*s ***Shall*** occur as described in *Section 7.3.1, "Transitions caused by a Request Message"*.

Figure 7.4 PPS Positive Voltage Transitions

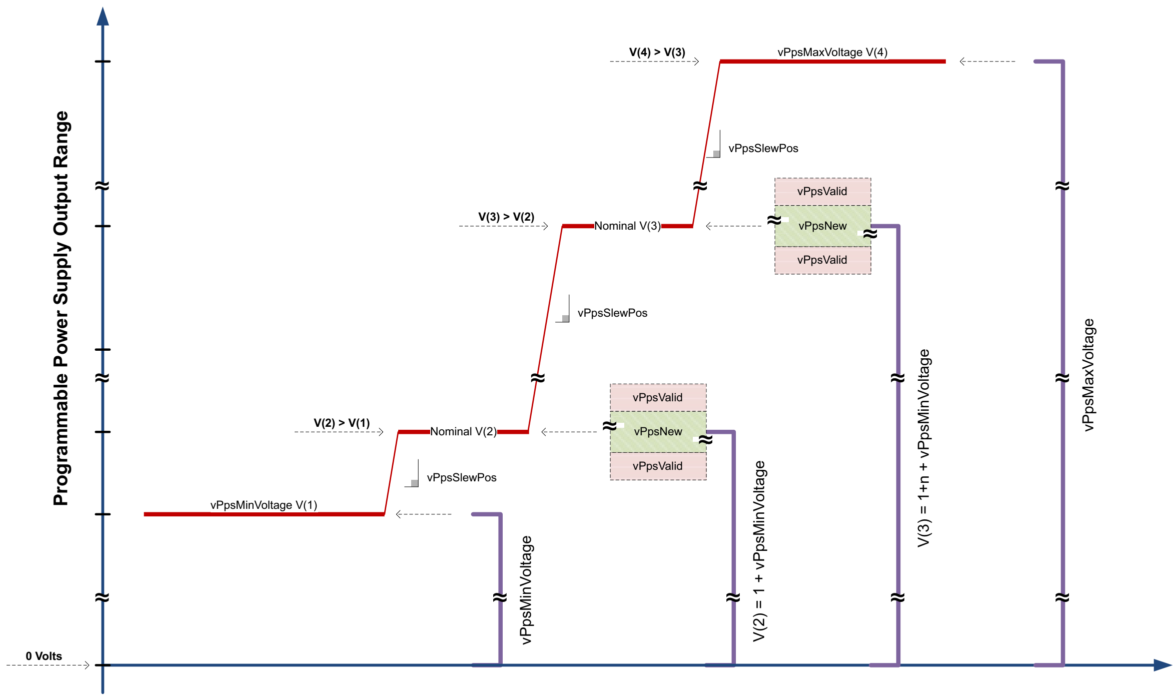
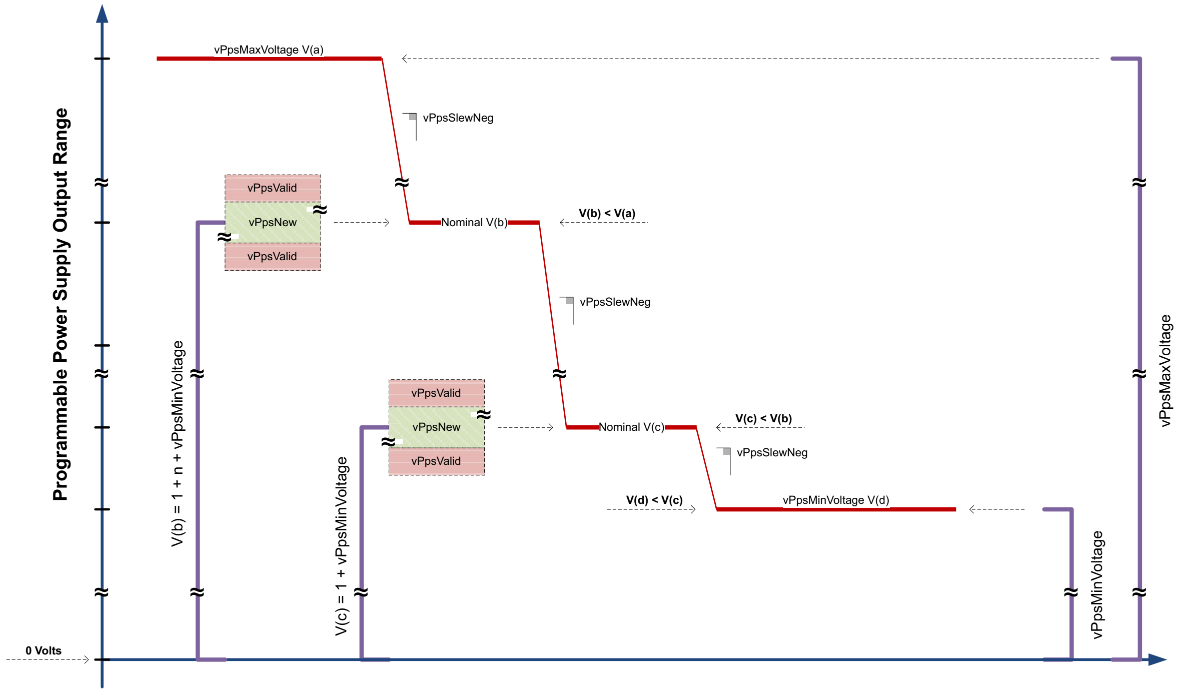


Figure 7.5 PPS Negative Voltage Transitions



Section 7.1.14, "Non-application of VBUS Slew Rate Limits" lists transitions that are exempt from the ***vPpsSlewNeg*** and ***vPpsSlewPos*** limits.

See *Section 7.1.8.1, "AVS/PPS Output Voltage Ripple"* for output voltage ripple limits.

See *Section 7.1.8.2, "AVS/PPS DNL Errors and Output Voltage/Current Tolerance"* for output voltage and current ***DNL*** step adjustments.

7.1.4.2.2 SPR Programmable Power Supply Current Limit

The Programmable Power Supply operating in *SPR PPS Mode* ***Shall*** limit its output current to the ***Operating Current*** field value in the *RDO* when the *Sink* attempts to draw more current than the ***Operating Current*** field value level. The programming step size for the Operating Current is ***iPpsCLStep***. All programming changes of the Operating Current ***Shall*** settle to the new ***Operating Current*** field value within ***tPpsCLProgramSettle***. The *SPR PPS* Operating Current regulation accuracy during *Current Limit* is defined as ***iPpsCLNew***. The minimum programmable *Current Limit* level is ***iPpsCLMin***. A *Source* that supports *SPR PPS Mode* ***Shall*** support *Current Limit* programmability between ***iPpsCLMin*** and the Maximum Current value in the *SPR PPS APDO*. A *Source* which receives a request for current below ***iPpsCLMin*** ***Should*** reject the request. A *Source* that accepts a request for current below ***iPpsCLMin*** ***Shall*** set its current limit at 1A.

The response of an *SPR PPS* to a load change depends on the Operating mode of the *SPR PPS* and the magnitude of the load change. These dependencies lead to one of four possible responses of an *SPR PPS* to any load change. They are differentiated by the value of the PPS Status OMF before and after the load change:

- If the PPS Status OMF is cleared both before and after the load change, the *SPR PPS* responds solely by maintaining the output voltage. The *SPR PPS* output voltage ***Shall*** remain within ***vPpsValid*** range. The *SPR PPS* response to the load change ***Shall*** settle within the ***vPpsNew*** tolerance band by the time ***tPpsTransient***. The Operating Mode Flag ***Shall*** remain cleared during the load change response of the *SPR PPS*.
- If the PPS Status OMF is cleared before the load change and set after the load change, the *SPR PPS* responds by reducing its output voltage to limit the *SPR PPS* output current. The *SPR PPS* output current ***Shall*** stay within the ***iPpsCVCLTransient*** range once it reaches the ***iPpsCVCLTransient*** range. The *SPR*

PPS response to the load change ***Shall*** settle within the ***iPpsCLNew*** tolerance band by the time ***tPpsCVCLTransient***. The Operating Mode Flag ***Shall*** be set when the *SPR PPS* load change response settles.

- If the PPS Status OMF is set both before and after the load change, the *SPR PPS* responds by adjusting its output voltage to maintain the output current. The *SPR PPS* output current ***Shall*** stay within the ***iPpsCLTransient*** range. The *SPR PPS* response to the load change ***Shall*** settle within the ***iPpsCLNew*** tolerance band by the time ***tPpsCLSettle***. The Operating Mode Flag ***Shall*** remain set during the load change response of the *SPR PPS*.
- If the PPS Status OMF is set before the load change and cleared after the load change, the PPS responds to the load change by increasing its output voltage to ***vPpsNew*** and then maintaining it. The *SPR PPS* output voltage ***Shall*** stay within the ***vPpsCLCVTransient*** range. The *SPR PPS* response to the load change ***Shall*** settle within the ***vPpsNew*** tolerance band by the time ***tPpsCLCVTransient***. The Operating Mode Flag ***Shall*** be cleared when the PPS load change response settles.

The *SPR PPS Source* ***Shall*** maintain its output voltage at the value requested in the PPS *RDO* for all static and dynamic load conditions except when in *Current Limit* operation. In response to any static or dynamic load condition during *Current Limit* operation that causes the *SPR PPS* output voltage to drop below ***vPpsShutdown*** the *Source* ***May*** send ***Hard Reset*** *Signaling* and ***Shall*** discharge *VBUS* to ***vSafe0V*** then resumes *USB Default Operation* at ***vSafe5V***.

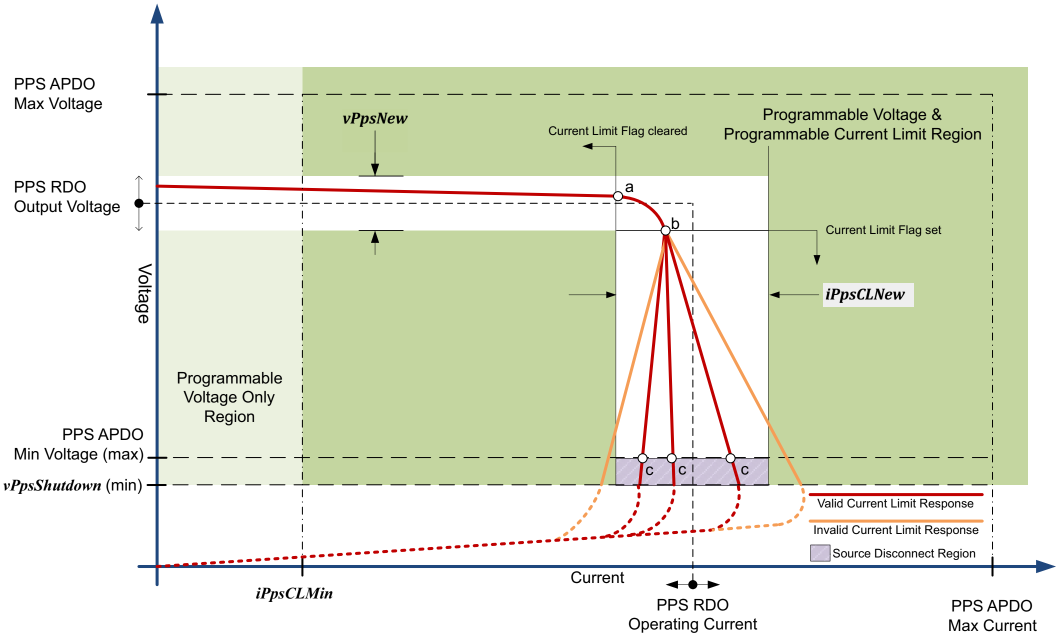
When the *Sink* attempts to draw more current than the Operating Current in the *RDO*, the *Source* ***Shall*** limit its output current. The current available from the *Source* during *Current Limit* mode ***Shall*** meet ***iPpsCLNew***. The *Sink* ***May Not*** reduce its Operating Current request in the *RDO* when the PPS Status OMF is set.

Current limiting ***Shall*** be performed by the *SPR PPS Source*. *Sink*s that rely on PPS Current Limiting ***Shall*** meet the requirements of *Section 7.2.9, "Robust Sink Operation"*. The *Source* ***Shall Not*** shutdown or otherwise disrupt the available output power while in *Current Limit* mode unless another protection mechanism as outlined in *Section 7.1.7, "Robust Source Operation"* is engaged to protect the *Source* from damage.

An *SPR PPS Source* that is operating in *Current Limit* ***Shall Not*** change its set-point in a manner that exceeds ***iPpsCLLoadStepRate*** or ***iPpsCLLoadReleaseRate***.

The relationship between *SPR PPS* programmable output voltage and *SPR PPS* programmable *Current Limit* ***Shall*** be as shown in *Figure 7.6, "SPR PPS Programmable Voltage and Current Limit"*. The transition between the *Constant Voltage* mode and the *Current Limit* mode occurs between points a and b. The PPS Status OMF ***Shall*** be set or cleared within this region. In *Current Limit* mode when the load resistance changes, the output current of the *Source* ***Shall*** stay within ***iPpsCLNew***. The proper behavior is represented by point c.

Figure 7.6 SPR PPS Programmable Voltage and Current Limit



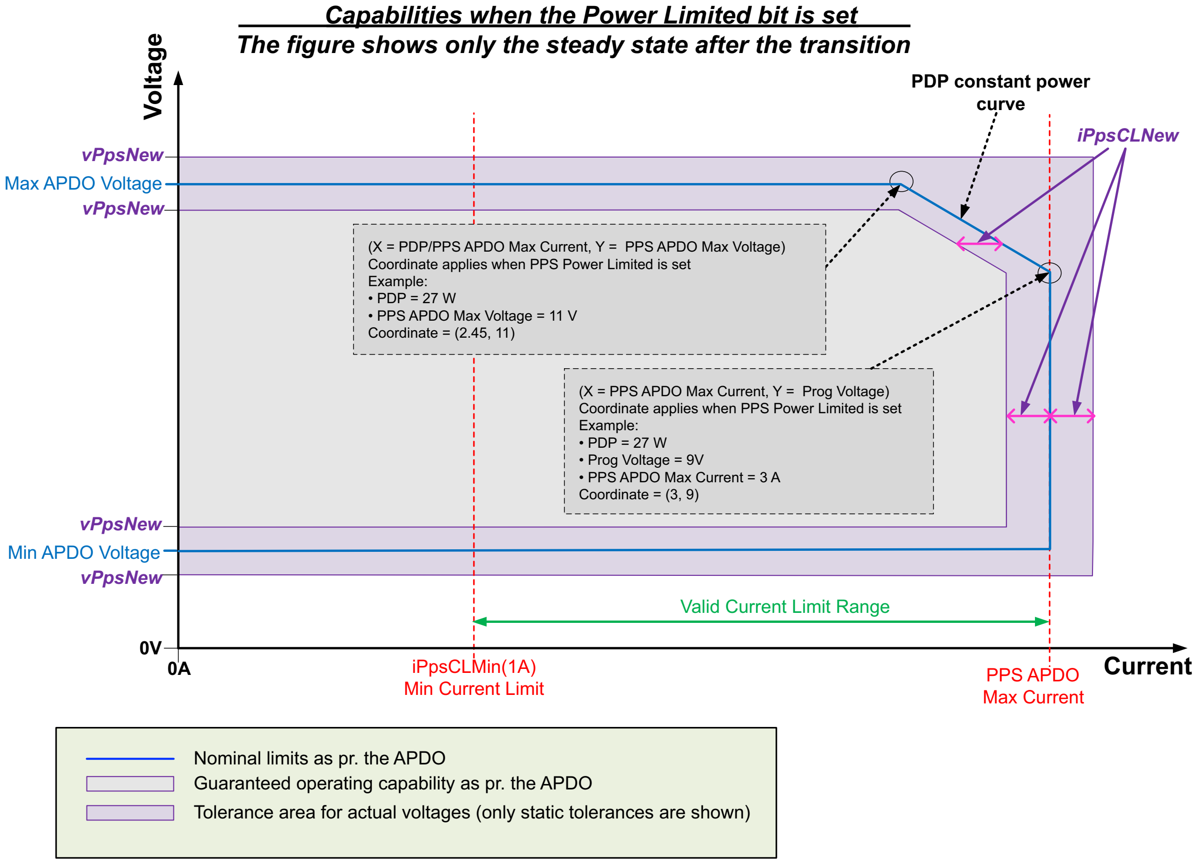
Point *a* represents entry into the transition region between Constant Voltage mode and Current Limit mode.
Point *b* represents exit from the transition region between Constant Voltage mode and Current Limit mode.
Point c represents the exit from the ***iPpsCLNew*** region as the voltage drops below the PPS APDO Min Voltage.
The Source ***May*** disconnect at any point inside the tolerance range of the minimum voltage defined in the PPS APDO.

7.1.4.2.3 SPR PPS Constant Power Mode

In Constant Power mode (when the PPS Power Limited bit is set) the *Source* ***May*** supply power that exceeds the *Source*'s *PDP Rating*. *Sinks* ***May*** limit their Operating Current request in the *RDO* and ***Shall*** meet the requirements of *Section 7.2.9, "Robust Sink Operation"*.

The tolerances along the Constant Power Curve ***Shall Not*** extend into the Guaranteed Capability Area of *Figure 7.7, "SPR PPS Constant Power"*.

Figure 7.7 SPR PPS Constant Power



Capabilities when the Power Limited bit is set
The figure shows only the steady state after the transition
Voltage
PDP constant power curve
iPpsCLNew
vPpsNew
Max APDO Voltage
vPpsNew
(X = PDP/PPS APDO Max Current, Y = PPS APDO Max Voltage)
Coordinate applies when PPS Power Limited is set
Example:
• PDP = 27 W
• PPS APDO Max Voltage = 11 V
Coordinate = (2.45, 11)
(X = PPS APDO Max Current, Y = Prog Voltage)
Coordinate applies when PPS Power Limited is set
Example:
• PDP = 27 W
• Prog Voltage = 9V
• PPS APDO Max Current = 3 A
Coordinate = (3, 9)
vPpsNew
Min APDO Voltage
vPpsNew
Valid Current Limit Range
0V
0A
iPpsCLMin(1A)
Min Current Limit
PPS APDO
Max Current
Current
Nominal limits as pr. the APDO
Guaranteed operating capability as pr. the APDO
Tolerance area for actual voltages (only static tolerances are shown)

7.1.4.3 Adjustable Voltage Supply (AVS)

7.1.4.3.1 Adjustable Voltage Supply Voltage Transitions

The *Adjustable Voltage Supply* (*AVS*) ***Shall*** transition *VBUS* over the defined voltage range in a controlled manner. The Output Voltage value in the *AVS RDO* defines the nominal value of the *AVS* output voltage after completing a voltage change and ***Shall*** settle within the limits defined by ***vAvsNew*** by ***tAvsSrcTransSmall*** for steps smaller than or equal to ***vAvsSmallStep***, or else, within the limits defined by ***vAvsNew*** by ***tAvsSrcTransLarge*** for steps larger than ***vAvsSmallStep***. Any overshoot beyond ***vAvsNew Shall Not*** exceed ***vAvsValid*** at any time. Any undershoot beyond ***vAvsNew Shall Not*** exceed ***vAvsValid*** at any time. The *AVS* output voltage ***May*** change in a stepwise or linear manner and the slew rate of either type of change ***Shall Not*** exceed ***vAvsSlewPos*** for voltage increases or ***vAvsSlewNeg*** for voltage decreases. The nominal requested voltage of all linear voltage changes ***Shall*** equate to an integer number of *LSB* changes. An *LSB* change of the *AVS* output voltage is defined as ***vAvsStep***. An *AVS* ***Shall*** be able to supply the *Negotiated* current level as it changes its output voltage to the requested level if the change of output voltage is less than or equal to ***vAvsSmallStep*** relative to ***vAvsNew***. All *AVS* voltage increases ***Shall*** result in a voltage that is greater than or equal to the previous *AVS* output voltage. Likewise, all *AVS* voltage decreases ***Shall*** result in a voltage that is less than or equal to the previous *AVS* output voltage. Any time the *Source* enters the *AVS* range of operation that voltage transition is considered a voltage step larger than ***vAvsSmallStep***.

When the *AVS* voltage steps up or down, a ***PS_RDY*** *Message* ***Shall*** be sent within:

- ***tAvsSrcTransLarge*** after the last bit of the ***GoodCRC*** *Message* following the ***Accept*** *Message* for steps larger than ***vAvsSmallStep***.
- ***tAvsSrcTransSmall*** after the last bit of the ***GoodCRC*** *Message* following the ***Accept*** *Message* for steps less than or equal to ***vAvsSmallStep*** provided the voltage on *VBUS* has reached ***vAvsNew***.

Figure 7.8, "AVS Positive Voltage Transitions" and *Figure 7.9, "AVS Negative Voltage Transitions"* below show the output voltage behavior of an *AVS* in response to positive and negative voltage change requests. The parameters ***vAvsMinVoltage*** and ***vAvsMaxVoltage*** define the lower and upper limits of the *AVS* range respectively:

- For *SPR AVS Source*s there are two possible voltage ranges where the ***vAvsMinVoltage*** is always 9V and ***vAvsMaxVoltage*** is either 15V or 20V depending on the *Source*'s *PDP*. See *Table 10.9, "SPR Adjustable Voltage Supply (AVS) Voltage Ranges"*.
- For *EPR AVS Sources* ***vAvsMinVoltage*** corresponds to ***Minimum Voltage*** field (always 15V) in the *EPR AVS APDO* and ***vAvsMaxVoltage*** corresponds to ***Maximum Voltage*** field in the *EPR AVS APDO*. See *Table 10.15, "EPR Adjustable Voltage Supply (AVS) Voltage Ranges"* for required ranges.

Figure 7.8 AVS Positive Voltage Transitions

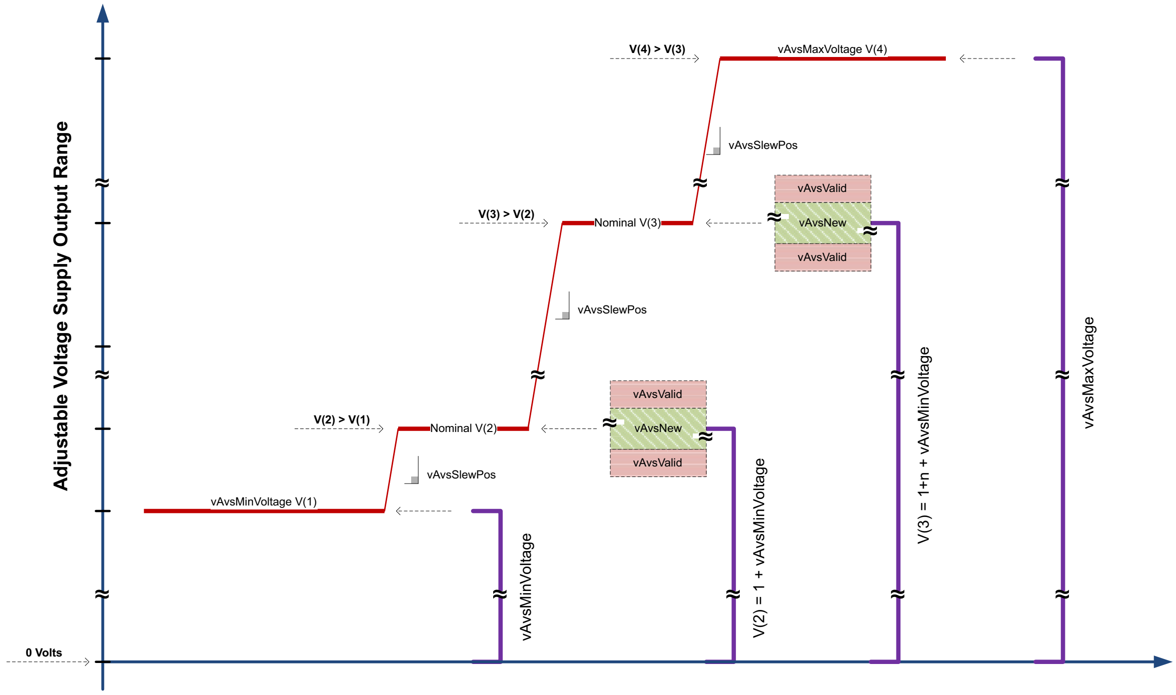
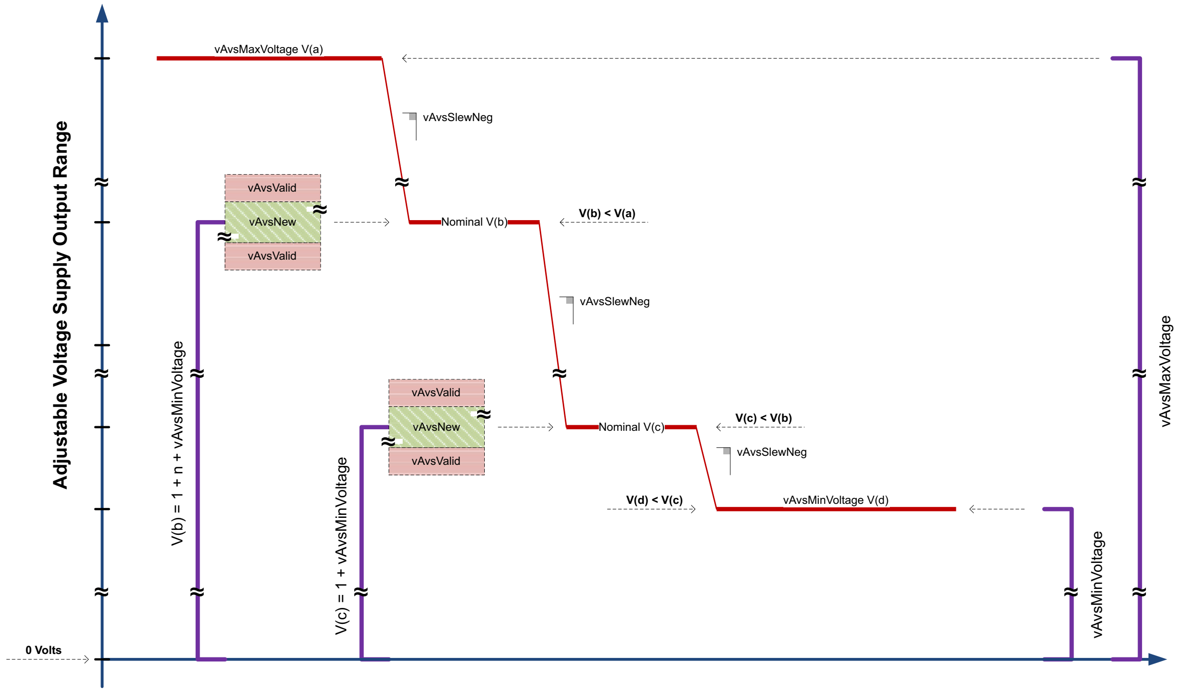


Figure 7.9 AVS Negative Voltage Transitions



See *Section 7.1.8.1, "AVS/PPS Output Voltage Ripple"* for output voltage ripple limits.

See *Section 7.1.8.2, "AVS/PPS DNL Errors and Output Voltage/Current Tolerance"* for output voltage ***DNL*** step adjustments.

7.1.4.3.2 Adjustable Voltage Supply Current

The *AVS* ***Shall*** maintain its output voltage at the value requested in the *AVS RDO* for all static and dynamic load conditions that do not exceed the Operating Current in the *RDO*. Unlike the *SPR PPS* programmable current, the *AVS* programmable power ***May*** range from zero to the *PDP*.

The maximum operating current:

- For *SPR Sources*, the maximum operating current is defined in the *SPR* ***Source_Capabilities*** *Message* ***Maximum Current 15V***/***Maximum Current 20V*** fields.

- For *EPR Sources*, the maximum operating current has to be calculated as the lower of the ***PDP*** field value/***Output Voltage*** or 5A whichever is lower. See *Table 10.12, "EPR Source Capabilities based on the Port Maximum PDP and using an EPR Capable Cable"*

7.1.5 Response to Hard Resets

Hard Reset *Signaling* indicates a communication failure has occurred and the *Source* ***Shall*** stop driving *VCONN*, ***Shall*** remove R_p from the *VCONN* pin and ***Shall*** drive *VBUS* to ***vSafe0V*** as shown in *Figure 7.10, "Source VBUS and VCONN Response to Hard Reset"*. The USB connection ***May*** reset during a *Hard Reset* since the *VBUS* voltage will be less than ***vSafe5V*** for an extended period of time. After establishing the ***vSafe0V*** voltage condition on *VBUS*, the *Source* ***Shall*** wait ***tSrcRecover*** before re-applying *VCONN* and restoring *VBUS* to ***vSafe5V***. A *Source* ***Shall*** conform to the *VCONN* timing as specified in ***[USB Type-C 2.4]***.

A *Sink* that enters *Hard Reset* can have ***cSnkBulkPd*** present until *VBUS* drops below ***vSafe0V***. The *Source* ***Shall*** take this into consideration.

Device operation during and after a *Hard Reset* is defined as follows:

- Self-powered devices ***Should Not*** disconnect from USB during a *Hard Reset* (see *Section 9.1.2, "Mapping to USB Device States"*).

- Self-powered devices operating at more than ***vSafe5V*** ***May Not*** maintain full functionality after a *Hard Reset*.

- Bus powered devices will disconnect from USB during a *Hard Reset* due to the loss of their power source.

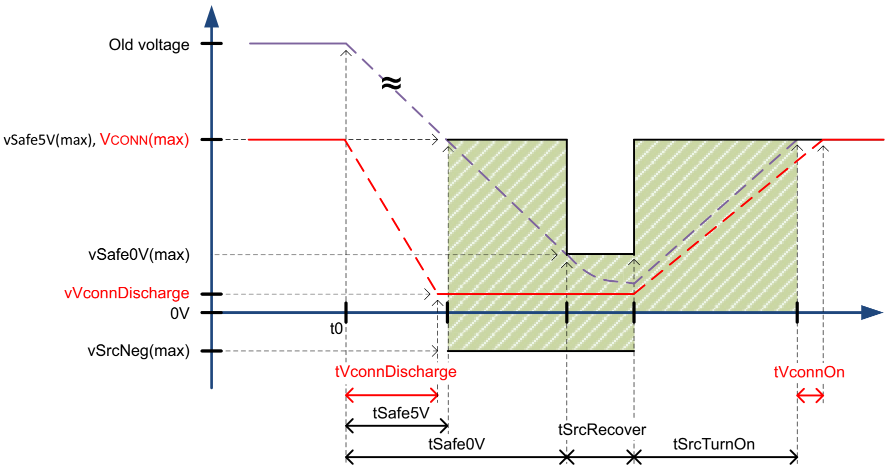
When a *Hard Reset* occurs the *Source* ***Shall*** stop driving *VCONN*, ***Shall*** remove R_p from the *VCONN* pin and ***Shall*** start to transition the *VBUS* voltage to ***vSafe0V*** either:

- ***tPSHardReset*** after the last bit of the ***Hard Reset*** *Signaling* has been received from the *Sink* or

- ***tPSHardReset*** after the last bit of the ***Hard Reset*** *Signaling* has been sent by the *Source*.

The *Source* ***Shall*** meet both ***tSafe5V*** and ***tSafe0V*** relative to the start of the voltage transition as shown in *Figure 7.10, "Source VBUS and VCONN Response to Hard Reset"*.

Figure 7.10 Source VBUS and VCONN Response to Hard Reset



VCONN will meet tVCONNDischarge relative to the start of the voltage transition as shown in *Figure 7.10, "Source VBUS and VCONN Response to Hard Reset"* due to the discharge circuitry in the *Cable Plug*. *VCONN* ***Shall*** meet tVCONNOn relative to *VBUS* reaching ***vSafe5V***.

Note: tVCONNOn and tVCONNDischarge are defined in ***[USB Type-C 2.4]***.

7.1.6 Changing the Output Power Capability

Some USB Power Delivery *Negotiations* will require the *Source* to adjust its output power capability without changing the output voltage. In this case the *Source* ***Shall*** be able to supply a higher or lower load current within ***tSrcReady***.

7.1.7 Robust Source Operation

7.1.7.1 Output Over Current Protection

Sources ***Shall*** implement over current protection to prevent damage from output current that exceeds the current handling capability of the *Source*. The definition of current handling capability is left to the discretion of the *Source* implementation and ***Shall*** take into consideration the current handling capability of the connector contacts. If the over current protection implementation does not use a *Hard Reset* or *Error Recovery*, it ***Shall Not*** interfere with the *Negotiated VBUS* current level.

After three consecutive over current events *Source* ***Shall*** go to ***ErrorRecovery***.

Sources ***Should*** attempt to send ***Hard Reset*** *Signaling* when over current protection engages followed by an ***Alert*** *Message* indicating an *OCP* event once an *Explicit Contract* has been established. The over current protection response ***May*** engage at either the *Port* or system level. Systems or ports that have engaged over current protection ***Should*** attempt to resume *USB Default Operation* after determining that the cause of over current is no longer present and ***May*** latch off to protect the *Port* or system. The definition of how to detect if the cause of over current is still present is left to the discretion of the *Source* implementation.

The *Source* ***Shall*** *Re-negotiate* with the *Sink* after choosing to resume *USB Default Operation*. The decision of how to *Re-negotiate* after an over current event is left to the discretion of the *Source* implementation.

The *Source* ***Shall*** prevent continual system or *Port* cycling if over current protection continues to engage after initially resuming either *USB Default Operation* or *Re-negotiation*. Latching off the *Port* or system is an acceptable response to recurring over current.

During the over current response and subsequent system or *Port* shutdown, all affected *Source* ports operating with *VBUS* greater than ***vSafe5V*** ***Shall*** discharge *VBUS* to ***vSafe5V*** by the time ***tSafe5V*** and ***vSafe0V*** by the time ***tSafe0V***.

7.1.7.2 Over Temperature Protection

*Source*s ***Shall*** implement Over Temperature Protection (*OTP*) to prevent damage from temperature that exceeds the thermal capability of the *Source*. The definition of thermal capability and the monitoring locations used to trigger the over temperature protection are left to the discretion of the *Source* implementation.

In order to avoid reaching an *OTP* event, *Source*s ***May*** proactively reduce the available power being offered to the *Sink*, even though these offers might be lower than the *Source* would be expected to offer during normal thermal operating conditions. Prior to reducing power, the *Source* ***Should*** generate ***Alert*** *Message* indicating an Operating Condition Change and set the Temperature Status bit in the *SOP* ***Status*** *Message* to Warning (10b).

*Source*s ***Should*** attempt to send ***Hard Reset*** *Signaling* when *OTP* engages followed by an ***Alert*** *Message* indicating an *OTP* event once an *Explicit Contract* has been established. The *OTP* response ***May*** engage at either the *Port* or system level. Systems or ports that have engaged *OTP* ***Should*** attempt to resume *USB Default Operation* and ***May*** latch off to protect the *Port* or system.

The *Source* ***Shall*** *Re-negotiate* with the *Sink* after choosing to resume *USB Default Operation*. The decision of how to *Re-negotiate* after an over temperature event is left to the discretion of the *Source* implementation.

The *Source* ***Shall*** prevent continual system or *Port* cycling if over temperature protection continues to engage after initially resuming either *USB Default Operation* or *Re-negotiation*. Latching off the *Port* or system is an acceptable response to recurring over temperature.

During the *OTP* and subsequent system or *Port* shutdown, all affected *Source* ports operating with *VBUS* greater than ***vSafe5V*** ***Shall*** discharge *VBUS* to ***vSafe5V*** by the time ***tSafe5V*** and ***vSafe0V*** by the time ***tSafe0V***.

7.1.7.3 vSafe5V Externally Applied to Ports Supplying vSafe5V

Safe operation mandates that Power Delivery *Source*s ***Shall*** be tolerant of ***vSafe5V*** being present on *VBUS* when simultaneously applying power to *VBUS*. Normal USB PD communication ***Shall*** be supported when this ***vSafe5V*** to ***vSafe5V*** connection exists.

7.1.7.4 Detach

A USB *Detach* is detected electrically using *CC* detection on the *USB Type-C* connector. When the *Source* is *Detached* the *Source* ***Shall*** transition to ***vSafe0V*** by ***tSafe0V*** relative to when the *Detach* event occurred. During the transition to ***vSafe0V*** the *VBUS* voltage ***Shall*** be below ***vSafe5V*** max by ***tSafe5V*** relative to when the *Detach* event occurred and ***Shall Not*** exceed ***vSafe5V*** max after this time.

*Source*s operating in *EPR Mode* need to avoid creating large differential voltages at the connector. See Appendix H in the ***[USB Type-C 2.4]*** specification for background information. To achieve this, *Source*s operating in *EPR Mode*, upon detecting a disconnect, ***Shall*** stop sourcing current and minimize *VBUS* capacitance. There ***May*** continue to be current sourced from the *Source* bulk capacitance, but that ***Should*** also be minimized by disconnecting as much of the *Source* bulk capacitance as possible. For example, the *Source* can stop sourcing from the Power Supply and the C1 portion of the *Source* bulk capacitance in *Figure 7.1, "Placement of Source Bulk Capacitance"* by disabling the Ohmic Interconnect switch.

The *Source* ***Should*** detect the disconnect, stop sourcing current, and minimize the *VBUS* capacitance as quickly as practical. If this is done after the *CC* contacts disconnect and before the *VBUS* contacts disconnect there is less risk of large differential voltages at the connector.

Note: A USB-PD transmission by the *Source* during a disconnect event will delay disconnect detection by the *Source*.

7.1.7.5 Output Voltage Limit

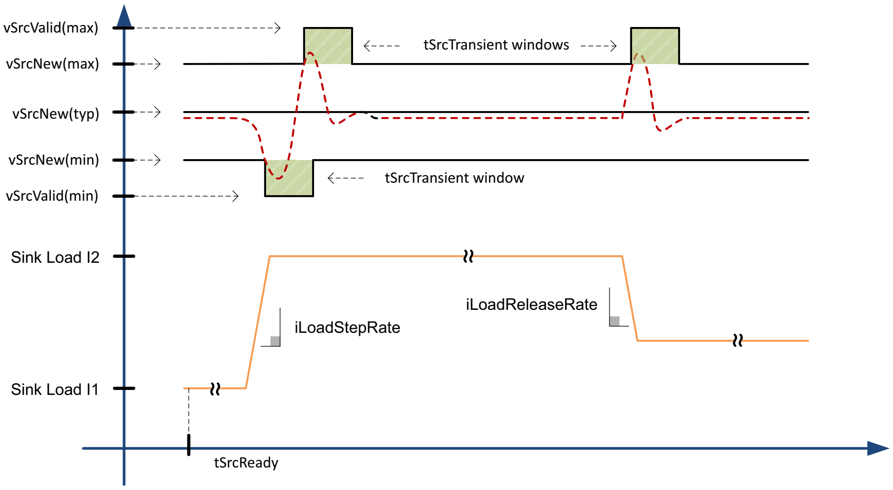
The output voltage of *Source*s ***Shall*** account for ***vSrcNew***, ***vSrcValid*** or ***vPpsNew***, ***vPpsValid*** or ***vAvsNew***, ***vAvsValid*** as determined by the *Negotiated VBUS* value. *Source*s ***Shall*** meet applicable safety and regulatory requirements.

7.1.8 Output Voltage Tolerance and Range

After a voltage transition is complete (i.e., after ***tSrcReady***) and during static load conditions the *Source* output voltage ***Shall*** remain within the ***vSrcNew*** or ***vSafe5V*** limits as applicable. The ranges defined by ***vSrcNew*** and ***vSafe5V*** account for DC regulation accuracy, line regulation, load regulation and output ripple. After a voltage transition is complete (i.e., after ***tSrcReady***) and during transient load conditions the *Source* output voltage ***Shall Not*** go beyond the range specified by ***vSrcValid***. The amount of time the *Source* output voltage can be in the band between either ***vSrcNew*** or ***vSafe5V*** and ***vSrcValid*** ***Shall Not*** exceed ***tSrcTransient***. Refer to *Table 7.23, "Source Electrical Parameters"* for the output voltage tolerance specifications. *Figure 7.11, "Application of vSrcNew and vSrcValid limits after tSrcReady"* illustrates the application of ***vSrcNew*** and ***vSrcValid*** after the voltage transition is complete.

The ***vSrcNew*** and ***vSrcValid*** limits ***Shall Not*** apply to *VBUS* during the *VBUS* discharge and switchover that occurs during a *Fast Role Swap* as described in *Section 7.1.13, "Fast Role Swap"*.

Figure 7.11 Application of vSrcNew and vSrcValid limits after tSrcReady

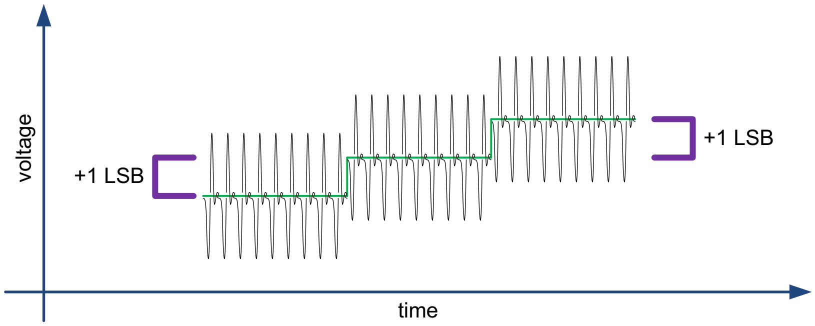


The *Source* output voltage ***Shall*** be measured at the connector receptacle. The stability of the *Source* ***Shall*** be tested in 25% load step increments from minimum load to maximum load and also from maximum load to minimum load. The transient behavior of the load current is defined in *Section 7.2.6, "Transient Load Behavior"*. The time between each step ***Shall*** be sufficient to allow for the output voltage to settle between load steps. In some systems it might be necessary to design the *Source* to compensate for the voltage drop between the output stage of the power supply electronics and the receptacle contact. The determination of whether compensation is necessary is left to the discretion of the *Source* implementation.

7.1.8.1 AVS/PPS Output Voltage Ripple

The *AVS*/*PPS* output voltage ripple is expected to exceed the magnitude of one or more *LSB* as show in the *Figure 7.12, "Expected AVS/PPS Ripple Relative to an LSB"*.

Figure 7.12 Expected AVS/PPS Ripple Relative to an LSB



7.1.8.2 AVS/PPS DNL Errors and Output Voltage/Current Tolerance

The PPS voltage and current discrete *LSB* steps have a ***DNL*** tolerance as shown in *Figure 7.13, "Allowed DNL errors and tolerance of Voltage and Current in AVS/PPS mode"* below. In absolute terms the step size of the *LSB* for both voltage and current is defined by ***vPpsStep***/***vAvsStep*** for voltage and ***iPpsCLStep*** for current. Several examples of ***Valid*** *LSB* steps are shown in *Figure 7.13, "Allowed DNL errors and tolerance of Voltage and Current in AVS/PPS mode"*:

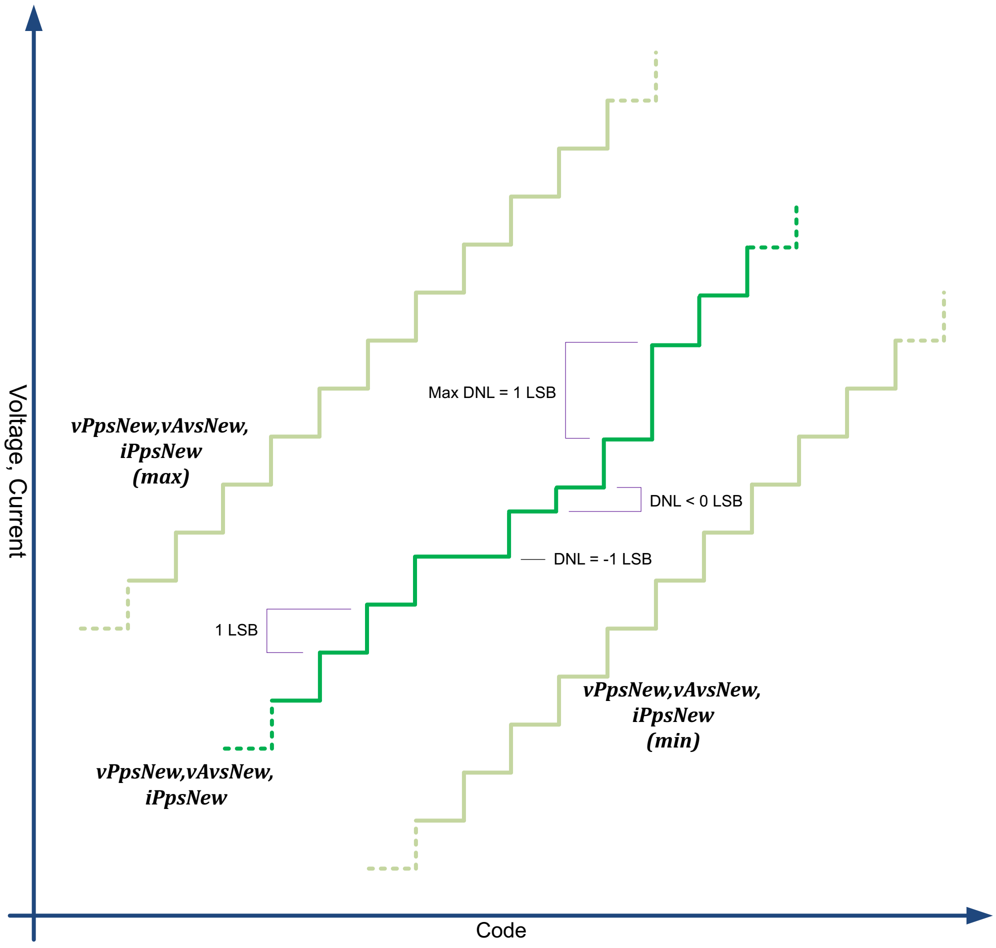
- The upper end of the ***DNL*** error (+1 *LSB*) shows the case where one step is effectively skipped.
- The lower end of the ***DNL*** error (-1 *LSB*) shows the case where the voltage or current set-point remained the same.

The ideal scenario for the ***DNL*** error (=0) matches the typical step size for the voltage or current.

The intent of ***DNL*** is to guarantee that changes to the voltage/current have the correct directionality, and that the maximum step size is clearly defined.

Note: The *Source* ***Should*** avoid scenarios where multiple consecutive steps have errors close to the Maximum and Minimum ***DNL***.

Figure 7.13 Allowed DNL errors and tolerance of Voltage and Current in AVS/PPS mode



7.1.8.3 Programmable Power Supply Output Voltage Tolerance and Range

After a voltage transition of a Programmable Power Supply is complete (i.e. after ***tPpsSrcTransSmall*** or ***tPpsSrcTransLarge***) and during static load conditions the *Source* output voltage ***Shall*** remain within the ***vPpsNew*** limits. The range defined by ***vPpsNew*** accounts for DC regulation accuracy, line regulation, load regulation and output ripple. After a voltage transition is complete (i.e. after ***tPpsSrcTransSmall*** or ***tPpsSrcTransLarge***) and during transient load conditions the *Source* output voltage ***Shall Not*** go beyond the range specified by ***vPpsValid***. The amount of time the *Source* output voltage can be in the band between ***vPpsNew*** and ***vPpsValid*** ***Shall Not*** exceed ***tPpsTransient***.

7.1.8.4 Adjustable Voltage Supply Output Voltage tolerance and Range

After a voltage transition of an *AVS* is complete (i.e. after ***tAvsSrcTransSmall*** or ***tAvsSrcTransLarge***) and during static load conditions the *Source* output voltage ***Shall*** remain within the ***vAvsNew*** limits. The range defined by ***vAvsNew*** accounts for DC regulation accuracy, line regulation, load regulation and output ripple. After a voltage transition is complete (i.e. after ***tAvsSrcTransSmall*** or ***tAvsSrcTransLarge***) and during transient load conditions the *Source* output voltage ***Shall Not*** go beyond the range specified by ***vAvsValid***. The amount of time the *Source* output voltage can be in the band between ***vAvsNew*** and ***vAvsValid*** ***Shall Not*** exceed ***tAvsTransient***.

7.1.9 Charging and Discharging the Bulk Capacitance on VBUS

The *Source* ***Shall*** charge and discharge the bulk capacitance on *VBUS* whenever the *Source* voltage is *Negotiated* to a different value. The charging or discharging occurs during the voltage transition and ***Shall Not*** interfere with the *Source*'s ability to meet ***tSrcReady***.

7.1.10 Swap Standby for Sources

*Source*s and *Sink*s of a *Dual-Role Power Port* ***Shall*** support *Swap Standby*. *Swap Standby* occurs for the *Source* after the *Source* power supply has discharged the bulk capacitance on *VBUS* to ***vSafe0V*** as part of the *Power Role Swap* transition.

While in *Swap Standby*:

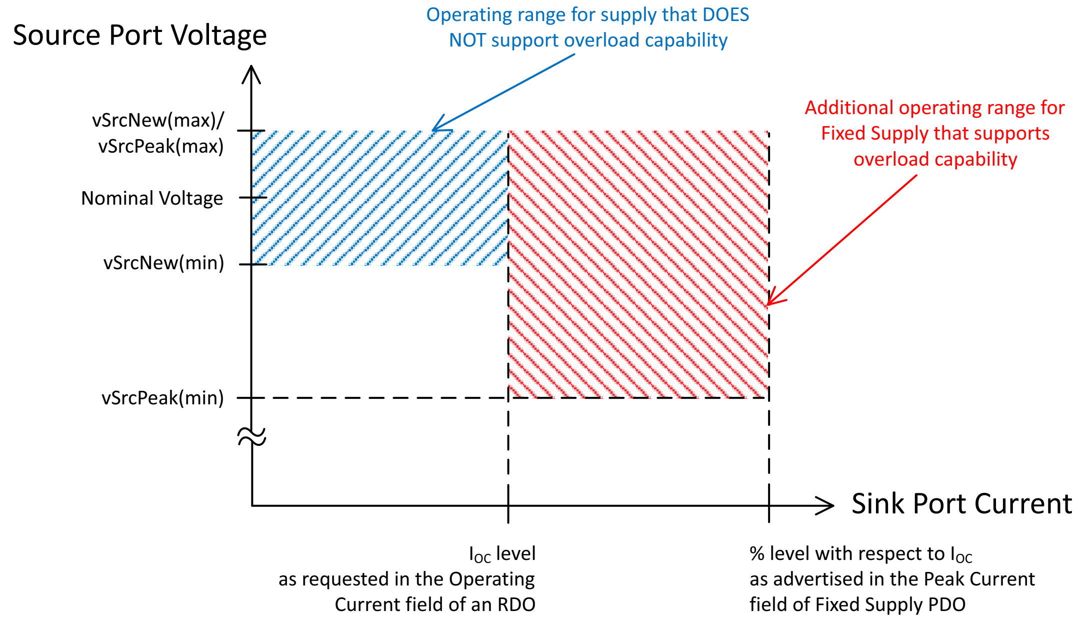
- The *Source* ***Shall Not*** drive *VBUS* that is therefore expected to remain at ***vSafe0V***.
- Any discharge circuitry that was used to achieve ***vSafe0V*** ***Shall*** be removed from *VBUS*.
- The *Dual-Role Power Port* ***Shall*** be configured as a *Sink*.
- The USB connection ***Shall Not*** reset even though ***vSafe5V*** is no longer present on *VBUS* (see *Section 9.1.2, "Mapping to USB Device States"*).

The ***PS_RDY*** *Message* associated with the *Source* being in *Swap Standby* ***Shall*** be sent after the *VBUS* drive is removed. The time for the *Source* to transition to *Swap Standby* ***Shall Not*** exceed ***tSrcSwapStdby***. Upon entering *Swap Standby*, the *Source* has relinquished its *Power Role* as *Source* and is ready to become the *New Sink*. The transition time from *Swap Standby* to being the *New Sink* ***Shall*** be no more than ***tNewSnk***. The *New Sink* ***May*** start using power after the new *Source* sends the ***PS_RDY*** *Message*.

7.1.11 Source Peak Current Operation

A *Source* that has the *Fixed Supply PDO* or *AVS APDO* Peak Current bits set to 01b, 10b and 11b ***Shall*** be designed to support one of the overload *Capabilities* defined in *Table 6.10, "Fixed Power Source Peak Current Capability"* or *Table 6.16, "EPR AVS Power Source Peak Current Capability"* respectively. The overload conditions are bound in magnitude, duration and duty cycle as listed in *Table 6.10, "Fixed Power Source Peak Current Capability"* or *Table 6.16, "EPR AVS Power Source Peak Current Capability"*. *Source*s are not required to support continuous overload operation. When overload conditions occur, the *Source* is allowed the range of ***vSrcPeak*** (instead of ***vSrcNew***) relative to the nominal value (see *Figure 7.14, "Source Peak Current Overload"*). When the overload capability is exceeded, the *Source* is expected take whatever action is necessary to prevent electrical or thermal damage to the *Source*. The *Source* ***May*** send a new ***Source_Capabilities*** *Message* with the *Fixed Supply PDO* or *AVS APDO* Peak Current bits set to 00b to prohibit overload operation even if an overload capability was previously *Negotiated* with the *Sink*.

Figure 7.14 Source Peak Current Overload


Source Port Voltage
Operating range for supply that DOES NOT support overload capability
Additional operating range for Fixed Supply that supports overload capability
vSrcNew(max)/
vSrcPeak(max)
Nominal Voltage
vSrcNew(min)
vSrcPeak(min)
Sink Port Current
I_OC level
as requested in the Operating Current field of an RDO
% level with respect to I_OC
as advertised in the Peak Current field of Fixed Supply PDO

7.1.12 Source Capabilities Extended Parameters

Implementers can choose to make available certain characteristics of a *PDUSB Source* as a set of ***Static*** and/or dynamic parameters to improve interoperability between external power sources and portable computing devices. The complete list of reportable ***Static*** parameters is described in full in *Section 6.5.1, "Source_Capabilities_Extended Message"* and listed in *Figure 6.37, "Source_Capabilities_Extended Message"*. The subset of parameters listed below directly represent *Source Capabilities* and are described in the rest of this section.

- Voltage Regulation.
- Holdup Time.
- Compliance.
- Peak Current.
- *Source* Inputs.
- Batteries.

7.1.12.1 Voltage Regulation Field

The power consumption of a device can change dynamically. The ability of the *Source* to regulate its voltage output might be important if the device is sensitive to fluctuations in voltage. The ***Voltage Regulation*** bit field is used to convey information about the *Source*s output regulation and tolerance to various load steps.

7.1.12.1.1 Load Step Slew Rate

The default load step slew rate is established at 150mA/µs. A *Source* ***Shall*** meet the following requirements under the load step reported in the ***Source_Capabilities_Extended*** *Message*:

- The *Source* ***Shall*** maintain *VBUS* regulation within the ***vSrcValid*** range.
- The noise on the *CC* line ***Shall*** remain below ***vNoiseIdle*** and ***vNoiseActive***.

Test conditions require a change in both positive and negative load steps from 1Hz to 5000Hz, up to the *Advertised* Load Step Magnitude of the full load output including from both 10 mA and 10% initial load. The *Source* ***Shall*** ensure that PD Communications meet the transmit and receive masks as specified in *Section 5.8.2, "Transmit and Receive Masks"* under all load conditions.

7.1.12.1.2 Load Step Magnitude

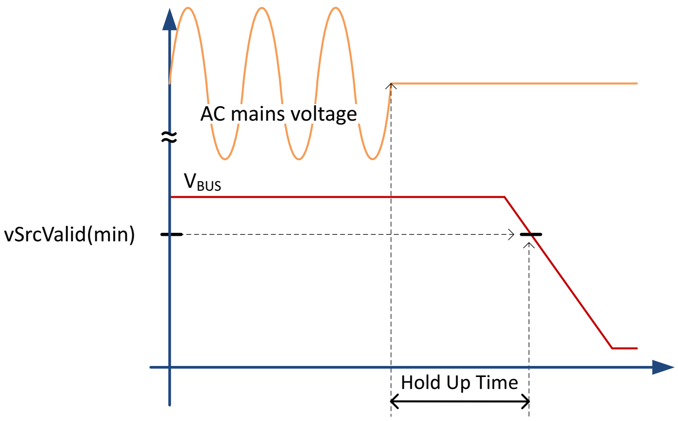
The default load step magnitude rate ***Shall*** be 25% of *IoC*. The *Source* ***May*** report higher capability tolerating a load step of 90% of *IoC*.

7.1.12.2 Holdup Time Field

The ***Holdup Time*** field ***Shall*** return a numeric value of the number of milliseconds the output voltage stays in regulation upon a short interruption of the *AC Supply*.

An *AC Supplied Source* ***Shall*** report its holdup time in this field. The holdup time is measured with the load at rated maximum, with the *AC Supply* at 115VAC rms and 60Hz (or at 230VAC rms and 50Hz for a *Source* that does not support 115VAC *AC Supply*). The reported time describes the minimum length of time from the last completed *AC Supply* input cycle (zero-degree phase angle) until when the output voltage decays below ***vSrcValid*** (min). *Sources* are recommended to support a minimum of 3ms and are preferred to support over 10 milliseconds holdup time (equivalent to a half cycle drop from the *AC Supply*). See *Figure 7.15, "Holdup Time Measurement"*.

Figure 7.15 Holdup Time Measurement



7.1.12.3 Compliance Field

An *SPR Source* claiming *LPS*, PS1 or PS2 compliance (see ***[IEC 62368-1]***) ***Shall*** report its *Capabilities* in the ***Compliance*** field. Since the *SPR Source* ***May*** have several potential output voltage and current settings, every *SPR Source* supply (each indicated by a *PDO*) ***Shall*** be compliant to *LPS* requirements.

Note: According to the requirements of ***[IEC 60950-1]*** and/or ***[IEC 62368-3]***, a device tested and certified with an *LPS Source* (*SPR Source* or *EPR Source* operating in *SPR Mode*) is prohibited from using a non-*LPS Source* (*EPR Source* operating in *EPR Mode*). Alternatively, ***[IEC 62368-1]***, classifies power sources according to their maximum, constrained power output (15watts or 100watts).

7.1.12.4 Peak Current

The *Source* reports its ability to source peak current delivery in excess of the *Negotiated* amount in the ***Peak Current*** field. The duration of peak current ***Shall*** be followed by a current consumption below the Operating Current (*IoC*) in order to maintain average power delivery below the *IoC* current.

A *Source* ***May*** have greater capability to source peak current than can be reported using the ***Peak Current*** field in the *Fixed Supply PDO* or *AVS APDO*. In this case the *Source* ***Shall*** report its additional capability in the ***Peak Current1***/***Peak Current2***/***Peak Current3*** fields in the ***Source_Capabilities_Extended*** *Message*.

Each overload period ***Shall*** be followed by a period of reduced current draw such that the rolling average current over the Overload Period field value with the specified Duty Cycle field value (see *Section 6.5.1.10, "Peak Current Field"*) ***Shall Not*** exceed the *Negotiated* current. This is calculated as:

Period of reduced current = (1 - value in Duty Cycle field/100) * value in Overload Period field

7.1.12.5 Source Inputs

The ***Source Inputs*** field identifies the possible inputs that provide power to the *Source*.

Note: Some *Sources* are only powered by a *Battery* (e.g., an automobile) rather than the more common *AC Supply*.

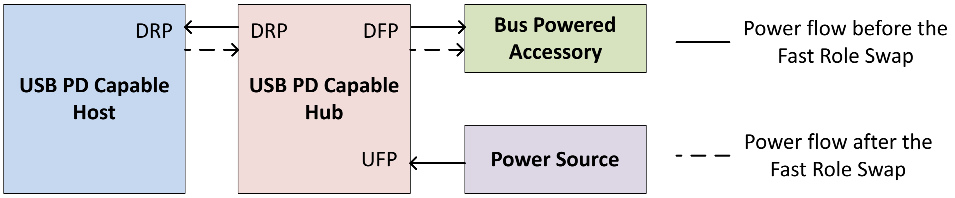
7.1.12.6 Batteries

The ***Number of Batteries/Battery Slots*** field ***Shall*** report the number of Batteries the *Source* supports. The *Source* ***Shall*** independently report the number of Hot Swappable Batteries and the number of *Fixed Batteries*.

7.1.13 Fast Role Swap

A *Fast Role Swap* limits the interruption of *VBUS* power to a bus powered accessory connected to a *Hub DFP* that has a *UFP Attached* to a power source and a *DRP Attached* to a *Host Port* supporting *DRP* as shown in *Figure 7.16, "VBUS Power during Fast Role Swap"*.

Figure 7.16 VBUS Power during Fast Role Swap



When the power source connected to the *Hub UFP* stops sourcing power and *VBUS* at the *Hub DRP* connector discharges below ***vSrcValid***(min), if *VBUS* has been *Negotiated* to a higher voltage than ***vSafe5V***, or ***vSafe5V*** (min) the *Fast Role Swap Request* ***Shall*** be sent from the *Hub DRP* to the *Host DRP* and the *Hub DRP* ***Shall*** sink power. In the *Fast Role Swap* use case, the *Hub DRP* behaves like a bidirectional power path. The *Hub DRP* ***Shall Not*** enable *VBUS* discharge circuitry when changing operation from *Initial Source* to *New Sink*. The *Hub DFP Port*(s) ***Shall*** support default *USB Type-C* Current (see ***[USB Type-C 2.4]***) until a new *Explicit Contract* is *Negotiated*.

After sending the *Fast Role Swap Request* and while *VBUS* > ***vSafe5V*** (min), the *New Sink* ***Shall Not*** draw more than ***iNewFrsSink*** until the *New Source* has applied its R_p. The *New Sink* ***Shall Not*** draw more than ***iSnkStdby*** from *VBUS* until ***tSnkFRSwap*** after it has started sending the *Fast Role Swap Request* or *VBUS* has fallen below ***vSafe5V*** (min). The ***tSnkFRSwap*** time ***Shall*** start at the beginning of the *Fast Role Swap Request* or when *VBUS* falls below ***vSafe5V*** (min), whichever comes later. After waiting for ***tSnkFRSwap***, the *New Sink* ***Shall Not*** draw more than ***iNewFrsSink*** until the *New Source* has applied its R_p. After the *New Source* has applied its R_p, the *New Sink* ***Shall*** be limited to *USB Type-C* Current (see ***[USB Type-C 2.4]***) in an *Implicit Contract* until a new *Explicit Contract* is *Negotiated*. All *Sink* requirements ***Shall*** apply to the *New Sink* after the *Fast Role Swap* is complete. The *Fast Role Swap* response of the *Host DRP* is described in *Section 7.2.10, "Fast Role Swap"* since the *Host DRP* is operating as the *Initial Sink* prior to the *Fast Role Swap*.

After the *VBUS* voltage level at the *Hub DRP* connector drops below ***vSafe5V*** a ***PS_RDY*** *Message* ***Shall*** be sent to the *Host DRP* as shown in the *Fast Role Swap* transition diagram of *Section 7.3.4, "Transitions Caused by Fast Role Swap"*.

Figure 7.17, "VBUS detection and timing during Fast Role Swap, initial VBUS (at new source) > vSafe5V(min)" and *Figure 7.18, "VBUS detection and timing during Fast Role Swap, initial VBUS (at new source) < vSafe5V(min)"* show the *VBUS* detection and timing for the *New Source* during a *Fast Role Swap* after the *Fast Role Swap Request* has been received. The *New Source* ***May*** turn on the *VBUS* output switch once *VBUS* is below ***vSafe5V*** (max). In this case, the *New Source* prevents *VBUS* from falling below ***vSafe5V*** (min). The new source ***Shall*** turn on the *VBUS* output switch within ***tSrcFRSwap*** of falling below ***vSafe5V*** (min).

VBUS might have started at ***vSafe5V*** or at higher voltage. When the *Fast Role Swap Request* is detected, *VBUS* could therefore be either above ***vSafe5V*** (max), within the ***vSafe5V*** range, or below ***vSafe5V*** (min). If the *Fast Role Swap Request* is detected when *VBUS* is below ***vSafe5V*** (min), then the new source ***Shall*** turn on the *VBUS* output switch within ***tSrcFRSwap*** of detecting the *Fast Role Swap Request*. In this case, the maximum time from the beginning of the *Fast Role Swap Request* to *VBUS* being sourced ***May*** be ***tSrcFRSwap*** (max) + ***tFRSwapRx*** (max).

Figure 7.17 VBUS detection and timing during Fast Role Swap, initial VBUS (at new source) > vSafe5V(min)

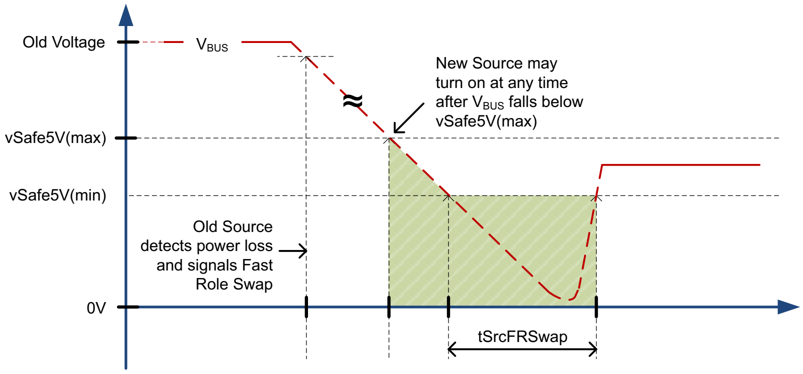
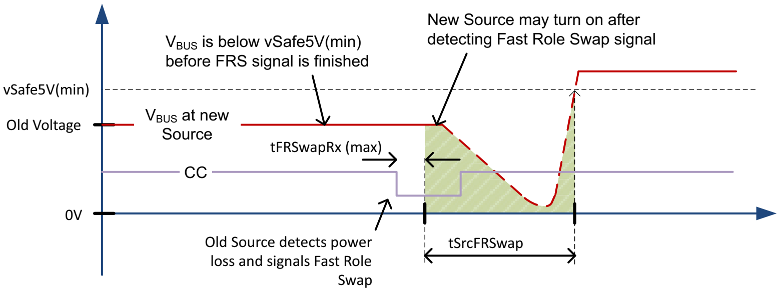

Old Voltage
VBUS
New Source may turn on at any time after VBUS falls below vSafe5V(max)
vSafe5V(max)
vSafe5V(min)
Old Source detects power loss and signals Fast Role Swap
0V
tSrcFRSwap

Figure 7.18 VBUS detection and timing during Fast Role Swap, initial VBUS (at new source) < vSafe5V(min)


VBUS is below vSafe5V(min) before FRS signal is finished
New Source may turn on after detecting Fast Role Swap signal
vSafe5V(min)
Old Voltage
VBUS at new Source
tFRSwapRx (max)
CC
0V
Old Source detects power loss and signals Fast Role Swap
tSrcFRSwap

7.1.14 Non-application of VBUS Slew Rate Limits

Scenarios where ***vSrcSlewPos*** and ***vPpsSlewPos*** *VBUS* slew rate limits do not apply and *VBUS* ***May*** transition faster than specified are as follows:

- When first applying *VBUS* after an *Attach*.
- When applying *VBUS* as part of a *Power Role Swap* to *Source Power Role*.
- When increasing *VBUS* from ***vSafe0V*** to ***vSafe5V*** during a *Hard Reset*.
- During a *Fast Role Swap* when the *Initial Sink* applies *VBUS*.

Scenarios where ***vSrcSlewNeg*** and ***vPpsSlewNeg*** *VBUS* slew rate limits do not apply and *VBUS* ***May*** transition faster than specified are as follows:

- When discharging *VBUS* to ***vSafe0V*** during a *Hard Reset*.
- When discharging *VBUS* to ***vSafe0V*** as part of a *Power Role Swap* to *Sink Power Role*.
- When discharging *VBUS* to ***vSafe0V*** after a *Detach*.
- During a *Fast Role Swap* when the *VBUS* power source connected to the *Hub UFP* stops sourcing power.

7.1.15 VCONN Power Cycle

7.1.15.1 UFP VCONN Power Cycle

The *Data Reset* process requires the *DFP* to be the *VCONN Source* by the end of the process. In the case where the *UFP* is the *VCONN Source*, the following steps ***Shall*** be followed:

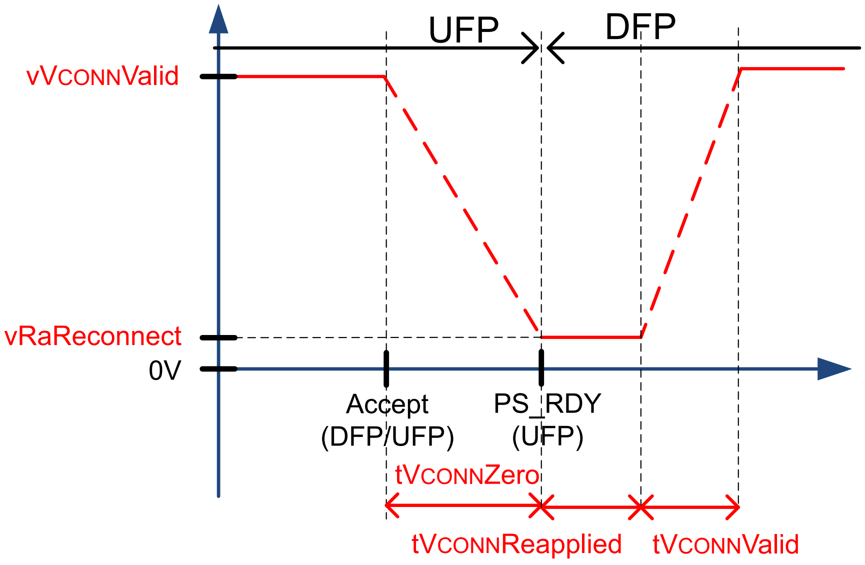
- Following the last bit of the ***GoodCRC*** *Message* acknowledging the ***Accept*** *Message* in response to the ***Data_Reset*** *Message*, the *UFP* ***Shall*** turn off *VCONN* and ensure it is below vRaReconnect (see ***[USB Type-C 2.4]***) within ***tVCONNZero***.
- When *VCONN* is below vRaReconnect, the *UFP* ***Shall*** send a ***PS_RDY*** *Message*.

Note: If the *UFP* was not sourcing *VCONN*, it still sends the ***PS_RDY*** *Message*.

- The *DFP* ***Shall*** wait ***tVCONNReapplied*** following the last bit of the ***GoodCRC*** *Message* acknowledging the ***PS_RDY*** *Message* before sourcing *VCONN*. The *DFP* ***Shall*** ensure *VCONN* is within vVCONNValid (see ***[USB Type-C 2.4]***) within ***tVCONNValid***.

Figure 7.19, "Data Reset UFP VCONN Power Cycle" below illustrates the *UFP VCONN* Power Cycle process.

Figure 7.19 Data Reset UFP VCONN Power Cycle



7.1.15.2 DFP VCONN Power Cycle

The *Data Reset* process requires the *DFP* to be the *VCONN Source* by the end of the process. In the case where the *DFP* is the *VCONN Source*, the following steps ***Shall*** be followed:

1) If the *DFP* sent the ***Data_Reset*** *Message* and is sourcing *VCONN* then it ***Shall*** turn off *VCONN* and ensure it is below vRaReconnect (see ***[USB Type-C 2.4]***) within ***tVCONNZero*** of the last bit of the ***GoodCRC*** *Message* acknowledging the ***Accept*** *Message* in response to the ***Data_Reset*** *Message*.

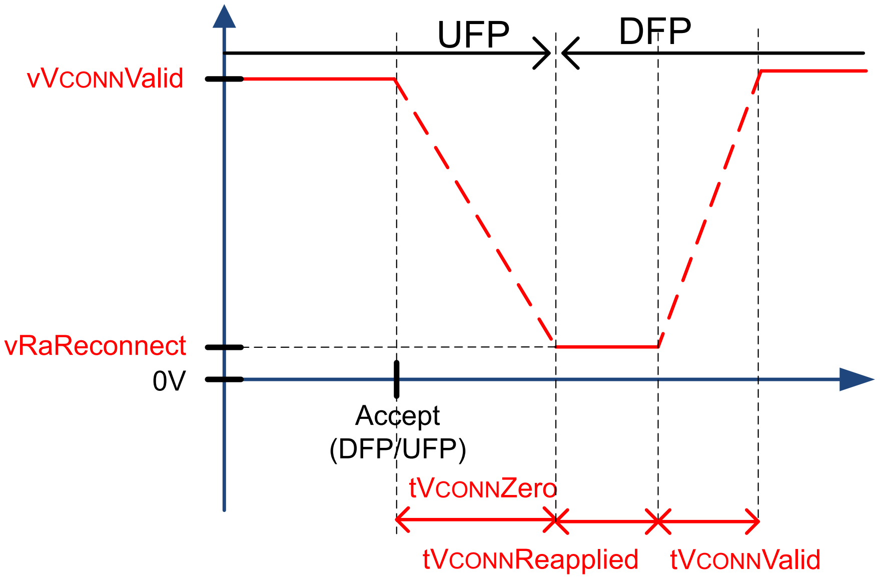
2) If the *UFP* sent the ***Data_Reset*** *Message* then the *DFP* ***Shall*** turn off *VCONN* and ensure it is below vRaReconnect (see ***[USB Type-C 2.4]***) within ***tVCONNZero*** following the last bit of the ***GoodCRC*** *Message* acknowledging the ***Accept*** *Message* in response to the ***Data_Reset*** *Message*.

3) When *VCONN* is below vRaReconnect, the *DFP* ***Shall*** wait ***tVCONNReapplied*** before sourcing *VCONN*.

4) The *DFP* ***Shall*** ensure *VCONN* is within vVCONNValid (see ***[USB Type-C 2.4]***) within ***tVCONNValid***.

Figure 7.20, "Data Reset DFP VCONN Power Cycle" below illustrates the *DFP VCONN* Power Cycle process.

Figure 7.20 Data Reset DFP VCONN Power Cycle



7.2 Sink Requirements

7.2.1 Behavioral Aspects

A *PDUSB Sink* exhibits the following behaviors:

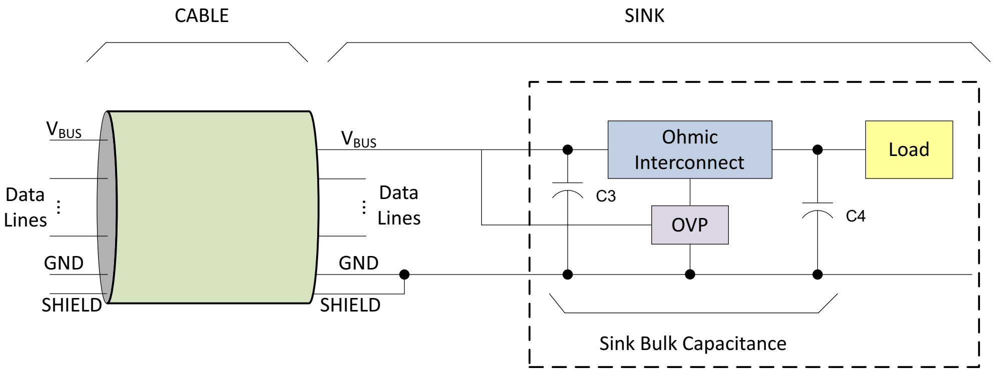
- ***Shall Not*** draw more than ***[USB Type-C 2.4]*** *USB Type-C* Current from *VBUS* while in a *Default Contract* or *Implicit Contract*.
- ***Shall*** follow the requirements as specified in *Section 7.1.5, "Response to Hard Resets"* when ***Hard Reset*** *Signaling* is received.
- ***Shall*** control *VBUS* in-rush current when increasing current consumption according to ***[USB 2.0]*** or ***[USB 3.2]*** as appropriate.

7.2.2 Sink Bulk Capacitance

The *Sink* bulk capacitance consists of C3 and C4 as shown in *Figure 7.21, "Placement of Sink Bulk Capacitance"*. The Ohmic Interconnect might consist of PCB traces for power distribution or power switching devices. The Ohmic Interconnect is expected to be part of an input Over Voltage Protection (*Sink OVP*) circuit implemented by the *Sink* as described in *Section 7.2.9.2, "Input Over Voltage Protection"* to protect against excessive *VBUS* input voltage. A *Sink* ***Shall*** implement *OVP*. The *Sink* ***Shall Not*** rely on the *Source* output voltage limit for its input *OVP*. The capacitance might be a single capacitor, a capacitor bank or distributed capacitance. An upper bound of ***cSnkBulkPd*** ***Shall Not*** be exceeded so that the transient charging, or discharging, of the total bulk capacitance on *VBUS* can be accounted for during voltage transitions.

The *Sink* bulk capacitance that is within the ***cSnkBulk*** max or ***cSnkBulkPd*** max limits is allowed to change to support a newly *Negotiated* power level. The capacitance can be changed when the *Sink* enters *Sink Standby* or during a voltage transition or when the *Sink* begins to operate at the new power level. Changing the *Sink* bulk capacitance ***Shall Not*** cause a transient current on *VBUS* that violates the present *Contract*. During a *Power Role Swap* the Default *Sink* ***Shall*** transition to *Swap Standby* before operating as the *New Source*. Any change in bulk capacitance required to complete the *Power Role Swap* ***Shall*** occur during *Swap Standby*.

Figure 7.21 Placement of Sink Bulk Capacitance



7.2.3 Sink Standby

The *Sink* ***Shall*** transition to *Sink Standby* before a positive voltage transition of *VBUS*. During *Sink Standby* the *Sink* ***Shall*** reduce the current drawn to ***iSnkStdby***. This allows the *Source* to manage the voltage transition as well as supply sufficient operating current to the *Sink* to maintain PD operation during the transition. The *Sink* ***Shall*** complete this transition to *Sink Standby* within ***tSnkStdby*** after evaluating the ***Accept*** *Message* from the *Source*. The transition when returning to *Sink* operation from *Sink Standby* ***Shall*** be completed within ***tSnkNewPower***. The ***iSnkStdby*** requirement ***Shall*** only apply if the *Sink* current draw is higher than this level.

See *Section 7.3, "Transitions"* for details.

7.2.3.1 Programmable Power Supply Sink Standby

A *Sink* is not required to transition to *Sink Standby* when operating within the *Negotiated* PPS *APDO*. A *Sink* ***May*** consume the Operating Current value in the PPS *RDO* during PPS output voltage changes. However, prior to operating the *SPR PPS* in *Current Limit*, the *Sink* ***Shall*** program the PPS Operating Voltage to the lowest practical level that satisfies the *Sink* load requirement. Doing so will minimize the inrush current that occurs when the transition to *Current Limit* occurs. When operating with an *SPR PPS Source* that is in *Current Limit*, the *Sink* ***Shall Not*** change its load in a manner that exceeds ***iPpsCLLoadStepRate*** or ***iPpsCLLoadReleaseRate***. The load change magnitude ***Shall Not*** request a change to the *Current Limit* set-point that exceeds ***iPpsCLLoadStep***.

If the *Sink Negotiates* for a new PPS *APDO*, that is expected to increase *VBUS* voltage, then the *Sink* ***Shall*** transition to *Sink Standby* while changing between PPS *APDOs* as described in *Section 7.3.1, "Transitions caused by a Request Message"*.

7.2.4 Suspend Power Consumption

When *Source* has set its ***USB Suspend Supported*** flag (see *Section 6.4.1.2.1.2, "USB Suspend Supported"*), a *Sink* ***Shall*** go to the lowest power state during USB suspend. The lowest power state ***Shall*** be ***pSnkSusp*** or lower for a PDUSB Peripheral and ***pHubSusp*** or lower for a *PDUSB Hub*. There is no requirement for the *Source* voltage to be changed during USB suspend.

7.2.5 Zero Negotiated Current

When a *Sink* Requests zero current as part of a power *Negotiation* with a *Source*, the *Sink* ***Shall*** go to the lowest power state, ***pSnkSusp*** or lower, where it can still communicate using PD signaling.

7.2.6 Transient Load Behavior

When a *Sink*'s operating current changes due to a load step, load release or any other change in load level, the positive or negative overshoot of the new load current ***Shall Not*** exceed the range defined by ***iOvershoot***. For the purposes of measuring ***iOvershoot*** the new load current value is defined as the average steady state value of the load current after the load step has settled. The rate of change of any shift in *Sink* load current during normal operation ***Shall Not*** exceed ***iLoadStepRate*** (for load steps) and ***iLoadReleaseRate*** (for load releases) as measured at the *Sink* receptacle.

The *Sink*'s operating current ***Shall Not*** change faster than the value reported in the *Source*'s Load Step Slew Rate in its ***Voltage Regulation*** bit field and ***Shall*** ensure that PD Communications meet the transmit and receive masks as specified in *Section 5.8.2, "Transmit and Receive Masks"*.

7.2.7 Swap Standby for Sinks

The *Sink* functionality in a *Dual-Role Power Port* ***Shall*** support *Swap Standby*. *Swap Standby* occurs for the *Sink* after evaluating the ***Accept*** *Message* from the *Source* during a *Power Role Swap*. While in *Swap Standby* the *Sink*'s current draw ***Shall Not*** exceed ***iSnkSwapStdby*** from *VBUS* and the *Dual-Role Power Port* ***Shall*** be configured as a *Source* after *VBUS* has been discharged to ***vSafe0V*** by the existing *Initial Source*. The *Sink*'s USB connection ***Should Not*** be reset even though ***vSafe5V*** is not present on the *VBUS* conductor (see *Section 9.1.2, "Mapping to USB Device States"*). The time for the *Sink* to transition to *Swap Standby* ***Shall*** be no more than ***tSnkSwapStdby***. When in *Swap Standby* the *Sink* has relinquished its *Power Role* as *Sink* and will prepare to become the *New Source*. The transition time from *Swap Standby* to *New Source* ***Shall*** be no more than ***tNewSrc***.

7.2.8 Sink Peak Current Operation

Sinks ***Shall*** only make use of a *Source* overload capability when the corresponding *Fixed Supply PDO* Peak Current (see *Section 6.4.1.2.1.8, "Peak Current"*) or *AVS APDO* Peak Current (see *Section 6.4.1.2.4.3.2, "Peak Current"*) bits are set to 01b, 10b and 11b. *Sinks* ***Shall*** manage thermal aspects of the overload event by not exceeding the average *Negotiated* output of a *Fixed Supply* or *AVS* that supports Peak Current operation.

Sinks that depend on the Peak Current capability for enhanced system performance ***Shall*** also function correctly when *Attached* to a *Source* that does not offer the Peak Current capability or when the Peak Current capability has been inhibited by the *Source*.

7.2.9 Robust Sink Operation

7.2.9.1 Sink Bulk Capacitance Discharge at Detach

When a *Source* is *Detached* from a *Sink*, the *Sink* ***Shall*** continue to draw power from its input bulk capacitance until *VBUS* is discharged to ***vSafe5V*** or lower by no longer than ***tSafe5V*** from the *Detach* event. This safe *Sink* requirement ***Shall*** apply to all *Sink*s operating with a *Negotiated VBUS* level greater than ***vSafe5V*** and ***Shall*** apply during all low power and high-power operating modes of the *Sink*.

If the *Detach* is detected during a *Sink* low power state, such as USB Suspend, the *Sink* can then draw as much power as needed from its bulk capacitance since a *Source* is no longer *Attached*. In order to achieve a successful *Detach* detect based on *VBUS* voltage level droop, the *Sink* power consumption ***Shall*** be high enough so that *VBUS* will decay below ***vSrcValid***(min) well within ***tSafe5V*** after the *Source* bulk capacitance is removed due to the *Detach*. Once adequate *VBUS* droop has been achieved, a discharge circuit can be enabled to meet the safe *Sink* requirement.

To illustrate the point, the following set of *Sink* conditions will not meet the safe *Sink* requirement without additional discharge circuitry:

- *Negotiated VBUS* = 20V.
- Maximum allowable supplied *VBUS* voltage = 21.55V.
- Maximum bulk capacitance = 30μF.
- Power consumption at *Detach* = 12.5mW.

When the *Detach* occurs (hence removal of the *Source* bulk capacitance) the 12.5mW power consumption will draw down the *VBUS* voltage from the worst-case maximum level of 21.55V to 17V in approximately 205ms. At this point, with *VBUS* well below ***vSrcValid*** (min) an approximate 100mW discharge circuit can be enabled to increase the rate of *Sink* bulk capacitance discharge and meet the safe *Sink* requirement. The power level of the discharge circuit is dependent on how much time is left to discharge the remaining voltage on the *Sink* bulk capacitance. If a *Sink* has the ability to detect the *Detach* in a different manner and in much less time than ***tSafe5V***, then this different manner of detection can be used to enable a discharge circuit, allowing even lower power dissipation during low power modes such as USB Suspend.

In most applications, the safe *Sink* requirement will limit the maximum *Sink* bulk capacitance well below the ***cSnkBulkPd*** limit. A *Detach* occurring during *Sink* high power operating modes must quickly discharge the *Sink* bulk capacitance to ***vSafe5V*** or lower as long as the *Sink* continues to draw adequate power until *VBUS* has decayed to ***vSafe5V*** or lower.

7.2.9.2 Input Over Voltage Protection

Sinks ***Shall*** implement input Over-Voltage Protection (*OVP*) to prevent damage from input voltage that exceeds the voltage handling capability of the *Sink*. The definition of voltage handling capability is left to the discretion of the *Sink* implementation. The over voltage response of *Sinks* ***Shall Not*** interfere with normal PD operation and ***Shall*** account for ***vSrcNew***, ***vSrcValid*** or ***vPpsNew***, ***vPpsValid*** as determined by the *Negotiated VBUS* value. SPR *Sinks* ***Should*** tolerate input voltages as high as ***vSprMax*** and ***Shall*** meet applicable safety requirements if ***vSprMax*** is exceeded. Likewise, *EPR Sinks* ***Should*** tolerate input voltages as high as ***vEprMax*** and ***Shall*** meet applicable safety requirements if ***vEprMax*** is exceeded.

Sinks ***Should*** attempt to send ***Hard Reset*** *Signaling* when OVP engages followed by an ***Alert*** *Message* indicating an *OVP* event once an *Explicit Contract* has been established. The *OVP* response ***May*** engage at either the *Port* or system level. Systems or ports that have engaged *OVP* ***Shall*** resume *USB Default Operation* when the *Source* has re-established ***vSafe5V*** on *VBUS*.

The *Sink* ***Shall*** be able to *Re-negotiate* with the *Source* after resuming *USB Default Operation*. The decision of how to respond to *Re-negotiation* after an *OVP* event is left to the discretion of the *Sink* implementation.

The *Sink* ***Shall*** prevent continual system or *Port* cycling if *OVP* continues to engage after initially resuming either *USB Default Operation* or *Re-negotiation*. Latching off the *Port* or system is an acceptable response to recurring over voltage.

7.2.9.3 Over Temperature Protection

*Sink*s ***Shall*** implement over temperature protection (*OTP*) to prevent damage from temperature that exceeds the thermal capability of the *Sink*. The definition of thermal capability and the monitoring locations used to trigger the over temperature protection are left to the discretion of the *Sink* implementation.

*Sink*s ***Shall*** attempt to send ***Hard Reset*** *Signaling* when over temperature protection engages followed by an ***Alert*** *Message* indicating an *OTP* event once an *Explicit Contract* has been established. The over temperature protection response ***May*** engage at either the *Port* or system level. Systems or ports that have engaged over temperature protection ***Should*** attempt to resume *USB Default Operation* after sufficient cooling is achieved and ***May*** latch off to protect the *Port* or system. The definition of sufficient cooling is left to the discretion of the *Sink* implementation.

The *Sink* ***Shall*** be able to *Re-negotiate* with the *Source* after resuming *USB Default Operation*. The decision of how to respond to *Re-negotiation* after an over temperature event is left to the discretion of the *Sink* implementation.

The *Sink* ***Shall*** prevent continual system or *Port* cycling if over temperature protection continues to engage after initially resuming either *USB Default Operation* or *Re-negotiation*. Latching off the *Port* or system is an acceptable response to recurring over temperature.

7.2.9.4 Over Current Protection

*Sink*s that operate with a Programmable Power Supply ***Shall*** implement their own internal current protection mechanism to protect against internal *VBUS* current faults as well as erratic *Source* current regulation. The *Sink* ***Shall*** never draw higher current than the Maximum Current value in the PPS *APDO*.

7.2.10 Fast Role Swap

As described in *Section 7.1.13, "Fast Role Swap"* a *Fast Role Swap* limits the interruption of *VBUS* power to a bus powered accessory connected to a *Hub DFP* that has a *UFP Attached* to a power source and a *DRP Attached* to a *Host Port* that supports *DRP*. This configuration is shown in *Figure 7.16, "VBUS Power during Fast Role Swap"*.

The *Host DRP*, upon establishing an *Explicit Contract*, ***Shall*** query the *Initial Source*'s *Sink Capabilities* to determine whether the *Initial Source* supports *Fast Role Swap*, and what level of current it requires. If the ***Sink_Capabilities*** *Message* received from the *Initial Source* has at least one of the ***Fast Role Swap required USB Type-C Current*** bits set, and the *Host DRP* is able to source the requested current at 5V, the *Host DRP* ***May*** arm itself for *Fast Role Swap*. If the *Host DRP* has not queried the *Sink Capabilities* from the *Initial Source*, or if the ***Sink_Capabilities*** *Message* reports no *Fast Role Swap* support or a current that is beyond what the *Host DRP* is able or willing to source in the event of a *Fast Role Swap*, the *Host DRP* ***Shall Not*** arm itself for *Fast Role Swap* and ***Shall Ignore*** any *Fast Role Swap Request*s that are detected.

When the *Host DRP* that supports *Fast Role Swap* detects the F*Fast Role Swap Request*, the *Host DRP* ***Shall*** stop sinking current and ***Shall*** be ready and able to source ***vSafe5V*** if the residual *VBUS* voltage level at the *Host DRP* connector is greater than ***vSafe5V***. When the residual *VBUS* voltage level at the *Host DRP* connector discharges below ***vSafe5V***(min) the *Host DRP* as the *New Source* ***Shall*** supply ***vSafe5V*** to the *Hub DRP* within ***tSrcFRSwap***. The *Host DRP* ***Shall Not*** enable *VBUS* discharge circuitry when changing *Power Role*s from *Initial Sink* to *New Source*.

The *New Source* ***Shall*** supply ***vSafe5V*** at *USB Type-C* Current (see ***[USB Type-C 2.4]***) at the value *Advertise*d in the ***Fast Role Swap required USB Type-C Current*** field (see *Section 6.4.1.3.1.6, "Fast Role Swap USB Type-C Current"*). All *Source* requirements ***Shall*** apply to the *New Source* after the *Fast Role Swap* is complete The *Fast Role Swap* response of the *Hub DRP* is described in *Section 7.1.13, "Fast Role Swap"* since the *Hub DRP* is operating as the *Initial Source* prior to the *Fast Role Swap*.

After the *Host DRP* is providing *VBUS* power to the *Hub DRP*, a ***PS_RDY*** *Message* ***Shall*** be sent to the *Hub DRP* as defined by the *Fast Role Swap Request* and the *AMS* detailed in *Section 7.3.4, "Transitions Caused by Fast Role Swap"*.

7.3 Transitions

The following sections illustrate the power supply's response to various types of *Negotiations*. The *Negotiations* are triggered by certain *Messages* or *Signaling*. It provides examples of the transitions and is organized around each of the *Messages* and Signals that result in a response from the power supply. The response to a *Message* or Signal can result in different transitions depending upon the power supply's starting conditions and the requested change.

- Transitions caused by a ***Request*** *Message*:
    - Generic transition between *(A)PDO* s:
        - Increase the current.
        - Increase the voltage.
        - Increase the voltage and the current.
        - Increase the voltage and decrease the current.
        - Decrease the voltage and increase the current.
        - Decrease the voltage and the current.
        - No change in Current or voltage.
    - Transitions within the same *PDO* (*Fixed Supply*, *Battery Supply*, *Variable Supply*):
        - Increase the current.
        - Decrease the current.
        - No change in current.
    - Transitions within the same PPS *APDO*:
        - Increasing the Programmable Power Supply (PPS) voltage.
        - Decreasing the Programmable Power Supply (PPS) voltage.
        - Increasing the Programmable Power Supply (PPS) Current.
        - Decreasing the Programmable Power Supply (PPS) Current.
        - Same Request Programmable Power Supply (PPS).
    - Transitions within the same *AVS APDO*:
        - Increasing the *Adjustable Voltage Supply* (*AVS*) voltage
        - Decreasing the *Adjustable Voltage Supply* (*AVS*) voltage
        - Same Request *Adjustable Voltage Supply* (*AVS*)
- Transitions caused by the ***PR_Swap*** *Message*:
    - *Source* requests a *Power Role Swap*
    - *Sink* requests a *Power Role Swap*
- Transitions caused by ***Hard Reset*** *Signaling*:
    - *Source* issues ***Hard Reset*** *Signaling*.
    - *Sink* issues ***Hard Reset*** *Signaling*.
- Transitions caused by the *Fast Role Swap Request*:
    - *Source* asserts R_d at its preferred ***[USB Type-C 2.4]*** current.

7.3.1 Transitions caused by a Request Message

This section describes transitions that are caused by a ***Request*** *Message*.

7.3.1.1 Changing the Source between Different (A)PDOs

In these transition descriptions the term *(A)PDO* is used to describe any *Power Data Object*, regardless of whether it is a *PDO* or an *APDO* in the *Capabilities Message*.

This section describes transitions in response to a ***Request*** *Message*:

- From one *(A)PDO* to another *(A)PDO*
- From an *Implicit Contract* to an *Explicit Contract*
- From ***[USB Type-C 2.4]***operation to the *First Explicit Contract*

These transitions usually result in a voltage change but is not required.

The interaction of the *Device Policy Manager*, the *Port Policy Engine* and the Power Supply that ***Shall*** be followed when increasing the current is shown in *Figure 7.23, "Transition Diagram for Increasing the Voltage and Current"* and *Figure 7.25, "Transition Diagram for Decreasing the Voltage and Increasing the Current"*.

The *Source* voltage as the transition starts ***Shall*** be any voltage within the ***Valid*** *VBUS* range of the previous *Source PDO* or *APDO*. The *Source* voltage after the transition is complete ***Shall*** be any voltage within the ***Valid*** *VBUS* range of the *New Source PDO* or *APDO*. The sequence that ***Shall*** be followed is described in *Table 7.2, "Sequence Diagram for Increasing the Voltage and Current"* and *Table 7.4, "Sequence Description for Decreasing the Voltage and Increasing the Current"*. The timing parameters that ***Shall*** be followed are listed in *Table 7.23, "Source Electrical Parameters"*, *Table 7.24, "Sink Electrical Parameters"*, and *Table 7.25, "Common Source/Sink Electrical Parameters"*.

Note: In this figure, the *Sink* has previously sent a ***Request*** *Message* to the *Source*.

The voltage is considered to increase if the change from V_{OLD} to V_{NEW} is greater than ***vSmallStep***. The determination ***Shall*** be based on the nominal *(A)PDO* voltage before and after, unless either *(A)PDO* is *Battery Supply* or *Variable Supply* when the worst case of the following is assumed in making this determination.

- Minimum voltage to voltage.
- Minimum voltage to Maximum voltage.
- Voltage to Maximum voltage.

The following sections begin with a description of the generic process followed by more specific examples of the most common transitions.

7.3.1.1.1 Examples of changes from one (A)PDO to another (A)PDO

The seven examples of *(A)PDO* change transitions below illustrate the most common transitions.

7.3.1.1.1.1 Increasing the Voltage

The interaction of the *System Policy*, *Device Policy*, and power supply that ***Shall*** be followed when changing from one *(A)PDO* to another while increasing the voltage is shown in *Figure 7.22, "Transition Diagram for Increasing the Voltage"*. The sequence that ***Shall*** be followed is described in *Table 7.1, "Sequence Description for Increasing the Voltage"*. The timing parameters that ***Shall*** be followed are listed in *Table 7.23, "Source Electrical Parameters"*, *Table 7.24, "Sink Electrical Parameters"*, and *Table 7.25, "Common Source/Sink Electrical Parameters"*.

Note: In *Figure 7.22, "Transition Diagram for Increasing the Voltage"*, the *Sink* has previously sent a *Request Message* to the *Source*.

Figure 7.22 Transition Diagram for Increasing the Voltage

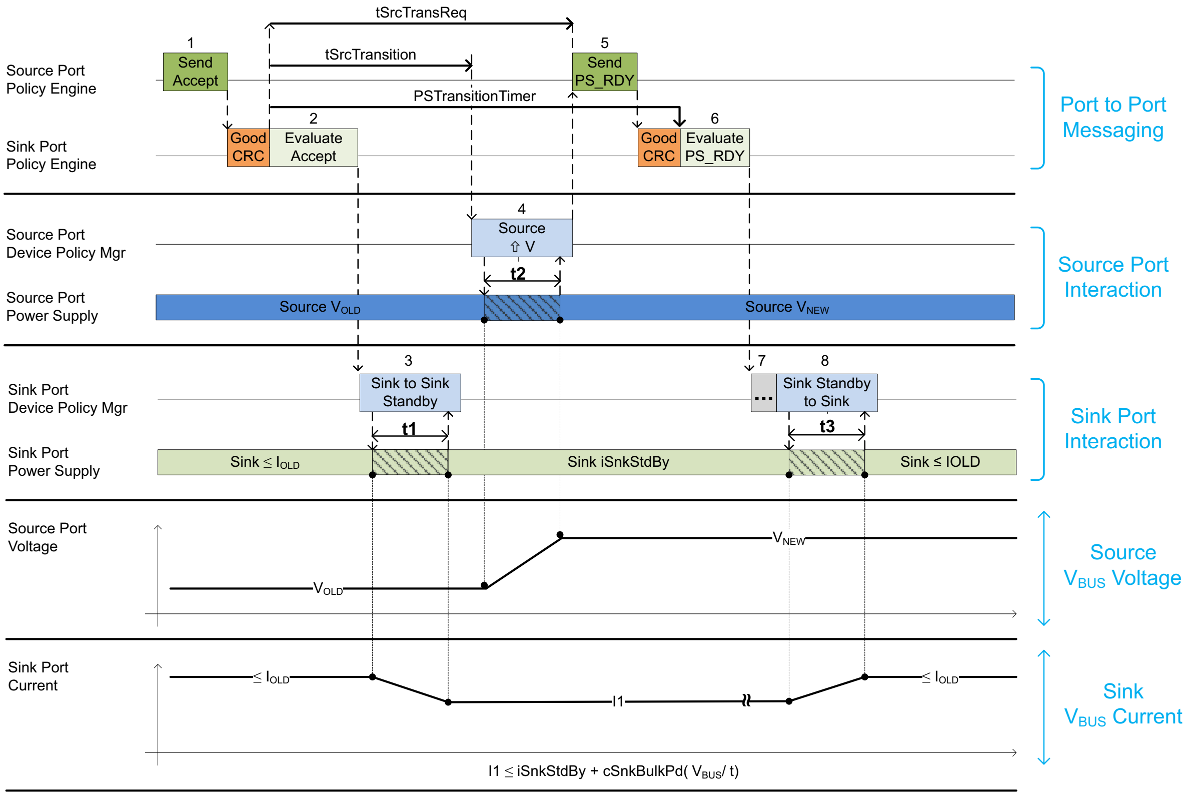


Table 7.1 Sequence Description for Increasing the Voltage

Step	Source Port	Sink Port
1	*Policy Engine* sends the ***Accept*** *Message* to the *Sink*.	*Policy Engine* receives the ***Accept*** *Message*.
2	*Protocol Layer* receives the ***GoodCRC*** *Message* from the *Sink*. The *Policy Engine* tells the *Device Policy Manager* to instruct the power supply to modify its output power.	*Protocol Layer* sends the ***GoodCRC*** *Message* to the *Source*. *Policy Engine* then starts the ***PSTransitionTimer*** and evaluates the ***Accept*** *Message*.
3		*Policy Engine* tells the *Device Policy Manager* to instruct the power supply to reduce current drawn to ***iSnkStdby*** within ***tSnkStdby*** (t1); t1 ***Shall*** complete before ***tSrcTransition***. The *Sink* ***Shall Not*** violate transient load behavior defined in *Section 7.2.6, "Transient Load Behavior"* while transitioning to and operating at the new power level.
4	***tSrcTransition*** after the ***GoodCRC*** *Message* was received, the power supply starts to change its output power capability. The power supply ***Shall*** be ready to operate at the new power level within ***tSrcReady*** (t2). The power supply informs the *Device Policy Manager* that it is ready to operate at the new power level. The power supply status is passed to the *Policy Engine*.	
5	The *Policy Engine* sends the ***PS_RDY*** *Message* to the *Sink* starting within ***tSrcTransReq*** of the end of the ***GoodCRC*** *Message* following the ***Accept*** *Message*.	The *Policy Engine* receives the ***PS_RDY*** *Message* from the *Source*.
6	*Protocol Layer* receives the ***GoodCRC*** *Message* from the *Sink*.	*Protocol Layer* sends the ***GoodCRC*** *Message* to the *Source*. *Policy Engine* then stops the ***PSTransitionTimer***, evaluates the ***PS_RDY*** *Message* from the *Source* and tells the *Device Policy Manager* that the *Source* is operating at the new *(A)PDO*. If the ***PS_RDY*** *Message* is not received before ***PSTransitionTimer*** times out the *Sink* sends ***Hard Reset*** *Signaling*.
7		The *Sink* ***May*** begin operating at the new power level any time after evaluation of the ***PS_RDY*** *Message*. This time duration is indeterminate.
8		The *Sink* ***Shall Not*** violate the transient load behavior defined in *Section 7.2.6, "Transient Load Behavior"* while transitioning to and operating at the new power level. The time duration (t3) depends on the magnitude of the load change.

7.3.1.1.1.2 Increasing the Voltage and Current

The interaction of the *System Policy*, *Device Policy*, and power supply that ***Shall*** be followed when changing from one *(A)PDO* to another while increasing the voltage and current is shown in *Figure 7.23, "Transition Diagram for Increasing the Voltage and Current"*. The sequence that ***Shall*** be followed is described in *Table 7.2, "Sequence Diagram for Increasing the Voltage and Current"*. The timing parameters that ***Shall*** be followed are listed in *Table 7.23, "Source Electrical Parameters"*, *Table 7.24, "Sink Electrical Parameters"*, and *Table 7.25, "Common Source/Sink Electrical Parameters"*.

Note: In *Figure 7.23, "Transition Diagram for Increasing the Voltage and Current"*, the *Sink* has previously sent a *Request Message* to the *Source*.

Figure 7.23 Transition Diagram for Increasing the Voltage and Current

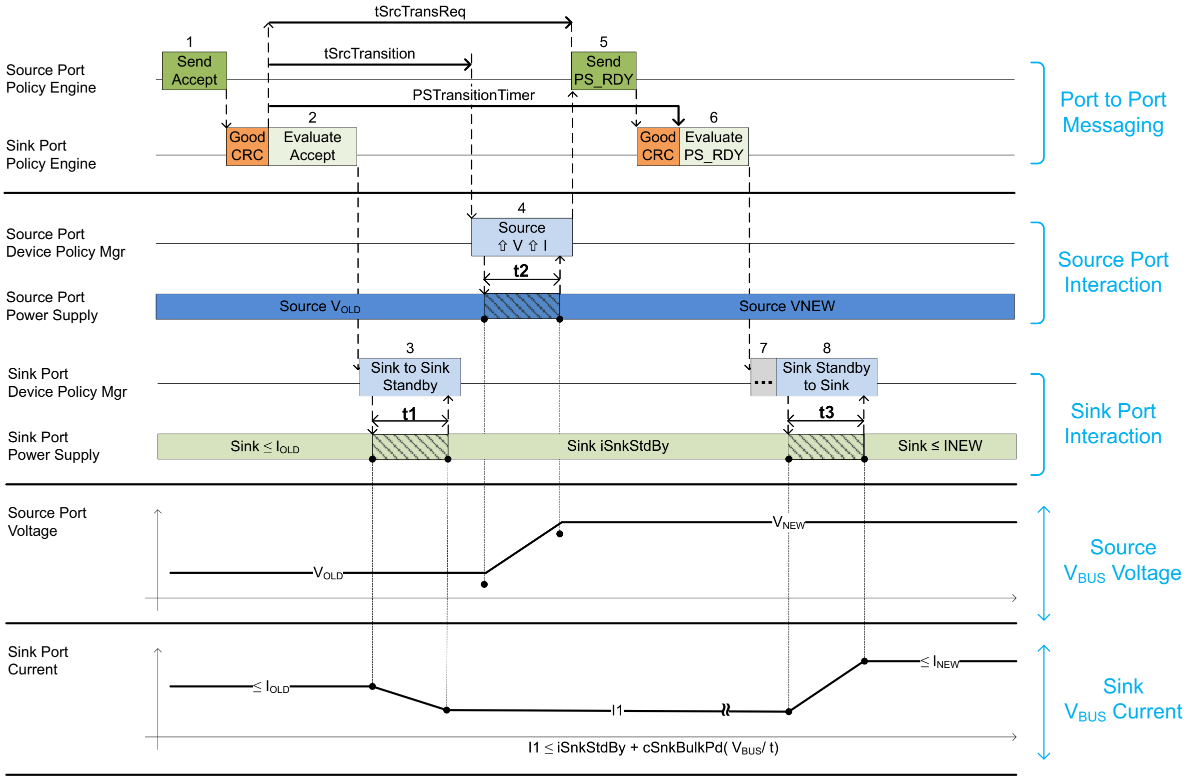


Table 7.2 Sequence Diagram for Increasing the Voltage and Current

Step	Source Port	Sink Port
1	*Policy Engine* sends the ***Accept*** *Message* to the *Sink*.	*Policy Engine* receives the ***Accept***.
2	*Protocol Layer* receives the ***GoodCRC*** *Message* from the *Sink*. The *Policy Engine* tells the *Device Policy Manager* to instruct the power supply to modify its output power.	*Protocol Layer* sends the ***GoodCRC*** *Message* to the *Source*. *Policy Engine* then starts the ***PSTransitionTimer*** and evaluates the ***Accept*** *Message*.
3		*Policy Engine* tells the *Device Policy Manager* to instruct the power supply to reduce current drawn to ***iSnkStdby*** within ***tSnkStdby*** (t1); t1 ***Shall*** complete before ***tSrcTransition***. The *Sink* ***Shall Not*** violate transient load behavior defined in *Section 7.2.6, "Transient Load Behavior"* while transitioning to and operating at the new power level.
4	***tSrcTransition*** after the ***GoodCRC*** *Message* was received, the power supply starts to change its output power capability. The power supply ***Shall*** be ready to operate at the new power level within ***tSrcReady*** (t2). The power supply informs the *Device Policy Manager* that it is ready to operate at the new power level. The power supply status is passed to the *Policy Engine*.	
5	The *Policy Engine* sends the ***PS_RDY*** *Message* to the *Sink* starting within ***tSrcTransReq*** of the end of the ***GoodCRC*** *Message* following the ***Accept*** *Message*.	The *Policy Engine* receives the ***PS_RDY*** *Message* from the *Source*.
6	*Protocol Layer* receives the ***GoodCRC*** *Message* from the *Sink*.	*Protocol Layer* sends the ***GoodCRC*** *Message* to the *Source*. *Policy Engine* then stops the ***PSTransitionTimer***, evaluates the ***PS_RDY*** *Message* from the *Source* and tells the *Device Policy Manager* that the *Source* is operating at the new *(A)PDO*. If the ***PS_RDY*** *Message* is not received before ***PSTransitionTimer*** times out, the *Sink* sends ***Hard Reset*** *Signaling*.
7		The *Sink* ***May*** begin operating at the new power level any time after evaluation of the ***PS_RDY*** *Message*. This time duration is indeterminate.
8		The *Sink* ***Shall Not*** violate the transient load behavior defined in *Section 7.2.6, "Transient Load Behavior"* while transitioning to and operating at the new power level. The time duration (t3) depends on the magnitude of the load change.

7.3.1.1.1.3 Increasing the Voltage and Decreasing the Current

The interaction of the *System Policy*, *Device Policy*, and power supply that ***Shall*** be followed when changing from one *(A)PDO* to another while increasing the voltage and decreasing the current is shown in *Figure 7.24, "Transition Diagram for Increasing the Voltage and Decreasing the Current"*. The sequence that ***Shall*** be followed is described in *Table 7.3, "Sequence Description for Increasing the Voltage and Decreasing the Current"*. The timing parameters that ***Shall*** be followed are listed in *Table 7.23, "Source Electrical Parameters"*, *Table 7.24, "Sink Electrical Parameters"*, and *Table 7.25, "Common Source/Sink Electrical Parameters"*.

Note: In *Figure 7.24, "Transition Diagram for Increasing the Voltage and Decreasing the Current"*, the *Sink* has previously sent a *Request Message* to the *Source*.

Figure 7.24 Transition Diagram for Increasing the Voltage and Decreasing the Current

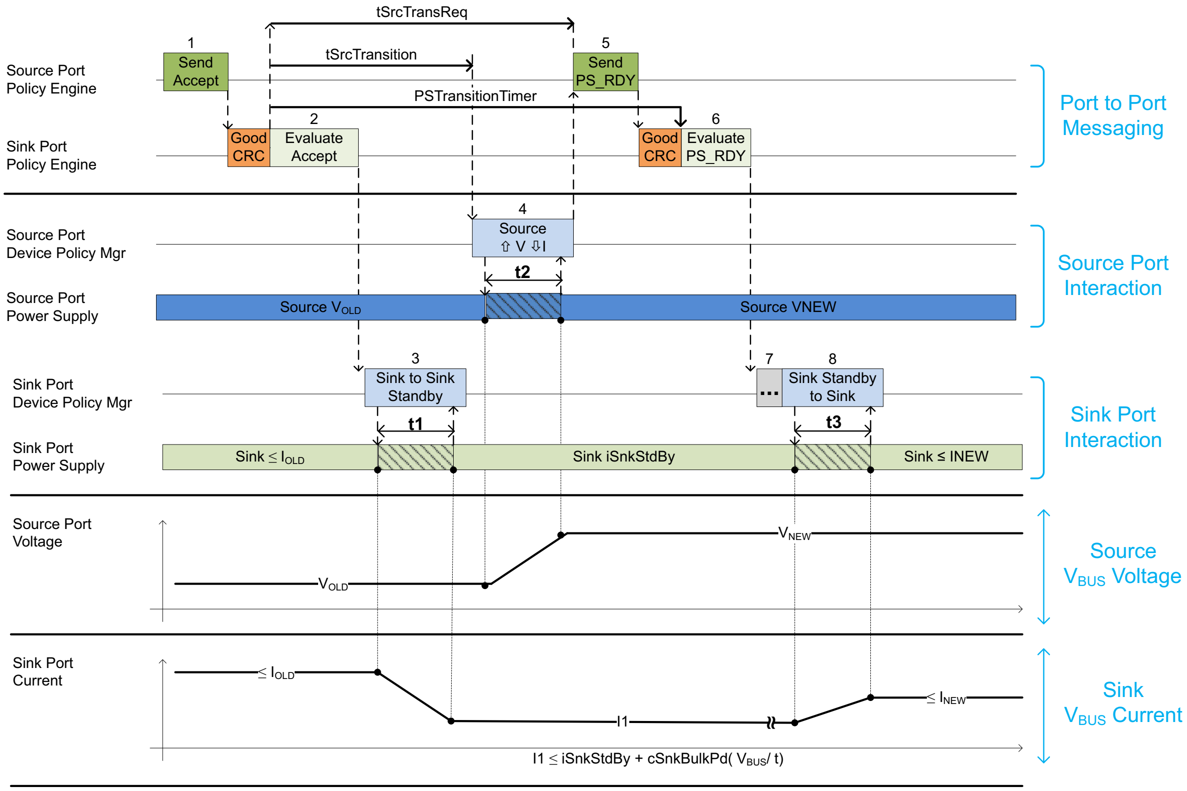


Table 7.3 Sequence Description for Increasing the Voltage and Decreasing the Current

Step	Source Port	Sink Port
1	*Policy Engine* sends the ***Accept*** *Message* to the *Sink*.	*Policy Engine* receives the ***Accept*** *Message*.
2	*Protocol Layer* receives the ***GoodCRC*** *Message* from the *Sink*. The *Policy Engine* tells the *Device Policy Manager* to instruct the power supply to modify its output power.	*Protocol Layer* sends the ***GoodCRC*** *Message* to the *Source*. *Policy Engine* then starts the ***PSTransitionTimer*** and evaluates the ***Accept*** *Message*.
3		*Policy Engine* tells the *Device Policy Manager* to instruct the power supply to reduce current drawn to ***iSnkStdby*** within ***tSnkStdby*** (t1); t1 ***Shall*** complete before ***tSrcTransition***. The *Sink* ***Shall Not*** violate transient load behavior defined in *Section 7.2.6, "Transient Load Behavior"* while transitioning to and operating at the new power level.
4	***tSrcTransition*** after the ***GoodCRC*** *Message* was received, the power supply starts to change its output power capability. The power supply ***Shall*** be ready to operate at the new power level within ***tSrcReady*** (t2). The power supply informs the *Device Policy Manager* that it is ready to operate at the new power level. The power supply status is passed to the *Policy Engine*.	
5	The *Policy Engine* sends the ***PS_RDY*** *Message* to the *Sink* starting within ***tSrcTransReq*** of the end of the ***GoodCRC*** *Message* following the ***Accept*** *Message*.	The *Policy Engine* receives the ***PS_RDY*** *Message* from the *Source*.
6	*Protocol Layer* receives the ***GoodCRC*** *Message* from the *Sink*.	*Protocol Layer* sends the ***GoodCRC*** *Message* to the *Source*. *Policy Engine* then stops the ***PSTransitionTimer***, evaluates the ***PS_RDY*** *Message* from the *Source* and tells the *Device Policy Manager* that the *Source* is operating at the new *(A)PDO*. If the ***PS_RDY*** *Message* is not received before ***PSTransitionTimer*** times out the *Sink* sends ***Hard Reset*** *Signaling*.
7		The *Sink* ***May*** begin operating at the new power level any time after evaluation of the ***PS_RDY*** *Message*. This time duration is indeterminate.
8		The *Sink* ***Shall Not*** violate the transient load behavior defined in *Section 7.2.6, "Transient Load Behavior"* while transitioning to and operating at the new power level. The time duration (t3) depends on the magnitude of the load change.

7.3.1.1.1.4 Decreasing the Voltage and Increasing the Current

The interaction of the *System Policy*, *Device Policy*, and power supply that ***Shall*** be followed when changing from one *(A)PDO* to another while decreasing the voltage and increasing the current is shown in *Figure 7.25, "Transition Diagram for Decreasing the Voltage and Increasing the Current"*. The sequence that ***Shall*** be followed is described in *Table 7.4, "Sequence Description for Decreasing the Voltage and Increasing the Current"*. The timing parameters that ***Shall*** be followed are listed in *Table 7.23, "Source Electrical Parameters"*, *Table 7.24, "Sink Electrical Parameters"*, and *Table 7.25, "Common Source/Sink Electrical Parameters"*.

Note: In *Figure 7.25, "Transition Diagram for Decreasing the Voltage and Increasing the Current"*, the *Sink* has previously sent a *Request Message* to the *Source*.

Figure 7.25 Transition Diagram for Decreasing the Voltage and Increasing the Current

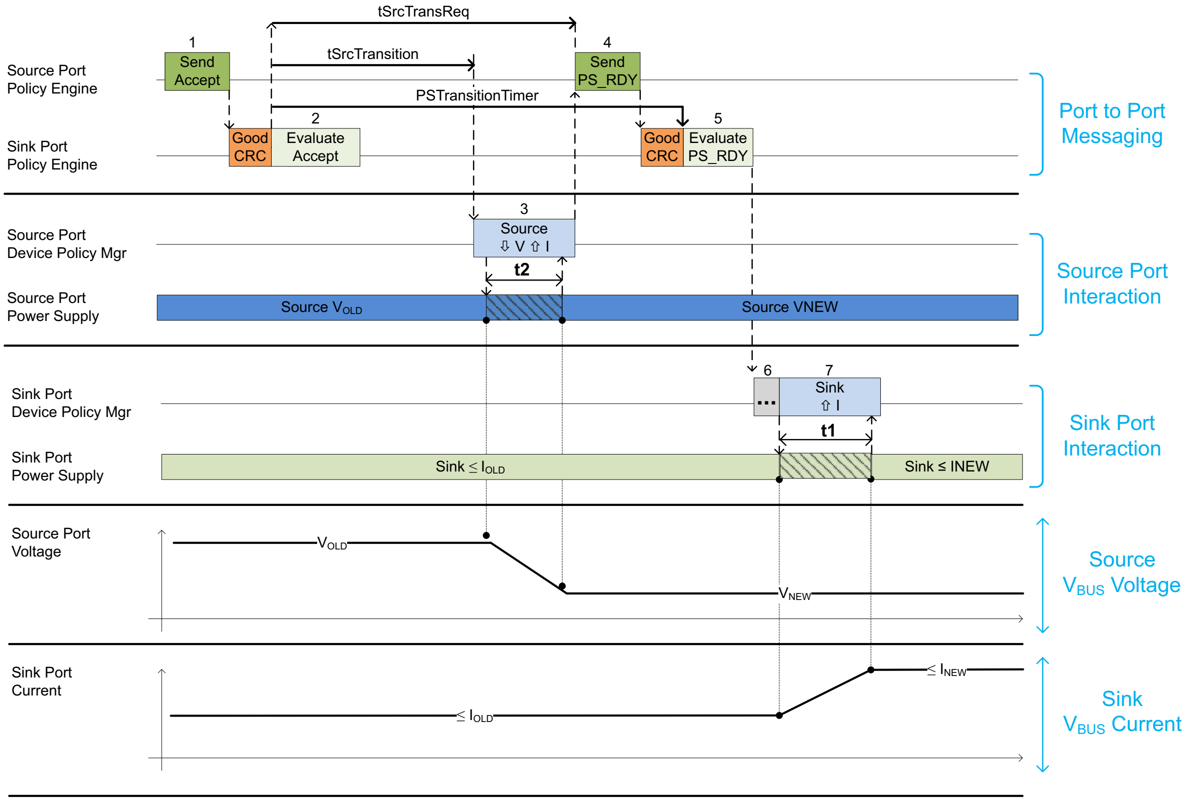


Table 7.4 Sequence Description for Decreasing the Voltage and Increasing the Current

Step	Source Port	Sink Port
1	*Policy Engine* sends the ***Accept*** *Message* to the *Sink*.	*Policy Engine* receives the ***Accept*** *Message*.
2	*Protocol Layer* receives the ***GoodCRC*** *Message* from the *Sink*. The *Policy Engine* tells the *Device Policy Manager* to instruct the power supply to modify its output power.	*Protocol Layer* sends the ***GoodCRC*** *Message* to the *Source*. *Policy Engine* then starts the ***PSTransitionTimer*** and evaluates the ***Accept*** *Message*.
3	***tSrcTransition*** after the ***GoodCRC*** *Message* was received, the power supply starts to change its output power capability. The power supply ***Shall*** be ready to operate at the new power level within ***tSrcReady*** (t1). The power supply informs the *Device Policy Manager* that it is ready to operate at the new power level. The power supply status is passed to the *Policy Engine*.	
4	The *Policy Engine* sends the ***PS_RDY*** *Message* to the *Sink* starting within ***tSrcTransReq*** of the end of the ***GoodCRC*** *Message* following the ***Accept*** *Message*.	The *Policy Engine* receives the ***PS_RDY*** *Message* from the *Source*.
5	*Protocol Layer* receives the ***GoodCRC*** *Message* from the *Sink*.	*Protocol Layer* sends the ***GoodCRC*** *Message* to the *Source*. *Policy Engine* then evaluates the ***PS_RDY*** *Message* from the *Source* and tells the *Device Policy Manager* it is okay to operate at the new power level.
6		The *Sink* ***May*** begin operating at the new power level any time after evaluation of the ***PS_RDY*** *Message*. This time duration is indeterminate.

7.3.1.1.1.5 Decreasing the Voltage

The interaction of the *System Policy*, *Device Policy*, and power supply that ***Shall*** be followed when changing from one *(A)PDO* to another while decreasing the voltage is shown in *Figure 7.26, "Transition Diagram for Decreasing the Voltage"*. The sequence that ***Shall*** be followed is described in *Table 7.5, "Sequence Description for Decreasing the Voltage"*. The timing parameters that ***Shall*** be followed are listed in *Table 7.23, "Source Electrical Parameters"*, *Table 7.24, "Sink Electrical Parameters"*, and *Table 7.25, "Common Source/Sink Electrical Parameters"*.

Note: In *Figure 7.26, "Transition Diagram for Decreasing the Voltage"*, the *Sink* has previously sent a *Request Message* to the *Source*.

Figure 7.26 Transition Diagram for Decreasing the Voltage

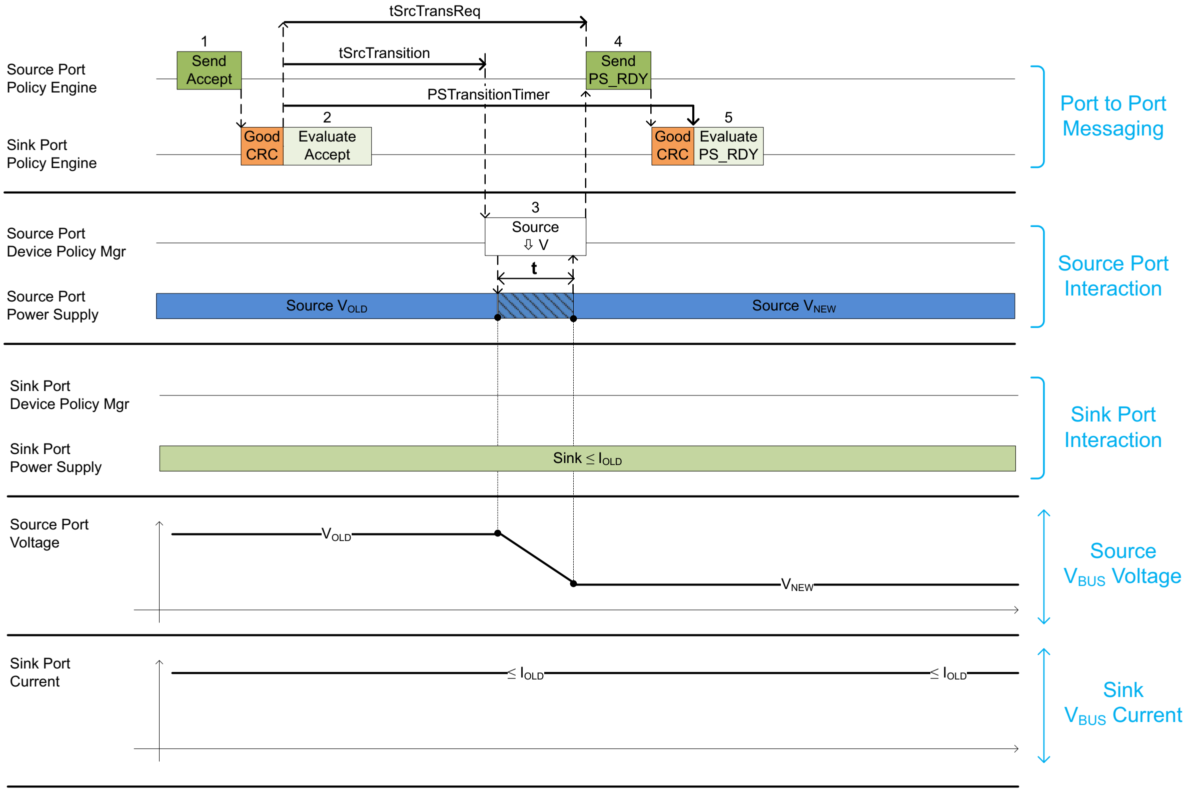


Table 7.5 Sequence Description for Decreasing the Voltage

Step	Source Port	Sink Port
1	*Policy Engine* sends the ***Accept*** *Message* to the *Sink*.	*Policy Engine* receives the ***Accept*** *Message*.
2	*Protocol Layer* receives the ***GoodCRC*** *Message* from the *Sink*. The *Policy Engine* tells the *Device Policy Manager* to instruct the power supply to modify its output power.	*Protocol Layer* sends the ***GoodCRC*** *Message* to the *Source*. *Policy Engine* then starts the ***PSTransitionTimer*** and evaluates the ***Accept*** *Message*.
3	***tSrcTransition*** after the ***GoodCRC*** *Message* was received, the power supply starts to change its output power capability. The power supply ***Shall*** be ready to operate at the new power level within ***tSrcReady*** (t1). The power supply informs the *Device Policy Manager* that it is ready to operate at the new power level. The power supply status is passed to the *Policy Engine*.	
4	The *Policy Engine* sends the ***PS_RDY*** *Message* to the *Sink* within ***tSrcTransReq*** of the end of the ***GoodCRC*** *Message* following the ***Accept*** *Message*.	The *Policy Engine* receives the ***PS_RDY*** *Message* from the *Source*.
5	*Protocol Layer* receives the ***GoodCRC*** *Message* from the *Sink*.	*Protocol Layer* sends the ***GoodCRC*** *Message* to the *Source*. *Policy Engine* then stops the ***PSTransitionTimer***, evaluates the ***PS_RDY*** *Message* from the *Source* and tells the *Device Policy Manager* that the *Source* is operating at the new *(A)PDO*. If the ***PS_RDY*** *Message* is not received before ***PSTransitionTimer*** times out the *Sink* sends ***Hard Reset*** *Signaling*.

7.3.1.1.1.6 Decreasing the Voltage and the Current

The interaction of the *System Policy*, *Device Policy*, and power supply that ***Shall*** be followed when changing from one *(A)PDO* to another while decreasing the voltage and current is shown in *Figure 7.28, "Transition Diagram for no change in Current or Voltage"*. The sequence that ***Shall*** be followed is described in *Table 7.6, "Sequence Description for Decreasing the Voltage and the Current"*. The timing parameters that ***Shall*** be followed are listed in *Table 7.23, "Source Electrical Parameters"*, *Table 7.24, "Sink Electrical Parameters"*, and *Table 7.25, "Common Source/Sink Electrical Parameters"*.

Note: In *Figure 7.27, "Transition Diagram for Decreasing the Voltage and the Current"*, the *Sink* has previously sent a *Request Message* to the *Source*.

Figure 7.27 Transition Diagram for Decreasing the Voltage and the Current

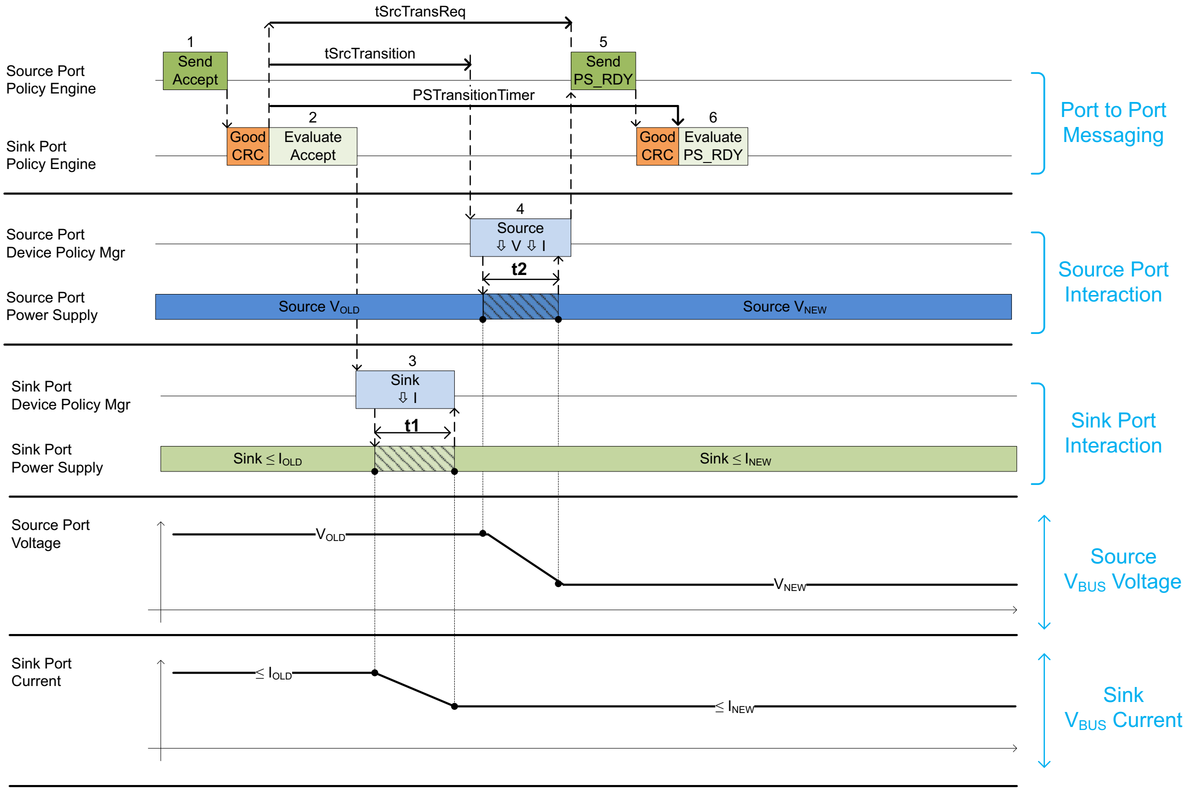


Table 7.6 Sequence Description for Decreasing the Voltage and the Current

Step	Source Port	Sink Port
1	*Policy Engine* sends the ***Accept*** *Message* to the *Sink*.	*Policy Engine* receives the ***Accept*** *Message*.
2	*Protocol Layer* receives the ***GoodCRC*** *Message* from the *Sink*. The *Policy Engine* tells the *Device Policy Manager* to instruct the power supply to modify its output power.	*Protocol Layer* sends the ***GoodCRC*** *Message* to the *Source*. *Policy Engine* then starts the ***PSTransitionTimer*** and evaluates the ***Accept*** *Message*.
3		The *Sink* ***Shall*** be able to operate with lower current within ***tSnkNewPower*** (t1); t1 ***Shall*** complete before ***tSrcTransition***. The *Sink* ***Shall Not*** violate transient load behavior defined in *Section 7.2.6, "Transient Load Behavior"* while transitioning to and operating at the new power level.
4	***tSrcTransition*** after the ***GoodCRC*** *Message* was received, the power supply starts to change its output power capability. The power supply ***Shall*** be ready to operate at the new power level within ***tSrcReady*** (t2). The power supply informs the *Device Policy Manager* that it is ready to operate at the new power level. The power supply status is passed to the *Policy Engine*.	
5	The *Policy Engine* sends the ***PS_RDY*** *Message* to the *Sink* starting within ***tSrcTransReq*** of the end of the ***GoodCRC*** *Message* following the ***Accept*** *Message*.	The *Policy Engine* receives the ***PS_RDY*** *Message* from the *Source*.
6	*Protocol Layer* receives the ***GoodCRC*** *Message* from the *Sink*.	*Protocol Layer* sends the ***GoodCRC*** *Message* to the *Source*. *Policy Engine* then stops the ***PSTransitionTimer***, evaluates the ***PS_RDY*** *Message* from the *Source* and tells the *Device Policy Manager* that the *Source* is operating at the new *(A)PDO*. If the ***PS_RDY*** *Message* is not received before ***PSTransitionTimer*** times out the *Sink* sends ***Hard Reset*** *Signaling*.
7		The *Sink* ***Shall Not*** violate the transient load behavior defined in *Section 7.2.6, "Transient Load Behavior"* while transitioning to and operating at the new power level.

7.3.1.1.1.7 No change in Current or Voltage

The interaction of the *System Policy*, *Device Policy*, and power supply that ***Shall*** be followed when changing from one *(A)PDO* to another while the *Sink* requests the same voltage and Current as it is currently operating at is shown in *Figure 7.28, "Transition Diagram for no change in Current or Voltage"*. The sequence that ***Shall*** be followed is described in *Table 7.7, "Sequence Description for no change in Current or Voltage"*. The timing parameters that ***Shall*** be followed are listed in *Table 7.23, "Source Electrical Parameters"*, *Table 7.24, "Sink Electrical Parameters"*, and *Table 7.25, "Common Source/Sink Electrical Parameters"*.

Note: In *Figure 7.28, "Transition Diagram for no change in Current or Voltage"*, the *Sink* has previously sent a *Request Message* to the *Source*.

Figure 7.28 Transition Diagram for no change in Current or Voltage

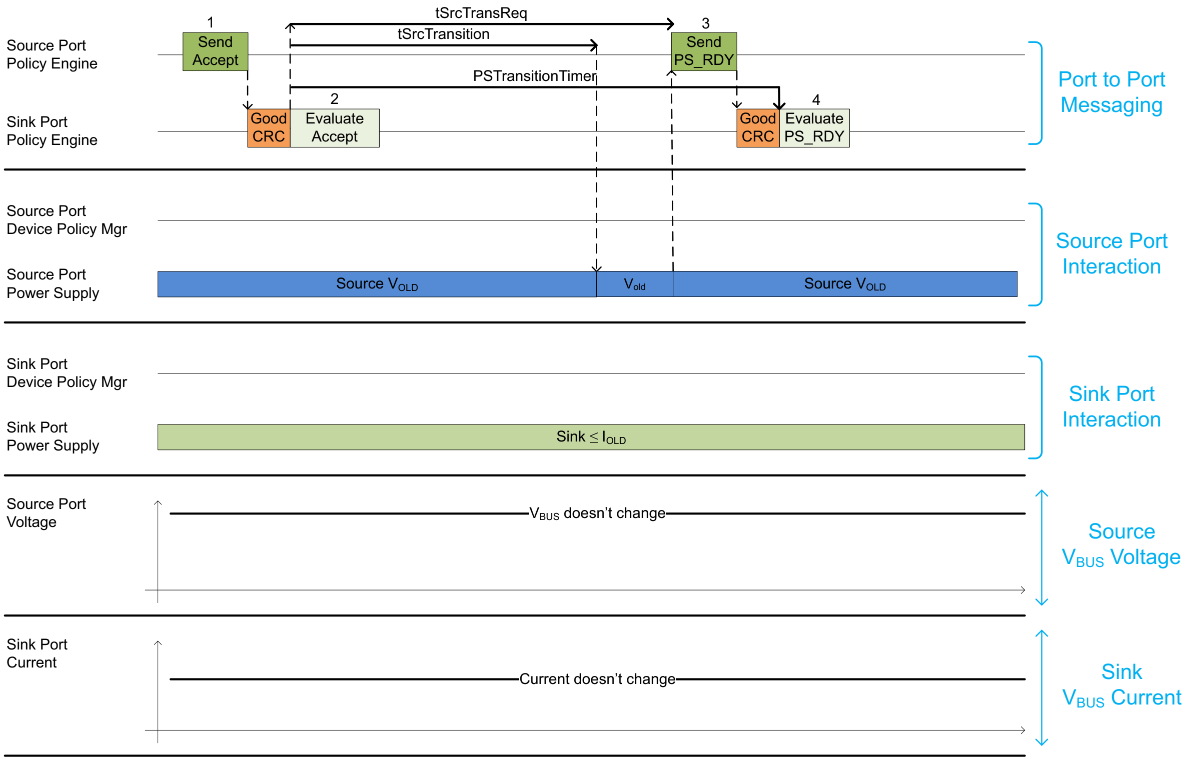


Table 7.7 Sequence Description for no change in Current or Voltage

Step	Source Port	Sink Port
1	*Policy Engine* sends the ***Accept*** *Message* to the *Sink*.	*Policy Engine* receives the ***Accept*** *Message*.
2	*Protocol Layer* receives the ***GoodCRC*** *Message* from the *Sink*.	*Protocol Layer* sends the ***GoodCRC*** *Message* to the *Source*. *Policy Engine* then starts the ***PSTransitionTimer*** and evaluates the ***Accept*** *Message*.
3	The *Policy Engine* waits ***tSrcTransition*** then sends the ***PS_RDY*** *Message* to the *Sink* starting within ***tSrcTransReq*** of the end of the ***GoodCRC*** *Message* following the ***Accept*** *Message*.	*Policy Engine* receives the ***PS_RDY*** *Message*.
4	*Policy Engine* receives the ***GoodCRC*** *Message* from the *Sink*. **Note:** The decision that no power transition is required could be made either by the *Device Policy Manager* or the power supply depending on implementation.	*Protocol Layer* sends the ***GoodCRC*** *Message* to the *Source*. *Policy Engine* evaluates the ***PS_RDY*** *Message*.

7.3.1.2 Transitions within the same Fixed, Battery or Variable PDO or between Different (A)PDOs

7.3.1.2.1 Increasing the Current Only

The interaction of the *System Policy*, *Device Policy*, and power supply that ***Shall*** be followed when increasing the current without changing the voltage is shown in *Figure 7.29, "Transition Diagram for Increasing the Current"*. The sequence that ***Shall*** be followed is described in *Table 7.8, "Sequence Description for Increasing the Current"*. The timing parameters that ***Shall*** be followed are listed in *Table 7.23, "Source Electrical Parameters"*, *Table 7.24, "Sink Electrical Parameters"*, and *Table 7.25, "Common Source/Sink Electrical Parameters"*.

Note: In *Figure 7.29, "Transition Diagram for Increasing the Current"*, the *Sink* has previously sent a *Request Message* to the *Source*.

Figure 7.29 Transition Diagram for Increasing the Current

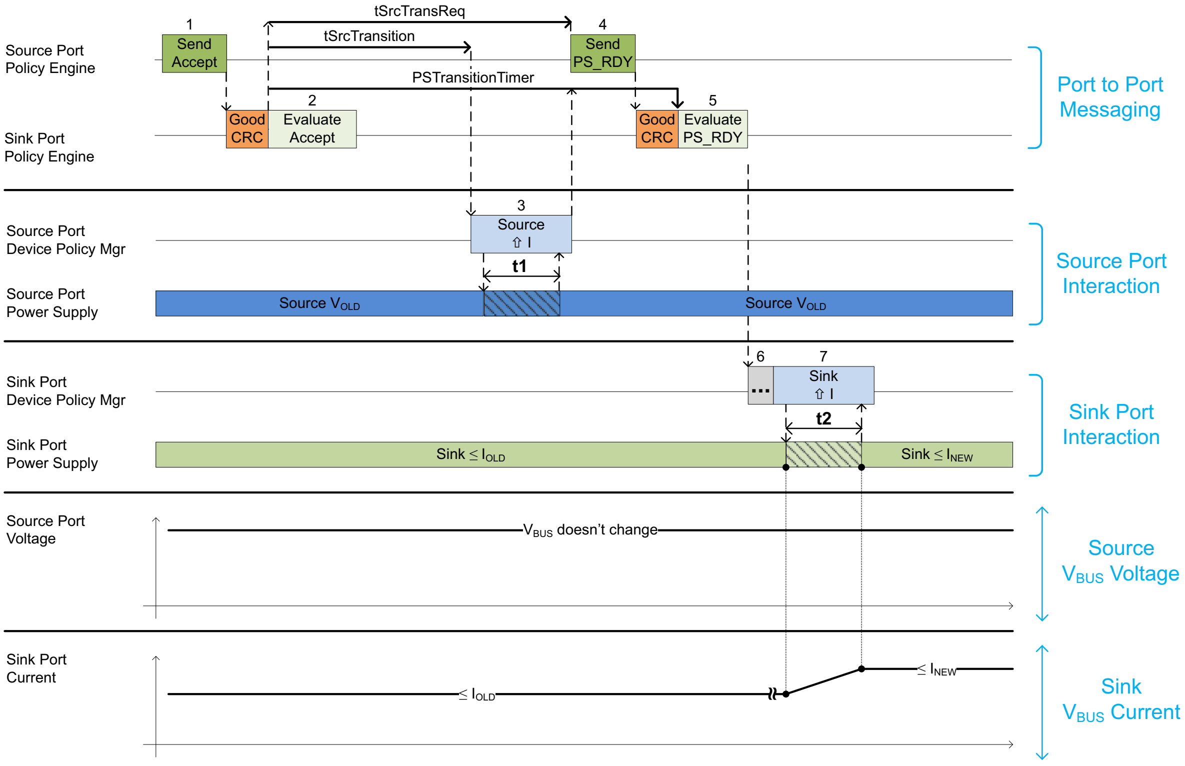


Table 7.8 Sequence Description for Increasing the Current

Step	Source Port	Sink Port
1	*Policy Engine* sends the ***Accept*** *Message* to the *Sink*.	*Policy Engine* receives the ***Accept*** *Message*.
2	*Protocol Layer* receives the ***GoodCRC*** *Message* from the *Sink*. The *Policy Engine* tells the *Device Policy Manager* to instruct the power supply to modify its output power.	*Protocol Layer* sends the ***GoodCRC*** *Message* to the *Source*. *Policy Engine* then starts the ***PSTransitionTimer*** and evaluates the ***Accept*** *Message*.
3	***tSrcTransition*** after the ***GoodCRC*** *Message* was received, the power supply starts to change its output power capability. The power supply ***Shall*** be ready to operate at the new power level within ***tSrcReady*** (t1). The power supply informs the *Device Policy Manager* that it is ready to operate at the new power level. The power supply status is passed to the *Policy Engine*.	
4	The *Policy Engine* sends the ***PS_RDY*** *Message* to the *Sink* starting within ***tSrcTransReq*** of the end of the ***GoodCRC*** *Message* following the ***Accept*** *Message*.	The *Policy Engine* receives the ***PS_RDY*** *Message* from the *Source*.
5	*Protocol Layer* receives the ***GoodCRC*** *Message* from the *Sink*.	*Protocol Layer* sends the ***GoodCRC*** *Message* to the *Source*. *Policy Engine* then stops the ***PSTransitionTimer***, evaluates the ***PS_RDY*** *Message* from the *Source* and tells the *Device Policy Manager* that the *Source* is operating at the new *(A)PDO*. If the ***PS_RDY*** *Message* is not received before ***PSTransitionTimer*** times out the *Sink* sends ***Hard Reset*** *Signaling*.
6		The *Sink* ***May*** begin operating at the new power level any time after evaluation of the ***PS_RDY*** *Message*. This time duration is indeterminate.
7		The *Sink* ***Shall Not*** violate the transient load behavior defined in *Section 7.2.6, "Transient Load Behavior"* while transitioning to and operating at the new power level. The time duration (t2) depends on the magnitude of the load change.

7.3.1.2.2 Decreasing the Current Only

The interaction of the *System Policy*, *Device Policy*, and power supply that ***Shall*** be followed when decreasing the current without changing the voltage is shown in *Figure 7.30, "Transition Diagram for Decreasing the Current"*. The sequence that ***Shall*** be followed is described in *Table 7.9, "Sequence Description for Decreasing the Current"*. The timing parameters that ***Shall*** be followed are listed in *Table 7.23, "Source Electrical Parameters"*, *Table 7.24, "Sink Electrical Parameters"*, and *Table 7.25, "Common Source/Sink Electrical Parameters"*.

Note: In *Figure 7.30, "Transition Diagram for Decreasing the Current"*, the *Sink* has previously sent a *Request Message* to the *Source*.

Figure 7.30 Transition Diagram for Decreasing the Current

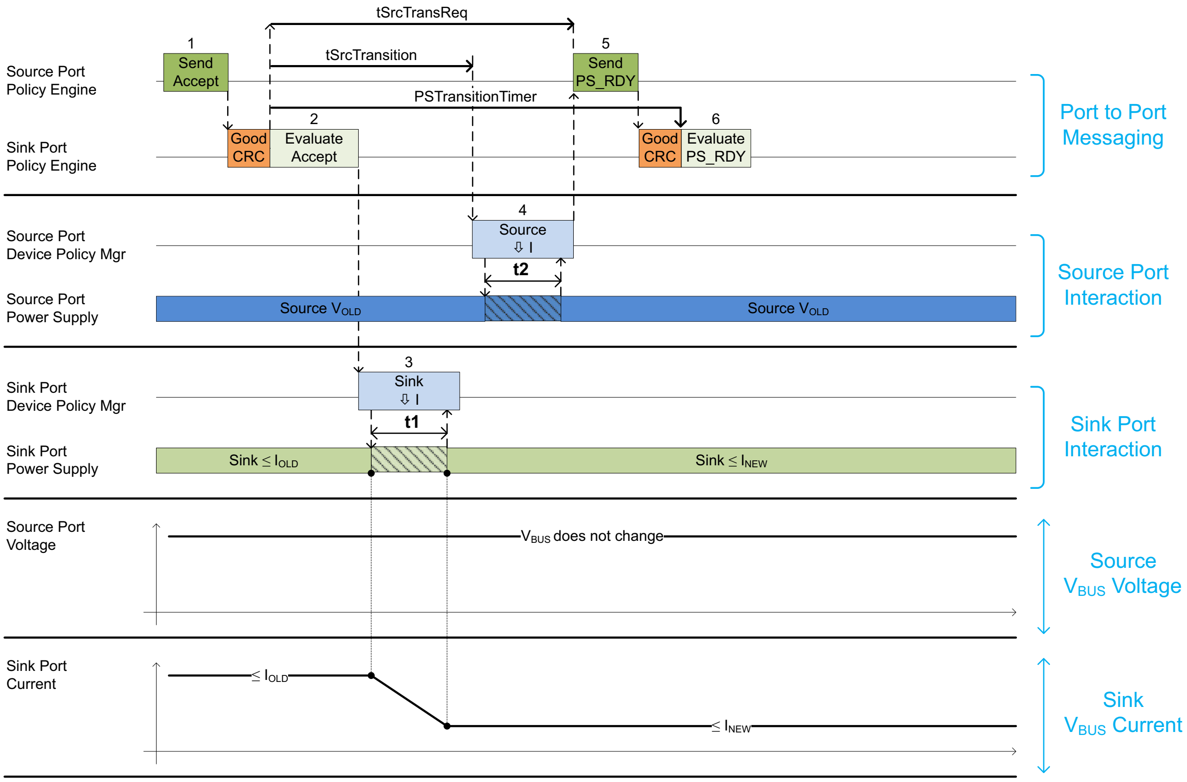


Table 7.9 Sequence Description for Decreasing the Current

Step	Source Port	Sink Port
1	*Policy Engine* sends the ***Accept*** *Message* to the *Sink*.	*Policy Engine* receives the ***Accept*** *Message*.
2	*Protocol Layer* receives the ***GoodCRC*** *Message* from the *Sink*. The *Policy Engine* tells the *Device Policy Manager* to instruct the power supply to modify its output power.	*Protocol Layer* sends the ***GoodCRC*** *Message* to the *Source*. *Policy Engine* then starts the ***PSTransitionTimer*** and evaluates the ***Accept*** *Message*. *Policy Engine* tells the *Device Policy Manager* to instruct the power supply to reduce power consumption.
3		The *Sink* ***Shall Not*** violate the transient load behavior defined in *Section 7.2.6, "Transient Load Behavior"* while transitioning to and operating at the new power level. The *Sink* ***Shall*** be able to operate with lower current within ***tSnkNewPower*** (t1); t1 ***Shall*** complete before ***tSrcTransition***.
4	***tSrcTransition*** after the ***GoodCRC*** *Message* was received, the power supply starts to change its output power capability. The power supply ***Shall*** be ready to operate at the new power level within ***tSrcReady*** (t2). The power supply informs the *Device Policy Manager* that it is ready to operate at the new power level. The power supply status is passed to the *Policy Engine*.	
5	The *Policy Engine* sends the ***PS_RDY*** *Message* to the *Sink* starting within ***tSrcTransReq*** of the end of the ***GoodCRC*** *Message* following the ***Accept*** *Message*.	The *Policy Engine* receives the ***PS_RDY*** *Message* from the *Source*.
6	*Protocol Layer* receives the ***GoodCRC*** *Message* from the *Sink*.	*Protocol Layer* sends the ***GoodCRC*** *Message* to the *Source*. *Policy Engine* then stops the ***PSTransitionTimer***, evaluates the ***PS_RDY*** *Message* from the *Source* and tells the *Device Policy Manager* that the *Source* is operating at the new *(A)PDO*. If the ***PS_RDY*** *Message* is not received before ***PSTransitionTimer*** times out the *Sink* sends ***Hard Reset*** *Signaling*.

7.3.1.3 Changing Voltage or Current within the same PPS APDO

7.3.1.3.1 Increasing the Programmable Power Supply (PPS) Voltage

The interaction of the *System Policy*, *Device Policy*, and power supply that ***Shall*** be followed when increasing the voltage is shown in *Figure 7.31, "Transition Diagram for Increasing the Programmable Power Supply Voltage"*. The sequence that ***Shall*** be followed is described in *Table 7.10, "Sequence Description for Increasing the Programmable Power Supply Voltage"*. The timing parameters that ***Shall*** be followed are listed in *Table 7.23, "Source Electrical Parameters"*, *Table 7.24, "Sink Electrical Parameters"*, and *Table 7.25, "Common Source/Sink Electrical Parameters"*.

Note: In *Figure 7.31, "Transition Diagram for Increasing the Programmable Power Supply Voltage"*, the *Sink* has previously sent a *Request Message* to the *Source*.

Figure 7.31 Transition Diagram for Increasing the Programmable Power Supply Voltage

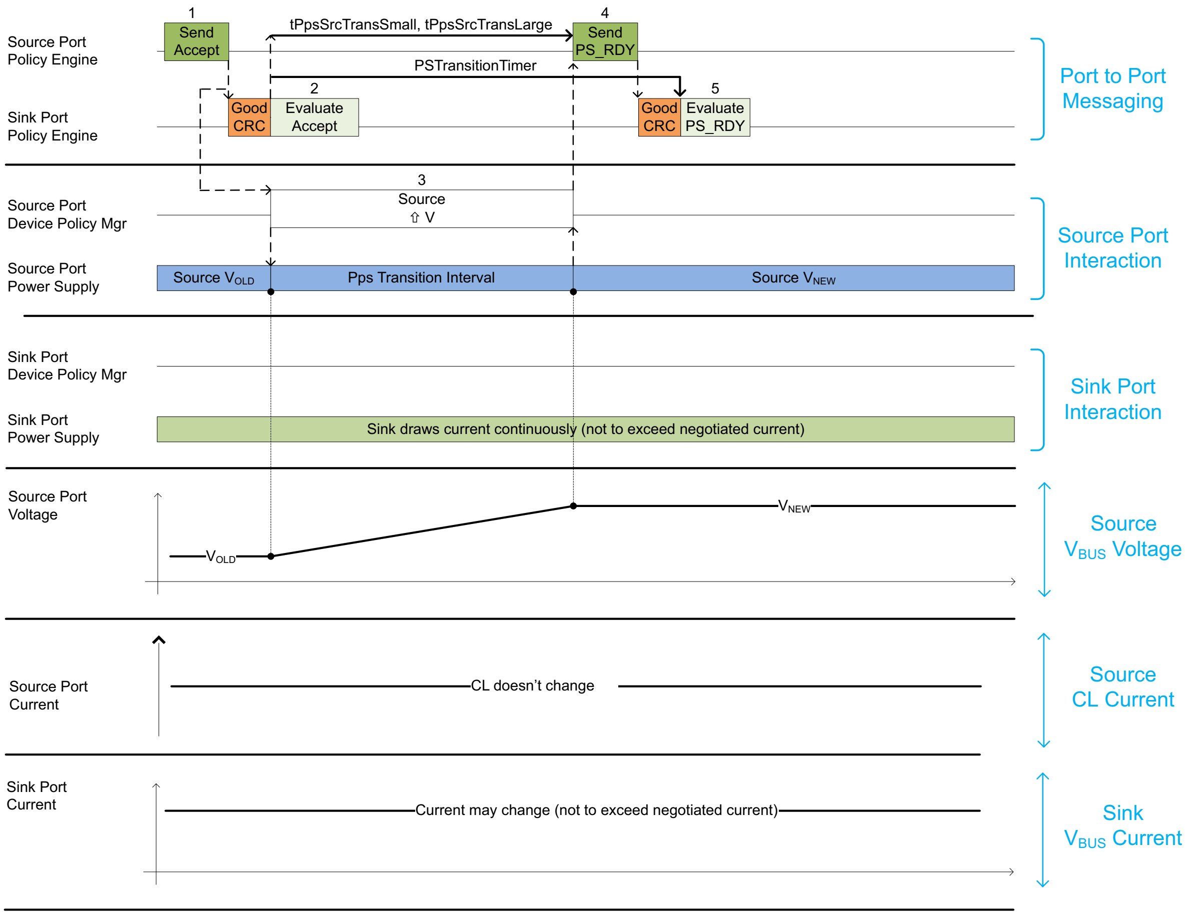


Table 7.10 Sequence Description for Increasing the Programmable Power Supply Voltage

Step	Source Port	Sink Port
1	*Policy Engine* sends the ***Accept*** *Message* to the *Sink*.	*Policy Engine* receives the ***Accept*** *Message*.
2	*Protocol Layer* receives the ***GoodCRC*** *Message* from the *Sink*. The *Policy Engine* tells the *Device Policy Manager* to instruct the power supply to increase its output voltage.	*Protocol Layer* sends the ***GoodCRC*** *Message* to the *Source*. *Policy Engine*. *Policy Engine* then starts the ***PSTransitionTimer*** and evaluates the ***Accept*** *Message*.
3	After sending the ***Accept*** *Message*, the Programmable Power Supply starts to increase its output voltage. The Programmable Power Supply new voltage set-point ***Shall*** be reached by ***tPpsSrcTransLarge*** for steps larger than ***vPpsSmallStep*** or else by ***tPpsSrcTransSmall***. The power supply informs the *Device Policy Manager* that it has reached the new set-point and whether *VBUS* is at the corresponding new level, or if the supply is operating in *CL* mode. The power supply status is passed to the *Policy Engine*.	
4	The *Policy Engine* sends the ***PS_RDY*** *Message* to the *Sink* starting within ***tPpsSrcTransSmall*** or ***tPpsSrcTransLarge*** of the end of the ***GoodCRC*** *Message* following the ***Accept*** *Message*.	The *Policy Engine* receives the ***PS_RDY*** *Message* from the *Source*.
5	*Protocol Layer* receives the ***GoodCRC*** *Message* from the *Sink*.	*Protocol Layer* sends the ***GoodCRC*** *Message* to the *Source*. *Policy Engine* then stops the ***PSTransitionTimer***, evaluates the ***PS_RDY*** *Message* from the *Source* and tells the *Device Policy Manager* that the *Source* is operating at the new voltage set point (corresponding to ***vPpsNew***). If the ***PS_RDY*** *Message* is not received before ***PSTransitionTimer*** times out the *Sink* sends ***Hard Reset*** *Signaling*.

7.3.1.3.2 Decreasing the Programmable Power Supply (PPS) Voltage

The interaction of the *System Policy*, *Device Policy*, and power supply that ***Shall*** be followed when decreasing the voltage is shown in *Figure 7.32, "Transition Diagram for Decreasing the Programmable Power Supply Voltage"*. The sequence that ***Shall*** be followed is described in *Table 7.11, "Sequence Description for Decreasing the Programmable Power Supply Voltage"*. The timing parameters that ***Shall*** be followed are listed in *Table 7.23, "Source Electrical Parameters"*, *Table 7.24, "Sink Electrical Parameters"*, and *Table 7.25, "Common Source/Sink Electrical Parameters"*.

Note: In *Figure 7.32, "Transition Diagram for Decreasing the Programmable Power Supply Voltage"*, the *Sink* has previously sent a *Request Message* to the *Source*.

Figure 7.32 Transition Diagram for Decreasing the Programmable Power Supply Voltage

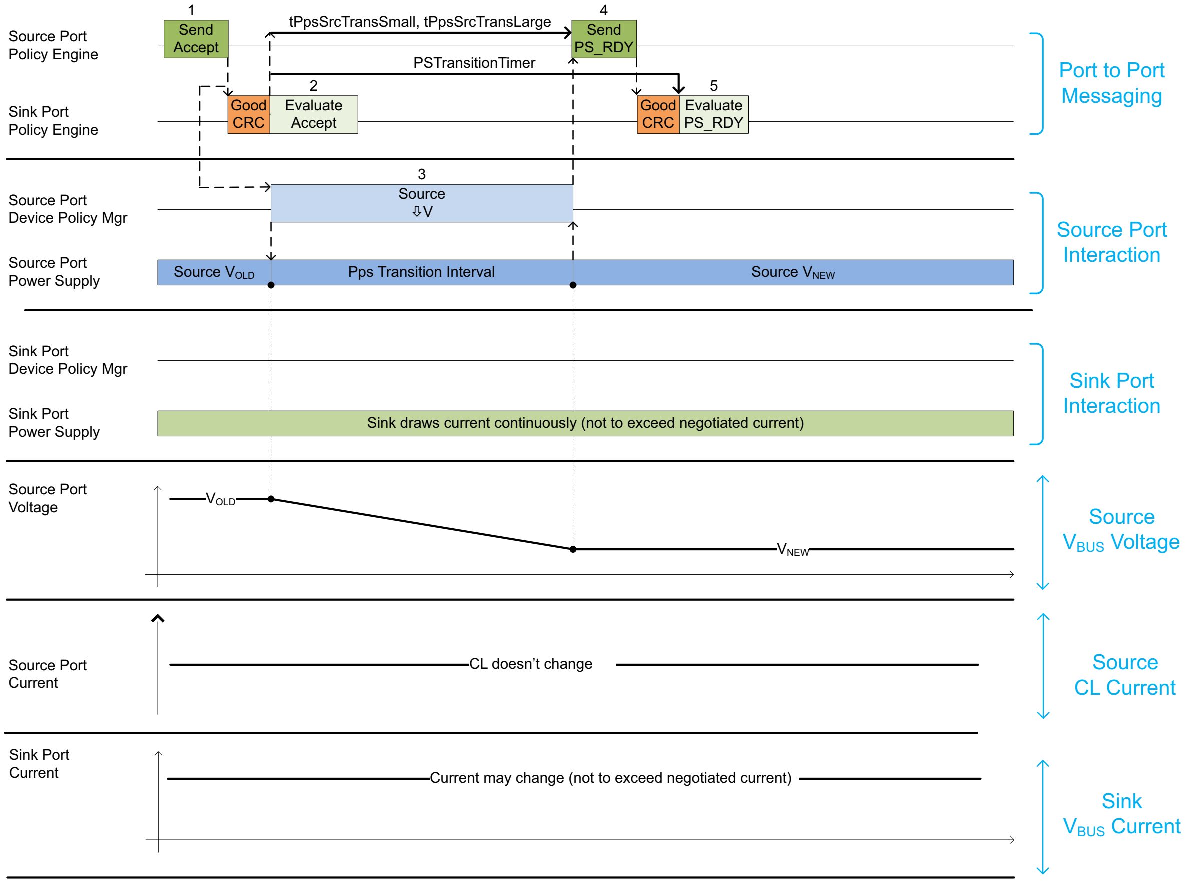


Table 7.11 Sequence Description for Decreasing the Programmable Power Supply Voltage

Step	Source Port	Sink Port
1	*Policy Engine* sends the ***Accept*** *Message* to the *Sink*.	*Policy Engine* receives the ***Accept*** *Message*.
2	*Protocol Layer* receives the ***GoodCRC*** *Message* from the *Sink*. The *Policy Engine* tells the *Device Policy Manager* to instruct the power supply to decrease its output voltage.	*Protocol Layer* sends the ***GoodCRC*** *Message* to the *Source*. *Policy Engine*. *Policy Engine* then starts the ***PSTransitionTimer*** and evaluates the ***Accept*** *Message*.
3	After sending the ***Accept*** *Message*, the Programmable Power Supply starts to decrease its output voltage. The Programmable Power Supply new voltage set-point (corresponding to ***vPpsNew***) ***Shall*** be reached by ***tPpsSrcTransLarge*** for steps larger than ***vPpsSmallStep*** or else by ***tPpsSrcTransSmall***. The power supply informs the *Device Policy Manager* that it has reached the new level. The power supply status is passed to the *Policy Engine*.	
4	The *Policy Engine* sends the ***PS_RDY*** *Message* to the *Sink* starting within ***tPpsSrcTransSmall*** or ***tPpsSrcTransLarge*** of the end of the ***GoodCRC*** *Message* following the ***Accept*** *Message*.	The *Policy Engine* receives the ***PS_RDY*** *Message* from the *Source*.
5	*Protocol Layer* receives the ***GoodCRC*** *Message* from the *Sink*.	*Protocol Layer* sends the ***GoodCRC*** *Message* to the *Source*. *Policy Engine* then stops the ***PSTransitionTimer***, evaluates the ***PS_RDY*** *Message* from the *Source* and tells the *Device Policy Manager* that the *Source* is operating at the new voltage set point (corresponding to ***vPpsNew***). If the ***PS_RDY*** *Message* is not received before ***PSTransitionTimer*** times out the *Sink* sends ***Hard Reset*** *Signaling*.

7.3.1.3.3 Increasing the Programmable Power Supply (PPS) Current

The interaction of the *System Policy*, *Device Policy*, and power supply that ***Shall*** be followed when increasing the current limit in the same *APDO*, not exceeding the maximum for that *APDO* and without changing the requested voltage is shown in *Figure 7.33, "Transition Diagram for increasing the Current in PPS mode"*. The sequence that ***Shall*** be followed is described in *Table 7.12, "Sequence Description for increasing the Current in PPS mode"*. The timing parameters that ***Shall*** be followed are listed in *Table 7.23, "Source Electrical Parameters"*, *Table 7.24, "Sink Electrical Parameters"*, and *Table 7.25, "Common Source/Sink Electrical Parameters"*.

Note: In *Figure 7.33, "Transition Diagram for increasing the Current in PPS mode"*, the *Sink* has previously sent a ***Request*** *Message* to the *Source*.

The *Sink* ***May*** draw current equal to the increasing *Current Limit* of the *Source* before it has received the ***PS_RDY*** *Message* for the new *Request*.

Figure 7.33 Transition Diagram for increasing the Current in PPS mode

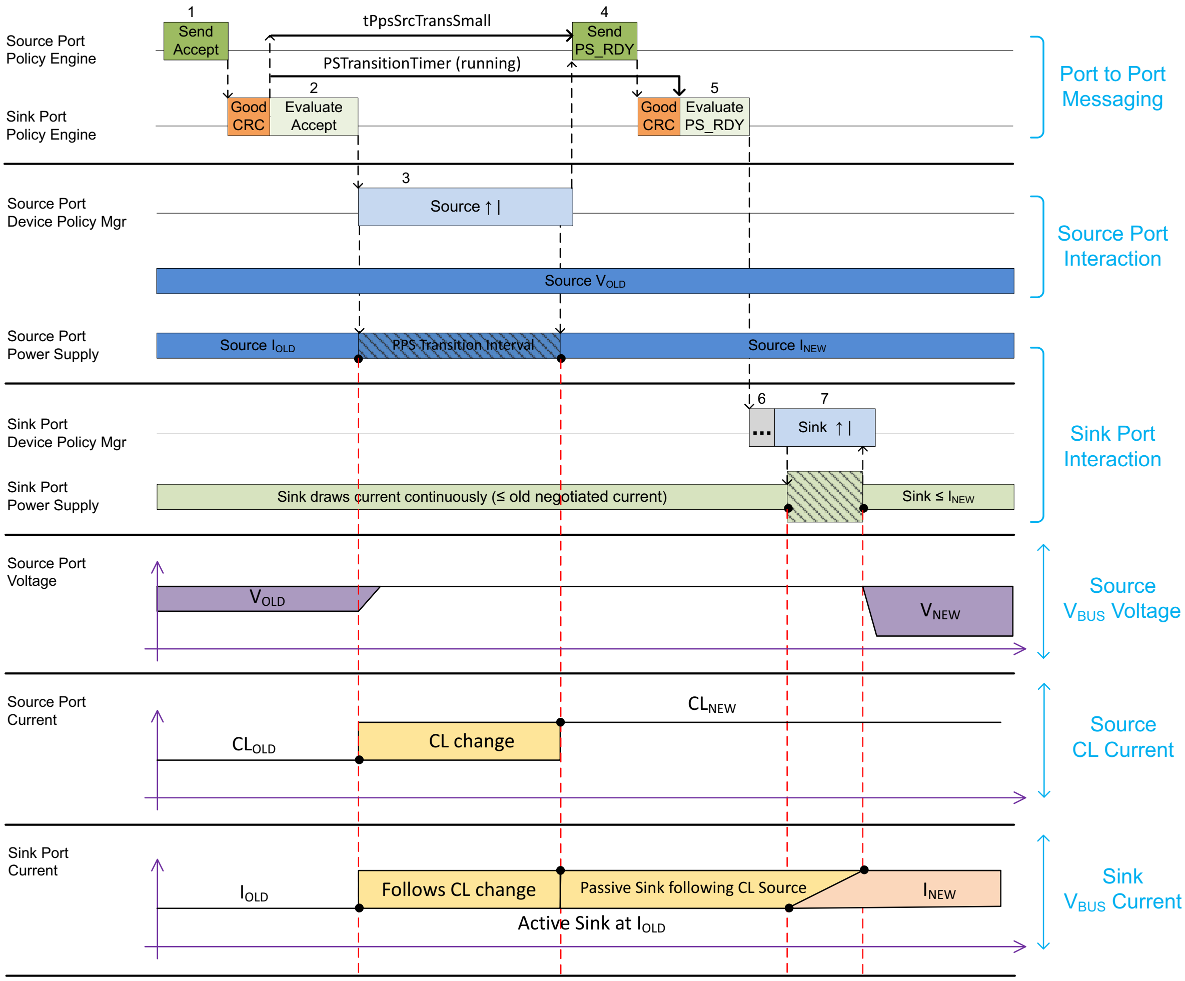


Table 7.12 Sequence Description for increasing the Current in PPS mode

Step	Source Port	Sink Port
1	*Policy Engine* sends the ***Accept*** *Message* to the *Sink*.	*Policy Engine* receives the ***Accept*** *Message*.
2	*Protocol Layer* receives the ***GoodCRC*** *Message* from the *Sink*. The *Policy Engine* tells the *Device Policy Manager* to instruct the power supply to increase its set-point for the current limit.	*Protocol Layer* sends the ***GoodCRC*** *Message* to the *Source*. *Policy Engine* then starts the ***PSTransitionTimer*** and evaluates the ***Accept*** *Message*.
3	The Power Supply increases its *Current Limit* set-point to the new requested value.	The *Sink* draws current according to the increased *Current Limit* of the *Source*.
4	The *Policy Engine* waits ***tPpsSrcTransSmall*** then sends the ***PS_RDY*** *Message* to the *Sink* starting within ***tPpsCLProgramSettle*** of the end of the ***GoodCRC*** *Message* following the ***Accept*** *Message*.	*Policy Engine* receives the ***PS_RDY*** *Message*.
5	*Policy Engine* receives the ***GoodCRC*** *Message* from the *Sink*.	*Protocol Layer* sends the ***GoodCRC*** *Message* to the *Source*.
6		*Policy Engine* then stops the ***PSTransitionTimer***, evaluates the ***PS_RDY*** *Message* and tells the *Device Policy Manager* it can increase the current up to the requested value without the *Source* going into *CL* mode. If the ***PS_RDY*** *Message* is not received before ***PSTransitionTimer*** times out the *Sink* sends ***Hard Reset*** *Signaling*.
7		The *Sink* increases its current.

7.3.1.3.4 Decreasing the Programmable Power Supply (PPS) Current

The interaction of the *System Policy*, *Device Policy*, and power supply that ***Shall*** be followed when decreasing the current limit in the same *APDO*, not exceeding the minimum for that *APDO* and without changing the requested voltage is shown in *Figure 7.34, "Transition Diagram for decreasing the Current in PPS mode"*. The sequence that ***Shall*** be followed is described in *Table 7.13, "Sequence Description for decreasing the Current in PPS mode"*. The timing parameters that ***Shall*** be followed are listed in *Table 7.23, "Source Electrical Parameters"*, *Table 7.24, "Sink Electrical Parameters"*, and *Table 7.25, "Common Source/Sink Electrical Parameters"*.

Note: In *Figure 7.34, "Transition Diagram for decreasing the Current in PPS mode"*, the *Sink* has previously sent a *Request Message* to the *Source*.

Figure 7.34 Transition Diagram for decreasing the Current in PPS mode

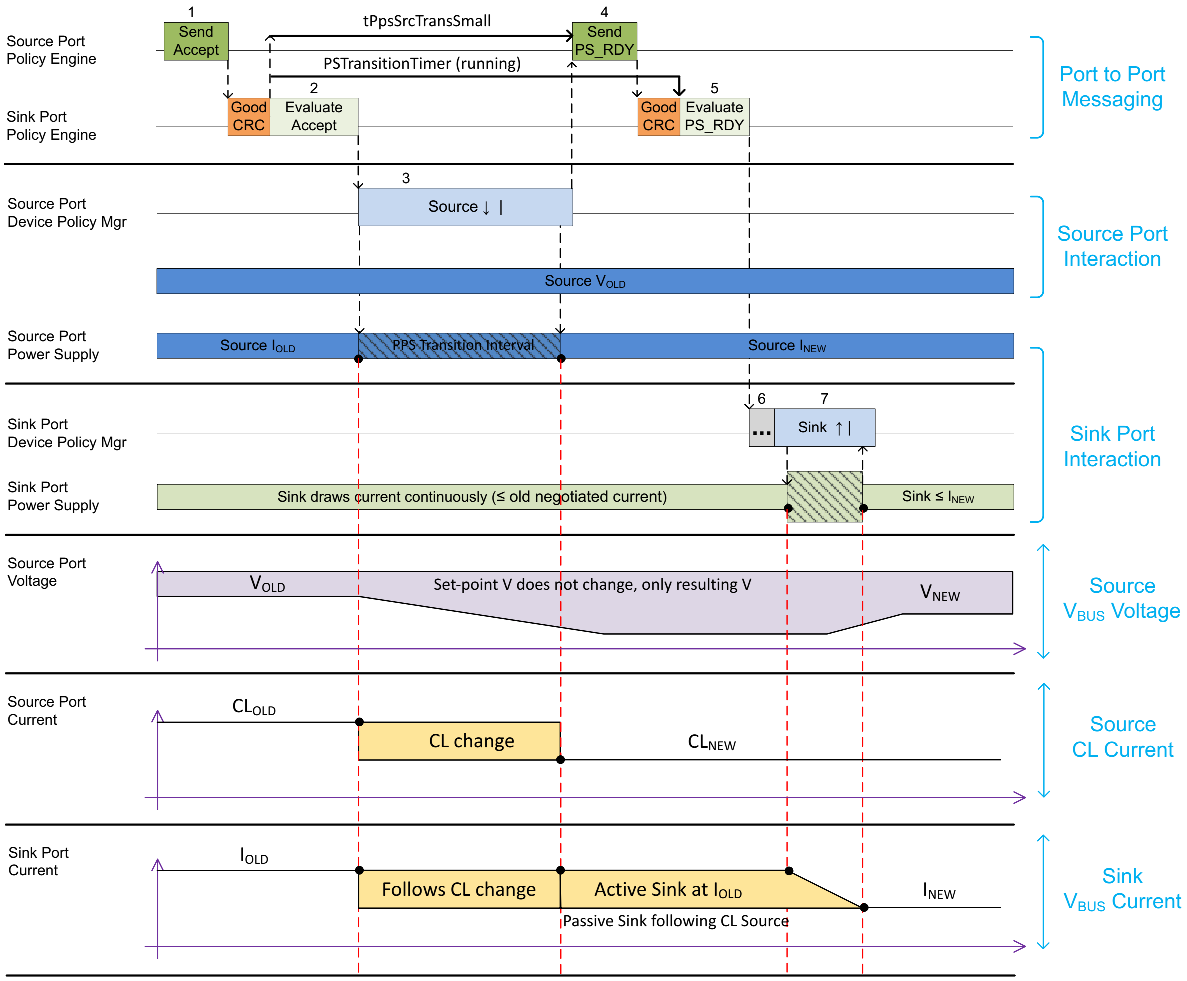


Table 7.13 Sequence Description for decreasing the Current in PPS mode

Step	Source Port	Sink Port
1	*Policy Engine* sends the ***Accept*** *Message* to the *Sink*.	*Policy Engine* receives the ***Accept*** *Message*.
2	*Protocol Layer* receives the ***GoodCRC*** *Message* from the *Sink*. The *Policy Engine* tells the *Device Policy Manager* to instruct the power supply to decrease its set-point for the current limit.	*Protocol Layer* sends the ***GoodCRC*** *Message* to the *Source*. *Policy Engine* then evaluates the ***Accept*** *Message* and instructs the *Sink* to reduce its current to below the new *Negotiated* current level and starts the ***PSTransitionTimer***.
3	The Power Supply decreases its *Current Limit* set-point to the new *Negotiated* value.	The *Sink* reduces its current to less than the new *Negotiated* current to prevent the *Source* from going into *Current Limit*.
4	The *Policy Engine* sends the ***PS_RDY*** *Message* to the *Sink* starting within ***tPpsSrcTransSmall*** of the end of the ***GoodCRC*** *Message* following the ***Accept*** *Message*.	
5	*Policy Engine* receives the ***GoodCRC*** *Message* from the *Sink*.	*Policy Engine* receives the ***PS_RDY*** *Message*.
6		*Protocol Layer* sends the ***GoodCRC*** *Message* to the *Source*. *Policy Engine* then stops the ***PSTransitionTimer*** and evaluates the ***PS_RDY*** *Message*. If the ***PS_RDY*** *Message* is not received before ***PSTransitionTimer*** times out the *Sink* sends ***Hard Reset*** *Signaling*.
7		The *Sink* is allowed to draw I_{NEW} but must be aware the voltage on *VBUS* can drop doing so.

7.3.1.3.5 Same Request Programmable Power Supply (PPS)

The interaction of the *System Policy*, *Device Policy*, and power supply that ***Shall*** be followed when the *Sink* requests the same voltage and current levels as the present *Negotiated* levels for voltage and current is shown in *Figure 7.35, "Transition Diagram for no change in Current or Voltage in PPS mode"*. The sequence that ***Shall*** be followed is described in *Table 7.14, "Sequence Description for no change in Current or Voltage in PPS mode"*. The timing parameters that ***Shall*** be followed are listed in *Table 7.23, "Source Electrical Parameters"*, *Table 7.24, "Sink Electrical Parameters"*, and *Table 7.25, "Common Source/Sink Electrical Parameters"*.

Note: In *Figure 7.35, "Transition Diagram for no change in Current or Voltage in PPS mode"*, the *Sink* has previously sent a *Request Message* to the *Source*.

Figure 7.35 Transition Diagram for no change in Current or Voltage in PPS mode

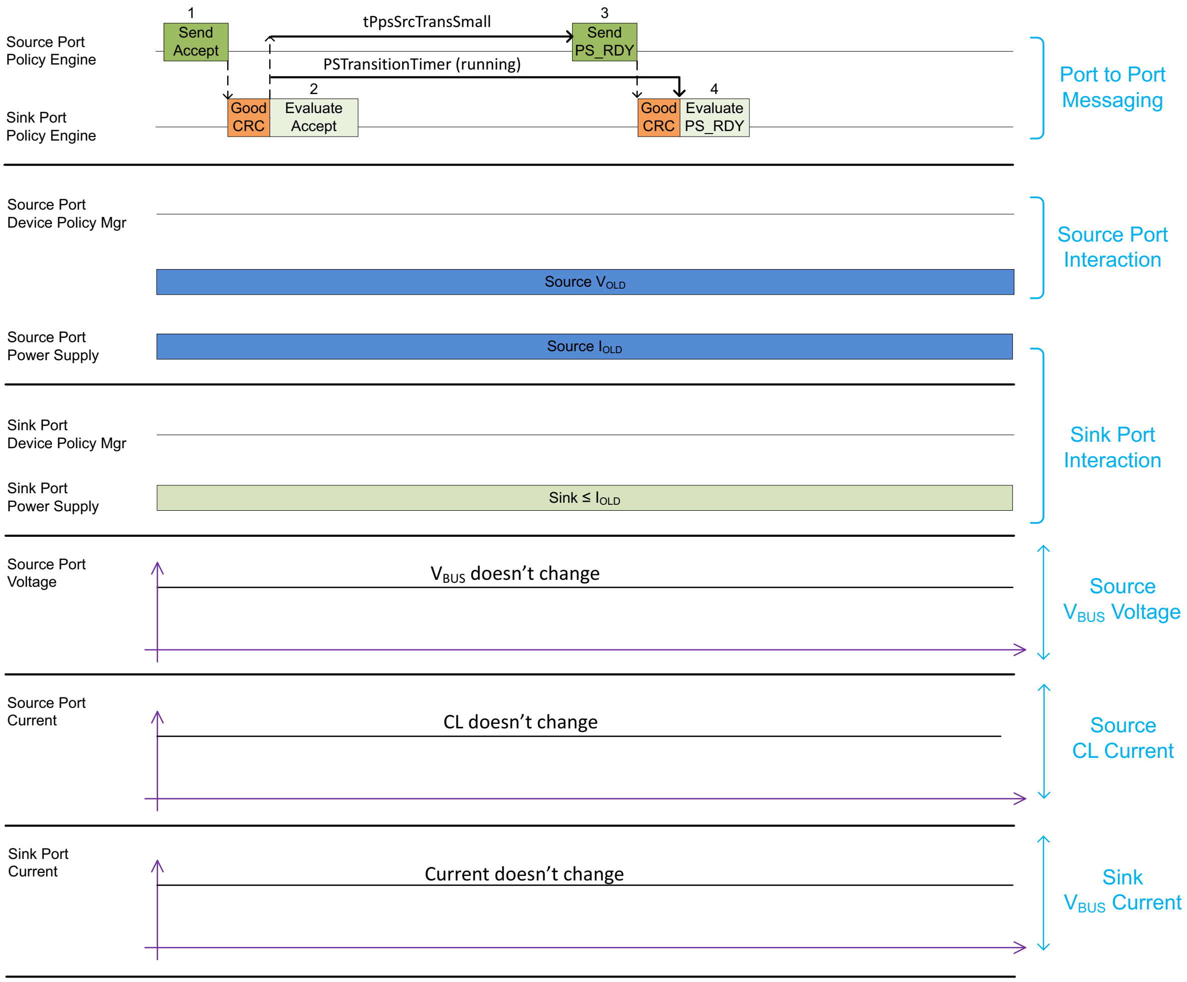


Table 7.14 Sequence Description for no change in Current or Voltage in PPS mode

Step	Source Port	Sink Port
1	*Policy Engine* sends the ***Accept*** *Message* to the *Sink*.	*Policy Engine* receives the ***Accept*** *Message*.
2	*Protocol Layer* receives the ***GoodCRC*** *Message* from the *Sink*.	*Protocol Layer* sends the ***GoodCRC*** *Message* to the *Source*. *Policy Engine* then evaluates the ***Accept*** *Message* and starts the ***PSTransitionTimer***.
3	The *Policy Engine* then sends the ***PS_RDY*** *Message* to the *Sink* starting within ***tPpsSrcTransSmall*** of the end of the ***GoodCRC*** *Message* following the ***Accept*** *Message*.	*Policy Engine* receives the ***PS_RDY*** *Message*.
4	*Policy Engine* receives the ***GoodCRC*** *Message* from the *Sink*. **Note:** The decision that no power transition is required could be made either by the *Device Policy Manager* or the power supply depending on implementation.	*Protocol Layer* sends the ***GoodCRC*** *Message* to the *Source*. *Policy Engine* then stops the ***PSTransitionTimer*** and evaluates the ***PS_RDY*** *Message* from the *Source*. The *Sink* is already operating at the new power level, so no further action is required. If the ***PS_RDY*** *Message* is not received before ***PSTransitionTimer*** times out the *Sink* sends ***Hard Reset*** *Signaling*.

7.3.1.4 Changing Voltage or Current within the same AVS APDO

7.3.1.4.1 Increasing the Adjustable Voltage Supply (AVS) Voltage

The interaction of the *System Policy*, *Device Policy*, and power supply that ***Shall*** be followed when increasing the voltage is shown in *Figure 7.36, "Transition Diagram for Increasing the Adjustable Power Supply Voltage"*. The sequence that ***Shall*** be followed is described in *Table 7.15, "Sequence Description for Increasing the Adjustable Voltage Supply Voltage"*. The timing parameters that ***Shall*** be followed are listed in*Table 7.23, "Source Electrical Parameters"*, *Table 7.24, "Sink Electrical Parameters"*, and *Table 7.25, "Common Source/Sink Electrical Parameters"*.

Note: In *Figure 7.36, "Transition Diagram for Increasing the Adjustable Power Supply Voltage"*, the *Sink* has previously sent a *Request Message* to the *Source*.

Figure 7.36 Transition Diagram for Increasing the Adjustable Power Supply Voltage

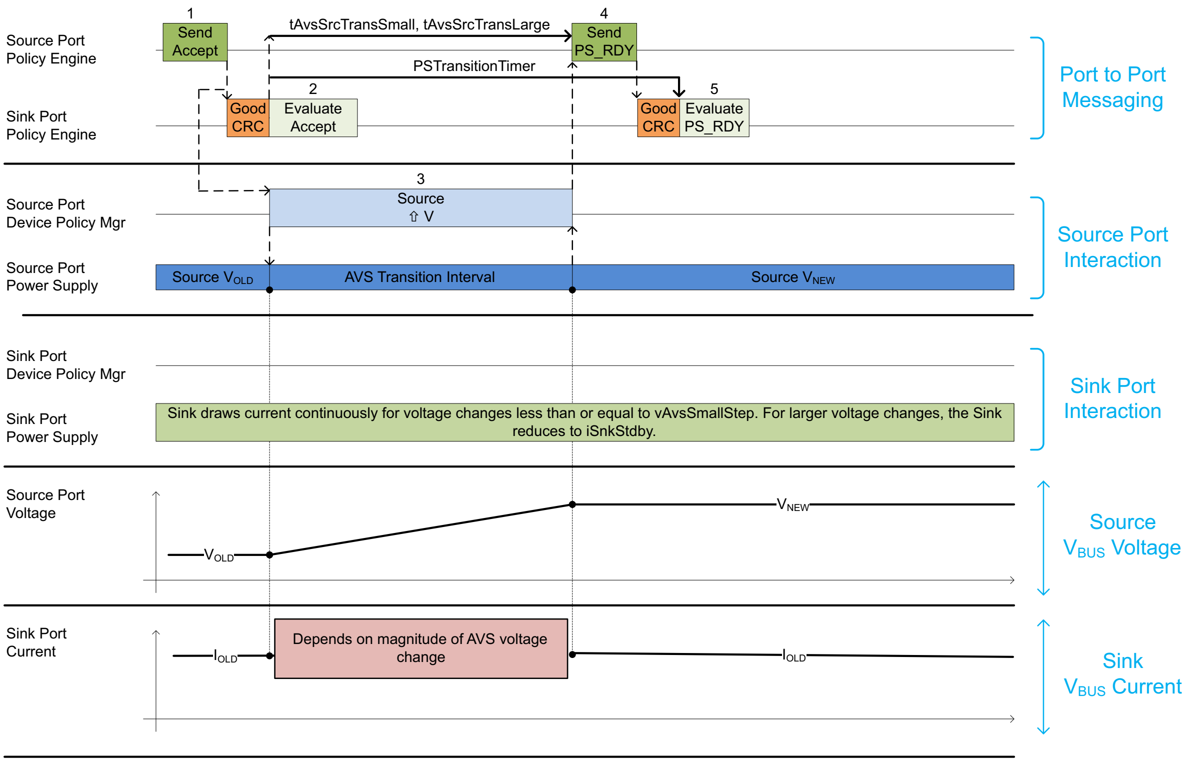


Table 7.15 Sequence Description for Increasing the Adjustable Voltage Supply Voltage

Step	Source Port	Sink Port
1	*Policy Engine* sends the ***Accept*** *Message* to the *Sink*.	*Policy Engine* receives the ***Accept*** *Message*.
2	*Protocol Layer* receives the ***GoodCRC*** *Message* from the *Sink*. The *Policy Engine* tells the *Device Policy Manager* to instruct the power supply to increase its output voltage.	*Protocol Layer* sends the ***GoodCRC*** *Message* to the *Source*. *Policy Engine*. *Policy Engine* then starts the ***PSTransitionTimer*** and evaluates the ***Accept*** *Message*. If the voltage increase is larger than ***vAvsSmallStep***, the *Sink* ***Shall*** reduce its current draw to ***iSnkStdby*** within ***tSnkStdby.*** The reduction to ***iSnkStdby*** is not required if the voltage increase is less than or equal to ***vAvsSmallStep***.
3	After sending the ***Accept*** *Message*, the *AVS* starts to increase its output voltage. The *AVS* new voltage set-point ***Shall*** be reached by ***tAvsSrcTransLarge*** for steps larger than ***vAvsSmallStep*** or else by ***tAvsSrcTransSmall***. The power supply informs the *Device Policy Manager* that it has reached the new level. The power supply status is passed to the *Policy Engine*.	
4	The *Policy Engine* sends the ***PS_RDY*** *Message* to the *Sink* starting within ***tAvsSrcTransSmall*** or ***tAvsSrcTransLarge*** of the end of the ***GoodCRC*** *Message* following the ***Accept*** *Message*.	The *Policy Engine* receives the ***PS_RDY*** *Message* from the *Source*.
5	*Protocol Layer* receives the ***GoodCRC*** *Message* from the *Sink*.	*Protocol Layer* sends the ***GoodCRC*** *Message* to the *Source*. *Policy Engine* then stops the ***PSTransitionTimer***, evaluates the ***PS_RDY*** *Message* from the *Source* and tells the *Device Policy Manager* that the *Source* is operating at the new voltage set point. The *Sink* ***May*** begin operating at the new power level any time after evaluation of the ***PS_RDY*** *Message*. If the ***PS_RDY*** *Message* is not received before ***PSTransitionTimer*** times out the *Sink* sends ***Hard Reset*** *Signaling*.

7.3.1.4.2 Decreasing the Adjustable Voltage Supply (AVS) Voltage

The interaction of the *System Policy*, *Device Policy*, and power supply that ***Shall*** be followed when decreasing the voltage is shown in *Figure 7.37, "Transition Diagram for Decreasing the Adjustable Voltage Supply Voltage"*. The sequence that ***Shall*** be followed is described in *Table 7.16, "Sequence Description for Decreasing the Adjustable Voltage Supply Voltage"*. The timing parameters that ***Shall*** be followed are listed in *Table 7.23, "Source Electrical Parameters"*, *Table 7.24, "Sink Electrical Parameters"*, and *Table 7.25, "Common Source/Sink Electrical Parameters"*.

Note: In *Figure 7.37, "Transition Diagram for Decreasing the Adjustable Voltage Supply Voltage"*, the *Sink* has previously sent a *Request Message* to the *Source*.

Figure 7.37 Transition Diagram for Decreasing the Adjustable Voltage Supply Voltage

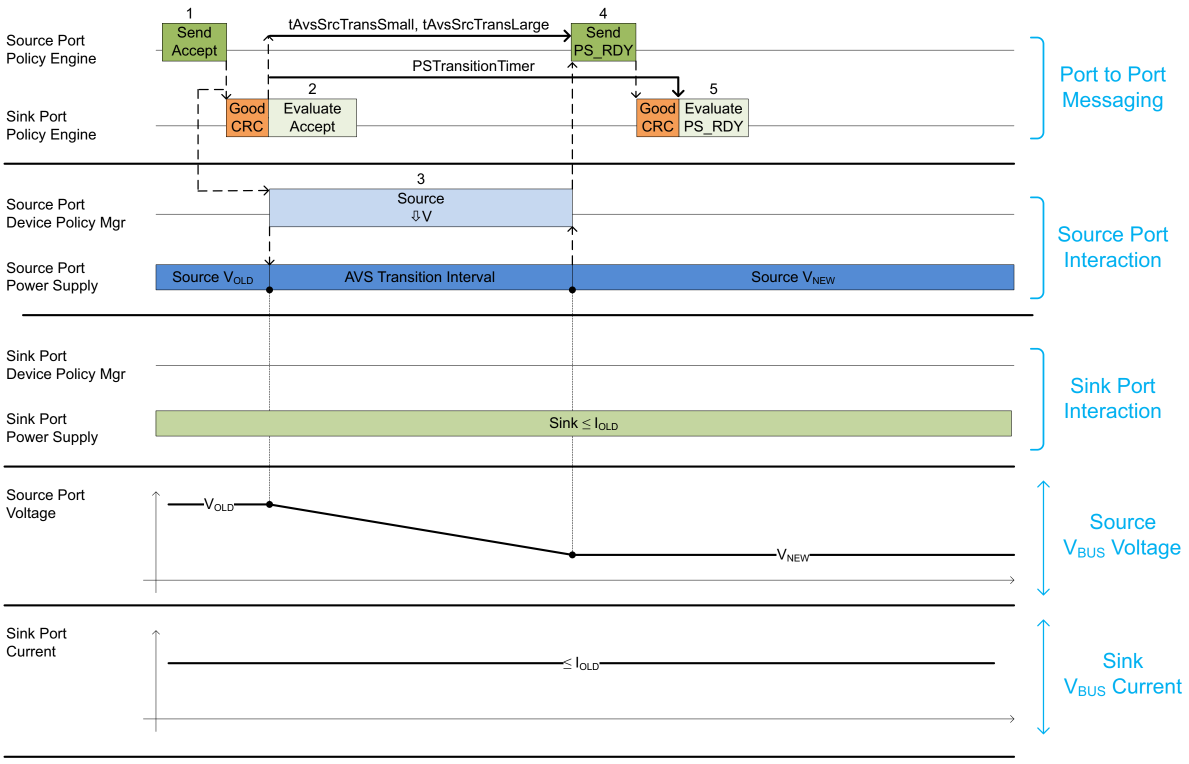


Table 7.16 Sequence Description for Decreasing the Adjustable Voltage Supply Voltage

Step	Source Port	Sink Port
1	*Policy Engine* sends the ***Accept*** *Message* to the *Sink*.	*Policy Engine* receives the ***Accept*** *Message*.
2	*Protocol Layer* receives the ***GoodCRC*** *Message* from the *Sink*. The *Policy Engine* tells the *Device Policy Manager* to instruct the power supply to decrease its output voltage.	*Protocol Layer* sends the ***GoodCRC*** *Message* to the *Source*. *Policy Engine* then and starts the ***PSTransitionTimer*** and evaluates the ***Accept*** *Message*.
3	After sending the ***Accept*** *Message*, the *AVS* starts to decrease its output voltage. The *AVS* new voltage set-point ***Shall*** be reached by ***tAvsSrcTransLarge*** for steps larger than ***vAvsSmallStep*** or else by ***tAvsSrcTransSmall***. The power supply informs the *Device Policy Manager* that it has reached the new level. The power supply status is passed to the *Policy Engine*.	
4	The *Policy Engine* sends the ***PS_RDY*** *Message* to the *Sink* starting within ***tAvsSrcTransSmall*** or ***tAvsSrcTransLarge*** of the end of the ***GoodCRC*** *Message* following the ***Accept*** *Message*.	The *Policy Engine* receives the ***PS_RDY*** *Message* from the *Source*.
5	*Protocol Layer* receives the ***GoodCRC*** *Message* from the *Sink*.	*Protocol Layer* sends the ***GoodCRC*** *Message* to the *Source*. *Policy Engine* then stops the ***PSTransitionTimer***, evaluates the ***PS_RDY*** *Message* from the *Source* and tells the *Device Policy Manager* that the *Source* is operating at the new voltage set point (corresponding to ***vAvsNew***). If the ***PS_RDY*** *Message* is not received before ***PSTransitionTimer*** times out the *Sink* sends ***Hard Reset*** *Signaling*.

7.3.1.4.3 Same Request Adjustable Voltage Supply (AVS) Voltage

The interaction of the *System Policy*, *Device Policy*, and power supply that ***Shall*** be followed when the *Sink* requests the same voltage and current levels as the present *Negotiated* levels for voltage and current as shown in *Figure 7.38, "Transition Diagram for no change in Current or Voltage in AVS mode"*. The sequence that ***Shall*** be followed is described in *Table 7.17, "Sequence Description for no change in Current or Voltage in AVS mode"*. The timing parameters that ***Shall*** be followed are listed in *Table 7.23, "Source Electrical Parameters"*, *Table 7.24, "Sink Electrical Parameters"*, and *Table 7.25, "Common Source/Sink Electrical Parameters"*.

Note: In *Figure 7.38, "Transition Diagram for no change in Current or Voltage in AVS mode"*, the *Sink* has previously sent a *Request Message* to the *Source*.

Figure 7.38 Transition Diagram for no change in Current or Voltage in AVS mode

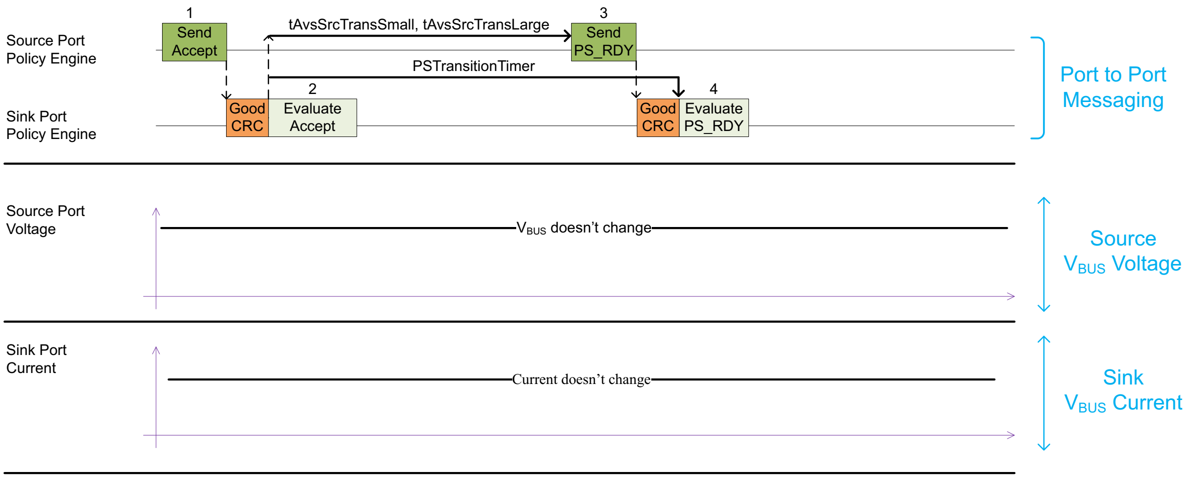


Table 7.17 Sequence Description for no change in Current or Voltage in AVS mode

Step	Source Port	Sink Port
1	*Policy Engine* sends the ***Accept*** *Message* to the *Sink*.	*Policy Engine* receives the ***Accept*** *Message*.
2	*Protocol Layer* receives the ***GoodCRC*** *Message* from the *Sink*.	*Protocol Layer* sends the ***GoodCRC*** *Message* to the *Source*. *Policy Engine* then and starts the ***PSTransitionTimer*** and evaluates the ***Accept*** *Message*.
3	The *Policy Engine* sends the ***PS_RDY*** *Message* to the *Sink* starting within ***tAvsSrcTransSmall*** of the end of the ***GoodCRC*** *Message* following the ***Accept*** *Message*.	The *Policy Engine* receives the ***PS_RDY*** *Message* from the *Source*.
4	*Protocol Layer* receives the ***GoodCRC*** *Message* from the *Sink*. **Note:** The decision that no power transition is required could be made either by the *Device Policy Manager* or the power supply depending on implementation.	*Protocol Layer* sends the ***GoodCRC*** *Message* to the *Source*. *Policy Engine* then stops the ***PSTransitionTimer***, evaluates the ***PS_RDY*** *Message* from the *Source*. The *Sink* is already operating at the new power level, so no further action is required. If the ***PS_RDY*** *Message* is not received before ***PSTransitionTimer*** times out the *Sink* sends ***Hard Reset*** *Signaling*.

7.3.2 Transitions Caused by Power Role Swap

7.3.2.1 Sink Requested Power Role Swap

The interaction of the *System Policy*, *Device Policy*, and power supply that ***Shall*** be followed during a *Sink* requested *Power Role Swap* is shown in *Figure 7.39, "Transition Diagram for a Sink Requested Power Role Swap"*. The sequence that ***Shall*** be followed is described in *Table 7.18, "Sequence Description for a Sink Requested Power Role Swap"*. The timing parameters that ***Shall*** be followed are listed in *Table 7.23, "Source Electrical Parameters"*, *Table 7.24, "Sink Electrical Parameters"*, and *Table 7.25, "Common Source/Sink Electrical Parameters"*.

Note: In *Figure 7.39, "Transition Diagram for a Sink Requested Power Role Swap"*, the *Sink* has previously sent a ***PR_Swap*** *Message* to the *Source*.

Figure 7.39 Transition Diagram for a Sink Requested Power Role Swap

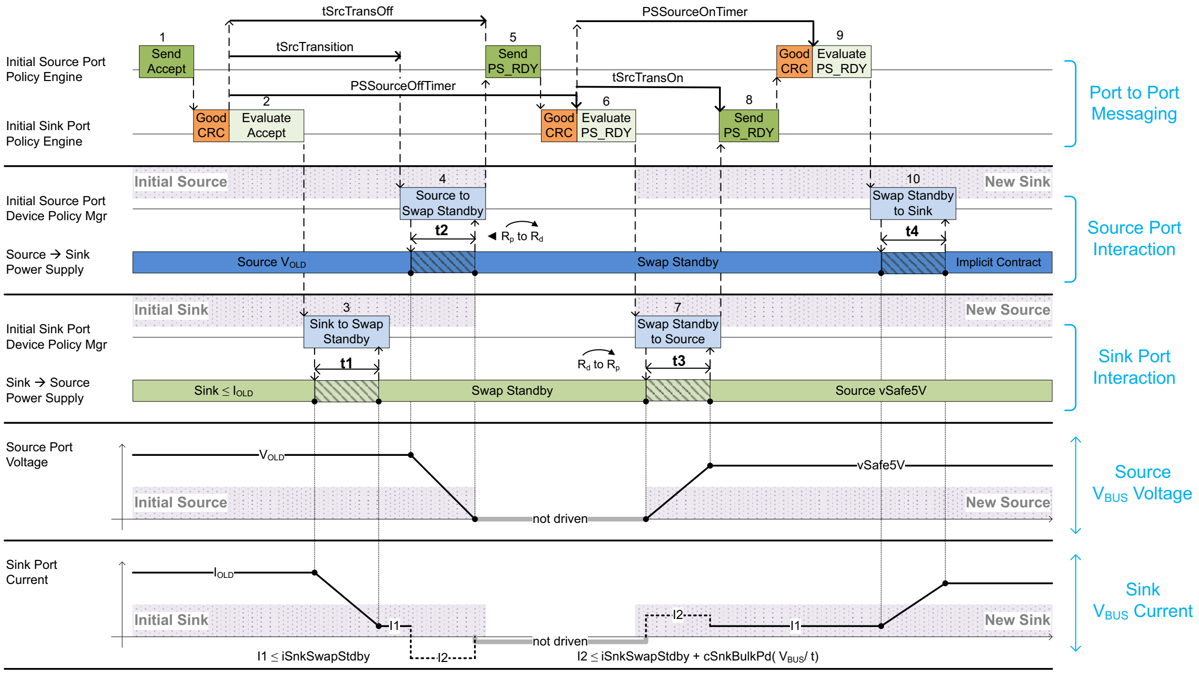


Table 7.18 Sequence Description for a Sink Requested Power Role Swap

Step	Initial Source Port → New Sink Port	Initial Sink Port → New Source Port
1	*Policy Engine* sends the ***Accept*** *Message* to the *Initial Sink*.	*Policy Engine* receives the ***Accept***.
2	*Protocol Layer* receives the ***GoodCRC*** *Message* from the *Sink*. The *Policy Engine* tells the *Device Policy Manager* to instruct the power supply to modify its output power.	*Protocol Layer* sends the ***GoodCRC*** *Message* to the *Initial Source*. *Policy Engine* then starts the ***PSSourceOffTimer*** and evaluates the ***Accept*** *Message*.
3		*Policy Engine* tells the *Device Policy Manager* to instruct the power supply to transition to *Swap Standby* within ***tSnkStdby*** (t1); t1 ***Shall*** complete before ***tSrcTransition*** min. When in *Sink Standby* the *Initial Sink* ***Shall Not*** draw more than ***iSnkSwapStdby*** (I1). The *Sink* ***Shall Not*** violate transient load behavior defined in Section 7.2.6, "Transient Load Behavior" while transitioning to and operating at the new power level.
4	***tSrcTransition*** after the ***GoodCRC*** *Message* was received, the power supply starts to change its output power capability to *Swap Standby* (see Section 7.1.10, "Swap Standby for Sources"). The power supply ***Shall*** complete the transition to *Swap Standby* within ***tSrcSwapStdby*** (t2). The power supply informs the *Device Policy Manager* that it is ready to operate as the *New Sink*. The *CC* termination is changed from R_p to R_d (see ***[USB Type-C 2.4]***). The power supply status is passed to the *Policy Engine*.	
5	The power supply is ready, and the *Policy Engine* sends the ***PS_RDY*** *Message* to the device that will become the *New Source*, starting within ***tSrcTransOff*** of the end of the ***GoodCRC*** *Message* following the ***Accept*** *Message*.	
6	*Protocol Layer* receives the ***GoodCRC*** *Message* from the device that will become the *New Source*. *Policy Engine* starts the ***PSSourceOnTimer***. Upon sending the ***PS_RDY*** *Message* and receiving the ***GoodCRC*** *Message* the *Initial Source* is ready to be the *New Sink*.	The *Protocol Layer* sends the ***GoodCRC*** *Message* to the *New Sink*. *Policy Engine* the stops the ***PSSourceOffTimer*** and tells the *Device Policy Manager* to instruct the power supply to operate as the *New Source*. If the ***PS_RDY*** *Message* is not received before ***PSTransitionTimer*** times out the *Sink* sends ***Hard Reset*** *Signaling*.
7		The *CC* termination is changed from R_d to R_p (see ***[USB Type-C 2.4]***). The power supply as the *New Source* transitions from *Swap Standby* to sourcing default ***vSafe5V*** within ***tNewSrc*** (t3). The power supply informs the *Device Policy Manager* that it is operating as the *New Source*.
8	*Policy Engine* receives the ***PS_RDY*** *Message* from the *Source*.	*Device Policy Manager* informs the *Policy Engine* the power supply is ready, and the *Policy Engine* sends the ***PS_RDY*** *Message* to the *New Sink*, starting within ***tSrcTransOn*** of the end of the ***GoodCRC*** *Message* following the ***Accept*** *Message*.

Table 7.18 Sequence Description for a Sink Requested Power Role Swap (Continued)

Step	Initial Source Port → New Sink Port	Initial Sink Port → New Source Port
9	*Protocol Layer* sends the ***GoodCRC*** *Message* to the *New Source* and then stops the ***PSSourceOnTimer***. *Policy Engine* evaluates the ***PS_RDY*** *Message* from the *New Source* and tells the *Device Policy Manager* to instruct the power supply to draw current as the *New Sink*.	*Protocol Layer* receives the ***GoodCRC*** *Message* from the *New Sink*.
10	The power supply as the *New Sink* transitions from *Swap Standby* and begins to drawing the current allowed by the *Implicit Contract*. The power supply informs the *Device Policy Manager* that it is operating as the *New Sink*. At this point subsequent *Negotiations* between the *New Source* and the *New Sink* ***May*** proceed as normal. The *Sink* ***Shall Not*** violate the transient load behavior defined in *Section 7.2.6, "Transient Load Behavior"* while transitioning to and operating at the new power level. The time duration (t4) depends on the magnitude of the load change (***iLoadStepRate***).	

7.3.2.2 Source Requested Power Role Swap

The interaction of the *System Policy*, *Device Policy*, and power supply that ***Shall*** be followed during a *Source* requested *Power Role Swap* is shown in *Figure 7.40, "Transition Diagram for a Source Requested Power Role Swap"*. The sequence that ***Shall*** be followed is described in *Table 7.19, "Sequence Description for a Source Requested Power Role Swap"*. The timing parameters that ***Shall*** be followed are listed in *Table 7.23, "Source Electrical Parameters"*, *Table 7.24, "Sink Electrical Parameters"*, and *Table 7.25, "Common Source/Sink Electrical Parameters"*.

Note: In *Figure 7.40, "Transition Diagram for a Source Requested Power Role Swap"*, the *Source* has previously sent a ***PR_Swap*** *Message* to the *Sink*.

Figure 7.40 Transition Diagram for a Source Requested Power Role Swap

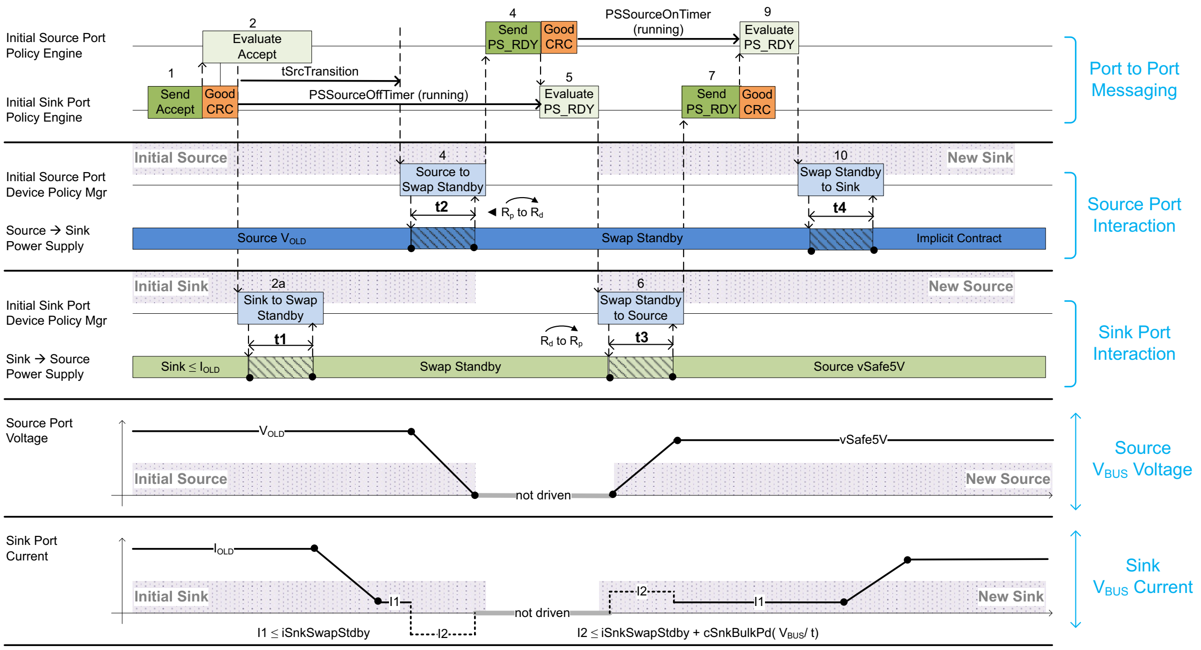


Table 7.19 Sequence Description for a Source Requested Power Role Swap

Step	Initial Source Port→ New Sink Port	Initial Sink Port → New Source Port
1	*Policy Engine* receives the ***Accept*** *Message*.	*Policy Engine* sends the ***Accept*** *Message* to the *Initial Source*.
2	*Protocol Layer* sends the ***GoodCRC*** *Message* to the *Sink*. The *Policy Engine* tells the *Device Policy Manager* to instruct the power supply to modify its output power.	*Protocol Layer* receives the ***GoodCRC*** *Message* from the *Initial Source*. *Policy Engine* starts the ***PSSourceOffTimer***.
2a		The *Policy Engine* tells the *Device Policy Manager* to instruct the power supply to transition to *Swap Standby*. The power supply ***Shall*** complete the transition to *Swap Standby* within ***tSnkStdby*** (t1); t1 ***Shall*** complete before ***tSrcTransition***. The *Sink* ***Shall Not*** violate the transient load behavior defined in *Section 7.2.6, "Transient Load Behavior"* while transitioning to and operating at the new power level. When in *Sink Standby* the *Initial Sink* ***Shall Not*** draw more than ***iSnkSwapStdby*** (I1).
3	***tSrcTransition*** after the ***GoodCRC*** *Message* was sent the power supply starts to change its output power capability to *Swap Standby* (see *Section 7.1.10, "Swap Standby for Sources"*). The power supply ***Shall*** complete the transition to *Swap Standby* within ***tSrcSwapStdby*** (t2). The power supply informs the *Device Policy Manager* that it is ready to operate as the *New Sink*. The *CC* termination is changed from R_p to R_d (see ***[USB Type-C 2.4]***). The power supply status is passed to the *Policy Engine*.	
4	The *Policy Engine* sends the ***PS_RDY*** *Message* to the device that will become the *New Source*, starting within ***tSrcTransOff*** of the end of the ***GoodCRC*** *Message* following the ***Accept*** *Message*.	*Policy Engine* receives the ***PS_RDY***.
5	*Protocol Layer* receives the ***GoodCRC*** *Message* from the soon to be *New Source*. *Policy Engine* starts the ***PSSourceOnTimer***. At this point the *Initial Source* is ready to be the *New Sink*.	*Protocol Layer* sends the ***GoodCRC*** *Message* to the *New Sink*. *Policy Engine* then stops the ***PSSourceOffTimer*** and tells the *Device Policy Manager* to instruct the power supply to operate as the *New Source*. If the ***PS_RDY*** *Message* is not received before the ***PSSourceOffTimer*** times out the *Sink* starts sending ***Hard Reset*** *Signaling*.
6		The *CC* termination is changed from R_d to R_p (see ***[USB Type-C 2.4]***). The power supply as the *New Source* transitions from *Swap Standby* to sourcing default ***vSafe5V*** within ***tNewSrc*** (t3). The power supply informs the *Device Policy Manager* that it is operating as the *New Source*.
7	*Policy Engine* receives the ***PS_RDY*** *Message*.	*Device Policy Manager* informs the *Policy Engine* the power supply is ready, and the *Policy Engine* sends the ***PS_RDY*** *Message* to the *New Sink*, starting within ***tSrcTransOn*** of the end of the ***GoodCRC*** *Message* following the ***Accept*** *Message*.

Table 7.19 Sequence Description for a Source Requested Power Role Swap (Continued)

Step	Initial Source Port→ New Sink Port	Initial Sink Port → New Source Port
8	*Protocol Layer* sends the ***GoodCRC*** *Message* to the *New Source* and then stops the ***PSSourceOnTimer***. *Policy Engine* evaluates the ***PS_RDY*** *Message* from the *New Source* and tells the *Device Policy Manager* to instruct the power supply to draw current as the *New Sink*.	*Protocol Layer* receives the ***GoodCRC*** *Message* from the *New Sink*.
9	The power supply as the *New Sink* transitions from *Swap Standby* to drawing the power allowed by the *Implicit Contract*. The power supply informs the *Device Policy Manager* that it is operating as the *New Sink*. At this point subsequent *Negotiations* between the *New Source* and the *New Sink* ***May*** proceed as normal. The *New Sink* ***Shall Not*** violate the transient load behavior defined in *Section 7.2.6, "Transient Load Behavior"* while transitioning to and operating at the new power level. The time duration (t4) depends on the magnitude of the load change (***iLoadStepRate***).	

7.3.3 Transitions Caused by Hard Reset

7.3.3.1 Source Initiated Hard Reset

The interaction of the *System Policy*, *Device Policy*, and power supply that ***Shall*** be followed during a *Source* Initiated *Hard Reset* is shown in *Figure 7.41, "Transition Diagram for a Source Initiated Hard Reset"*. The sequence that ***Shall*** be followed is described in *Table 7.20, "Sequence Description for a Source Initiated Hard Reset"*. The timing parameters that ***Shall*** be applied are listed in *Table 7.23, "Source Electrical Parameters"*, *Table 7.24, "Sink Electrical Parameters"*, and *Table 7.25, "Common Source/Sink Electrical Parameters"*.

Figure 7.41 Transition Diagram for a Source Initiated Hard Reset

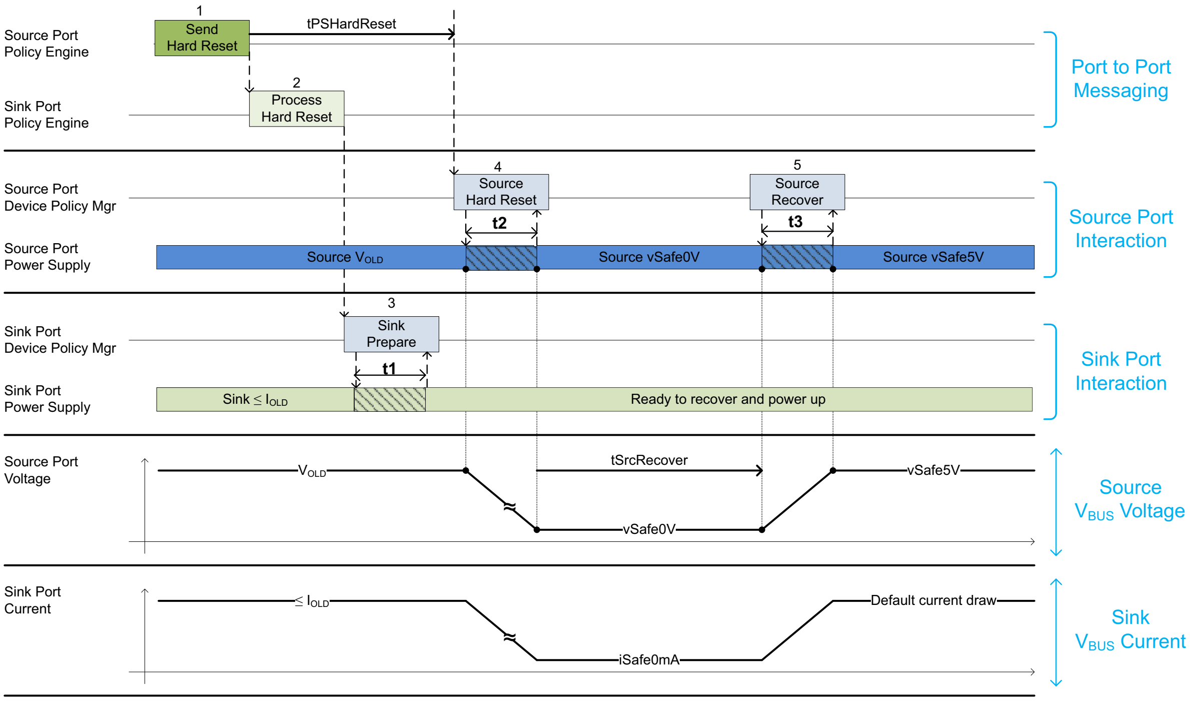


Table 7.20 Sequence Description for a Source Initiated Hard Reset

Step	Source Port	Sink Port
1	*Policy Engine* sends ***Hard Reset*** *Signaling* to the *Sink*.	*Sink* receives ***Hard Reset*** *Signaling*.
2		*Policy Engine* is informed of the *Hard Reset*. *Policy Engine* tells the *Device Policy Manager* to instruct the power supply to prepare for a *Hard Reset*.
3		The *Sink* prepares for the *Hard Reset* within ***tSnkHardResetPrepare*** (t1) and passes an indication to the *Device Policy Manager* The *Sink* ***Shall Not*** draw more than ***iSafe0mA*** when *VBUS* is driven to ***vSafe0V***.
4	*Policy Engine* waits ***tPSHardReset*** after sending ***Hard Reset*** *Signaling* and then tells the *Device Policy Manager* to instruct the power supply to perform a *Hard Reset*. The transition to ***vSafe0V*** ***Shall*** occur within ***tSafe0V*** (t2).	
5	After ***tSrcRecover*** the *Source* applies power to *VBUS* in an attempt to re-establish communication with the *Sink* and resume *USB Default Operation*. The transition to ***vSafe5V*** ***Shall*** occur within ***tSrcTurnOn*** (t3).	The *Sink* ***Shall Not*** violate the transient load behavior defined in *Section 7.2.6, "Transient Load Behavior"* while transitioning to and operating at the new power level.

7.3.3.2 Sink Initiated Hard Reset

The interaction of the *System Policy*, *Device Policy*, and power supply that ***Shall*** be followed during a *Sink* Initiated *Hard Reset* is shown in *Figure 7.42, "Transition Diagram for a Sink Initiated Hard Reset"*. The sequence that ***Shall*** be followed is described in *Table 7.21, "Sequence Description for a Sink Initiated Hard Reset"*. The timing parameters that ***Shall*** be followed are listed in *Table 7.23, "Source Electrical Parameters"*, *Table 7.24, "Sink Electrical Parameters"*, and *Table 7.25, "Common Source/Sink Electrical Parameters"*.

Figure 7.42 Transition Diagram for a Sink Initiated Hard Reset

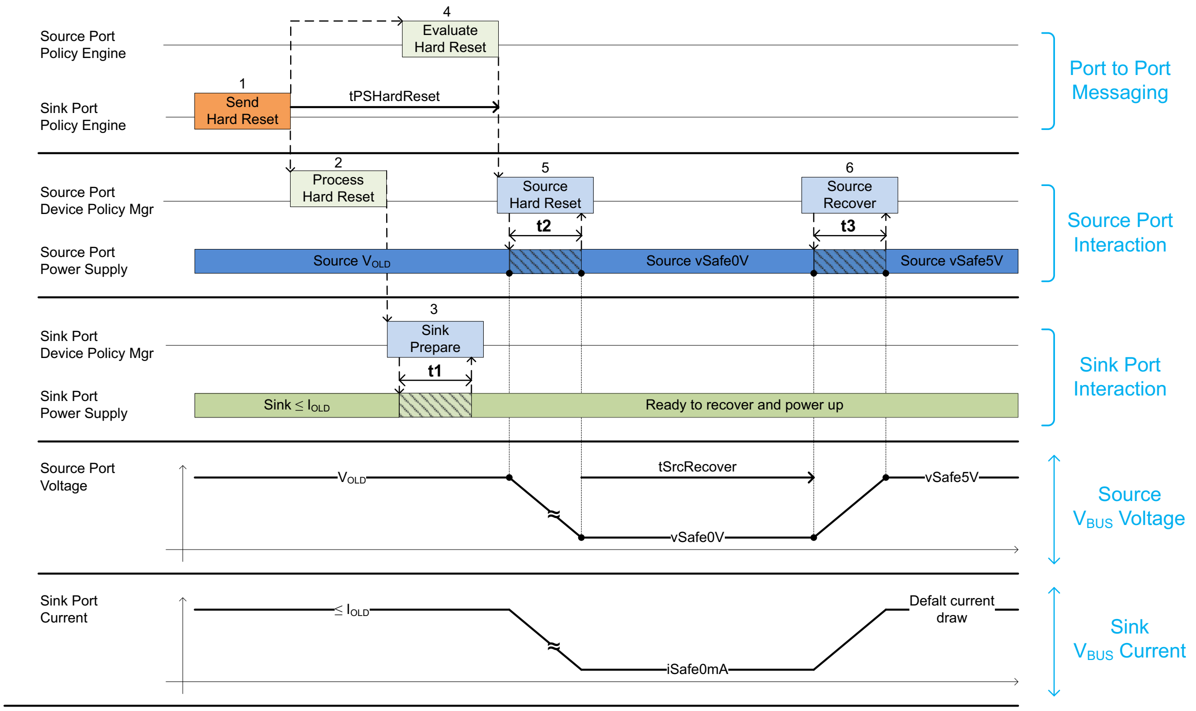


Table 7.21 Sequence Description for a Sink Initiated Hard Reset

Step	Source Port	Sink Port
1		*Policy Engine* sends ***Hard Reset*** *Signaling* to the *Source*.
2		*Policy Engine* tells the *Device Policy Manager* to instruct the power supply to prepare for a *Hard Reset*.
3		The *Sink* prepares for the *Hard Reset* within ***tSnkHardResetPrepare*** (t1) and passes an indication to the *Device Policy Manager*. The *Sink* ***Shall Not*** draw more than ***iSafe0mA*** when *VBUS* is driven to ***vSafe0V***.
4	*Policy Engine* is informed of the *Hard Reset*.	
5	*Policy Engine* waits ***tPSHardReset*** after receiving ***Hard Reset*** *Signaling* and then tells the *Device Policy Manager* to instruct the power supply to perform a *Hard Reset*. The transition to ***vSafe0V*** ***Shall*** occur within ***tSafe0V*** (t2).	
6	After ***tSrcRecover*** the *Source* applies power to *VBUS* in an attempt to re-establish communication with the *Sink* and resume *USB Default Operation*. The transition to ***vSafe5V*** ***Shall*** occur within ***tSrcTurnOn*** (t3).	The *Sink* ***Shall Not*** violate the transient load behavior defined in *Section 7.2.6, "Transient Load Behavior"* while transitioning to and operating at the new power level.

7.3.4 Transitions Caused by Fast Role Swap

7.3.4.1 Fast Role Swap

The interaction of the *System Policy*, *Device Policy*, and power supply that ***Shall*** be followed during a *Fast Role Swap* is shown in *Figure 7.43, "Transition Diagram for Fast Role Swap"*. The parallel sequences that ***Shall*** be followed are described in *Table 7.22, "Sequence Description for Fast Role Swap"*. The timing parameters that ***Shall*** be followed are listed in *Table 7.23, "Source Electrical Parameters"*, *Table 7.24, "Sink Electrical Parameters"*, and *Table 7.25, "Common Source/Sink Electrical Parameters"*. *Negotiation*s between the *New Source* and the *New Sink* ***May*** occur after the *New Source* sends the final ***PS_RDY*** *Message*.

Note: In *Figure 7.43, "Transition Diagram for Fast Role Swap"*. and *Table 7.22, "Sequence Description for Fast Role Swap"* numbers are used to indicate *Message* related steps and letters are used to indicate other events.

Figure 7.43 Transition Diagram for Fast Role Swap

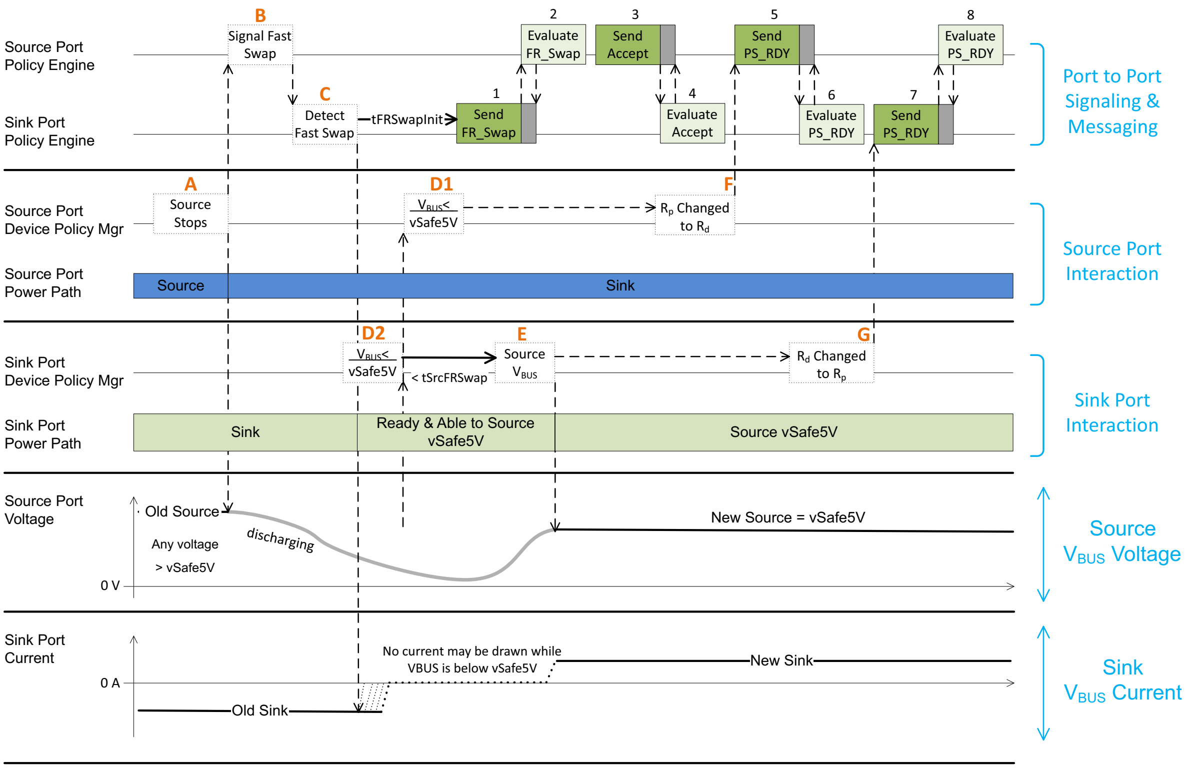


Table 7.22 Sequence Description for Fast Role Swap

Step	Initial Source Port→ New Sink Port	Initial Sink Port → New Source Port
Fast Role Swap Request and Power Transition		
A	The *Source* connected to the *Hub UFP* (see *Figure 7.16, "VBUS Power during Fast Role Swap"*) stops sourcing *VBUS*.	
B	*Policy Engine* sends the *Fast Role Swap Request* to the *Initial Sink* on the *CC* wire. When *VBUS* < ***vSafe5V*** (min), it tells the *Device Policy Manager* not to draw more than ***iSnkStdby*** until the ***tSnkFRSwap*** timer has elapsed.	
C		*Policy Engine* detects the *Fast Role Swap Request* on the *CC* wire from the *Initial Source* and ***Shall*** send the ***FR_Swap*** *Message* back to the *Initial Source* (that is no longer powering *VBUS*) within time ***tFRSwapInit***.
D1	The *Policy Engine* monitors for *VBUS* ≤ ***vSafe5V*** so that a ***PS_RDY*** *Message* can be sent to the *New Source* at Step 5 of the messaging sequence.	
D2		The *Policy Engine* monitors for *VBUS* ≤ ***vSafe5V*** so the *Initial Sink* can assume the *Power Role* of *New Source* and begin to source *VBUS*.
E		When *VBUS* = ***vSafe5V*** the *New Source* ***May*** provide power to *VBUS*. When *VBUS* < ***vSafe5V*** the *New Source* ***Shall*** provide power to *VBUS* within ***tSrcFRSwap***. Once the *New Source* is providing power, the ***PS_RDY*** *Message* can be sent to the *New Sink* at Step 7 of the messaging sequence.
F	The *CC* termination is changed from R_p to R_d (see ***[USB Type-C 2.4]***) before the *New Sink* sends the ***PS_RDY*** *Message* at Step 5 to the *New Source*.	
G		The *CC* termination is changed from R_d to R_p (see ***[USB Type-C 2.4]***) before the *New Source* sends the ***PS_RDY*** *Message* at Step 7 to the *New Sink*.
Fast Role Swap Message Sequence		
1	*Policy Engine* receives the ***FR_Swap*** *Message* from the *Initial Sink* that is transitioning to be the *New Source*.	*Policy Engine* sends the ***FR_Swap*** *Message* to the *Initial Source* (that is no longer powering *VBUS*) after detecting the *Fast Role Swap Request* at Step C.
2	*Protocol Layer* sends the ***GoodCRC*** *Message* to the *Initial Sink*. *Policy Engine* then evaluates the ***FR_Swap*** *Message*.	*Protocol Layer* receives the ***GoodCRC*** *Message* from the *Initial Source*.
3	*Policy Engine* sends an ***Accept*** *Message* to the *Initial Sink* that is transitioning to be the *New Source*.	*Policy Engine* receives the ***Accept*** *Message* from the *Initial Source* that is transitioning to be the *New Sink*.
4	*Protocol Layer* receives the ***GoodCRC*** *Message* from the *Initial Sink* that is transitioning to be the *New Source*.	*Protocol Layer* sends the ***GoodCRC*** *Message* to the *Initial Source* that is transitioning to be the *New Sink*.

Table 7.22 Sequence Description for Fast Role Swap (Continued)

Step	Initial Source Port→ New Sink Port	Initial Sink Port → New Source Port
5	*Policy Engine* sends a ***PS_RDY*** *Message* to the *Initial Sink* that is transitioning to be the *New Source*. The *Policy Engine* ***Shall*** start the ***PS_RDY*** *Message* at least ***tFRSwap5V*** after it has sent the ***Accept*** *Message*, and when Step D1 has also been completed.	*Policy Engine* receives the ***PS_RDY*** *Message* from the *New Sink*.
6	*Protocol Layer* receives the ***GoodCRC*** *Message* from the *New Source*.	*Protocol Layer* sends the ***GoodCRC*** *Message* from the *Initial Sink* that has completed the transition to *New Source*. *Policy Engine* then evaluates the ***PS_RDY*** *Message*.
7	*Policy Engine* receives the ***PS_RDY*** *Message* from the *New Source*.	*Policy Engine* sends a ***PS_RDY*** *Message* to the *New Sink*. The *Policy Engine* ***Shall*** wait for Step E before sending the ***PS_RDY*** *Message*, and ***Shall*** send the ***PS_RDY*** *Message* within ***tFRSwapComplete*** of receiving the ***PS_RDY*** *Message* from the *Initial Source* Port.

7.4 Electrical Parameters

7.4.1 Source Electrical Parameters

The *Source* Electrical Parameters that ***Shall*** be followed are specified in *Table 7.23, "Source Electrical Parameters"*.

Table 7.23 Source Electrical Parameters

Parameter	Description	MIN	TYP	MAX	UNITS	Reference
cSrcBulk	*Source* bulk capacitance when a *Port* is powered from a dedicated supply.[1]	10			µF	*Section 7.1.2*
cSrcBulkShared	*Source* bulk capacitance when a *Port* is powered from a shared supply.[1]	120			µF	*Section 7.1.2*
DNL (*Differential Non-Linearity*)	Deviation between ideal analog values corresponding to adjacent input digital values	-1	0	+1	*LSB*	*Section 7.1.4.2.1*
iPpsCLMin	*SPR PPS* Minimum *Current Limit* setting.	1			A	*Section 7.1.4.2.2*
iPpsCLNew	*Current Limit* accuracy					*Section 7.1.4.2.2*
	1A ≤ Operating Current ≤ 3A	-150		150	mA	
	Operating current > 3A	-5		5	%	
iPpsCLStep	*SPR PPS Current Limit* programming step size (1 *LSB*).		50		mA	*Section 7.1.4.2.2*
iPpsCLLoadReleaseRate	Maximum load decrease slew rate during *Current Limit* set-point changes.	-150			mA/µs	*Section 7.1.4.2.2*
iPpsCLLoadStepRate	Maximum load increase slew rate during *Current Limit* set-point changes.			150	mA/µs	*Section 7.1.4.2.2*
iPpsCLTransient	Allowed output current overshoot when a load increase occurs while in *CL* mode.			New load + 100	mA	*Section 7.1.4.2.2*
	Allowed output current undershoot when a load decrease occurs while in *CL* mode.	New load – 100			mA	

1) The *Source* ***Shall*** charge and discharge the total bulk capacitance to meet the transition time requirements.

Table 7.23 Source Electrical Parameters (Continued)

Parameter	Description	MIN	TYP	MAX	UNITS	Reference
iPpsCVCLTransient	*CV* to *CL* transient current bounds assuming the Operating Voltage reduction of Section 7.2.3.1, "Programmable Power Supply Sink Standby".	***iPpsCLNew*** - 100		New load + 500	mA	Section 7.1.4.2.2
tAvsTransient	The maximum time for the *AVS* to be between ***vAvsNew*** and ***vAvsValid*** in response to a load transient.			5	ms	Section 7.1.8.4
tAvsSrcTransLarge	The time the *AVS* set-point ***Shall*** transition between requested voltages for steps larger than ***vAvsSmallStep***.	0		700	ms	Section 7.1.4.3.1
tAvsSrcTransSmall	The time the *AVS* set-point ***Shall*** transition between requested voltages for steps smaller than ***vAvsSmallStep***.	0		50	ms	Section 7.1.4.3.1
tNewSnk	Time allowed for an *Initial Source* in *Swap Standby* to transition *New Sink* operation.			15	ms	Section 7.1.10 Figure 7.39 Figure 7.40
tPpsCLCVTransient	*CL* to *CV* transient voltage settling time.			275	ms	Section 7.1.4.2.2
tPpsCLProgramSettle	*SPR PPS Current Limit* programming settling time.			250	ms	Section 7.1.4.2.2
tPpsCLSettle	*CL* load transient current settling time.			250	ms	Section 7.1.4.2.2
tPpsCVCLTransient	*CV* to *CL* transient settling time.			250	ms	Section 7.1.8.3
tPpsSrcTransLarge	The time the Programmable Power Supply's set-point ***Shall*** transition between requested voltages for steps larger than ***vPpsSmallStep***.	0		275	ms	Section 7.3.1.3

1) The *Source* ***Shall*** charge and discharge the total bulk capacitance to meet the transition time requirements.

Table 7.23 Source Electrical Parameters (Continued)

Parameter	Description	MIN	TYP	MAX	UNITS	Reference
tPpsSrcTransSmall	The time the Programmable Power Supply's set-point ***Shall*** transition between requested voltages for steps less than or equal to ***vPpsSmallStep***.	0		25	ms	*Section 7.3.1.3*
tPpsTransient	The maximum time for the Programmable Power Supply to be between ***vPpsNew*** and ***vPpsValid*** in response to a load transient when target load is greater than or equal to 60mA.			5	ms	*Section 7.1.8.3*
	The maximum time for the Programmable Power Supply to be between ***vPpsNew*** and ***vPpsValid*** in response to a load transient when target load is less than 60mA.			150	ms	*Section 7.1.8.3*
tSrcFRSwap	Time from the *Initial Sink* detecting that *VBUS* has dropped below ***vSafe5V*** until the *Initial Sink*/new *Source* is able to supply *USB Type-C* Current (see ***[USB Type-C 2.4]***)			150	µs	*Section 7.1.13*
1) The *Source* ***Shall*** charge and discharge the total bulk capacitance to meet the transition time requirements.						

Table 7.23 Source Electrical Parameters (Continued)

Parameter		Description	MIN	TYP	MAX	UNITS	Reference
tSrcReady	*SPR Mode*	Time from positive/ negative transition start (t0) to when the *Source* is ready to provide the newly *Negotiated* power level. Applies only to *SPR Mode* voltage transitions.			285	ms	Figure 7.2 Figure 7.3
	EPR Mode	Time from positive/ negative transition start (t0) to when the *Source* is ready to provide the newly *Negotiated* power level. Applies to *EPR Mode* voltage transitions and any voltage transition that either begins or ends in *EPR Mode*.			720		
tSrcRecover	*SPR Mode*	Time allotted for the *Source* to recover.	0.66		1.0	s	Section 7.1.5
	EPR Mode		1.085		1.425		
tSrcSettle	*SPR Mode*	Time from positive/ negative transition start (t0) to when the transitioning voltage is within the range ***vSrcNew***. Applies only to *SPR Mode* voltage transitions.			275	ms	Figure 7.2
	EPR Mode	Time from positive/ negative transition start (t0) to when the transitioning voltage is within the range ***vAvsNew***. Applies to *EPR Mode* voltage transitions and any voltage transition that either begins or ends in *EPR Mode*.			700		
tSrcSwapStdby		The maximum time for the *Source* to transition to *Swap Standby*.			650	ms	Section 7.1.10 Figure 7.17 Figure 7.18
1) The *Source* ***Shall*** charge and discharge the total bulk capacitance to meet the transition time requirements.							

Table 7.23 Source Electrical Parameters (Continued)

Parameter		Description	MIN	TYP	MAX	UNITS	Reference
tSrcTransient		The maximum time for the *Source* output voltage to be between ***vSrcNew*** and ***vSrcValid*** in response to a load transient when target load is greater or equal to than 60mA.			5	ms	*Section 7.1.8*
		The maximum time for the *Source* output voltage to be between ***vSrcNew*** and ***vSrcValid*** in response to a load transient when target load is less than 60mA.			150	ms	*Section 7.1.8*
tSrcTransition		The time the *Source* ***Shall*** wait before transitioning the power supply to ensure that the *Sink* has sufficient time to prepare (does not apply to transitions within the same PPS or *AVS APDO*).	25		35	ms	*Section 7.3*
tSrcTransOff	*SPR Mode*	Time from the last bit of the ***GoodCRC*** *Message* acknowledging the ***Accept*** *Message* in response to the ***PR_Swap*** *Message* until the ***PS_RDY*** *Message* must be started. Applies only to *SPR Mode* voltage transitions.			690	ms	*Section 7.3.2*
tSrcTransOn		Time from the last bit of the ***GoodCRC*** *Message* acknowledging the ***PS_RDY*** *Message* sent by the new *Source*, in response to the ***PR_Swap*** *Message* until the ***PS_RDY*** *Message* must be started.			280	ms	*Section 7.3.2*
1) The *Source* ***Shall*** charge and discharge the total bulk capacitance to meet the transition time requirements.							

Table 7.23 Source Electrical Parameters (Continued)

Parameter		Description	MIN	TYP	MAX	UNITS	Reference
tSrcTransReq	*SPR Mode*	Time from the last bit of the ***GoodCRC*** *Message* acknowledging the ***Accept*** *Message* in response to the ***Request*** *Message* until the ***PS_RDY*** *Message* must be started. Applies only to *SPR Mode* voltage transitions.			325	ms	*Section 7.3*
	EPR Mode	Time from the last bit of the ***GoodCRC*** *Message* acknowledging the ***Accept*** *Message* in response to the ***Request*** *Message* until the ***PS_RDY*** *Message* must be started. Applies to *EPR Mode* voltage transitions and any voltage transition that either begins or ends in *EPR Mode*.			760	ms	*Section 7.3*
tSrcTurnOn		Transition time from ***vSafe0V*** to ***vSafe5V***.			275	ms	*Figure 7.10* *Table 7.20* *Table 7.21*
vAvsMaxVoltage		Maximum Voltage Field in the *AVS APDO*.	*APDO* Max Voltage *0.95		*APDO* Max Voltage * 1.05	V	*Section 7.1.4.3.1*
vAvsMinVoltage		Minimum Voltage Field in the *AVS APDO*.	*APDO* Min Voltage *0.95		*APDO* Min Voltage * 1.05	V	*Section 7.1.4.3.1*
vAvsNew		Adjustable *RDO* Output Voltage measured at the *Source* receptacle.	*RDO* Output Voltage *0.95	*RDO* Output Voltage	*RDO* Output Voltage *1.05	V	*Section 7.1.8.4*
vAvsSlewNeg		*AVS* maximum slew rate for negative voltage changes.			-30	mV/µs	*Section 7.1.8.4*
1) The *Source* ***Shall*** charge and discharge the total bulk capacitance to meet the transition time requirements.							

Table 7.23 Source Electrical Parameters (Continued)

Parameter	Description	MIN	TYP	MAX	UNITS	Reference
vAvsSlewPos	*AVS* maximum slew rate for positive voltage changes.			30	mV/µs	*Section 7.1.8.4*
vAvsSmallStep	*AVS* step size defined as a small step relative to the previous ***vAvsNew***.	-1.0		1.0	V	*Section 7.1.4.3.1*
vAvsStep	*AVS* voltage programming step size.		100		mV	*Section 7.1.8.4*
vAvsValid	The range in addition to ***vAvsNew*** which the *AVS* output is considered ***Valid*** during and after a transition as well as in response to a transient load condition.	-0.5		0.5	V	*Section 7.1.8.4*
vPpsCLCVTransient	*CL* to *CV* load transient voltage bounds.	Operating Voltage * 0.95 – 0.1V		Operating Voltage * 1.05 + 0.1V	V	*Section 7.1.4.2.2*
vPpsMaxVoltage	Maximum Voltage Field in the Programmable Power Supply *APDO*.	*APDO* Max Voltage *0.95		*APDO* Max Voltage * 1.05	V	*Section 7.1.4.2.1*
vPpsMinVoltage	Minimum Voltage Field in the Programmable Power Supply *APDO*.	*APDO* Min Voltage *0.95		*APDO* Min Voltage * 1.05	V	*Section 7.1.4.2.1*
vPpsNew	Programmable *RDO* Output Voltage measured at the *Source* receptacle.	*RDO* Output Voltage *0.95	*RDO* Output Voltage	*RDO* Output Voltage *1.05	V	*Section 7.1.8.3*
vPpsShutdown	The voltage at which the *SPR PPS* shuts down when operating in *CL*.	*APDO* Minimum Voltage * 0.85		*APDO* Minimum Voltage * 0.95	V	*Section 7.1.4.2.2*
vPpsSlewNeg	Programmable Power Supply maximum slew rate for negative voltage changes			-30	mV/µs	*Section 7.1.8.3*
vPpsSlewPos	Programmable Power Supply maximum slew rate for positive voltage changes			30	mV/µs	*Section 7.1.8.3*

1) The *Source* ***Shall*** charge and discharge the total bulk capacitance to meet the transition time requirements.

Table 7.23 Source Electrical Parameters (Continued)

Parameter	Description	MIN	TYP	MAX	UNITS	Reference
vPpsSmallStep	PPS Step size defined as a small step relative to the previous ***vPpsNew***.	-500		500	mV	*Section 7.1.4.2.2*
vPpsStep	PPS voltage programming step size (1 *LSB*).		20		mV	*Section 7.1.8.3*
vPpsValid	The range in addition to ***vPpsNew*** which the Programmable Power Supply output is considered ***Valid*** in response to a load step.	-0.1		0.1	V	*Section 7.1.8.3*
vSmallStep	*VBUS* step size increase defined as a small step relative to the previous *VBUS* when Requesting a different *(A)PDO*.			500	mV	*Section 7.1.4.3.1*
vSrcNeg	Most negative voltage allowed during transition.			-0.3	V	*Figure 7.10*
vSrcNew	*Fixed Supply* output measured at the *Source* receptacle.	PDO Voltage *0.95	PDO Voltage	PDO Voltage *1.05	V	*Table 7.2*
	Variable Supply output measured at the *Source* receptacle.	PDO Minimum Voltage		PDO Maximum Voltage	V	
	Battery Supply output measured at the *Source* receptacle.	PDO Minimum Voltage		PDO Maximum Voltage	V	
vSrcPeak	The range that a *Fixed Supply* or *EPR AVS* in Peak Current operation is allowed when overload conditions occur.	PDO Voltage *0.90		PDO Voltage *1.05	V	*Table 6.10* *Table 6.16* *Figure 7.14*
vSrcSlewNeg	Maximum slew rate allowed for negative voltage transitions. Limits current based on a 3 A connector rating and maximum *Sink* bulk capacitance of 100 µF.			-30	mV/µs	*Section 7.1.4.2* *Table 7.2*
1) The *Source* ***Shall*** charge and discharge the total bulk capacitance to meet the transition time requirements.						

Table 7.23 Source Electrical Parameters (Continued)

Parameter	Description	MIN	TYP	MAX	UNITS	Reference
vSrcSlewPos	Maximum slew rate allowed for positive voltage transitions. Limits current based on a 3 A connector rating and maximum *Sink* bulk capacitance of 100 µF.			30	mV/µs	*Section 7.1.4* *Figure 7.2*
vSrcValid	The range in addition to ***vSrcNew*** which a newly *Negotiated* voltage is considered ***Valid*** during and after a transition as well as in response to a transient load condition. This range also applies to ***vSafe5V***.	-0.5		0.5	V	*Figure 7.2* *Figure 7.3* *Section 7.1.8*
1) The *Source* ***Shall*** charge and discharge the total bulk capacitance to meet the transition time requirements.						

7.4.2 Sink Electrical Parameters

The *Sink* Electrical Parameters that ***Shall*** be followed are specified in *Table 7.24, "Sink Electrical Parameters"*.

Table 7.24 Sink Electrical Parameters

Parameter	Description	MIN	TYP	MAX	UNITS	Reference
cSnkBulk	*Sink* bulk capacitance on *VBUS* at *Attach* and during *FRS* after the *Initial Source* stops sourcing and prior to establishing the *First Explicit Contract* (see *Appendix E, "FRS System Level Example"* for an example).[1]			See ***[USB 3.2]***		*Section 7.2.2* ***[USB 3.2]***
cSnkBulkPd	Bulk capacitance on *VBUS* a *Sink* is allowed after a successful *Negotiation*.[1]			100	µF	*Section 7.2.2*
iLoadReleaseRate	Load release di/dt.	-150			mA/µs	*Section 7.2.6*
iLoadStepRate	Load step di/dt.			150	mA/µs	*Section 7.2.6*
iNewFrsSink	Maximum current the *New Sink* can draw during a *Fast Role Swap* until the *New Source* applies R_p. Matches the required ***Fast Role Swap required USB Type-C Current*** Current field of the *Fixed Supply* PDO of the *Initial Source*'s ***Sink_Capabilities*** *Message*.			Default USB current or 1.5 or 3.0	A	*Section 7.1.13*
iOvershoot	Positive or negative overshoot when a load change occurs less than or equal to ***iLoadStepRate***; relative to the settled value after the load change.	-230		230	mA	*Section 7.2.6*
iPpsCLLoadStep	Maximum Current set-point change while operating in *CL* mode.	-500		500	mA	*Section 7.2.3.1*
iSafe0mA	Maximum current a *Sink* is allowed to draw when *VBUS* is driven to ***vSafe0V***.			1.0	mA	*Figure 7.29* *Figure 7.30*
iSnkStdby	Maximum current during voltage transition.			500	mA	*Section 7.2.3*
iSnkSwapStdby	Maximum current a *Sink* can draw during *Swap Standby*. Ideally this current is very near to 0 mA largely influenced by *Port* leakage current.			2.5	mA	*Section 7.2.7*
1) If more bypass capacitance than ***cSnkBulk*** max or ***cSnkBulkPd*** max is required in the device, then the device ***Shall*** incorporate some form of *VBUS* surge current limiting as described in ***[USB 3.2]*** Section 11.4.4.1.						

Table 7.24 Sink Electrical Parameters (Continued)

Parameter	Description	MIN	TYP	MAX	UNITS	Reference
pHubSusp	Suspend power consumption for a *Hub*. 25mW + 25mW per downstream *Port* for up to 4 ports.			125	mW	*Section 7.2.3*
pSnkSusp	Suspend power consumption for a peripheral device.			25	mW	*Section 7.2.3*
tNewSrc	Maximum time allowed for an *Initial Sink* in *Swap Standby* to transition to *New Source* operation.			275	ms	*Section 7.2.7* *Table 7.18* *Table 7.19*
tSnkFRSwap	Time during a *Fast Role Swap* when the *New Sink* can draw no more than ***iSnkStdby***.			200	µs	*Section 7.1.13*
tSnkHardResetPrepare	Time allotted for the *Sink* power electronics to prepare for a *Hard Reset*.			15	ms	*Table 7.12*
tSnkNewPower	Maximum transition time between power levels.			15	ms	*Section 7.2.3*
tSnkRecover	Time for the *Sink* to resume *USB Default Operation*.			150	ms	*Table 7.20*
tSnkStdby	Time to transition to *Sink Standby* from *Sink*.			15	ms	*Section 7.2.3*
tSnkSwapStdby	Maximum time for the *Sink* to transition to *Swap Standby*.			15	ms	*Section 7.2.7*
vEprMax	Highest voltage an *EPR Sink* is expected to tolerate			55	V	*Section 7.2.9.2*
vSprMax	Highest voltage an *SPR Sink* is expected to tolerate			24	V	*Section 7.2.9.2*

1) If more bypass capacitance than ***cSnkBulk*** max or ***cSnkBulkPd*** max is required in the device, then the device ***Shall*** incorporate some form of *VBUS* surge current limiting as described in ***[USB 3.2]*** Section 11.4.4.1.

7.4.3 Common Electrical Parameters

Electrical Parameters that are common to both the *Source* and the *Sink* that ***Shall*** be followed are specified in *Table 7.25, "Common Source/Sink Electrical Parameters"*".

Table 7.25 Common Source/Sink Electrical Parameters

Parameter	Description	MIN	TYP	MAX	UNITS	Reference
tSafe0V	Time to reach ***vSafe0V*** max.			650	ms	*Section 7.1.5* *Figure 7.10* *Table 7.20* *Table 7.21*
tSafe5V	Time to reach ***vSafe5V*** max.			275	ms	*Section 7.1.5* *Figure 7.10* *Table 7.20* *Table 7.21*
tVCONNReapplied	When the *UFP* is the *VCONN Source*: time from the last bit of the ***GoodCRC*** acknowledging the ***PS_RDY*** *Message* before reapplying *VCONN*. When the *DFP* is the *VCONN Source*: time from when *VCONN* drops below vRaReconnect.	10		20	ms	*Figure 7.19* *Figure 7.20*
tVCONNValid	Time from ***tVCONNReapplied*** until *VCONN* is within vVconnValid (see ***[USB Type-C 2.4]***).[1]	0		5	ms	*Figure 7.19* *Figure 7.20*
tVCONNZero	Time from the last bit of the ***GoodCRC*** acknowledging the ***Accept*** *Message* in response to the ***Data_Reset*** *Message* until *VCONN* is below vRaReconnect (see ***[USB Type-C 2.4]***).			125	ms	*Figure 7.19* *Figure 7.20*
vSafe0V	Safe operating voltage at "zero volts".	0		0.8	V	*Section 7.1.5*
vSafe5V	Safe operating voltage at 5V. See ***[USB 2.0]*** and ***[USB 3.2]*** for allowable *VBUS* voltage range.	4.75		5.5	V	*Section 7.1.5*

1) tVCONNStable (See ***[USB Type-C 2.4]***) still applies.

8 Device Policy

8.1 Overview

This section describes the *Device Policy* and *Policy Engine* that implements it. For an overview of the architecture and how the *Device Policy Manager* fits into this architecture, please see *Section 2.6, "Architectural Overview"*.

8.2 Device Policy Manager

The *Device Policy Manager* is responsible for managing the power used by one or more USB Power Delivery ports. In order to have sufficient knowledge to complete this task it needs relevant information about the device it resides in. Firstly, it has a priori knowledge of the device including the *Capabilities* of the power supply and the receptacles on each *Port* since these will for example have specific current ratings. It also has to know information from the *USB-C® Port Control* module regarding cable insertion, type and rating of cable etc. It also has to have information from the power supply about changes in its *Capabilities* as well as being able to request power supply changes. With all of this information the *Device Policy Manager* is able to provide up to date information regarding the *Capabilities* available to a specific *Port* and to manage the power resources within the device.

When working out the *Capabilities* for a given *Source Port* the *Device Policy Manager* will take into account firstly the current rating of the *Port*'s receptacle and whether the inserted cable is PD or non-PD rated and if so, what is the capability of the plug. This will set an upper bound for the *Capabilities* which might be offered. After this the *Device Policy Manager* will consider the available power supply resources since this will bound which voltages and currents might be offered. Finally, the *Device Policy Manager* will consider what power is currently allocated to other ports, which power is in the Power Reserve and any other amendments to Policy from the *System Policy Manager*. The *Device Policy Manager* will offer a set of *Capabilities* within the bounds detailed above.

When selecting a capability for a given *Sink Port* the *Device Policy Manager* will look at the *Capabilities* offered by the *Source*. This will set an upper bound for the *Capabilities* which might be requested. The *Device Policy Manager* will also consider which *Capabilities* are required by the *Sink* in order to operate. If an appropriate match for voltage and Current can be found within the limits of the receptacle and cable, then this will be requested from the *Source*. If an appropriate match cannot be found then a request for an offered voltage and current will be made, along with an indication of a *Capabilities Mismatch*.

USB PD defines two types of power sources:

- Predefined voltage sources (*Fixed Supply*, *Variable Supply* and *Battery Supply*)
- Programmable voltage sources:
    - Programmable Power Supply (PPS)
    - *Adjustable Voltage Supply* (*AVS*)

The first are generally used for classic charging wherein the *Charger* electronics reside inside the *Sink*. The *Device Policy Manager* in the *Sink* requests a fixed voltage from the list of PDOs offered by the *Source* and which is converted internally to charge the *Sink*'s *Battery* and/or power its function.

The second moves the *Charger* electronics that manage the voltage control outside the *Sink* and back into the *Source* itself. When in *SPR PPS Mode*, the *Device Policy Manager* in the *Sink* requests a specific voltage with a 20mV accuracy and sets a current limit. Unlike traditional USB where *Sink*s are responsible for limiting the current, they consume, the *SPR PPS Source* limits the current to what the *Sink* has requested. When operating in, the *Device Policy Manager* in the *Sink* requests a specific voltage with a 100mV accuracy and requests a maximum current it is allowed to draw.

Note: The *AVS Source*s unlike *SPR PPS Source*s do not support current limit mode. A *Sink* operating in is responsible not to draw more current than it requests.

The process to request power is the same for both types of power *Source*s although the actual format and contents of the request are slightly different. The primary operational differences are:

- A *Sink* that is using *SPR PPS* is required to periodically sent requests to let the *Source* know it is still alive and communicating. When this communication fails a *Hard Reset* results.
- A *Sink* operating in *SPR Mode* has no special timing requirements.
- A *Sink* operating in *EPR Mode* is required to periodically communicate with the *Source* to let it know it is still operational. If the communication fails, a *Hard Reset* results.

For *Dual-Role Power Port*s the *Device Policy Manager* manages the functionality of both a *Source* and a *Sink*. In addition, it is able to manage the *Power Role Swap* process between the two. In terms of power management this could mean that a *Port* which is initially consuming power as a *Sink* is able to become a power resource as a *Source*. Conversely, *Attached Source*s might request that power be provided to them.

The functionality within the *Device Policy Manager* (and to a certain extent the *Policy Engine*) is scalable depending on the complexity of the device, including the number of different power supply *Capabilities* and the number of different features supported for example *System Policy Manager* interface or *Capabilities Mismatch*, and the number of ports being managed. Within these parameters it is possible to implement devices from very simple power supplies to more complex power supplies or devices such as *USB Hub*s or Hard Drives. Within multi-*Port* devices it is also permitted to have a combination of USB Power Delivery and non-USB Power Delivery ports which ***Should*** all be managed by the *Device Policy Manager*.

As noted in *Section 2.6, "Architectural Overview"* the logical architecture used in the PD specification will vary depending on the implementation. This means that different implementations of the *Device Policy Manager* might be relatively small or large depending on the complexity of the device, as indicated above. It is also possible to allocate different responsibilities between the *Policy Engine* and the *Device Policy Manager*, which will lead to different types of architectures and interfaces.

The *Device Policy Manager* is responsible for the following:

- Maintaining the *Local Policy* for the device.
- For a *Source*, monitoring the present *Capabilities* and triggering notifications of the change.
- For a *Sink*, evaluating and responding to *Capabilities* related requests from the *Policy Engine* for a given *Port*.
- Control of the *Source*/*Sink* in the device.
- Control of the *USB-C*® *Port Control* module for each *Port*.
- Interface to the *Policy Engine* for a given *Port*.

The *Device Policy Manager* is responsible for the following ***Optional*** features when implemented:

- Communications with the *System Policy* over USB.
- For *Source*s with multiple ports monitoring and balancing power requirements across these ports.
- Monitoring of batteries and AC power supplies.
- Managing Modes in its *Port Partner* and *Cable Plug*(s).

8.2.1 Capabilities

The *Device Policy Manager* in a *Provider* ***Shall*** know the power supplies available in the device and their *Capabilities*. In addition, it ***Shall*** be aware of any other PD sources of power such as batteries and AC inputs. The available power sources and existing demands on the device ***Shall*** be taken into account when presenting *Capabilities* to a *Sink*.

The *Device Policy Manager* in a *Consumer* ***Shall*** know the requirements of the *Sink* and use this to evaluate the *Capabilities* offered by a *Source*. It ***Shall*** be aware of its own power sources e.g., Batteries or AC supplies where these have a bearing on its operation as a *Sink*.

The *Device Policy Manager* in a *Dual-Role Power Device* ***Shall*** combine the above *Capabilities* and ***Shall*** also be able to present the dual-role nature of the device to an *Attached* PD Capable device.

8.2.2 System Policy

A given PD Capable device might have no USB capability, or PD might have been added to a USB device in such a way that PD is not integrated with USB. In these two cases there ***Shall*** be no requirement for the *Device Policy Manager* to interact with the USB interface of the device. The following requirements ***Shall*** only apply to PD devices that expose PD functionality over USB.

The *Device Policy Manager* ***Shall*** communicate over USB with the *System Policy Manager* according to the requirements detailed in ***[UCSI]***. Whenever requested the *Device Policy Manager* ***Shall*** implement a *Local Policy* according to that requested by the *System Policy Manager*. For example, the *System Policy Manager* might request that a *Battery* powered Device temporarily stops charging so that there is sufficient power for an HDD to spin up.

Note: Due to timing constraints, a PD Capable device ***Shall*** be able to respond autonomously to all time-critical PD related requests.

8.2.3 Control of Source/Sink

The *Device Policy Manager* for a *Provider* ***Shall*** manage the power supply for each PD *Source Port* and ***Shall*** know at any given time what the *Negotiated* power is. It ***Shall*** request transitions of the supply and inform the *Policy Engine* whenever a transition completes.

The *Device Policy Manager* for a *Consumer* ***Shall*** manage the *Sink* for each PD *Sink Port* and ***Shall*** know at any given time what the *Negotiated* power is.

The *Device Policy Manager* for a *Dual-Role Power Device* ***Shall*** manage the transition between *Source*/*Sink Power Roles* for each PD *Dual-Role Power Port* and ***Shall*** know at any given time what *Power Role* the *Port* is in.

8.2.4 Cable Detection

8.2.4.1 Device Policy Manager in a Provider

The *Device Policy Manager* in the *Provider* ***Shall*** control the *USB-C*® *Port Control* module and ***Shall*** be able to use the *USB-C*® *Port Control* module to determine the *Attachment* status.

Note: It might be necessary for the *Device Policy Manager* to also initiate additional discovery using the ***Discover Identity*** *Command* in order to determine the full *Capabilities* of the cabling (see Section 6.4.4.3.1, "Discover Identity").

8.2.4.2 Device Policy Manager in a Consumer

The *Device Policy Manager* in a *Consumer* controls the *USB-C*® *Port Control* module and ***Shall*** be able to use the *USB-C*® *Port Control* module to determine the *Attachment* status.

8.2.4.3 Device Policy Manager in a Consumer/Provider

The *Device Policy Manager* in a *Consumer/Provider* inherits characteristics of *Consumer*s and *Provider*s and ***Shall*** control the *USB-C*® *Port Control* module in order to support the *Dead Battery* back-powering case to determine the following for a given *Port*:

- *Attachment* of a USB Power Delivery *Provider/Consumer* which supports *Dead Battery* back-powering.
- Presence of *VBUS*.

8.2.4.4 Device Policy Manager in a Provider/Consumer

The *Device Policy Manager* in a *Provider/Consumer* inherits characteristics of *Consumer*s and *Provider*s and ***May*** control the *USB-C*® *Port Control* module in order to support the *Dead Battery* back-powering case to determine the following for a given *Port*:

- Presence of *VBUS*.

8.2.5 Managing Power Requirements

It is the responsibility of the *Device Policy Manager* in a *Provider* to be aware of the power requirements of all devices connected to its *Source Port*s. This includes being aware of any reserve power that might be required by devices in the future and ensuring that power is shared optimally amongst *Attached* PD Capable devices. This is a key function of the *Device Policy Manager*; whose implementation is critical to ensuring that all PD Capable devices get the power they require in a timely fashion in order to facilitate smooth operation. This is balanced by the fact that the *Device Policy Manager* is responsible for managing the sources of power that are, by definition, finite.

The *Consumer*'s *Device Policy Manager* ***Shall*** ensure that it takes no more power than is required to perform its functions and when its requirements change, it Should make a new *Request*. The *Provider*, after satisfying the *Request*, ***Should*** reclaim any unused power to ensure that it can meet total power requirements of *Attached Sink*s on at least one *Port*.

Note: It is expected that a future design guide will provide additional guidance.

8.2.5.1 Managing the Power Reserve

There might be some products where a Device has certain functionality at one power level and a greater functionality at another, for example a Printer/Scanner that operates only as a printer with one power level and as a scanner if it can get more power. While the visibility of the linkage between power and functionality might only be apparent to the *USB Host*; the *Device Policy Manager* ***Should*** provide mechanisms to manage the power requirements of such Devices.

It is the *Device Policy Manager*'s responsibility to allocate power and maintain a power reserve so as not to over-subscribe its available power resource. A Device with multiple ports such as a *Hub* ***Shall*** always attempt to meet the incremental demands of the *Port* requiring the highest incremental power from its power reserve.

8.2.5.2 Power Capability Mismatch

A *Capabilities Mismatch* occurs when a *Consumer* cannot obtain required power from a *Provider* (or the *Source* is not PD Capable) and the *Consumer* requires such *Capabilities* to operate. Different actions are taken by the *Device Policy Manager* and the *System Policy Manager* in this case.

8.2.5.2.1 Local device handling of mismatch

The *Consumer*'s *Device Policy Manager* ***Shall*** cause a notification to be displayed to the end user that a power *Capabilities Mismatch* has occurred. Examples of such feedback can include:

- For a simple Device an LED ***May*** be used to indicate the failure. For example, during connection the LED could be solid amber. If the connection is successful, the LED could change to green. If the connection fails, it could be red or alternately blink amber.
- A more sophisticated Device with a user interface, e.g., a mobile device or monitor, ***Should*** provide notification through the user interface on the Device.

The *Provider*'s *Device Policy Manager* ***May*** cause a notification to be displayed to the user of the power *Capabilities Mismatch*.

Because the *Capabilities Mismatch* might not cause operational failure, the *Provider*'s *Device Policy Manager* ***Should Not*** display a notification to the user if the power offered to the *Sink* meets or exceeds the ***SPR Sink Minimum PDP***/***EPR Sink Minimum PDP*** *Advertise*d in the ***Sink_Capabilities_Extended*** *Message* (see Section 6.5.13, "Sink_Capabilities_Extended Message"). If a notification is displayed, it ***Should Not*** be shown as an error unless the power offered to the *Sink* is less than the ***SPR Sink Minimum PDP***/***EPR Sink Minimum PDP*** *Advertise*d in the ***Sink_Capabilities_Extended*** *Message*.

8.2.5.2.2 Device Policy Manager Communication with System Policy

In a USB Power Delivery aware system with an active *System Policy Manager* (see Section 8.2.2, "System Policy"), the *Device Policy Manager* ***Shall*** notify the *System Policy Manager* of the mismatch. This information ***Shall*** be passed back to the *System Policy Manager* using the mechanisms described in ***[UCSI]***. The *System Policy Manager* ***Should*** ensure that the user is informed of the condition. When another *Port* in the system could satisfy the *Consumer*'s power requirements the user ***Should*** be directed to move the Device to the alternate *Port*.

In order to identify a more suitable *Source Port* for the *Consumer* the *System Policy Manager* ***Shall*** communicate with the *Device Policy Manager* in order to determine the *Consumer*'s requirements. The *Device Policy Manager* ***Shall*** use a ***Get_Sink_Cap*** *Message* (see *Section 6.3.8, "Get_Sink_Cap Message"*) to discover which power levels can be utilized by the *Consumer*.

8.2.6 Use of "Unconstrained Power" bit with Batteries and AC supplies

The *Device Policy Manager* in a *Provider* or *Consumer* ***May*** monitor the status of any variable sources of power that could have an impact on its *Capabilities* as a *Source* such as Batteries and AC supplies and reflect this in the "Unconstrained Power" bit (see *Section 6.4.1.2.1.3, "Unconstrained Power"* and *Section 6.4.1.3.1.3, "Unconstrained Power"*) provided as part of the ***Source_Capabilities*** or ***Sink_Capabilities*** *Message* (see *Section 6.4.1, "Capabilities Message"*). When monitored, and a USB interface is supported, the External Power status (see ***[UCSI]***) and the *Battery* state (see *Section 9.4.1, "GetBatteryStatus"*) ***Shall*** also be reported to the *System Policy Manager* using the USB interface.

8.2.6.1 AC Supplies

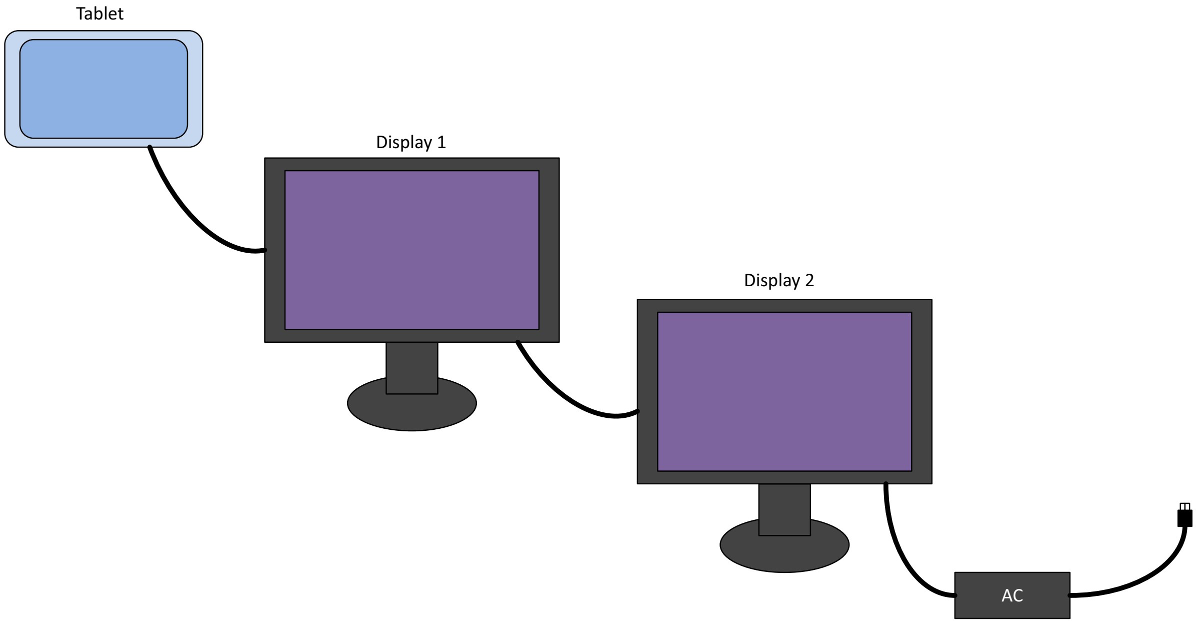
The Unconstrained Power bit provided by *Source*s and *Sink*s (see *Section 6.4.1.2.1.3, "Unconstrained Power"* and *Section 6.4.1.3.1.3, "Unconstrained Power"*) notifies a connected device that it is acceptable to use the *Advertise*d power for charging as well as for what is needed for normal operation. A device that sets the Unconstrained Power bit has either an external source of power that is sufficient to adequately power the system while charging external devices or expects to charge external devices as a primary state of function (such as a battery pack).

In the case of the external power source, the power can either be from an *AC Supply* directly connected to the device or from an *AC Supply* connected to an *Attached* device, which is also getting unconstrained power from its power supply. The Unconstrained Power bit is in this way communicated through a PD system indicating that the origin of the power is from a single or multiple AC supplies, from a battery bank, or similar:

- If the "Unconstrained Power" bit is set, then that power is originally sourced from an *AC Supply*.
- Devices capable of consuming on multiple ports can only claim that they have "Unconstrained Power" for the power *Advertise*d as a *Provider Port* if there is unconstrained power beyond that needed for normal operation coming from external supplies, (e.g., multiple AC supplies).
- This concept applies as the power is routed through multiple *Provider* and *Consumer* tiers, so, as an example. Power provided out of a monitor that is connected to a monitor that gets power from an *AC Supply*, will claim it has "Unconstrained Power" even though it is not directly connected to the *AC Supply*.

An example use case is a Tablet computer that is used with two USB A/V displays that are daisy chained (see *Figure 8.1, "Example of daisy chained displays"*). The tablet and 1st display are not externally powered, (meaning, they have no source of power outside of USB PD). The 2nd display has an external supply *Attached* which could either be a USB PD based supply or some other form of external supply. When the displays are connected as shown, the power adapter *Attached* to the 2nd display is able to power both the 1st display and the tablet. In this case the 2nd display will indicate the presence of a sufficiently sized *Charger* to the 1st display, by setting its "Unconstrained Power" bit. The 1st display will then in turn assess and indicate the presence of the extra power to the tablet by setting its "Unconstrained Power" bit. Power is transmitted through the system to all devices, provided that there is sufficient power available from the external supply.

Figure 8.1 Example of daisy chained displays



Another example use case is a laptop computer that is *Attached* to both an external supply and a Tablet computer. In this situation, if the external supply is large enough to power the laptop in its normal state as well as charge an external device, the laptop would set its "Unconstrained Power" bit and the tablet will allow itself to charge at its peak rate. If the external supply is small, however, and would not prevent the laptop from discharging if maximal power is drawn by the external device, the laptop would not set its "Unconstrained Power" bit, and the tablet can choose to draw less than what is offered. This amount could be just enough to prevent the tablet from discharging, or none at all. Alternatively, if the tablet determines that the laptop has significantly larger battery with more charge than the tablet has, the tablet can still choose to charge itself, although possibly not at the maximal rate.

In this way, *Sink*s that do not receive the ***Unconstrained Power*** bit from the connected *Source* can still choose to charge their batteries, or charge at a reduced rate, if their policy determines that the impact to the *Source* is minimal -- such as in the case of a phone with a small battery charging from a laptop with a large battery. These policies can be decided via further USB PD communication.

8.2.6.2 Battery Supplies

When monitored, and a USB interface is supported, the *Battery* state ***Shall*** be reported to the *System Policy Manager* using the USB interface.

If the device is *Battery*-powered but is in a state that is primarily for charging external devices, the device is considered to be an unconstrained source of power and thus ***Should*** set the "Unconstrained Power" bit.

A simplified algorithm is detailed below to ensure that *Battery* powered devices will get charge from non-*Battery* powered devices when possible, and also to ensure that devices do not constantly *Power Role Swap* back and forth.

When two devices are connected that do not have Unconstrained Power, they ***Should*** define their own policies so as to prevent constant *Power Role Swap*ping.

This algorithm uses the "Unconstrained Power" bit (see *Section 6.4.1.2.1.3, "Unconstrained Power"* and *Section 6.4.1.3.1.3, "Unconstrained Power"*), thus the decisions are based on the availability and sufficiency of an external supply, not the full *Capabilities* of a system or device or product.

Recommendations:

- *Provider/Consumer*s using large external sources ("Unconstrained Power" bit set) ***Should*** always deny *Power Role Swap* requests from *Consumer/Provider*s not using external sources ("Unconstrained Power" bit cleared).

- *Provider/Consumer*s not using large external sources ("Unconstrained Powered" bit cleared) ***Should*** always accept a *Power Role Swap* request from a *Consumer/Provider* using large external power sources ("Unconstrained Power" bit set) unless the requester is not able to provide the requirements of the present *Provider/Consumer*.

8.2.7 Interface to the Policy Engine

The *Device Policy Manager* ***Shall*** maintain an interface to the *Policy Engine* for each *Port* in the device.

8.2.7.1 Device Policy Manager in a Provider

The *Device Policy Manager* in a *Provider* ***Shall*** also provide the following functions to the *Policy Engine*:

- Inform the *Policy Engine* of changes in cable/ device *Attachment* status for a given cable.
- Inform the *Policy Engine* whenever the *Source Capabilities* available for a *Port* change.
- Evaluate requests from an *Attached Consumer* and provide responses to the *Policy Engine*.
- Respond to requests for power supply transitions from the *Policy Engine*.
- Indication to *Policy Engine* when power supply transitions are complete.
- Maintain a power reserve for devices operating on a *Port* at less than maximum power.

8.2.7.2 Device Policy Manager in a Consumer

The *Device Policy Manager* in a *Consumer* ***Shall*** also provide the following functions to the *Policy Engine*:

- Inform the *Policy Engine* of changes in cable/device *Attachment* status.
- Inform the *Policy Engine* whenever the power requirements for a *Port* change.
- Evaluate *Source Capabilities* and provide suitable responses:
  - Request from offered *Capabilities*.
  - Indicate whether additional power is required.
- Respond to requests for *Sink* transitions from the *Policy Engine*.

8.2.7.3 Device Policy Manager in a Dual-Role Power Device

The *Device Policy Manager* in a *Dual-Role Power Device* ***Shall*** provide the following functions to the *Policy Engine*:

- *Provider Device Policy Manager*
- *Consumer Device Policy Manager*
- Interface for the *Policy Engine* to request power supply transitions from *Source* to *Sink* and vice versa.
- Indications to *Policy Engine* during *Power Role Swap* transitions.

8.2.7.4 Device Policy Manager in a Dual-Role Power Device Dead Battery handling

The *Device Policy Manager* in a *Dual-Role Power Device* with a *Dead Battery* ***Should***:

- Switch Ports to *Sink*-only or *Sink DFP* operation to obtain power from the next *Attached Source*.
- Use *VBUS* from the *Attached Source* to power the USB Power Delivery communications as well as charging to enable the *Negotiation* of higher input power.

8.3 Policy Engine

8.3.1 Introduction

There is one *Policy Engine* instance per *Port* that interacts with the *Device Policy Manager* in order to implement the present *Local Policy* for that particular *Port*. This section includes:

- *AMS*s for various operations.
- State diagrams covering operation of Sources, *Sink*s and *Cable Plug*s.

8.3.2 Atomic Message Sequence Diagrams

8.3.2.1 Introduction

The *Policy Engine* drives the *Atomic Message Sequences* (*AMS*) and responses based on both the expected *AMS*s and the present *Local Policy*.

An *AMS* ***Shall*** be defined as a *Message* sequence that starts and/or ends in either the ***PE_SRC_Ready***, ***PE_SNK_Ready*** or ***PE_CBL_Ready*** states (see *Section 8.3.3.2, "Policy Engine Source Port State Diagram"*, *Section 8.3.3.3, "Policy Engine Sink Port State Diagram"* and *Section 8.3.3.25, "Cable Plug Specific State Diagrams"*).

In addition, the *Cable Plug* discovery sequence specified in *Section 8.3.3.25.3, "Source Startup Structured VDM Discover Identity of a Cable Plug State Diagram"* ***Shall*** be defined as an *AMS*.

The *Source* and *Sink* indicate to the *Protocol Layer* when an *AMS* starts and ends on entry to/exit from ***PE_SRC_Ready*** or ***PE_SNK_Ready*** (see *Section 8.3.3.2, "Policy Engine Source Port State Diagram"* and *Section 8.3.3.3, "Policy Engine Sink Port State Diagram"*).

An *AMS* ***Shall*** be considered to have been started by the *Initiator* when the protocol engine signals the *Policy Engine* that transmission is a success (the ***GoodCRC*** *Message* has been received in response to the initial *Message*). For the receiving *Port* the *AMS* ***Shall*** be considered to have started when the initial *Message* has arrived.

An *AMS* ***Shall*** be considered to have ended:

- When the *Protocol Layer* signals the *Policy Engine* that transmission of the final *Message* in the *AMS* is a success and for the opposite *Port* when the final *Message* has been received.
- A ***Soft_Reset*** *Message*, ***Hard Reset*** *Signaling* for *SOP'* or *SOP''* or ***Cable Reset*** *Signaling* has been sent or received.

Section 8.3.2.1.3, "Atomic Message Sequences" gives details of these *AMS*'s.

This section contains sequence diagrams that highlight some of the more interesting transactions. It is by no means a complete summary of all possible combinations but is ***Informative*** in nature.

8.3.2.1.1 Basic Message Exchange

Figure 8.2, "Basic Message Exchange (Successful)" below illustrates how a *Message* is sent. *Table 8.1, "Basic Message Flow"* details the steps in the flow. Note that the sender might be either a *Source* or *Sink* while the receiver might be either a *Sink* or *Source*. The basic *Message* sequence is the same. It starts when the *Message* Sender's *Protocol Layer* at the behest of its *Policy Engine* forms a *Message* that it passes to the *PHY Layer*.

Figure 8.2 Basic Message Exchange (Successful)

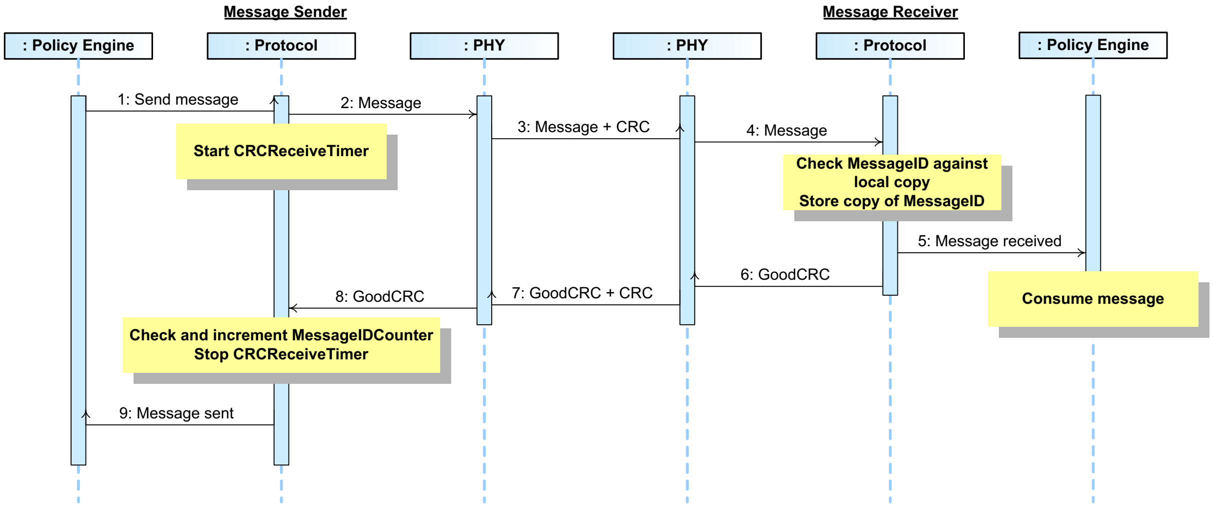


Table 8.1 Basic Message Flow

Step	Message Sender	Message Receiver
1	*Policy Engine* directs *Protocol Layer* to send a *Message*.	
2	*Protocol Layer* creates the *Message* and passes to *PHY Layer*.	
3	*PHY Layer* appends a *CRC* and sends the *Message*. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the *Message* and checks the *CRC* to verify the *Message*.
4		*PHY Layer* removes the *CRC* and forwards the *Message* to the *Protocol Layer*.
5		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. *Protocol Layer* forwards the received *Message* information to the *Policy Engine* that consumes it.
6		*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it to the *PHY Layer*.
7	*PHY Layer* receives the *Message* and checks the *CRC* to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.
8	*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*. *Protocol Layer* checks and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***.	
9	*Protocol Layer* informs the *Policy Engine* that the *Message* was successfully sent.	

8.3.2.1.2 Errors in Basic Message flow

There are various points during the *Message* flow where failures in communication or other issues can occur. *Figure 8.3, "Basic Message flow indicating possible errors"* is an annotated version of *Figure 8.2, "Basic Message Exchange (Successful)"* indicating at which point issues can occur. *Table 8.2, "Potential issues in Basic Message Flow"* details the steps in the flow.

Figure 8.3 Basic Message flow indicating possible errors

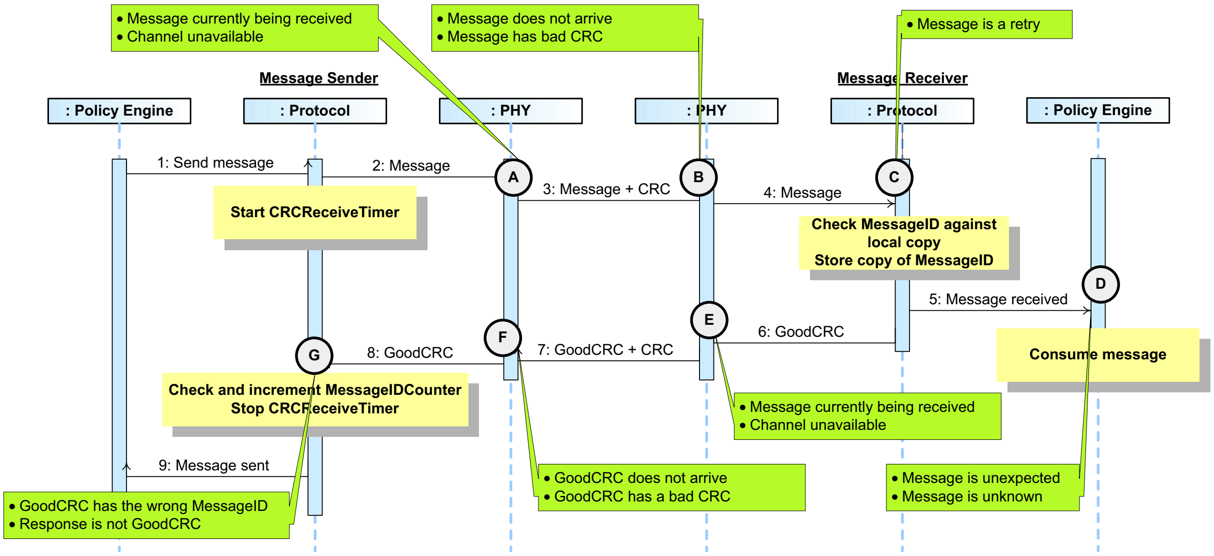


Table 8.2 Potential issues in Basic Message Flow

Point	Possible issues
A	1) There is an incoming *Message* on the channel meaning that the *PHY Layer* is unable to send. In this case the outgoing *Message* is removed from the queue and the incoming *Message* processed. 2) Due to some sort of noise on the line it is not possible to transmit. In this case the outgoing *Message* is ***Discarded*** by the *PHY Layer*. Retransmission is via the *Protocol Layer*'s normal mechanism.
B	1) *Message* does not arrive at the *PHY Layer* due to noise on the channel. 2) *Message* arrives but has been corrupted and has a bad *CRC*. There is no *Message* to pass up to the *Protocol Layer* on the receiver which means a ***GoodCRC*** *Message* is not sent. This leads to a ***CRCReceiveTimer*** timeout in the *Message* Sender.
C	1) ***MessageID*** of received *Message* matches stored ***MessageID*** so this is a retry. *Message* is not passed up to the *Policy Engine*.
D	1) *Policy Engine* receives a known *Message* that it was not expecting. 2) *Policy Engine* receives an *Unrecognized Message*. These cases are errors in the protocol which could lead to the generation of a ***Soft_Reset*** *Message*.
E	Same as point A but at the *Message* Receiver side.

Table 8.2 Potential issues in Basic Message Flow

Point	Possible issues
F	1) ***GoodCRC*** *Message* response does not arrive at the *Message* Sender side due to the noise on the channel. 2) ***GoodCRC*** *Message* response arrives but has a bad *CRC*. A ***GoodCRC*** *Message* is not received by the *Message* Sender's *Protocol Layer*. This leads to a ***CRCReceiveTimer*** timeout in the *Message* Sender.
G	1) ***GoodCRC*** *Message* is received but does contain the same ***MessageID*** as the transmitted *Message*. 2) A *Message* is received but it is not a ***GoodCRC*** *Message* (similar case to that of an unexpected or unknown *Message* but this time detected in the *Protocol Layer*). Both of these issues indicate errors in receiving an expected ***GoodCRC*** *Message* which will lead to a ***CRCReceiveTimer*** timeout in the *Protocol Layer* and a subsequent retry (except for communications with *Cable Plugs*).

Figure 8.4, "Basic Message Flow with Bad followed by a Retry" illustrates one of these cases; the basic *Message* flow with a retry due to a bad *CRC* at the *Message* Receiver. It starts when the *Message* Sender's *Protocol Layer* at the behest of its *Policy Engine* forms a *Message* that it passes to the *PHY Layer*. The *Protocol Layer* is responsible for retries on a "'n' strikes and you are out" basis (***nRetryCount***). *Table 8.3, "Basic Message Flow with CRC failure"* details the steps in the flow.

Figure 8.4 Basic Message Flow with Bad followed by a Retry

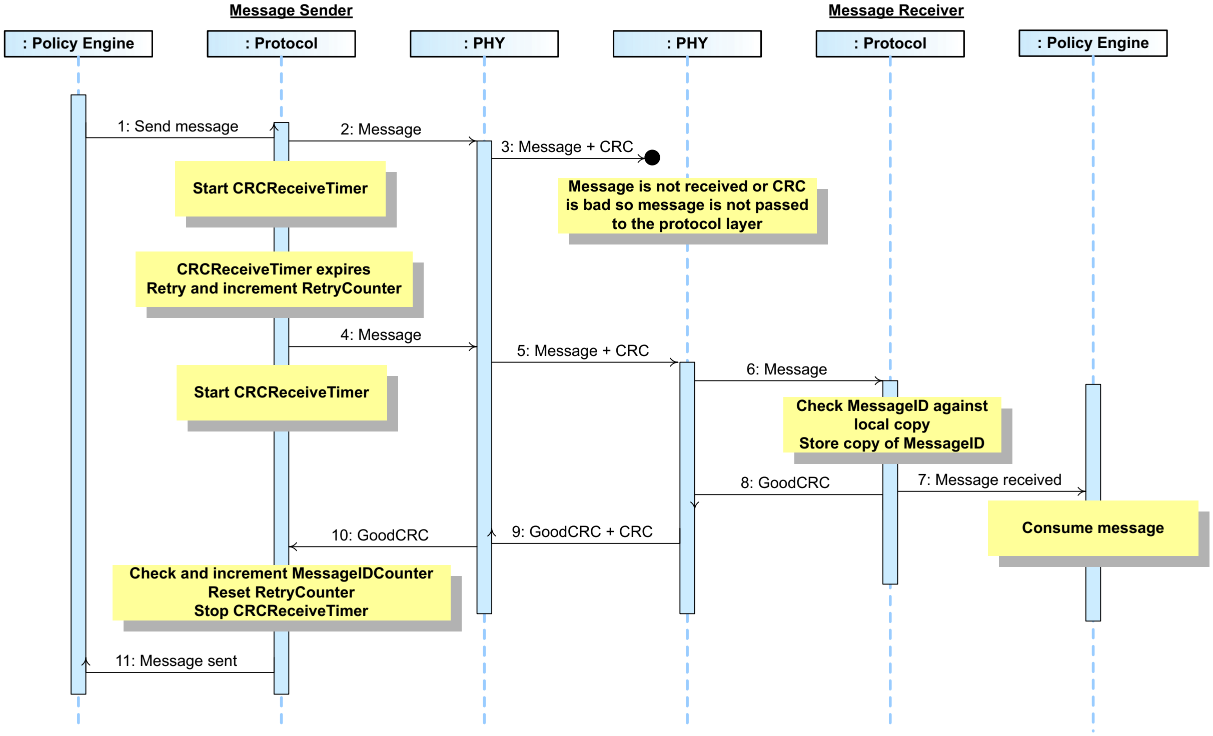


Table 8.3 Basic Message Flow with CRC failure

Step	Message Sender	Message Receiver
1	*Policy Engine* directs *Protocol Layer* to send a *Message*.	
2	*Protocol Layer* creates the *Message* and passes to *PHY Layer*.	
3	*PHY Layer* appends a *CRC* and sends the *Message*. Starts ***CRCReceiveTimer***.	*PHY Layer* receives no *Message* or a *Message* with an incorrect *CRC*. Nothing is passed to *Protocol Layer*.
4	Since no response is received, the ***CRCReceiveTimer*** will expire and trigger the first retry by the *Protocol Layer*. The ***RetryCounter*** is incremented. *Protocol Layer* passes the *Message* to the *PHY Layer*.	
5	*PHY Layer* appends a *CRC* and sends the *Message*. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the *Message* and checks the *CRC* to verify the *Message*.
6		*PHY Layer* removes the *CRC* and forwards the *Message* to the *Protocol Layer*.
7		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. *Protocol Layer* forwards the received *Message* information to the *Policy Engine* that consumes it.
8		*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it to the *PHY Layer*.
9	*PHY Layer* receives the *Message* and checks the *CRC* to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.
10	*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.	
11	*Protocol Layer* verifies the ***MessageID***, stops ***CRCReceiveTimer*** and resets the ***RetryCounter***. *Protocol Layer* informs the *Policy Engine* that the *Message* was successfully sent.	

8.3.2.1.3 Atomic Message Sequences

The types of *Atomic Message Sequences* (*AMS*) are listed in *Table 8.4, "Atomic Message Sequences"*. The following tables list sequences of either *Messages* or combinations of *Messages* and one or more embedded *AMS*es which are *Non-interruptible*. Where there is an embedded *AMS* the entire *Message* sequence is treated as an *AMS* and the R_p value used for *Collision Avoidance* (see *Section 5.7, "Collision Avoidance"*) ***Shall*** only be changed on leaving or entering the ready state at the beginning or end of the entire *Message* sequence, and not at the start or end of the embedded *AMS*.

Note: An *AMS* is has not started until the first *Message* in the sequence has been successfully sent (i.e., a ***GoodCRC*** *Message* has been received acknowledging the *Message*).

Table 8.31, "AMS: Hard Reset" details a *Hard Reset* (which is *Signaling* not an *AMS*) followed by an *SPR Contract Negotiation AMS* which ***Shall*** be treated as *Non-interruptible*.

Table 8.4 Atomic Message Sequences

Type of AMS	Table Reference	Section Reference
Power *Negotiation* (SPR)	*Table 8.5, "AMS: Power Negotiation (SPR)"*	*Section 8.3.2.2.1*
Power *Negotiation* (EPR)	*Table 8.6, "AMS: Power Negotiation (EPR)"*	*Section 8.3.2.2.2*
Unsupported Message	*Table 8.7, "AMS: Unsupported Message"*	*Section 8.3.2.3*
Soft Reset	*Table 8.8, "AMS: Soft Reset"*	*Section 8.3.2.4*
Data Reset	*Table 8.9, "AMS: Data Reset"*	*Section 8.3.2.5*
Hard Reset	*Table 8.31, "AMS: Hard Reset"*	*Section 8.3.2.6*
Power Role Swap	*Table 8.10, "AMS: Power Role Swap"*	*Section 8.3.2.7*
Fast Role Swap	*Table 8.11, "AMS: Fast Role Swap"*	*Section 8.3.2.8*
Data Role Swap	*Table 8.12, "AMS: Data Role Swap"*	*Section 8.3.2.9*
VCONN Swap	*Table 8.13, "AMS: VCONN Swap"*	*Section 8.3.2.10*
Alert	*Table 8.14, "AMS: Alert"*	*Section 8.3.2.11.1*
Status	*Table 8.15, "AMS: Status"*	*Section 8.3.2.11.2*
Source Capabilities/ *Sink Capabilities* (SPR)	*Table 8.16, "AMS: Source/Sink Capabilities (SPR)"*	*Section 8.3.2.11.3.1*
Source Capabilities/ *Sink Capabilities* (EPR)	*Table 8.17, "AMS: Source/Sink Capabilities (EPR)"*	*Section 8.3.2.11.3.2*
Extended Capabilities	*Table 8.18, "AMS: Extended Capabilities"*	*Section 8.3.2.11.4*
Battery Capabilities and Status	*Table 8.19, "AMS: Battery Capabilities"*	*Section 8.3.2.11.5*
Manufacturer Information	*Table 8.20, "AMS: Manufacturer Information"*	*Section 8.3.2.11.6*
Country Codes	*Table 8.21, "AMS: Country Codes"*	*Section 8.3.2.11.7*
Country Information	*Table 8.22, "AMS: Country Information"*	*Section 8.3.2.11.8*
Revision Information	*Table 8.23, "AMS: Revision Information"*	*Section 8.3.2.11.9*
Source Information	*Table 8.24, "AMS: Source Information"*	*Section 8.3.2.11.10*
Security	*Table 8.25, "AMS: Security"*	*Section 8.3.2.12*
Firmware Update	*Table 8.26, "AMS: Firmware Update"*	*Section 8.3.2.13*
Structured VDM	*Table 8.27, "AMS: Structured VDM"*	*Section 8.3.2.14*
Built-In Self-Test (BIST)	*Table 8.28, "AMS: Built-In Self-Test (BIST)"*	*Section 8.3.2.15*
Enter USB	*Table 8.29, "AMS: Enter USB"*	*Section 8.3.2.16*
Unstructured VDM	*Table 8.30, "AMS: Unstructured VDM"*	*Section 8.3.2.17*

8.3.2.1.3.1 AMS: Power Negotiation (SPR)

Table 8.5 AMS: Power Negotiation (SPR)

AMS	Message Sequence	Conditions	AMS Ref	State Machine Ref
SPR Explicit Contract *Negotiation* (Accept)	1. ***Source_Capabilities*** *Message* 2. ***Request*** *Message* 3. ***Accept*** *Message* 4. ***PS_RDY*** *Message*	Started by *Source*, *SPR Mode*	*Section 8.3.2.2.1.1.1*	*Section 8.3.3.2*, *Section 8.3.3.3*
SPR Explicit Contract *Negotiation* (Reject)	1. ***Source_Capabilities*** *Message* 2. ***Request*** *Message* 3. ***Reject*** *Message*		*Section 8.3.2.2.1.1.2*	
SPR Explicit Contract *Negotiation* (Wait)	1. ***Source_Capabilities*** *Message* 2. ***Request*** *Message* 3. ***Wait*** *Message*		*Section 8.3.2.2.1.1.3*	
SPR PPS Keep Alive	1. ***Request*** *Message* 2. ***Accept*** *Message* 3. ***PS_RDY*** *Message*	Started by *Sink*, *SPR Mode*	*Section 8.3.2.2.1.2*	*Section 8.3.3.3*
SPR Sink Makes Request (Accept)	1. ***Request*** *Message* 2. ***Accept*** *Message* 3. ***PS_RDY*** *Message*		*Section 8.3.2.2.1.3.1*	*Section 8.3.3.2*, *Section 8.3.3.3*
SPR Sink Makes Request (Reject)	1. ***Request*** *Message* 2. ***Reject*** *Message*		*Section 8.3.2.2.1.3.2*	
SPR Sink Makes Request (Wait)	1. ***Request*** *Message* 2. ***Wait*** *Message*		*Section 8.3.2.2.1.3.3*	

8.3.2.1.3.2 AMS: Power Negotiation (EPR)

Table 8.6 AMS: Power Negotiation (EPR)

AMS	Message Sequence	Conditions	AMS Ref	State Machine Ref
Entering *EPR Mode* (Success)	1. ***EPR_Mode*** (Enter) *Message* 2. ***EPR_Mode*** (Enter Acknowledge) *Message* 3. *VCONN Source* Swap, initiated by non- *VCONN Source* (Accept) AMS (***Optional***). 4. *Initiator* to *Responder* Discover Identity (ACK) AMS (***Optional*** for Sources with captive cables) 5. ***EPR_Mode*** (Enter Succeeded) *Message* 6. EPR Explicit Contract Negotiation AMS	Started by *Sink*, *SPR Mode*	Section 8.3.2.2.2.1, Section 8.3.2.10.1, Section 8.3.2.10.2, Section 8.3.2.12.3, Section 8.3.2.2.2.4	Section 8.3.3.25.1, Section 8.3.3.25.2, Section 8.3.3.19, Section 8.3.3.20.1, Section 8.3.3.21.1, Section 8.3.3.2, Section 8.3.3.3
Entering *EPR Mode* (Failure due to non-*EPR Cable*)	1. ***EPR_Mode*** (Enter) *Message* 2. ***EPR_Mode*** (Enter Acknowledge) *Message* 3. *VCONN Source* Swap, initiated by non- *VCONN Source* (Accept) AMS(***Optional***). 4. *Initiator* to *Responder* Discover Identity (ACK) AMS (***Optional*** for Sources with captive cables) 5. ***EPR_Mode*** (Enter Failed) *Message*	Started by *Sink*, *SPR Mode*	Section 8.3.2.2.2.2, Section 8.3.2.10.1, Section 8.3.2.10.2, Section 8.3.2.12.3	Section 8.3.3.25.1, Section 8.3.3.25.2, Section 8.3.3.19, Section 8.3.3.20.1, Section 8.3.3.21.1
Entering *EPR Mode* (Failure of *VCONN Swap*)	1. ***EPR_Mode*** (Enter) *Message*. 2. ***EPR_Mode*** (Enter Acknowledge) *Message*. 3. *VCONN Source* Swap, initiated by non- *VCONN Source* (Reject) AMS(***Optional***). 4. ***EPR_Mode*** (Enter Failed) *Message*	Started by *Sink*, *SPR Mode*	Section 8.3.2.2.2.3, Section 8.3.2.10.1, Section 8.3.2.10.2	Section 8.3.3.25.1, Section 8.3.3.25.2, Section 8.3.3.19

Table 8.6 AMS: Power Negotiation (EPR)

AMS	Message Sequence	Conditions	AMS Ref	State Machine Ref
EPR Explicit Contract *Negotiation* (Accept)	1. ***EPR_Source_Capabilities*** *Message* 2. ***EPR_Request*** *Message* 3. ***Accept*** *Message* 4. ***PS_RDY*** *Message*	Started by *Source*, *EPR Mode*	*Section 8.3.2.2.2.2.1*	*Section 8.3.3.2*, *Section 8.3.3.3*
EPR Explicit Contract *Negotiation* (Reject)	1. ***EPR_Source_Capabilities*** *Message* 2. ***EPR_Request*** *Message* 3. ***Reject*** *Message*		*Section 8.3.2.2.2.2.2*	
EPR Explicit Contract *Negotiation* (Wait)	1. ***EPR_Source_Capabilities*** *Message* 2. ***EPR_Request*** *Message* 3. ***Wait*** *Message*		*Section 8.3.2.2.2.2.3*	
EPR Keep Alive	1. ***EPR_KeepAlive*** *Message* 2. ***EPR_KeepAlive_Ack*** *Message*	Started by *Sink*, *EPR Mode*	*Section 8.3.2.2.2.3*	
Exiting *EPR Mode* (*Sink* Initiated)	1. ***EPR_Mode*** (Exit) *Message* 2. SPR Explicit Contract Negotiation AMS	Started by *Sink*, *EPR Mode*	*Section 8.3.2.2.2.4.1*, *Section 8.3.2.2.1.1*	*Section 8.3.3.25.3*, *Section 8.3.3.25.4*, *Section 8.3.3.2*, *Section 8.3.3.3*
Exiting *EPR Mode* (*Source* Initiated)	1. ***EPR_Mode*** (Exit) *Message* 2. SPR Explicit Contract Negotiation AMS	Started by *Source*, *EPR Mode*	*Section 8.3.2.2.2.4.2*, *Section 8.3.2.2.1.1*	
EPR Sink Makes Request (Accept)	1. ***EPR_Request*** *Message* 2. ***Accept*** *Message* 3. ***PS_RDY*** *Message*	Started by *Sink*, *EPR Mode*	*Section 8.3.2.2.2.5.1*	*Section 8.3.3.2*, *Section 8.3.3.3*
EPR Sink Makes Request (Reject)	1. ***EPR_Request*** *Message* 2. ***Reject*** *Message*	Started by *Sink*, *EPR Mode*	*Section 8.3.2.2.2.5.2*	
EPR Sink Makes Request (Wait)	1. ***EPR_Request*** *Message* 2. ***Wait*** *Message*	Started by *Sink*, *EPR Mode*	*Section 8.3.2.2.2.5.3*	

8.3.2.1.3.3 AMS: Unsupported Message

Table 8.7 AMS: Unsupported Message

AMS	Message Sequence	Conditions	AMS Ref	State Machine Ref
Unsupported Message	1. Any *Message* which is not supported by the *Source* or *Sink* 2. ***Not_Supported*** *Message*	Started by *Source* or *Sink*	Section 8.3.2.3	Section 8.3.6.2

8.3.2.1.3.4 AMS: Soft Reset

Table 8.8 AMS: Soft Reset

AMS	Message Sequence	Conditions	AMS Ref	State Machine Ref
Soft Reset	1. ***Soft_Reset*** *Message* 2. ***Accept*** *Message* 3. In *SPR Mode*: SPR Explicit Contract Negotiation AMS 4. or in *EPR Mode*: EPR Explicit Contract Negotiation AMS.	Started by *Source* or *Sink*	Section 8.3.2.4, Section 8.3.2.2.1.1, Section 8.3.2.2.1.1, Section 8.3.2.2.2.2	Section 8.3.3.4.1, Section 8.3.3.4.2, Section 8.3.3.25.2.1, Section 8.3.3.25.2.3, Section 8.3.3.25.2.4, Section 8.3.3.2, Section 8.3.3.3

8.3.2.1.3.5 AMS: Data Reset

Table 8.9 AMS: Data Reset

AMS	Message Sequence	Conditions	AMS Ref	State Machine Ref
DFP Initiated *Data Reset* where the *DFP* is the VCONN *Source*	1. ***Data_Reset*** *Message* 2. ***Accept*** *Message* 3. ***Data_Reset_Complete*** *Message*	Started by *DFP*	Section 8.3.2.5.1	Section 8.3.3.5.1, Section 8.3.3.5.2
DFP Receives *Data Reset* where the *DFP* is the VCONN *Source*	1. ***Data_Reset*** *Message* 2. ***Accept*** *Message* 3. ***Data_Reset_Complete*** *Message*	Started by *UFP*	Section 8.3.2.5.2	
DFP Initiated *Data Reset* where the *UFP* is the VCONN *Source*	1. ***Data_Reset*** *Message* 2. ***Accept*** *Message* 3. ***PS_RDY*** *Message* 4. ***Data_Reset_Complete*** *Message*	Started by *DFP*	Section 8.3.2.5.3	
DFP Receives *Data Reset* where the *UFP* is the VCONN *Source*	1. ***Data_Reset*** *Message* 2. ***Accept*** *Message* 3. ***PS_RDY*** *Message* 4. ***Data_Reset_Complete*** *Message*	Started by *UFP*	Section 8.3.2.5.4	

8.3.2.1.3.6 AMS: Power Role Swap

Table 8.10 AMS: Power Role Swap

AMS	Message Sequence	Conditions	AMS Ref	State Machine Ref
Source Initiated *Power Role Swap* (Accept)	1. ***PR_Swap*** *Message* 2. ***Accept*** *Message* 3. ***PS_RDY*** *Message* 4. ***PS_RDY*** *Message* 5. SPR Explicit Contract Negotiation AMS	Started by *Source*	Section 8.3.2.7.1.1, Section 8.3.2.2.1.1	Section 8.3.3.19.3, Section 8.3.3.19.4, Section 8.3.3.2, Section 8.3.3.3
Source Initiated *Power Role Swap* (Reject)	1. ***PR_Swap*** *Message* 2. ***Reject*** *Message*		Section 8.3.2.7.1.2	
Source Initiated *Power Role Swap* (Wait)	1. ***PR_Swap*** *Message* 2. ***Wait*** *Message*		Section 8.3.2.7.1.1	
Sink Initiated *Power Role Swap* (Accept)	1. ***PR_Swap*** *Message* 2. ***Accept*** *Message* 3. ***PS_RDY*** *Message* 4. ***PS_RDY*** *Message* 5. SPR Explicit Contract Negotiation AMS	Started by *Sink*	Section 8.3.2.7.2.1, Section 8.3.2.2.1.1	
Sink Initiated *Power Role Swap* (Reject)	1. ***PR_Swap*** *Message* 2. ***Reject*** *Message*		Section 8.3.2.7.2.2	
Sink Initiated *Power Role Swap* (Wait)	1. ***PR_Swap*** *Message* 2. ***Wait*** *Message*		Section 8.3.2.7.2.3	

8.3.2.1.3.7 AMS: Fast Role Swap

Table 8.11 AMS: Fast Role Swap

AMS	Message Sequence	Conditions	AMS Ref	State Machine Ref
Fast Role Swap	1. ***FR_Swap*** *Message* 2. ***Accept*** *Message* 3. ***PS_RDY*** *Message* 4. ***PS_RDY*** *Message* 5. SPR Explicit Contract Negotiation AMS	Started by *Sink*	Section 8.3.2.8, Section 8.3.2.2.1.1	Section 8.3.3.2, Section 8.3.3.3, Section 8.3.3.19.5, Section 8.3.3.19.6

8.3.2.1.3.8 AMS: Data Role Swap

Table 8.12 AMS: Data Role Swap

AMS	Message Sequence	Conditions	AMS Ref	State Machine Ref
Data Role Swap, Initiated by *UFP* Operating as *Sink* (Accept)	1. ***DR_Swap*** *Message* 2. ***Accept*** *Message*	Started by *Sink*	*Section 8.3.2.9.1.1*	*Section 8.3.3.19.1*, *Section 8.3.3.19.2*
Data Role Swap, Initiated by *UFP* Operating as *Sink* (Reject)	1. ***DR_Swap*** *Message* 2. ***Reject*** *Message*		*Section 8.3.2.9.1.2*	
Data Role Swap, Initiated by *UFP* Operating as *Sink* (Wait)	1. ***DR_Swap*** *Message* 2. ***Wait*** *Message*		*Section 8.3.2.9.1.3*	
Data Role Swap, Initiated by *UFP* Operating as *Source* (Accept)	1. ***DR_Swap*** *Message* 2. ***Accept*** *Message*	Started by *Source*	*Section 8.3.2.9.2.1*	
Data Role Swap, Initiated by *UFP* Operating as *Source* (Reject)	1. ***DR_Swap*** *Message* 2. ***Reject*** *Message*		*Section 8.3.2.9.2.2*	
Data Role Swap, Initiated by *UFP* Operating as *Source* (Wait)	1. ***DR_Swap*** *Message* 2. ***Wait*** *Message*		*Section 8.3.2.9.2.3*	
Data Role Swap, Initiated by *DFP* Operating as *Source* (Accept)	1. ***DR_Swap*** *Message* 2. ***Accept*** *Message*	Started by *Source*	*Section 8.3.2.9.3.1*	
Data Role Swap, Initiated by *DFP* Operating as *Source* (Reject)	1. ***DR_Swap*** *Message* 2. ***Reject*** *Message*		*Section 8.3.2.9.3.2*	
Data Role Swap, Initiated by *DFP* Operating as *Source* (Wait)	1. ***DR_Swap*** *Message* 2. ***Wait*** *Message*		*Section 8.3.2.9.3.3*	
Data Role Swap, Initiated by *DFP* Operating as *Sink* (Accept)	1. ***DR_Swap*** *Message* 2. ***Accept*** *Message*	Started by *Sink*	*Section 8.3.2.9.4.1*	
Data Role Swap, Initiated by *DFP* Operating as *Sink* (Reject)	1. ***DR_Swap*** *Message* 2. ***Reject*** *Message*		*Section 8.3.2.9.4.2*	
Data Role Swap, Initiated by *DFP* Operating as *Sink* (Wait)	1. ***DR_Swap*** *Message* 2. ***Wait*** *Message*		*Section 8.3.2.9.4.3*	

8.3.2.1.3.9 AMS: VCONN Swap

Table 8.13 AMS: VCONN Swap

AMS	Message Sequence	Conditions	AMS Ref	State Machine Ref
VCONN Source Swap, initiated by *VCONN Source* (Accept)	1. ***VCONN_Swap** Message* 2. ***Accept** Message* 3. ***PS_RDY** Message*	Started by *VCONN Source*	Section 8.3.2.10.1.1	Section 8.3.3.20
VCONN Source Swap, initiated by *VCONN Source* (Reject)	1. ***VCONN_Swap** Message* 2. ***Reject** Message*		Section 8.3.2.10.1.2	
VCONN Source Swap, initiated by *VCONN Source* (Wait)	1. ***VCONN_Swap** Message* 2. ***Wait** Message*		Section 8.3.2.10.1.3	
VCONN Source Swap, initiated by non-*VCONN Source* (Accept)	1. ***VCONN_Swap** Message* 2. ***Accept** Message* 3. ***PS_RDY** Message*	Started by non-*VCONN Source*	Section 8.3.2.10.2.1	
VCONN Source Swap, initiated by non-*VCONN Source* (Reject)	1. ***VCONN_Swap** Message* 2. ***Reject** Message*		Section 8.3.2.10.2.2	
VCONN Source Swap, initiated by non-*VCONN Source* (Wait)	1. ***VCONN_Swap** Message* 2. ***Wait** Message*		Section 8.3.2.10.2.3	

8.3.2.1.3.10 AMS: Alert

Table 8.14 AMS: Alert

AMS	Message Sequence	Conditions	AMS Ref	AMS Ref
Source sends Alert to a *Sink* (***SenderResponseTimer*** Timeout)	1. ***Alert** Message*	Started by *Source*	Section 8.3.2.11.1.1	Section 8.3.3.7.1, Section 8.3.3.7.2
Source sends Alert to a *Sink* (***Get_Status** Message*)	1. ***Alert** Message* 2. Sink Gets Source Status AMS			
Sink sends Alert to a *Source* (***SenderResponseTimer*** Timeout)	1. ***Alert** Message*	Started by *Sink*	Section 8.3.2.11.1.2	Section 8.3.3.7.3, Section 8.3.3.7.4
Sink sends Alert to a *Source* (***Get_Status** Message*)	1. ***Alert** Message* 2. Source Gets Sink Status AMS			

8.3.2.1.3.11 AMS: Status

Table 8.15 AMS: Status

AMS	Message Sequence	Conditions	AMS Ref	State Machine Ref
Sink Gets *Source* Status	1. ***Get_Status*** *Message* 2. ***Status*** *Message*	Started by *Sink* Started by *Source*	Section 8.3.2.11.2.1, Section 8.3.2.11.2.2	Section 8.3.3.10.1, Section 8.3.3.10.2
Source Gets *Sink* Status	1. ***Get_Status*** *Message* 2. ***Status*** *Message*			
VCONN Source Gets *Cable Plug* Status	1. ***Get_Status*** *Message* 2. ***Status*** *Message*	Started by *VCONN Source* Started by *Sink*	Section 8.3.2.11.2.3, Section 8.3.2.11.2.4	
Sink Gets *Source* PPS Status	1. ***Get_PPS_Status*** *Message* 2. ***PPS_Status*** *Message*			Section 8.3.3.10.3, Section 8.3.3.10.4

8.3.2.1.3.12 AMS: Source/Sink Capabilities (SPR)

Table 8.16 AMS: Source/Sink Capabilities (SPR)

AMS	Message Sequence	Conditions	AMS Ref	State Machine Ref
Sink Gets *Source Capabilities* (*EPR Mode*)	1. ***Get_Source_Cap*** *Message* 2. ***Source_Capabilities*** *Message*	Started by *Sink*	Section 8.3.2.11.3.1.1, Section 8.3.2.2.1.3.1, Section 8.3.2.2.1.3.2, Section 8.3.2.2.1.3.3	Section 8.3.3.2, Section 8.3.3.3,
Sink Gets *Source Capabilities* (Accept in *SPR Mode*)	1. ***Get_Source_Cap*** *Message* 2. ***Source_Capabilities*** *Message* 3. In *SPR Mode* only: SPR Sink Makes Request (Accept) AMS			
Sink Gets *Source Capabilities* (Reject in *SPR Mode*)	1. ***Get_Source_Cap*** *Message* 2. ***Source_Capabilities*** *Message* 3. In *SPR Mode* only: SPR Sink Makes Request (Reject) AMS			
Sink Gets *Source Capabilities* (Wait in *SPR Mode*)	1. ***Get_Source_Cap*** *Message* 2. ***Source_Capabilities*** *Message* 3. In *SPR Mode* only: SPR Sink Makes Request (Wait) AMS			
Dual-Role Power Source Gets *Source Capabilities* from a *Dual-Role Power Sink*	1. ***Get_Source_Cap*** *Message* 2. ***Source_Capabilities*** *Message*	Started by *Source*	Section 8.3.2.11.3.1.2	Section 8.3.3.19.7, Section 8.3.3.19.10
Source Gets *Sink Capabilities*	1. ***Get_Sink_Cap*** *Message* 2. ***Sink_Capabilities*** *Message*	Started by *Source*	Section 8.3.2.11.3.1.3	Section 8.3.3.2, Section 8.3.3.3,
Dual-Role Power Sink Get *Sink Capabilities* from a *Dual-Role Power Source*	1. ***Get_Sink_Cap*** *Message* 2. ***Sink_Capabilities*** *Message*	Started by *Sink*	Section 8.3.2.11.3.1.4	Section 8.3.3.19.9, Section 8.3.3.19.8

8.3.2.1.3.13 AMS: Source/Sink Capabilities (EPR)

Table 8.17 AMS: Source/Sink Capabilities (EPR)

AMS	Message Sequence	Conditions	AMS Ref	State Machine Ref
Sink Gets EPR *Source Capabilities* (*SPR Mode*)	1. ***EPR_Get_Source_Cap*** *Message* 2. ***EPR_Source_Capabilities*** *Message*	Started by *Sink*	*Section 8.3.2.11.3.2.1*, *Section 8.3.2.2.2.5.1*, *Section 8.3.2.2.2.5.2*, *Section 8.3.2.2.2.5.3*	*Section 8.3.3.2*, *Section 8.3.3.3*,
Sink Gets EPR *Source Capabilities* (Accept in *EPR Mode*)	1. ***EPR_Get_Source_Cap*** *Message* 2. ***EPR_Source_Capabilities*** *Message* 3. In *EPR Mode* only: *EPR Sink* Makes Request (Accept) AMS			
Sink Gets EPR *Source Capabilities* (Reject in *EPR Mode*)	1. ***EPR_Get_Source_Cap*** *Message* 2. ***EPR_Source_Capabilities*** *Message* 3. In *EPR Mode* only: *EPR Sink* Makes Request (Reject) AMS			
Sink Gets EPR *Source Capabilities* (Wait in *EPR Mode*)	1. ***EPR_Get_Source_Cap*** *Message* 2. ***EPR_Source_Capabilities*** *Message* 3. In *EPR Mode* only: *EPR Sink* Makes Request (Wait) AMS			
Dual-Role Power Source Gets *Source Capabilities* from a *Dual-Role Power EPR Sink*	1. ***EPR_Get_Source_Cap*** *Message* 2. ***EPR_Source_Capabilities*** *Message*	Started by *Source*	*Section 8.3.2.11.3.2.2*	*Section 8.3.3.19.7*, *Section 8.3.3.19.10*
Source Gets *Sink EPR Capabilities*	1. ***EPR_Get_Sink_Cap*** *Message* 2. ***EPR_Sink_Capabilities*** *Message*	Started by *Source*	*Section 8.3.2.11.3.2.3*	*Section 8.3.3.2*, *Section 8.3.3.3*,
Dual-Role Power Sink Get *Sink EPR Capabilities* from a *Dual-Role Power Source*	1. ***EPR_Get_Sink_Cap*** *Message* 2. ***EPR_Sink_Capabilities*** *Message*	Started by *Sink*	*Section 8.3.2.11.3.2.4*	*Section 8.3.3.19.8*, *Section 8.3.3.19.9*

8.3.2.1.3.14 AMS: Extended Capabilities

Table 8.18 AMS: Extended Capabilities

AMS	Interruptible	Message Sequence	Conditions	AMS Ref
Sink Gets *Source Extended Capabilities*	1. ***Get_Source_Cap_Extended*** *Message* 2. ***Source_Capabilities_Extended*** *essage*	Started by *Sink* *M*	[Section 8.3.2.11.4.1](#)	[Section 8.3.3.8.1](#), [Section 8.3.3.8.2](#)
Dual-Role Power Source Gets *Source Extended Capabilities* from a *Dual-Role Power Sink*	1. ***Get_Source_Cap_Extended*** *Message* 2. ***Source_Capabilities_Extended*** *essage*	*M* Started by *Source*	[Section 8.3.2.11.4.2](#)	[Section 8.3.3.19.11](#), [Section 8.3.3.19.12](#)
Source Gets *Sink Extended Capabilities*	1. ***Get_Sink_Cap_Extended*** *Message* 2. ***Sink_Capabilities_Extended*** *Message*	Started by *Source*	[Section 8.3.2.11.4.3](#)	[Section 8.3.3.8.3](#), [Section 8.3.3.8.4](#)
Dual-Role Power Sink Gets *Sink Extended Capabilities* from a *Dual-Role Power Source*	1. ***Get_Sink_Cap_Extended*** *Message* 2. ***Sink_Capabilities_Extended*** *Message*	Started by *Sink*	[Section 8.3.2.11.4.4](#)	[Section 8.3.3.19.13](#), [Section 8.3.3.19.14](#)

8.3.2.1.3.15 AMS: Battery Capabilities

Table 8.19 AMS: Battery Capabilities

AMS	Message Sequence	Conditions	AMS Ref	State Machine Ref
Sink Gets *Battery Capabilities*	1. ***Get_Battery_Cap*** *Message* 2. ***Battery_Capabilities*** *Message*	Started by *Sink*	[Section 8.3.2.11.5.1](#)	[Section 8.3.3.11.1](#), [Section 8.3.3.11.2](#)
Source Gets *Battery Capabilities*	1. ***Get_Battery_Cap*** *Message* 2. ***Battery_Capabilities*** *Message*	Started by *Source*	[Section 8.3.2.11.5.2](#)	
Sink Gets *Battery* Status	1. ***Get_Battery_Status*** *Message* 2. ***Battery_Status*** *Message*	Started by *Sink*	[Section 8.3.2.11.5.3](#)	[Section 8.3.3.12.1](#), [Section 8.3.3.12.2](#)
Sink Gets *Battery* Status	1. ***Get_Battery_Cap*** *Message* 2. ***Battery_Status*** *Message*	Started by *Sink*	[Section 8.3.2.11.5.4](#)	

8.3.2.1.3.16 AMS: Manufacturer Information

Table 8.20 AMS: Manufacturer Information

AMS	Message Sequence	Conditions	AMS Ref	State Machine Ref
Source Gets *Port* Manufacturer Information from a *Sink*	1. ***Get_Manufacturer_Info*** *Message* 2. ***Manufacturer_Info*** *Message*	Started by *Source*	*Section 8.3.2.11.6.1*	*Section 8.3.3.12.1*, *Section 8.3.3.12.2*
Sink Gets *Port* Manufacturer Information from a *Source*	1. ***Get_Manufacturer_Info*** *Message* 2. ***Manufacturer_Info*** *Message*	Started by *Sink*	*Section 8.3.2.11.6.2*	
Source Gets *Battery* Manufacturer Information from a *Sink*	1. ***Get_Manufacturer_Info*** *Message* 2. ***Manufacturer_Info*** *Message*	Started by *Source*	*Section 8.3.2.11.6.3*	
Sink Gets *Battery* Manufacturer Information from a *Source*	1. ***Get_Manufacturer_Info*** *Message* 2. ***Manufacturer_Info*** *Message*	Started by *Sink*	*Section 8.3.2.11.6.4*	
VCONN Source Gets Manufacturer Information from a *Cable Plug*	1. ***Get_Manufacturer_Info*** *Message* 2. ***Manufacturer_Info*** *Message*	Started by *VCONN Source*	*Section 8.3.2.11.6.5*	

8.3.2.1.3.17 AMS: Country Codes

Table 8.21 AMS: Country Codes

AMS	Message Sequence	Conditions	AMS Ref	State Machine Ref
Source Gets Country Codes from a *Sink*	1. ***Get_Country_Codes*** *Message* 2. ***Country_Codes*** *Message*	Started by *Source*	*Section 8.3.2.11.7.1*	*Section 8.3.3.14.1*, *Section 8.3.3.14.2*
Sink Gets Country Codes from a *Source*	1. ***Get_Country_Codes*** *Message* 2. ***Country_Codes*** *Message*	Started by *Sink*	*Section 8.3.2.11.7.2*	
VCONN Source Gets Country Codes from a *Cable Plug*	1. ***Get_Country_Codes*** *Message* 2. ***Country_Codes*** *Message*	Started by *VCONN Source*	*Section 8.3.2.11.7.3*	

8.3.2.1.3.18 AMS: Country Information

Table 8.22 AMS: Country Information

AMS	Message Sequence	Conditions	AMS Ref	State Machine Ref
Source Gets Country Information from a *Sink*	1. ***Get_Country_Info*** *Message* 2. ***Country_Info*** *Message*	Started by *Source*	*Section 8.3.2.11.8.1*	*Section 8.3.3.14.3*, *Section 8.3.3.14.4*
Sink Gets Country Information from a *Source*	1. ***Get_Country_Info*** *Message* 2. ***Country_Info*** *Message*	Started by *Sink*	*Section 8.3.2.11.8.2*	
VCONN Source Gets Country Information from a *Cable Plug*	1. ***Get_Country_Info*** *Message* 2. ***Country_Info*** *Message*	Started by *VCONN Source*	*Section 8.3.2.11.8.3*	

8.3.2.1.3.19 AMS: Revision Information

Table 8.23 AMS: Revision Information

AMS	Message Sequence	Conditions	AMS Ref	State Machine Ref
Source Gets Revision Information from a *Sink*	1. ***Get_Revision*** *Message* 2. ***Revision*** *Message*	Started by *Source*	Section 8.3.2.11.9.1	Section 8.3.3.15.1, Section 8.3.3.15.2
Sink Gets Revision Information from a *Source*	1. ***Get_Revision*** *Message* 2. ***Revision*** *Message*	Started by *Sink*	Section 8.3.2.11.9.2	
VCONN Source Gets Revision Information from a *Cable Plug*	1. ***Get_Revision*** *Message* 2. ***Revision*** *Message*	Started by *VCONN Source*	Section 8.3.2.11.9.1	

8.3.2.1.3.20 AMS: Source Information

Table 8.24 AMS: Source Information

AMS	Message Sequence	Conditions	AMS Ref	State Machine Ref
Sink Gets *Source* Information	1. ***Get_Source_Cap_Extended*** *Message* 2. ***Source_Capabilities_Extended*** *essage*	Started by *Sink* *M*	Section 8.3.2.11.10.1	Section 8.3.3.9.1, Section 8.3.3.9.2
Dual-Role Power Source Gets *Source* Information from a *Dual-Role Power Sink*	1. ***Get_Source_Cap_Extended*** *Message* 2. ***Source_Capabilities_Extended*** *essage*	Started by *M* *Source*	Section 8.3.2.11.10.2	Section 8.3.3.19.15, Section 8.3.3.19.16

8.3.2.1.3.21 AMS: Security

Table 8.25 AMS: Security

AMS	Message Sequence	Conditions	AMS Ref	State Machine Ref
Source requests security exchange with *Sink*	1. ***Security_Request*** *Message*	Started by *Source*	Section 8.3.2.12.1	Section 8.3.3.17.1, Section 8.3.3.17.2, Section 8.3.3.17.3
Sink requests security exchange with *Source*	1. ***Security_Request*** *Message*	Started by *Sink*	Section 8.3.2.12.2	
VCONN Source requests security exchange with *Cable Plug*	1. ***Security_Request*** *Message*	Started by *VCONN Source*	Section 8.3.2.12.3	
Source responds to security exchange with *Sink*	1. ***Security_Response*** *Message*	Started by *Source*	Section 8.3.2.12.1	
Sink responds to security exchange with *Source*	1. ***Security_Response*** *Message*	Started by *Sink*	Section 8.3.2.12.2	
VCONN Source requests security exchange with *Cable Plug*	1. ***Security_Response*** *Message*	Started by *VCONN Source*	Section 8.3.2.12.3	

8.3.2.1.3.22 AMS: Firmware Update

Table 8.26 AMS: Firmware Update

AMS	Message Sequence	Conditions	AMS Ref	State Machine Ref
Source requests firmware update exchange with *Sink*	1. ***Firmware_Update_Request*** *Message*	Started by *Source*	Section 8.3.2.13.1	Section 8.3.3.18.1, Section 8.3.3.18.2, Section 8.3.3.18.3
Sink requests firmware update exchange with *Source*	1. ***Firmware_Update_Request*** *Message*	Started by *Sink*	Section 8.3.2.13.2	
VCONN Source requests firmware update exchange with *Cable Plug*	1. ***Firmware_Update_Request*** *Message*	Started by *VCONN Source*	Section 8.3.2.13.3	
Source responds to firmware update exchange with *Sink*	1. ***Firmware_Update_Response*** *Message*	Started by *Source*	Section 8.3.2.13.1	
Sink responds to firmware update exchange with *Source*	1. ***Firmware_Update_Response*** *Message*	Started by *Sink*	Section 8.3.2.13.2	
VCONN Source responds to firmware update exchange with *Cable Plug*	1. ***Firmware_Update_Response*** *Message*	Started by *VCONN Source*	Section 8.3.2.13.3	

8.3.2.1.3.23 AMS: Structured VDM

Table 8.27 AMS: Structured VDM

AMS	Message Sequence	Conditions	AMS Ref	State Machine Ref
Initiator to *Responder* Discover Identity (ACK)	1. ***Discover Identity REQ*** *Command* 2. ***Discover Identity ACK*** *Command*	Started by *Initiator*	Section 8.3.2.14.1.1	Section 8.3.3.21.1, Section 8.3.3.22.1
Initiator to *Responder* Discover Identity (NAK)	1. ***Discover Identity REQ*** *Command* 2. ***Discover Identity NAK*** *Command*		Section 8.3.2.14.1.2	
Initiator to *Responder* Discover Identity (BUSY)	1. ***Discover Identity REQ*** *Command* 2. ***Discover Identity BUSY*** *Command*		Section 8.3.2.14.1.3	
Initiator to *Responder* Discover *SVIDs* (ACK)	1. ***Discover SVIDs REQ*** *Command* 2. ***Discover SVIDs ACK*** *Command*		Section 8.3.2.14.2.1	Section 8.3.3.21.2, Section 8.3.3.22.2
Initiator to *Responder* Discover *SVIDs* (NAK)	1. ***Discover SVIDs REQ*** *Command* 2. ***Discover SVIDs NAK*** *Command*		Section 8.3.2.14.2.2	
Initiator to *Responder* Discover *SVIDs* (BUSY)	1. ***Discover SVIDs REQ*** *Command* 2. ***Discover SVIDs BUSY*** *Command*		Section 8.3.2.14.2.3	
Initiator to *Responder* Discover Modes (ACK)	1. ***Discover Modes REQ*** *Command* 2. ***Discover Modes ACK*** *Command*		Section 8.3.2.14.3.1	Section 8.3.3.21.3, Section 8.3.3.22.3
Initiator to *Responder* Discover Modes (NAK)	1. ***Discover Modes REQ*** *Command* 2. ***Discover Modes NAK*** *Command*		Section 8.3.2.14.3.2	
Initiator to *Responder* Discover Modes (BUSY)	1. ***Discover Modes REQ*** *Command* 2. ***Discover Modes BUSY*** *Command*		Section 8.3.2.14.3.3	
DFP to *UFP* Enter Mode	1. ***Enter Mode REQ*** *Command* 2. ***Enter Mode ACK*** *Command*	Started by *DFP*	Section 8.3.2.14.4.1	Section 8.3.3.23.1, Section 8.3.3.24.1
DFP to *UFP* Exit Mode	1. ***Exit Mode REQ*** *Command* 2. ***Exit Mode ACK*** *Command*		Section 8.3.2.14.4.2	Section 8.3.3.23.2, Section 8.3.3.24.2
DFP to *Cable Plug* Enter Mode	1. ***Enter Mode REQ*** *Command* 2. ***Enter Mode ACK*** *Command*		Section 8.3.2.14.4.3	Section 8.3.3.23.1, Section 8.3.3.25.4.1
DFP to *Cable Plug* Exit Mode	1. ***Exit Mode REQ*** *Command* 2. ***Exit Mode ACK*** *Command*		Section 8.3.2.14.4.4	Section 8.3.3.23.2, Section 8.3.3.25.4.2
Initiator to *Responder* Attention	1. ***Attention REQ*** *Command*	Started by *Initiator*	Section 8.3.2.14.4.5	Section 8.3.3.21.4, Section 8.3.3.22.4

8.3.2.1.3.24 AMS: Built-In Self-Test (BIST)

Table 8.28 AMS: Built-In Self-Test (BIST)

AMS	Message Sequence	Conditions	AMS Ref	State Machine Ref
BIST Carrier Mode	1. ***BIST*** (***BIST Carrier Mode***) Message	Started by *Tester*	Section 8.3.2.15.1	Section 8.3.3.27.1
BIST Test Data Mode	1. ***BIST*** (***BIST Test Data***) Message		Section 8.3.2.15.2	Section 8.3.3.27.2
BIST Shared Capacity Test Mode	1. ***BIST*** (***BIST Shared Test Mode Entry***) Message 2. Series of Messages 3. ***BIST*** (***BIST Shared Test Mode Exit***) Message		Section 8.3.2.15.3	Section 8.3.3.27.3

8.3.2.1.3.25 AMS: Enter USB

Table 8.29 AMS: Enter USB

AMS	Message Sequence	Conditions	AMS Ref	State Machine Ref
UFP Entering USB4® Mode (Accept)	1. ***Enter_USB*** Message 2. ***Accept*** Message	Started by *DFP*	Section 8.3.2.16.1.1	Section 8.3.3.16.1, Section 8.3.3.16.2
UFP Entering USB4 Mode (Reject)	1. ***Enter_USB*** Message 2. ***Reject*** Message		Section 8.3.2.16.1.2	
UFP Entering USB4 Mode (Wait)	1. ***Enter_USB*** Message 2. ***Wait*** Message		Section 8.3.2.16.1.3	
Cable Plug Entering USB4 Mode (Accept)	1. ***Enter_USB*** Message 2. ***Accept*** Message		Section 8.3.2.16.2.1	
Cable Plug Entering USB4 Mode (Reject)	1. ***Enter_USB*** Message 2. ***Reject*** Message		Section 8.3.2.16.2.2	
Cable Plug Entering USB4 Mode (Wait)	1. ***Enter_USB*** Message 2. ***Wait*** Message		Section 8.3.2.16.2.3	

8.3.2.1.3.26 AMS: Unstructured VDM

Table 8.30 AMS: Unstructured VDM

AMS	Message Sequence	AMS Ref	State Machine Ref
Unstructured VDM	1. Unstructured ***Vendor_Defined*** Message	Section 8.3.2.17.1	
VDEM	1. ***Vendor_Defined_Extended*** Message	Section 8.3.2.17.2	

8.3.2.1.3.27 AMS: Hard Reset

Table 8.31 AMS: Hard Reset

AMS	Interruptible	Message Sequence	Conditions	AMS Ref	State Machine Ref
Source Initiated *Hard Reset*	No	1. ***Hard Reset*** *Signaling* 2. SPR Explicit Contract Negotiation AMS	Started by *Source*	*Section 8.3.2.6.1*, *Section 8.3.2.2.1.1*	*Section 8.3.3.2*, *Section 8.3.3.3*
Sink Initiated *Hard Reset*	No	1. ***Hard Reset*** *Signaling* 2. SPR Explicit Contract Negotiation AMS	Started by *Sink*	*Section 8.3.2.6.2*, *Section 8.3.2.2.1.1*	
Source Initiated *Hard Reset – Sink* Long Reset	No	1. ***Hard Reset*** *Signaling* 2. SPR Explicit Contract Negotiation AMS	Started by *Source*	*Section 8.3.2.6.3*, *Section 8.3.2.2.1.1*	

8.3.2.2 Power Negotiation

8.3.2.2.1 SPR

8.3.2.2.1.1 SPR Explicit Contract Negotiation

8.3.2.2.1.1.1 SPR Explicit Contract Negotiation (Accept)

Figure 8.5, "Successful Fixed, Variable or Battery SPR Power Negotiation" illustrates an example of a successful *Message* flow while negotiating an *Explicit Contract* in *SPR Mode*. The *Negotiation* goes through 5 distinct phases:

- The *Source* sends out its power *Capabilities* in a ***Source_Capabilities*** *Message*.
- The *Sink* evaluates these *Capabilities*, and, in the request, phase selects one power level by sending a ***Request*** *Message*.
- The *Source* evaluates the request and accepts the request with an ***Accept*** *Message*.
- The *Source* transitions to the new power level and then informs the *Sink* by sending a ***PS_RDY*** *Message*.
- The *Sink* starts using the new power level.
- For *SPR PPS* operation:
- the *Source* starts its keep alive timer.
- the *Sink* starts its request timer to send periodic ***Request*** *Message*s.

Figure 8.5 Successful Fixed, Variable or Battery SPR Power Negotiation

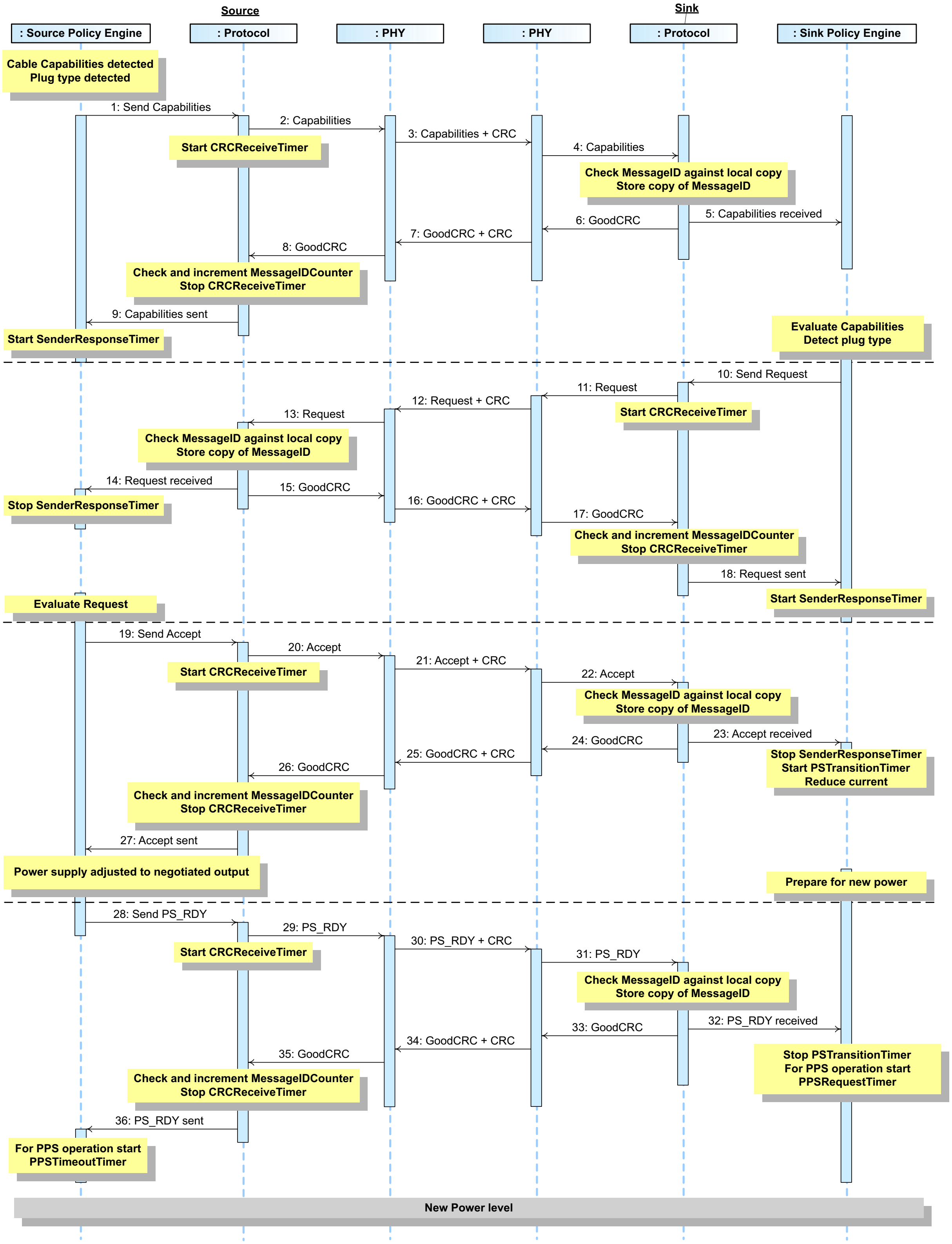


Table 8.32, "Steps for a successful Power Negotiation" below provides a detailed explanation of what happens at each labeled step in *Figure 8.5, "Successful Fixed, Variable or Battery SPR Power Negotiation"* above.

Table 8.32 Steps for a successful Power Negotiation

Step	Source	Sink
1	The *Cable Capabilities* or Plug Type are detected if these are not already known (see *Section 4.4, "Cable Type Detection"*). *Policy Engine* directs the *Protocol Layer* to send a ***Source_Capabilities*** *Message* that represents the power supply's present capabilities.	
2	*Protocol Layer* creates the *Message* and passes to *PHY Layer*.	
3	*PHY Layer* appends *CRC* and sends the ***Source_Capabilities*** *Message*. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the ***Source_Capabilities*** *Message* and checks the *CRC* to verify the *Message*.
4		*PHY Layer* removes the *CRC* and forwards the ***Source_Capabilities*** *Message* to the *Protocol Layer*.
5		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Source_Capabilities*** *Message* information to the *Policy Engine* that consumes it.
6		*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.
7	*PHY Layer* receives the ***GoodCRC*** *Message* and checks the *CRC* to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.
8	*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.	
9	*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Source_Capabilities*** *Message* was successfully sent. *Policy Engine* starts ***SenderResponseTimer***.	
10		*Policy Engine* evaluates the ***Source_Capabilities*** *Message* sent by the *Source*, detects the plug type if this is necessary (see *Section 4.4, "Cable Type Detection"*) and selects which power it would like. It tells the *Protocol Layer* to form the data (e.g., *Power Data Object*) that represents its ***Request*** into a *Message*.
11		*Protocol Layer* creates the ***Request*** *Message* and passes to *PHY Layer*.
12	*PHY Layer* receives the ***Request*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.	*PHY Layer* appends a *CRC* and sends the ***Request*** *Message*. Starts ***CRCReceiveTimer***.
13	*PHY Layer* removes the *CRC* and forwards the ***Request*** *Message* to the *Protocol Layer*.	
14	*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* passes the Request information to the *Policy Engine*. *Policy Engine* stops ***SenderResponseTimer***.	

Table 8.32 Steps for a successful Power Negotiation

Step	Source	Sink
15	The *Protocol Layer* generates a ***GoodCRC*** *Message* and passes it to its *PHY Layer*.	
16	*PHY Layer* appends *CRC* and sends the *Message*.	*PHY Layer* receives the *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
17		*PHY Layer* forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.
18		The *Protocol Layer* verifies and increments the ***MessageIDCounter***. It informs the *Policy Engine* that the ***Request*** *Message* was successfully sent. The *Protocol Layer* stops the ***CRCReceiveTimer***. The *Policy Engine* starts ***SenderResponseTimer***.
19	*Policy Engine* evaluates the ***Request*** *Message* sent by the *Sink* and decides if it can meet the request. It tells the *Protocol Layer* to form an ***Accept*** *Message*.	
20	The *Protocol Layer* forms the ***Accept*** *Message* that is passed to the *PHY Layer*.	
21	*PHY Layer* appends *CRC* and sends the ***Accept*** *Message*. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
22		*PHY Layer* forwards the ***Accept*** *Message* to the *Protocol Layer*.
23		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. *Protocol Layer* informs the *Policy Engine* that an ***Accept*** *Message* has been received. The *Policy Engine* stops ***SenderResponseTimer,*** starts the ***PSTransitionTimer*** and reduces its current draw. The *DPM* prepares the Power supply for transition to the new power level.
24		The *Protocol Layer* generates a ***GoodCRC*** *Message* and passes it to its *PHY Layer*.
25	*PHY Layer* receives the *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.	*PHY Layer* appends *CRC* and sends the *Message*.
26	*PHY Layer* forwards the ***GoodCRC*** *Message* to the *Protocol Layer*. The *Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops the ***CRCReceiveTimer***.	
27	The *Protocol Layer* informs the *Policy Engine* that an ***Accept*** *Message* was successfully sent.	
Power supply Adjusts its Output to the *Negotiated* Value		
28	The *DPM* informs the *Policy Engine* that the power supply has settled at the new operating condition and tells the *Protocol Layer* to send a ***PS_RDY*** *Message*.	
29	The *Protocol Layer* forms the ***PS_RDY*** *Message*.	
30	*PHY Layer* appends *CRC* and sends the ***PS_RDY*** *Message*. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the ***PS_RDY*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
31		*PHY Layer* forwards the ***PS_RDY*** *Message* to the *Protocol Layer*.

Table 8.32 Steps for a successful Power Negotiation

Step	Source	Sink
32		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. *Protocol Layer* informs the *Policy Engine* that a RS_RDY has been received. The *Policy Engine* stops the ***PSTransitionTimer***. When in *SPR PPS Mode* the *Policy Engine* starts the ***SinkPPSPeriodicTimer***.
33		The *Protocol Layer* generates a ***GoodCRC*** *Message* and passes it to its *PHY Layer*.
34	*PHY Layer* receives the *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.	*PHY Layer* appends *CRC* and sends the *Message*.
35	*PHY Layer* forwards the ***GoodCRC*** *Message* to the *Protocol Layer*. The *Protocol Layer* verifies and increments the ***MessageIDCounter***. Stops the ***CRCReceiveTimer***.	
36	The *Protocol Layer* informs the *Policy Engine* that the ***PS_RDY*** *Message* was successfully sent.	
37	When in *SPR PPS Mode* the *Policy Engine* starts the ***SourcePPSCommTimer***.	
New Power Level *Negotiated*		

8.3.2.2.1.1.2 SPR Explicit Contract Negotiation (Reject)

Figure 8.6, "Rejected Fixed, Variable or Battery SPR Power Negotiation" illustrates an example of a *Message* flow where the request is rejected while negotiating an *Explicit Contract* in *SPR Mode*. The *Negotiation* goes through the following phases:

- The *Source* sends out its power *Capabilities* in a ***Source_Capabilities*** *Message*.
- The *Sink* evaluates these *Capabilities*, and, in the request, phase selects one power level by sending a ***Request*** *Message*.
- The *Source* evaluates the request and rejects the request with a ***Reject*** *Message*.

Figure 8.6 Rejected Fixed, Variable or Battery SPR Power Negotiation

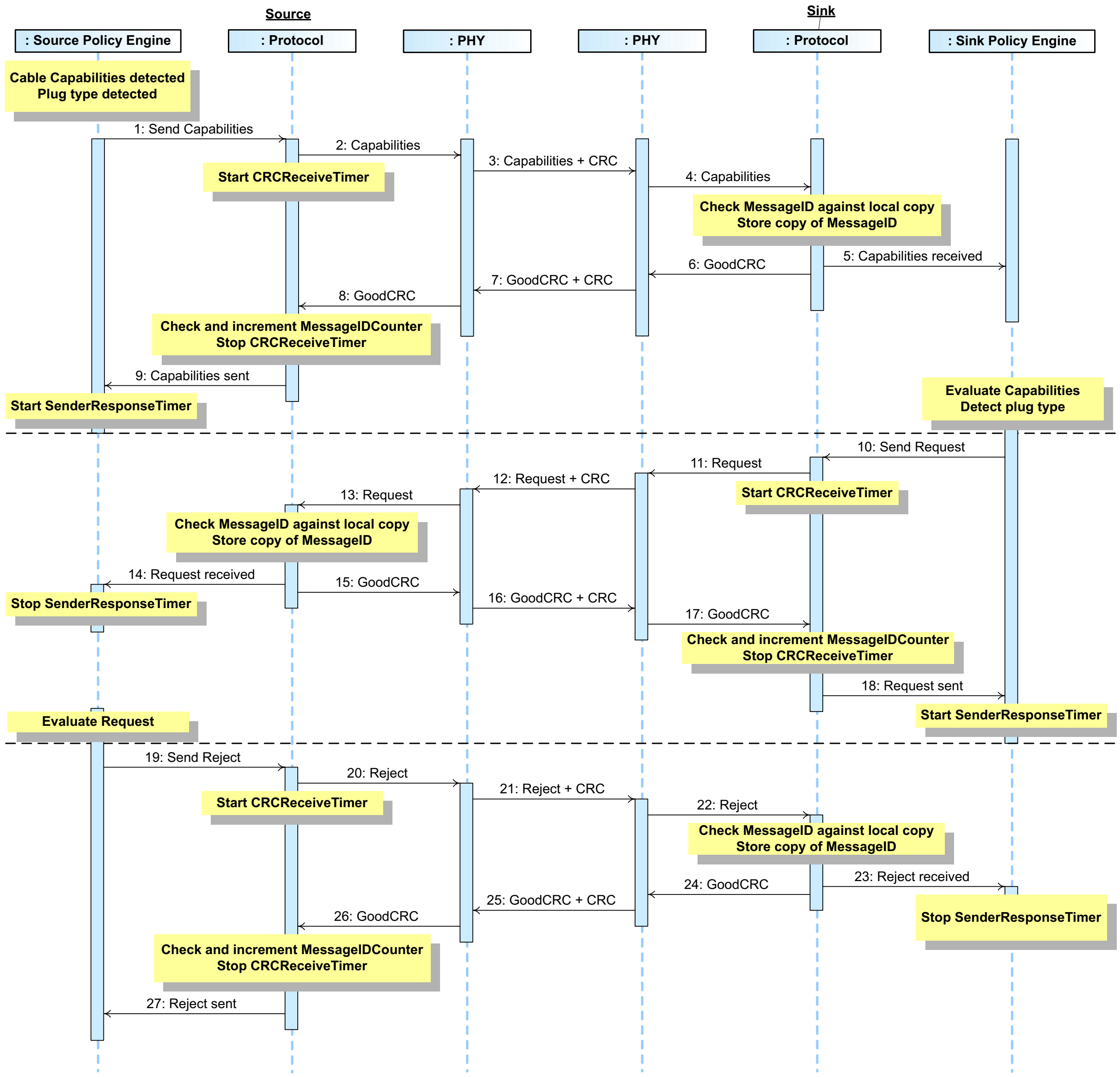


Table 8.33, "Steps for a rejected Power Negotiation" below provides a detailed explanation of what happens at each labeled step in *Figure 8.6, "Rejected Fixed, Variable or Battery SPR Power Negotiation"* above.

Table 8.33 Steps for a rejected Power Negotiation

Step	Source	Sink
1	The *Cable Capabilities* or Plug Type are detected if these are not already known (see *Section 4.4, "Cable Type Detection"*). *Policy Engine* directs the *Protocol Layer* to send a ***Source_Capabilities*** *Message* that represents the power supply's present capabilities.	
2	*Protocol Layer* creates the *Message* and passes to *PHY Layer*.	
3	*PHY Layer* appends *CRC* and sends the ***Source_Capabilities*** *Message*. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the ***Source_Capabilities*** *Message* and checks the *CRC* to verify the *Message*.
4		*PHY Layer* removes the *CRC* and forwards the ***Source_Capabilities*** *Message* to the *Protocol Layer*.
5		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Source_Capabilities*** *Message* information to the *Policy Engine* that consumes it.
6		*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.
7	*PHY Layer* receives the ***GoodCRC*** *Message* and checks the *CRC* to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.
8	*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.	
9	*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Source_Capabilities*** *Message* was successfully sent. *Policy Engine* starts ***SenderResponseTimer***.	
10		*Policy Engine* evaluates the ***Source_Capabilities*** *Message* sent by the *Source*, detects the plug type if this is necessary (see *Section 4.4, "Cable Type Detection"*) and selects which power it would like. It tells the *Protocol Layer* to form the data (e.g., *Power Data Object*) that represents its Request into a *Message*.
11		*Protocol Layer* creates the ***Request*** *Message* and passes to *PHY Layer*.
12	*PHY Layer* receives the ***Request*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.	*PHY Layer* appends a *CRC* and sends the ***Request*** *Message*. Starts ***CRCReceiveTimer***.
13	*PHY Layer* removes the *CRC* and forwards the ***Request*** *Message* to the *Protocol Layer*.	
14	*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* passes the Request information to the *Policy Engine*. *Policy Engine* stops ***SenderResponseTimer***.	

Table 8.33 Steps for a rejected Power Negotiation

Step	Source	Sink
15	The *Protocol Layer* generates a ***GoodCRC*** *Message* and passes it to its *PHY Layer*.	
16	*PHY Layer* appends *CRC* and sends the *Message*.	*PHY Layer* receives the *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
17		*PHY Layer* forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.
18		The *Protocol Layer* verifies and increments the ***MessageIDCounter***. It informs the *Policy Engine* that the ***Request*** *Message* was successfully sent. The *Protocol Layer* stops the ***CRCReceiveTimer***. The *Policy Engine* starts ***SenderResponseTimer***.
19	*Policy Engine* evaluates the ***Request*** *Message* sent by the *Sink* and decides it can't meet the request. It tells the *Protocol Layer* to form a ***Reject*** *Message*.	
20	The *Protocol Layer* forms the ***Reject*** *Message* that is passed to the *PHY Layer*.	
21	*PHY Layer* appends *CRC* and sends the ***Reject*** *Message*. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
22		*PHY Layer* forwards the ***Reject*** *Message* to the *Protocol Layer*.
23		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. *Protocol Layer* informs the *Policy Engine* that a ***Reject*** *Message* has been received. The *Policy Engine* stops ***SenderResponseTimer.***
24		The *Protocol Layer* generates a ***GoodCRC*** *Message* and passes it to its *PHY Layer*.
25	*PHY Layer* receives the *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.	*PHY Layer* appends *CRC* and sends the *Message*.
26	*PHY Layer* forwards the ***GoodCRC*** *Message* to the *Protocol Layer*. The *Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops the ***CRCReceiveTimer***.	
27	The *Protocol Layer* informs the *Policy Engine* that a ***Reject*** *Message* was successfully sent.	

8.3.2.2.1.1.3 SPR Explicit Contract Negotiation (Wait)

Figure 8.7, "Wait response to Fixed, Variable or Battery SPR Power Negotiation" illustrates an example of a *Message* flow where the request is responded to with wait while negotiating an *Explicit Contract* in *SPR Mode*. The *Negotiation* goes through the following phases:

- The *Source* sends out its power *Capabilities* in a ***Source_Capabilities*** *Message*.
- The *Sink* evaluates these *Capabilities*, and, in the request, phase selects one power level by sending a ***Request*** *Message*.
- The *Source* evaluates the request and rejects the request with a ***Wait*** *Message*.

Figure 8.7 Wait response to Fixed, Variable or Battery SPR Power Negotiation

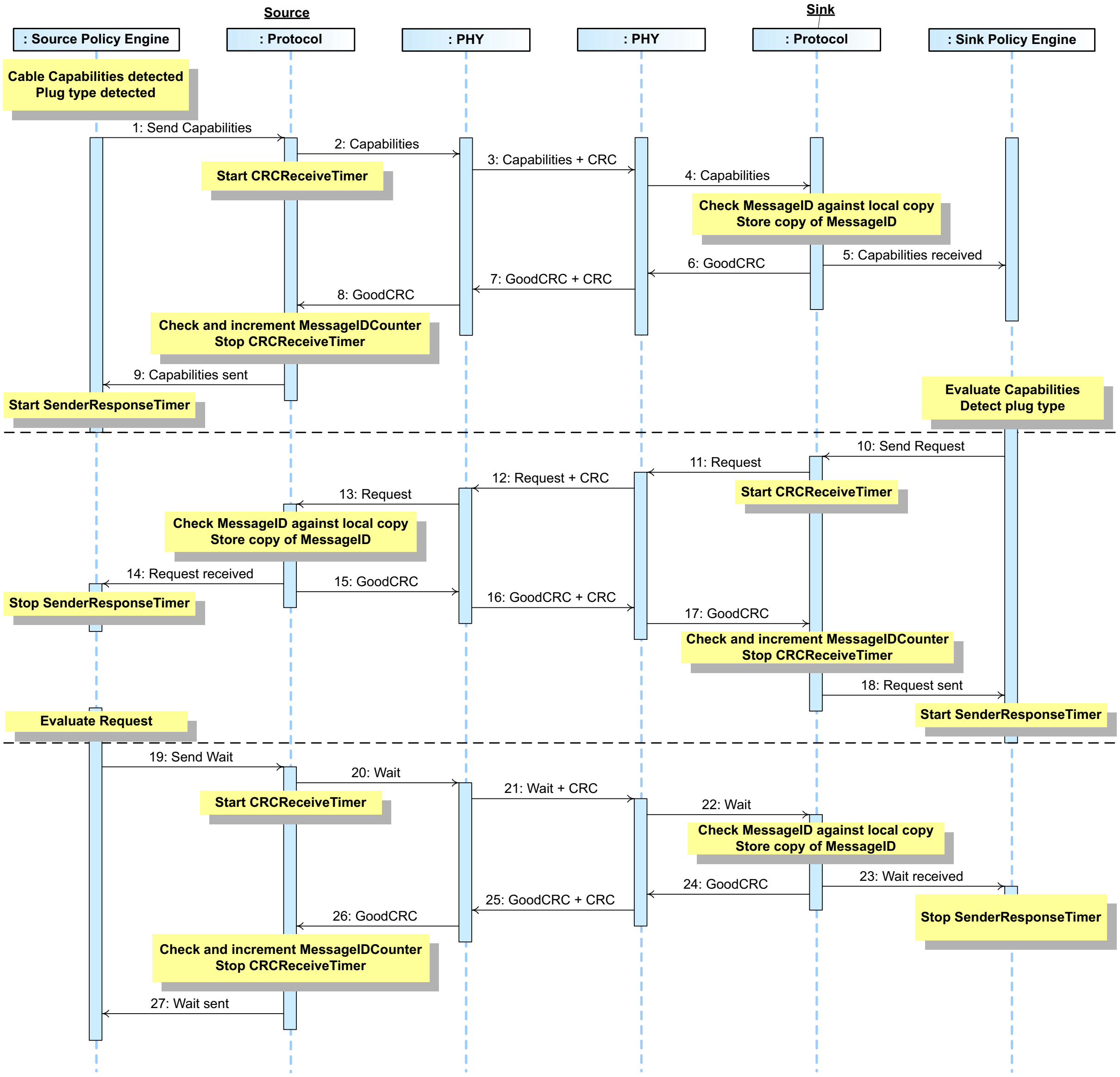


Table 8.34, "Steps for a Wait response to a Power Negotiation" below provides a detailed explanation of what happens at each labeled step in *Figure 8.7, "Wait response to Fixed, Variable or Battery SPR Power Negotiation"* above.

Table 8.34 Steps for a Wait response to a Power Negotiation

Step	Source	Sink
1	The *Cable Capabilities* or Plug Type are detected if these are not already known (see *Section 4.4, "Cable Type Detection"*). *Policy Engine* directs the *Protocol Layer* to send a ***Source_Capabilities*** *Message* that represents the power supply's present capabilities.	
2	*Protocol Layer* creates the *Message* and passes to *PHY Layer*.	
3	*PHY Layer* appends *CRC* and sends the ***Source_Capabilities*** *Message*. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the ***Source_Capabilities*** *Message* and checks the *CRC* to verify the *Message*.
4		*PHY Layer* removes the *CRC* and forwards the ***Source_Capabilities*** *Message* to the *Protocol Layer*.
5		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Source_Capabilities*** *Message* information to the *Policy Engine* that consumes it.
6		*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.
7	*PHY Layer* receives the ***GoodCRC*** *Message* and checks the *CRC* to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.
8	*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.	
9	*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Source_Capabilities*** *Message* was successfully sent. *Policy Engine* starts ***SenderResponseTimer***.	
10		*Policy Engine* evaluates the ***Source_Capabilities*** *Message* sent by the *Source*, detects the plug type if this is necessary (see *Section 4.4, "Cable Type Detection"*) and selects which power it would like. It tells the *Protocol Layer* to form the data (e.g., *Power Data Object*) that represents its Request into a *Message*.
11		*Protocol Layer* creates the ***Request*** *Message* and passes to *PHY Layer*.
12	*PHY Layer* receives the ***Request*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.	*PHY Layer* appends a *CRC* and sends the ***Request*** *Message*. Starts ***CRCReceiveTimer***.
13	*PHY Layer* removes the *CRC* and forwards the ***Request*** *Message* to the *Protocol Layer*.	
14	*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* passes the Request information to the *Policy Engine*. *Policy Engine* stops ***SenderResponseTimer***.	

Table 8.34 Steps for a Wait response to a Power Negotiation

Step	Source	Sink
15	The *Protocol Layer* generates a ***GoodCRC*** *Message* and passes it to its *PHY Layer*.	
16	*PHY Layer* appends *CRC* and sends the *Message*.	*PHY Layer* receives the *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
17		*PHY Layer* forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.
18		The *Protocol Layer* verifies and increments the ***MessageIDCounter***. It informs the *Policy Engine* that the ***Request*** *Message* was successfully sent. The *Protocol Layer* stops the ***CRCReceiveTimer***. The *Policy Engine* starts ***SenderResponseTimer***.
19	*Policy Engine* evaluates the ***Request*** *Message* sent by the *Sink* and decides if it can meet the request. It tells the *Protocol Layer* to form a ***Wait*** *Message*.	
20	The *Protocol Layer* forms the ***Wait*** *Message* that is passed to the *PHY Layer*.	
21	*PHY Layer* appends *CRC* and sends the ***Wait*** *Message*. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
22		*PHY Layer* forwards the ***Wait*** *Message* to the *Protocol Layer*.
23		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. *Protocol Layer* informs the *Policy Engine* that a ***Wait*** *Message* has been received. The *Policy Engine* stops ***SenderResponseTimer***.
24		The *Protocol Layer* generates a ***GoodCRC*** *Message* and passes it to its *PHY Layer*.
25	*PHY Layer* receives the *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.	*PHY Layer* appends *CRC* and sends the *Message*.
26	*PHY Layer* forwards the ***GoodCRC*** *Message* to the *Protocol Layer*. The *Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops the ***CRCReceiveTimer***.	
27	The *Protocol Layer* informs the *Policy Engine* that a ***Wait*** *Message* was successfully sent.	

8.3.2.2.1.2 SPR PPS Keep Alive

This is an example of *SPR PPS* keep alive operation during an *Explicit Contract* with *SPR PPS* as the *APDO*. Figure 8.8, "SPR PPS Keep Alive" shows the *Messages* as they flow across the bus and within the devices to accomplish the keep alive.

Figure 8.8 SPR PPS Keep Alive

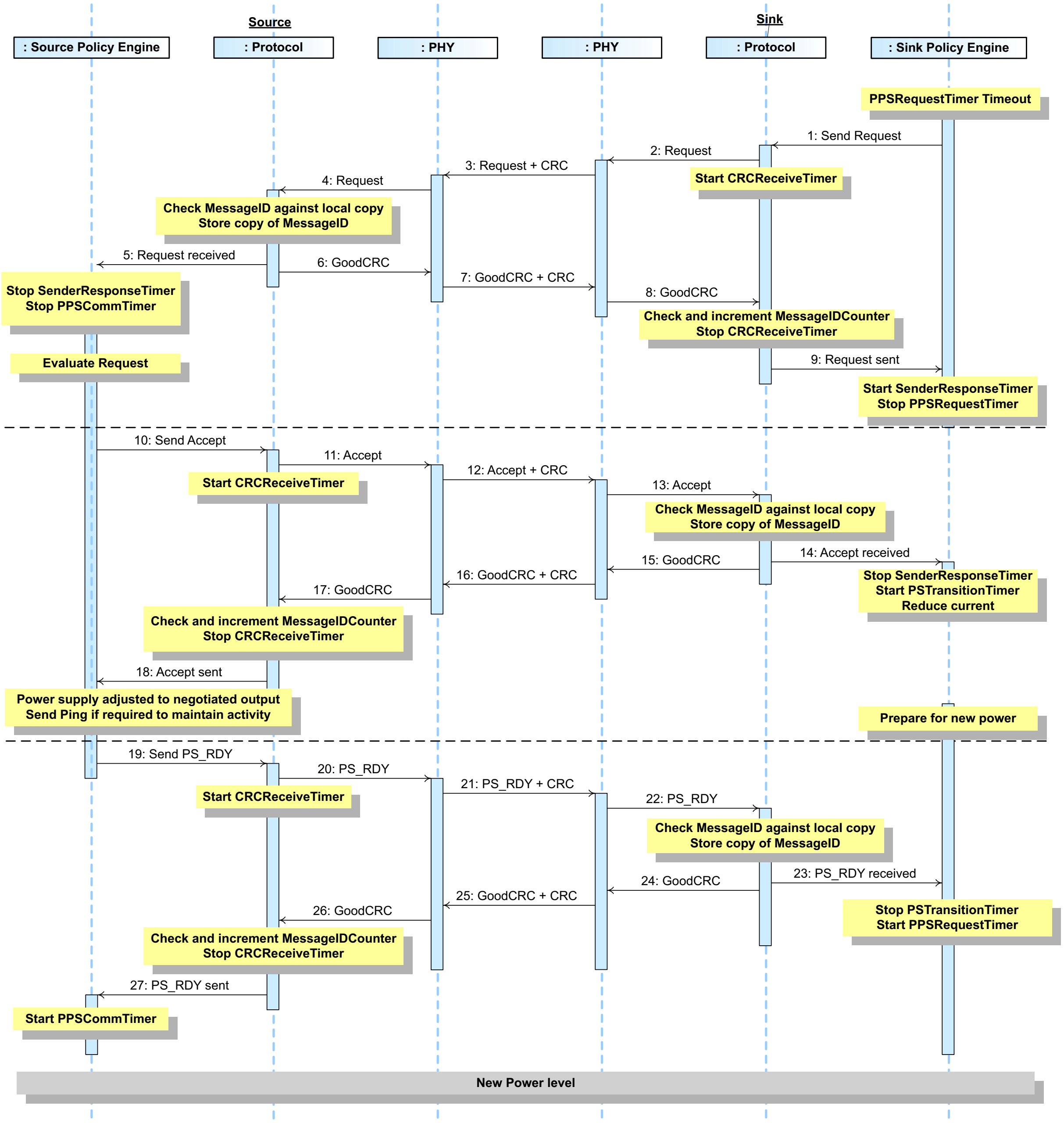


Table 8.35, "Steps for SPR PPS Keep Alive" below provides a detailed explanation of what happens at each labeled step in *Figure 8.8, "SPR PPS Keep Alive"* above.

Table 8.35 Steps for SPR PPS Keep Alive

Step	Source	Sink
1		The ***SinkPPSPeriodicTimer*** times out in the *Policy Engine*. The *Policy Engine* tells the *Protocol Layer* to form a ***Request*** *Message*. The *Protocol Layer* creates the ***Request*** *Message* and passes it to *PHY Layer*.
2	*PHY Layer* receives the ***Request*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.	*PHY Layer* appends a *CRC* and sends the ***Request*** *Message*. Starts ***CRCReceiveTimer***.
3	*PHY Layer* removes the *CRC* and forwards the ***Request*** *Message* to the *Protocol Layer*.	
4	*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* passes the Request information to the *Policy Engine*. *Policy Engine* stops the ***SourcePPSCommTimer.***	
5	The *Protocol Layer* generates a ***GoodCRC*** *Message* and passes it to its *PHY Layer*.	
6	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.	*PHY Layer* receives the ***GoodCRC*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
7		*PHY Layer* forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.
8		The *Protocol Layer* verifies and increments the ***MessageIDCounter***. It informs the *Policy Engine* that the ***Request*** *Message* was successfully sent. The *Protocol Layer* stops the ***CRCReceiveTimer***. The *Policy Engine* starts ***SenderResponseTimer***.
9	*Policy Engine* requests the *DPM* to evaluate the ***Request*** *Message* sent by the *Sink* and decides if the *Source* can meet the request. The *Policy Engine* tells the *Protocol Layer* to form an ***Accept*** *Message*.	
10	The *Protocol Layer* forms the ***Accept*** *Message* that is passed to the *PHY Layer*.	
11	*PHY Layer* appends *CRC* and sends the ***Accept*** *Message*. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the ***Accept*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
12		*PHY Layer* forwards the ***Accept*** *Message* to the *Protocol Layer*.
13		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. *Protocol Layer* informs the *Policy Engine* that an ***Accept*** *Message* has been received. The *Policy Engine* stops ***SenderResponseTimer***, starts the ***PSTransitionTimer*** and reduces its current draw. The *DPM* prepares the Power supply for transition to the new power level.

Table 8.35 Steps for SPR PPS Keep Alive

Step	Source	Sink
14		The *Protocol Layer* generates a ***GoodCRC*** *Message* and passes it to its *PHY Layer*.
15	*PHY Layer* receives the ***GoodCRC*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.
16	*PHY Layer* forwards the ***GoodCRC*** *Message* to the *Protocol Layer*. The *Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops the ***CRCReceiveTimer***.	
17	The *Protocol Layer* informs the *Policy Engine* that an ***Accept*** *Message* was successfully sent.	
Power supply Adjusts its Output to the *Negotiated* Value		
18	The *DPM* informs the *Policy Engine* that the power supply has settled at the new operating condition and tells the *Protocol Layer* to send a ***PS_RDY*** *Message*.	
19	The *Protocol Layer* forms the ***PS_RDY*** *Message*.	
20	*PHY Layer* appends *CRC* and sends the ***PS_RDY*** *Message*. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the ***PS_RDY*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
21		*PHY Layer* forwards the ***PS_RDY*** *Message* to the *Protocol Layer*.
22		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. *Protocol Layer* informs the *Policy Engine* that a RS_RDY has been received. The *Policy Engine* stops the ***PSTransitionTimer***. When in *SPR PPS Mode* the *Policy Engine* starts the ***SinkPPSPeriodicTimer***.
23		The *Protocol Layer* generates a ***GoodCRC*** *Message* and passes it to its *PHY Layer*.
24	*PHY Layer* receives the ***GoodCRC*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.
25	*PHY Layer* forwards the ***GoodCRC*** *Message* to the *Protocol Layer*. The *Protocol Layer* verifies and increments the ***MessageIDCounter***. Stops the ***CRCReceiveTimer***.	
26	The *Protocol Layer* informs the *Policy Engine* that the ***PS_RDY*** *Message* was successfully sent.	
27	When in *SPR PPS Mode* the *Policy Engine* starts the ***SourcePPSCommTimer***.	

8.3.2.2.1.3 SPR Sink Makes Request

8.3.2.2.1.3.1 SPR Sink Makes Request (Accept)

This is an example of SPR when a *Sink* makes a Request which is Accepted during an *Explicit Contract*. Figure 8.9, "SPR Sink Makes Request (Accept)" shows the *Messages* as they flow across the bus and within the devices to accomplish the keep alive.

Figure 8.9 SPR Sink Makes Request (Accept)

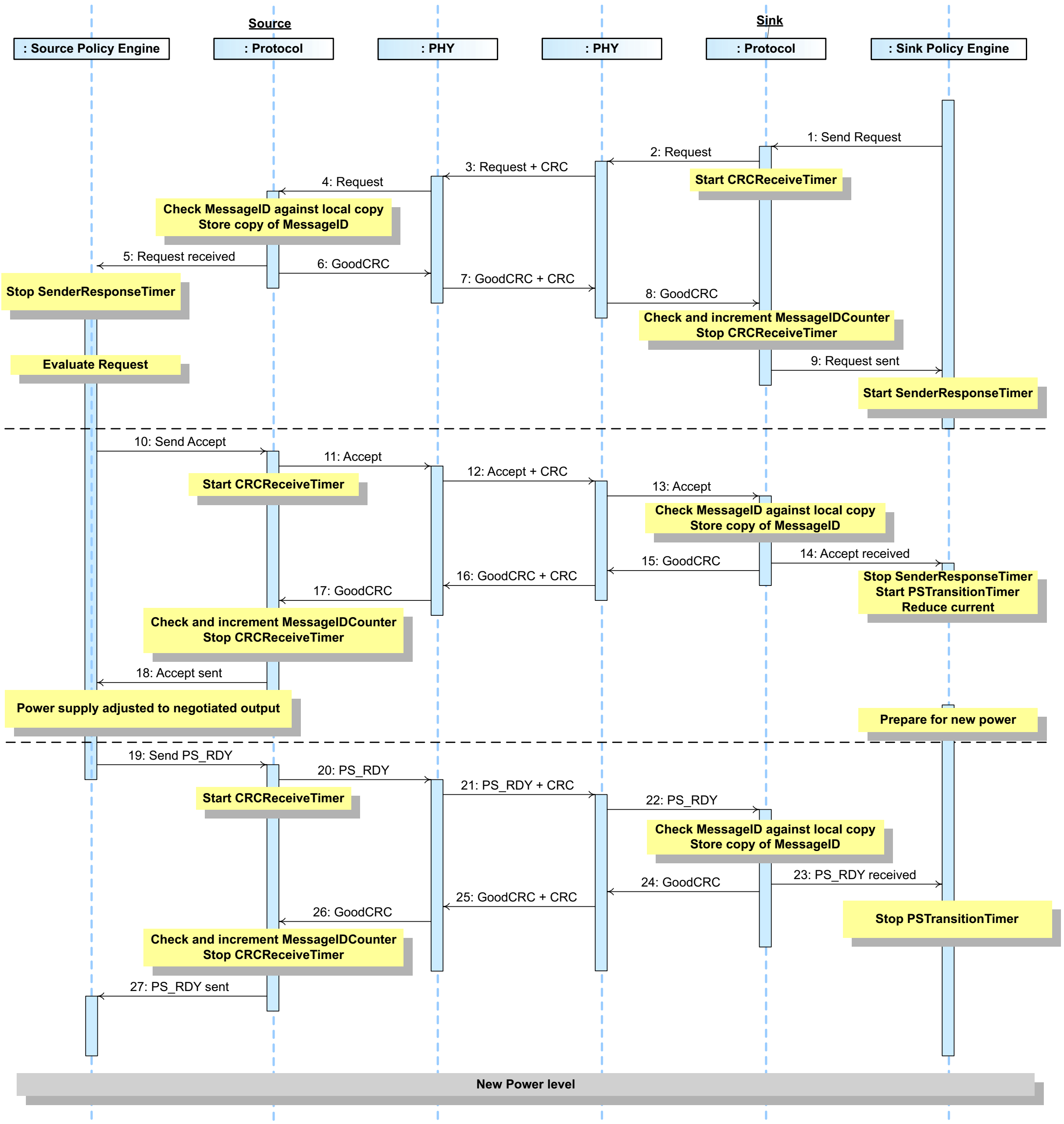


Table 8.36, "Steps for SPR Sink Makes Request (Accept)" below provides a detailed explanation of what happens at each labeled step in *Figure 8.9, "SPR Sink Makes Request (Accept)"* above.

Table 8.36 Steps for SPR Sink Makes Request (Accept)

Step	Source	Sink
1		*DPM* tells the *Policy Engine* to request a different power level. The *Policy Engine* tells the *Protocol Layer* to form a ***Request*** *Message*. The *Protocol Layer* creates the ***Request*** *Message* and passes it to *PHY Layer*.
2	*PHY Layer* receives the ***Request*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.	*PHY Layer* appends a *CRC* and sends the ***Request*** *Message*. Starts ***CRCReceiveTimer***.
3	*PHY Layer* removes the *CRC* and forwards the ***Request*** *Message* to the *Protocol Layer*.	
4	*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* passes the Request information to the *Policy Engine*.	
5	The *Protocol Layer* generates a ***GoodCRC*** *Message* and passes it to its *PHY Layer*.	
6	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.	*PHY Layer* receives the ***GoodCRC*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
7		*PHY Layer* forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.
8		The *Protocol Layer* verifies and increments the ***MessageIDCounter***. It informs the *Policy Engine* that the ***Request*** *Message* was successfully sent. The *Protocol Layer* stops the ***CRCReceiveTimer***. The *Policy Engine* starts ***SenderResponseTimer***.
9	*Policy Engine* requests the *DPM* to evaluate the ***Request*** *Message* sent by the *Sink* and decides if the *Source* can meet the request. The *Policy Engine* tells the *Protocol Layer* to form an ***Accept*** *Message*.	
10	The *Protocol Layer* forms the ***Accept*** *Message* that is passed to the *PHY Layer*.	
11	*PHY Layer* appends *CRC* and sends the ***Accept*** *Message*. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the ***Accept*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
12		*PHY Layer* forwards the ***Accept*** *Message* to the *Protocol Layer*.
13		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. *Protocol Layer* informs the *Policy Engine* that an ***Accept*** *Message* has been received. The *Policy Engine* stops ***SenderResponseTimer***, starts the ***PSTransitionTimer*** and reduces its current draw. The *DPM* prepares the Power supply for transition to the new power level.

Table 8.36 Steps for SPR Sink Makes Request (Accept)

Step	Source	Sink
14		The *Protocol Layer* generates a ***GoodCRC*** *Message* and passes it to its *PHY Layer*.
15	*PHY Layer* receives the ***GoodCRC*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.
16	*PHY Layer* forwards the ***GoodCRC*** *Message* to the *Protocol Layer*. The *Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops the ***CRCReceiveTimer***.	
17	The *Protocol Layer* informs the *Policy Engine* that an ***Accept*** *Message* was successfully sent.	
Power supply Adjusts its Output to the *Negotiated* Value		
18	The *DPM* informs the *Policy Engine* that the power supply has settled at the new operating condition and tells the *Protocol Layer* to send a ***PS_RDY*** *Message*.	
19	The *Protocol Layer* forms the ***PS_RDY*** *Message*.	
20	*PHY Layer* appends *CRC* and sends the ***PS_RDY*** *Message*. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the ***PS_RDY*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
21		*PHY Layer* forwards the ***PS_RDY*** *Message* to the *Protocol Layer*.
22		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. *Protocol Layer* informs the *Policy Engine* that a RS_RDY has been received. The *Policy Engine* stops the ***PSTransitionTimer***.
23		The *Protocol Layer* generates a ***GoodCRC*** *Message* and passes it to its *PHY Layer*.
24	*PHY Layer* receives the ***GoodCRC*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.
25	*PHY Layer* forwards the ***GoodCRC*** *Message* to the *Protocol Layer*. The *Protocol Layer* verifies and increments the ***MessageIDCounter***. Stops the ***CRCReceiveTimer***.	
26	The *Protocol Layer* informs the *Policy Engine* that the ***PS_RDY*** *Message* was successfully sent.	
New Power Level *Negotiated*		

8.3.2.2.1.3.2 SPR Sink Makes Request (Reject)

This is an example of SPR when a *Sink* makes a Request which is Rejected during an *Explicit Contract*. Figure 8.10, "SPR Sink Makes Request (Reject)" shows the *Message*s as they flow across the bus and within the devices to accomplish the keep alive.

Figure 8.10 SPR Sink Makes Request (Reject)

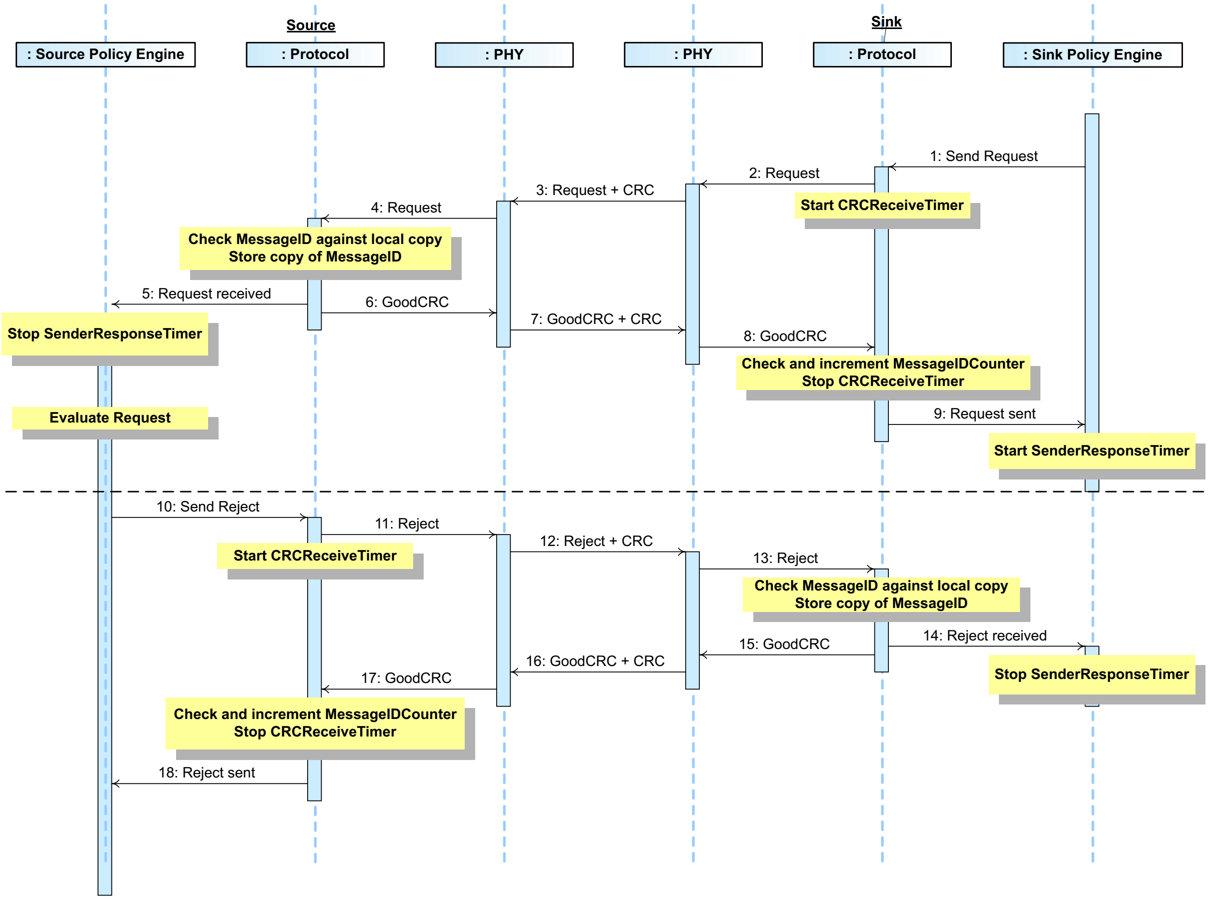


Table 8.37, "Steps for SPR Sink Makes Request (Reject)" below provides a detailed explanation of what happens at each labeled step in *Figure 8.10, "SPR Sink Makes Request (Reject)"* above.

Table 8.37 Steps for SPR Sink Makes Request (Reject)

Step	Source	Sink
1		*DPM* tells the *Policy Engine* to request a different power level. The *Policy Engine* tells the *Protocol Layer* to form a ***Request*** *Message*. The *Protocol Layer* creates the ***Request*** *Message* and passes it to *PHY Layer*.
2	*PHY Layer* receives the ***Request*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.	*PHY Layer* appends a *CRC* and sends the ***Request*** *Message*. Starts ***CRCReceiveTimer***.
3	*PHY Layer* removes the *CRC* and forwards the ***Request*** *Message* to the *Protocol Layer*.	
4	*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* passes the Request information to the *Policy Engine*.	
5	The *Protocol Layer* generates a ***GoodCRC*** *Message* and passes it to its *PHY Layer*.	
6	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.	*PHY Layer* receives the ***GoodCRC*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
7		*PHY Layer* forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.
8		The *Protocol Layer* verifies and increments the ***MessageIDCounter***. It informs the *Policy Engine* that the ***Request*** *Message* was successfully sent. The *Protocol Layer* stops the ***CRCReceiveTimer.*** The *Policy Engine* starts ***SenderResponseTimer***.
9	*Policy Engine* requests the *DPM* to evaluate the ***Request*** *Message* sent by the *Sink* and decides that the *Source* can't meet the request. The *Policy Engine* tells the *Protocol Layer* to form a ***Reject*** *Message*.	
10	The *Protocol Layer* forms the ***Reject*** *Message* that is passed to the *PHY Layer*.	
11	*PHY Layer* appends *CRC* and sends the ***Reject*** *Message*. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the ***Reject*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
12		*PHY Layer* forwards the ***Reject*** *Message* to the *Protocol Layer*.
13		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. *Protocol Layer* informs the *Policy Engine* that an ***Reject*** *Message* has been received. The *Policy Engine* informs the *DPM* that the Request has been rejected.
14		The *Protocol Layer* generates a ***GoodCRC*** *Message* and passes it to its *PHY Layer*.

Table 8.37 Steps for SPR Sink Makes Request (Reject)

Step	Source	Sink
15	*PHY Layer* receives the ***GoodCRC*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.
16	*PHY Layer* forwards the ***GoodCRC*** *Message* to the *Protocol Layer*. The *Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops the ***CRCReceiveTimer***.	
17	The *Protocol Layer* informs the *Policy Engine* that a ***Reject*** *Message* was successfully sent.	

8.3.2.2.1.3.3 SPR Sink Makes Request (Wait)

This is an example of SPR when a *Sink* makes a Request which is responded to with a ***Wait*** *Message* during an *Explicit Contract*. Figure 8.11, "SPR Sink Makes Request (Wait)" shows the *Messages* as they flow across the bus and within the devices to accomplish the keep alive.

Figure 8.11 SPR Sink Makes Request (Wait)

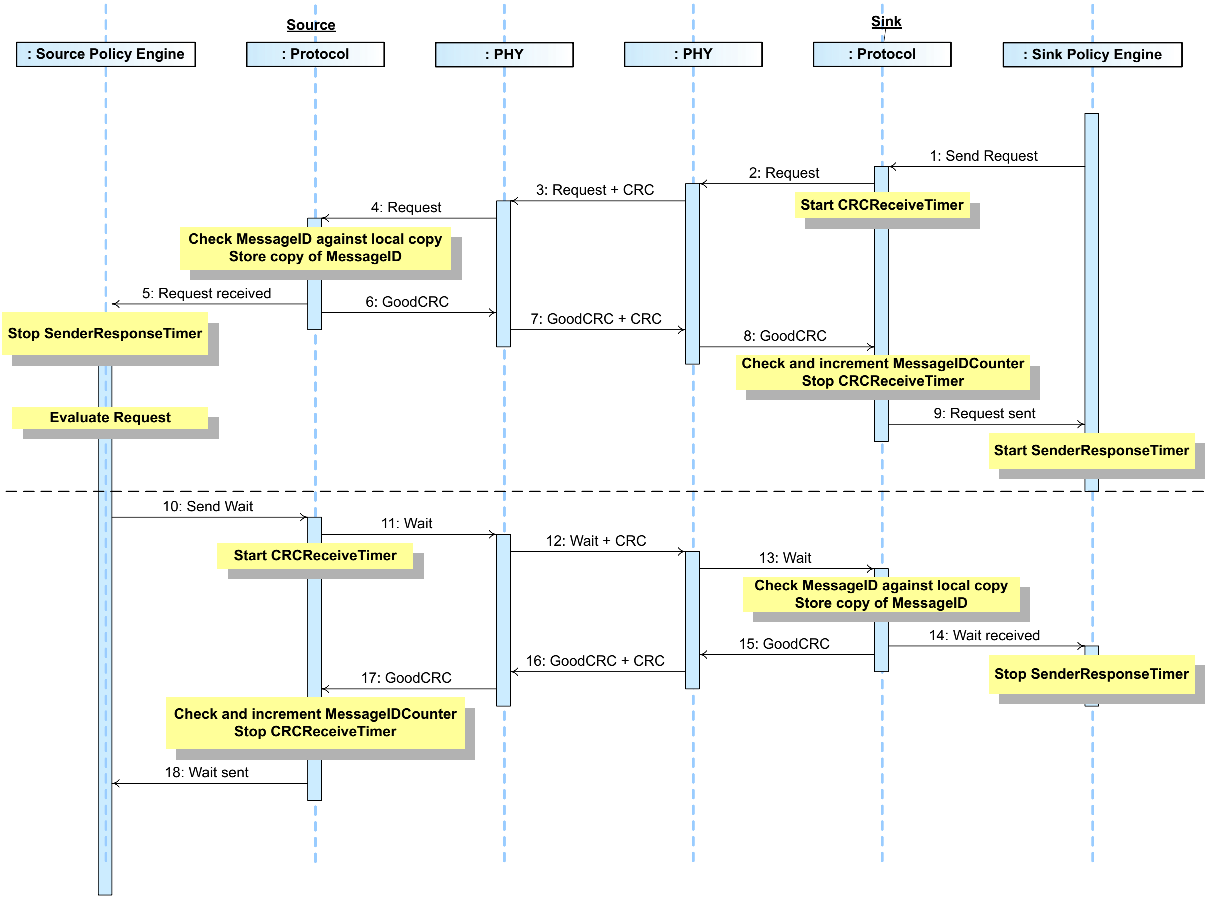


Table 8.38, "Steps for SPR Sink Makes Request (Wait)" below provides a detailed explanation of what happens at each labeled step in *Figure 8.11, "SPR Sink Makes Request (Wait)"* above.

Table 8.38 Steps for SPR Sink Makes Request (Wait)

Step	Source	Sink
1		*DPM* tells the *Policy Engine* to request a different power level. The *Policy Engine* tells the *Protocol Layer* to form a ***Request*** *Message*. The *Protocol Layer* creates the ***Request*** *Message* and passes it to *PHY Layer*.
2	*PHY Layer* receives the ***Request*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.	*PHY Layer* appends a *CRC* and sends the ***Request*** *Message*. Starts ***CRCReceiveTimer***.
3	*PHY Layer* removes the *CRC* and forwards the ***Request*** *Message* to the *Protocol Layer*.	
4	*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* passes the Request information to the *Policy Engine*.	
5	The *Protocol Layer* generates a ***GoodCRC*** *Message* and passes it to its *PHY Layer*.	
6	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.	*PHY Layer* receives the ***GoodCRC*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
7		*PHY Layer* forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.
8		The *Protocol Layer* verifies and increments the ***MessageIDCounter***. It informs the *Policy Engine* that the ***Request*** *Message* was successfully sent. The *Protocol Layer* stops the ***CRCReceiveTimer***. The *Policy Engine* starts ***SenderResponseTimer***.
9	*Policy Engine* requests the *DPM* to evaluate the ***Request*** *Message* sent by the *Sink* and decides if the *Source* can meet the request. The *Policy Engine* tells the *Protocol Layer* to form a ***Wait*** *Message*.	
10	The *Protocol Layer* forms the ***Wait*** *Message* that is passed to the *PHY Layer*.	
11	*PHY Layer* appends *CRC* and sends the ***Wait*** *Message*. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the ***Wait*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
12		*PHY Layer* forwards the ***Wait*** *Message* to the *Protocol Layer*.
13		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. *Protocol Layer* informs the *Policy Engine* that an ***Wait*** *Message* has been received. The *Policy Engine* informs the *DPM* that the Request has been rejected.
14		The *Protocol Layer* generates a ***GoodCRC*** *Message* and passes it to its *PHY Layer*.

Table 8.38 Steps for SPR Sink Makes Request (Wait)

Step	Source	Sink
15	*PHY Layer* receives the ***GoodCRC*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.
16	*PHY Layer* forwards the ***GoodCRC*** *Message* to the *Protocol Layer*. The *Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops the ***CRCReceiveTimer***.	
17	The *Protocol Layer* informs the *Policy Engine* that a ***Wait*** *Message* was successfully sent.	

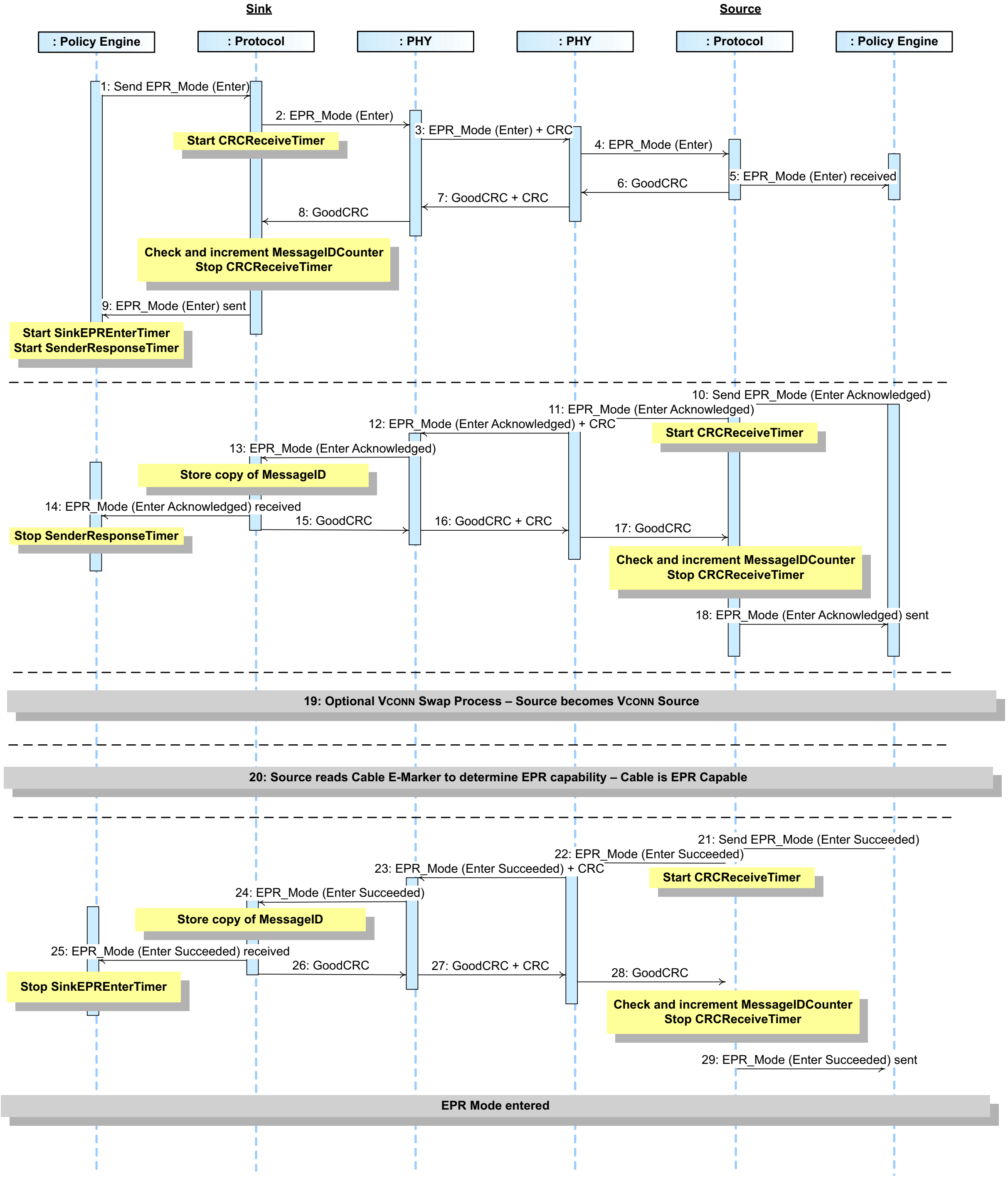
8.3.2.2.2 EPR

8.3.2.2.2.1 Entering EPR Mode

8.3.2.2.2.1.1 Entering EPR Mode (Success)

This is an example of an Enter *EPR Mode* operation where the *Sink* requests *EPR Mode* when this process succeeds. *Figure 8.12, "Entering EPR Mode (Success)"* shows the *Messages* as they flow across the bus and within the devices to accomplish the Enter EPR process.

Figure 8.12 Entering EPR Mode (Success)



Sink
Source
: Policy Engine
: Protocol
: PHY
: PHY
: Protocol
: Policy Engine
1: Send EPR_Mode (Enter)
2: EPR_Mode (Enter)
Start CRCReceiveTimer
3: EPR_Mode (Enter) + CRC
4: EPR_Mode (Enter)
5: EPR_Mode (Enter) received
6: GoodCRC
7: GoodCRC + CRC
8: GoodCRC
Check and increment MessageIDCounter
Stop CRCReceiveTimer
9: EPR_Mode (Enter) sent
Start SinkEPREnterTimer
Start SenderResponseTimer
10: Send EPR_Mode (Enter Acknowledged)
11: EPR_Mode (Enter Acknowledged)
12: EPR_Mode (Enter Acknowledged) + CRC
Start CRCReceiveTimer
13: EPR_Mode (Enter Acknowledged)
Store copy of MessageID
14: EPR_Mode (Enter Acknowledged) received
15: GoodCRC
16: GoodCRC + CRC
17: GoodCRC
Stop SenderResponseTimer
Check and increment MessageIDCounter
Stop CRCReceiveTimer
18: EPR_Mode (Enter Acknowledged) sent
19: Optional VCONN Swap Process – Source becomes VCONN Source
20: Source reads Cable E-Marker to determine EPR capability – Cable is EPR Capable
21: Send EPR_Mode (Enter Succeeded)
22: EPR_Mode (Enter Succeeded)
23: EPR_Mode (Enter Succeeded) + CRC
Start CRCReceiveTimer
24: EPR_Mode (Enter Succeeded)
Store copy of MessageID
25: EPR_Mode (Enter Succeeded) received
26: GoodCRC
27: GoodCRC + CRC
28: GoodCRC
Stop SinkEPREnterTimer
Check and increment MessageIDCounter
Stop CRCReceiveTimer
29: EPR_Mode (Enter Succeeded) sent
EPR Mode entered

Table 8.39, "Steps for Entering EPR Mode (Success)" below provides a detailed explanation of what happens at each labeled step in *Figure 8.12, "Entering EPR Mode (Success)"* above.

Table 8.39 Steps for Entering EPR Mode (Success)

Step	Sink	Source
1	The *Policy Engine* directs the *Protocol Layer* to generate an ***EPR_Mode*** (Enter) *Message* to request entry to *EPR Mode*.	
2	*Protocol Layer* creates the *Message* and passes to *PHY Layer*.	
3	*PHY Layer* appends *CRC* and sends the ***EPR_Mode*** (Enter) *Message*. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the ***EPR_Mode*** (Enter) *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
4		*PHY Layer* removes the *CRC* and forwards the ***EPR_Mode*** (Enter) *Message* to the *Protocol Layer*.
5		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***EPR_Mode*** (Enter) *Message* information to the *Policy Engine* that consumes it.
6		*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.
7	*PHY Layer* receives the ***GoodCRC*** and checks the *CRC* to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.
8	*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.	
9	*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***EPR_Mode*** (Enter)***Source_Capabilities*** *Message* was successfully sent. The *Policy Engine* starts the ***SenderResponseTimer*** and the ***SinkEPREnterTimer***.	
10		*Policy Engine* evaluates the ***EPR_Mode*** (Enter) *Message* sent by the *Sink*. It tells the *Protocol Layer* to form a ***EPR_Mode*** (Enter Acknowledged) *Message*.
11		*Protocol Layer* creates the ***EPR_Mode*** (Enter Acknowledged) *Message* and passes to *PHY Layer*.
12	*PHY Layer* receives the ***EPR_Mode*** (Enter Acknowledged) *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.	*PHY Layer* appends a *CRC* and sends the ***EPR_Mode*** (Enter Acknowledged) *Message*. Starts ***CRCReceiveTimer***.
13	*PHY Layer* removes the *CRC* and forwards the ***EPR_Mode*** (Enter Acknowledged) *Message* to the *Protocol Layer*.	
14	*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* passes the ***EPR_Mode*** (Enter Acknowledged) information to the *Policy Engine*. The *Policy Engine* stops the ***SenderResponseTimer***.	
15	The *Protocol Layer* generates a ***GoodCRC*** *Message* and passes it to its *PHY Layer*.	

Table 8.39 Steps for Entering EPR Mode (Success)

Step	Sink	Source
16	*PHY Layer* appends *CRC* and sends the *Message*.	*PHY Layer* receives the *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
17		*PHY Layer* forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.
18		The *Protocol Layer* verifies and increments the ***MessageIDCounter***. It informs the *Policy Engine* that the ***EPR_Mode*** (Enter Acknowledged) *Message* was successfully sent. The *Protocol Layer* stops the ***CRCReceiveTimer***.
19	If the *Source* is not the *VCONN Source* the *Source* initiates the *VCONN Swap* process as described in *Section 8.3.2.10, "VCONN Swap"*.	
20	The *Source* performs *Cable Discovery* to determine whether the cable supports EPR. The *Cable Discovery* process is described in *Section 8.3.2.14.1, "Discover Identity"*.	
21		The *Source* is now the *VCONN Source* and has determined that the *Sink* and the cable are *EPR Capable*. The *Policy Engine* tells the *Protocol Layer* to form a ***EPR_Mode*** (Enter Succeeded) *Message*.
22		*Protocol Layer* creates the ***EPR_Mode*** (Enter Succeeded) *Message* and passes to *PHY Layer*.
23	*PHY Layer* receives the ***EPR_Mode*** (Enter Succeeded) *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.	*PHY Layer* appends a *CRC* and sends the ***EPR_Mode*** (Enter Succeeded) *Message*. Starts ***CRCReceiveTimer***.
24	*PHY Layer* removes the *CRC* and forwards the ***EPR_Mode*** (Enter Succeeded) *Message* to the *Protocol Layer*.	
25	*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* passes the ***EPR_Mode*** (Enter Succeeded) information to the *Policy Engine*. The *Policy Engine* stops the ***SinkEPREnterTimer***.	
26	The *Protocol Layer* generates a ***GoodCRC*** *Message* and passes it to its *PHY Layer*.	
27	*PHY Layer* appends *CRC* and sends the *Message*.	*PHY Layer* receives the *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
28		*PHY Layer* forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.
29		The *Protocol Layer* verifies and increments the ***MessageIDCounter***. It informs the *Policy Engine* that the ***EPR_Mode*** (Enter Succeeded) *Message* was successfully sent. The *Protocol Layer* stops the ***CRCReceiveTimer***.
EPR Mode Entered		

8.3.2.2.2.1.2 Entering EPR Mode (Failure due to non-EPR cable)

This is an example of an Enter *EPR Mode* operation where the *Sink* requests *EPR Mode* when this process fails due to the cable not being capable of EPR. *Figure 8.13, "Entering EPR Mode (Failure due to non-EPR cable)"* shows the *Messages* as they flow across the bus and within the devices to accomplish the Enter EPR process.

Figure 8.13 Entering EPR Mode (Failure due to non-EPR cable)

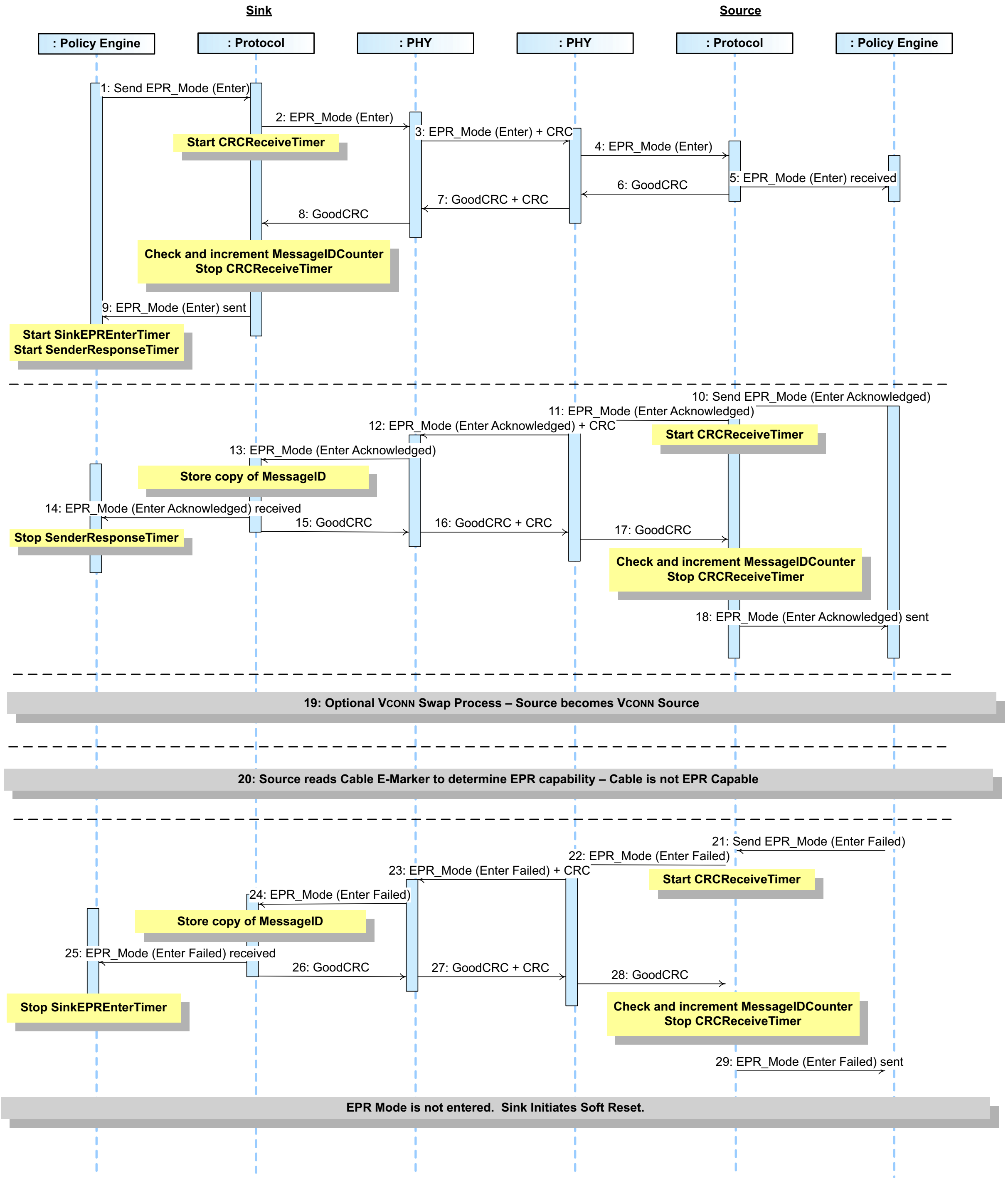

Sink
Source
: Policy Engine
: Protocol
: PHY
: PHY
: Protocol
: Policy Engine
1: Send EPR_Mode (Enter)
2: EPR_Mode (Enter)
Start CRCReceiveTimer
3: EPR_Mode (Enter) + CRC
4: EPR_Mode (Enter)
5: EPR_Mode (Enter) received
6: GoodCRC
7: GoodCRC + CRC
8: GoodCRC
Check and increment MessageIDCounter
Stop CRCReceiveTimer
9: EPR_Mode (Enter) sent
Start SinkEPREnterTimer
Start SenderResponseTimer
10: Send EPR_Mode (Enter Acknowledged)
11: EPR_Mode (Enter Acknowledged)
12: EPR_Mode (Enter Acknowledged) + CRC
Start CRCReceiveTimer
13: EPR_Mode (Enter Acknowledged)
Store copy of MessageID
14: EPR_Mode (Enter Acknowledged) received
15: GoodCRC
16: GoodCRC + CRC
17: GoodCRC
Stop SenderResponseTimer
Check and increment MessageIDCounter
Stop CRCReceiveTimer
18: EPR_Mode (Enter Acknowledged) sent
19: Optional VCONN Swap Process – Source becomes VCONN Source
20: Source reads Cable E-Marker to determine EPR capability – Cable is not EPR Capable
21: Send EPR_Mode (Enter Failed)
22: EPR_Mode (Enter Failed)
23: EPR_Mode (Enter Failed) + CRC
Start CRCReceiveTimer
24: EPR_Mode (Enter Failed)
Store copy of MessageID
25: EPR_Mode (Enter Failed) received
26: GoodCRC
27: GoodCRC + CRC
28: GoodCRC
Stop SinkEPREnterTimer
Check and increment MessageIDCounter
Stop CRCReceiveTimer
29: EPR_Mode (Enter Failed) sent
EPR Mode is not entered. Sink Initiates Soft Reset.

Table 8.40, "Steps for Entering EPR Mode (Failure due to non-EPR cable)" below provides a detailed explanation of what happens at each labeled step in *Figure 8.13, "Entering EPR Mode (Failure due to non-EPR cable)"* above.

Table 8.40 Steps for Entering EPR Mode (Failure due to non-EPR cable)

Step	Sink	Source
1	The *Policy Engine* directs the *Protocol Layer* to generate an ***EPR_Mode*** (Enter) *Message* to request entry to *EPR Mode*.	
2	*Protocol Layer* creates the *Message* and passes to *PHY Layer*.	
3	*PHY Layer* appends *CRC* and sends the ***EPR_Mode*** (Enter) *Message*. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the ***EPR_Mode*** (Enter) *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
4		*PHY Layer* removes the *CRC* and forwards the ***EPR_Mode*** (Enter) *Message* to the *Protocol Layer*.
5		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***EPR_Mode*** (Enter) *Message* information to the *Policy Engine* that consumes it.
6		*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.
7	*PHY Layer* receives the ***GoodCRC*** and checks the *CRC* to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.
8	*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.	
9	*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***EPR_Mode*** (Enter) *Message* was successfully sent. The *Policy Engine* starts the ***SenderResponseTimer*** and the ***SinkEPREnterTimer***.	
10		*Policy Engine* evaluates the ***EPR_Mode*** (Enter) *Message* sent by the *Sink*. It tells the *Protocol Layer* to form a ***EPR_Mode*** (Enter Acknowledged) *Message*.
11		*Protocol Layer* creates the ***EPR_Mode*** (Enter Acknowledged) *Message* and passes to *PHY Layer*.
12	*PHY Layer* receives the ***EPR_Mode*** (Enter Acknowledged) *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.	*PHY Layer* appends a *CRC* and sends the ***EPR_Mode*** (Enter Acknowledged) *Message*. Starts ***CRCReceiveTimer***.
13	*PHY Layer* removes the *CRC* and forwards the ***EPR_Mode*** (Enter Acknowledged) *Message* to the *Protocol Layer*.	
14	*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* passes the ***EPR_Mode*** (Enter Acknowledged) information to the *Policy Engine*. The *Policy Engine* stops the ***SenderResponseTimer.***	
15	The *Protocol Layer* generates a ***GoodCRC*** *Message* and passes it to its *PHY Layer*.	

Table 8.40 Steps for Entering EPR Mode (Failure due to non-EPR cable)

Step	Sink	Source
16	*PHY Layer* appends *CRC* and sends the *Message*.	*PHY Layer* receives the *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
17		*PHY Layer* forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.
18		The *Protocol Layer* verifies and increments the ***MessageIDCounter***. It informs the *Policy Engine* that the ***EPR_Mode*** (Enter Acknowledged) *Message* was successfully sent. The *Protocol Layer* stops the ***CRCReceiveTimer***.
19	If the *Source* is not the *VCONN Source* the *Source* initiates the *VCONN Swap* process as described in *Section 8.3.2.10, "VCONN Swap"*.	
20	The *Source* performs *Cable Discovery* to determine whether the cable supports EPR; cable is not *EPR Capable*. The *Cable Discovery* process is described in *Section 8.3.2.14.1, "Discover Identity"*.	
21		The *Source* determines that there has been a failure or incompatibility during the EPR process (see *Section 6.4.10, "EPR_Mode Message"*). The *Policy Engine* tells the *Protocol Layer* to form a ***EPR_Mode*** (Enter Failed) *Message*.
22		*Protocol Layer* creates the ***EPR_Mode*** (Enter Failed) *Message* and passes to *PHY Layer*.
23	*PHY Layer* receives the ***EPR_Mode*** (Enter Failed) *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.	*PHY Layer* appends a *CRC* and sends the ***EPR_Mode*** (Enter Failed) *Message*. Starts ***CRCReceiveTimer***.
24	*PHY Layer* removes the *CRC* and forwards the ***EPR_Mode*** (Enter Failed) *Message* to the *Protocol Layer*.	
25	*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* passes the ***EPR_Mode*** (Enter Failed) information to the *Policy Engine*. The *Policy Engine* stops the ***SinkEPREnterTimer***.	
26	The *Protocol Layer* generates a ***GoodCRC*** *Message* and passes it to its *PHY Layer*.	
27	*PHY Layer* appends *CRC* and sends the *Message*.	*PHY Layer* receives the *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
28		*PHY Layer* forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.
29		The *Protocol Layer* verifies and increments the ***MessageIDCounter***. It informs the *Policy Engine* that the ***EPR_Mode*** (Enter Failed) *Message* was successfully sent. The *Protocol Layer* stops the ***CRCReceiveTimer***.
EPR Mode is not entered. *Sink* Initiates *Soft Reset*		

8.3.2.2.2.1.3 Entering EPR Mode (Failure of VCONN Swap)

This is an example of an Enter *EPR Mode* operation where the *Sink* requests *EPR Mode* when this process fails due to a failure of the *VCONN Swap* process. *Figure 8.14, "Entering EPR Mode (Failure of VCONN Swap)"* shows the *Messages* as they flow across the bus and within the devices to accomplish the Enter EPR process.

Figure 8.14 Entering EPR Mode (Failure of VCONN Swap)

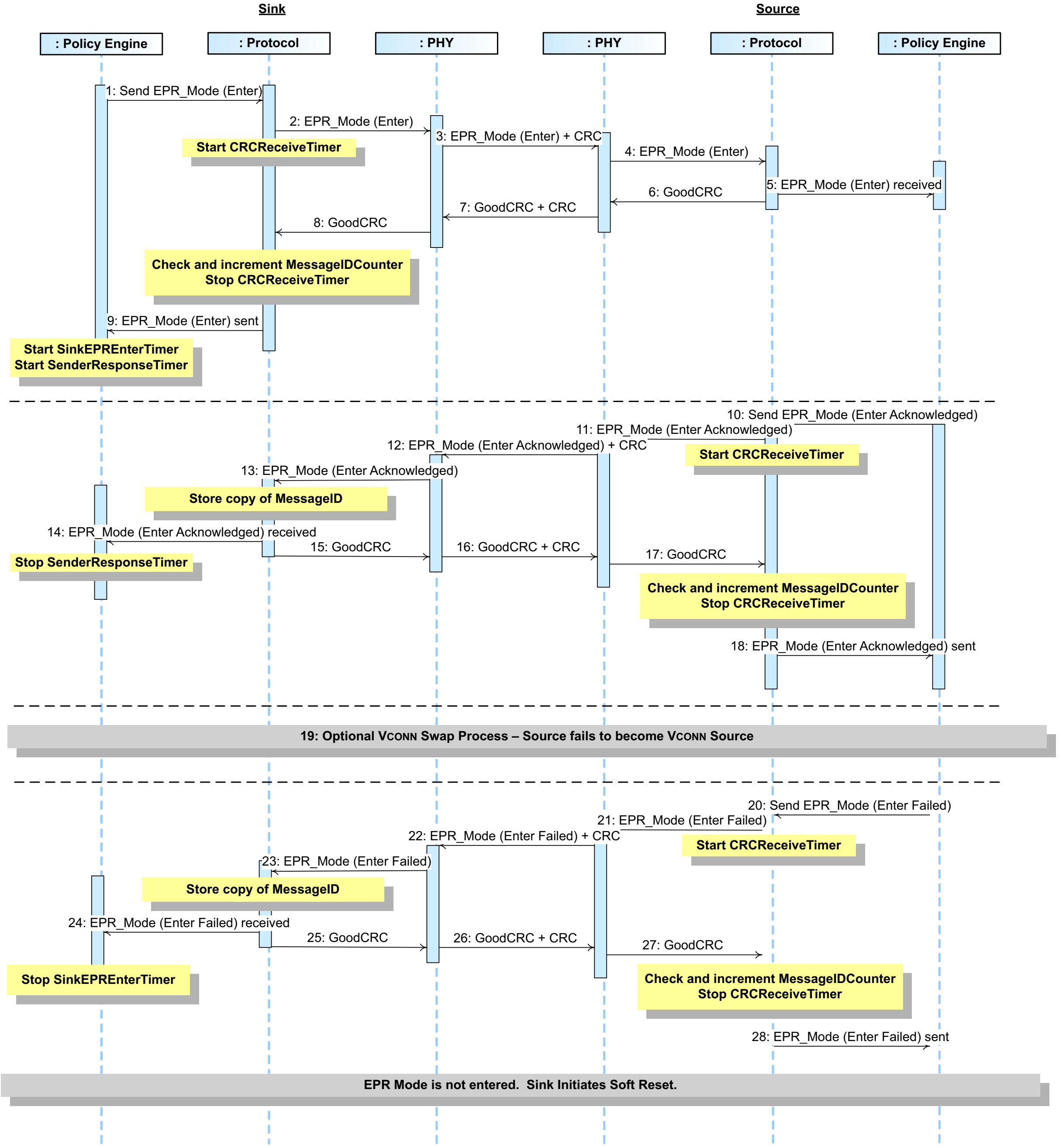

Sink
Source
: Policy Engine
: Protocol
: PHY
: PHY
: Protocol
: Policy Engine
1: Send EPR_Mode (Enter)
2: EPR_Mode (Enter)
Start CRCReceiveTimer
3: EPR_Mode (Enter) + CRC
4: EPR_Mode (Enter)
5: EPR_Mode (Enter) received
6: GoodCRC
7: GoodCRC + CRC
8: GoodCRC
Check and increment MessageIDCounter
Stop CRCReceiveTimer
9: EPR_Mode (Enter) sent
Start SinkEPREnterTimer
Start SenderResponseTimer
10: Send EPR_Mode (Enter Acknowledged)
11: EPR_Mode (Enter Acknowledged)
12: EPR_Mode (Enter Acknowledged) + CRC
Start CRCReceiveTimer
13: EPR_Mode (Enter Acknowledged)
Store copy of MessageID
14: EPR_Mode (Enter Acknowledged) received
15: GoodCRC
16: GoodCRC + CRC
17: GoodCRC
Stop SenderResponseTimer
Check and increment MessageIDCounter
Stop CRCReceiveTimer
18: EPR_Mode (Enter Acknowledged) sent
19: Optional VCONN Swap Process – Source fails to become VCONN Source
20: Send EPR_Mode (Enter Failed)
21: EPR_Mode (Enter Failed)
22: EPR_Mode (Enter Failed) + CRC
Start CRCReceiveTimer
23: EPR_Mode (Enter Failed)
Store copy of MessageID
24: EPR_Mode (Enter Failed) received
25: GoodCRC
26: GoodCRC + CRC
27: GoodCRC
Stop SinkEPREnterTimer
Check and increment MessageIDCounter
Stop CRCReceiveTimer
28: EPR_Mode (Enter Failed) sent
EPR Mode is not entered. Sink Initiates Soft Reset.

Table 8.41, "Steps for Entering EPR Mode (Failure of VCONN Swap)" below provides a detailed explanation of what happens at each labeled step in *Figure 8.14, "Entering EPR Mode (Failure of VCONN Swap)"* above.

Table 8.41 Steps for Entering EPR Mode (Failure of VCONN Swap)

Step	Sink	Source
1	The *Policy Engine* directs the *Protocol Layer* to generate an ***EPR_Mode*** (Enter) *Message* to request entry to *EPR Mode*.	
2	*Protocol Layer* creates the *Message* and passes to *PHY Layer*.	
3	*PHY Layer* appends *CRC* and sends the ***EPR_Mode*** (Enter) *Message*. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the ***EPR_Mode*** (Enter) *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
4		*PHY Layer* removes the *CRC* and forwards the ***EPR_Mode*** (Enter) *Message* to the *Protocol Layer*.
5		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***EPR_Mode*** (Enter) *Message* information to the *Policy Engine* that consumes it.
6		*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.
7	*PHY Layer* receives the ***GoodCRC*** and checks the *CRC* to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.
8	*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.	
9	*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***EPR_Mode*** (Enter) *Message* was successfully sent. The *Policy Engine* starts the ***SenderResponseTimer*** and the ***SinkEPREnterTimer***.	
10		*Policy Engine* evaluates the ***EPR_Mode*** (Enter) *Message* sent by the *Sink*. It tells the *Protocol Layer* to form a ***EPR_Mode*** (Enter Acknowledged) *Message*.
11		*Protocol Layer* creates the ***EPR_Mode*** (Enter Acknowledged) *Message* and passes to *PHY Layer*.
12	*PHY Layer* receives the ***EPR_Mode*** (Enter Acknowledged) *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.	*PHY Layer* appends a *CRC* and sends the ***EPR_Mode*** (Enter Acknowledged) *Message*. Starts ***CRCReceiveTimer***.
13	*PHY Layer* removes the *CRC* and forwards the ***EPR_Mode*** (Enter Acknowledged) *Message* to the *Protocol Layer*.	
14	*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* passes the ***EPR_Mode*** (Enter Acknowledged) information to the *Policy Engine*. The *Policy Engine* stops the ***SenderResponseTimer***.	
15	The *Protocol Layer* generates a ***GoodCRC*** *Message* and passes it to its *PHY Layer*.	

Table 8.41 Steps for Entering EPR Mode (Failure of VCONN Swap)

Step	Sink	Source
16	*PHY Layer* appends *CRC* and sends the *Message*.	*PHY Layer* receives the *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
17		*PHY Layer* forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.
18		The *Protocol Layer* verifies and increments the ***MessageIDCounter***. It informs the *Policy Engine* that the ***EPR_Mode*** (Enter Acknowledged) *Message* was successfully sent. The *Protocol Layer* stops the ***CRCReceiveTimer***.
19	If the *Source* is not the *VCONN Source* the *Source* initiates the *VCONN Swap* process as described in *Section 8.3.2.10, "VCONN Swap"*. In this case the *VCONN Swap* process fails.	
20		The *Source* determines that there has been a failure or incompatibility during the EPR process (see *Section 6.4.10, "EPR_Mode Message"*). The *Policy Engine* tells the *Protocol Layer* to form a ***EPR_Mode*** (Enter Failed) *Message*.
21		*Protocol Layer* creates the ***EPR_Mode*** (Enter Failed) *Message* and passes to *PHY Layer*.
22	*PHY Layer* receives the ***EPR_Mode*** (Enter Failed) *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.	*PHY Layer* appends a *CRC* and sends the ***EPR_Mode*** (Enter Failed) *Message*. Starts ***CRCReceiveTimer***.
23	*PHY Layer* removes the *CRC* and forwards the ***EPR_Mode*** (Enter Failed) *Message* to the *Protocol Layer*.	
24	*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* passes the ***EPR_Mode*** (Enter Failed) information to the *Policy Engine*. The *Policy Engine* stops the ***SinkEPREnterTimer***.	
25	The *Protocol Layer* generates a ***GoodCRC*** *Message* and passes it to its *PHY Layer*.	
26	*PHY Layer* appends *CRC* and sends the *Message*.	*PHY Layer* receives the *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
27		*PHY Layer* forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.
28		The *Protocol Layer* verifies and increments the ***MessageIDCounter***. It informs the *Policy Engine* that the ***EPR_Mode*** (Enter Failed) *Message* was successfully sent. The *Protocol Layer* stops the ***CRCReceiveTimer***.
EPR Mode is not entered. *Sink* Initiates *Soft Reset*		

8.3.2.2.2.2 EPR Explicit Contract Negotiation

8.3.2.2.2.2.1 EPR Explicit Contract Negotiation (Accept)

Figure 8.15, "Successful Fixed EPR Power Negotiation" illustrates an example of a successful *Message* flow while negotiating an *Explicit Contract* in *EPR Mode*. The *Negotiation* goes through several distinct phases:

- The *Source* sends out its power *Capabilities* in an ***EPR_Source_Capabilities*** *Message*.
- The *Sink* evaluates these *Capabilities* and, in the request phase, selects one power level by sending an ***EPR_Request*** *Message*.
- The *Source* evaluates the request and accepts the request with an ***Accept*** *Message*.
- The *Source* transitions to the new power level and then informs the *Sink* by sending a ***PS_RDY*** *Message*.
- The *Sink* starts using the new power level.
- the *Source* starts its keep alive timer
- the *Sink* starts its request timer to send periodic ***EPR_KeepAlive*** *Message*s

Figure 8.15 Successful Fixed EPR Power Negotiation

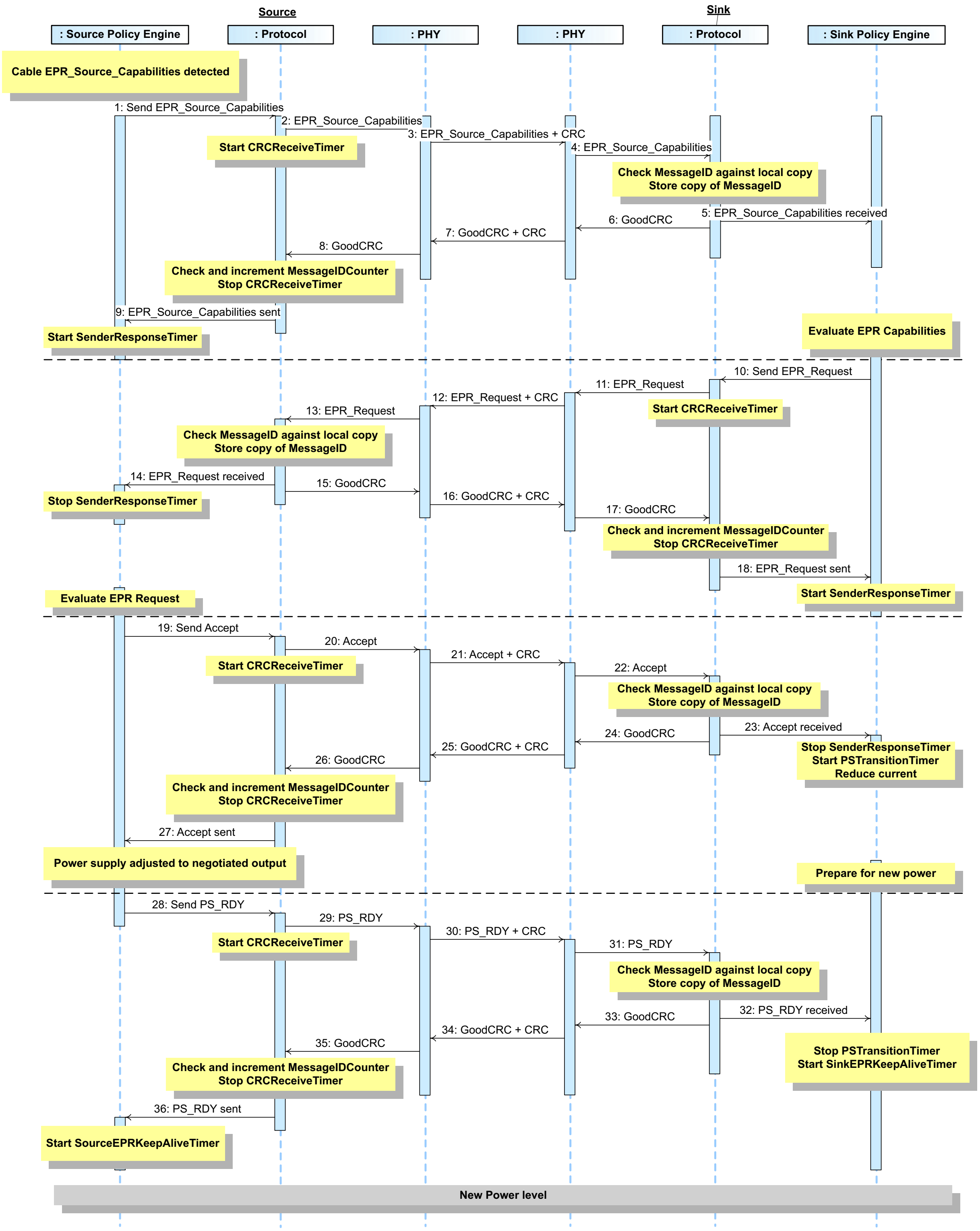


Table 8.42, "Steps for a successful EPR Power Negotiation" below provides a detailed explanation of what happens at each labeled step in *Figure 8.15, "Successful Fixed EPR Power Negotiation"* above.

Table 8.42 Steps for a successful EPR Power Negotiation

Step	Source	Sink
1	The *Cable Capabilities* are detected if these are not already known (see *Section 4.4, "Cable Type Detection"*). *Policy Engine* directs the *Protocol Layer* to send a ***EPR_Source_Capabilities*** *Message* that represents the power supply's present capabilities.	
2	*Protocol Layer* creates the *Message* and passes to *PHY Layer*.	
3	*PHY Layer* appends *CRC* and sends the ***Source_Capabilities*** *Message*. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the ***EPR_Source_Capabilities*** *Message* and checks the *CRC* to verify the *Message*.
4		*PHY Layer* removes the *CRC* and forwards the ***EPR_Source_Capabilities*** *Message* to the *Protocol Layer*.
5		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***EPR_Source_Capabilities*** *Message* information to the *Policy Engine* that consumes it.
6		*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.
7	*PHY Layer* receives the ***GoodCRC*** *Message* and checks the *CRC* to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.
8	*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.	
9	*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***EPR_Source_Capabilities*** *Message* was successfully sent. *Policy Engine* starts ***SenderResponseTimer***.	
10		*Policy Engine* evaluates the ***EPR_Source_Capabilities*** *Message* sent by the *Source* and selects which power it would like. It tells the *Protocol Layer* to form the data (e.g., *Power Data Object*) that represents its Request into a *Message*.
11		*Protocol Layer* creates the ***EPR_Request*** *Message* and passes to *PHY Layer*.
12	*PHY Layer* receives the ***EPR_Request*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.	*PHY Layer* appends a *CRC* and sends the ***EPR_Request*** *Message*. Starts ***CRCReceiveTimer***.
13	*PHY Layer* removes the *CRC* and forwards the ***EPR_Request*** *Message* to the *Protocol Layer*.	
14	*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* passes the Request information to the *Policy Engine*. *Policy Engine* stops ***SenderResponseTimer***.	
15	The *Protocol Layer* generates a ***GoodCRC*** *Message* and passes it to its *PHY Layer*.	

Table 8.42 Steps for a successful EPR Power Negotiation

Step	Source	Sink
16	*PHY Layer* appends *CRC* and sends the *Message*.	*PHY Layer* receives the *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
17		*PHY Layer* forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.
18		The *Protocol Layer* verifies and increments the ***MessageIDCounter***. It informs the *Policy Engine* that the ***EPR_Request*** *Message* was successfully sent. The *Protocol Layer* stops the ***CRCReceiveTimer***. The *Policy Engine* starts ***SenderResponseTimer***.
19	*Policy Engine* evaluates the ***EPR_Request*** *Message* sent by the *Sink* and decides if it can meet the request. It tells the *Protocol Layer* to form an ***Accept*** *Message*.	
20	The *Protocol Layer* forms the ***Accept*** *Message* that is passed to the *PHY Layer*.	
21	*PHY Layer* appends *CRC* and sends the ***Accept*** *Message*. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
22		*PHY Layer* forwards the ***Accept*** *Message* to the *Protocol Layer*.
23		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. *Protocol Layer* informs the *Policy Engine* that an ***Accept*** *Message* has been received. The *Policy Engine* stops ***SenderResponseTimer***, starts the ***PSTransitionTimer*** and reduces its current draw. The *DPM* prepares the Power supply for transition to the new power level.
24		The *Protocol Layer* generates a ***GoodCRC*** *Message* and passes it to its *PHY Layer*.
25	*PHY Layer* receives the *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.	*PHY Layer* appends *CRC* and sends the *Message*.
26	*PHY Layer* forwards the ***GoodCRC*** *Message* to the *Protocol Layer*. The *Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops the ***CRCReceiveTimer***.	
27	The *Protocol Layer* informs the *Policy Engine* that an ***Accept*** *Message* was successfully sent.	
Power supply Adjusts its Output to the *Negotiated* Value		
28	The *DPM* informs the *Policy Engine* that the power supply has settled at the new operating condition and tells the *Protocol Layer* to send a ***PS_RDY*** *Message*.	
29	The *Protocol Layer* forms the ***PS_RDY*** *Message*.	
30	*PHY Layer* appends *CRC* and sends the ***PS_RDY*** *Message*. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the ***PS_RDY*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
31		*PHY Layer* forwards the ***PS_RDY*** *Message* to the *Protocol Layer*.

Table 8.42 Steps for a successful EPR Power Negotiation

Step	Source	Sink
32		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. *Protocol Layer* informs the *Policy Engine* that a RS_RDY has been received. The *Policy Engine* stops the ***PSTransitionTimer***. The *Policy Engine* starts the ***SinkEPRKeepAliveTimer***.
33		The *Protocol Layer* generates a ***GoodCRC*** *Message* and passes it to its *PHY Layer*.
34	*PHY Layer* receives the *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.	*PHY Layer* appends *CRC* and sends the *Message*.
35	*PHY Layer* forwards the ***GoodCRC*** *Message* to the *Protocol Layer*. The *Protocol Layer* verifies and increments the ***MessageIDCounter***. Stops the ***CRCReceiveTimer***.	
36	The *Protocol Layer* informs the *Policy Engine* that the ***PS_RDY*** *Message* was successfully sent.	
37	When in EPR operation the *Policy Engine* starts the ***SourceEPRKeepAliveTimer***.	

8.3.2.2.2.2.2 EPR Explicit Contract Negotiation (Reject)

Figure 8.16, "Rejected Fixed EPR Power Negotiation" illustrates an example of a *Message* flow where the request is rejected while negotiating an *Explicit Contract* in *EPR Mode*. The *Negotiation* goes through several distinct phases:

- The *Source* sends out its power *Capabilities* in an ***EPR_Source_Capabilities*** *Message*.
- The *Sink* evaluates these *Capabilities* and, in the request phase, selects one power level by sending an ***EPR_Request*** *Message*.
- The *Source* evaluates the request and accepts the request with a ***Reject*** *Message*.

Figure 8.16 Rejected Fixed EPR Power Negotiation

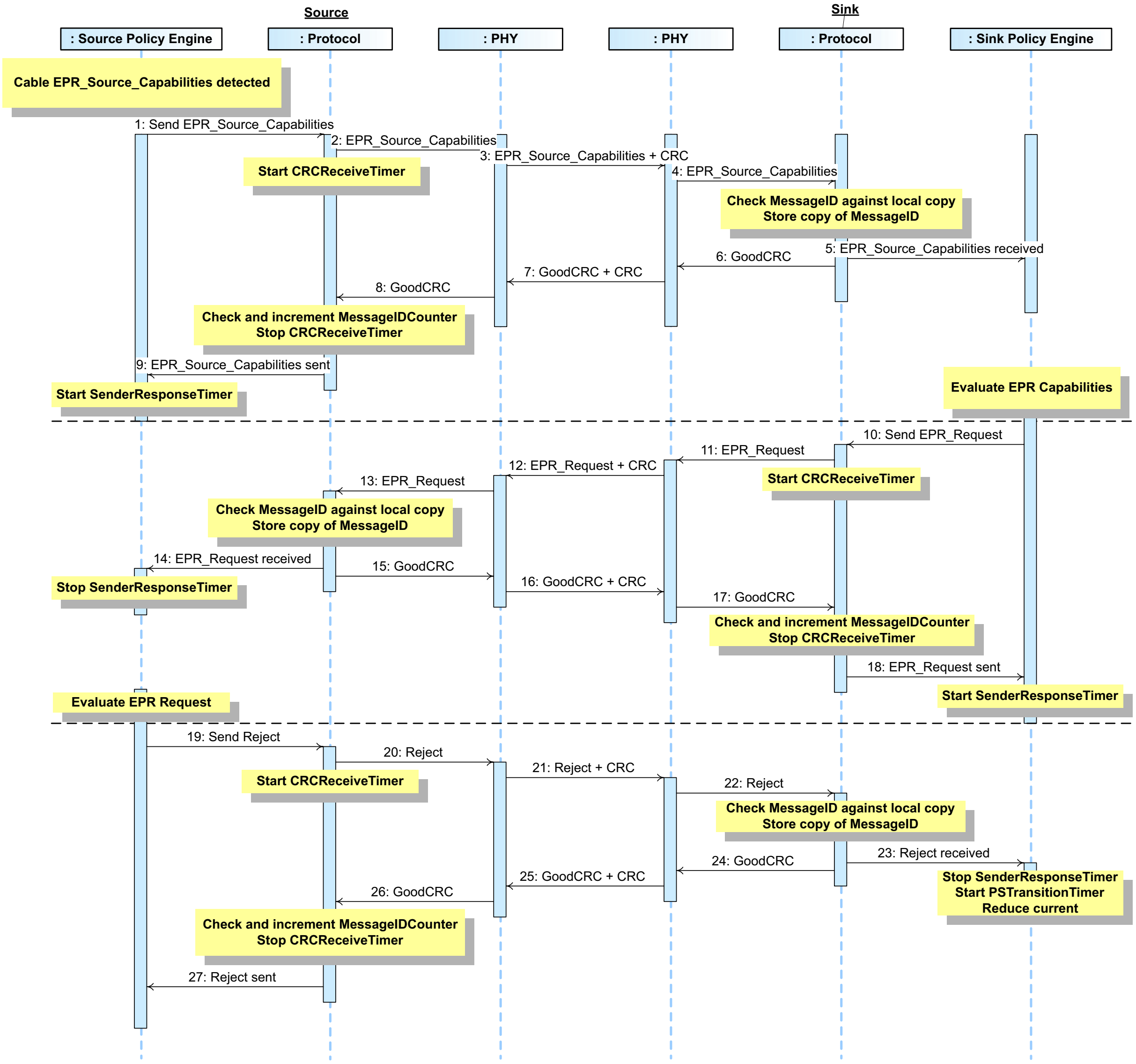


Table 8.43, "Steps for a Rejected EPR Power Negotiation" below provides a detailed explanation of what happens at each labeled step in *Figure 8.16, "Rejected Fixed EPR Power Negotiation"* above.

Table 8.43 Steps for a Rejected EPR Power Negotiation

Step	Source	Sink
1	The *Cable Capabilities* are detected if these are not already known (see *Section 4.4, "Cable Type Detection"*). *Policy Engine* directs the *Protocol Layer* to send a ***EPR_Source_Capabilities*** *Message* that represents the power supply's present capabilities.	
2	*Protocol Layer* creates the *Message* and passes to *PHY Layer*.	
3	*PHY Layer* appends *CRC* and sends the ***Source_Capabilities*** *Message*. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the ***EPR_Source_Capabilities*** *Message* and checks the *CRC* to verify the *Message*.
4		*PHY Layer* removes the *CRC* and forwards the ***EPR_Source_Capabilities*** *Message* to the *Protocol Layer*.
5		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***EPR_Source_Capabilities*** *Message* information to the *Policy Engine* that consumes it.
6		*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.
7	*PHY Layer* receives the ***GoodCRC*** *Message* and checks the *CRC* to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.
8	*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.	
9	*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***EPR_Source_Capabilities*** *Message* was successfully sent. *Policy Engine* starts ***SenderResponseTimer***.	
10		*Policy Engine* evaluates the ***EPR_Source_Capabilities*** *Message* sent by the *Source* and selects which power it would like. It tells the *Protocol Layer* to form the data (e.g., *Power Data Object*) that represents its Request into a *Message*.
11		*Protocol Layer* creates the ***EPR_Request*** *Message* and passes to *PHY Layer*.
12	*PHY Layer* receives the ***EPR_Request*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.	*PHY Layer* appends a *CRC* and sends the ***EPR_Request*** *Message*. Starts ***CRCReceiveTimer***.
13	*PHY Layer* removes the *CRC* and forwards the ***EPR_Request*** *Message* to the *Protocol Layer*.	
14	*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* passes the Request information to the *Policy Engine*. *Policy Engine* stops ***SenderResponseTimer***.	
15	The *Protocol Layer* generates a ***GoodCRC*** *Message* and passes it to its *PHY Layer*.	

Table 8.43 Steps for a Rejected EPR Power Negotiation

Step	Source	Sink
16	*PHY Layer* appends *CRC* and sends the *Message*.	*PHY Layer* receives the *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
17		*PHY Layer* forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.
18		The *Protocol Layer* verifies and increments the ***MessageIDCounter***. It informs the *Policy Engine* that the ***EPR_Request*** *Message* was successfully sent. The *Protocol Layer* stops the ***CRCReceiveTimer***. The *Policy Engine* starts ***SenderResponseTimer***.
19	*Policy Engine* evaluates the ***EPR_Request*** *Message* sent by the *Sink* and decides it can't meet the request. It tells the *Protocol Layer* to form a ***Reject*** *Message*.	
20	The *Protocol Layer* forms the ***Reject*** *Message* that is passed to the *PHY Layer*.	
21	*PHY Layer* appends *CRC* and sends the ***Reject*** *Message*. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
22		*PHY Layer* forwards the ***Reject*** *Message* to the *Protocol Layer*.
23		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. *Protocol Layer* informs the *Policy Engine* that a ***Reject*** *Message* has been received. The *Policy Engine* stops ***SenderResponseTimer***.
24		The *Protocol Layer* generates a ***GoodCRC*** *Message* and passes it to its *PHY Layer*.
25	*PHY Layer* receives the *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.	*PHY Layer* appends *CRC* and sends the *Message*.
26	*PHY Layer* forwards the ***GoodCRC*** *Message* to the *Protocol Layer*. The *Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops the ***CRCReceiveTimer***.	
27	The *Protocol Layer* informs the *Policy Engine* that a ***Reject*** *Message* was successfully sent.	

8.3.2.2.2.2.3 EPR Explicit Contract Negotiation (Wait)

Figure 8.17, "Wait response to Fixed EPR Power Negotiation" illustrates an example of a *Message* flow where the request is responded to with wait while negotiating an *Explicit Contract* in *EPR Mode*. The *Negotiation* goes through several distinct phases:

- The *Source* sends out its power *Capabilities* in an ***EPR_Source_Capabilities*** *Message*.
- The *Sink* evaluates these *Capabilities* and, in the request phase, selects one power level by sending an ***EPR_Request*** *Message*.
- The *Source* evaluates the request and accepts the request with a ***Wait*** *Message*.

Figure 8.17 Wait response to Fixed EPR Power Negotiation

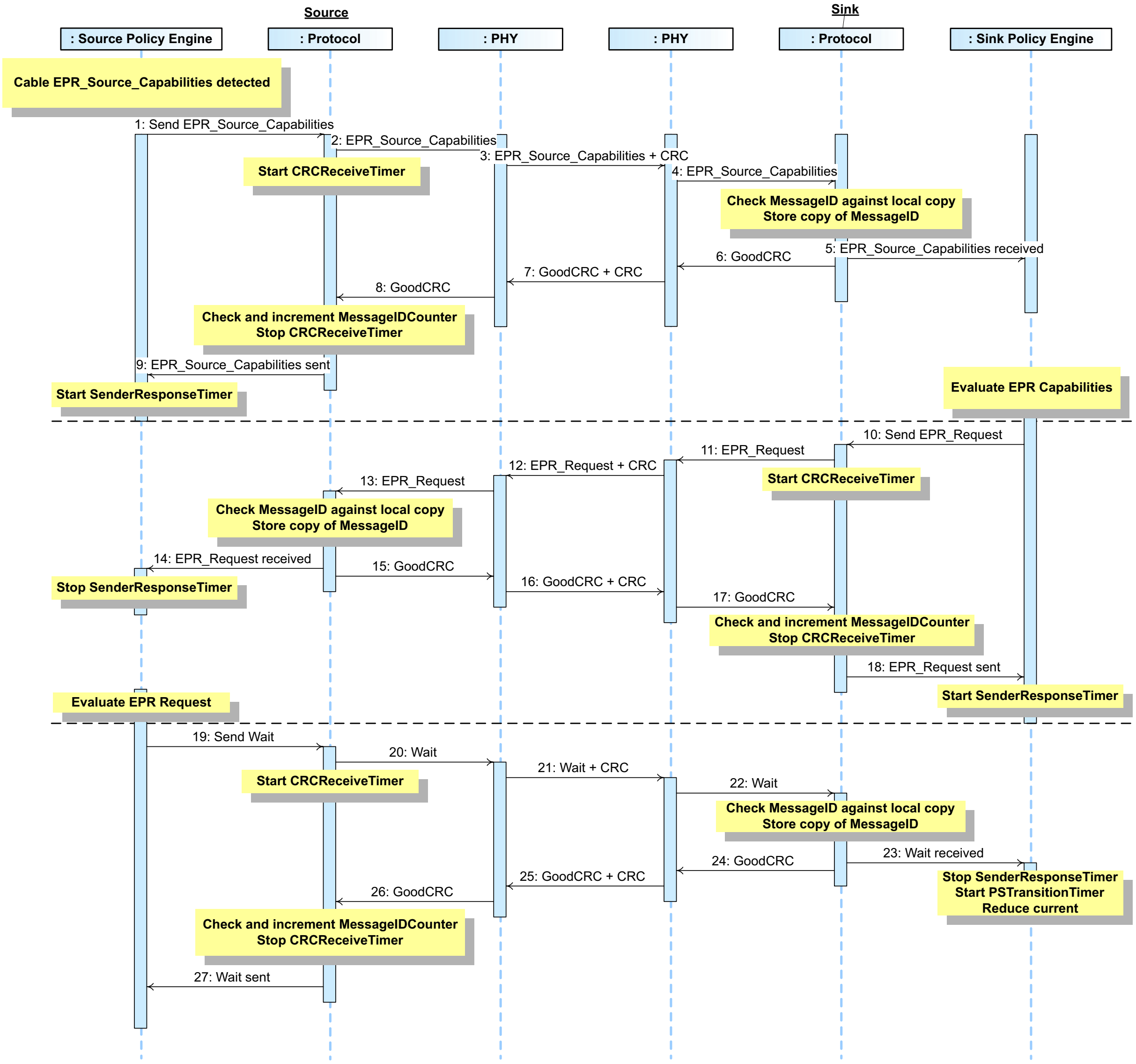


Table 8.44, "Steps for a Wait response to an EPR Power Negotiation" below provides a detailed explanation of what happens at each labeled step in *Figure 8.17, "Wait response to Fixed EPR Power Negotiation"* above.

Table 8.44 Steps for a Wait response to an EPR Power Negotiation

Step	Source	Sink
1	The *Cable Capabilities* are detected if these are not already known (see *Section 4.4, "Cable Type Detection"*). *Policy Engine* directs the *Protocol Layer* to send a ***EPR_Source_Capabilities*** *Message* that represents the power supply's present capabilities.	
2	*Protocol Layer* creates the *Message* and passes to *PHY Layer*.	
3	*PHY Layer* appends *CRC* and sends the ***Source_Capabilities*** *Message*. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the ***EPR_Source_Capabilities*** *Message* and checks the *CRC* to verify the *Message*.
4		*PHY Layer* removes the *CRC* and forwards the ***EPR_Source_Capabilities*** *Message* to the *Protocol Layer*.
5		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***EPR_Source_Capabilities*** *Message* information to the *Policy Engine* that consumes it.
6		*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.
7	*PHY Layer* receives the ***GoodCRC*** *Message* and checks the *CRC* to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.
8	*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.	
9	*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***EPR_Source_Capabilities*** *Message* was successfully sent. *Policy Engine* starts ***SenderResponseTimer***.	
10		*Policy Engine* evaluates the ***EPR_Source_Capabilities*** *Message* sent by the *Source* and selects which power it would like. It tells the *Protocol Layer* to form the data (e.g., *Power Data Object*) that represents its Request into a *Message*.
11		*Protocol Layer* creates the ***EPR_Request*** *Message* and passes to *PHY Layer*.
12	*PHY Layer* receives the ***EPR_Request*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.	*PHY Layer* appends a *CRC* and sends the ***EPR_Request*** *Message*. Starts ***CRCReceiveTimer***.
13	*PHY Layer* removes the *CRC* and forwards the ***EPR_Request*** *Message* to the *Protocol Layer*.	
14	*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* passes the Request information to the *Policy Engine*. *Policy Engine* stops ***SenderResponseTimer***.	
15	The *Protocol Layer* generates a ***GoodCRC*** *Message* and passes it to its *PHY Layer*.	

Table 8.44 Steps for a Wait response to an EPR Power Negotiation

Step	Source	Sink
16	*PHY Layer* appends *CRC* and sends the *Message*.	*PHY Layer* receives the *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
17		*PHY Layer* forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.
18		The *Protocol Layer* verifies and increments the ***MessageIDCounter***. It informs the *Policy Engine* that the ***EPR_Request*** *Message* was successfully sent. The *Protocol Layer* stops the ***CRCReceiveTimer***. The *Policy Engine* starts ***SenderResponseTimer***.
19	*Policy Engine* evaluates the ***EPR_Request*** *Message* sent by the *Sink* and decides if it can meet the request. It tells the *Protocol Layer* to form a ***Wait*** *Message*.	
20	The *Protocol Layer* forms the ***Wait*** *Message* that is passed to the *PHY Layer*.	
21	*PHY Layer* appends *CRC* and sends the ***Wait*** *Message*. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
22		*PHY Layer* forwards the ***Wait*** *Message* to the *Protocol Layer*.
23		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. *Protocol Layer* informs the *Policy Engine* that a ***Wait*** *Message* has been received. The *Policy Engine* stops ***SenderResponseTimer***.
24		The *Protocol Layer* generates a ***GoodCRC*** *Message* and passes it to its *PHY Layer*.
25	*PHY Layer* receives the *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.	*PHY Layer* appends *CRC* and sends the *Message*.
26	*PHY Layer* forwards the ***GoodCRC*** *Message* to the *Protocol Layer*. The *Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops the ***CRCReceiveTimer***.	
27	The *Protocol Layer* informs the *Policy Engine* that a ***Wait*** *Message* was successfully sent.	

8.3.2.2.2.3 EPR Keep Alive

This is an example of keep alive operation during an *Explicit Contract* in *EPR Mode*. Figure 8.18, "EPR Keep Alive"shows the *Messages* as they flow across the bus and within the devices to accomplish the keep alive.

Figure 8.18 EPR Keep Alive

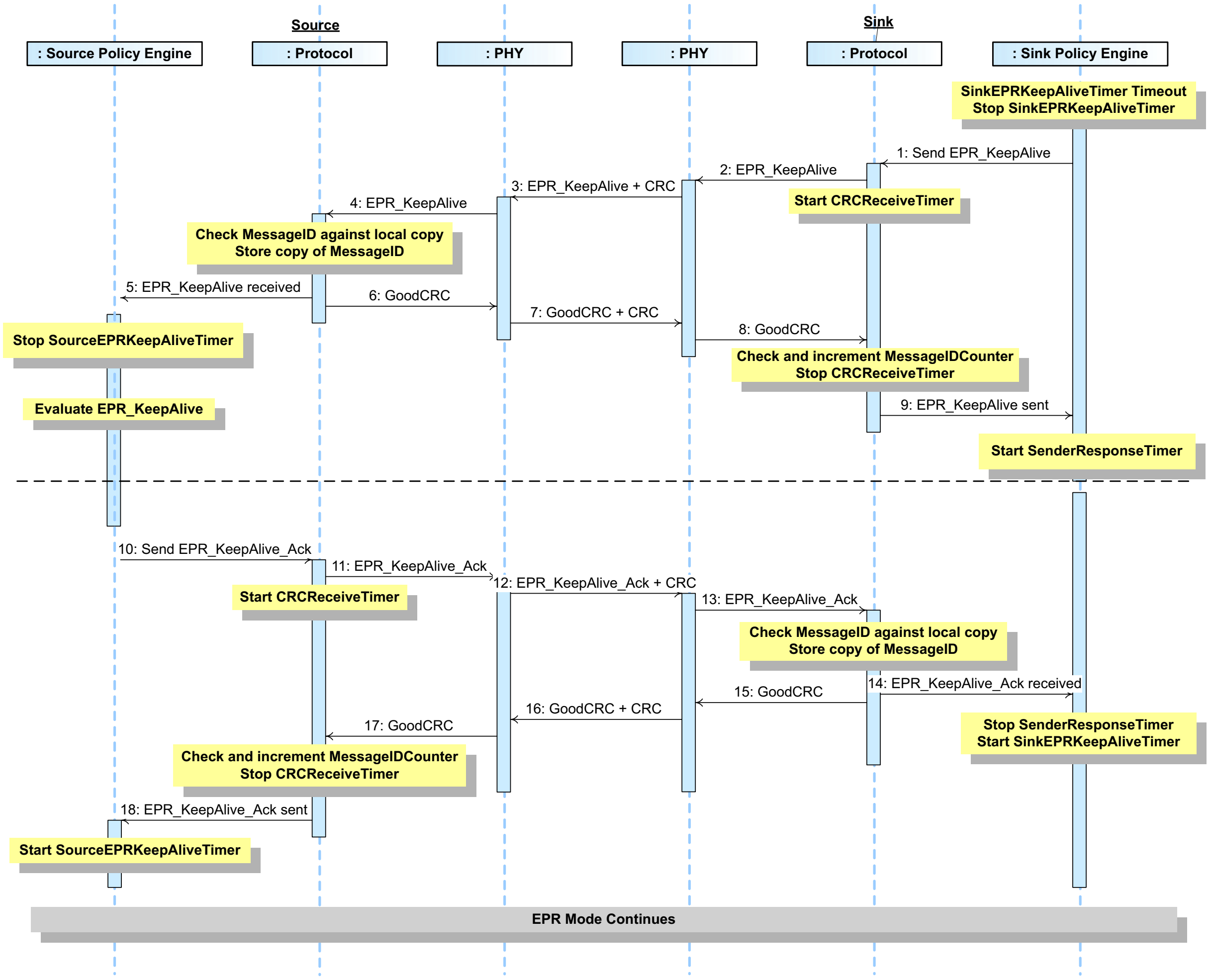


Table 8.45, "Steps for EPR Keep Alive" below provides a detailed explanation of what happens at each labeled step in *Figure 8.18, "EPR Keep Alive"* above.

Table 8.45 Steps for EPR Keep Alive

Step	Source	Sink
1		The ***SinkEPRKeepAliveTimer*** times out in the *Policy Engine*. The *Policy Engine* stops the ***SinkEPRKeepAliveTimer*** timer and tells the *Protocol Layer* to form an ***EPR_KeepAlive*** *Message*.
2		The *Protocol Layer* creates the ***EPR_KeepAlive*** *Message* and passes it to *PHY Layer*. The *Protocol Layer*.
3	*PHY Layer* receives the ***EPR_KeepAlive*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.	*PHY Layer* appends a *CRC* and sends the ***Request*** *Message*. Starts ***CRCReceiveTimer***.
4	*PHY Layer* removes the *CRC* and forwards the ***EPR_KeepAlive*** *Message* to the *Protocol Layer*.	
5	*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* passes the Request information to the *Policy Engine*. *Policy Engine* stops the ***SourceEPRKeepAliveTimer.***	
6	The *Protocol Layer* generates a ***GoodCRC*** *Message* and passes it to its *PHY Layer*.	
7	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.	*PHY Layer* receives the ***GoodCRC*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
8		*PHY Layer* forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.
9		The *Protocol Layer* verifies and increments the ***MessageIDCounter***. It informs the *Policy Engine* that the ***SinkEPRKeepAliveTimer*** *Message* was successfully sent. The *Protocol Layer* stops the ***CRCReceiveTimer***. The *Policy Engine* starts ***SenderResponseTimer***.
10	*Policy Engine* requests the *DPM* to evaluate the ***SourceEPRKeepAliveTimer*** *Message* sent by the *Sink* and decides if the *Source* can meet the request. The *Policy Engine* tells the *Protocol Layer* to form an ***EPR_KeepAlive_Ack*** *Message*.	
11	The *Protocol Layer* forms the ***EPR_KeepAlive_Ack*** *Message* that is passed to the *PHY Layer*.	
12	*PHY Layer* appends *CRC* and sends the ***EPR_KeepAlive_Ack*** *Message*. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the ***EPR_KeepAlive_Ack*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
13		*PHY Layer* forwards the ***EPR_KeepAlive_Ack*** *Message* to the *Protocol Layer*.
14		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. *Protocol Layer* informs the *Policy Engine* that an ***Accept*** *Message* has been received. The *Policy Engine* stops ***SenderResponseTimer***, starts the ***SinkEPRKeepAliveTimer***.

Table 8.45 Steps for EPR Keep Alive

Step	Source	Sink
15		The *Protocol Layer* generates a ***GoodCRC*** *Message* and passes it to its *PHY Layer*.
16	*PHY Layer* receives the ***GoodCRC*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.
17	*PHY Layer* forwards the ***GoodCRC*** *Message* to the *Protocol Layer*. The *Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops the ***CRCReceiveTimer***.	
18	The *Protocol Layer* informs the *Policy Engine* that an ***EPR_KeepAlive_Ack*** *Message* was successfully sent. The *Policy Engine* starts the ***SourceEPRKeepAliveTimer***.	
EPR Mode Continues		

8.3.2.2.2.4 Exiting EPR Mode

8.3.2.2.2.4.1 Exiting EPR Mode (Sink Initiated)

This is an example of an Exit *EPR Mode* operation where the *Sink* requests *EPR Mode* to be exited. Figure 8.19, "Exiting EPR Mode (Sink Initiated)" shows the *Messages* as they flow across the bus and within the devices to accomplish the Exit EPR process.

Figure 8.19 Exiting EPR Mode (Sink Initiated)

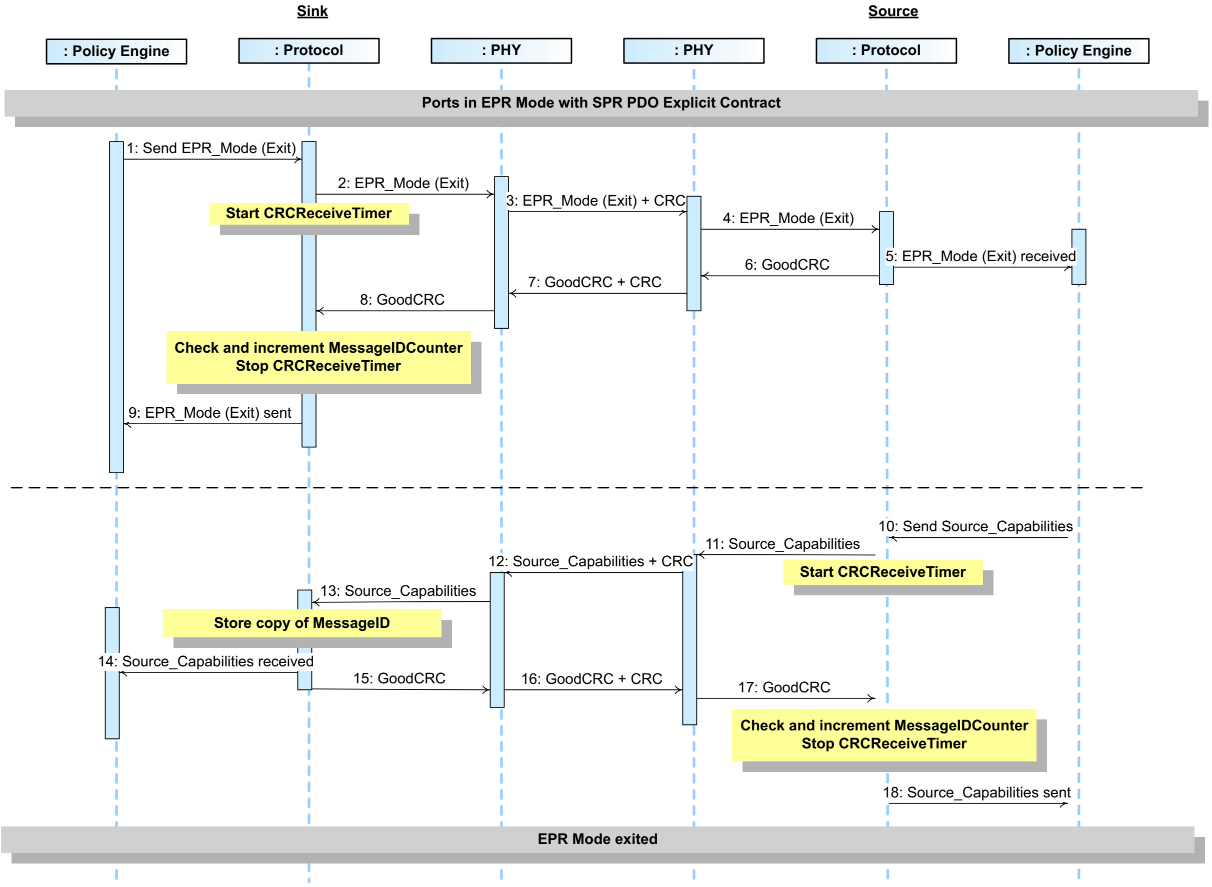


Table 8.46, "Steps for Exiting EPR Mode (Sink Initiated)" below provides a detailed explanation of what happens at each labeled step in *Figure 8.19, "Exiting EPR Mode (Sink Initiated)"* above.

Table 8.46 Steps for Exiting EPR Mode (Sink Initiated)

Step	Sink	Source
The *Port Partners* are in an *Explicit Contract* using an *SPR (A)PDO* (Voltage <= 20V)		
1	The *Policy Engine* directs the *Protocol Layer* to generate an ***EPR_Mode*** (Exit) *Message* to request entry to *EPR Mode*.	
2	*Protocol Layer* creates the *Message* and passes to *PHY Layer*.	
3	*PHY Layer* appends *CRC* and sends the ***EPR_Mode*** (Exit) *Message*. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the ***EPR_Mode*** (Exit) *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
4		*PHY Layer* removes the *CRC* and forwards the ***EPR_Mode*** (Exit) *Message* to the *Protocol Layer*.
5		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***EPR_Mode*** (Exit) *Message* information to the *Policy Engine* that consumes it.
6		*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.
7	*PHY Layer* receives the ***GoodCRC*** and checks the *CRC* to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.
8	*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.	
9	*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***EPR_Mode*** (Exit) *Message* was successfully sent.	
10		*Policy Engine* evaluates the ***EPR_Mode*** (Exit) *Message* sent by the *Sink*. It tells the *Protocol Layer* to form a ***Source_Capabilities*** *Message*.
11		*Protocol Layer* creates the ***Source_Capabilities*** *Message* and passes to *PHY Layer*.
12	*PHY Layer* receives the ***Source_Capabilities*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.	*PHY Layer* appends a *CRC* and sends the ***Source_Capabilities*** *Message*. Starts ***CRCReceiveTimer***.
13	*PHY Layer* removes the *CRC* and forwards the ***Source_Capabilities*** *Message* to the *Protocol Layer*.	
14	*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* passes the ***EPR_Mode*** (Enter Succeeded) information to the *Policy Engine*.	
15	The *Protocol Layer* generates a ***GoodCRC*** *Message* and passes it to its *PHY Layer*.	
16	*PHY Layer* appends *CRC* and sends the *Message*.	*PHY Layer* receives the *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.

Table 8.46 Steps for Exiting EPR Mode (Sink Initiated)

Step	Sink	Source
17		*PHY Layer* forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.
18		The *Protocol Layer* verifies and increments the ***MessageIDCounter.*** It informs the *Policy Engine* that the ***Source_Capabilities*** *Message* was successfully sent. The *Protocol Layer* stops the ***CRCReceiveTimer***.
EPR Mode Exited. Power *Negotiation* proceeds as defined in *Section 8.3.2.2.1.1, "SPR Explicit Contract Negotiation"*.		

8.3.2.2.2.4.2 Exiting EPR Mode (Source Initiated)

This is an example of an Exit *EPR Mode* operation where the *Source* requests *EPR Mode* to be exited. [Figure 8.20, "Exiting EPR Mode (Source Initiated)"](#) shows the *Messages* as they flow across the bus and within the devices to accomplish the Exit EPR process.

Figure 8.20 Exiting EPR Mode (Source Initiated)

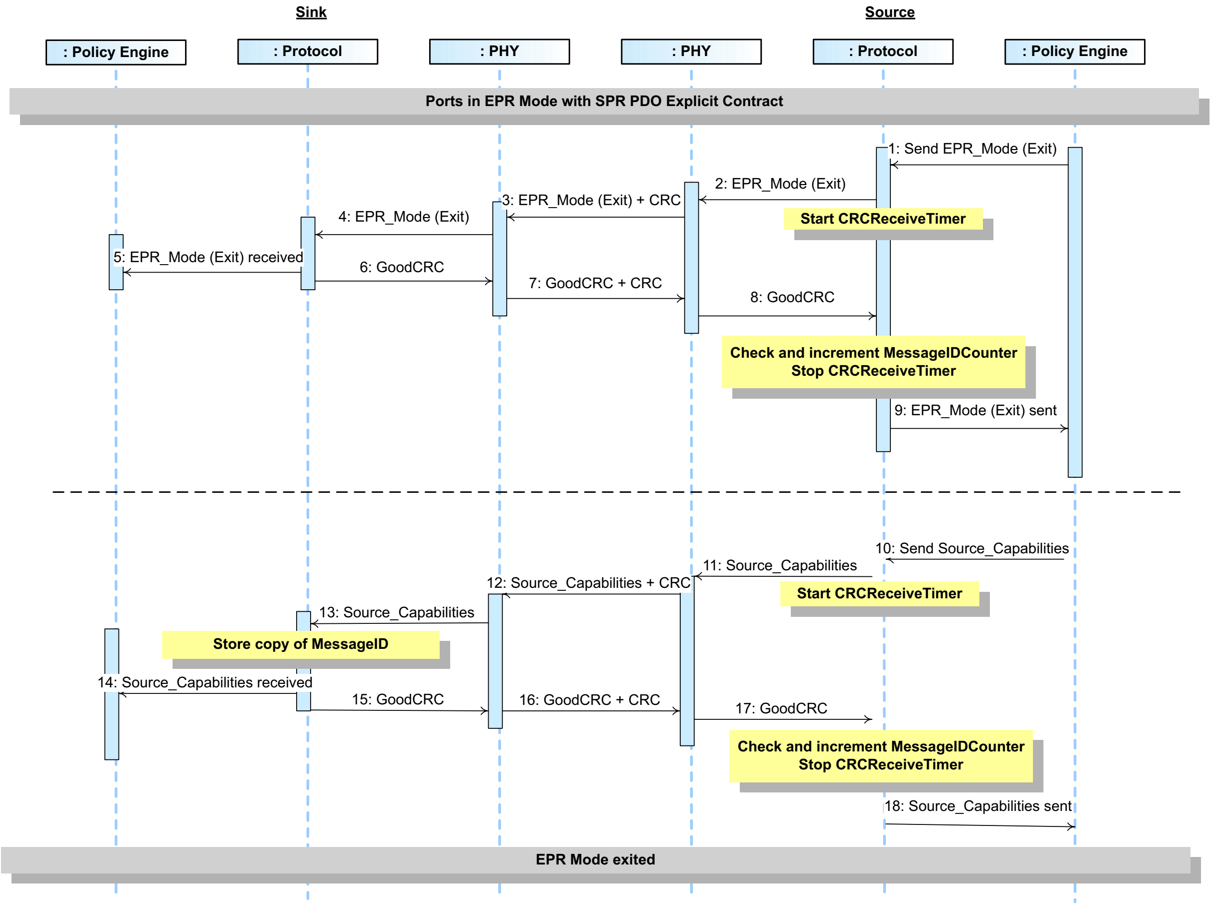


Table 8.47, "Steps for Exiting EPR Mode (Source Initiated)" below provides a detailed explanation of what happens at each labeled step in *Figure 8.20, "Exiting EPR Mode (Source Initiated)"* above.

Table 8.47 Steps for Exiting EPR Mode (Source Initiated)

Step	Sink	Source
The *Port Partners* are in an *Explicit Contract* using an *SPR (A)PDO* (Voltage <= 20V)		
1		The *Policy Engine* directs the *Protocol Layer* to generate an ***EPR_Mode*** (Exit) *Message* to request entry to *EPR Mode*.
2		*Protocol Layer* creates the *Message* and passes to *PHY Layer*.
3	*PHY Layer* receives the ***EPR_Mode*** (Exit) *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***EPR_Mode*** (Exit) *Message*. Starts ***CRCReceiveTimer***.
4	*PHY Layer* removes the *CRC* and forwards the ***EPR_Mode*** (Exit) *Message* to the *Protocol Layer*.	
5	*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***EPR_Mode*** (Exit) *Message* information to the *Policy Engine* that consumes it.	
6	*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.	
7	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.	*PHY Layer* receives the ***GoodCRC*** and checks the *CRC* to verify the *Message*.
8		*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.
9		*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***EPR_Mode*** (Exit) *Message* was successfully sent.
10		*Policy Engine* evaluates the ***EPR_Mode*** (Exit) *Message* sent by the *Sink*. It tells the *Protocol Layer* to form a ***Source_Capabilities*** *Message*.
11		*Protocol Layer* creates the ***Source_Capabilities*** *Message* and passes to *PHY Layer*. Starts ***CRCReceiveTimer***.
12	*PHY Layer* receives the ***Source_Capabilities*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.	*PHY Layer* appends a *CRC* and sends the ***Source_Capabilities*** *Message*.
13	*PHY Layer* removes the *CRC* and forwards the ***Source_Capabilities*** *Message* to the *Protocol Layer*.	
14	*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* passes the ***EPR_Mode*** (Enter Succeeded) information to the *Policy Engine*.	
15	The *Protocol Layer* generates a ***GoodCRC*** *Message* and passes it to its *PHY Layer*.	
16	*PHY Layer* appends *CRC* and sends the *Message*.	*PHY Layer* receives the *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.

Table 8.47 Steps for Exiting EPR Mode (Source Initiated)

Step	Sink	Source
17		*PHY Layer* forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.
18		The *Protocol Layer* verifies and increments the ***MessageIDCounter***. It informs the *Policy Engine* that the ***Source_Capabilities*** *Message* was successfully sent. The *Protocol Layer* stops the ***CRCReceiveTimer***.
EPR Mode Exited. Power *Negotiation* proceeds as defined in *Section 8.3.2.2.1.1, "SPR Explicit Contract Negotiation"*.		

8.3.2.2.2.5 EPR Sink Makes Request

8.3.2.2.2.5.1 EPR Sink Makes Request (Accept)

This is an example of EPR when a *Sink* makes a Request which is Accepted during an *Explicit Contract*. Figure 8.21, "EPR Sink Makes Request (Accept)" shows the *Messages* as they flow across the bus and within the devices to accomplish the keep alive.

Figure 8.21 EPR Sink Makes Request (Accept)

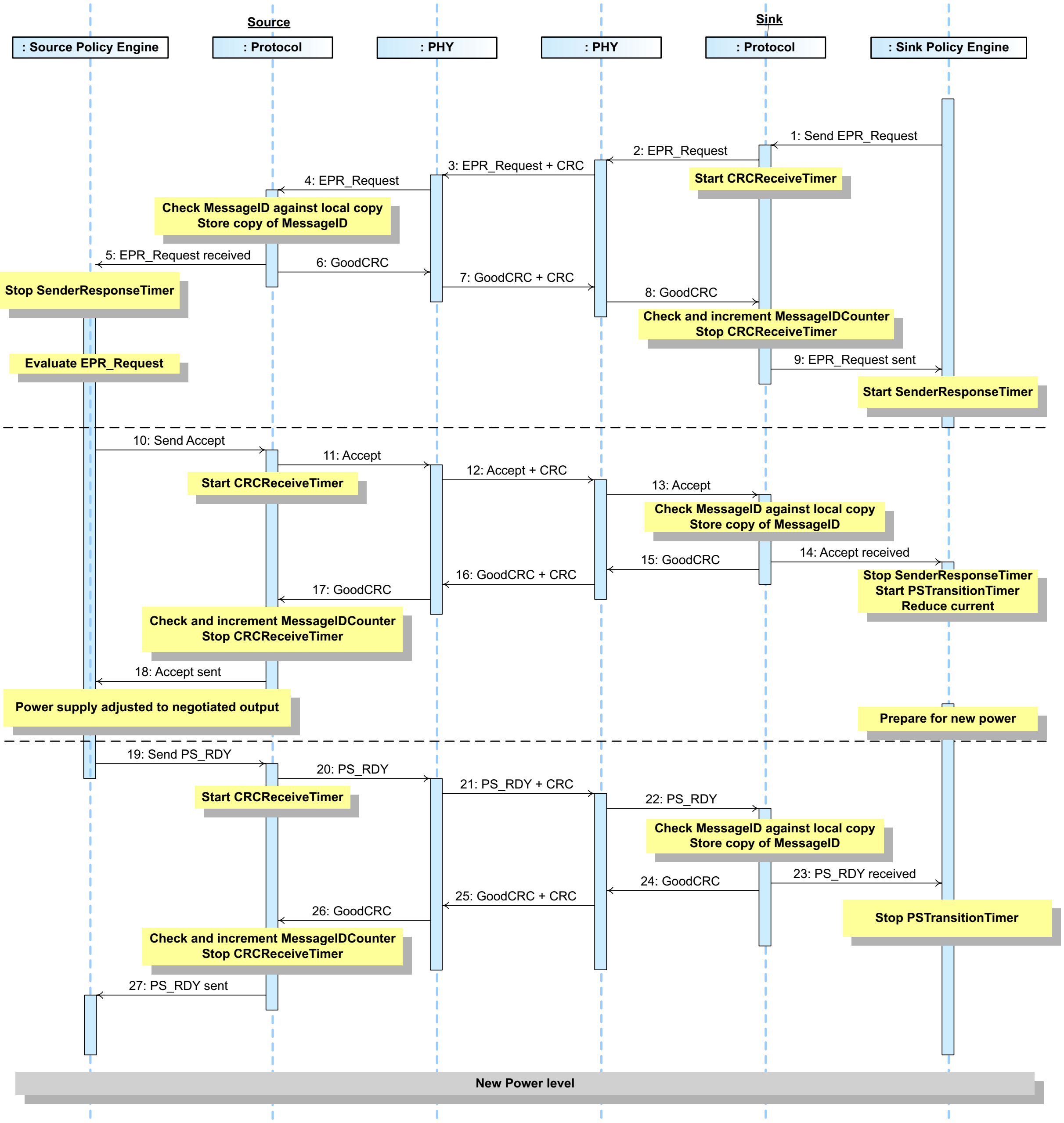


Table 8.48, "Steps for EPR Sink Makes Request (Accept)" below provides a detailed explanation of what happens at each labeled step in *Figure 8.21, "EPR Sink Makes Request (Accept)"* above.

Table 8.48 Steps for EPR Sink Makes Request (Accept)

Step	Source	Sink
1		*DPM* tells the *Policy Engine* to request a different power level. The *Policy Engine* tells the *Protocol Layer* to form an ***EPR_Request*** *Message*. The *Protocol Layer* creates the ***EPR_Request*** *Message* and passes it to *PHY Layer*.
2	*PHY Layer* receives the ***EPR_Request*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.	*PHY Layer* appends a *CRC* and sends the ***EPR_Request*** *Message*. Starts ***CRCReceiveTimer***.
3	*PHY Layer* removes the *CRC* and forwards the ***EPR_Request*** *Message* to the *Protocol Layer*.	
4	*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* passes the Request information to the *Policy Engine*.	
5	The *Protocol Layer* generates a ***GoodCRC*** *Message* and passes it to its *PHY Layer*.	
6	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.	*PHY Layer* receives the ***GoodCRC*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
7		*PHY Layer* forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.
8		The *Protocol Layer* verifies and increments the ***MessageIDCounter***. It informs the *Policy Engine* that the ***EPR_Request*** *Message* was successfully sent. The *Protocol Layer* stops the ***CRCReceiveTimer***. The *Policy Engine* starts ***SenderResponseTimer***.
9	*Policy Engine* requests the *DPM* to evaluate the ***EPR_Request*** *Message* sent by the *Sink* and decides if the *Source* can meet the request. The *Policy Engine* tells the *Protocol Layer* to form an ***Accept*** *Message*.	
10	The *Protocol Layer* forms the ***Accept*** *Message* that is passed to the *PHY Layer*.	
11	*PHY Layer* appends *CRC* and sends the ***Accept*** *Message*. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the ***Accept*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
12		*PHY Layer* forwards the ***Accept*** *Message* to the *Protocol Layer*.
13		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. *Protocol Layer* informs the *Policy Engine* that an ***Accept*** *Message* has been received. The *Policy Engine* stops ***SenderResponseTimer***, starts the ***PSTransitionTimer*** and reduces its current draw. The *DPM* prepares the Power supply for transition to the new power level.

Table 8.48 Steps for EPR Sink Makes Request (Accept)

Step	Source	Sink
14		The *Protocol Layer* generates a ***GoodCRC*** *Message* and passes it to its *PHY Layer*.
15	*PHY Layer* receives the ***GoodCRC*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.
16	*PHY Layer* forwards the ***GoodCRC*** *Message* to the *Protocol Layer*. The *Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops the ***CRCReceiveTimer***.	
17	The *Protocol Layer* informs the *Policy Engine* that an ***Accept*** *Message* was successfully sent.	
Power supply Adjusts its Output to the *Negotiated* Value		
18	The *DPM* informs the *Policy Engine* that the power supply has settled at the new operating condition and tells the *Protocol Layer* to send a ***PS_RDY*** *Message*.	
19	The *Protocol Layer* forms the ***PS_RDY*** *Message*.	
20	*PHY Layer* appends *CRC* and sends the ***PS_RDY*** *Message*. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the ***PS_RDY*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
21		*PHY Layer* forwards the ***PS_RDY*** *Message* to the *Protocol Layer*.
22		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. *Protocol Layer* informs the *Policy Engine* that a RS_RDY has been received. The *Policy Engine* stops the ***PSTransitionTimer***.
23		The *Protocol Layer* generates a ***GoodCRC*** *Message* and passes it to its *PHY Layer*.
24	*PHY Layer* receives the ***GoodCRC*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.
25	*PHY Layer* forwards the ***GoodCRC*** *Message* to the *Protocol Layer*. The *Protocol Layer* verifies and increments the ***MessageIDCounter***. Stops the ***CRCReceiveTimer***.	
26	The *Protocol Layer* informs the *Policy Engine* that the ***PS_RDY*** *Message* was successfully sent.	
New Power Level *Negotiated*		

8.3.2.2.2.5.2 EPR Sink Makes Request (Reject)

This is an example of EPR when a *Sink* makes a Request which is Rejected during an *Explicit Contract*. Figure 8.22, "EPR Sink Makes Request (Reject)" shows the *Message*s as they flow across the bus and within the devices to accomplish the keep alive.

Figure 8.22 EPR Sink Makes Request (Reject)

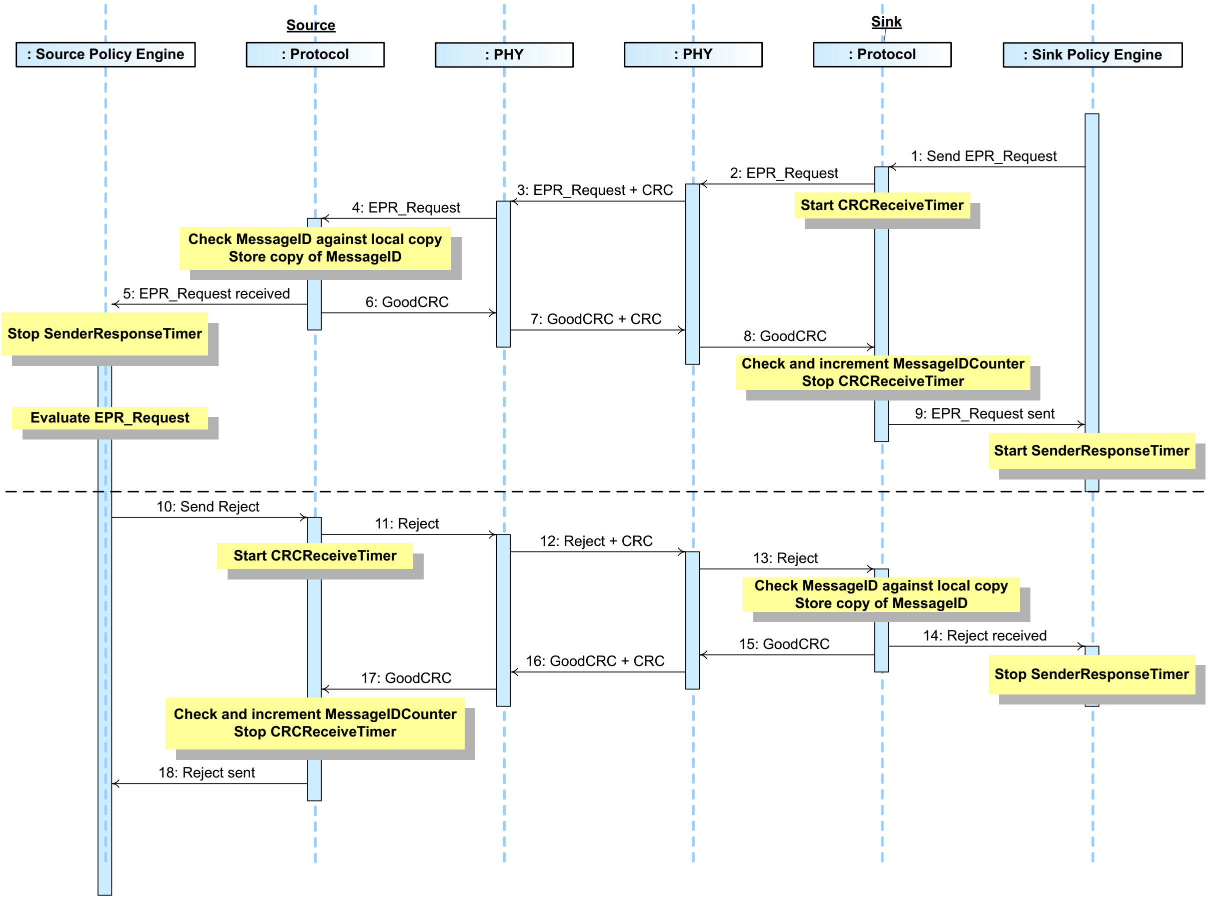


Table 8.49, "Steps for EPR Sink Makes Request (Reject)" below provides a detailed explanation of what happens at each labeled step in *Figure 8.22, "EPR Sink Makes Request (Reject)"* above.

Table 8.49 Steps for EPR Sink Makes Request (Reject)

Step	Source	Sink
1		*DPM* tells the *Policy Engine* to request a different power level. The *Policy Engine* tells the *Protocol Layer* to form an ***EPR_Request*** *Message*. The *Protocol Layer* creates the ***Request*** *Message* and passes it to *PHY Layer*.
2	*PHY Layer* receives the ***EPR_Request*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.	*PHY Layer* appends a *CRC* and sends the ***EPR_Request*** *Message*. Starts ***CRCReceiveTimer***.
3	*PHY Layer* removes the *CRC* and forwards the ***EPR_Request*** *Message* to the *Protocol Layer*.	
4	*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* passes the Request information to the *Policy Engine*.	
5	The *Protocol Layer* generates a ***GoodCRC*** *Message* and passes it to its *PHY Layer*.	
6	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.	*PHY Layer* receives the ***GoodCRC*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
7		*PHY Layer* forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.
8		The *Protocol Layer* verifies and increments the ***MessageIDCounter***. It informs the *Policy Engine* that the ***EPR_Request*** *Message* was successfully sent. The *Protocol Layer* stops the ***CRCReceiveTimer***. The *Policy Engine* starts ***SenderResponseTimer***.
9	*Policy Engine* requests the *DPM* to evaluate the ***EPR_Request*** *Message* sent by the *Sink* and decides that the *Source* can't meet the request. The *Policy Engine* tells the *Protocol Layer* to form a ***Reject*** *Message*.	
10	The *Protocol Layer* forms the ***Reject*** *Message* that is passed to the *PHY Layer*.	
11	*PHY Layer* appends *CRC* and sends the ***Reject*** *Message*. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the ***Reject*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
12		*PHY Layer* forwards the ***Reject*** *Message* to the *Protocol Layer*.
13		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. *Protocol Layer* informs the *Policy Engine* that an ***Reject*** *Message* has been received. The *Policy Engine* informs the *DPM* that the Request has been rejected.
14		The *Protocol Layer* generates a ***GoodCRC*** *Message* and passes it to its *PHY Layer*.

Table 8.49 Steps for EPR Sink Makes Request (Reject)

Step	Source	Sink
15	*PHY Layer* receives the ***GoodCRC*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.
16	*PHY Layer* forwards the ***GoodCRC*** *Message* to the *Protocol Layer*. The *Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops the ***CRCReceiveTimer***.	
17	The *Protocol Layer* informs the *Policy Engine* that a ***Reject*** *Message* was successfully sent.	

8.3.2.2.2.5.3 EPR Sink Makes Request (Wait)

This is an example of SPR when a *Sink* makes a Request which is responded to with a ***Wait*** *Message* during an *Explicit Contract*. *Figure 8.23, "EPR Sink Makes Request (Wait)"* shows the *Messages* as they flow across the bus and within the devices to accomplish the keep alive.

Figure 8.23 EPR Sink Makes Request (Wait)

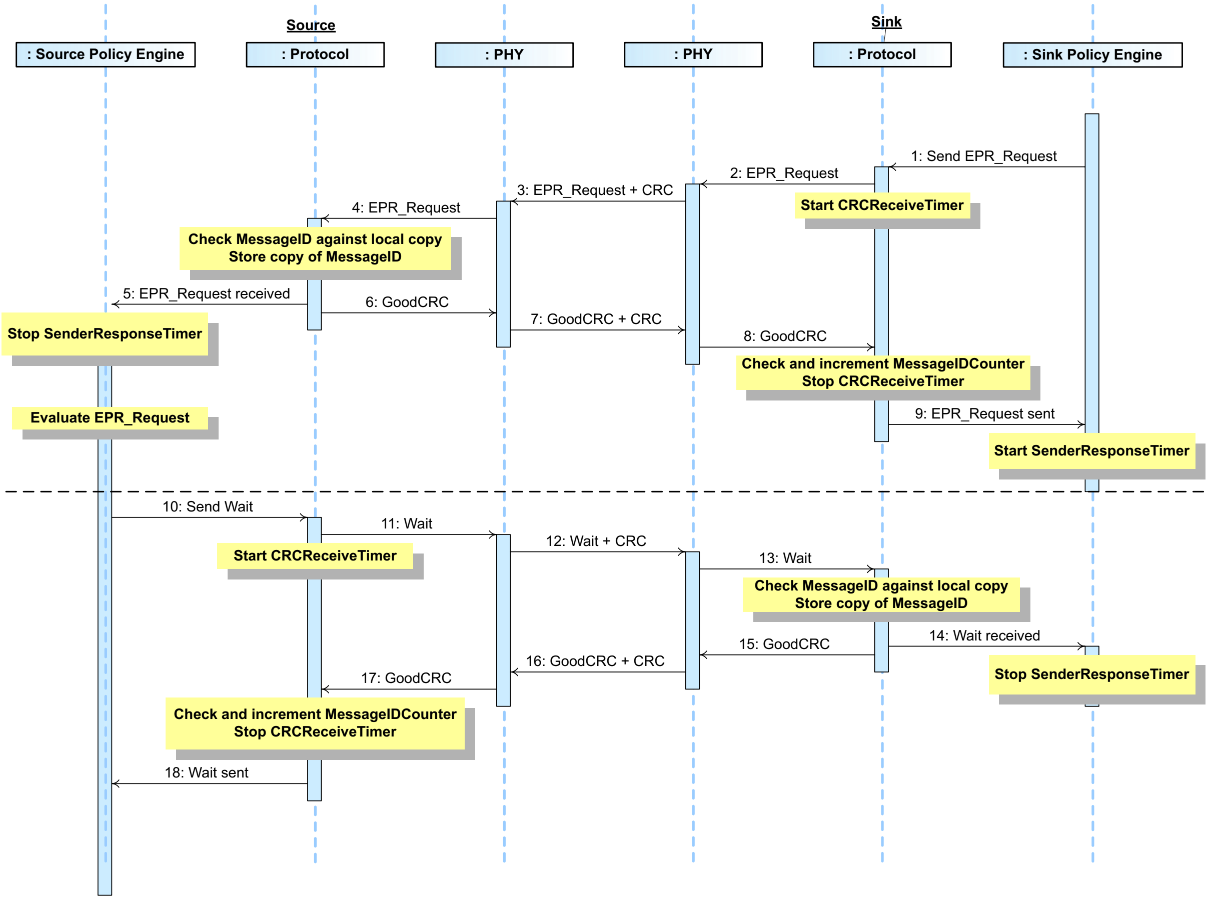


Table 8.50, "Steps for SPR Sink Makes Request (Wait)" below provides a detailed explanation of what happens at each labeled step in *Figure 8.23, "EPR Sink Makes Request (Wait)"* above.

Table 8.50 Steps for SPR Sink Makes Request (Wait)

Step	Source	Sink
1		*DPM* tells the *Policy Engine* to request a different power level. The *Policy Engine* tells the *Protocol Layer* to form an ***EPR_Request*** *Message*. The *Protocol Layer* creates the ***EPR_Request*** *Message* and passes it to *PHY Layer*.
2	*PHY Layer* receives the ***EPR_Request*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.	*PHY Layer* appends a *CRC* and sends the ***EPR_Request*** *Message*. Starts ***CRCReceiveTimer***.
3	*PHY Layer* removes the *CRC* and forwards the ***EPR_Request*** *Message* to the *Protocol Layer*.	
4	*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* passes the Request information to the *Policy Engine*.	
5	The *Protocol Layer* generates a ***GoodCRC*** *Message* and passes it to its *PHY Layer*.	
6	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.	*PHY Layer* receives the ***GoodCRC*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
7		*PHY Layer* forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.
8		The *Protocol Layer* verifies and increments the ***MessageIDCounter***. It informs the *Policy Engine* that the ***Request*** *Message* was successfully sent. The *Protocol Layer* stops the ***CRCReceiveTimer***. The *Policy Engine* starts ***SenderResponseTimer***.
9	*Policy Engine* requests the *DPM* to evaluate the ***EPR_Request*** *Message* sent by the *Sink* and decides if the *Source* can meet the request. The *Policy Engine* tells the *Protocol Layer* to form a ***Wait*** *Message*.	
10	The *Protocol Layer* forms the ***Wait*** *Message* that is passed to the *PHY Layer*.	
11	*PHY Layer* appends *CRC* and sends the ***Wait*** *Message*. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the ***Wait*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
12		*PHY Layer* forwards the ***Wait*** *Message* to the *Protocol Layer*.
13		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. *Protocol Layer* informs the *Policy Engine* that an ***Wait*** *Message* has been received. The *Policy Engine* informs the *DPM* that the Request has been rejected.
14		The *Protocol Layer* generates a ***GoodCRC*** *Message* and passes it to its *PHY Layer*.

Table 8.50 Steps for SPR Sink Makes Request (Wait)

Step	Source	Sink
15	*PHY Layer* receives the ***GoodCRC*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.
16	*PHY Layer* forwards the ***GoodCRC*** *Message* to the *Protocol Layer*. The *Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops the ***CRCReceiveTimer***.	
17	The *Protocol Layer* informs the *Policy Engine* that a ***Wait*** *Message* was successfully sent.	

8.3.2.3 Unsupported Message

This is an example of the response to an *Unsupported Message*. Figure 8.24, "Unsupported message" shows the *Messages* as they flow across the bus and within the devices.

Figure 8.24 Unsupported message

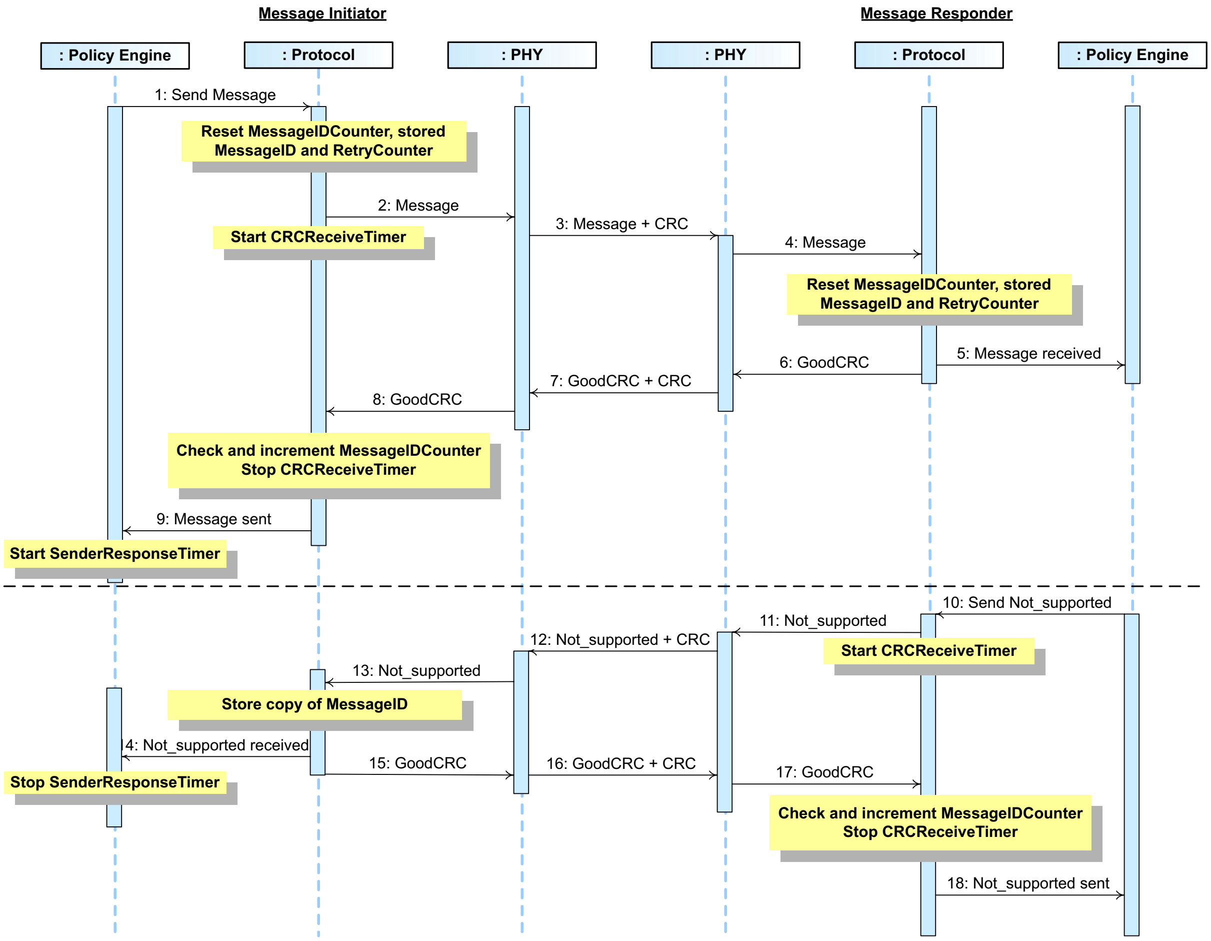


Table 8.51, "Steps for an Unsupported Message" below provides a detailed explanation of what happens at each labeled step in *Figure 8.24, "Unsupported message"* above.

Table 8.51 Steps for an Unsupported Message

Step	Message Initiator	Message Responder
1	The *Policy Engine* directs the *Protocol Layer* to generate a *Message*.	
2	*Protocol Layer* resets ***MessageIDCounter***, stored ***MessageID*** and ***RetryCounter***. *Protocol Layer* creates the *Message* and passes to *PHY Layer*.	
3	*PHY Layer* appends *CRC* and sends the *Message*. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
4		*PHY Layer* removes the *CRC* and forwards the *Message* to the *Protocol Layer*.
5		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received *Message* information to the *Policy Engine* that consumes it.
6		*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.
7	*PHY Layer* receives the ***GoodCRC*** and checks the *CRC* to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.
8	*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.	
9	*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the *Message* was successfully sent. *Policy Engine* starts ***SenderResponseTimer***.	
10		*Policy Engine* tells the *Protocol Layer* to form an ***Not_Supported*** *Message*.
11		*Protocol Layer* creates the ***Not_Supported*** *Message* and passes to *PHY Layer*.
12	*PHY Layer* receives the ***Not_Supported*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.	*PHY Layer* appends a *CRC* and sends the ***Not_Supported*** *Message*. Starts ***CRCReceiveTimer***.
13	*Protocol Layer* stores the ***MessageID*** of the incoming *Message*.	
14	The *Protocol Layer* forwards the received ***Not_Supported*** *Message* information to the *Policy Engine* that consumes it.	
15	*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.	
16	*PHY Layer* appends a *CRC* and sends the ***GoodCRC*** *Message*.	*PHY Layer* receives ***GoodCRC*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.

Table 8.51 Steps for an Unsupported Message

Step	Message Initiator	Message Responder
17		*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.
18		*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Not_Supported*** *Message* was successfully sent.

8.3.2.4 Soft Reset

This is an example of a *Soft Reset* operation. *Figure 8.25, "Soft Reset"* shows the *Messages* as they flow across the bus and within the devices to accomplish the *Soft Reset*.

Figure 8.25 Soft Reset

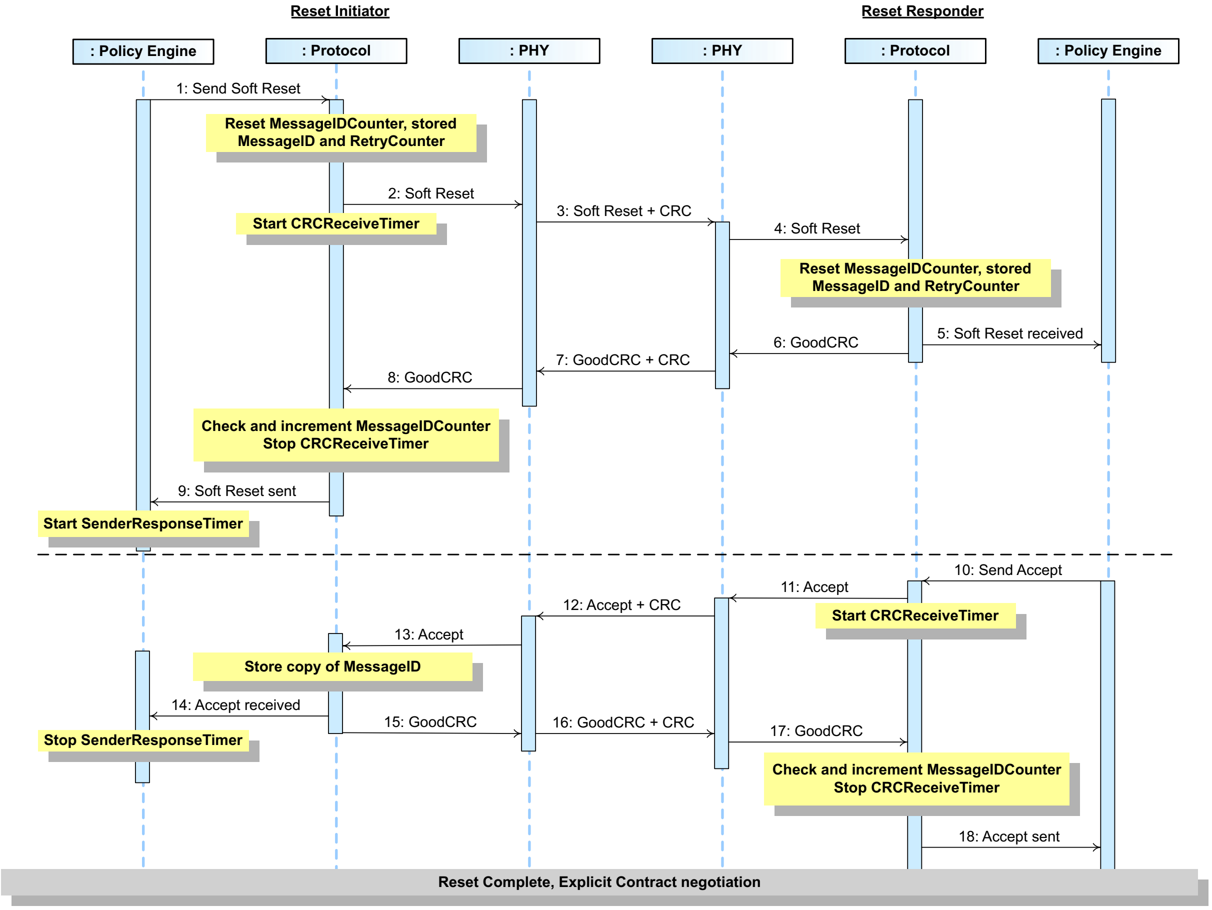


Table 8.52, "Steps for a Soft Reset" below provides a detailed explanation of what happens at each labeled step in *Figure 8.25, "Soft Reset"* above.

Table 8.52 Steps for a Soft Reset

Step	Reset Initiator	Reset Responder
1	The *Policy Engine* directs the *Protocol Layer* to generate a ***Soft_Reset*** *Message* to request a *Soft Reset*.	
2	*Protocol Layer* resets ***MessageIDCounter***, stored ***MessageID*** and ***RetryCounter***. *Protocol Layer* creates the *Message* and passes to *PHY Layer*.	
3	*PHY Layer* appends *CRC* and sends the ***Soft_Reset*** *Message*. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the ***Soft_Reset*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
4		*PHY Layer* removes the *CRC* and forwards the ***Soft_Reset*** *Message* to the *Protocol Layer*.
5		*Protocol Layer* does not check the ***MessageID*** in the incoming *Message* and resets ***MessageIDCounter***, stored ***MessageID*** and ***RetryCounter***. The *Protocol Layer* forwards the received ***Soft_Reset*** *Message* information to the *Policy Engine* that consumes it.
6		*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.
7	*PHY Layer* receives the ***GoodCRC*** and checks the *CRC* to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.
8	*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.	
9	*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Soft_Reset*** *Message* was successfully sent. *Policy Engine* starts ***SenderResponseTimer***.	
10		*Policy Engine* tells the *Protocol Layer* to form an ***Accept*** *Message*.
11		*Protocol Layer* creates the *Message* and passes to *PHY Layer*.
12	*PHY Layer* receives the *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.	*PHY Layer* appends a *CRC* and sends the ***Accept*** *Message*. Starts ***CRCReceiveTimer***.
13	*Protocol Layer* stores the ***MessageID*** of the incoming *Message*.	
14	The *Protocol Layer* forwards the received ***Accept*** *Message* information to the *Policy Engine* that consumes it.	
15	*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.	
16	*PHY Layer* appends a *CRC* and sends the ***GoodCRC*** *Message*.	*PHY Layer* receives ***GoodCRC*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
17		*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.

Table 8.52 Steps for a Soft Reset

Step	Reset Initiator	Reset Responder
18		*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Accept*** *Message* was successfully sent.
The reset is complete and protocol communication can restart. *Port Partner*s perform an *Explicit Contract Negotiation* to re-synchronize their state machines.		

8.3.2.5 Data Reset

8.3.2.5.1 DFP Initiated Data Reset where the DFP is the VCONN Source

This is an example of a *Data Reset* operation where the *DFP* is also the *VCONN Source* and initiates a *Data Reset*. *Figure 8.26, "DFP Initiated Data Reset where the DFP is the VCONN Source"* shows the *Messages* as they flow across the bus and within the devices to accomplish the *Data Reset*.

Figure 8.26 DFP Initiated Data Reset where the DFP is the VCONN Source

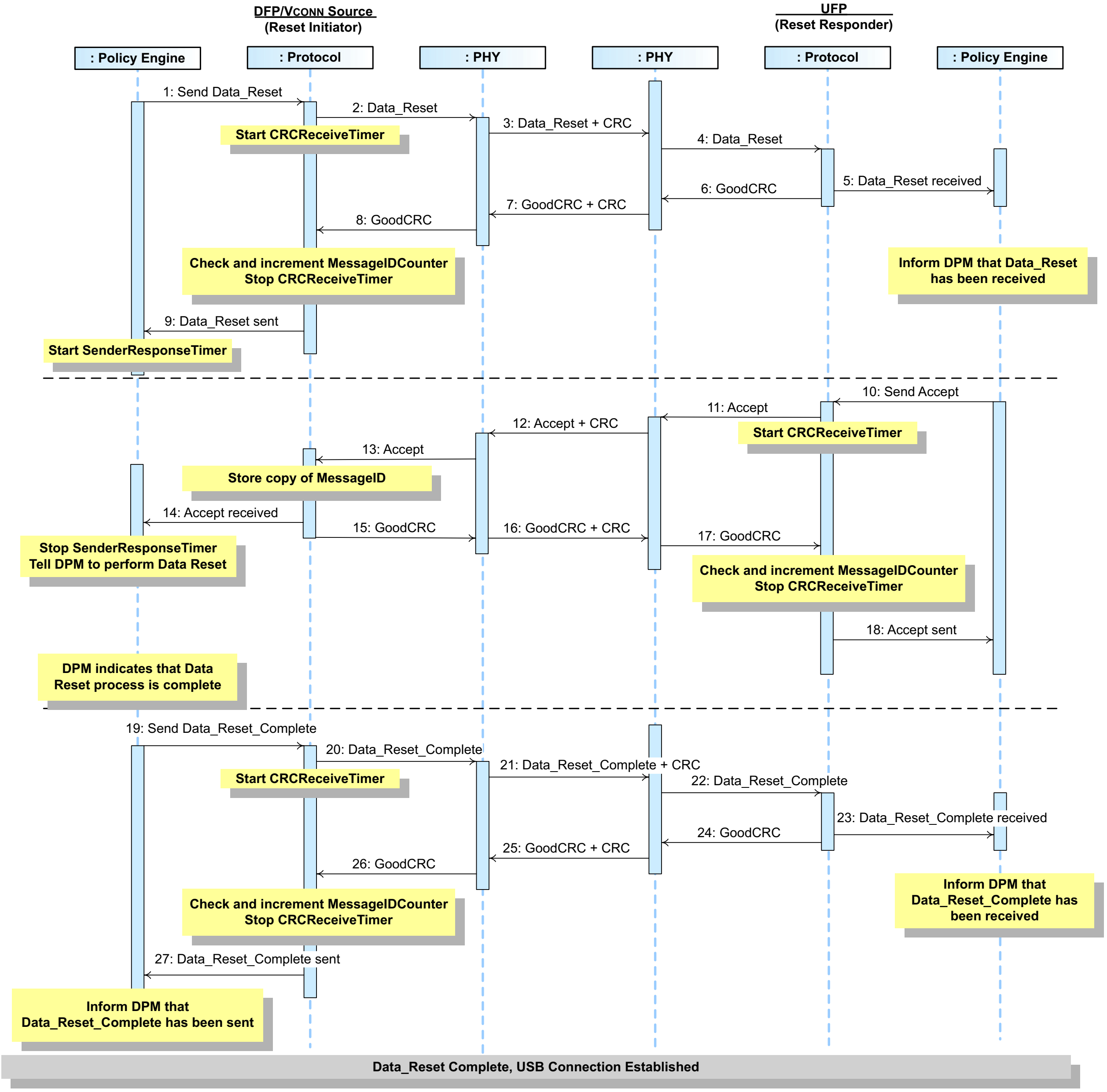


Table 8.53, "Steps for a DFP Initiated Data Reset where the DFP is the VCONN Source" below provides a detailed explanation of what happens at each labeled step in *Figure 8.26, "DFP Initiated Data Reset where the DFP is the VCONN Source"* above.

Table 8.53 Steps for a DFP Initiated Data Reset where the DFP is the VCONN Source

Step	DFP/VCONN Source (Reset Initiator)	UFP (Reset Responder)
1	The *Policy Engine* directs the *Protocol Layer* to generate a ***Data_Reset*** *Message* to request a *Data Reset*.	
2	*Protocol Layer* creates the *Message* and passes to *PHY Layer*.	
3	*PHY Layer* appends *CRC* and sends the ***Data_Reset*** *Message*. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the ***Data_Reset*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
4		*PHY Layer* removes the *CRC* and forwards the ***Data_Reset*** *Message* to the *Protocol Layer*.
5		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Data_Reset*** *Message* information to the *Policy Engine* that consumes it. The *Policy Engine* informs the *DPM* that a ***Data_Reset*** *Message* has been received.
6		*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.
7	*PHY Layer* receives the ***GoodCRC*** and checks the *CRC* to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.
8	*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.	
9	*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Data_Reset*** *Message* was successfully sent. *Policy Engine* starts ***SenderResponseTimer***.	
10		*Policy Engine* tells the *Protocol Layer* to form an ***Accept*** *Message*.
11		*Protocol Layer* creates the *Message* and passes to *PHY Layer*.
12	*PHY Layer* receives the *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.	*PHY Layer* appends a *CRC* and sends the ***Accept*** *Message*. Starts ***CRCReceiveTimer***.
13	*Protocol Layer* stores the ***MessageID*** of the incoming *Message*.	
14	The *Protocol Layer* forwards the received ***Accept*** *Message* information to the *Policy Engine* that consumes it. The *Policy Engine* stops the ***SenderResponseTimer*** and tells the *DPM* to perform a *Data Reset*. The *DPM* proceeds to cycle *VCONN* and then reset the data connection.	
15	*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.	

Table 8.53 Steps for a DFP Initiated Data Reset where the DFP is the VCONN Source

Step	DFP/VCONN Source (Reset Initiator)	UFP (Reset Responder)
16	*PHY Layer* appends a *CRC* and sends the ***GoodCRC*** *Message*.	*PHY Layer* receives ***GoodCRC*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
17		*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.
18		*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Accept*** *Message* was successfully sent.
19	The *DPM* indicates that the *Data Reset* process is complete. The *Policy Engine* directs the *Protocol Layer* to generate a ***Data_Reset_Complete*** *Message*.	
20	*Protocol Layer* creates the *Message* and passes to *PHY Layer*.	
21	*PHY Layer* appends *CRC* and sends the ***Data_Reset_Complete*** *Message*. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the ***Data_Reset_Complete*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
22		*PHY Layer* removes the *CRC* and forwards the ***Data_Reset_Complete*** *Message* to the *Protocol Layer*.
23		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Data_Reset_Complete*** *Message* information to the *Policy Engine* that consumes it. The *Policy Engine* informs the *DPM* that a ***Data_Reset_Complete*** *Message* has been received.
24		*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.
25	*PHY Layer* receives the ***GoodCRC*** and checks the *CRC* to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.
26	*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.	
27	*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Data_Reset_Complete*** *Message* was successfully sent. The *Policy Engine* informs the *DPM* that the ***Data_Reset_Complete*** *Message* was successfully sent.	
The *Data Reset* is complete as defined in Section 6.3.14, "Data_Reset Message" Step 5. *Port Partners* re-establish a USB data connection.		

8.3.2.5.2 DFP Receives Data Reset where the DFP is the VCONN Source

This is an example of a *Data Reset* operation where the *DFP* receives a ***Data_Reset*** *Message* and is the *VCONN Source*. *Figure 8.27, "DFP Receives Data Reset where the DFP is the VCONN Source"* shows the *Messages* as they flow across the bus and within the devices to accomplish the *Data Reset*.

Figure 8.27 DFP Receives Data Reset where the DFP is the VCONN Source

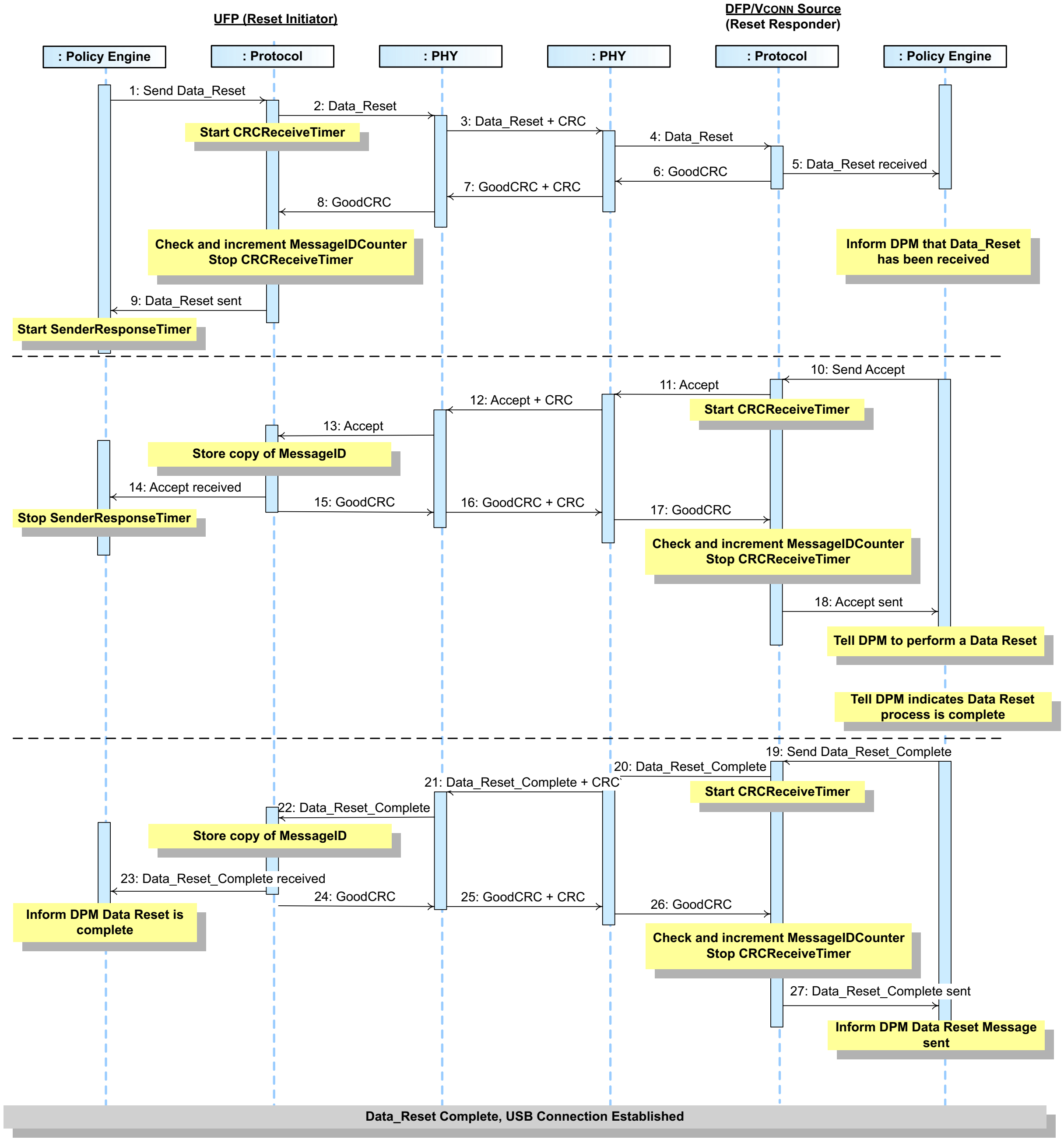


Table 8.54, "Steps for a DFP Receiving a Data Reset where the DFP is the VCONNSource" below provides a detailed explanation of what happens at each labeled step in F*Figure 8.27, "DFP Receives Data Reset where the DFP is the VCONN Source"* above.

Table 8.54 Steps for a DFP Receiving a Data Reset where the DFP is the VCONNSource

Step	UFP (Reset Initiator)	DFP/VCONN Source (Reset Responder)
1	The *Policy Engine* directs the *Protocol Layer* to generate a ***Data_Reset*** *Message* to request a *Data Reset*.	
2	*Protocol Layer* creates the *Message* and passes to *PHY Layer*.	
3	*PHY Layer* appends *CRC* and sends the ***Data_Reset*** *Message*. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the ***Data_Reset*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
4		*PHY Layer* removes the *CRC* and forwards the ***Data_Reset*** *Message* to the *Protocol Layer*.
5		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Data_Reset*** *Message* information to the *Policy Engine* that consumes it. The *Policy Engine* informs the *DPM* that a ***Data_Reset*** *Message* has been received.
6		*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.
7	*PHY Layer* receives the ***GoodCRC*** and checks the *CRC* to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.
8	*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.	
9	*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Data_Reset*** *Message* was successfully sent. *Policy Engine* starts ***SenderResponseTimer***.	
10		*Policy Engine* tells the *Protocol Layer* to form an ***Accept*** *Message*.
11		*Protocol Layer* creates the *Message* and passes to *PHY Layer*.
12	*PHY Layer* receives the *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.	*PHY Layer* appends a *CRC* and sends the *Message*. Starts ***CRCReceiveTimer***.
13	*Protocol Layer* stores the ***MessageID*** of the incoming *Message*.	
14	The *Protocol Layer* forwards the received ***Accept*** *Message* information to the *Policy Engine* that consumes it. The *Policy Engine* stops the ***SenderResponseTimer***. The *DPM* proceeds to cycle *VCONN* and then reset the data connection.	
15	*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.	

Table 8.54 Steps for a DFP Receiving a Data Reset where the DFP is the VCONNSource

Step	UFP (Reset Initiator)	DFP/VCONN Source (Reset Responder)
16	*PHY Layer* appends a *CRC* and sends the ***GoodCRC*** *Message*.	*PHY Layer* receives ***GoodCRC*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
17		*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.
18		*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Accept*** *Message* was successfully sent. The *Policy Engine* tells the *DPM* to perform a *Data Reset*.
19		The *DPM* indicates that the *Data Reset* process is complete. The *Policy Engine* directs the *Protocol Layer* to generate a ***Data_Reset_Complete*** *Message*.
20		*Protocol Layer* creates the *Message* and passes to *PHY Layer*.
21	*PHY Layer* receives the ***Data_Reset_Complete*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***Data_Reset_Complete*** *Message*. Starts ***CRCReceiveTimer***.
22	*PHY Layer* removes the *CRC* and forwards the ***Data_Reset_Complete*** *Message* to the *Protocol Layer*.	
23	*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Data_Reset_Complete*** *Message* information to the *Policy Engine* that consumes it. The *Policy Engine* informs the *DPM* that a ***Data_Reset_Complete*** *Message* has been received.	
24	*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.	
25	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.	*PHY Layer* receives the ***GoodCRC*** and checks the *CRC* to verify the *Message*.
26		*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.
27		*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Data_Reset_Complete*** *Message* was successfully sent. The *Policy Engine* informs the *DPM* that the ***Data_Reset_Complete*** *Message* was successfully sent.
The reset is complete as defined in *Section 6.3.14, "Data_Reset Message"* Step *5*. *Port Partners* re-establish a USB data connection.		

8.3.2.5.3 DFP Initiated Data Reset where the UFP is the VCONN Source

This is an example of a *Data Reset* operation where the *DFP* initiates a *Data Reset* and the *UFP* is the *VCONN Source*. *Figure 8.28, "DFP Initiated Data Reset where the UFP is the VCONN Source"* shows the *Message*s as they flow across the bus and within the devices to accomplish the *Data Reset*.

Figure 8.28 DFP Initiated Data Reset where the UFP is the VCONN Source

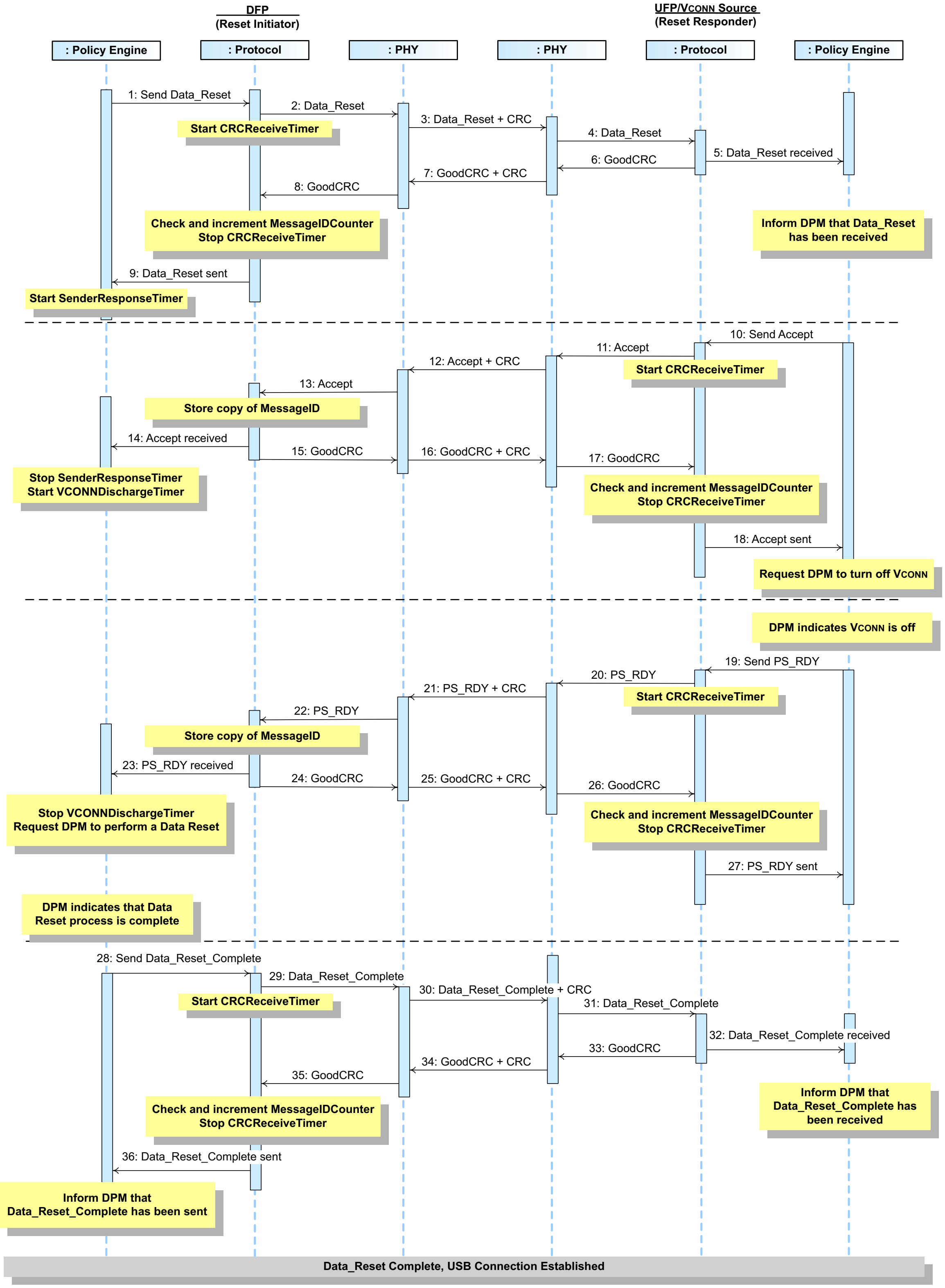


Table 8.55, "Steps for a DFP Initiated Data Reset where the UFP is the VCONN Source" below provides a detailed explanation of what happens at each labeled step in *Figure 8.28, "DFP Initiated Data Reset where the UFP is the VCONN Source"* above.

Table 8.55 Steps for a DFP Initiated Data Reset where the UFP is the VCONN Source

Step	DFP (Reset Initiator)	UFP/VCONN Source (Reset Responder)
1	The *Policy Engine* directs the *Protocol Layer* to generate a ***Data_Reset*** *Message* to request a *Soft Reset*.	
2	*Protocol Layer* creates the *Message* and passes to *PHY Layer*.	
3	*PHY Layer* appends *CRC* and sends the ***Data_Reset*** *Message*. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the ***Data_Reset*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
4		*PHY Layer* removes the *CRC* and forwards the ***Data_Reset*** *Message* to the *Protocol Layer*.
5		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Data_Reset*** *Message* information to the *Policy Engine* that consumes it. The *Policy Engine* informs the *DPM* that a ***Data_Reset*** *Message* has been received.
6		*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.
7	*PHY Layer* receives the ***GoodCRC*** and checks the *CRC* to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.
8	*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.	
9	*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Data_Reset*** *Message* was successfully sent. *Policy Engine* starts ***SenderResponseTimer***.	
10		*Policy Engine* tells the *Protocol Layer* to form an ***Accept*** *Message*.
11		*Protocol Layer* creates the *Message* and passes to *PHY Layer*.
12	*PHY Layer* receives the *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.	*PHY Layer* appends a *CRC* and sends the *Message*. Starts ***CRCReceiveTimer***.
13	*Protocol Layer* stores the ***MessageID*** of the incoming *Message*.	
14	The *Protocol Layer* forwards the received ***Accept*** *Message* information to the *Policy Engine* that consumes it. The *Policy Engine* stops the ***SenderResponseTimer*** and starts the ***VCONNDischargeTimer***.	
15	*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.	
16	*PHY Layer* appends a *CRC* and sends the ***GoodCRC*** *Message*.	*PHY Layer* receives ***GoodCRC*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.

Table 8.55 Steps for a DFP Initiated Data Reset where the UFP is the VCONN Source

Step	DFP (Reset Initiator)	UFP/VCONN Source (Reset Responder)
17		*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.
18		*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Accept*** *Message* was successfully sent. The *Policy Engine* requests the *DPM* to turn off *VCONN*.
19		When the *DPM* indicates *VCONN* has been turned off the *Policy Engine* tells the *Protocol Layer* to form an ***PS_RDY*** *Message*.
20		*Protocol Layer* creates the *Message* and passes to *PHY Layer*.
21	*PHY Layer* receives the *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.	*PHY Layer* appends a *CRC* and sends the ***Accept*** *Message*. Starts ***CRCReceiveTimer***.
22	*Protocol Layer* stores the ***MessageID*** of the incoming *Message*.	
23	The *Protocol Layer* forwards the received ***PS_RDY*** *Message* information to the *Policy Engine* that consumes it. The *Policy Engine* stops the ***VCONNDischargeTimer*** and tells the *DPM* to perform a *Data Reset*. The *DPM* proceeds to turn on *VCONN* and then reset the data connection.	
24	*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.	
25	*PHY Layer* appends a *CRC* and sends the ***GoodCRC*** *Message*.	*PHY Layer* receives ***GoodCRC*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
26		*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.
27		*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***PS_RDY*** *Message* was successfully sent.
28	The *DPM* indicates that the *Data Reset* process is complete. The *Policy Engine* directs the *Protocol Layer* to generate a ***Data_Reset_Complete*** *Message*.	
29	*Protocol Layer* creates the *Message* and passes to *PHY Layer*.	
30	*PHY Layer* appends *CRC* and sends the ***Data_Reset_Complete*** *Message*. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the ***Data_Reset_Complete*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
31		*PHY Layer* removes the *CRC* and forwards the ***Data_Reset_Complete*** *Message* to the *Protocol Layer*.

Table 8.55 Steps for a DFP Initiated Data Reset where the UFP is the VCONN Source

Step	DFP (Reset Initiator)	UFP/VCONN Source (Reset Responder)
32		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Data_Reset_Complete*** *Message* information to the *Policy Engine* that consumes it. The *Policy Engine* informs the *DPM* that a ***Data_Reset_Complete*** *Message* has been received.
33		*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.
34	*PHY Layer* receives the ***GoodCRC*** and checks the *CRC* to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.
35	*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.	
36	*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Data_Reset_Complete*** *Message* was successfully sent. The *Policy Engine* informs the *DPM* that the ***Data_Reset_Complete*** *Message* was successfully sent.	
The reset is complete as defined in *Section 6.3.14, "Data_Reset Message"* Step 5. *Port Partner*s re-establish a USB data connection.		

8.3.2.5.4 DFP Receives Data Reset where the UFP is the VCONN Source

This is an example of a *Data Reset* operation where the *DFP* receives a ***Data_Reset*** *Message* and the *UFP* is the *VCONN Source*. *Figure 8.29, "DFP Receives a Data Reset where the UFP is the VCONN Source"* shows the *Messages* as they flow across the bus and within the devices to accomplish the *Data Reset*.

Figure 8.29 DFP Receives a Data Reset where the UFP is the VCONN Source

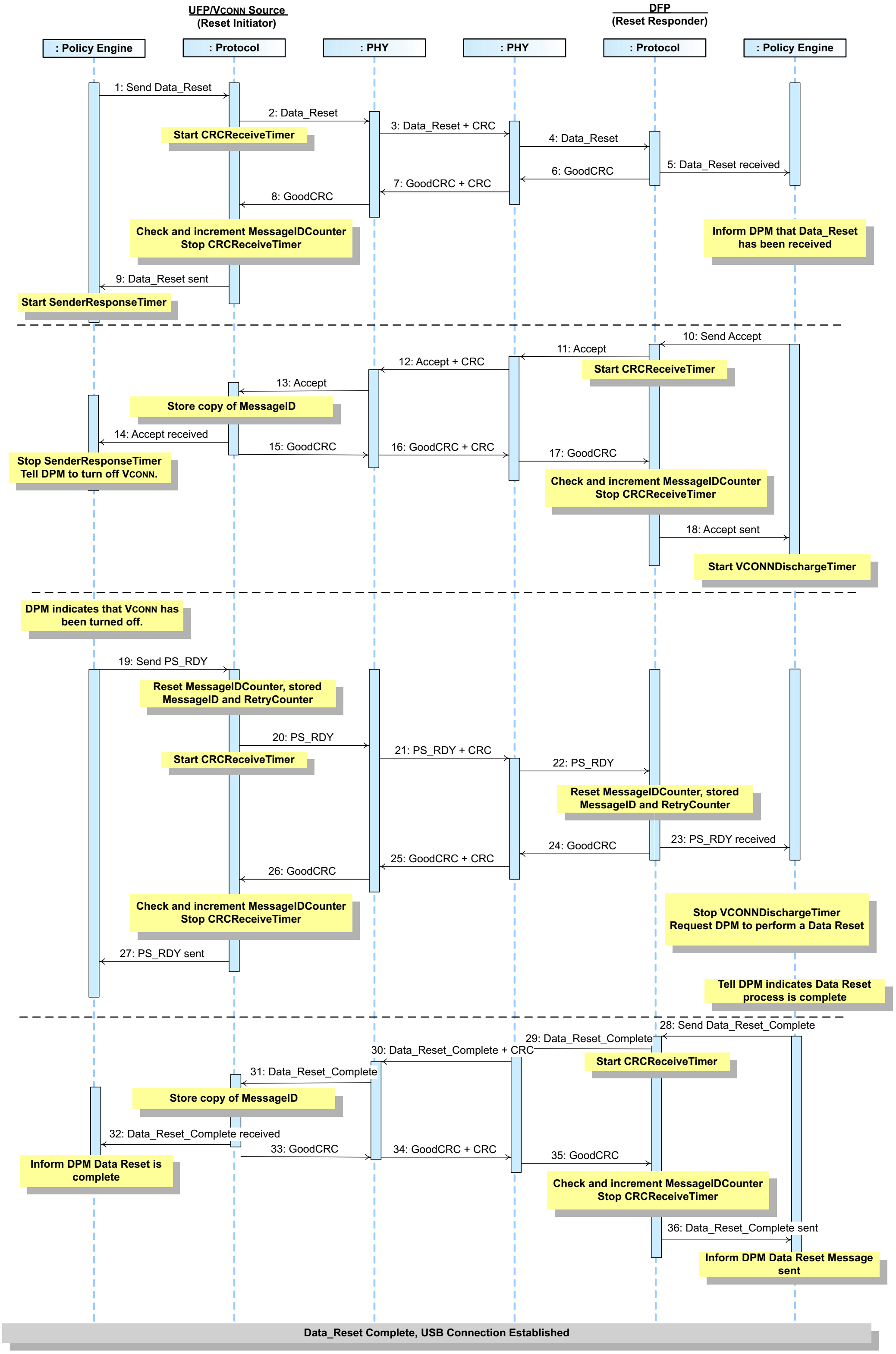


Table 8.56, "Steps for a DFP Receiving a Data Reset where the UFP is the VCONN Source" below provides a detailed explanation of what happens at each labeled step in *Figure 8.29, "DFP Receives a Data Reset where the UFP is the VCONN Source"* above.

Table 8.56 Steps for a DFP Receiving a Data Reset where the UFP is the VCONN Source

Step	UFP/VCONN Source (Reset Initiator)	DFP (Reset Responder)
1	The *Policy Engine* directs the *Protocol Layer* to generate a ***Data_Reset*** *Message* to request a *Soft Reset*.	
2	*Protocol Layer* creates the *Message* and passes to *PHY Layer*.	
3	*PHY Layer* appends *CRC* and sends the ***Data_Reset*** *Message*. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the ***Data_Reset*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
4		*PHY Layer* removes the *CRC* and forwards the ***Data_Reset*** *Message* to the *Protocol Layer*.
5		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Data_Reset*** *Message* information to the *Policy Engine* that consumes it. The *Policy Engine* informs the *DPM* that a ***Data_Reset*** *Message* has been received.
6		*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.
7	*PHY Layer* receives the ***GoodCRC*** and checks the *CRC* to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.
8	*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.	
9	*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Data_Reset*** *Message* was successfully sent. *Policy Engine* starts ***SenderResponseTimer***.	
10		*Policy Engine* tells the *Protocol Layer* to form an ***Accept*** *Message*.
11		*Protocol Layer* creates the *Message* and passes to *PHY Layer*.
12	*PHY Layer* receives the *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.	*PHY Layer* appends a *CRC* and sends the *Message*. Starts ***CRCReceiveTimer***.
13	*Protocol Layer* stores the ***MessageID*** of the incoming *Message*.	
14	The *Protocol Layer* forwards the received ***Accept*** *Message* information to the *Policy Engine* that consumes it. The *Policy Engine* stops the ***SenderResponseTimer*** and tells the *DPM* to turn off *VCONN*.	
15	*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.	
16	*PHY Layer* appends a *CRC* and sends the ***GoodCRC*** *Message*.	*PHY Layer* receives ***GoodCRC*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.

Table 8.56 Steps for a DFP Receiving a Data Reset where the UFP is the VCONN Source

Step	UFP/VCONN Source (Reset Initiator)	DFP (Reset Responder)
17		*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.
18		*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Accept*** *Message* was successfully sent. The *Policy Engine* starts the ***VCONNDischargeTimer***.
19	When the *DPM* indicates that *VCONN* has been turned off the *Policy Engine* directs the *Protocol Layer* to generate a ***PS_RDY*** *Message* to request a *Soft Reset*.	
20	*Protocol Layer* creates the *Message* and passes to *PHY Layer*.	
21	*PHY Layer* appends *CRC* and sends the ***PS_RDY*** *Message*. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the ***PS_RDY*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
22		*PHY Layer* removes the *CRC* and forwards the ***PS_RDY*** *Message* to the *Protocol Layer*.
23		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***PS_RDY*** *Message* information to the *Policy Engine* that consumes it. The *Policy Engine* stops the ***VCONNDischargeTimer*** and requests the *DPM* perform a *Data Reset*. The *DPM* proceeds to turn on *VCONN* and then reset the data connection.
24		*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.
25	*PHY Layer* receives ***GoodCRC*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.
26	*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.	
27	*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***PS_RDY*** *Message* was successfully sent.	
28		The *DPM* indicates that the *Data Reset* process is complete. The *Policy Engine* directs the *Protocol Layer* to generate a ***Data_Reset_Complete*** *Message*.
29		*Protocol Layer* creates the *Message* and passes to *PHY Layer*.
30	*PHY Layer* receives the ***Data_Reset_Complete*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***Data_Reset_Complete*** *Message*. Starts ***CRCReceiveTimer***.
31	*PHY Layer* removes the *CRC* and forwards the ***Data_Reset_Complete*** *Message* to the *Protocol Layer*.	

Table 8.56 Steps for a DFP Receiving a Data Reset where the UFP is the VCONN Source

Step	UFP/VCONN Source (Reset Initiator)	DFP (Reset Responder)
32	*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Data_Reset_Complete*** *Message* information to the *Policy Engine* that consumes it. The *Policy Engine* informs the *DPM* that a ***Data_Reset_Complete*** *Message* has been received.	
33	*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.	
34	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.	*PHY Layer* receives the ***GoodCRC*** and checks the *CRC* to verify the *Message*.
35		*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.
36		*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Data_Reset_Complete*** *Message* was successfully sent. The *Policy Engine* informs the *DPM* that the ***Data_Reset_Complete*** *Message* was successfully sent.
The reset is complete as defined in *Section 6.3.14, "Data_Reset Message"* Step 5. *Port Partner*s re-establish a USB data connection.		

8.3.2.6 Hard Reset

The following sections describe the steps required for a USB Power Delivery *Hard Reset*. The *Hard Reset* returns the operation of the USB Power Delivery to default *Power Role*/*Data Role* and operating voltage/current. During the *Hard Reset* USB Power Delivery *PHY Layer* communications ***Shall*** be disabled preventing communication between the *Port Partner*.

Note: *Hard Reset*, in this case, is applied to the USB Power Delivery capability of an individual *Port* on which the *Hard Reset* is requested. A side effect of the *Hard Reset* is that it might reset other functions on the *Port* such as USB.

8.3.2.6.1 Source Initiated Hard Reset

This is an example of a *Hard Reset* operation when initiated by a *Source*. Figure 8.30, "Source initiated Hard Reset" shows the *Messages* as they flow across the bus and within the devices to accomplish the *Hard Reset*.

Figure 8.30 Source initiated Hard Reset

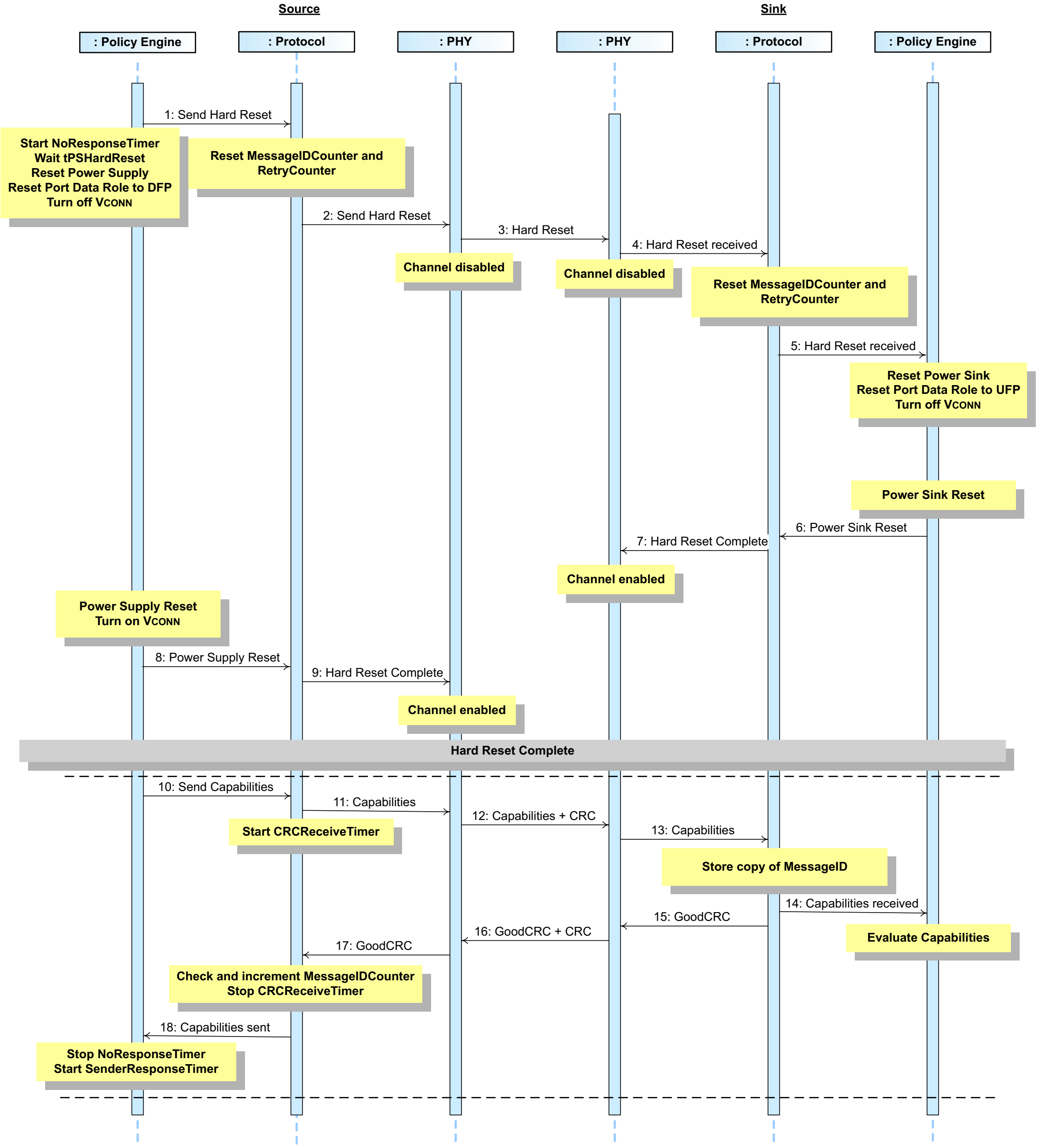


Table 8.57, "Steps for Source initiated Hard Reset" below provides a detailed explanation of what happens at each labeled step in *Figure 8.30, "Source initiated Hard Reset"* above.

Table 8.57 Steps for Source initiated Hard Reset

Step	Source	Sink
1	The *Policy Engine* directs the *Protocol Layer* to generate ***Hard Reset*** *Signaling*. The *Policy Engine* starts the ***NoResponseTimer*** and requests the *DPM* to reset the power supply to *USB Default Operation*. The *Policy Engine* requests the *DPM* to reset the ***Port Data Role*** to *DFP* and to turn off *VCONN* if this is on.	
2	*Protocol Layer* resets ***MessageIDCounter*** and ***RetryCounter.*** *Protocol Layer* requests the *PHY Layer* send ***Hard Reset*** *Signaling*.	
3	*PHY Layer* sends ***Hard Reset*** *Signaling* and then disables the *PHY Layer* communications channel for transmission and reception.	*PHY Layer* receives the ***Hard Reset*** *Signaling* and disables the *PHY Layer* communications channel for transmission and reception.
4		*PHY Layer* informs the *Protocol Layer* of the *Hard Reset*. *Protocol Layer* resets ***MessageIDCounter*** and ***RetryCounter***.
5		The *Protocol Layer* informs the *Policy Engine* of the *Hard Reset*. The *Policy Engine* requests the *DPM* to reset the Power *Sink* to *USB Default Operation*. The *Policy Engine* requests the *DPM* to reset the ***Port Data Role*** to *UFP* and to turn off *VCONN* if this is on.
6		The Power *Sink* returns to *USB Default Operation*. The *Policy Engine* informs the *Protocol Layer* that the Power *Sink* has been reset.
7		The *Protocol Layer* informs the *PHY Layer* that the *Hard Reset* is complete. The *PHY Layer* enables the *PHY Layer* communications channel for transmission and reception.
8	The power supply is reset to *USB Default Operation*. and *VCONN* is turned on. The *Policy Engine* informs the *Protocol Layer* that the power supply has been reset.	
9	The *Protocol Layer* informs the *PHY Layer* that the *Hard Reset* is complete. The *PHY Layer* enables the *PHY Layer* communications channel for transmission and reception.	
The reset is complete and protocol communication can restart.		
10	*Policy Engine* directs the *Protocol Layer* to send a ***Source_Capabilities*** *Message* that represents the power supply's present capabilities.	
11	*Protocol Layer* creates the *Message* and passes to *PHY Layer*.	
12	*PHY Layer* appends *CRC* and sends the ***Source_Capabilities*** *Message*. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the ***Source_Capabilities*** *Message* and checks the *CRC* to verify the *Message*.

Table 8.57 Steps for Source initiated Hard Reset

Step	Source	Sink
13		*PHY Layer* removes the *CRC* and forwards the ***Source_Capabilities*** *Message* to the *Protocol Layer*.
14		*Protocol Layer* stores the ***MessageID*** of the incoming *Message*. The *Protocol Layer* forwards the received ***Source_Capabilities*** *Message* information to the *Policy Engine* that consumes it.
15		*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.
16	*PHY Layer* receives the ***GoodCRC*** *Message* and checks the *CRC* to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.
17	*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.	
18	*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Source_Capabilities*** *Message* was successfully sent. *Policy Engine* stops the ***NoResponseTimer*** and starts the ***SenderResponseTimer***.	
USB Power Delivery communication is re-established.		

8.3.2.6.2 Sink Initiated Hard Reset

This is an example of a *Hard Reset* operation when initiated by a *Sink*. *Figure 8.31, "Sink Initiated Hard Reset"* shows the *Messages* as they flow across the bus and within the devices to accomplish the *Hard Reset*.

Figure 8.31 Sink Initiated Hard Reset

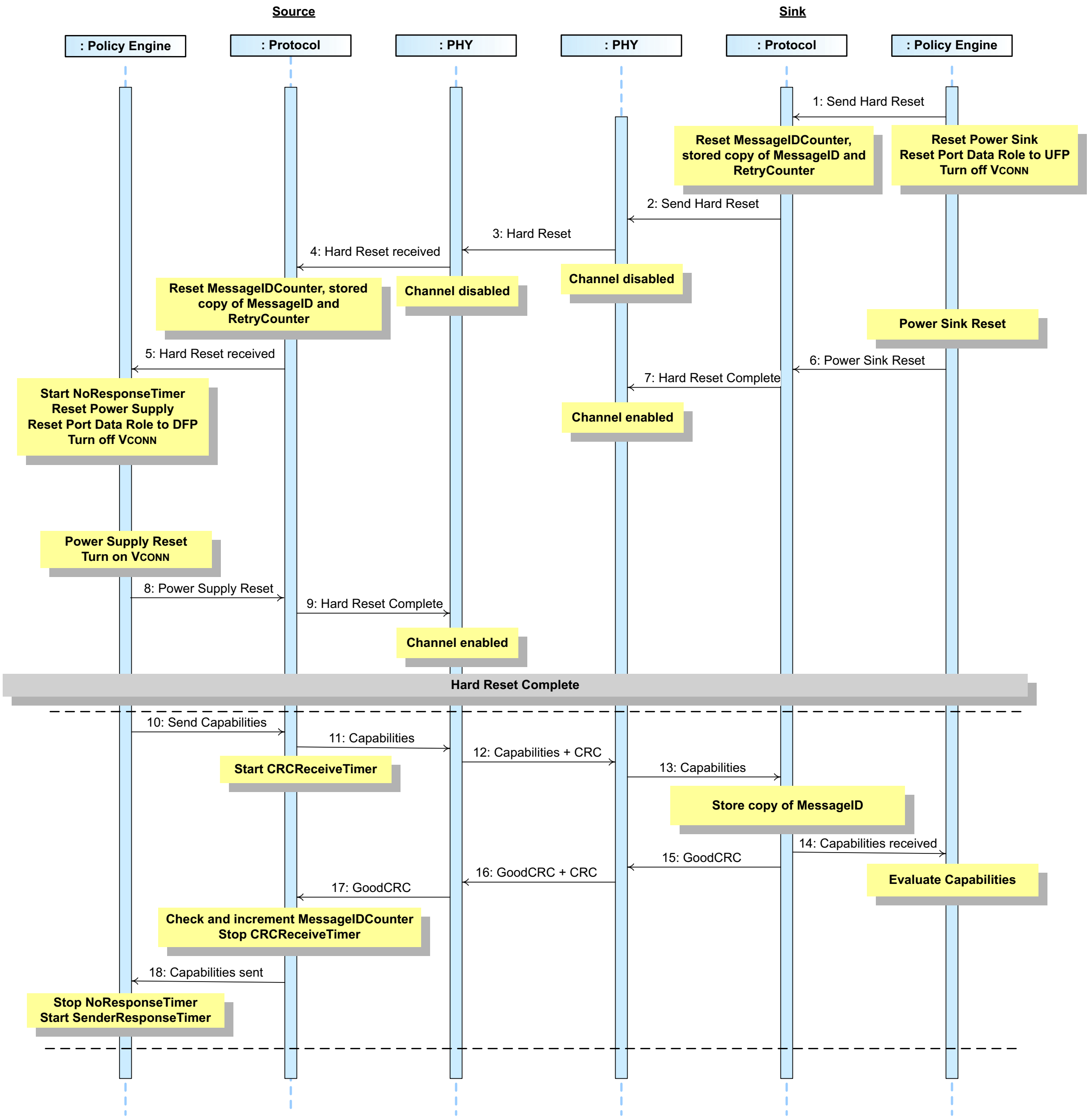


Table 8.58, "Steps for Sink initiated Hard Reset" below provides a detailed explanation of what happens at each labeled step in *Figure 8.31, "Sink Initiated Hard Reset"* above.

Table 8.58 Steps for Sink initiated Hard Reset

Step	Source	Sink
1		The *Policy Engine* directs the *Protocol Layer* to generate ***Hard Reset*** *Signaling*. The *Policy Engine* requests the *DPM* to reset the power supply to *USB Default Operation*. The *Policy Engine* requests the *DPM* to reset the ***Port Data Role*** to *UFP* and to turn off *VCONN* if this is on.
2		*Protocol Layer* resets ***MessageIDCounter***, stored copy of ***MessageID*** and ***RetryCounter***. *Protocol Layer* requests the *PHY Layer* send ***Hard Reset*** *Signaling*.
3	*PHY Layer* receives the ***Hard Reset*** *Signaling* and disables the *PHY Layer* communications channel for transmission and reception.	*PHY Layer* sends the ***Hard Reset*** *Signaling* and then disables the *PHY Layer* communications channel for transmission and reception.
4	*PHY Layer* informs the *Protocol Layer* of the *Hard Reset*. *Protocol Layer* resets ***MessageIDCounter***, stored copy of ***MessageID*** and ***RetryCounter***.	
5	The *Protocol Layer* Informs the *Policy Engine* of the *Hard Reset*. The *Policy Engine* starts the ***NoResponseTimer*** and requests the *DPM* to reset the Power *Sink* to *USB Default Operation*. The *Policy Engine* requests the *DPM* to reset the ***Port Data Role*** to *DFP* and to turn off *VCONN* if this is on.	
6		The Power *Sink* returns to *USB Default Operation*. The *Policy Engine* informs the *Protocol Layer* that the Power *Sink* has been reset.
7		The *Protocol Layer* informs the *PHY Layer* that the *Hard Reset* is complete. The *PHY Layer* enables the *PHY Layer* communications channel for transmission and reception.
8	The power supply is reset to *USB Default Operation* and *VCONN* is turned on. The *Policy Engine* informs the *Protocol Layer* that the power supply has been reset.	
9	The *Protocol Layer* informs the *PHY Layer* that the *Hard Reset* is complete. The *PHY Layer* enables the *PHY Layer* communications channel for transmission and reception.	
The reset is complete and protocol communication can restart.		
10	*Policy Engine* directs the *Protocol Layer* to send a ***Source_Capabilities*** *Message* that represents the power supply's present capabilities.	
11	*Protocol Layer* creates the *Message* and passes to *PHY Layer*.	
12	*PHY Layer* appends *CRC* and sends the ***Source_Capabilities*** *Message*. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the ***Source_Capabilities*** *Message* and checks the *CRC* to verify the *Message*.

Table 8.58 Steps for Sink initiated Hard Reset

Step	Source	Sink
13		*PHY Layer* removes the *CRC* and forwards the ***Source_Capabilities*** *Message* to the *Protocol Layer*.
14		*Protocol Layer* stores the ***MessageID*** of the incoming *Message*. The *Protocol Layer* forwards the received ***Source_Capabilities*** *Message* information to the *Policy Engine* that consumes it.
15		*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.
16	*PHY Layer* receives the ***GoodCRC*** *Message* and checks the *CRC* to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.
17	*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.	
18	*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Source_Capabilities*** *Message* was successfully sent. *Policy Engine* stops the ***NoResponseTimer*** and starts the ***SenderResponseTimer***.	
USB Power Delivery communication is re-established.		

8.3.2.6.3 Source Initiated Hard Reset - Sink Long Reset

This is an example of a *Hard Reset* operation when initiated by a *Source*. In this example the *Sink* is slow responding to the reset causing the *Source* to send multiple ***Source_Capabilities*** *Message*s before it receives a ***GoodCRC*** *Message* response. *Figure 8.32, "Source initiated reset - Sink long reset"* shows the *Messages* as they flow across the bus and within the devices to accomplish the *Hard Reset*.

Figure 8.32 Source initiated reset - Sink long reset

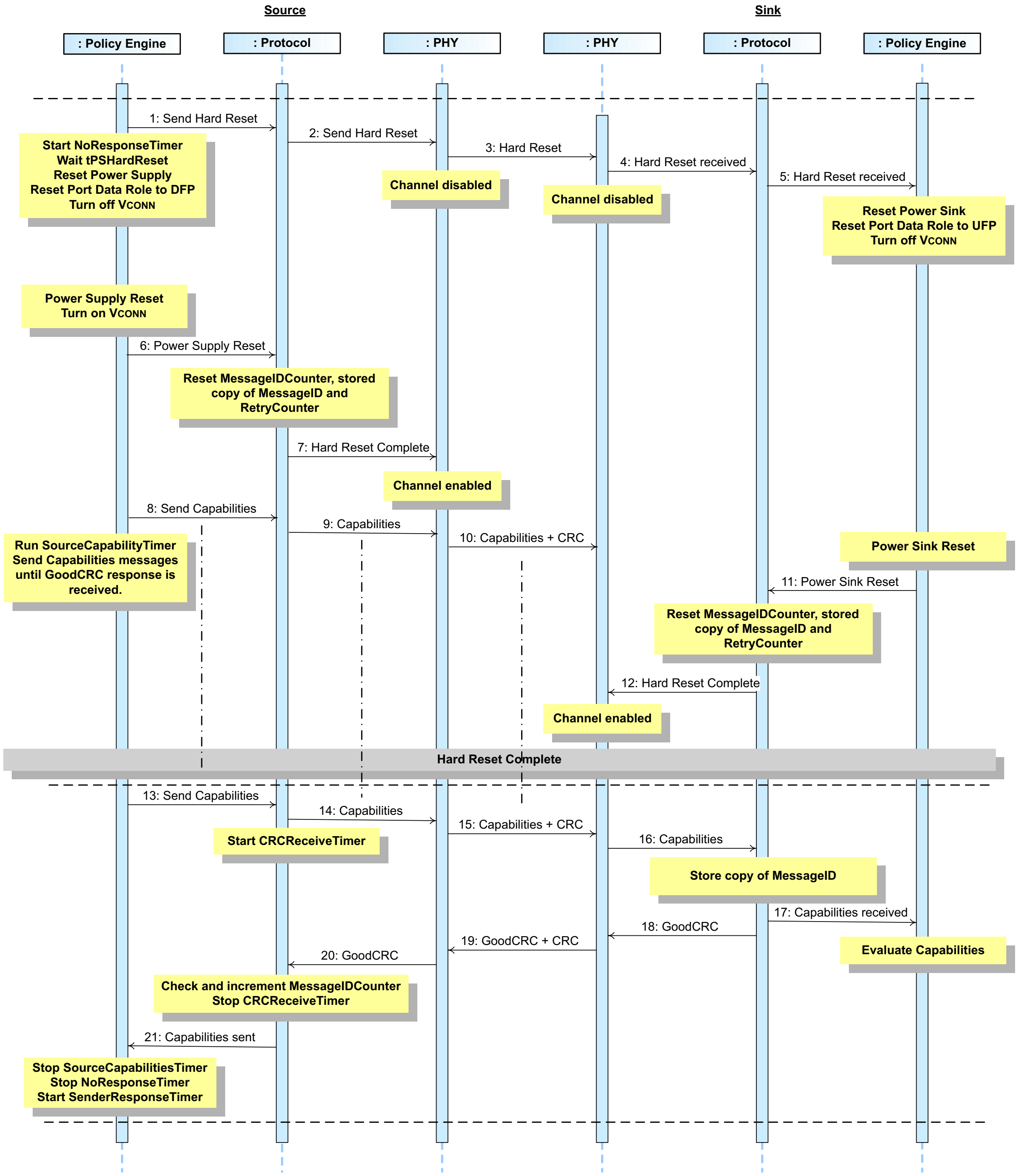


Table 8.59, "Steps for Source initiated Hard Reset - Sink long reset" below provides a detailed explanation of what happens at each labeled step in *Figure 8.32, "Source initiated reset - Sink long reset"* above.

Table 8.59 Steps for Source initiated Hard Reset - Sink long reset

Step	Source	Sink
1	The *Policy Engine* directs the *Protocol Layer* to generate ***Hard Reset*** *Signaling*. The *Policy Engine* starts the ***NoResponseTimer*** and requests the *DPM* to reset the power supply to *USB Default Operation*. The *Policy Engine* requests the *DPM* to reset the ***Port Data Role*** to *DFP* and to turn off *VCONN* if this is on.	
2	*Protocol Layer* resets ***MessageIDCounter***, stored copy of ***MessageID*** and ***RetryCounter***. *Protocol Layer* requests the *PHY Layer* send ***Hard Reset*** *Signaling*.	
3	*PHY Layer* sends the ***Hard Reset*** *Signaling* and then disables the *PHY Layer* communications channel for transmission and reception.	*PHY Layer* receives the ***Hard Reset*** *Signaling* and disables the *PHY Layer* communications channel for transmission and reception.
4		*PHY Layer* informs the *Protocol Layer* of the *Hard Reset*. *Protocol Layer* resets ***MessageIDCounter***, stored copy of ***MessageID*** and ***RetryCounter***.
5		The *Protocol Layer* Informs the *Policy Engine* of the *Hard Reset*. The *Policy Engine* requests the *DPM* to reset the Power *Sink* to *USB Default Operation*. The *Policy Engine* requests the *DPM* to reset the ***Port Data Role*** to *UFP* and to turn off *VCONN* if this is on.
6	The power supply is reset to *USB Default Operation* and *VCONN* is turned on. The *Policy Engine* informs the *Protocol Layer* that the power supply has been reset.	
7	The *Protocol Layer* informs the *PHY Layer* that the *Hard Reset* is complete. The *PHY Layer* enables the *PHY Layer* communications channel for transmission and reception.	
The reset is complete and protocol communication can restart.		
8	*Policy Engine* directs the *Protocol Layer* to send a ***Source_Capabilities*** *Message* that represents the power supply's present capabilities. *Policy Engine* starts the ***SourceCapabilityTimer***. The ***SourceCapabilityTimer*** times out one or more times until a ***GoodCRC*** *Message* response is received.	
9	*Protocol Layer* creates the *Message* and passes to *PHY Layer*.	
10	*PHY Layer* appends *CRC* and sends the ***Source_Capabilities*** *Message*. Starts ***CRCReceiveTimer***.	**Note:** ***Source_Capabilities*** *Message* not received since channel is disabled.
11		The Power *Sink* returns to *USB Default Operation*. The *Policy Engine* informs the *Protocol Layer* that the Power *Sink* has been reset.

Table 8.59 Steps for Source initiated Hard Reset - Sink long reset

Step	Source	Sink
12		The *Protocol Layer* informs the *PHY Layer* that the *Hard Reset* is complete. The *PHY Layer* enables the *PHY Layer* communications channel for transmission and reception.
The reset is complete and protocol communication can restart.		
13	*Policy Engine* directs the *Protocol Layer* to send a ***Source_Capabilities*** *Message* that represents the power supply's present capabilities. Starts the ***SourceCapabilityTimer***.	
14	*Protocol Layer* creates the *Message* and passes to *PHY Layer*.	
15	*PHY Layer* appends *CRC* and sends the ***Source_Capabilities*** *Message*. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the ***Source_Capabilities*** *Message* and checks the *CRC* to verify the *Message*.
16		*PHY Layer* removes the *CRC* and forwards the ***Source_Capabilities*** *Message* to the *Protocol Layer*.
17		*Protocol Layer* stores the ***MessageID*** of the incoming *Message*. The *Protocol Layer* forwards the received ***Source_Capabilities*** *Message* information to the *Policy Engine* that consumes it.
18		*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.
19	*PHY Layer* receives the ***GoodCRC*** *Message* and checks the *CRC* to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.
20	*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.	
21	*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Source_Capabilities*** *Message* was successfully sent. *Policy Engine* stops the ***SourceCapabilityTimer***, stops the ***NoResponseTimer*** and starts the ***SenderResponseTimer***.	
USB Power Delivery communication is re-established.		

8.3.2.7 Power Role Swap

8.3.2.7.1 Source Initiated Power Role Swap

8.3.2.7.1.1 Source Initiated Power Role Swap (Accept)

This is an example of a successful *Power Role Swap* operation initiated by a *Port* which initially, at the start of this *Message* sequence, is acting as a *Source* and therefore has R_p pulled up on its *CC* wire. It does not include any subsequent Power *Negotiation* which is required in order to establish an *Explicit Contract* (see *Section 8.3.2.2, "Power Negotiation"*).

There are four distinct phases to the *Power Role Swap*:

- A ***PR_Swap*** *Message* is sent.
- An ***Accept*** *Message* in response to the ***PR_Swap*** *Message*.
- The *New Sink* sets its power output to ***vSafe0V***, then asserts R_d and sends a ***PS_RDY*** *Message* when this process is complete.
- The *New Source* asserts R_p, then sets its power output to ***vSafe5V*** and sends a ***PS_RDY*** *Message* when it is ready to supply power.

Figure 8.33, "Successful Power Role Swap Sequence Initiated by the Source" shows the *Message*s as they flow across the bus and within the devices to accomplish the *Power Role Swap* sequence.

Figure 8.33 Successful Power Role Swap Sequence Initiated by the Source

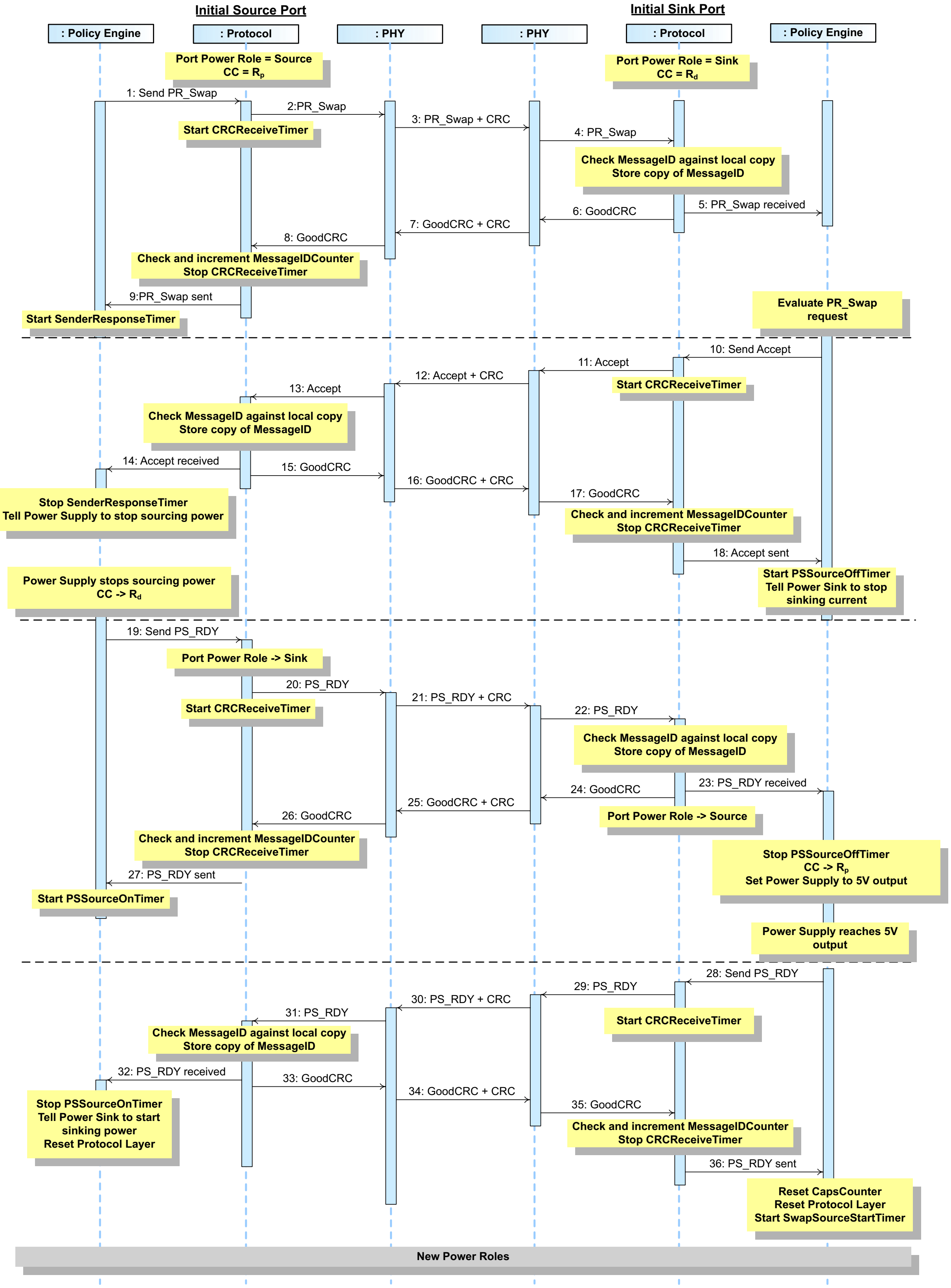


Table 8.60, "Steps for a Successful Source Initiated Power Role Swap Sequence" below provides a detailed explanation of what happens at each labeled step in *Figure 8.33, "Successful Power Role Swap Sequence Initiated by the Source"* above.

Table 8.60 Steps for a Successful Source Initiated Power Role Swap Sequence

Step	Initial Source Port	Initially Sink Port
1	The *Port* has ***Port Power Role*** set to *Source* and the R_p pull up on its *CC* wire. *Policy Engine* directs the *Protocol Layer* to send a ***PR_Swap*** *Message*.	The *Port* has ***Port Power Role*** set to *Sink* with the R_d pull down on its *CC* wire.
2	*Protocol Layer* creates the *Message* and passes to *PHY Layer*.	
3	*PHY Layer* appends *CRC* and sends the ***PR_Swap*** *Message*. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the ***PR_Swap*** *Message* and checks the *CRC* to verify the *Message*.
4		*PHY Layer* removes the *CRC* and forwards the ***PR_Swap*** *Message* to the *Protocol Layer*.
5		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***PR_Swap*** *Message* information to the *Policy Engine* that consumes it.
6		*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.
7	*PHY Layer* receives the ***GoodCRC*** *Message* and checks the *CRC* to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.
8	*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.	
9	*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***PR_Swap*** *Message* was successfully sent. *Policy Engine* starts ***SenderResponseTimer***.	
10		*Policy Engine* evaluates the ***PR_Swap*** *Message* sent by the *Source* and decides that it is able and willing to do the *Power Role Swap*. It tells the *Protocol Layer* to form an ***Accept*** *Message*.
11		*Protocol Layer* creates the *Message* and passes to *PHY Layer*.
12	*PHY Layer* receives the *Message* and compares the *CRC* it calculated with the one sent to verify the ***Accept*** *Message*.	*PHY Layer* appends a *CRC* and sends the ***Accept*** *Message*. Starts ***CRCReceiveTimer***.
13	*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Accept*** *Message* information to the *Policy Engine* that consumes it.	
14	The *Policy Engine* requests its power supply to stop supplying power and stops the ***SenderResponseTimer***.	
15	*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.	

Table 8.60 Steps for a Successful Source Initiated Power Role Swap Sequence

Step	Initial Source Port	Initially Sink Port
16	*PHY Layer* appends a *CRC* and sends the ***GoodCRC*** *Message*.	*PHY Layer* receives ***GoodCRC*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
17		*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.
18		*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Accept*** *Message* was successfully sent. The *Policy Engine* starts the ***PSSourceOffTimer*** and tells the power supply to stop sinking current.
19	The *Policy Engine* determines its power supply is no longer supplying *VBUS*. The *Policy Engine* requests the *DPM* to assert the R_d pull down on the *CC* wire. The *Policy Engine* then directs the *Protocol Layer* to generate a ***PS_RDY*** *Message*, with the ***Port Power Role*** *Message*set to *Sink*, to tell its *Port Partner* that it can begin to source *VBUS*.	
20	*Protocol Layer* sets the ***Port Power Role*** *Message* to *Sink*, creates the *Message* and passes to *PHY Layer*.	
21	*PHY Layer* appends *CRC* and sends the ***PS_RDY*** *Message*. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the ***PS_RDY*** *Message* and checks the *CRC* to verify the *Message*.
22		*PHY Layer* removes the *CRC* and forwards the ***PS_RDY*** *Message* to the *Protocol Layer*.
23		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***PS_RDY*** *Message* information to the *Policy Engine* that consumes it. The *Policy Engine* stops the ***PSSourceOffTimer***, directs the *DPM* to apply the R_p pull up and then starts switching the power supply to ***vSafe5V*** *Source* operation.
24		*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.
25	*PHY Layer* receives the ***GoodCRC*** *Message* and checks the *CRC* to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.
26	*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.	
27	*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***PS_RDY*** *Message* was successfully sent. *Policy Engine* starts ***PSSourceOnTimer***.	
28		*Policy Engine*, when its power supply is ready to supply power, tells the *Protocol Layer* to form a ***PS_RDY*** *Message*. The ***Port Power Role*** *Message*is set to *Source*.
29		*Protocol Layer* creates the ***PS_RDY*** *Message* and passes to *PHY Layer*.

Table 8.60 Steps for a Successful Source Initiated Power Role Swap Sequence

Step	Initial Source Port	Initially Sink Port
30	*PHY Layer* receives the ***PS_RDY*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.	*PHY Layer* appends a *CRC* and sends the ***PS_RDY*** *Message*. Starts ***CRCReceiveTimer***.
31	*PHY Layer* removes the *CRC* and forwards the ***PS_RDY*** *Message* to the *Protocol Layer*.	
32	*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***PS_RDY*** *Message* information to the *Policy Engine* that consumes it.	
33	*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.	
34	*PHY Layer* appends a *CRC* and sends the ***GoodCRC*** *Message*. The *Policy Engine* stops the ***PSSourceOnTimer***, informs the power supply it can now sink power and resets the *Protocol Layer*.	*PHY Layer* receives ***GoodCRC*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
35		*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.
36		*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***PS_RDY*** *Message* was successfully sent. The *Policy Engine* resets the ***CapsCounter***, resets the *Protocol Layer* and starts the ***SwapSourceStartTimer*** which must timeout before sending any ***Source_Capabilities*** *Messages*.
The *Power Role Swap* is complete, the *Power Roles* have been reversed and the *Port Partners* are free to *Negotiate* for more power.		

8.3.2.7.1.2 Source Initiated Power Role Swap (Reject)

This is an example of a rejected *Power Role Swap* operation initiated by a *Port* which initially, at the start of this *Message* sequence, is acting as a *Source* and therefore has R_p pulled up on its *CC* wire.

There are several phases to the *Power Role Swap*:

- A ***PR_Swap*** *Message* is sent.
- An ***Reject*** *Message* in response to the ***PR_Swap*** *Message*.

Figure 8.34, "Rejected Power Role Swap Sequence Initiated by the Source" shows the *Messages* as they flow across the bus and within the devices.

Figure 8.34 Rejected Power Role Swap Sequence Initiated by the Source

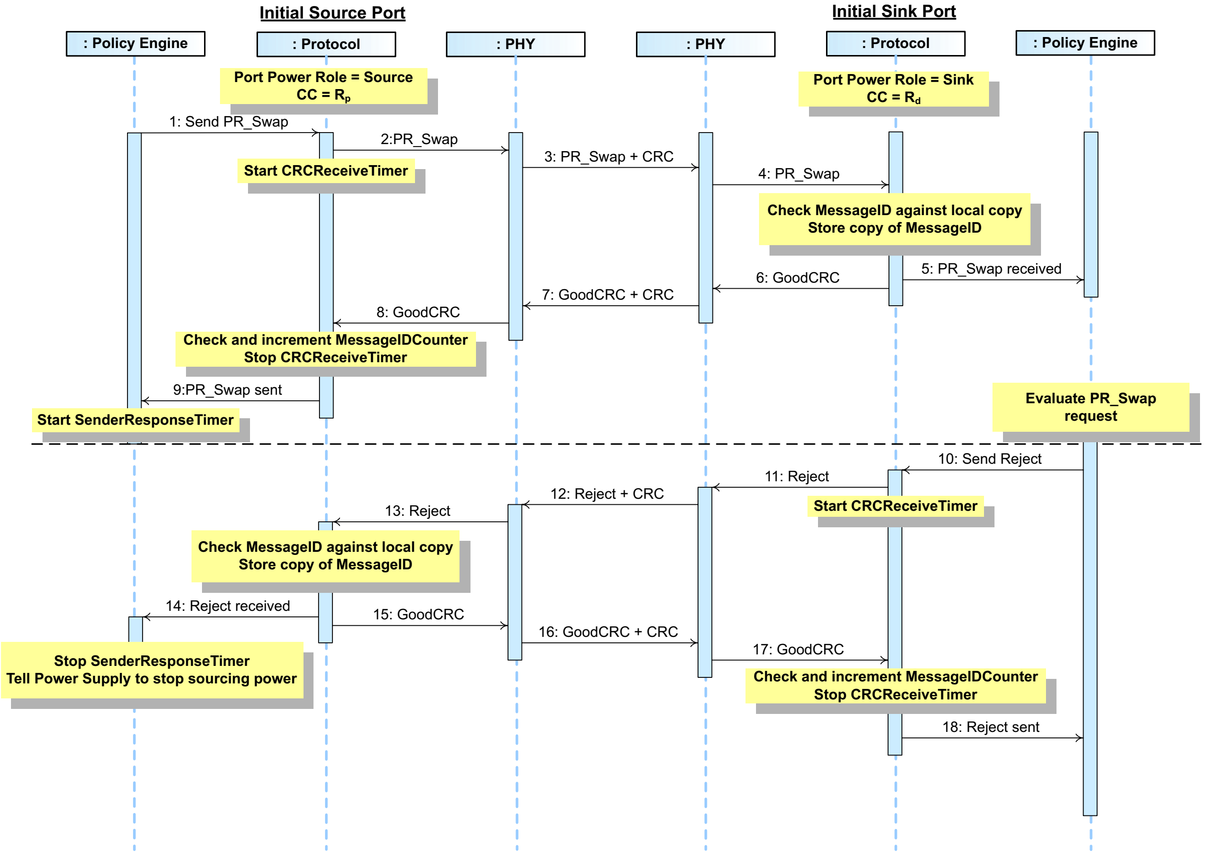


Table 8.61, "Steps for a Rejected Source Initiated Power Role Swap Sequence" below provides a detailed explanation of what happens at each labeled step in *Figure 8.34, "Rejected Power Role Swap Sequence Initiated by the Source"* above.

Table 8.61 Steps for a Rejected Source Initiated Power Role Swap Sequence

Step	Initial Source Port	Initially Sink Port
1	The *Port* has ***Port Power Role*** set to *Source* and the R_p pull up on its *CC* wire. *Policy Engine* directs the *Protocol Layer* to send a ***PR_Swap*** *Message*.	The *Port* has ***Port Power Role*** set to *Sink* with the R_d pull down on its *CC* wire.
2	*Protocol Layer* creates the *Message* and passes to *PHY Layer*.	
3	*PHY Layer* appends *CRC* and sends the ***PR_Swap*** *Message*. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the ***PR_Swap*** *Message* and checks the *CRC* to verify the *Message*.
4		*PHY Layer* removes the *CRC* and forwards the ***PR_Swap*** *Message* to the *Protocol Layer*.
5		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***PR_Swap*** *Message* information to the *Policy Engine* that consumes it.
6		*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.
7	*PHY Layer* receives the ***GoodCRC*** *Message* and checks the *CRC* to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.
8	*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.	
9	*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***PR_Swap*** *Message* was successfully sent. *Policy Engine* starts ***SenderResponseTimer***.	
10		*Policy Engine* evaluates the ***PR_Swap*** *Message* sent by the *Source* and decides that it is unable and unwilling to do the *Power Role Swap*. It tells the *Protocol Layer* to form a ***Reject*** *Message*.
11		*Protocol Layer* creates the *Message* and passes to *PHY Layer*.
12	*PHY Layer* receives the *Message* and compares the *CRC* it calculated with the one sent to verify the ***Reject*** *Message*.	*PHY Layer* appends a *CRC* and sends the ***Reject*** *Message*. Starts ***CRCReceiveTimer***.
13	*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Reject*** *Message* information to the *Policy Engine* that consumes it.	
14	The *Policy Engine* stops the ***SenderResponseTimer***.	
15	*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.	

Table 8.61 Steps for a Rejected Source Initiated Power Role Swap Sequence

Step	Initial Source Port	Initially Sink Port
16	*PHY Layer* appends a *CRC* and sends the ***GoodCRC*** *Message*.	*PHY Layer* receives ***GoodCRC*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
17		*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.
18		*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Reject*** *Message* was successfully sent.

8.3.2.7.1.3 Source Initiated Power Role Swap (Wait)

This is an example of a *Power Role Swap* operation, with a wait response, initiated by a *Port* which initially, at the start of this *Message* sequence, is acting as a *Source* and therefore has R_p pulled up on its *CC* wire.

There are several phases to the *Power Role Swap*:

- A ***PR_Swap*** *Message* is sent.
- A ***Wait*** *Message* in response to the ***PR_Swap*** *Message*.

Figure 8.35, "Power Role Swap Sequence with wait Initiated by the Source" shows the *Message*s as they flow across the bus and within the devices.

Figure 8.35 Power Role Swap Sequence with wait Initiated by the Source

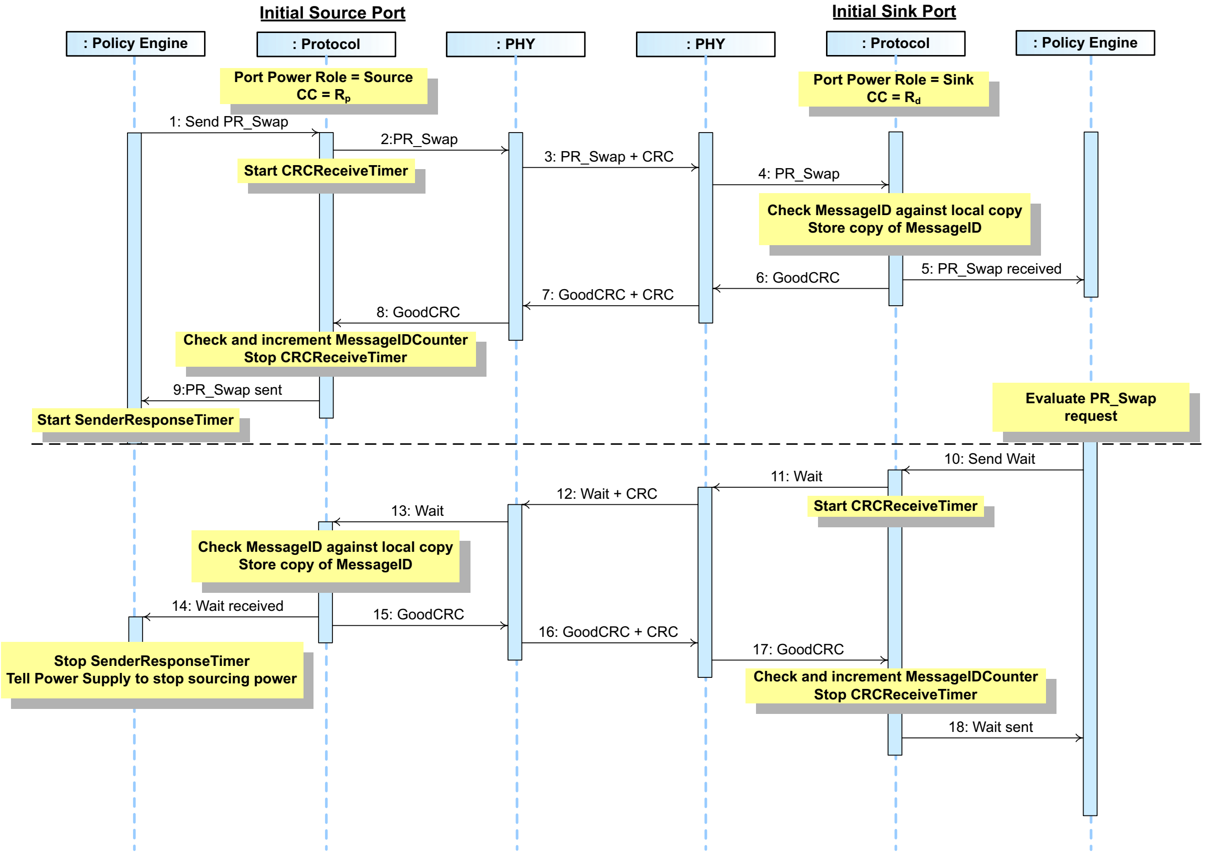


Table 8.62, "Steps for a Source Initiated Power Role Swap with Wait Sequence" below provides a detailed explanation of what happens at each labeled step in *Figure 8.35, "Power Role Swap Sequence with wait Initiated by the Source"* above.

Table 8.62 Steps for a Source Initiated Power Role Swap with Wait Sequence

Step	Initial Source Port	Initially Sink Port
1	The *Port* has ***Port Power Role*** set to *Source* and the R_p pull up on its *CC* wire. *Policy Engine* directs the *Protocol Layer* to send a ***PR_Swap*** *Message*.	The *Port* has ***Port Power Role*** set to *Sink* with the R_d pull down on its *CC* wire.
2	*Protocol Layer* creates the *Message* and passes to *PHY Layer*.	
3	*PHY Layer* appends *CRC* and sends the ***PR_Swap*** *Message*. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the ***PR_Swap*** *Message* and checks the *CRC* to verify the *Message*.
4		*PHY Layer* removes the *CRC* and forwards the ***PR_Swap*** *Message* to the *Protocol Layer*.
5		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***PR_Swap*** *Message* information to the *Policy Engine* that consumes it.
6		*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.
7	*PHY Layer* receives the ***GoodCRC*** *Message* and checks the *CRC* to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.
8	*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.	
9	*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***PR_Swap*** *Message* was successfully sent. *Policy Engine* starts ***SenderResponseTimer***.	
10		*Policy Engine* evaluates the ***PR_Swap*** *Message* sent by the *Source* and decides that it is able and willing to do the *Power Role Swap* but not at this time. It tells the *Protocol Layer* to form a ***Wait*** *Message*.
11		*Protocol Layer* creates the *Message* and passes to *PHY Layer*.
12	*PHY Layer* receives the *Message* and compares the *CRC* it calculated with the one sent to verify the ***Wait*** *Message*.	*PHY Layer* appends a *CRC* and sends the ***Wait*** *Message*. Starts ***CRCReceiveTimer***.
13	*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Wait*** *Message* information to the *Policy Engine* that consumes it.	
14	The *Policy Engine* stops the ***SenderResponseTimer***.	
15	*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.	

Table 8.62 Steps for a Source Initiated Power Role Swap with Wait Sequence

Step	Initial Source Port	Initially Sink Port
16	*PHY Layer* appends a *CRC* and sends the ***GoodCRC*** *Message*.	*PHY Layer* receives ***GoodCRC*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
17		*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.
18		*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Wait*** *Message* was successfully sent.

8.3.2.7.2 Sink Initiated Power Role Swap

8.3.2.7.2.1 Sink Initiated Power Role Swap (Accept)

This is an example of a successful *Power Role Swap* operation initiated by a *Port* which initially, at the start of this *Message* sequence, is acting as a *Sink* and therefore has R_d pulled down on its *CC* wire. It does not include any subsequent Power *Negotiation* which is required in order to establish an *Explicit Contract* (see Section 8.3.2.2, "Power Negotiation").

There are four distinct phases to the *Power Role Swap*:

- A ***PR_Swap*** *Message* is sent.
- An ***Accept*** *Message* in response to the ***PR_Swap*** *Message*.
- The *New Sink* sets its power output to ***vSafe0V***, then asserts R_d and sends a ***PS_RDY*** *Message* when this process is complete.
- The *New Source* asserts R_p, then sets its power output to ***vSafe5V*** and sends a ***PS_RDY*** *Message* when it is ready to supply power.

Figure 8.36, "Successful Power Role Swap Sequence Initiated by the Sink" shows the *Message*s as they flow across the bus and within the devices to accomplish the *Power Role Swap*.

Figure 8.36 Successful Power Role Swap Sequence Initiated by the Sink

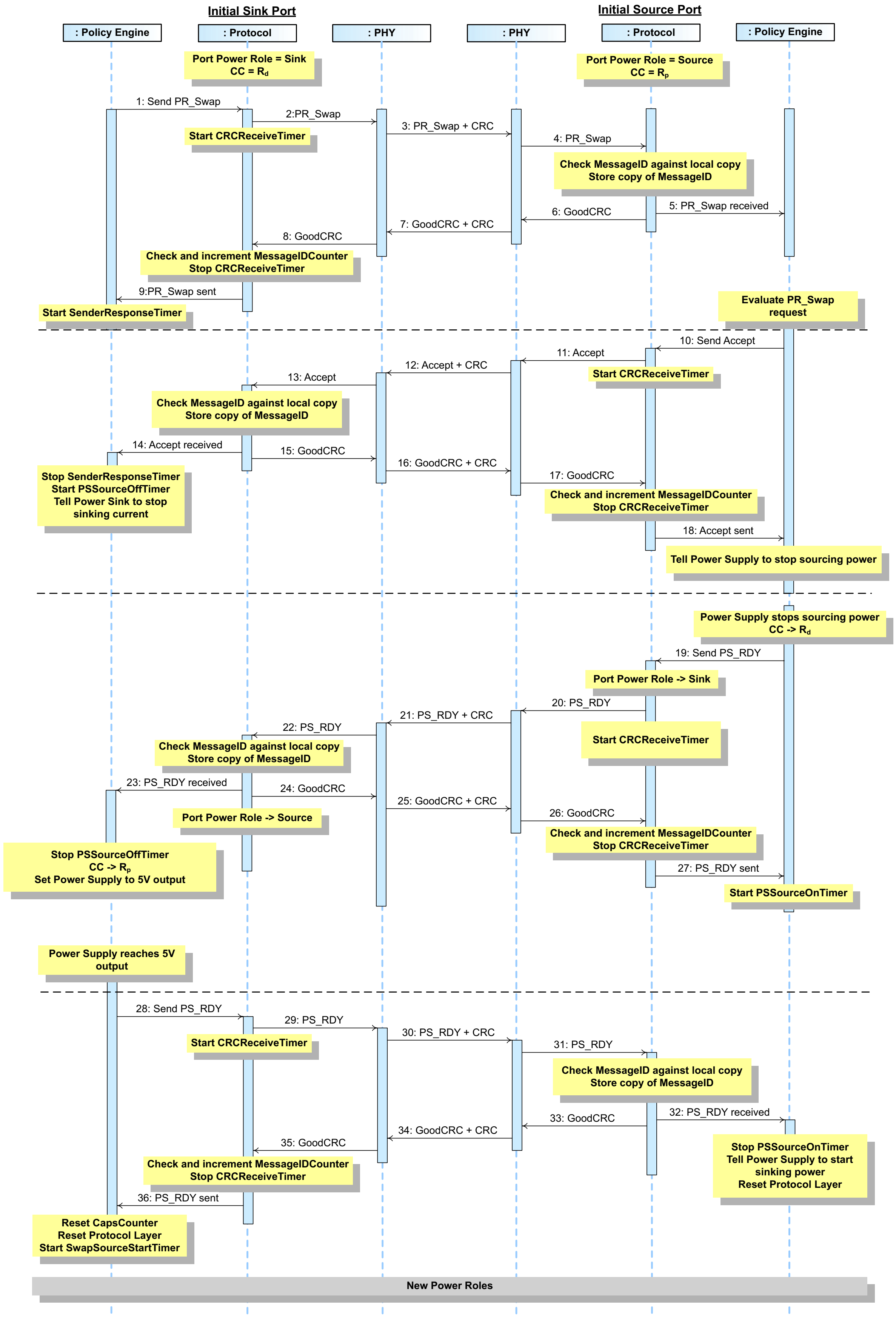


Table 8.63, "Steps for a Successful Sink Initiated Power Role Swap Sequence" below provides a detailed explanation of what happens at each labeled step in *Figure 8.36, "Successful Power Role Swap Sequence Initiated by the Sink"* above.

Table 8.63 Steps for a Successful Sink Initiated Power Role Swap Sequence

Step	Initial Sink Port	Initial Source Port
1	The *Port* has ***Port Power Role*** set to *Sink* with the R_d pull down on its *CC* wire. *Policy Engine* directs the *Protocol Layer* to send a ***PR_Swap*** *Message*.	The *Port* has ***Port Power Role*** set to *Source* and the R_p pull up on its *CC* wire.
2	*Protocol Layer* creates the *Message* and passes to *PHY Layer*.	
3	*PHY Layer* appends *CRC* and sends the ***PR_Swap*** *Message*. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the ***PR_Swap*** *Message* and checks the *CRC* to verify the *Message*.
4		*PHY Layer* removes the *CRC* and forwards the ***PR_Swap*** *Message* to the *Protocol Layer*.
5		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***PR_Swap*** *Message* information to the *Policy Engine* that consumes it.
6		*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.
7	*PHY Layer* receives the ***GoodCRC*** *Message* and checks the *CRC* to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.
8	*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.	
9	*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***PR_Swap*** *Message* was successfully sent. *Policy Engine* starts ***SenderResponseTimer***.	
10		*Policy Engine* evaluates the ***PR_Swap*** *Message* sent by the *Sink* and decides that it is able and willing to do the *Power Role Swap*. It tells the *Protocol Layer* to form an ***Accept*** *Message*.
11		*Protocol Layer* creates the *Message* and passes to *PHY Layer*.
12	*PHY Layer* receives the *Message* and compares the *CRC* it calculated with the one sent to verify the ***Accept*** *Message*.	*PHY Layer* appends a *CRC* and sends the ***Accept*** *Message*. Starts ***CRCReceiveTimer***.
13	*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Accept*** *Message* information to the *Policy Engine* that consumes it.	
14	The *Policy Engine* stops the ***SenderResponseTimer***, starts the ***PSSourceOffTimer*** and tells the power supply to stop sinking current.	

Table 8.63 Steps for a Successful Sink Initiated Power Role Swap Sequence

Step	Initial Sink Port	Initial Source Port
15	*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.	
16	*PHY Layer* appends a *CRC* and sends the ***GoodCRC*** *Message*.	*PHY Layer* receives ***GoodCRC*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
17		*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.
18		*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Accept*** *Message* was successfully sent. The *Policy Engine* tells the power supply to stop supplying power.
19		The *Policy Engine* determines its power supply is no longer supplying *VBUS*. The *Policy Engine* requests the *DPM* to assert the R_d pull down on the *CC* wire. The *Policy Engine* then directs the *Protocol Layer* to generate a ***PS_RDY*** *Message*, with the ***Port Power Role*** *Message*set to *Sink*, to tell its *Port Partner* that it can begin to source *VBUS*.
20		*Protocol Layer* sets the ***Port Power Role*** *Message*to *Sink*, creates the *Message* and passes to *PHY Layer*.
21	*PHY Layer* receives the ***PS_RDY*** *Message* and checks the *CRC* to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***PS_RDY*** *Message*. Starts ***CRCReceiveTimer***.
22	*PHY Layer* removes the *CRC* and forwards the ***PS_RDY*** *Message* to the *Protocol Layer*.	
23	*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***PS_RDY*** *Message* information to the *Policy Engine* that consumes it. The *Policy Engine* stops the ***PSSourceOffTimer***, directs the *DPM* to apply the R_p pull up and then starts switching the power supply to ***vSafe5V*** *Source* operation.	
24	*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.	
25	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.	*PHY Layer* receives the ***GoodCRC*** *Message* and checks the *CRC* to verify the *Message*.
26		*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.
27		*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***PS_RDY*** *Message* was successfully sent. *Policy Engine* starts ***PSSourceOnTimer***.
28	*Policy Engine*, when its power supply is ready to supply power, tells the *Protocol Layer* to form a ***PS_RDY*** *Message*. The ***Port Power Role*** *Message*is set to *Source*.	
29	*Protocol Layer* creates the ***PS_RDY*** *Message* and passes to *PHY Layer*.	

Table 8.63 Steps for a Successful Sink Initiated Power Role Swap Sequence

Step	Initial Sink Port	Initial Source Port
30	*PHY Layer* appends a *CRC* and sends the ***PS_RDY*** *Message*. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the ***PS_RDY*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
31		*PHY Layer* removes the *CRC* and forwards the ***PS_RDY*** *Message* to the *Protocol Layer*.
32		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***PS_RDY*** *Message* information to the *Policy Engine* that consumes it. The *Policy Engine* stops the ***PSSourceOnTimer***, informs the power supply that it can start consuming power.
33		*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.
34	*PHY Layer* receives ***GoodCRC*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.	*PHY Layer* appends a *CRC* and sends the ***GoodCRC*** *Message*. The *Policy Engine* stops the ***PSSourceOnTimer***, informs the power supply it can now sink power and resets the *Protocol Layer*.
35	*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** to the *Protocol Layer*.	
36	*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***PS_RDY*** *Message* was successfully sent. The *Policy Engine* resets the ***CapsCounter***, resets the *Protocol Layer* and starts the ***SwapSourceStartTimer*** which must timeout before sending any ***Source_Capabilities*** *Messages*.	
The *Power Role Swap* is complete, the *Power Roles* have been reversed and the *Port Partners* are free to *Negotiate* for more power.		

8.3.2.7.2.2 Sink Initiated Power Role Swap (Reject)

This is an example of a rejected *Power Role Swap* operation initiated by a *Port* which initially, at the start of this *Message* sequence, is acting as a *Sink* and therefore has R_d pulled down on its *CC* wire.

There are several phases to the *Power Role Swap*:

- A ***PR_Swap*** *Message* is sent.
- A ***Reject*** *Message* in response to the ***PR_Swap*** *Message*.

Figure 8.37, "Rejected Power Role Swap Sequence Initiated by the Sink" shows the *Message*s as they flow across the bus and within the devices.

Figure 8.37 Rejected Power Role Swap Sequence Initiated by the Sink

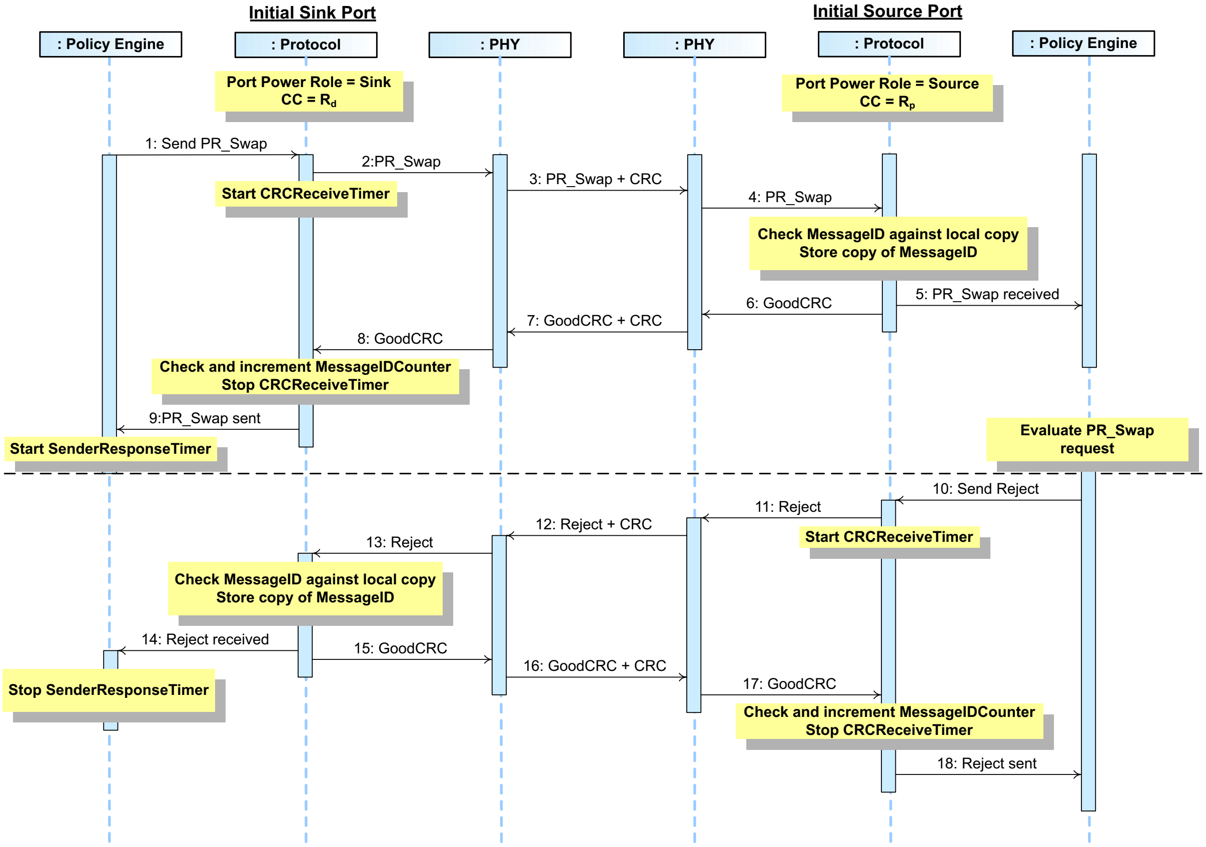


Table 8.64, "Steps for a Rejected Sink Initiated Power Role Swap Sequence" below provides a detailed explanation of what happens at each labeled step in *Figure 8.37, "Rejected Power Role Swap Sequence Initiated by the Sink"* above.

Table 8.64 Steps for a Rejected Sink Initiated Power Role Swap Sequence

Step	Initial Sink Port	Initial Source Port
1	The *Port* has ***Port Power Role*** set to *Sink* with the R_d pull down on its *CC* wire. *Policy Engine* directs the *Protocol Layer* to send a ***PR_Swap*** *Message*.	The *Port* has ***Port Power Role*** set to *Source* and the R_p pull up on its *CC* wire.
2	*Protocol Layer* creates the *Message* and passes to *PHY Layer*.	
3	*PHY Layer* appends *CRC* and sends the ***PR_Swap*** *Message*. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the ***PR_Swap*** *Message* and checks the *CRC* to verify the *Message*.
4		*PHY Layer* removes the *CRC* and forwards the ***PR_Swap*** *Message* to the *Protocol Layer*.
5		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***PR_Swap*** *Message* information to the *Policy Engine* that consumes it.
6		*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.
7	*PHY Layer* receives the ***GoodCRC*** *Message* and checks the *CRC* to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.
8	*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.	
9	*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***PR_Swap*** *Message* was successfully sent. *Policy Engine* starts ***SenderResponseTimer***.	
10		*Policy Engine* evaluates the ***PR_Swap*** *Message* sent by the *Sink* and decides that it is unable and unwilling to do the *Power Role Swap*. It tells the *Protocol Layer* to form a ***Reject*** *Message*.
11		*Protocol Layer* creates the *Message* and passes to *PHY Layer*.
12	*PHY Layer* receives the *Message* and compares the *CRC* it calculated with the one sent to verify the ***Reject*** *Message*.	*PHY Layer* appends a *CRC* and sends the ***Accept*** *Message*. Starts ***CRCReceiveTimer***.
13	*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Reject*** *Message* information to the *Policy Engine* that consumes it.	
14	The *Policy Engine* stops the ***SenderResponseTimer***.	
15	*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.	

Table 8.64 Steps for a Rejected Sink Initiated Power Role Swap Sequence

Step	Initial Sink Port	Initial Source Port
16	*PHY Layer* appends a *CRC* and sends the ***GoodCRC*** *Message*.	*PHY Layer* receives ***GoodCRC*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
17		*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.
18		*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Reject*** *Message* was successfully sent

8.3.2.7.2.3 Sink Initiated Power Role Swap (Wait)

This is an example of a *Power Role Swap* operation, responded to with wait, initiated by a *Port* which initially, at the start of this *Message* sequence, is acting as a *Sink* and therefore has R_d pulled down on its *CC* wire.

There are several phases to the *Power Role Swap*:

- A ***PR_Swap*** *Message* is sent.
- A ***Wait*** *Message* in response to the ***PR_Swap*** *Message*.

Figure 8.38, "Power Role Swap Sequence with wait Initiated by the Sink" shows the *Message*s as they flow across the bus and within the devices.

Figure 8.38 Power Role Swap Sequence with wait Initiated by the Sink

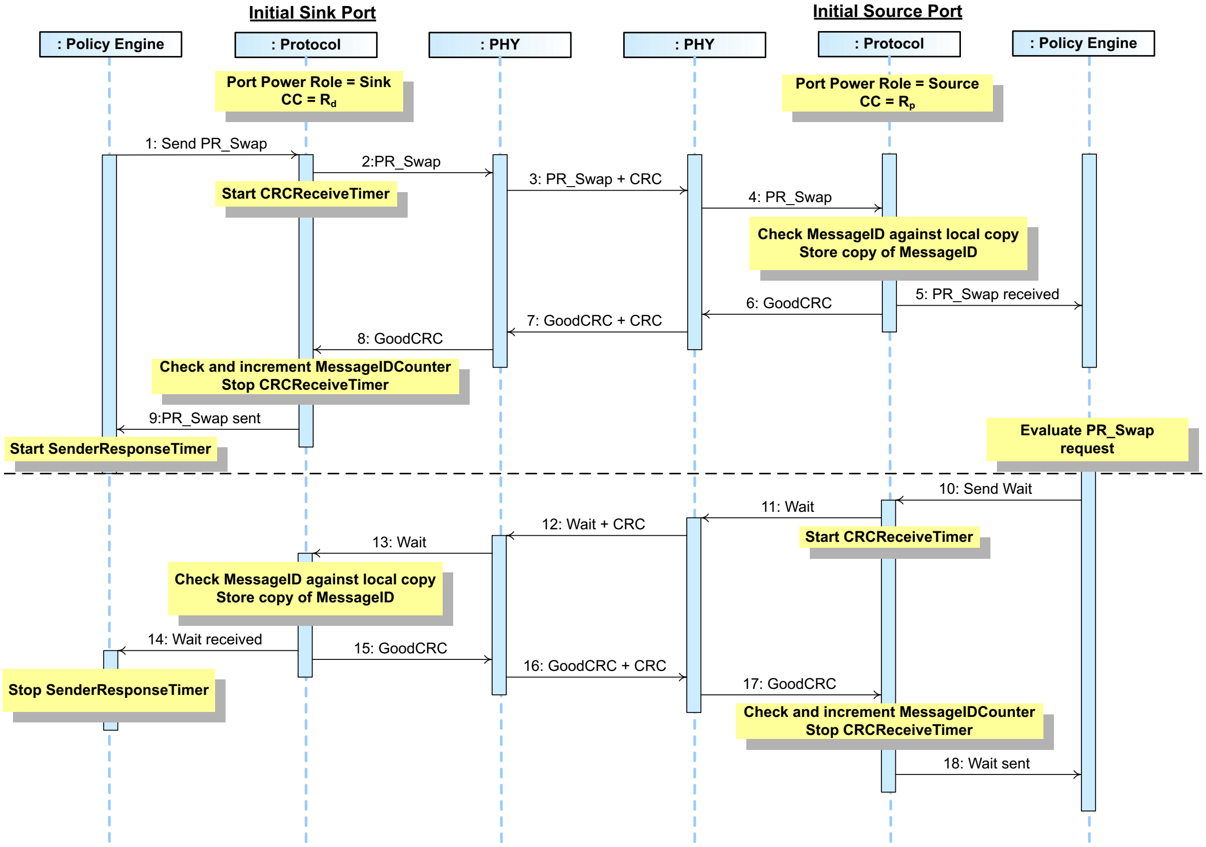


Table 8.65, "Steps for a Sink Initiated Power Role Swap with Wait Sequence" below provides a detailed explanation of what happens at each labeled step in *Figure 8.38, "Power Role Swap Sequence with wait Initiated by the Sink"* above.

Table 8.65 Steps for a Sink Initiated Power Role Swap with Wait Sequence

Step	Initial Sink Port	Initial Source Port
1	The *Port* has ***Port Power Role*** set to *Sink* with the R_d pull down on its *CC* wire. *Policy Engine* directs the *Protocol Layer* to send a ***PR_Swap*** *Message*.	The *Port* has ***Port Power Role*** set to *Source* and the R_p pull up on its *CC* wire.
2	*Protocol Layer* creates the *Message* and passes to *PHY Layer*.	
3	*PHY Layer* appends *CRC* and sends the ***PR_Swap*** *Message*. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the ***PR_Swap*** *Message* and checks the *CRC* to verify the *Message*.
4		*PHY Layer* removes the *CRC* and forwards the ***PR_Swap*** *Message* to the *Protocol Layer*.
5		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***PR_Swap*** *Message* information to the *Policy Engine* that consumes it.
6		*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.
7	*PHY Layer* receives the ***GoodCRC*** *Message* and checks the *CRC* to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.
8	*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.	
9	*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***PR_Swap*** *Message* was successfully sent. *Policy Engine* starts ***SenderResponseTimer***.	
10		*Policy Engine* evaluates the ***PR_Swap*** *Message* sent by the *Sink* and decides that it is able and willing to do the *Power Role Swap* but not at this time. It tells the *Protocol Layer* to form a ***Wait*** *Message*.
11		*Protocol Layer* creates the *Message* and passes to *PHY Layer*.
12	*PHY Layer* receives the *Message* and compares the *CRC* it calculated with the one sent to verify the ***Wait*** *Message*.	*PHY Layer* appends a *CRC* and sends the ***Wait*** *Message*. Starts ***CRCReceiveTimer***.
13	*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Wait*** *Message* information to the *Policy Engine* that consumes it.	
14	The *Policy Engine* stops the ***SenderResponseTimer***.	
15	*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.	

Table 8.65 Steps for a Sink Initiated Power Role Swap with Wait Sequence

Step	Initial Sink Port	Initial Source Port
16	*PHY Layer* appends a *CRC* and sends the ***GoodCRC*** *Message*.	*PHY Layer* receives ***GoodCRC*** *Message* and compares the *CRC* it calculated with the one sent to verify the ***Wait*** *Message*.
17		*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.
18		*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Wait*** *Message* was successfully sent

8.3.2.8 Fast Role Swap

This is an example of a successful *Fast Role Swap* operation initiated by a *Port* that is initially a *Source* and therefore has R_p pulled up on its *CC* wire and which has lost power and needs to get ***vSafe5V*** quickly. It does not include any subsequent Power *Negotiation* which is required in order to establish an *Explicit Contract* (see *Section 8.3.2.2, "Power Negotiation"*).

There are several distinct phases to the *Fast Role Swap Negotiation*:

- The *Initial Source* stops driving its power output which starts transitioning to ***vSafe0V*** and send the *Fast Role Swap Request* on the *CC* wire; these could occur in either order or simultaneously.
- The *Initial Sink* stops sinking power. At this point the *New Source* still has R_d asserted and the *New Sink* still has R_p asserted.
- An ***FR_Swap*** *Message* is sent by the *New Source* within ***tFRSwapInit*** of detecting the Fast Swap signal.
- An ***Accept*** *Message* is sent by the *New Sink* in response to the ***FR_Swap*** *Message*.
- The *New Sink* asserts R_d and sends a ***PS_RDY*** *Message* indicating that the voltage on *VBUS* is at or below ***vSafe5V***.
- The *New Source* asserts R_p and sends a ***PS_RDY*** *Message* indicating that it is acting as a *Source* and is supplying ***vSafe5V***.

Note: The *New Source* can start applying *VBUS* when *VBUS* is at or below ***vSafe5V*** (max) but will start driving *VBUS* to ***vSafe5V*** no later than ***tSrcFRSwap*** after detecting both the *Fast Role Swap Request* and that *VBUS* has dropped below ***vSafe5V*** (min).

Figure 8.39, "Successful Fast Role Swap Sequence" shows the *Message*s as they flow across the bus and within the devices to accomplish the *Fast Role Swap*.

Figure 8.39 Successful Fast Role Swap Sequence

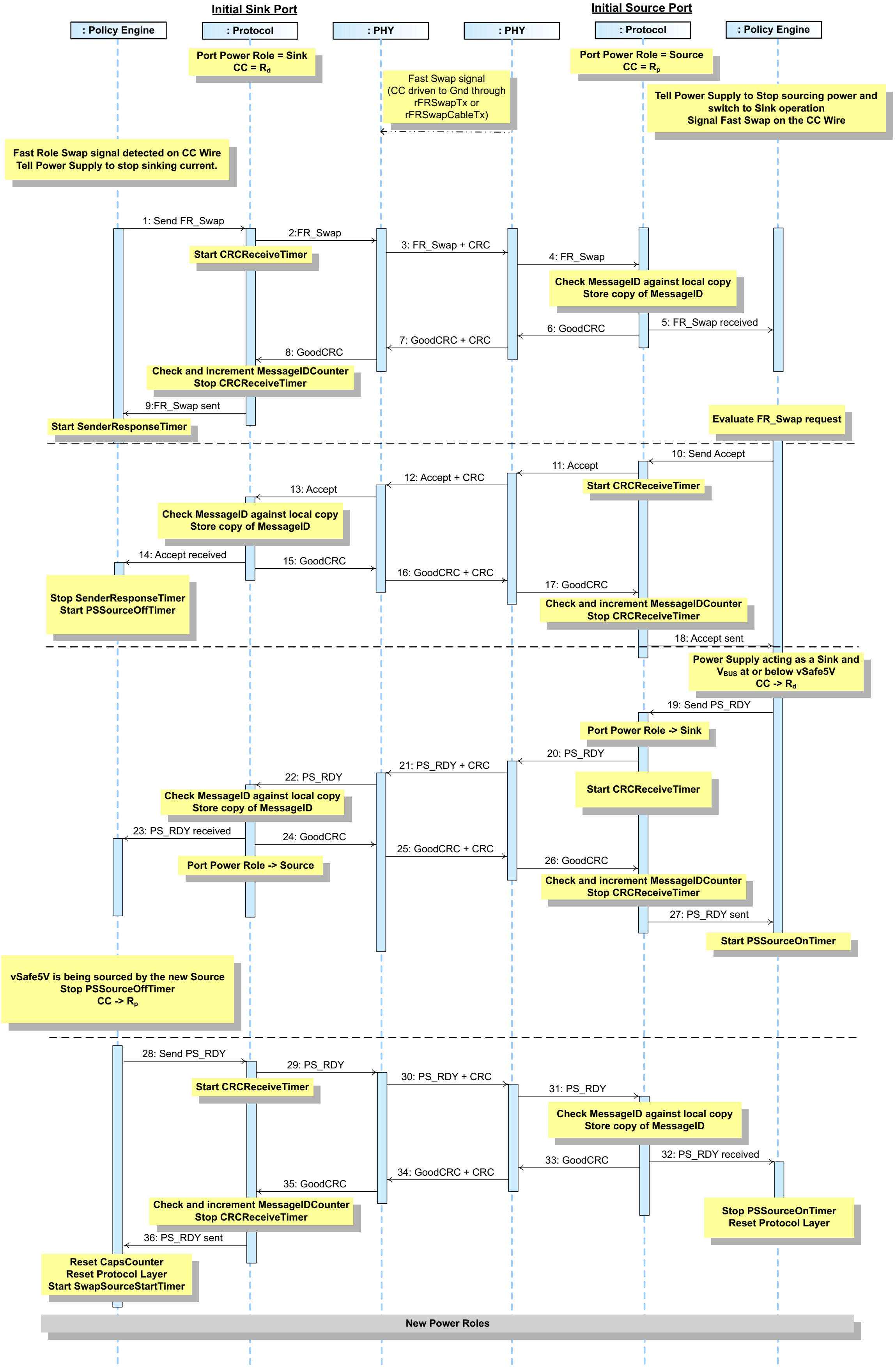


Table 8.66, "Steps for a Successful Fast Role Swap Sequence" below provides a detailed explanation of what happens at each labeled step in *Figure 8.39, "Successful Fast Role Swap Sequence"* above.

Table 8.66 Steps for a Successful Fast Role Swap Sequence

Step	Initial Sink Port	Initial Source Port
1	The *Port* has ***Port Power Role*** set to *Sink* with the R_d pull down on its *CC* wire. The *DPM* detects Fast Swap on the *CC* wire and tells the power supply to stop sinking current. The *Policy Engine* directs the *Protocol Layer* to send an ***FR_Swap*** *Message* within ***tFRSwapInit*** of detecting the Fast Swap signal.	The *Port* has ***Port Power Role*** set to *Source* and the R_p pull up on its *CC* wire. The *DPM* tells the Power Supply to stop sourcing power and switch to *Sink* operation. The *DPM* signals Fast Swap on the *CC* wire by driving *CC* to ground with a resistance of less than ***rFRSwapTx*** for at least ***tFRSwapTx***.
2	*Protocol Layer* creates the *Message* and passes to *PHY Layer*.	
3	*PHY Layer* appends *CRC* and sends the ***FR_Swap*** *Message*. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the ***FR_Swap*** *Message* and checks the *CRC* to verify the *Message*.
4		*PHY Layer* removes the *CRC* and forwards the ***PR_Swap*** *Message* to the *Protocol Layer*.
5		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***FR_Swap*** *Message* information to the *Policy Engine* that consumes it.
6		*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.
7	*PHY Layer* receives the ***GoodCRC*** *Message* and checks the *CRC* to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.
8	*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.	
9	*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***FR_Swap*** *Message* was successfully sent. *Policy Engine* starts ***SenderResponseTimer***.	
10		*Policy Engine* evaluates the ***PR_Swap*** *Message* sent by the *Sink* and decides that it is able and willing to do the *Power Role Swap*. It tells the *Protocol Layer* to form an ***Accept*** *Message*.
11		*Protocol Layer* creates the *Message* and passes to *PHY Layer*.
12	*PHY Layer* receives the *Message* and compares the *CRC* it calculated with the one sent to verify the ***Accept*** *Message*.	*PHY Layer* appends a *CRC* and sends the ***Accept*** *Message*. Starts ***CRCReceiveTimer***.
13	*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***PR_Swap*** *Message* information to the *Policy Engine* that consumes it.	
14	The *Policy Engine* stops the ***SenderResponseTimer***, starts the ***PSSourceOffTimer***.	

Table 8.66 Steps for a Successful Fast Role Swap Sequence

Step	Initial Sink Port	Initial Source Port
15	*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.	
16	*PHY Layer* appends a *CRC* and sends the ***GoodCRC*** *Message*.	*PHY Layer* receives ***GoodCRC*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
17		*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.
18		*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Accept*** *Message* was successfully sent.
19		The *Policy Engine* determines its power supply is no longer supplying *VBUS* and is acting as a *Sink*. The *Policy Engine* requests the *DPM* to assert the R_d pull down on the *CC* wire. The *Policy Engine* then directs the *Protocol Layer* to generate a ***PS_RDY*** *Message*, with the ***Port Power Role*** *Message*set to *Sink*, to tell its *Port Partner* that it can begin to source *VBUS*.
20		*Protocol Layer* sets the ***Port Power Role*** *Message*to *Sink*, creates the *Message* and passes to *PHY Layer*.
21	*PHY Layer* receives the ***PS_RDY*** *Message* and checks the *CRC* to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***PS_RDY*** *Message*. Starts ***CRCReceiveTimer***.
22	*PHY Layer* removes the *CRC* and forwards the ***PS_RDY*** *Message* to the *Protocol Layer*.	
23	*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***PS_RDY*** *Message* information to the *Policy Engine* that consumes it. The *Policy Engine* stops the ***PSSourceOffTimer***.	
24	*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.	
25	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.	*PHY Layer* receives the ***GoodCRC*** *Message* and checks the *CRC* to verify the *Message*.
26		*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.
27		*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***PS_RDY*** *Message* was successfully sent. *Policy Engine* starts ***PSSourceOnTimer***.

Table 8.66 Steps for a Successful Fast Role Swap Sequence

Step	Initial Sink Port	Initial Source Port
28	The *Policy Engine* directs the *DPM* to apply the R_p pull up. **Note:** At some point (either before or after receiving the ***PS_RDY*** *Message*) the *New Source* has applied ***vSafe5V*** no later than ***tSrcFRSwap*** after detecting the *Fast Role Swap Request* and that *VBUS* has dropped below ***vSafe5V***. *Policy Engine*, when its power supply is ready to supply power, tells the *Protocol Layer* to form a ***PS_RDY*** *Message*. The ***Port Power Role*** *Message*is set to *Source*.	
29	*Protocol Layer* creates the ***PS_RDY*** *Message* and passes to *PHY Layer*.	
30	*PHY Layer* appends a *CRC* and sends the ***PS_RDY*** *Message*. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the ***PS_RDY*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
31		*PHY Layer* removes the *CRC* and forwards the ***PS_RDY*** *Message* to the *Protocol Layer*.
32		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***PS_RDY*** *Message* information to the *Policy Engine* that consumes it. The *Policy Engine* stops the ***PSSourceOnTimer***.
33		*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.
34	*PHY Layer* receives ***GoodCRC*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.	*PHY Layer* appends a *CRC* and sends the ***GoodCRC*** *Message*. The *Policy Engine* resets the *Protocol Layer*.
35	*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** to the *Protocol Layer*.	
36	*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***PS_RDY*** *Message* was successfully sent. The *Policy Engine* resets the ***CapsCounter***, resets the *Protocol Layer* and starts the ***SwapSourceStartTimer*** which must timeout before sending any ***Source_Capabilities*** *Messages*.	
The *Fast Role Swap* is complete, the *Power Roles* have been reversed and the *Port Partner*s are free to *Negotiate* for more power.		

8.3.2.9 Data Role Swap

8.3.2.9.1 Data Role Swap, Initiated by UFP Operating as Sink

8.3.2.9.1.1 Data Role Swap, Initiated by UFP Operating as Sink (Accept)

Figure 8.40, "Data Role Swap, UFP operating as Sink initiates" shows an example sequence between a *Port*, which is initially a *UFP* (*Device*) and a *Sink* (R_d asserted), and a *Port* which is initially a *DFP* (*Host*) and a *Source* (R_p asserted). A *Data Role Swap* is initiated by the *UFP*. During the process the *Port Partner*s maintain their operation as either a *Source* or a *Sink* (power and R_p/R_d remain constant) but exchange *Data Roles* between *DFP* (*Host*) and *UFP* (*Device*).

Figure 8.40 Data Role Swap, UFP operating as Sink initiates

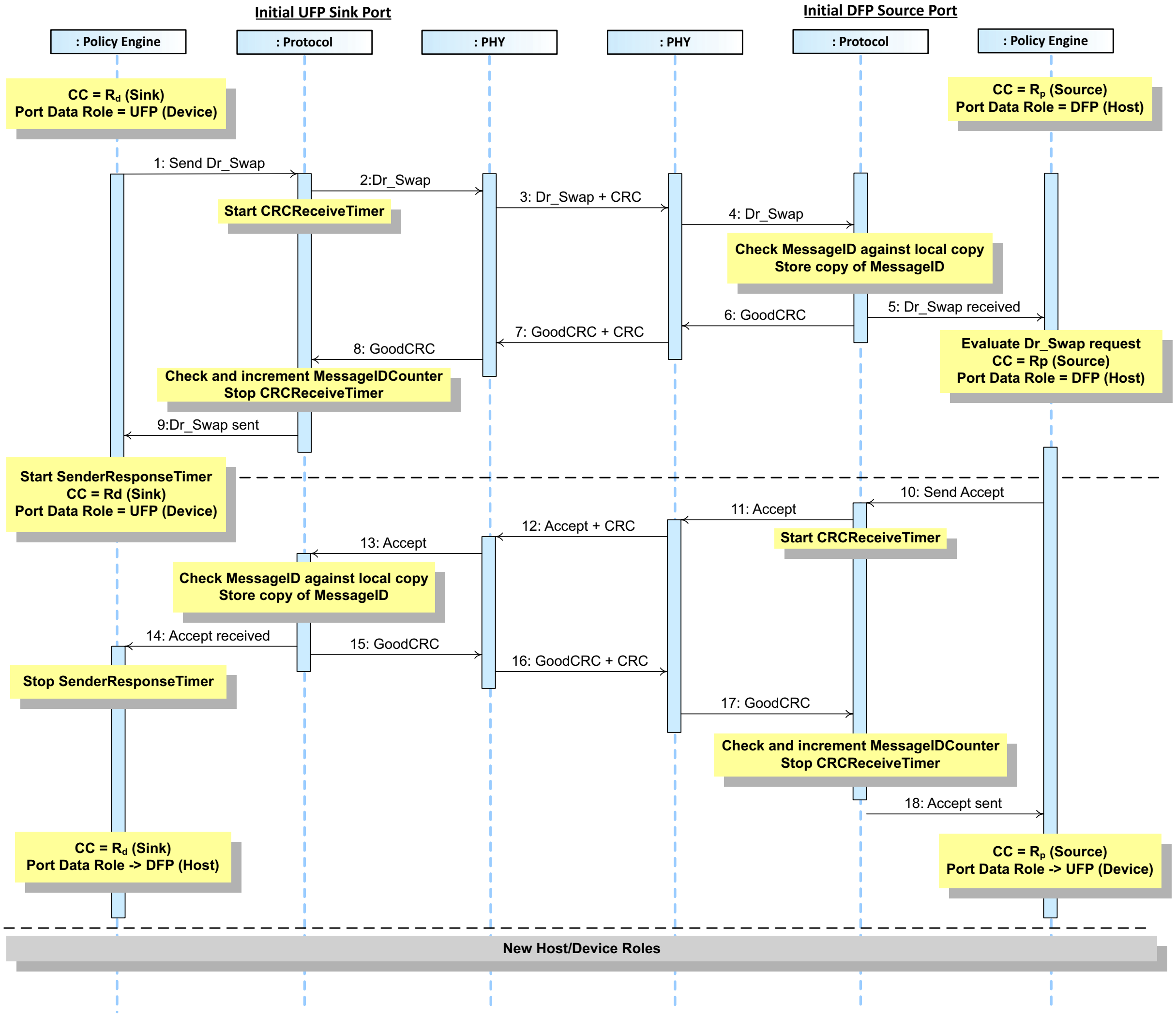


Table 8.67, "Steps for Data Role Swap, UFP operating as Sink initiates" below provides a detailed explanation of what happens at each labeled step in *Figure 8.40, "Data Role Swap, UFP operating as Sink initiates"* above.

Table 8.67 Steps for Data Role Swap, UFP operating as Sink initiates

Step	Initial UFP Sink Port	Initial DFP Source Port
1	*Port* starts as a *UFP* (*Device*) operating as a *Sink* with R_d asserted and ***Port Data Role*** set to *UFP*. The *Policy Engine* directs the *Protocol Layer* to send a ***DR_Swap*** *Message*.	*Port* starts as a *DFP* (*Host*) operating as *Source* with R_p asserted and ***Port Data Role*** set to *DFP*.
2	*Protocol Layer* creates the ***DR_Swap*** *Message* and passes to *PHY Layer*.	
3	*PHY Layer* appends *CRC* and sends the ***DR_Swap*** *Message*. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the ***DR_Swap*** *Message* and checks the *CRC* to verify the *Message*.
4		*PHY Layer* removes the *CRC* and forwards the ***DR_Swap*** *Message* to the *Protocol Layer*.
5		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***DR_Swap*** *Message* information to the *Policy Engine* that consumes it.
6		*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.
7	*PHY Layer* receives the ***GoodCRC*** *Message* and checks the *CRC* to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.
8	*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.	
9	*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***DR_Swap*** *Message* was successfully sent. *Policy Engine* starts ***SenderResponseTimer***.	
10		*Policy Engine* evaluates the ***DR_Swap*** *Message* and decides that it is able and willing to do the *Data Role Swap*. It tells the *Protocol Layer* to form an ***Accept*** *Message*.
11		*Protocol Layer* creates the ***Accept*** *Message* and passes to *PHY Layer*.
12	*PHY Layer* receives the ***Accept*** *Message* and checks the *CRC* to verify the *Message*.	*PHY Layer* appends a *CRC* and sends the ***Accept*** *Message*. Starts ***CRCReceiveTimer***.
13	*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Accept*** *Message* information to the *Policy Engine* that consumes it.	
14	The *Policy Engine* stops the ***SenderResponseTimer***.	
15	*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.	
16	*PHY Layer* appends a *CRC* and sends the ***GoodCRC*** *Message*.	*PHY Layer* receives ***GoodCRC*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.

Table 8.67 Steps for Data Role Swap, UFP operating as Sink initiates

Step	Initial UFP Sink Port	Initial DFP Source Port
17		*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.
18	The *Policy Engine* requests that *Data Role* is changed from *UFP* (*Device*) to *DFP* (*Host*). The Power Delivery *Data Role* is now a *DFP* (*Host*), with ***Port Data Role*** set to *DFP*, still operating as a *Sink* (R_d asserted).	*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Accept*** *Message* was successfully sent. The *Policy Engine* requests that the *Data Role* is changed to *UFP* (*Device*), with ***Port Data Role*** set to *UFP* and continues supplying power as a *Source* (R_p asserted).
The *Data Role Swap* is complete; the *Data Role*s have been reversed while maintaining the direction of power flow.		

8.3.2.9.1.2 Data Role Swap, Initiated by UFP Operating as Sink (Reject)

Figure 8.41, "Rejected Data Role Swap, UFP operating as Sink initiates" shows an example sequence between a *Port*, which is initially a *UFP* (*Device*) and a *Sink* (R_d asserted), and a *Port* which is initially a *DFP* (*Host*) and a *Source* (R_p asserted). A *Data Role Swap* is initiated by the *UFP*. During the process the *Port Partner*s maintain their operation as either a *Source* or a *Sink* (power and R_p/R_d remain constant) and the exchange of *Data Roles* is rejected.

Figure 8.41 Rejected Data Role Swap, UFP operating as Sink initiates

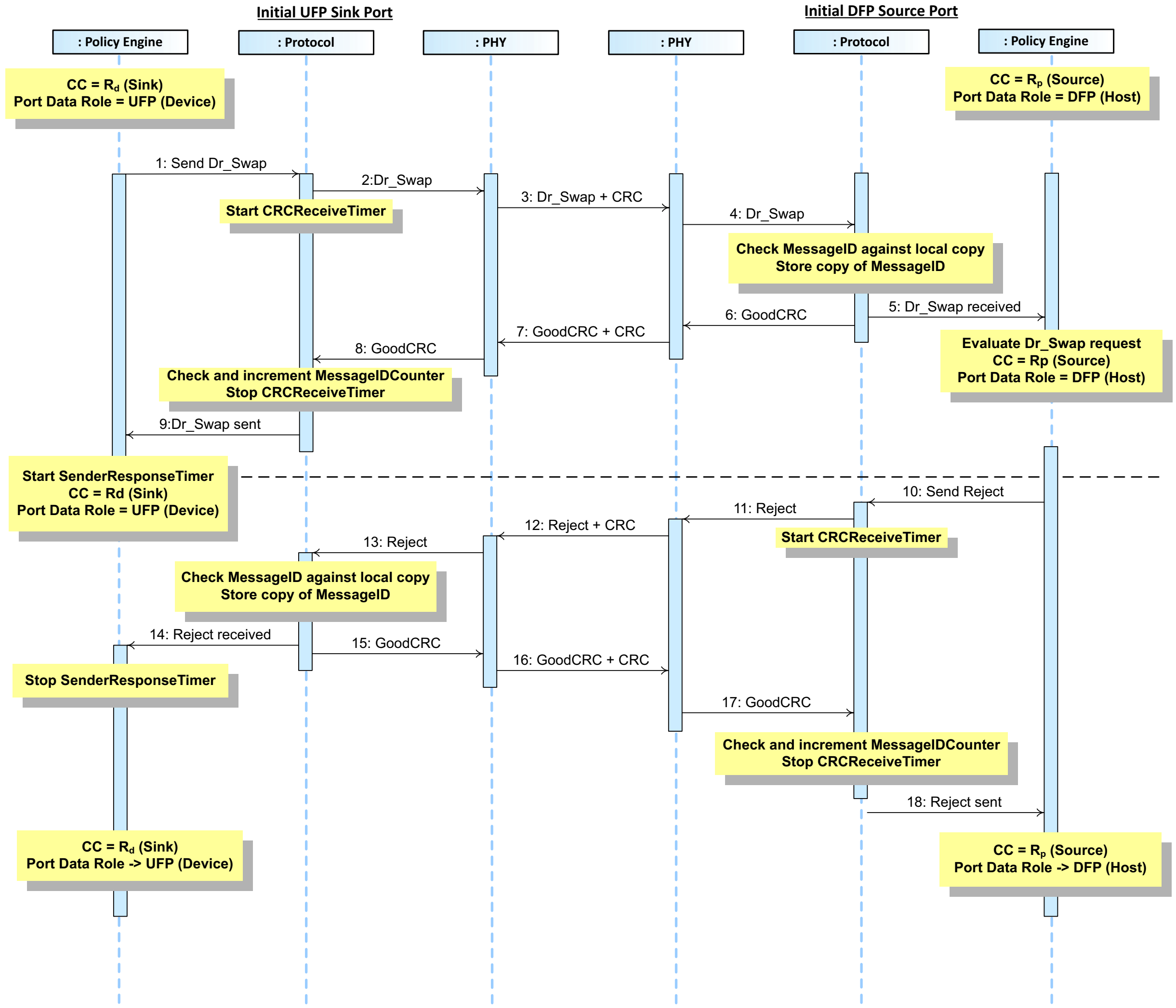


Table 8.68, "Steps for Rejected Data Role Swap, UFP operating as Sink initiates" below provides a detailed explanation of what happens at each labeled step in *Figure 8.41, "Rejected Data Role Swap, UFP operating as Sink initiates"* above.

Table 8.68 Steps for Rejected Data Role Swap, UFP operating as Sink initiates

Step	Initial UFP Sink Port	Initial DFP Source Port
1	*Port* starts as a *UFP* (*Device*) operating as a *Sink* with R_d asserted and ***Port Data Role*** set to *UFP*. The *Policy Engine* directs the *Protocol Layer* to send a ***DR_Swap*** *Message*.	*Port* starts as a *DFP* (*Host*) operating as *Source* with R_p asserted and ***Port Data Role*** set to *DFP*.
2	*Protocol Layer* creates the ***DR_Swap*** *Message* and passes to *PHY Layer*.	
3	*PHY Layer* appends *CRC* and sends the ***DR_Swap*** *Message*. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the ***DR_Swap*** *Message* and checks the *CRC* to verify the *Message*.
4		*PHY Layer* removes the *CRC* and forwards the ***DR_Swap*** *Message* to the *Protocol Layer*.
5		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***DR_Swap*** *Message* information to the *Policy Engine* that consumes it.
6		*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.
7	*PHY Layer* receives the ***GoodCRC*** *Message* and checks the *CRC* to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.
8	*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.	
9	*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***DR_Swap*** *Message* was successfully sent. *Policy Engine* starts ***SenderResponseTimer***.	
10		*Policy Engine* evaluates the ***DR_Swap*** *Message* and decides that it is unable and unwilling to do the *Data Role Swap*. It tells the *Protocol Layer* to form a ***Reject*** *Message*.
11		*Protocol Layer* creates the ***Reject*** *Message* and passes to *PHY Layer*.
12	*PHY Layer* receives the ***Reject*** *Message* and checks the *CRC* to verify the *Message*.	*PHY Layer* appends a *CRC* and sends the ***Reject*** *Message*. Starts ***CRCReceiveTimer***.
13	*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Reject*** *Message* information to the *Policy Engine* that consumes it.	
14	The *Policy Engine* stops the ***SenderResponseTimer***.	
15	*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.	

Table 8.68 Steps for Rejected Data Role Swap, UFP operating as Sink initiates

Step	Initial UFP Sink Port	Initial DFP Source Port
16	*PHY Layer* appends a *CRC* and sends the ***GoodCRC*** *Message*.	*PHY Layer* receives ***GoodCRC*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
17		*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.
18		*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Reject*** *Message* was successfully sent.

8.3.2.9.1.3 Data Role Swap, Initiated by UFP Operating as Sink (Wait)

Figure 8.42, "Data Role Swap with Wait, UFP operating as Sink initiates" shows an example sequence between a *Port*, which is initially a *UFP* (*Device*) and a *Sink* (R_d asserted), and a *Port* which is initially a *DFP* (*Host*) and a *Source* (R_p asserted). A *Data Role Swap* is initiated by the *UFP*. During the process the *Port Partner*s maintain their operation as either a *Source* or a *Sink* (power and R_p/R_d remain constant) and the exchange of *Data Roles* is delayed with a wait.

Figure 8.42 Data Role Swap with Wait, UFP operating as Sink initiates

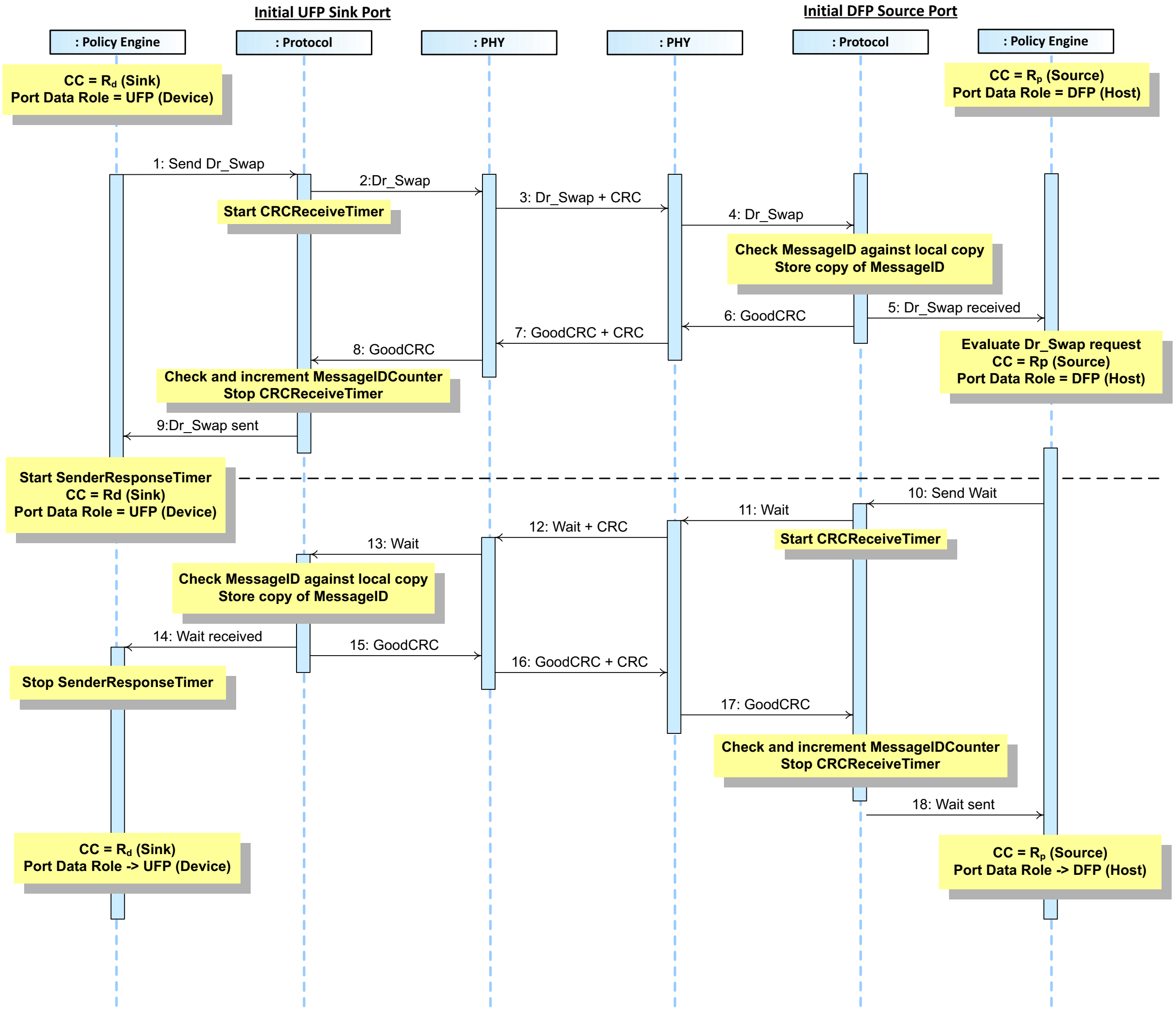


Table 8.69, "Steps for Data Role Swap with Wait, UFP operating as Sink initiates" below provides a detailed explanation of what happens at each labeled step in *Figure 8.42, "Data Role Swap with Wait, UFP operating as Sink initiates"* above.

Table 8.69 Steps for Data Role Swap with Wait, UFP operating as Sink initiates

Step	Initial UFP Sink Port	Initial DFP Source Port
1	*Port* starts as a *UFP* (*Device*) operating as a *Sink* with R_d asserted and ***Port Data Role*** set to *UFP*. The *Policy Engine* directs the *Protocol Layer* to send a ***DR_Swap*** *Message*.	*Port* starts as a *DFP* (*Host*) operating as *Source* with R_p asserted and ***Port Data Role*** set to *DFP*.
2	*Protocol Layer* creates the ***DR_Swap*** *Message* and passes to *PHY Layer*.	
3	*PHY Layer* appends *CRC* and sends the ***DR_Swap*** *Message*. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the ***DR_Swap*** *Message* and checks the *CRC* to verify the *Message*.
4		*PHY Layer* removes the *CRC* and forwards the ***DR_Swap*** *Message* to the *Protocol Layer*.
5		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***DR_Swap*** *Message* information to the *Policy Engine* that consumes it.
6		*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.
7	*PHY Layer* receives the ***GoodCRC*** *Message* and checks the *CRC* to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.
8	*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.	
9	*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***DR_Swap*** *Message* was successfully sent. *Policy Engine* starts ***SenderResponseTimer***.	
10		*Policy Engine* evaluates the ***DR_Swap*** *Message* and decides that it is able and willing to do the *Data Role Swap* but not at this time. It tells the *Protocol Layer* to form a ***Wait*** *Message*.
11		*Protocol Layer* creates the ***Wait*** *Message* and passes to *PHY Layer*.
12	*PHY Layer* receives the ***Wait*** *Message* and checks the *CRC* to verify the *Message*.	*PHY Layer* appends a *CRC* and sends the ***Wait*** *Message*. Starts ***CRCReceiveTimer***.
13	*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Wait*** *Message* information to the *Policy Engine* that consumes it.	
14	The *Policy Engine* stops the ***SenderResponseTimer***.	
15	*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.	

Table 8.69 Steps for Data Role Swap with Wait, UFP operating as Sink initiates

Step	Initial UFP Sink Port	Initial DFP Source Port
16	*PHY Layer* appends a *CRC* and sends the ***GoodCRC*** *Message*.	*PHY Layer* receives ***GoodCRC*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
17		*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.
18		*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Wait*** *Message* was successfully sent.

8.3.2.9.2 Data Role Swap, Initiated by UFP Operating as Source

8.3.2.9.2.1 Data Role Swap, Initiated by UFP Operating as Source (Accept)

Figure 8.43, "Data Role Swap, UFP operating as Source initiates" shows an example sequence between a *Port*, which is initially a *UFP* (*Device*) and a *Source* (R_p asserted), and a *Port* which is initially a *DFP* (*Host*) and a *Sink* (R_d asserted). A *Data Role Swap* is initiated by the *UFP*. During the process the *Port Partner*s maintain their operation as either a *Source* or a *Sink* (power and R_p/R_d remain constant) but exchange *Data Role*s between *DFP* (*Host*) and *UFP* (*Device*).

Figure 8.43 Data Role Swap, UFP operating as Source initiates

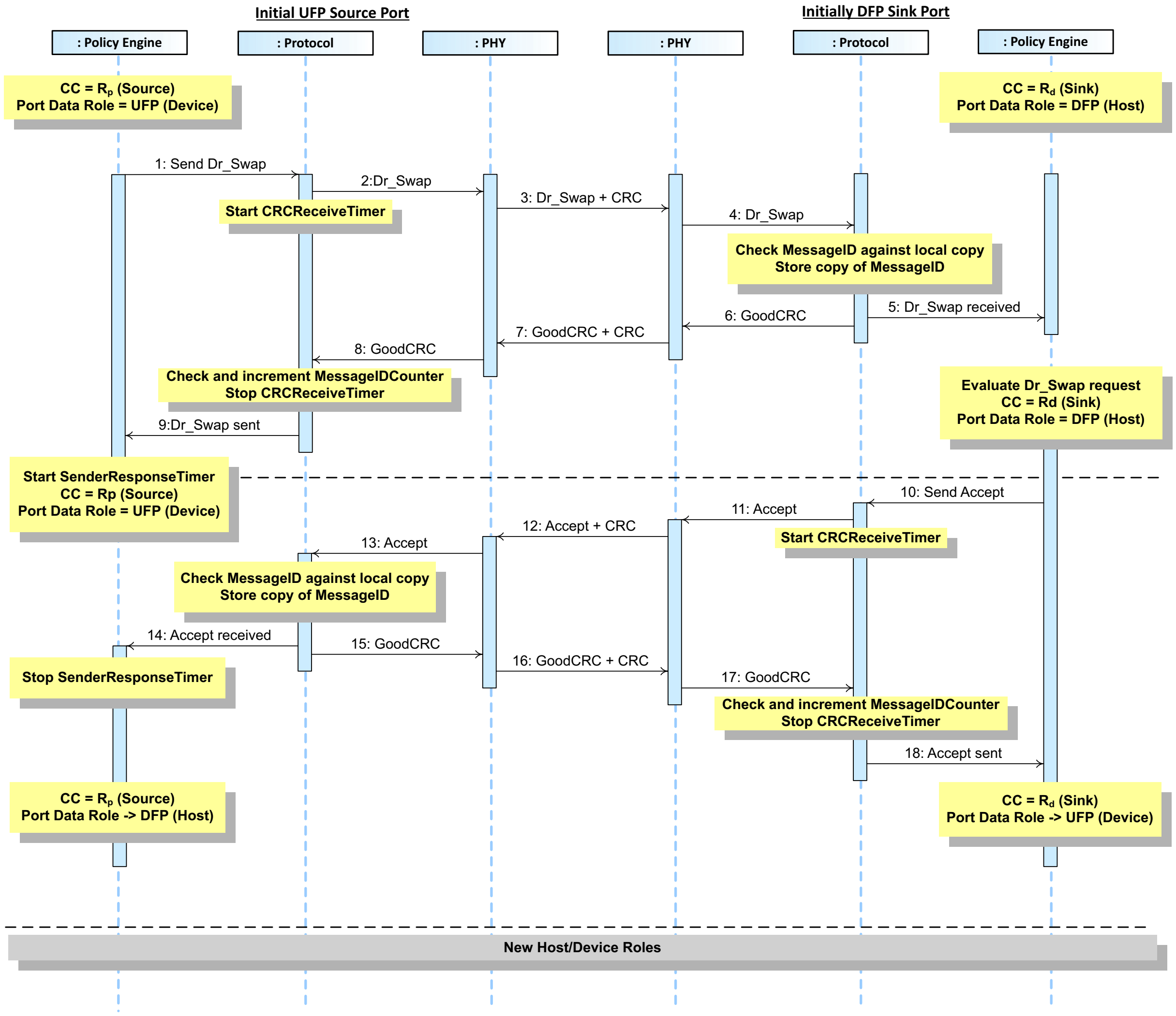


Table 8.70, "Steps for Data Role Swap, UFP operating as Source initiates" below provides a detailed explanation of what happens at each labeled step in *Figure 8.43, "Data Role Swap, UFP operating as Source initiates"* above.

Table 8.70 Steps for Data Role Swap, UFP operating as Source initiates

Step	Initial UFP Source Port	Initial DFP Sink Port
1	*Port* starts as a *UFP* (*Device*) operating as *Source* with R_p asserted and ***Port Data Role*** set to *UFP*. The *Policy Engine* directs the *Protocol Layer* to send a ***DR_Swap*** *Message*.	*Port* starts as a *DFP* (*Host*) operating as a *Sink* with R_d asserted and ***Port Data Role*** set to *DFP*.
2	*Protocol Layer* creates the ***DR_Swap*** *Message* and passes to *PHY Layer*.	
3	*PHY Layer* appends *CRC* and sends the ***DR_Swap*** *Message*. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the ***DR_Swap*** *Message* and checks the *CRC* to verify the *Message*.
4		*PHY Layer* removes the *CRC* and forwards the ***DR_Swap*** *Message* to the *Protocol Layer*.
5		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***DR_Swap*** *Message* information to the *Policy Engine* that consumes it.
6		*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.
7	*PHY Layer* receives the ***GoodCRC*** *Message* and checks the *CRC* to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.
8	*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.	
9	*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***DR_Swap*** *Message* was successfully sent. *Policy Engine* starts ***SenderResponseTimer***.	
10		*Policy Engine* evaluates the ***DR_Swap*** *Message* and decides that it is able and willing to do the *Data Role Swap*. It tells the *Protocol Layer* to form an ***Accept*** *Message*.
11		*Protocol Layer* creates the ***Accept*** *Message* and passes to *PHY Layer*.
12	*PHY Layer* receives the ***Accept*** *Message* and checks the *CRC* to verify the *Message*.	*PHY Layer* appends a *CRC* and sends the ***Accept*** *Message*. Starts ***CRCReceiveTimer***.
13	*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Accept*** *Message* information to the *Policy Engine* that consumes it.	
14	The *Policy Engine* stops the ***SenderResponseTimer***.	
15	*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.	
16	*PHY Layer* appends a *CRC* and sends the ***GoodCRC*** *Message*.	*PHY Layer* receives ***GoodCRC*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.

Table 8.70 Steps for Data Role Swap, UFP operating as Source initiates

Step	Initial UFP Source Port	Initial DFP Sink Port
17		*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.
18	The *Policy Engine* requests that *Data Role* is changed from *UFP* (*Device*) to *DFP* (*Host*). The Power Delivery *Data Role* is now a *DFP* (*Host*), and **Port Data Role** set to *DFP* and continues supplying power as a *Source* (R_p asserted).	*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Accept*** *Message* was successfully sent. The *Policy Engine* requests that the *Data Role* is changed to *UFP* (*Device*), with **Port Data Role** set to *UFP* and still operating as a *Sink* (R_p asserted).
The *Data Role Swap* is complete; the *Data Roles* have been reversed while maintaining the direction of power flow.		

8.3.2.9.2.2 Data Role Swap, Initiated by UFP Operating as Source (Reject)

Figure 8.44, "Rejected Data Role Swap, UFP operating as Source initiates" shows an example sequence between a *Port*, which is initially a *UFP* (*Device*) and a *Source* (R_p asserted), and a *Port* which is initially a *DFP* (*Host*) and a *Sink* (R_d asserted). A *Data Role Swap* is initiated by the *UFP*. During the process the *Port Partner*s maintain their operation as either a *Source* or a *Sink* (power and R_p/R_d remain constant) and the exchange of *Data Roles* is rejected.

Figure 8.44 Rejected Data Role Swap, UFP operating as Source initiates

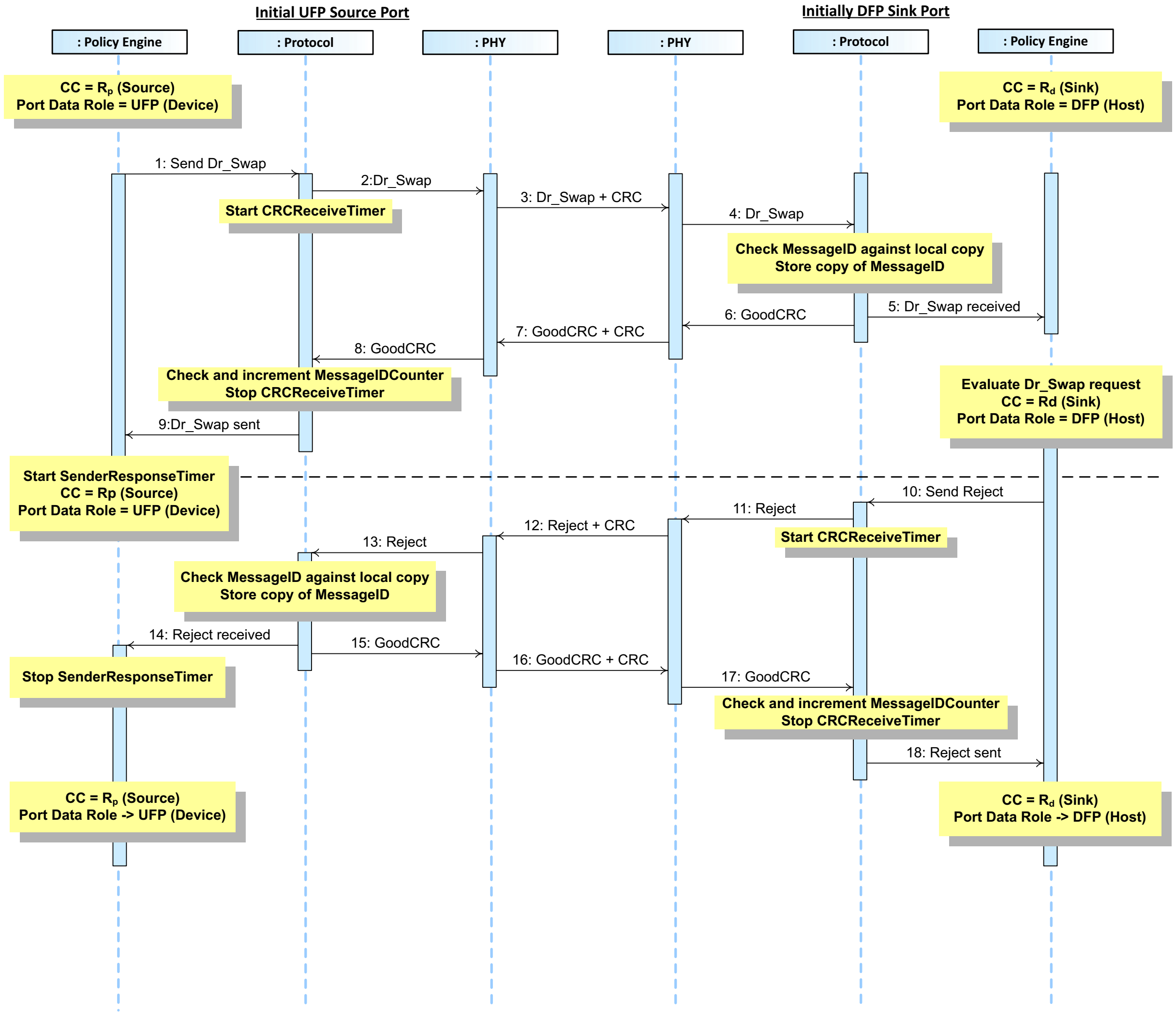


Table 8.71, "Steps for Rejected Data Role Swap, UFP operating as Source initiates" below provides a detailed explanation of what happens at each labeled step in *Figure 8.44, "Rejected Data Role Swap, UFP operating as Source initiates"* above.

Table 8.71 Steps for Rejected Data Role Swap, UFP operating as Source initiates

Step	Initial UFP Source Port	Initial DFP Sink Port
1	*Port* starts as a *UFP* (*Device*) operating as *Source* with R_p asserted and ***Port Data Role*** set to *UFP*. The *Policy Engine* directs the *Protocol Layer* to send a ***DR_Swap*** *Message*.	*Port* starts as a *DFP* (*Host*) operating as a *Sink* with R_d asserted and ***Port Data Role*** set to *DFP*.
2	*Protocol Layer* creates the ***DR_Swap*** *Message* and passes to *PHY Layer*.	
3	*PHY Layer* appends *CRC* and sends the ***DR_Swap*** *Message*. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the ***DR_Swap*** *Message* and checks the *CRC* to verify the *Message*.
4		*PHY Layer* removes the *CRC* and forwards the ***DR_Swap*** *Message* to the *Protocol Layer*.
5		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***DR_Swap*** *Message* information to the *Policy Engine* that consumes it.
6		*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.
7	*PHY Layer* receives the ***GoodCRC*** *Message* and checks the *CRC* to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.
8	*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.	
9	*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***DR_Swap*** *Message* was successfully sent. *Policy Engine* starts ***SenderResponseTimer***.	
10		*Policy Engine* evaluates the ***DR_Swap*** *Message* and decides that it is unable and unwilling to do the *Data Role Swap*. It tells the *Protocol Layer* to form a ***Reject*** *Message*.
11		*Protocol Layer* creates the ***Reject*** *Message* and passes to *PHY Layer*.
12	*PHY Layer* receives the ***Reject*** *Message* and checks the *CRC* to verify the *Message*.	*PHY Layer* appends a *CRC* and sends the ***Reject*** *Message*. Starts ***CRCReceiveTimer***.
13	*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Reject*** *Message* information to the *Policy Engine* that consumes it.	
14	The *Policy Engine* stops the ***SenderResponseTimer***.	
15	*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.	

Table 8.71 Steps for Rejected Data Role Swap, UFP operating as Source initiates

Step	Initial UFP Source Port	Initial DFP Sink Port
16	*PHY Layer* appends a *CRC* and sends the ***GoodCRC*** *Message*.	*PHY Layer* receives ***GoodCRC*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
17		*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.
18		*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Reject*** *Message* was successfully sent.

8.3.2.9.2.3 Data Role Swap, Initiated by UFP Operating as Source (Wait)

Figure 8.45, "Data Role Swap with Wait, UFP operating as Source initiates" shows an example sequence between a *Port*, which is initially a *UFP* (*Device*) and a *Source* (R_p asserted), and a *Port* which is initially a *DFP* (*Host*) and a *Sink* (R_d asserted). A *Data Role Swap* is initiated by the *UFP*. During the process the *Port Partner*s maintain their operation as either a *Source* or a *Sink* (power and R_p/R_d remain constant) and the exchange of *Data Roles* is delayed with a wait.

Figure 8.45 Data Role Swap with Wait, UFP operating as Source initiates

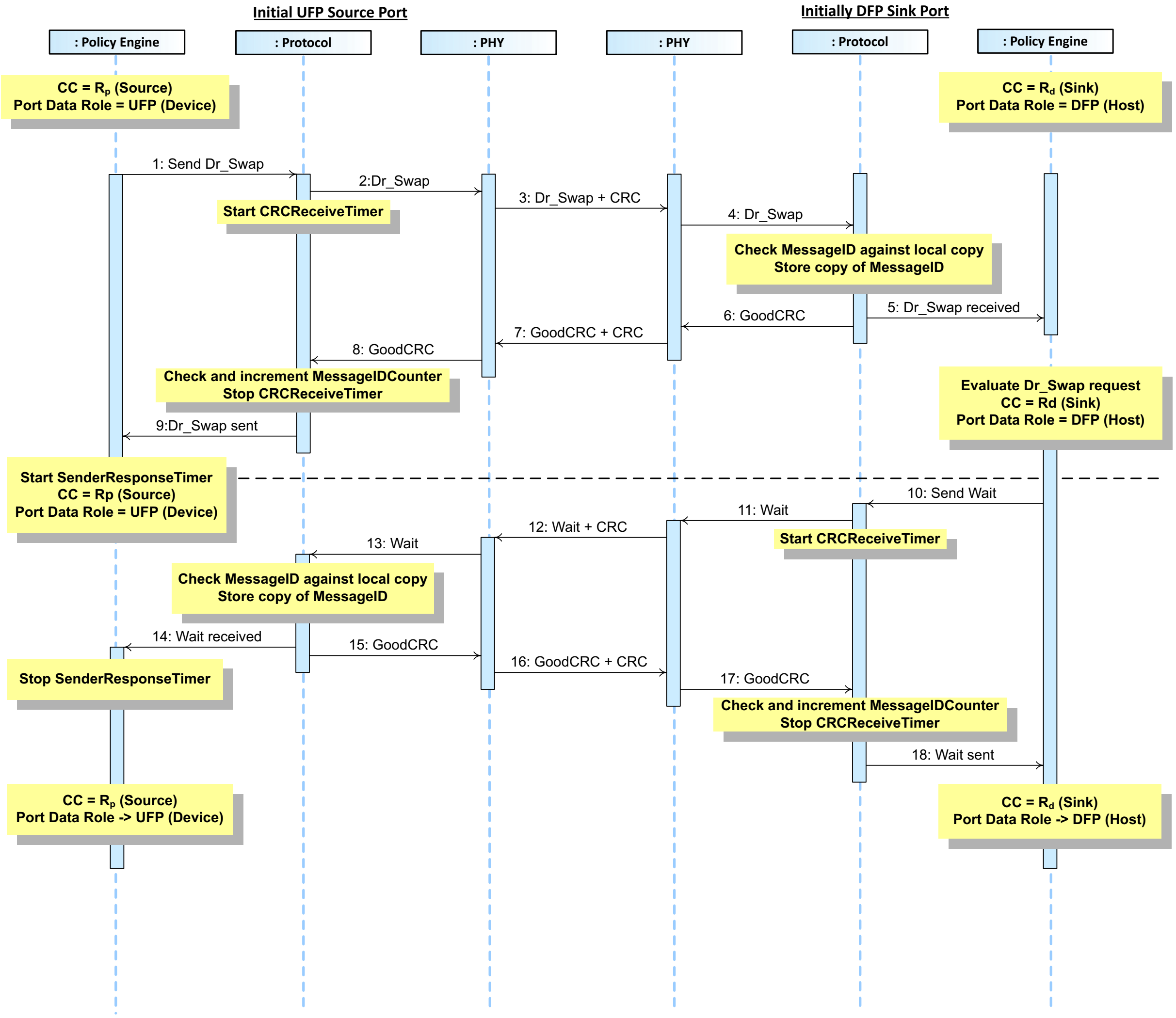


Table 8.72, "Steps for Data Role Swap with Wait, UFP operating as Source initiates" below provides a detailed explanation of what happens at each labeled step in *Figure 8.45, "Data Role Swap with Wait, UFP operating as Source initiates"* above.

Table 8.72 Steps for Data Role Swap with Wait, UFP operating as Source initiates

Step	Initial UFP Source Port	Initial DFP Sink Port
1	*Port* starts as a *UFP* (*Device*) operating as *Source* with R_p asserted and ***Port Data Role*** set to *UFP*. The *Policy Engine* directs the *Protocol Layer* to send a ***DR_Swap*** *Message*.	*Port* starts as a *DFP* (*Host*) operating as a *Sink* with R_d asserted and ***Port Data Role*** set to *DFP*.
2	*Protocol Layer* creates the ***DR_Swap*** *Message* and passes to *PHY Layer*.	
3	*PHY Layer* appends *CRC* and sends the ***DR_Swap*** *Message*. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the ***DR_Swap*** *Message* and checks the *CRC* to verify the *Message*.
4		*PHY Layer* removes the *CRC* and forwards the ***DR_Swap*** *Message* to the *Protocol Layer*.
5		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***DR_Swap*** *Message* information to the *Policy Engine* that consumes it.
6		*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.
7	*PHY Layer* receives the ***GoodCRC*** *Message* and checks the *CRC* to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.
8	*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.	
9	*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***DR_Swap*** *Message* was successfully sent. *Policy Engine* starts ***SenderResponseTimer***.	
10		*Policy Engine* evaluates the ***DR_Swap*** *Message* and decides that it is able and willing to do the *Data Role Swap*but not at this time. It tells the *Protocol Layer* to form a ***Wait*** *Message*.
11		*Protocol Layer* creates the ***Wait*** *Message* and passes to *PHY Layer*.
12	*PHY Layer* receives the ***Wait*** *Message* and checks the *CRC* to verify the *Message*.	*PHY Layer* appends a *CRC* and sends the ***Wait*** *Message*. Starts ***CRCReceiveTimer***.
13	*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Wait*** *Message* information to the *Policy Engine* that consumes it.	
14	The *Policy Engine* stops the ***SenderResponseTimer***.	
15	*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.	

Table 8.72 Steps for Data Role Swap with Wait, UFP operating as Source initiates

Step	Initial UFP Source Port	Initial DFP Sink Port
16	*PHY Layer* appends a *CRC* and sends the ***GoodCRC*** *Message*.	*PHY Layer* receives ***GoodCRC*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
17		*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.
18		*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Wait*** *Message* was successfully sent.

8.3.2.9.3 Data Role Swap, Initiated by DFP Operating as Source

8.3.2.9.3.1 Data Role Swap, Initiated by DFP Operating as Source (Accept)

Figure 8.46, "Data Role Swap, DFP operating as Source initiates" shows an example sequence between a *Port*, which is initially a *UFP* (*Device*) and a *Sink* (R_d asserted), and a *Port* which is initially a *DFP* and a *Source* (R_p asserted). A *Data Role Swap* is initiated by the *DFP*. During the process the *Port Partner*s maintain their operation as either a *Source* or a *Sink* (power and R_p/R_d remain constant) but exchange *Data Roles* between *DFP* (*Host*) and *UFP* (*Device*).

Figure 8.46 Data Role Swap, DFP operating as Source initiates

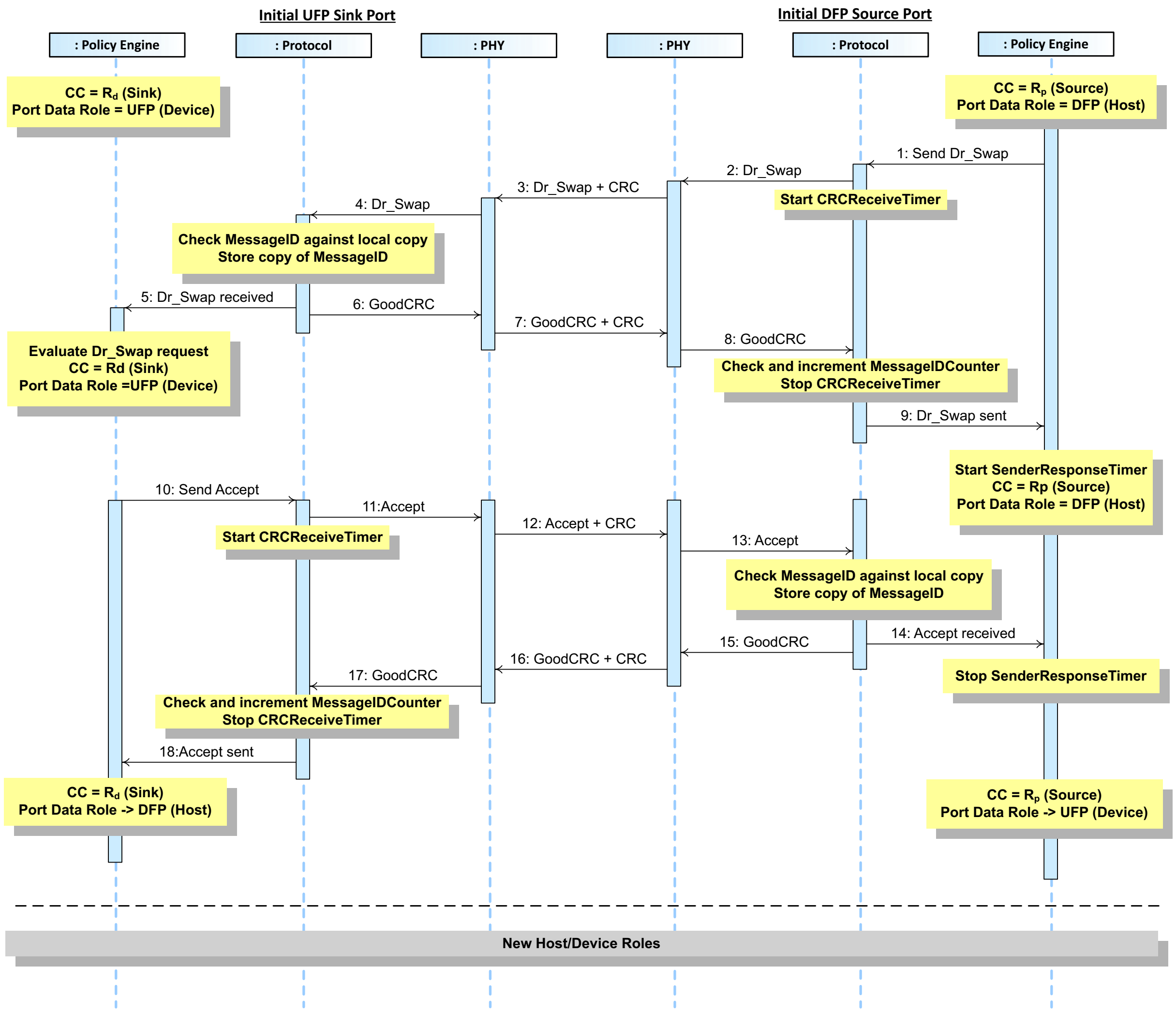


Table 8.73, "Steps for Data Role Swap, DFP operating as Source initiates" below provides a detailed explanation of what happens at each labeled step in *Figure 8.46, "Data Role Swap, DFP operating as Source initiates"* above.

Table 8.73 Steps for Data Role Swap, DFP operating as Source initiates

Step	Initial UFP Sink Port	Initial DFP Source Port
1	*Port* starts as a *UFP* (*Device*) operating as a *Sink* with R_d asserted and ***Port Data Role*** set to *UFP*.	*Port* starts as a *DFP* (*Host*) operating as *Source* with R_p asserted and ***Port Data Role*** set to *DFP*. The *Policy Engine* directs the *Protocol Layer* to send a ***DR_Swap*** *Message*.
2		*Protocol Layer* creates the ***DR_Swap*** *Message* and passes to *PHY Layer*.
3	*PHY Layer* receives the ***DR_Swap*** *Message* and checks the *CRC* to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***DR_Swap*** *Message*. Starts ***CRCReceiveTimer***.
4	*PHY Layer* removes the *CRC* and forwards the ***DR_Swap*** *Message* to the *Protocol Layer*.	
5	*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***DR_Swap*** *Message* information to the *Policy Engine* that consumes it.	
6	*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.	
7	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.	*PHY Layer* receives the ***GoodCRC*** *Message* and checks the *CRC* to verify the *Message*.
8		*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.
9		*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***DR_Swap*** *Message* was successfully sent. *Policy Engine* starts ***SenderResponseTimer***.
10	*Policy Engine* evaluates the ***DR_Swap*** *Message* and decides that it is able and willing to do the *Data Role Swap*. It tells the *Protocol Layer* to form an ***Accept*** *Message*.	
11	*Protocol Layer* creates the ***Accept*** *Message* and passes to *PHY Layer*.	
12	*PHY Layer* appends a *CRC* and sends the ***Accept*** *Message*. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the ***Accept*** *Message* and checks the *CRC* to verify the *Message*.
13		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Accept*** *Message* information to the *Policy Engine* that consumes it.
14		The *Policy Engine* stops the ***SenderResponseTimer***.
15		*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.
16	*PHY Layer* receives ***GoodCRC*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.	*PHY Layer* appends a *CRC* and sends the ***GoodCRC*** *Message*.

Table 8.73 Steps for Data Role Swap, DFP operating as Source initiates

Step	Initial UFP Sink Port	Initial DFP Source Port
17	*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.	
18	*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Accept*** *Message* was successfully sent. The *Policy Engine* requests that the *Data Role* is changed to *DFP* (*Host*), with ***Port Data Role*** set to *DFP*, still operating as a *Sink* (R_{d} asserted).	The *Policy Engine* requests that *Data Role* is changed from *DFP* (*Host*) to *UFP* (*Device*). The Power Delivery *Data Role* is now a *UFP* (*Device*), with ***Port Data Role*** set to *UFP* and continues supplying power as a *Source* (R_{p} asserted).
The *Data Role Swap* is complete; the *Data Roles* have been reversed while maintaining the direction of power flow.		

8.3.2.9.3.2 Data Role Swap, Initiated by DFP Operating as Source (Reject)

Figure 8.47, "Rejected Data Role Swap, DFP operating as Source initiates" shows an example sequence between a *Port*, which is initially a *UFP* (*Device*) and a *Sink* (R_d asserted), and a *Port* which is initially a *DFP* and a *Source* (R_p asserted). A *Data Role Swap* is initiated by the *DFP*. During the process the *Port Partners* maintain their operation as either a *Source* or a *Sink* (power and R_p/R_d remain constant) and the exchange of *Data Roles* is rejected.

Figure 8.47 Rejected Data Role Swap, DFP operating as Source initiates

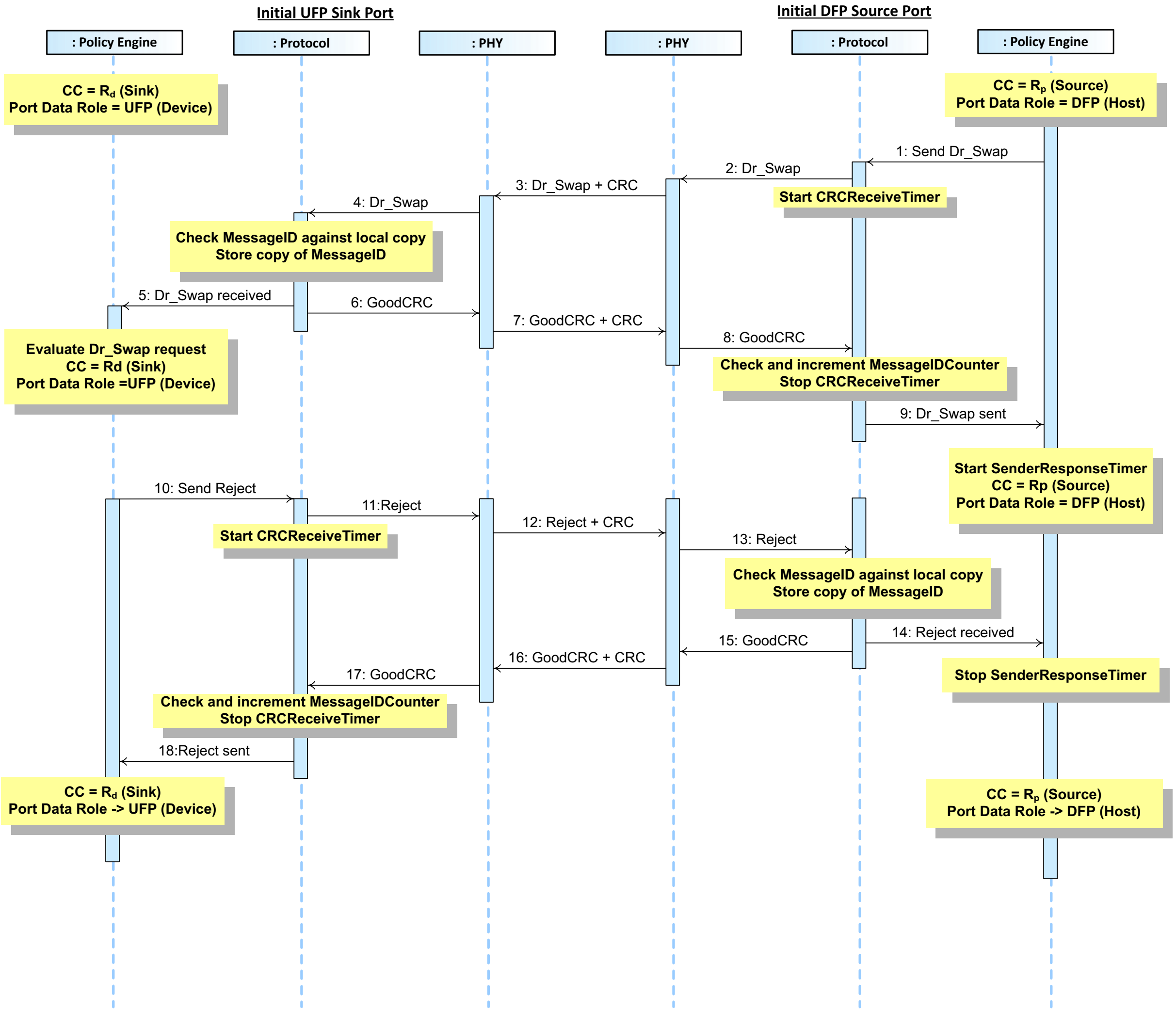


Table 8.74, "Steps for Rejected Data Role Swap, DFP operating as Source initiates" below provides a detailed explanation of what happens at each labeled step in *Figure 8.47, "Rejected Data Role Swap, DFP operating as Source initiates"* above.

Table 8.74 Steps for Rejected Data Role Swap, DFP operating as Source initiates

Step	Initial UFP Sink Port	Initial DFP Source Port
1	*Port* starts as a *UFP* (*Device*) operating as a *Sink* with R_d asserted and ***Port Data Role*** set to *UFP*.	*Port* starts as a *DFP* (*Host*) operating as *Source* with R_p asserted and ***Port Data Role*** set to *DFP*. The *Policy Engine* directs the *Protocol Layer* to send a ***DR_Swap*** *Message*.
2		*Protocol Layer* creates the ***DR_Swap*** *Message* and passes to *PHY Layer*.
3	*PHY Layer* receives the ***DR_Swap*** *Message* and checks the *CRC* to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***DR_Swap*** *Message*. Starts ***CRCReceiveTimer***.
4	*PHY Layer* removes the *CRC* and forwards the ***DR_Swap*** *Message* to the *Protocol Layer*.	
5	*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***DR_Swap*** *Message* information to the *Policy Engine* that consumes it.	
6	*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.	
7	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.	*PHY Layer* receives the ***GoodCRC*** *Message* and checks the *CRC* to verify the *Message*.
8		*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.
9		*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***DR_Swap*** *Message* was successfully sent. *Policy Engine* starts ***SenderResponseTimer***.
10	*Policy Engine* evaluates the ***DR_Swap*** *Message* and decides that it is unable and unwilling to do the *Data Role Swap*. It tells the *Protocol Layer* to form an ***Reject*** *Message*.	
11	*Protocol Layer* creates the ***Reject*** *Message* and passes to *PHY Layer*.	
12	*PHY Layer* appends a *CRC* and sends the ***Reject*** *Message*. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the ***Reject*** *Message* and checks the *CRC* to verify the *Message*.
13		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Reject*** *Message* information to the *Policy Engine* that consumes it.
14		The *Policy Engine* stops the ***SenderResponseTimer***.
15		*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.

Table 8.74 Steps for Rejected Data Role Swap, DFP operating as Source initiates

Step	Initial UFP Sink Port	Initial DFP Source Port
16	*PHY Layer* receives ***GoodCRC*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.	*PHY Layer* appends a *CRC* and sends the ***GoodCRC*** *Message*.
17	*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.	
18	*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Reject*** *Message* was successfully sent.	

8.3.2.9.3.3 Data Role Swap, Initiated by DFP Operating as Source (Wait)

Figure 8.48, "Data Role Swap with Wait, DFP operating as Source initiates" shows an example sequence between a *Port*, which is initially a *UFP* (*Device*) and a *Sink* (R_d asserted), and a *Port* which is initially a *DFP* and a *Source* (R_p asserted). A *Data Role Swap* is initiated by the *DFP*. During the process the *Port Partner*s maintain their operation as either a *Source* or a *Sink* (power and R_p/R_d remain constant) and the exchange of *Data Roles* is delayed by wait.

Figure 8.48 Data Role Swap with Wait, DFP operating as Source initiates

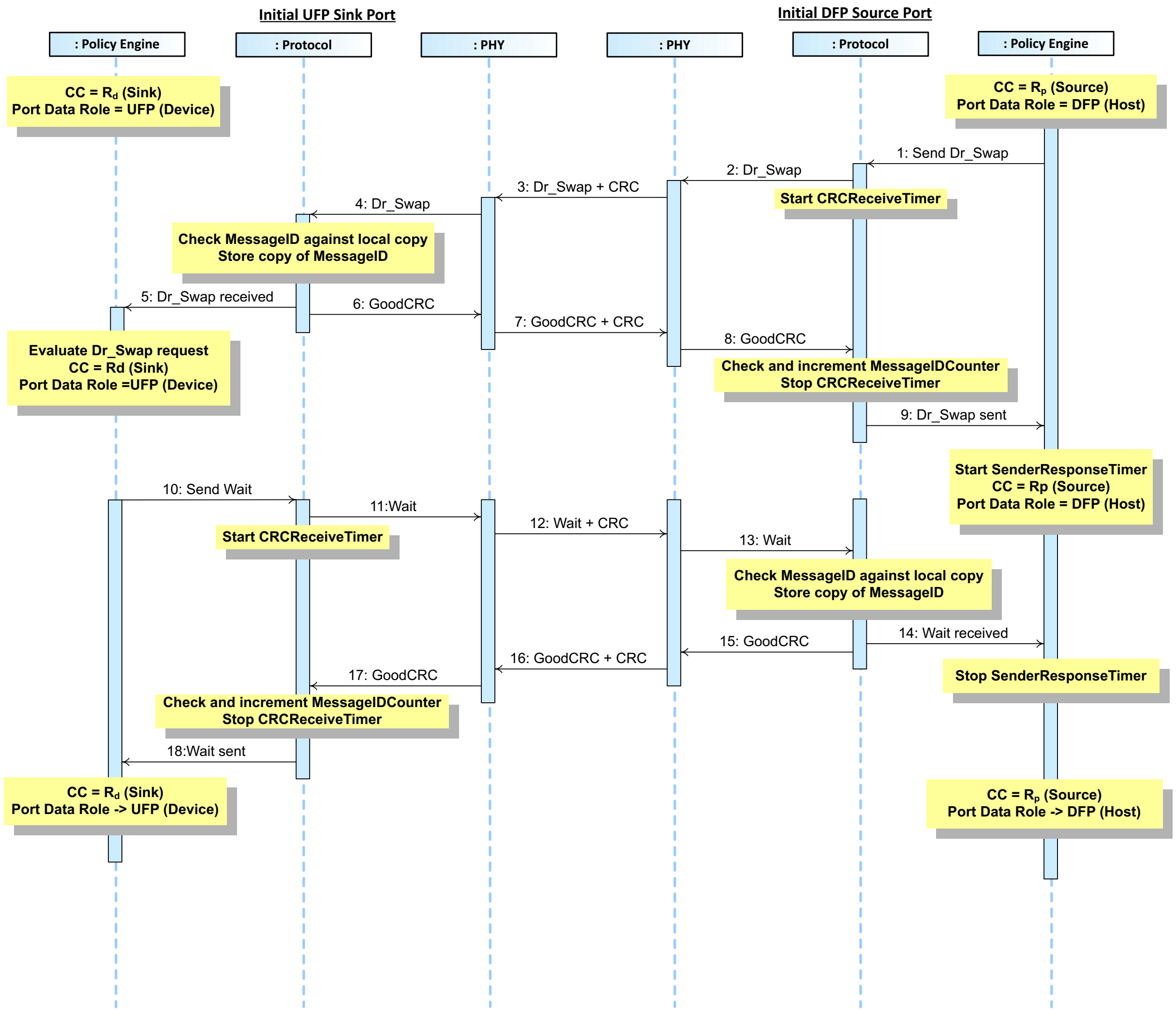


Table 8.75, "Steps for Data Role Swap with Wait, DFP operating as Source initiates" below provides a detailed explanation of what happens at each labeled step in *Figure 8.48, "Data Role Swap with Wait, DFP operating as Source initiates"* above.

Table 8.75 Steps for Data Role Swap with Wait, DFP operating as Source initiates

Step	Initial UFP Sink Port	Initial DFP Source Port
1	*Port* starts as a *UFP* (*Device*) operating as a *Sink* with R_d asserted and ***Port Data Role*** set to *UFP*.	*Port* starts as a *DFP* (*Host*) operating as *Source* with R_p asserted and ***Port Data Role*** set to *DFP*. The *Policy Engine* directs the *Protocol Layer* to send a ***DR_Swap*** *Message*.
2		*Protocol Layer* creates the ***DR_Swap*** *Message* and passes to *PHY Layer*.
3	*PHY Layer* receives the ***DR_Swap*** *Message* and checks the *CRC* to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***DR_Swap*** *Message*. Starts ***CRCReceiveTimer***.
4	*PHY Layer* removes the *CRC* and forwards the ***DR_Swap*** *Message* to the *Protocol Layer*.	
5	*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***DR_Swap*** *Message* information to the *Policy Engine* that consumes it.	
6	*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.	
7	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.	*PHY Layer* receives the ***GoodCRC*** *Message* and checks the *CRC* to verify the *Message*.
8		*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.
9		*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***DR_Swap*** *Message* was successfully sent. *Policy Engine* starts ***SenderResponseTimer***.
10	*Policy Engine* evaluates the ***DR_Swap*** *Message* and decides that it is able and willing to do the *Data Role Swap*but not at this time. It tells the *Protocol Layer* to form an ***Wait*** *Message*.	
11	*Protocol Layer* creates the ***Wait*** *Message* and passes to *PHY Layer*.	
12	*PHY Layer* appends a *CRC* and sends the ***Wait*** *Message*. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the ***Wait*** *Message* and checks the *CRC* to verify the *Message*.
13		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Wait*** *Message* information to the *Policy Engine* that consumes it.
14		The *Policy Engine* stops the ***SenderResponseTimer***.
15		*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.
16	*PHY Layer* receives ***GoodCRC*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.	*PHY Layer* appends a *CRC* and sends the ***GoodCRC*** *Message*.

Table 8.75 Steps for Data Role Swap with Wait, DFP operating as Source initiates

Step	Initial UFP Sink Port	Initial DFP Source Port
17	*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.	
18	*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Wait*** *Message* was successfully sent.	

8.3.2.9.4 Data Role Swap, Initiated by DFP Operating as Sink

8.3.2.9.4.1 Data Role Swap, Initiated by DFP Operating as Sink (Accept)

Figure 8.49, "Data Role Swap, DFP operating as Sink initiates" shows an example sequence between a *Port*, which is initially a *UFP* (*Device*) and a *Source* (R_p asserted), and a *Port* which is initially a *DFP* (*Host*) and a *Sink* (R_d asserted). A *Data Role Swap* is initiated by the *DFP*. During the process the *Port Partner*s maintain their operation as either a *Source* or a *Sink* (power and R_p/R_d remain constant) but exchange *Data Roles* between *DFP* (*Host*) and *UFP* (*Device*).

Figure 8.49 Data Role Swap, DFP operating as Sink initiates

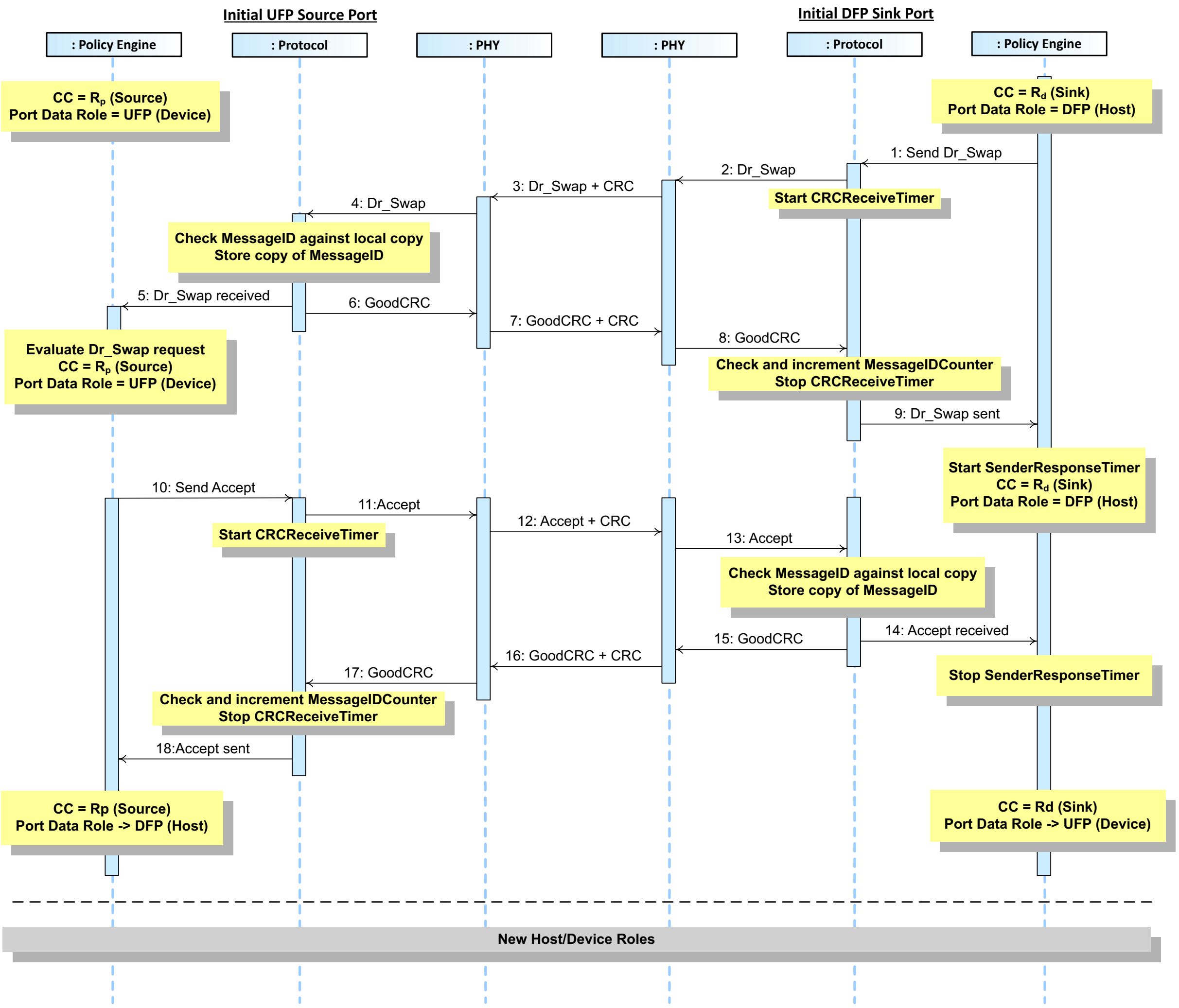


Table 8.76, "Steps for Data Role Swap, DFP operating as Sink initiates" below provides a detailed explanation of what happens at each labeled step in *Figure 8.49, "Data Role Swap, DFP operating as Sink initiates"* above.

Table 8.76 Steps for Data Role Swap, DFP operating as Sink initiates

Step	Initial UFP Source Port	Initial DFP Sink Port
1	*Port* starts as a *UFP* (*Device*) operating as *Source* with R_p asserted and ***Port Data Role*** set to *UFP*.	*Port* starts as a *DFP* (*Host*) operating as a *Sink* with R_d asserted and ***Port Data Role*** set to *DFP*. The *Policy Engine* directs the *Protocol Layer* to send a ***DR_Swap*** *Message*.
2		*Protocol Layer* creates the ***DR_Swap*** *Message* and passes to *PHY Layer*.
3	*PHY Layer* receives the ***DR_Swap*** *Message* and checks the *CRC* to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***DR_Swap*** *Message*. Starts ***CRCReceiveTimer***.
4	*PHY Layer* removes the *CRC* and forwards the ***DR_Swap*** *Message* to the *Protocol Layer*.	
5	*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***DR_Swap*** *Message* information to the *Policy Engine* that consumes it.	
6	*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.	
7	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.	*PHY Layer* receives the ***GoodCRC*** *Message* and checks the *CRC* to verify the *Message*.
8		*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.
9		*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***DR_Swap*** *Message* was successfully sent. *Policy Engine* starts ***SenderResponseTimer***.
10	*Policy Engine* evaluates the ***DR_Swap*** *Message* and decides that it is able and willing to do the *Data Role Swap*. It tells the *Protocol Layer* to form an ***Accept*** *Message*.	
11	*Protocol Layer* creates the ***Accept*** *Message* and passes to *PHY Layer*.	
12	*PHY Layer* appends a *CRC* and sends the ***Accept*** *Message*. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the ***Accept*** *Message* and checks the *CRC* to verify the *Message*.
13		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Accept*** *Message* information to the *Policy Engine* that consumes it.
14		The *Policy Engine* stops the ***SenderResponseTimer***.
15		*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.
16	*PHY Layer* receives ***GoodCRC*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.	*PHY Layer* appends a *CRC* and sends the ***GoodCRC*** *Message*.

Table 8.76 Steps for Data Role Swap, DFP operating as Sink initiates

Step	Initial UFP Source Port	Initial DFP Sink Port
17	*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.	
18	*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Accept*** *Message* was successfully sent. The *Policy Engine* requests that the *Data Role* is changed to *DFP* (*Host*), with ***Port Data Role*** set to *DFP* and continues supplying power as a *Source* (R_p asserted).	The *Policy Engine* requests that *Data Role* is changed from *DFP* (*Host*) to *UFP* (*Device*). The Power Delivery *Data Role* is now a *UFP* (*Device*), with ***Port Data Role*** set to *UFP*, still operating as a *Sink* (R_d asserted).
The *Data Role Swap* is complete; the *Data Roles* have been reversed while maintaining the direction of power flow.		

8.3.2.9.4.2 Data Role Swap, Initiated by DFP Operating as Sink (Reject)

Figure 8.50, "Rejected Data Role Swap, DFP operating as Sink initiates" shows an example sequence between a *Port*, which is initially a *UFP* (*Device*) and a *Source* (R_p asserted), and a *Port* which is initially a *DFP* (*Host*) and a *Sink* (R_d asserted). A *Data Role Swap* is initiated by the *DFP*. During the process the *Port Partner*s maintain their operation as either a *Source* or a *Sink* (power and R_p/R_d remain constant) and the exchange of *Data Roles* is rejected.

Figure 8.50 Rejected Data Role Swap, DFP operating as Sink initiates

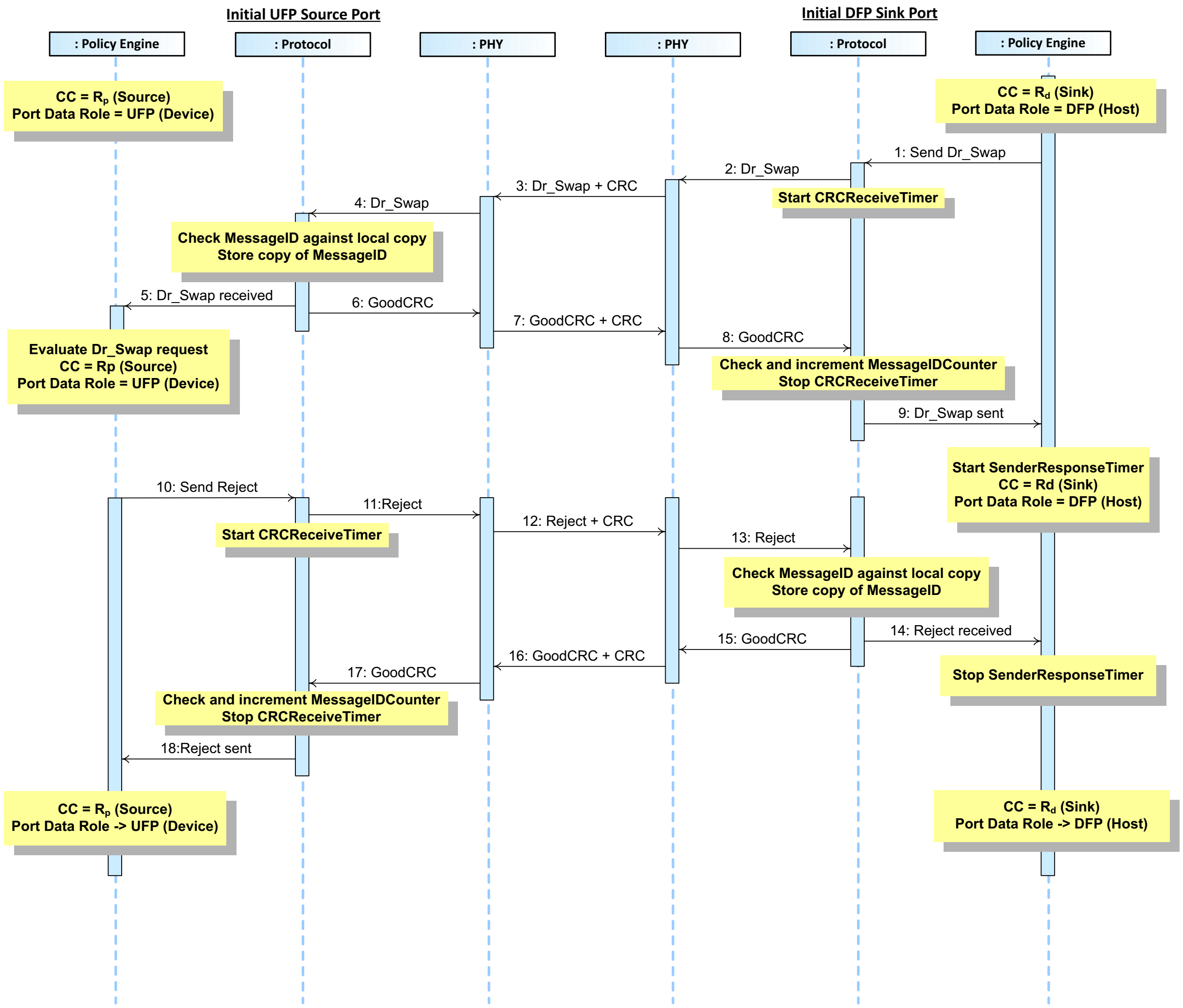


Table 8.77, "Steps for Rejected Data Role Swap, DFP operating as Sink initiates" below provides a detailed explanation of what happens at each labeled step in *Figure 8.50, "Rejected Data Role Swap, DFP operating as Sink initiates"* above.

Table 8.77 Steps for Rejected Data Role Swap, DFP operating as Sink initiates

Step	Initial UFP Source Port	Initial DFP Sink Port
1	*Port* starts as a *UFP* (*Device*) operating as *Source* with R_p asserted and ***Port Data Role*** set to *UFP*.	*Port* starts as a *DFP* (*Host*) operating as a *Sink* with R_d asserted and ***Port Data Role*** set to *DFP*. The *Policy Engine* directs the *Protocol Layer* to send a ***DR_Swap*** *Message*.
2		*Protocol Layer* creates the ***DR_Swap*** *Message* and passes to *PHY Layer*.
3	*PHY Layer* receives the ***DR_Swap*** *Message* and checks the *CRC* to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***DR_Swap*** *Message*. Starts ***CRCReceiveTimer***.
4	*PHY Layer* removes the *CRC* and forwards the ***DR_Swap*** *Message* to the *Protocol Layer*.	
5	*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***DR_Swap*** *Message* information to the *Policy Engine* that consumes it.	
6	*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.	
7	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.	*PHY Layer* receives the ***GoodCRC*** *Message* and checks the *CRC* to verify the *Message*.
8		*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.
9		*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***DR_Swap*** *Message* was successfully sent. *Policy Engine* starts ***SenderResponseTimer***.
10	*Policy Engine* evaluates the ***DR_Swap*** *Message* and decides that it is unable and unwilling to do the *Data Role Swap*. It tells the *Protocol Layer* to form an ***Reject*** *Message*.	
11	*Protocol Layer* creates the ***Reject*** *Message* and passes to *PHY Layer*.	
12	*PHY Layer* appends a *CRC* and sends the ***Reject*** *Message*. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the ***Reject*** *Message* and checks the *CRC* to verify the *Message*.
13		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Reject*** *Message* information to the *Policy Engine* that consumes it.
14		The *Policy Engine* stops the ***SenderResponseTimer***.
15		*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.

Table 8.77 Steps for Rejected Data Role Swap, DFP operating as Sink initiates

Step	Initial UFP Source Port	Initial DFP Sink Port
16	*PHY Layer* receives ***GoodCRC*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.	*PHY Layer* appends a *CRC* and sends the ***GoodCRC*** *Message*.
17	*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.	
18	*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Reject*** *Message* was successfully sent.	

8.3.2.9.4.3 Data Role Swap, Initiated by DFP Operating as Sink (Wait)

Figure 8.51, "Data Role Swap with Wait, DFP operating as Sink initiates" shows an example sequence between a *Port*, which is initially a *UFP* (*Device*) and a *Source* (R_p asserted), and a *Port* which is initially a *DFP* (*Host*) and a *Sink* (R_d asserted). A *Data Role Swap* is initiated by the *DFP*. During the process the *Port Partner*s maintain their operation as either a *Source* or a *Sink* (power and R_p/R_d remain constant) and the exchange of *Data Roles* is delayed with a wait.

Figure 8.51 Data Role Swap with Wait, DFP operating as Sink initiates

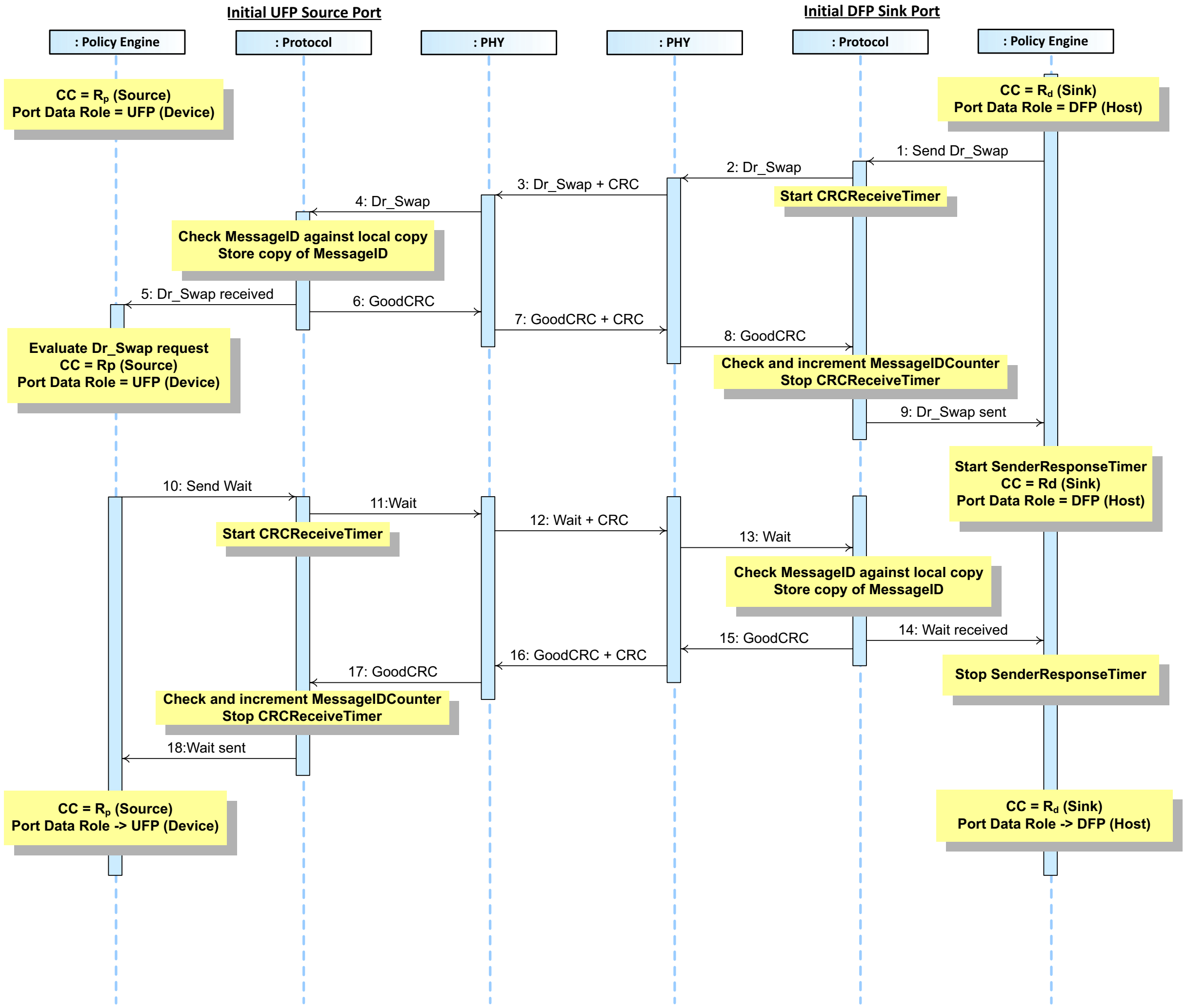


Table 8.78, "Steps for Data Role Swap with Wait, DFP operating as Sink initiates" below provides a detailed explanation of what happens at each labeled step in *Figure 8.51, "Data Role Swap with Wait, DFP operating as Sink initiates"* above.

Table 8.78 Steps for Data Role Swap with Wait, DFP operating as Sink initiates

Step	Initial UFP Source Port	Initial DFP Sink Port
1	*Port* starts as a *UFP* (*Device*) operating as *Source* with R_p asserted and ***Port Data Role*** set to *UFP*.	*Port* starts as a *DFP* (*Host*) operating as a *Sink* with R_d asserted and ***Port Data Role*** set to *DFP*. The *Policy Engine* directs the *Protocol Layer* to send a ***DR_Swap*** *Message*.
2		*Protocol Layer* creates the ***DR_Swap*** *Message* and passes to *PHY Layer*.
3	*PHY Layer* receives the ***DR_Swap*** *Message* and checks the *CRC* to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***DR_Swap*** *Message*. Starts ***CRCReceiveTimer***.
4	*PHY Layer* removes the *CRC* and forwards the ***DR_Swap*** *Message* to the *Protocol Layer*.	
5	*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***DR_Swap*** *Message* information to the *Policy Engine* that consumes it.	
6	*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.	
7	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.	*PHY Layer* receives the ***GoodCRC*** *Message* and checks the *CRC* to verify the *Message*.
8		*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.
9		*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***DR_Swap*** *Message* was successfully sent. *Policy Engine* starts ***SenderResponseTimer***.
10	*Policy Engine* evaluates the ***DR_Swap*** *Message* and decides that it is able and willing to do the *Data Role Swap*but not at this time. It tells the *Protocol Layer* to form a ***Wait*** *Message*.	
11	*Protocol Layer* creates the ***Wait*** *Message* and passes to *PHY Layer*.	
12	*PHY Layer* appends a *CRC* and sends the ***Wait*** *Message*. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the ***Wait*** *Message* and checks the *CRC* to verify the *Message*.
13		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Reject*** *Message* information to the *Policy Engine* that consumes it.
14		The *Policy Engine* stops the ***SenderResponseTimer***.
15		*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.

Table 8.78 Steps for Data Role Swap with Wait, DFP operating as Sink initiates

Step	Initial UFP Source Port	Initial DFP Sink Port
16	*PHY Layer* receives ***GoodCRC*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.	*PHY Layer* appends a *CRC* and sends the ***GoodCRC*** *Message*.
17	*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.	
18	*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Wait*** *Message* was successfully sent.	

8.3.2.10 VCONN Swap

8.3.2.10.1 VCONN Source Swap, initiated by VCONN Source

8.3.2.10.1.1 VCONN Source Swap, initiated by VCONN Source (Accept)

Figure 8.52, "Successful VCONN Source Swap, initiated by VCONN Source" shows an example sequence where the *VCONN Source* and tells its *Port Partner* to supply *VCONN*. During the process the *Port Partner*s, keep their *Power Role* as *Source* or *Sink*, maintain their operation as either a *Source* or a *Sink* (power remains constant) but exchange the *VCONN Source* role.

Figure 8.52 Successful VCONN Source Swap, initiated by VCONN Source

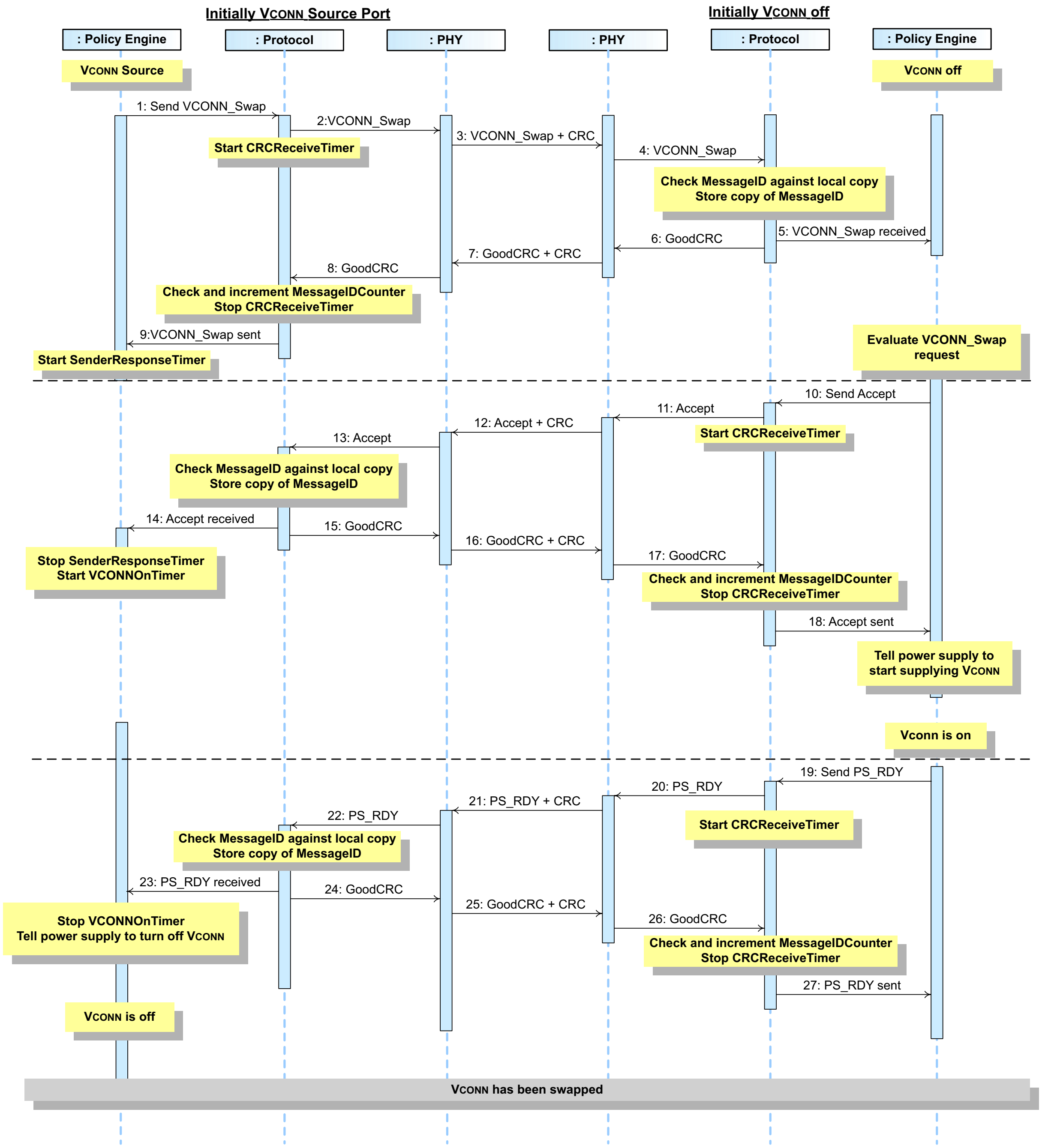


Table 8.79, "Steps for Source to Sink VCONN Source Swap" below provides a detailed explanation of what happens at each labeled step in *Figure 8.52, "Successful VCONN Source Swap, initiated by VCONN Source"* above.

Table 8.79 Steps for Source to Sink VCONN Source Swap

Step	Initially VCONN Source	Initially VCONN off
1	The *VCONN Source*'s *Policy Engine* directs the *Protocol Layer* to send a ***VCONN_Swap*** *Message*.	*VCONN* is off.
2	*Protocol Layer* creates the ***VCONN_Swap*** *Message* and passes to *PHY Layer*.	
3	*PHY Layer* appends *CRC* and sends the ***VCONN_Swap*** *Message*. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the ***VCONN_Swap*** *Message* and checks the *CRC* to verify the *Message*.
4		*PHY Layer* removes the *CRC* and forwards the ***VCONN_Swap*** *Message* to the *Protocol Layer*.
5		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***VCONN_Swap*** *Message* information to the *Policy Engine* that consumes it.
6		*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.
7	*PHY Layer* receives the ***GoodCRC*** *Message* and checks the *CRC* to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.
8	*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.	
9	*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***VCONN_Swap*** *Message* was successfully sent. *Policy Engine* starts ***SenderResponseTimer***.	
10		*Policy Engine* evaluates the ***VCONN_Swap*** *Message* sent by the *Source* and decides that it is able and willing to do the *VCONN Swap*. It tells the *Protocol Layer* to form an ***Accept*** *Message*.
11		*Protocol Layer* creates the *Message* and passes to *PHY Layer*.
12	*PHY Layer* receives the ***Accept*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.	*PHY Layer* appends a *CRC* and sends the ***Accept*** *Message*. Starts ***CRCReceiveTimer***.
13	*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Accept*** *Message* information to the *Policy Engine* that consumes it.	
14	The *Policy Engine* stops the ***SenderResponseTimer*** and starts the ***VCONNOnTimer***.	
15	*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.	
16	*PHY Layer* appends a *CRC* and sends the ***GoodCRC*** *Message*.	*PHY Layer* receives ***GoodCRC*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.

Table 8.79 Steps for Source to Sink VCONN Source Swap

Step	Initially VCONN Source	Initially VCONN off
17		*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.
18		*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Accept*** *Message* was successfully sent. The *Policy Engine* asks the *DPM* to turn on *VCONN*.
19		The *DPM* informs the *Policy Engine* that its power supply is supplying *VCONN*. The *Policy Engine* directs the *Protocol Layer* to generate a ***PS_RDY*** *Message* to tell the *Source* it can turn off *VCONN*.
20		*Protocol Layer* creates the ***PS_RDY*** *Message* and passes to *PHY Layer*.
21	*PHY Layer* receives the ***PS_RDY*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.	*PHY Layer* appends a *CRC* and sends the ***PS_RDY*** *Message*. Starts ***CRCReceiveTimer***.
22	*PHY Layer* removes the *CRC* and forwards the ***PS_RDY*** *Message* to the *Protocol Layer*.	
23	*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***PS_RDY*** *Message* information to the *Policy Engine* that consumes it.	
24	*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.	
25	*PHY Layer* appends a *CRC* and sends the ***GoodCRC*** *Message*. The *Policy Engine* stops the ***VCONNOnTimer***, and tells the power supply to stop sourcing *VCONN*.	*PHY Layer* receives ***GoodCRC*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
26		*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.
27	*VCONN* is off.	*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***PS_RDY*** *Message* was successfully sent.
The *Port Partners* have swapped *VCONN Source* role.		

8.3.2.10.1.2 VCONN Source Swap, initiated by VCONN Source (Reject)

Figure 8.53, "Rejected VCONN Source Swap, initiated by VCONN Source" shows an example sequence where the *VCONN Source* and tells its *Port Partner* to supply *VCONN* and is rejected. During the process the *Port Partners*, keep their *Power Role* as *Source* or *Sink*, maintain their operation as either a *Source* or a *Sink* (power remains constant) and don't exchange the *VCONN Source* role.

Figure 8.53 Rejected VCONN Source Swap, initiated by VCONN Source

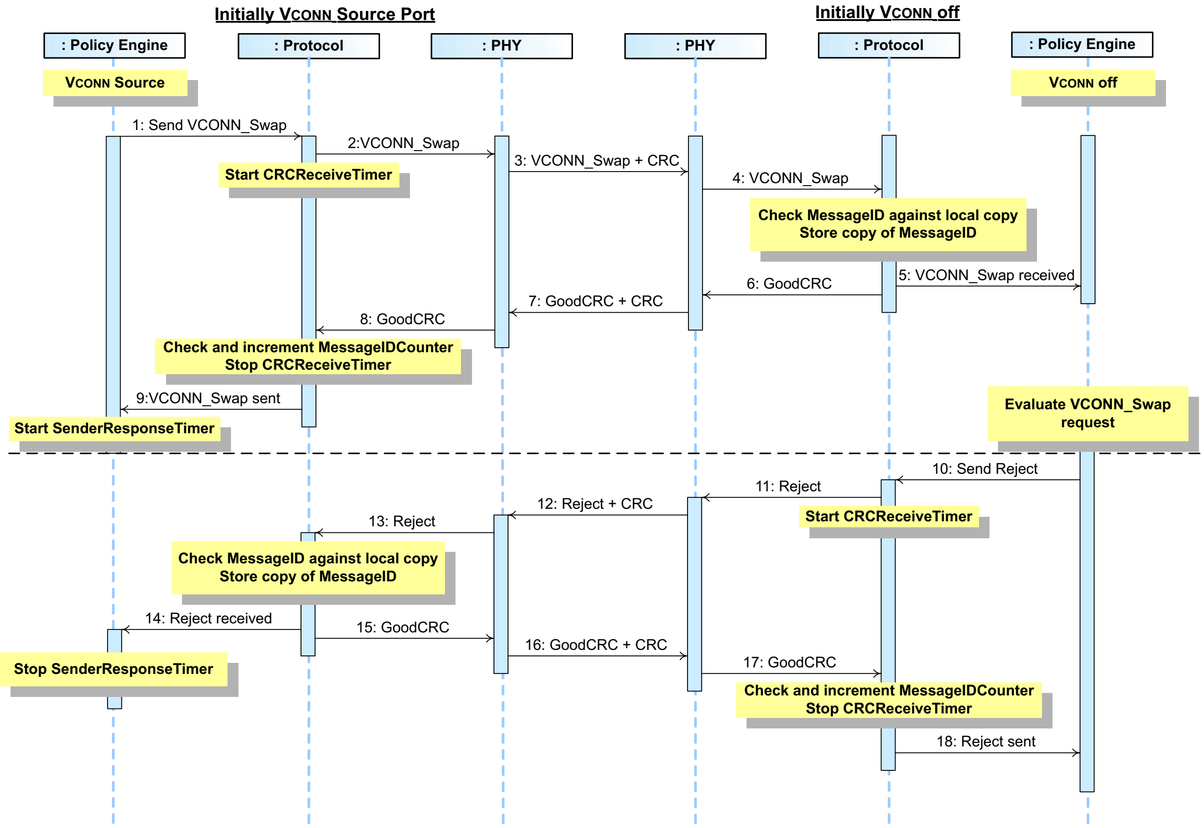


Table 8.80, "Steps for Rejected VCONN Source Swap" below provides a detailed explanation of what happens at each labeled step in *Figure 8.53, "Rejected VCONN Source Swap, initiated by VCONN Source"* above.

Table 8.80 Steps for Rejected VCONN Source Swap

Step	Initially VCONN Source	Initially VCONN off
1	The *VCONN Source*'s *Policy Engine* directs the *Protocol Layer* to send a ***VCONN_Swap*** *Message*.	*VCONN* is off.
2	*Protocol Layer* creates the ***VCONN_Swap*** *Message* and passes to *PHY Layer*.	
3	*PHY Layer* appends *CRC* and sends the ***VCONN_Swap*** *Message*. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the ***VCONN_Swap*** *Message* and checks the *CRC* to verify the *Message*.
4		*PHY Layer* removes the *CRC* and forwards the ***VCONN_Swap*** *Message* to the *Protocol Layer*.
5		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***VCONN_Swap*** *Message* information to the *Policy Engine* that consumes it.
6		*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.
7	*PHY Layer* receives the ***GoodCRC*** *Message* and checks the *CRC* to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.
8	*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.	
9	*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***VCONN_Swap*** *Message* was successfully sent. *Policy Engine* starts ***SenderResponseTimer***.	
10		*Policy Engine* evaluates the ***VCONN_Swap*** *Message* sent by the *Source* and decides that it is unable and unwilling to do the *VCONN Swap*. It tells the *Protocol Layer* to form an ***Reject*** *Message*.
11		*Protocol Layer* creates the *Message* and passes to *PHY Layer*.
12	*PHY Layer* receives the ***Reject*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.	*PHY Layer* appends a *CRC* and sends the ***Reject*** *Message*. Starts ***CRCReceiveTimer***.
13	*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Reject*** *Message* information to the *Policy Engine* that consumes it.	
14	The *Policy Engine* stops the ***SenderResponseTimer*** and starts the ***VCONNOnTimer***.	
15	*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.	
16	*PHY Layer* appends a *CRC* and sends the ***GoodCRC*** *Message*.	*PHY Layer* receives ***GoodCRC*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.

Table 8.80 Steps for Rejected VCONN Source Swap

Step	Initially VCONN Source	Initially VCONN off
17		*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.
18		*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Reject*** *Message* was successfully sent

8.3.2.10.1.3 VCONN Source Swap, initiated by VCONN Source (Wait)

Figure 8.54, "VCONN Source Swap with Wait, initiated by VCONN Source" shows an example sequence where the *VCONN Source* and tells its *Port Partner* to supply *VCONN* and is told to wait. During the process the *Port Partner*s, keep their *Power Role* as *Source* or *Sink*, maintain their operation as either a *Source* or a *Sink* (power remains constant) and don't exchange the *VCONN Source* role.

Figure 8.54 VCONN Source Swap with Wait, initiated by VCONN Source

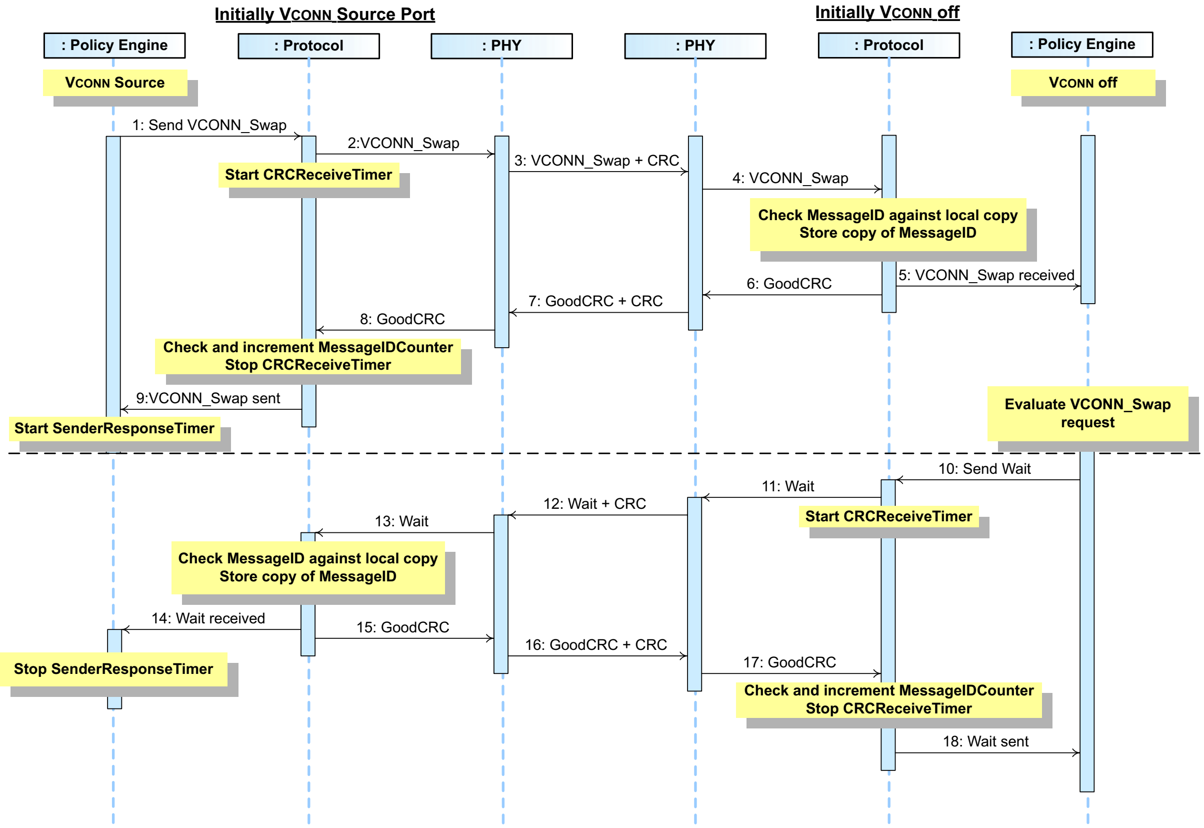


Table 8.81, "Steps for VCONN Source Swap with Wait" below provides a detailed explanation of what happens at each labeled step in *Figure 8.54, "VCONN Source Swap with Wait, initiated by VCONN Source"* above.

Table 8.81 Steps for VCONN Source Swap with Wait

Step	Initially VCONN Source	Initially VCONN off
1	The *VCONN Source*'s *Policy Engine* directs the *Protocol Layer* to send a ***VCONN_Swap*** *Message*.	*VCONN* is off.
2	*Protocol Layer* creates the ***VCONN_Swap*** *Message* and passes to *PHY Layer*.	
3	*PHY Layer* appends *CRC* and sends the ***VCONN_Swap*** *Message*. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the ***VCONN_Swap*** *Message* and checks the *CRC* to verify the *Message*.
4		*PHY Layer* removes the *CRC* and forwards the ***VCONN_Swap*** *Message* to the *Protocol Layer*.
5		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***VCONN_Swap*** *Message* information to the *Policy Engine* that consumes it.
6		*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.
7	*PHY Layer* receives the ***GoodCRC*** *Message* and checks the *CRC* to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.
8	*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.	
9	*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***VCONN_Swap*** *Message* was successfully sent. *Policy Engine* starts ***SenderResponseTimer***.	
10		*Policy Engine* evaluates the ***VCONN_Swap*** *Message* sent by the *Source* and decides that it is able and willing to do the *VCONN Swap* but not at this time. It tells the *Protocol Layer* to form an ***Wait*** *Message*.
11		*Protocol Layer* creates the *Message* and passes to *PHY Layer*.
12	*PHY Layer* receives the ***Wait*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.	*PHY Layer* appends a *CRC* and sends the ***Wait*** *Message*. Starts ***CRCReceiveTimer***.
13	*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Wait*** *Message* information to the *Policy Engine* that consumes it.	
14	The *Policy Engine* stops the ***SenderResponseTimer*** and starts the ***VCONNOnTimer***.	
15	*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.	
16	*PHY Layer* appends a *CRC* and sends the ***GoodCRC*** *Message*.	*PHY Layer* receives ***GoodCRC*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.

Table 8.81 Steps for VCONN Source Swap with Wait

Step	Initially VCONN Source	Initially VCONN off
17		*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.
18		*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Wait*** *Message* was successfully sent

8.3.2.10.2 VCONN Source Swap, initiated by non-VCONN Source

8.3.2.10.2.1 VCONN Source Swap, initiated by non-VCONN Source (Accept)

Figure 8.55, "VCONN Source Swap, initiated by non-VCONN Source" shows an example where the *Port* which is not initially supplying *VCONN* and requests a *VCONN Swap*. During the process the *Port Partner*s, keep their *Power Role* as *Source* or *Sink*, maintain their operation as either a *Source* or a *Sink* (power remains constant) but exchange the *VCONN Source*.

Figure 8.55 VCONN Source Swap, initiated by non-VCONN Source

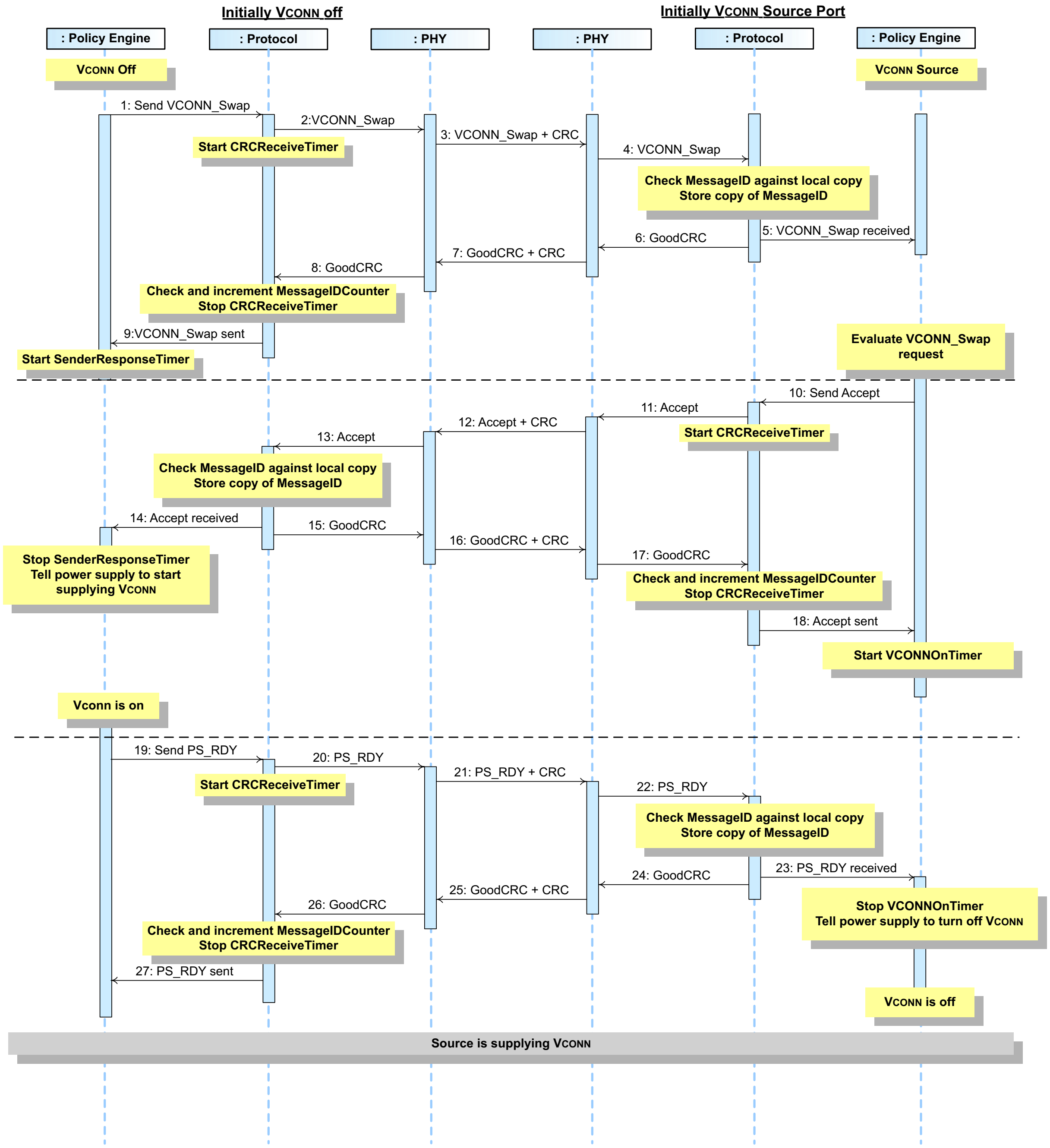


Table 8.82, "Steps for VCONN Source Swap, Initiated by non-VCONN Source" below provides a detailed explanation of what happens at each labeled step in *Figure 8.55, "VCONN Source Swap, initiated by non-VCONN Source"* above.

Table 8.82 Steps for VCONN Source Swap, Initiated by non-VCONN Source

Step	Initially VCONN off	Initially VCONN Source
1	The *Source* starts with *VCONN* off. The *Policy Engine* directs the *Protocol Layer* to send a ***VCONN_Swap*** *Message*.	The *Sink* starts as the *VCONN Source*.
2	*Protocol Layer* creates the ***VCONN_Swap*** *Message* and passes to *PHY Layer*.	
3	*PHY Layer* appends *CRC* and sends the ***VCONN_Swap*** *Message*. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the ***VCONN_Swap*** *Message* and checks the *CRC* to verify the *Message*.
4		*PHY Layer* removes the *CRC* and forwards the ***VCONN_Swap*** *Message* to the *Protocol Layer*.
5		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***VCONN_Swap*** *Message* information to the *Policy Engine* that consumes it.
6		*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.
7	*PHY Layer* receives the ***GoodCRC*** *Message* and checks the *CRC* to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.
8	*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.	
9	*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***VCONN_Swap*** *Message* was successfully sent. *Policy Engine* starts ***SenderResponseTimer***.	
10		*Policy Engine* evaluates the ***VCONN_Swap*** *Message* sent by the *Source* and decides that it is able and willing to do the *VCONN Swap*. It tells the *Protocol Layer* to form an ***Accept*** *Message*.
11		*Protocol Layer* creates the *Message* and passes to *PHY Layer*.
12	*PHY Layer* receives the ***Accept*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.	*PHY Layer* appends a *CRC* and sends the ***Accept*** *Message*. Starts ***CRCReceiveTimer***.
13	*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Accept*** *Message* information to the *Policy Engine* that consumes it.	
14	The *Policy Engine* stops the ***SenderResponseTimer***. The *Policy Engine* tells the *DPM* to turn on *VCONN*.	
15	*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.	
16	*PHY Layer* appends a *CRC* and sends the ***GoodCRC*** *Message*.	*PHY Layer* receives ***GoodCRC*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.

Table 8.82 Steps for VCONN Source Swap, Initiated by non-VCONN Source

Step	Initially VCONN off	Initially VCONN Source
17		*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.
18		*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Accept*** *Message* was successfully sent. The *Policy Engine* starts the ***VCONNOnTimer***.
19	The *DPM* tells the *Policy Engine* that its power supply is supplying *VCONN*. The *Policy Engine* directs the *Protocol Layer* to generate a ***PS_RDY*** *Message* to tell the *Sink* it can turn off *VCONN*.	
20	*Protocol Layer* creates the ***PS_RDY*** *Message* and passes to *PHY Layer*.	
21	*PHY Layer* appends a *CRC* and sends the ***PS_RDY*** *Message*. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the ***PS_RDY*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
22		*PHY Layer* removes the *CRC* and forwards the ***PS_RDY*** *Message* to the *Protocol Layer*.
23		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***PS_RDY*** *Message* information to the *Policy Engine* that consumes it.
24		*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.
25	*PHY Layer* receives ***GoodCRC*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.	*PHY Layer* appends a *CRC* and sends the ***GoodCRC*** *Message*. The *Policy Engine* stops the ***VCONNOnTimer***, and tells the power supply to stop sourcing *VCONN*.
26	*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.	
27	*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***PS_RDY*** *Message* was successfully sent.	*VCONN* is off.
The *Port Partners* have swapped *VCONN Source* role.		

8.3.2.10.2.2 VCONN Source Swap, initiated by non-VCONN Source (Reject)

Figure 8.56, "Rejected VCONN Source Swap, initiated by non-VCONN Source" shows an example where the *Port* which is not initially supplying *VCONN* and requests a *VCONN Swap* which is rejected. During the process the *Port Partner*s, keep their *Power Role* as *Source* or *Sink*, maintain their operation as either a *Source* or a *Sink* (power remains constant) and don't exchange the *VCONN Source*.

Figure 8.56 Rejected VCONN Source Swap, initiated by non-VCONN Source

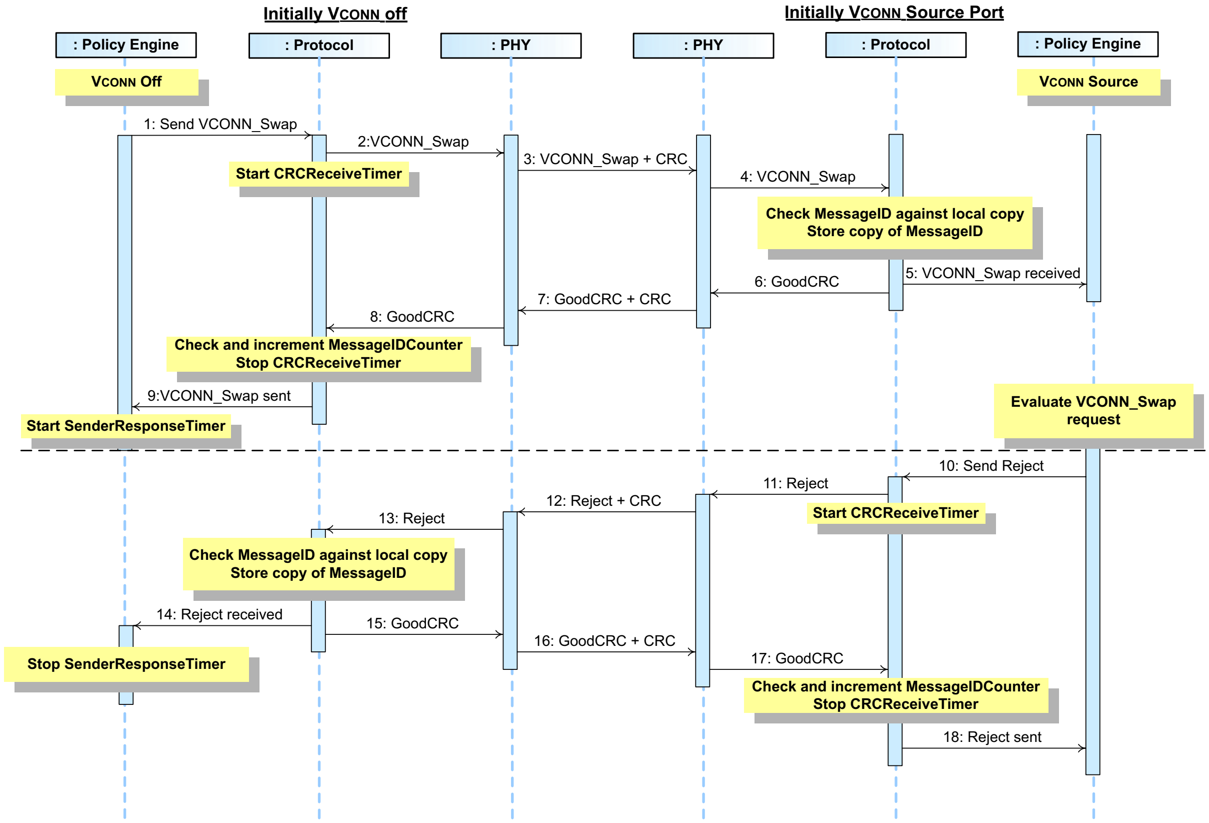


Table 8.83, "Steps for Rejected VCONN Source Swap, Initiated by non-VCONN Source" below provides a detailed explanation of what happens at each labeled step in *Figure 8.56, "Rejected VCONN Source Swap, initiated by non-VCONN Source"* above.

Table 8.83 Steps for Rejected VCONN Source Swap, Initiated by non-VCONN Source

Step	Initially VCONN off	Initially VCONN Source
1	The *Source* starts with *VCONN* off. The *Policy Engine* directs the *Protocol Layer* to send a ***VCONN_Swap*** *Message*.	The *Sink* starts as the *VCONN Source*.
2	*Protocol Layer* creates the ***VCONN_Swap*** *Message* and passes to *PHY Layer*.	
3	*PHY Layer* appends *CRC* and sends the ***VCONN_Swap*** *Message*. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the ***VCONN_Swap*** *Message* and checks the *CRC* to verify the *Message*.
4		*PHY Layer* removes the *CRC* and forwards the ***VCONN_Swap*** *Message* to the *Protocol Layer*.
5		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***VCONN_Swap*** *Message* information to the *Policy Engine* that consumes it.
6		*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.
7	*PHY Layer* receives the ***GoodCRC*** *Message* and checks the *CRC* to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.
8	*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.	
9	*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***VCONN_Swap*** *Message* was successfully sent. *Policy Engine* starts ***SenderResponseTimer***.	
10		*Policy Engine* evaluates the ***VCONN_Swap*** *Message* sent by the *Source* and decides that it is unable and unwilling to do the *VCONN Swap*. It tells the *Protocol Layer* to form a ***Reject*** *Message*.
11		*Protocol Layer* creates the *Message* and passes to *PHY Layer*.
12	*PHY Layer* receives the ***Reject*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.	*PHY Layer* appends a *CRC* and sends the ***Reject*** *Message*. Starts ***CRCReceiveTimer***.
13	*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Reject*** *Message* information to the *Policy Engine* that consumes it.	
14	The *Policy Engine* stops the ***SenderResponseTimer***. The *Policy Engine* tells the *DPM* to turn on *VCONN*.	
15	*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.	

Table 8.83 Steps for Rejected VCONN Source Swap, Initiated by non-VCONN Source

Step	Initially VCONN off	Initially VCONN Source
16	*PHY Layer* appends a *CRC* and sends the ***GoodCRC*** *Message*.	*PHY Layer* receives ***GoodCRC*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
17		*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.
18		*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Reject*** *Message* was successfully sent.

8.3.2.10.2.3 VCONN Source Swap (Wait)

Figure 8.57, "VCONN Source Swap with Wait" shows an example where the *Port* requests a *VCONN Swap* which is delayed with a wait. During the process the *Port Partners*, keep their *Power Role* as *Source* or *Sink*, maintain their operation as either a *Source* or a *Sink* (power remains constant) and don't exchange the *VCONN Source*.

Figure 8.57 VCONN Source Swap with Wait

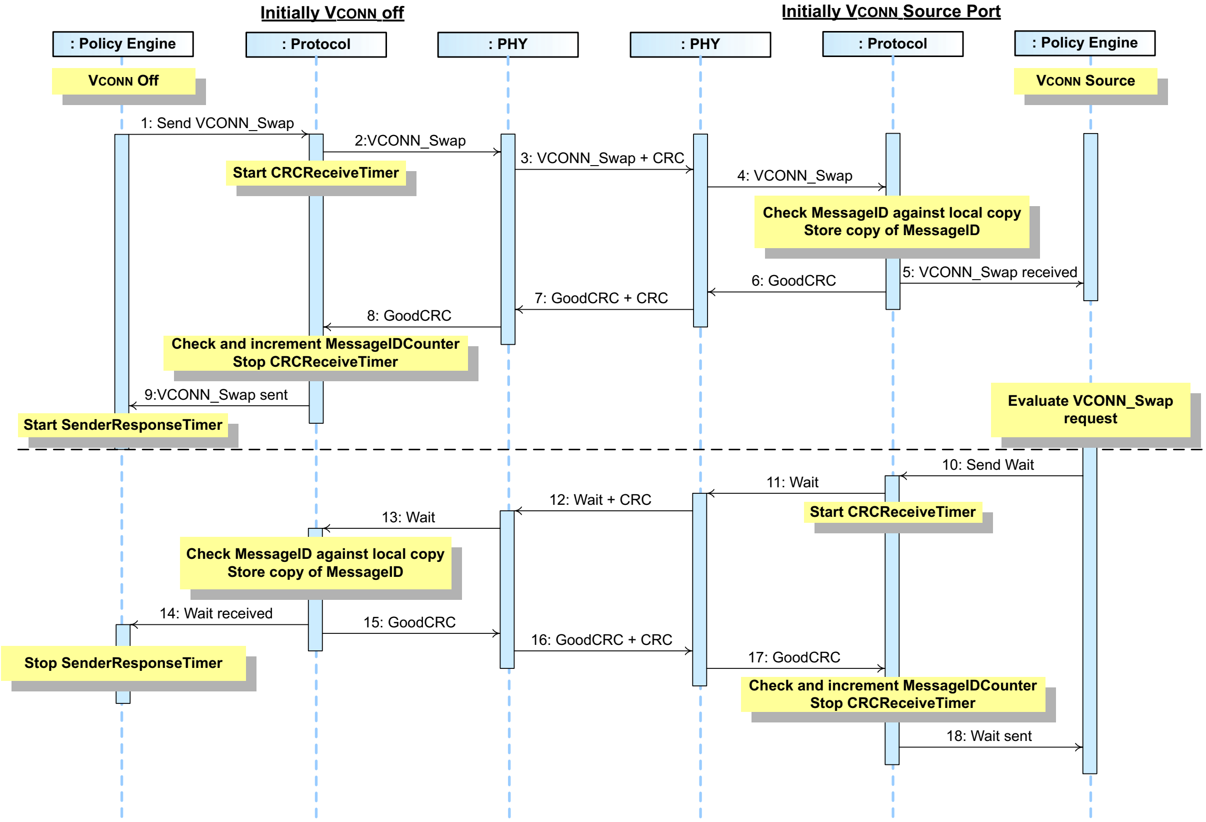


Table 8.84, "Steps for VCONN Source Swap with Wait" below provides a detailed explanation of what happens at each labeled step in *Figure 8.57, "VCONN Source Swap with Wait"* above.

Table 8.84 Steps for VCONN Source Swap with Wait

Step	Initially VCONN off	Initially VCONN Source
1	The *Source* starts with *VCONN* off. The *Policy Engine* directs the *Protocol Layer* to send a ***VCONN_Swap*** *Message*.	The *Sink* starts as the *VCONN Source*.
2	*Protocol Layer* creates the ***VCONN_Swap*** *Message* and passes to *PHY Layer*.	
3	*PHY Layer* appends *CRC* and sends the ***VCONN_Swap*** *Message*. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the ***VCONN_Swap*** *Message* and checks the *CRC* to verify the *Message*.
4		*PHY Layer* removes the *CRC* and forwards the ***VCONN_Swap*** *Message* to the *Protocol Layer*.
5		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***VCONN_Swap*** *Message* information to the *Policy Engine* that consumes it.
6		*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.
7	*PHY Layer* receives the ***GoodCRC*** *Message* and checks the *CRC* to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.
8	*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.	
9	*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***VCONN_Swap*** *Message* was successfully sent. *Policy Engine* starts ***SenderResponseTimer***.	
10		*Policy Engine* evaluates the ***VCONN_Swap*** *Message* sent by the *Source* and decides that it is able and willing to do the *VCONN Swap* but not at this time. It tells the *Protocol Layer* to form a ***Wait*** *Message*.
11		*Protocol Layer* creates the *Message* and passes to *PHY Layer*.
12	*PHY Layer* receives the ***Wait*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.	*PHY Layer* appends a *CRC* and sends the ***Wait*** *Message*. Starts ***CRCReceiveTimer***.
13	*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Wait*** *Message* information to the *Policy Engine* that consumes it.	
14	The *Policy Engine* stops the ***SenderResponseTimer***. The *Policy Engine* tells the *DPM* to turn on *VCONN*.	
15	*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.	
16	*PHY Layer* appends a *CRC* and sends the ***GoodCRC*** *Message*.	*PHY Layer* receives ***GoodCRC*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.

Table 8.84 Steps for VCONN Source Swap with Wait

Step	Initially VCONN off	Initially VCONN Source
17		*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.
18		*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Wait*** *Message* was successfully sent.

8.3.2.11 Additional Capabilities, Status and Information

8.3.2.11.1 Alert

8.3.2.11.1.1 Source sends Alert to a Sink

Figure 8.58, "Source Alert to Sink" shows an example sequence between a *Source* and a *Sink* where the *Source* alerts the *Sink* that there has been a status change. This AMS will be followed by getting the *Source* status to determine further details of the alert (see Section 8.3.2.11.2, "Status").

Figure 8.58 Source Alert to Sink

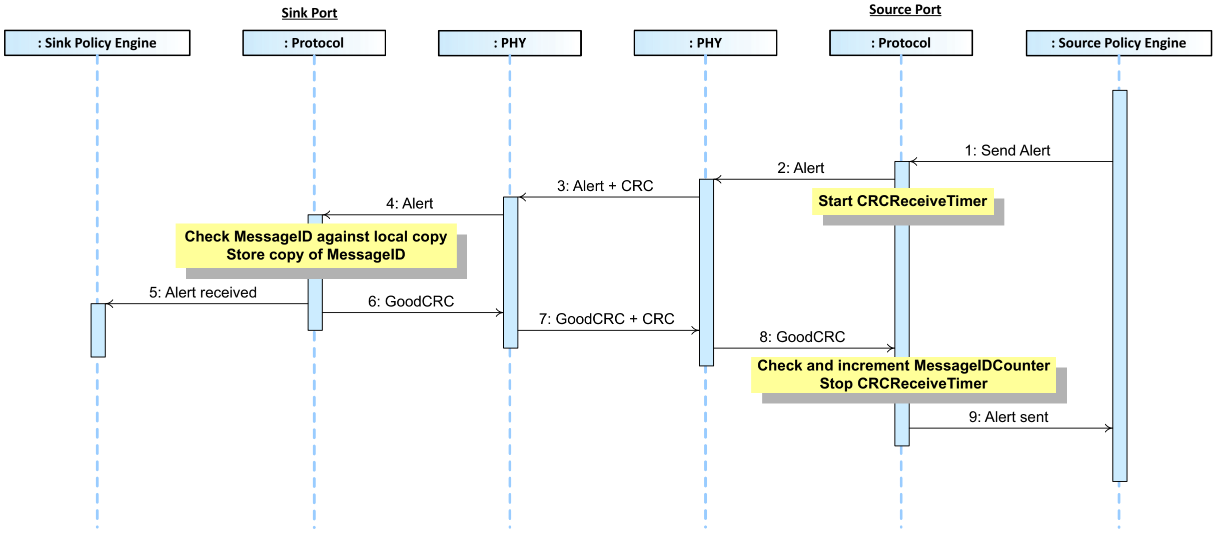


Table 8.85, "Steps for Source Alert to Sink" below provides a detailed explanation of what happens at each labeled step in *Figure 8.58, "Source Alert to Sink"* above.

Table 8.85 Steps for Source Alert to Sink

Step	Sink	Source
1		The *DPM* indicates a *Source* alert condition. The *Policy Engine* tells the *Protocol Layer* to form an ***Alert*** *Message*.
2		*Protocol Layer* creates the ***Alert*** *Message* and passes to *PHY Layer*.
3	*PHY Layer* receives the ***Alert*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.	*PHY Layer* appends a *CRC* and sends the ***Alert*** *Message*. Starts ***CRCReceiveTimer***.
4	*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Alert*** *Message* to the *Policy Engine* that consumes it.	
5	The *Policy Engine* informs the *DPM*.	
6	*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.	
7	*PHY Layer* appends a *CRC* and sends the ***GoodCRC*** *Message*.	*PHY Layer* receives ***GoodCRC*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
8		*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.
9		*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Alert*** *Message* was successfully sent.

8.3.2.11.1.2 Sink sends Alert to a Source

Figure 8.59, "Sink Alert to Source" shows an example sequence between a *Source* and a *Sink* where the *Sink* alerts the *Source* that there has been a status change. This AMS will be followed by getting the *Sink* status to determine further details of the alert (see Section 8.3.2.11.2, "Status").

Figure 8.59 Sink Alert to Source

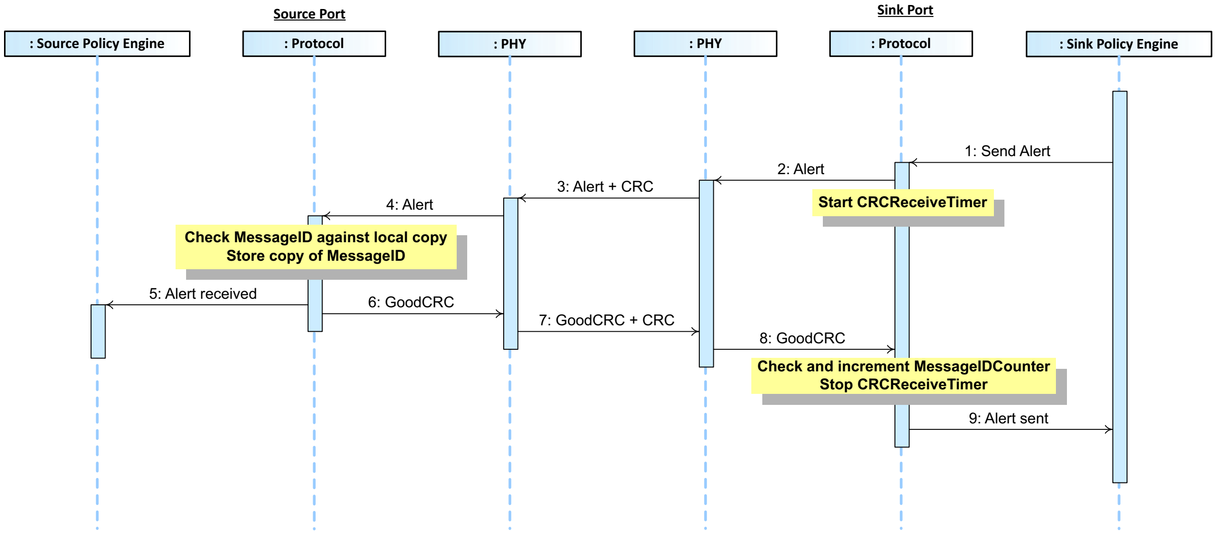


Table 8.86, "Steps for Sink Alert to Source" below provides a detailed explanation of what happens at each labeled step in *Figure 8.59, "Sink Alert to Source"* above.

Table 8.86 Steps for Sink Alert to Source

Step	Source	Sink
1		The *DPM* indicates a *Sink* alert condition. The *Policy Engine* tells the *Protocol Layer* to form an ***Alert*** *Message*.
2		*Protocol Layer* creates the ***Alert*** *Message* and passes to *PHY Layer*.
3	*PHY Layer* receives the ***Alert*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.	*PHY Layer* appends a *CRC* and sends the ***Alert*** *Message*. Starts ***CRCReceiveTimer***.
4	*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Alert*** *Message* to the *Policy Engine* that consumes it.	
5	The *Policy Engine* informs the *DPM*.	
6	*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.	
7	*PHY Layer* appends a *CRC* and sends the ***GoodCRC*** *Message*.	*PHY Layer* receives ***GoodCRC*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
8		*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.
9		*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Alert*** *Message* was successfully sent.

8.3.2.11.2 Status

8.3.2.11.2.1 Sink Gets Source Status

Figure 8.60, "Sink Gets Source Status" shows an example sequence between a *Source* and a *Sink* where, after the *Sink* has received an alert (see *Section 8.3.2.11.2, "Status"*) that there has been a status change, the *Sink* gets more details on the change.

Figure 8.60 Sink Gets Source Status

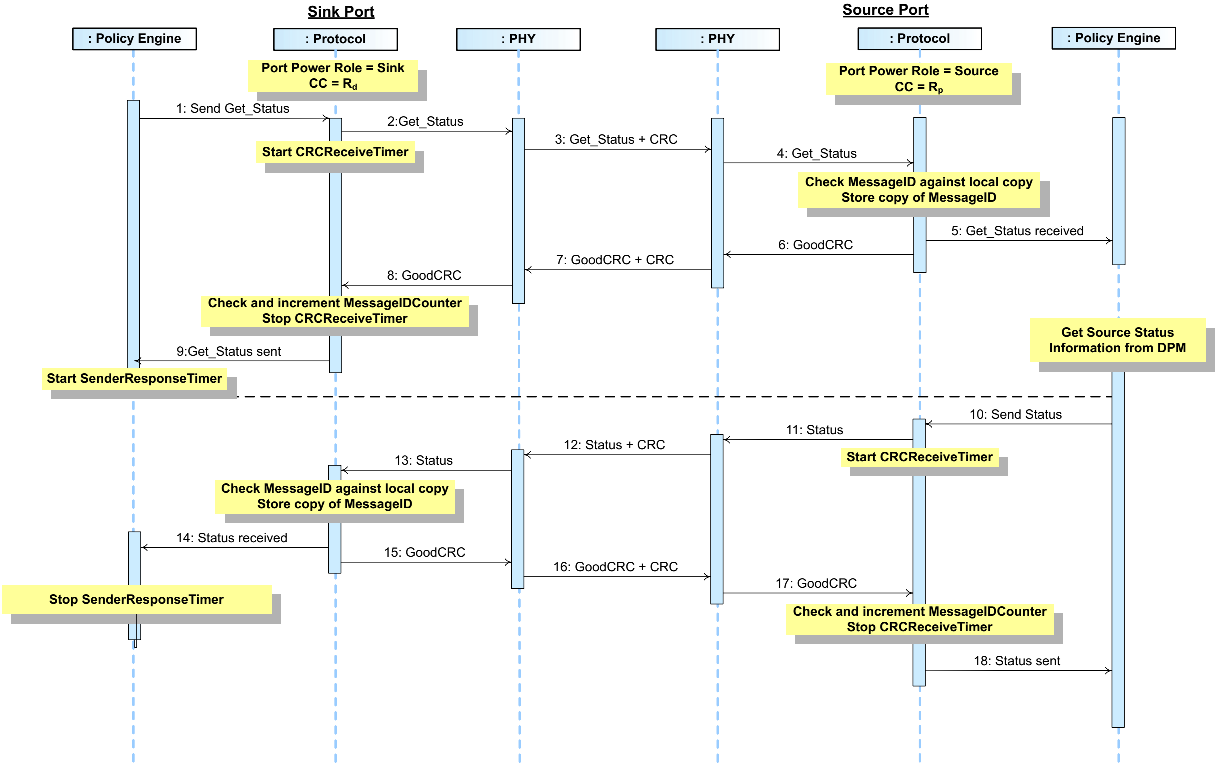


Table 8.87, "Steps for a Sink getting Source Status Sequence" below provides a detailed explanation of what happens at each labeled step in *Figure 8.60, "Sink Gets Source Status"* above.

Table 8.87 Steps for a Sink getting Source Status Sequence

Step	Sink Port	Source Port
1	The *Port* has ***Port Power Role*** set to *Sink* with the R_d pull down on its *CC* wire. *Policy Engine* directs the *Protocol Layer* to send a ***Get_Status*** *Message*.	The *Port* has ***Port Power Role*** set to *Source* and the R_p pull up on its *CC* wire.
2	*Protocol Layer* creates the *Message* and passes to *PHY Layer*.	
3	*PHY Layer* appends *CRC* and sends the ***Get_Status*** *Message*. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the ***Get_Status*** *Message* and checks the *CRC* to verify the *Message*.
4		*PHY Layer* removes the *CRC* and forwards the ***Get_Status*** *Message* to the *Protocol Layer*.
5		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Get_Status*** *Message* information to the *Policy Engine* that consumes it.
6		*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.
7	*PHY Layer* receives the ***GoodCRC*** *Message* and checks the *CRC* to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.
8	*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.	
9	*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Get_Status*** *Message* was successfully sent. *Policy Engine* starts ***SenderResponseTimer***.	
10		*Policy Engine* requests the *DPM* for the present *Source* status which is provided. The *Policy Engine* tells the *Protocol Layer* to form a ***Status*** *Message*.
11		*Protocol Layer* creates the *Message* and passes to *PHY Layer*.
12	*PHY Layer* receives the *Message* and compares the *CRC* it calculated with the one sent to verify the ***Status*** *Message*.	*PHY Layer* appends a *CRC* and sends the ***Status*** *Message*. Starts ***CRCReceiveTimer***.
13	*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Status*** *Message* information to the *Policy Engine* that consumes it.	
14	The *Policy Engine* stops the ***SenderResponseTimer***.	
15	*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.	

Table 8.87 Steps for a Sink getting Source Status Sequence

Step	Sink Port	Source Port
16	*PHY Layer* appends a *CRC* and sends the ***GoodCRC*** *Message*.	*PHY Layer* receives ***GoodCRC*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
17		*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.
18		*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Status*** *Message* was successfully sent.
The *Source* has informed the *Sink* of its present status.		

8.3.2.11.2.2 Source Gets Sink Status

Figure 8.61, "Source Gets Sink Status" shows an example sequence between a *Source* and a *Sink* where, after the *Source* has received an alert (see Section 8.3.2.11.2, "Status") that there has been a status change, the *Source* gets more details on the change.

Figure 8.61 Source Gets Sink Status

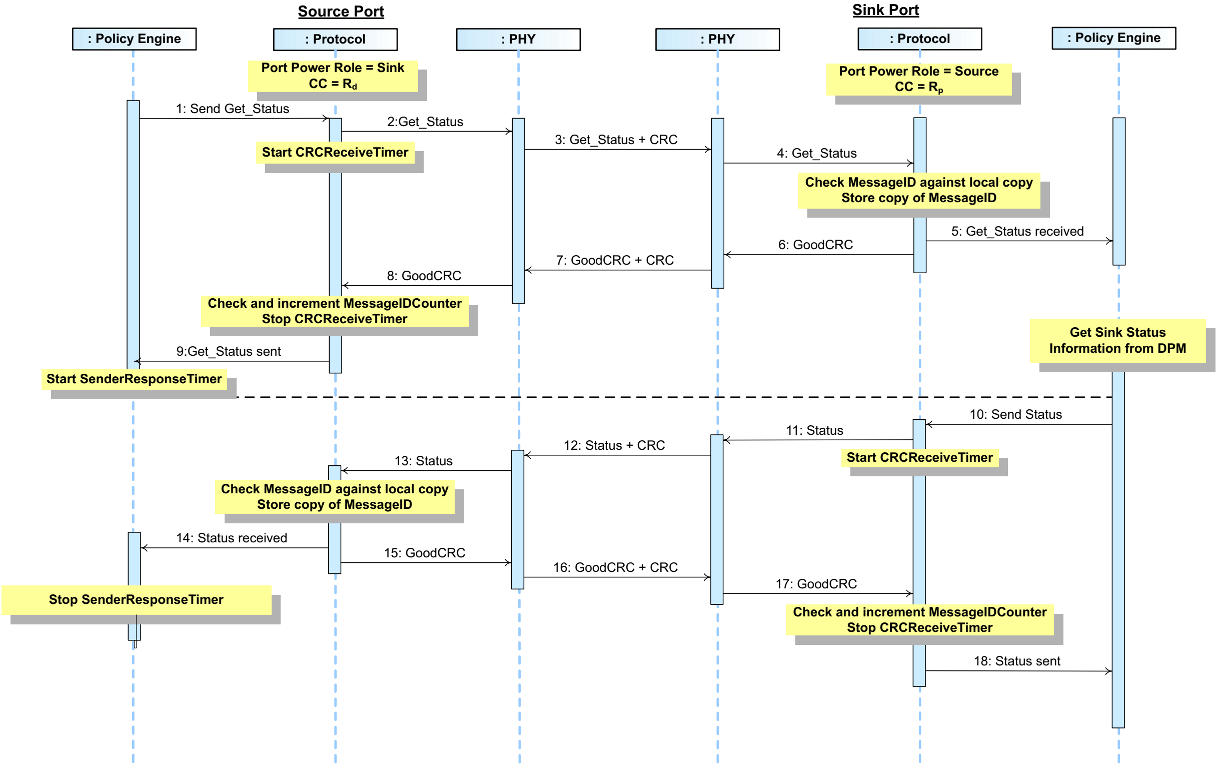


Table 8.88, "Steps for a Source getting Sink Status Sequence" below provides a detailed explanation of what happens at each labeled step in *Figure 8.61, "Source Gets Sink Status"* above.

Table 8.88 Steps for a Source getting Sink Status Sequence

Step	Source Port	Sink Port
1	The *Port* has ***Port Power Role*** set to *Source* and the R_p pull up on its *CC* wire. *Policy Engine* directs the *Protocol Layer* to send a ***Get_Status*** *Message*.	The *Port* has ***Port Power Role*** set to *Sink* with the R_d pull down on its *CC* wire.
2	*Protocol Layer* creates the *Message* and passes to *PHY Layer*.	
3	*PHY Layer* appends *CRC* and sends the ***Get_Status*** *Message*. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the ***Get_Status*** *Message* and checks the *CRC* to verify the *Message*.
4		*PHY Layer* removes the *CRC* and forwards the ***Get_Status*** *Message* to the *Protocol Layer*.
5		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Get_Status*** *Message* information to the *Policy Engine* that consumes it.
6		*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.
7	*PHY Layer* receives the ***GoodCRC*** *Message* and checks the *CRC* to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.
8	*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.	
9	*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Get_Status*** *Message* was successfully sent. *Policy Engine* starts ***SenderResponseTimer***.	
10		*Policy Engine* requests the *DPM* for the present *Source* status which is provided. The *Policy Engine* tells the *Protocol Layer* to form a ***Status*** *Message*.
11		*Protocol Layer* creates the *Message* and passes to *PHY Layer*.
12	*PHY Layer* receives the *Message* and compares the *CRC* it calculated with the one sent to verify the ***Status*** *Message*.	*PHY Layer* appends a *CRC* and sends the ***Status*** *Message*. Starts ***CRCReceiveTimer***.
13	*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Status*** *Message* information to the *Policy Engine* that consumes it.	
14	The *Policy Engine* stops the ***SenderResponseTimer***.	
15	*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.	

Table 8.88 Steps for a Source getting Sink Status Sequence

Step	Source Port	Sink Port
16	*PHY Layer* appends a *CRC* and sends the ***GoodCRC*** *Message*.	*PHY Layer* receives ***GoodCRC*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
17		*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.
18		*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Status*** *Message* was successfully sent.
The *Sink* has informed the *Source* of its present status.		

8.3.2.11.2.3 VCONN Source Gets Cable Plug Status

Figure 8.62, "VCONN Source Gets Cable Plug Status" shows an example sequence between a *VCONN Source* and a *Cable Plug* where, after the *VCONN Source* has received an alert (see *Section 8.3.2.11.2, "Status"*) that there has been a status change, the *VCONN Source* gets more details on the change.

Figure 8.62 VCONN Source Gets Cable Plug Status

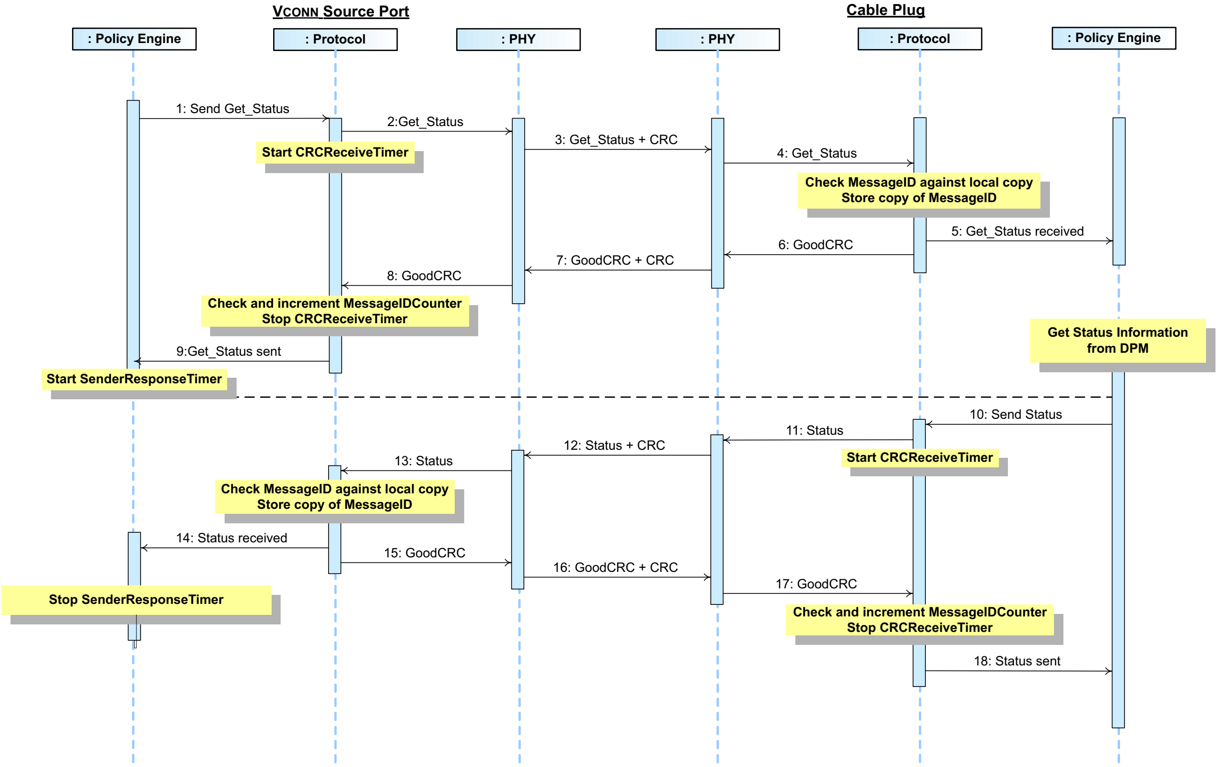


Table 8.89, "Steps for a VCONN Source getting Cable Plug Status Sequence" below provides a detailed explanation of what happens at each labeled step in *Figure 8.62, "VCONN Source Gets Cable Plug Status"* above.

Table 8.89 Steps for a VCONN Source getting Cable Plug Status Sequence

Step	VCONN Source Port	Cable Plug
1	*Policy Engine* directs the *Protocol Layer* to send a ***Get_Status*** *Message*.	
2	*Protocol Layer* creates the *Message* and passes to *PHY Layer*.	
3	*PHY Layer* appends *CRC* and sends the ***Get_Status*** *Message*. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the ***Get_Status*** *Message* and checks the *CRC* to verify the *Message*.
4		*PHY Layer* removes the *CRC* and forwards the ***Get_Status*** *Message* to the *Protocol Layer*.
5		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Get_Status*** *Message* information to the *Policy Engine* that consumes it.
6		*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.
7	*PHY Layer* receives the ***GoodCRC*** *Message* and checks the *CRC* to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.
8	*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.	
9	*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Get_Status*** *Message* was successfully sent. *Policy Engine* starts ***SenderResponseTimer***.	
10		*Policy Engine* requests the *DPM* for the present *Source* status which is provided. The *Policy Engine* tells the *Protocol Layer* to form a ***Status*** *Message*.
11		*Protocol Layer* creates the *Message* and passes to *PHY Layer*.
12	*PHY Layer* receives the *Message* and compares the *CRC* it calculated with the one sent to verify the ***Status*** *Message*.	*PHY Layer* appends a *CRC* and sends the ***Status*** *Message*. Starts ***CRCReceiveTimer***.
13	*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Status*** *Message* information to the *Policy Engine* that consumes it.	
14	The *Policy Engine* stops the ***SenderResponseTimer***.	
15	*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.	
16	*PHY Layer* appends a *CRC* and sends the ***GoodCRC*** *Message*.	*PHY Layer* receives ***GoodCRC*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
17		*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.

Table 8.89 Steps for a VCONN Source getting Cable Plug Status Sequence

Step	VCONN Source Port	Cable Plug
18		*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Status*** *Message* was successfully sent.
The *Cable Plug* has informed the *VCONN Source* of its present status.		

8.3.2.11.2.4 Sink Gets Source PPS Status

Figure 8.63, "Sink Gets Source PPS Status" shows an example sequence between a *Source* and a *Sink* where, after the *Sink* has received an alert (see *Section 8.3.2.11.2, "Status"*) that there has been a PPS status change, the *Sink* gets more details on the change.

Figure 8.63 Sink Gets Source PPS Status

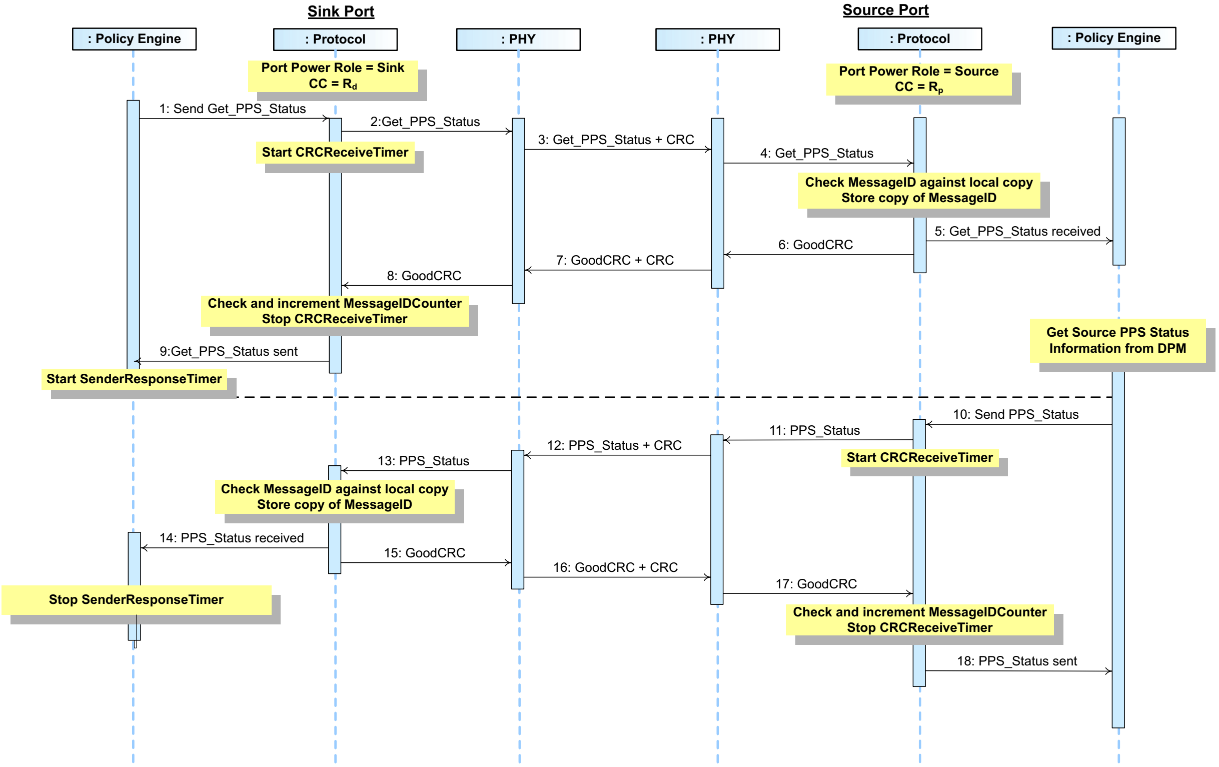


Table 8.90, "Steps for a Sink getting Source PPS status Sequence" below provides a detailed explanation of what happens at each labeled step in *Figure 8.63, "Sink Gets Source PPS Status"* above.

Table 8.90 Steps for a Sink getting Source PPS status Sequence

Step	Sink Port	Source Port
1	The *Port* has **Port Power Role** set to *Sink* with the R_d pull down on its *CC* wire. *Policy Engine* directs the *Protocol Layer* to send a ***Get_PPS_Status*** *Message*.	The *Port* has **Port Power Role** set to *Source* and the R_p pull up on its *CC* wire.
2	*Protocol Layer* creates the *Message* and passes to *PHY Layer*.	
3	*PHY Layer* appends *CRC* and sends the ***Get_PPS_Status*** *Message*. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the ***Get_PPS_Status*** *Message* and checks the *CRC* to verify the *Message*.
4		*PHY Layer* removes the *CRC* and forwards the ***Get_Status*** *Message* to the *Protocol Layer*.
5		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Get_PPS_Status*** *Message* information to the *Policy Engine* that consumes it.
6		*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.
7	*PHY Layer* receives the ***GoodCRC*** *Message* and checks the *CRC* to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.
8	*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.	
9	*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Get_PPS_Status*** *Message* was successfully sent. *Policy Engine* starts ***SenderResponseTimer***.	
10		*Policy Engine* requests the *DPM* for the present *Source* status which is provided. The *Policy Engine* tells the *Protocol Layer* to form a ***PPS_Status*** *Message*.
11		*Protocol Layer* creates the *Message* and passes to *PHY Layer*.
12	*PHY Layer* receives the *Message* and compares the *CRC* it calculated with the one sent to verify the ***PPS_Status*** *Message*.	*PHY Layer* appends a *CRC* and sends the ***PPS_Status*** *Message*. Starts ***CRCReceiveTimer***.
13	*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***PPS_Status*** *Message* information to the *Policy Engine* that consumes it.	
14	The *Policy Engine* stops the ***SenderResponseTimer***.	
15	*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.	

Table 8.90 Steps for a Sink getting Source PPS status Sequence

Step	Sink Port	Source Port
16	*PHY Layer* appends a *CRC* and sends the ***GoodCRC*** *Message*.	*PHY Layer* receives ***GoodCRC*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
17		*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.
18		*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***PPS_Status*** *Message* was successfully sent.
The *Source* has informed the *Sink* of its present PPS status.		

8.3.2.11.3 Source/Sink Capabilities

8.3.2.11.3.1 SPR

8.3.2.11.3.1.1 Sink Gets Source Capabilities

Figure 8.64, "Sink Gets Source's Capabilities" shows an example sequence between a *Source* and a *Sink* when the *Sink* gets the *Source Capabilities*.

Figure 8.64 Sink Gets Source's Capabilities

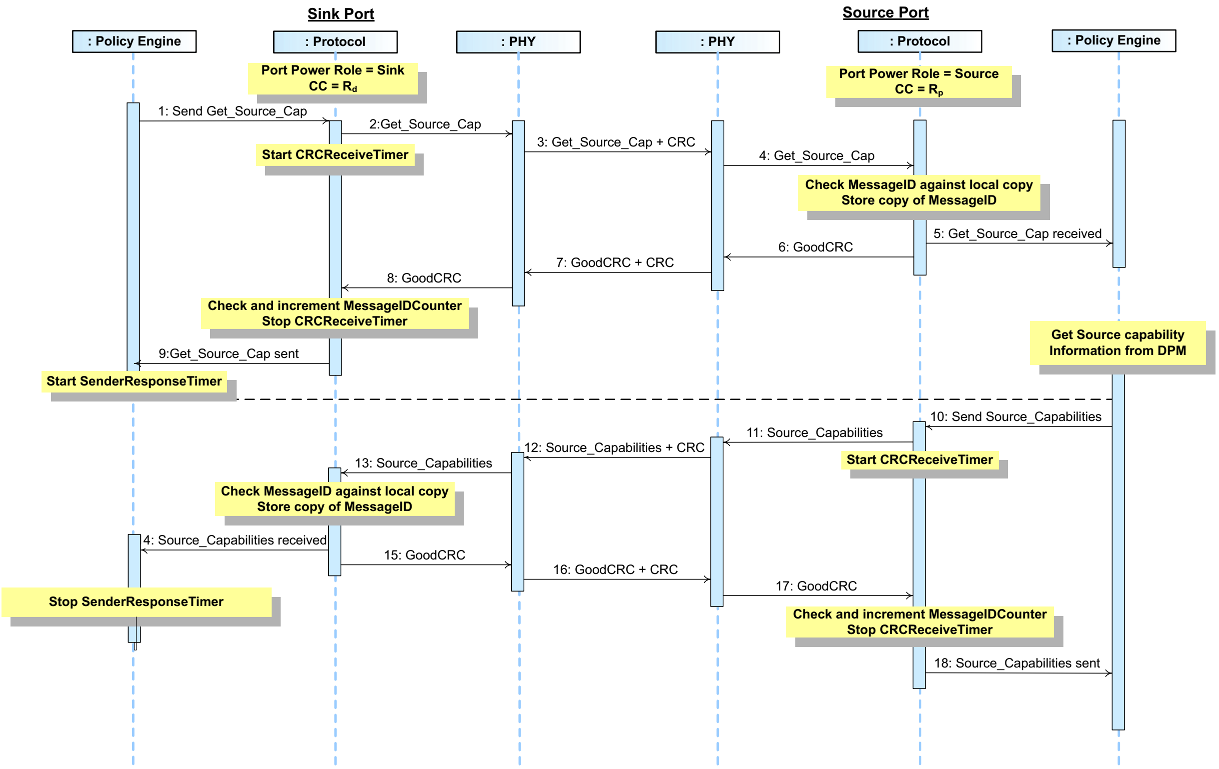


Table 8.91, "Steps for a Sink getting Source Capabilities Sequence" below provides a detailed explanation of what happens at each labeled step in *Figure 8.64, "Sink Gets Source's Capabilities"* above.

Table 8.91 Steps for a Sink getting Source Capabilities Sequence

Step	Sink Port	Source Port
1	The *Port* has ***Port Power Role*** set to *Sink* with the R_d pull down on its *CC* wire. *Policy Engine* directs the *Protocol Layer* to send a ***Get_Source_Cap*** *Message*.	The *Port* has ***Port Power Role*** set to *Source* and the R_p pull up on its *CC* wire.
2	*Protocol Layer* creates the *Message* and passes to *PHY Layer*.	
3	*PHY Layer* appends *CRC* and sends the ***Get_Source_Cap*** *Message*. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the ***Get_Source_Cap*** *Message* and checks the *CRC* to verify the *Message*.
4		*PHY Layer* removes the *CRC* and forwards the ***Get_Source_Cap*** *Message* to the *Protocol Layer*.
5		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Get_Source_Cap*** *Message* information to the *Policy Engine* that consumes it.
6		*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.
7	*PHY Layer* receives the ***GoodCRC*** *Message* and checks the *CRC* to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.
8	*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.	
9	*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Get_Source_Cap*** *Message* was successfully sent. *Policy Engine* starts ***SenderResponseTimer***.	
10		*Policy Engine* requests the *DPM* for the present *Source Capabilities* which are provided. The *Policy Engine* tells the *Protocol Layer* to form a ***Source_Capabilities*** *Message*.
11		*Protocol Layer* creates the *Message* and passes to *PHY Layer*.
12	*PHY Layer* receives the *Message* and compares the *CRC* it calculated with the one sent to verify the ***Source_Capabilities*** *Message*.	*PHY Layer* appends a *CRC* and sends the ***Source_Capabilities*** *Message*. Starts ***CRCReceiveTimer***.
13	*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Source_Capabilities*** *Message* information to the *Policy Engine* that consumes it.	
14	The *Policy Engine* stops the ***SenderResponseTimer***.	
15	*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.	

Table 8.91 Steps for a Sink getting Source Capabilities Sequence

Step	Sink Port	Source Port
16	*PHY Layer* appends a *CRC* and sends the ***GoodCRC*** *Message*.	*PHY Layer* receives ***GoodCRC*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
17		*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.
18		*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Source_Capabilities*** *Message* was successfully sent.
The *Source* has informed the *Sink* of its capabilities.		

8.3.2.11.3.1.2 Dual-Role Source Gets Source Capabilities from a Dual-Role Sink

Figure 8.65, "Dual-Role Source Gets Dual-Role Sink's Capabilities as a Source" shows an example sequence between a *Dual-Role Power Source* and a *Dual-Role Power Sink* when the *Source* gets the *Sink Capabilities* as a *Source*.

Figure 8.65 Dual-Role Source Gets Dual-Role Sink's Capabilities as a Source

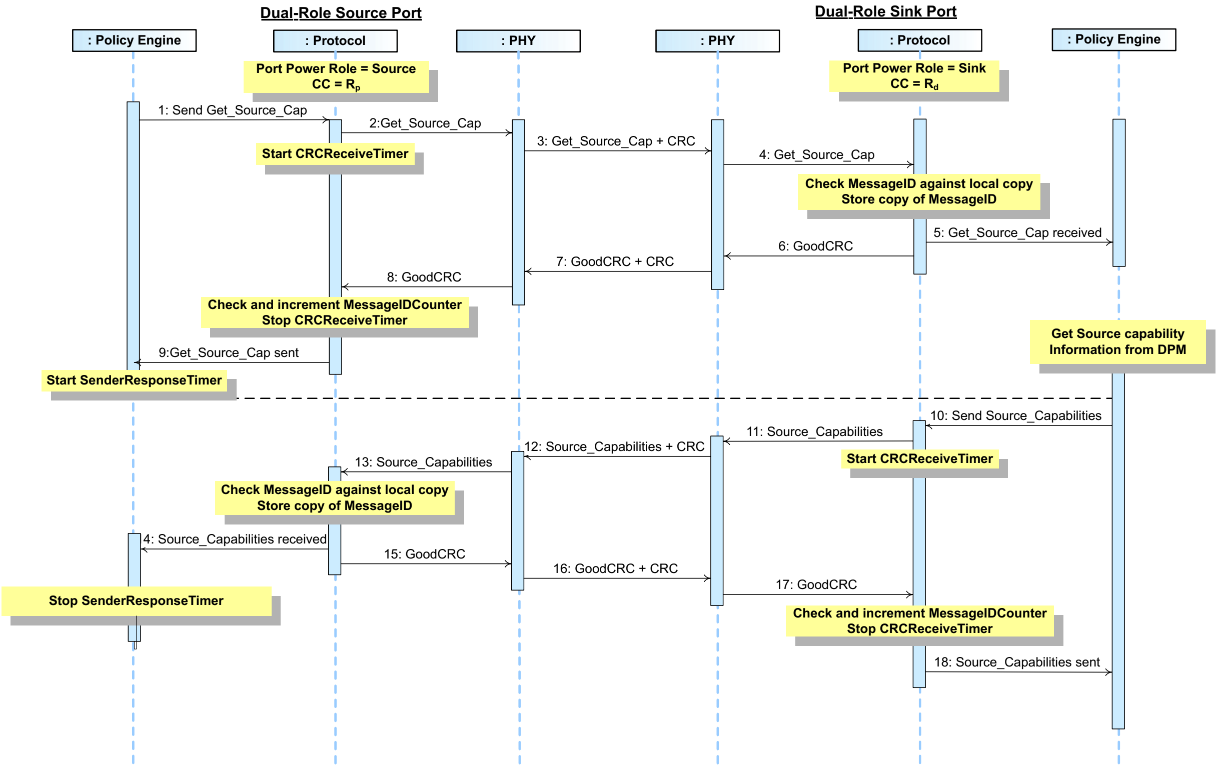


Table 8.92, "Steps for a Dual-Role Source getting Dual-Role Sink's capabilities as a Source Sequence" below provides a detailed explanation of what happens at each labeled step in *Figure 8.65, "Dual-Role Source Gets Dual-Role Sink's Capabilities as a Source"* above.

Table 8.92 Steps for a Dual-Role Source getting Dual-Role Sink's capabilities as a Source Sequence

Step	Dual-Role Source Port	Dual-Role Sink Port
1	The *Port* has ***Port Power Role*** set to *Source* and the R_p pull up on its *CC* wire. *Policy Engine* directs the *Protocol Layer* to send a ***Get_Source_Cap*** *Message*.	The *Port* has ***Port Power Role*** set to *Sink* with the R_d pull down on its *CC* wire.
2	*Protocol Layer* creates the *Message* and passes to *PHY Layer*.	
3	*PHY Layer* appends *CRC* and sends the ***Get_Source_Cap*** *Message*. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the ***Get_Source_Cap*** *Message* and checks the *CRC* to verify the *Message*.
4		*PHY Layer* removes the *CRC* and forwards the ***Get_Source_Cap*** *Message* to the *Protocol Layer*.
5		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Get_Source_Cap*** *Message* information to the *Policy Engine* that consumes it.
6		*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.
7	*PHY Layer* receives the ***GoodCRC*** *Message* and checks the *CRC* to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.
8	*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.	
9	*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Get_Source_Cap*** *Message* was successfully sent. *Policy Engine* starts ***SenderResponseTimer***.	
10		*Policy Engine* requests the *DPM* for the present *Source Capabilities* which are provided. The *Policy Engine* tells the *Protocol Layer* to form a ***Source_Capabilities*** *Message*.
11		*Protocol Layer* creates the *Message* and passes to *PHY Layer*.
12	*PHY Layer* receives the *Message* and compares the *CRC* it calculated with the one sent to verify the ***Source_Capabilities*** *Message*.	*PHY Layer* appends a *CRC* and sends the ***Source_Capabilities*** *Message*. Starts ***CRCReceiveTimer***.
13	*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Source_Capabilities*** *Message* information to the *Policy Engine* that consumes it.	
14	The *Policy Engine* stops the ***SenderResponseTimer***.	
15	*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.	

Table 8.92 Steps for a Dual-Role Source getting Dual-Role Sink's capabilities as a Source Sequence

Step	Dual-Role Source Port	Dual-Role Sink Port
16	*PHY Layer* appends a *CRC* and sends the ***GoodCRC*** *Message*.	*PHY Layer* receives ***GoodCRC*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
17		*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.
18		*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Source_Capabilities*** *Message* was successfully sent.
The *Dual-Role Power Sink* has informed the *Dual-Role Power Source* of its capabilities.		

8.3.2.11.3.1.3 Source Gets Sink Capabilities

Figure 8.66, "Source Gets Sink's Capabilities" shows an example sequence between a *Source* and a *Sink* when the *Source* gets the *Sink Capabilities*.

Figure 8.66 Source Gets Sink's Capabilities

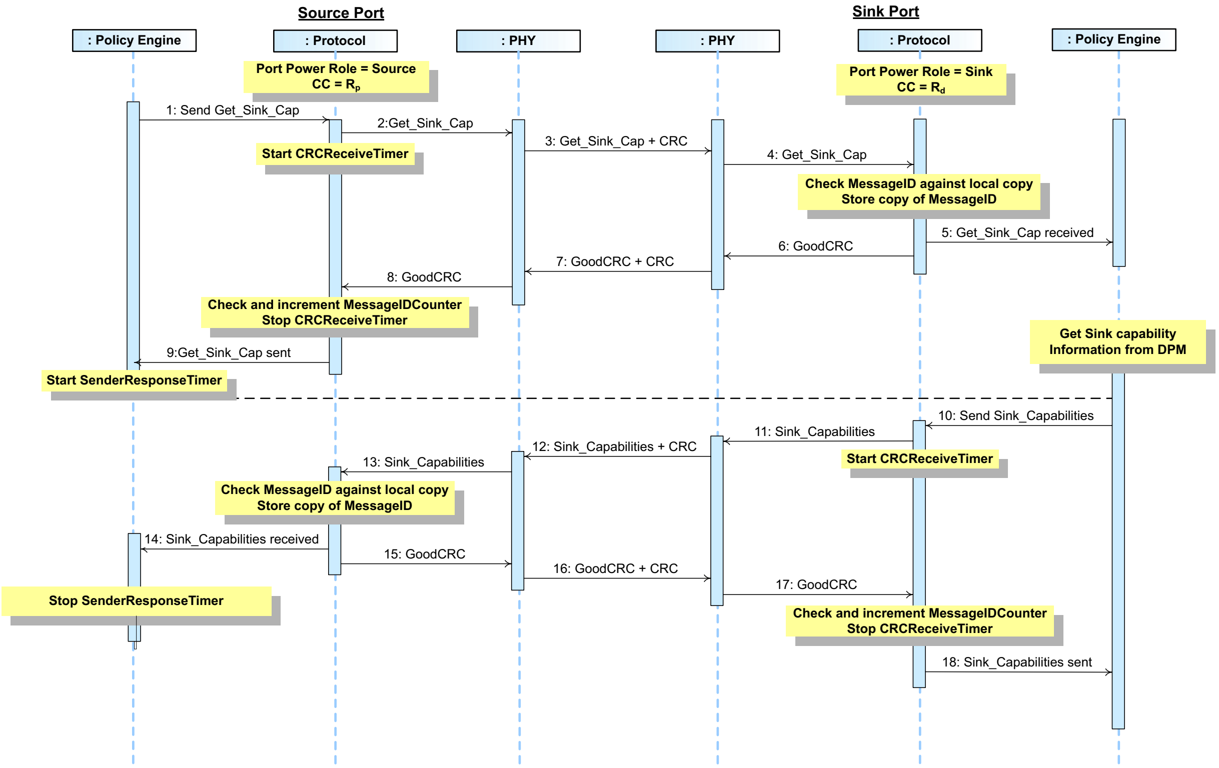


Table 8.93, "Steps for a Source getting Sink Capabilities Sequence" below provides a detailed explanation of what happens at each labeled step in *Figure 8.66, "Source Gets Sink's Capabilities"* above.

Table 8.93 Steps for a Source getting Sink Capabilities Sequence

Step	Source Port	Sink Port
1	The *Port* has ***Port Power Role*** set to *Source* and the R_p pull up on its *CC* wire. *Policy Engine* directs the *Protocol Layer* to send a ***Get_Sink_Cap*** *Message*.	The *Port* has ***Port Power Role*** set to *Sink* with the R_d pull down on its *CC* wire.
2	*Protocol Layer* creates the *Message* and passes to *PHY Layer*.	
3	*PHY Layer* appends *CRC* and sends the ***Get_Sink_Cap*** *Message*. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the ***Get_Sink_Cap*** *Message* and checks the *CRC* to verify the *Message*.
4		*PHY Layer* removes the *CRC* and forwards the ***Get_Sink_Cap*** *Message* to the *Protocol Layer*.
5		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Get_Sink_Cap*** *Message* information to the *Policy Engine* that consumes it.
6		*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.
7	*PHY Layer* receives the ***GoodCRC*** *Message* and checks the *CRC* to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.
8	*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.	
9	*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Get_Sink_Cap*** *Message* was successfully sent. *Policy Engine* starts ***SenderResponseTimer***.	
10		*Policy Engine* requests the *DPM* for the present *Sink Capabilities* which are provided. The *Policy Engine* tells the *Protocol Layer* to form a ***Sink_Capabilities*** *Message*.
11		*Protocol Layer* creates the *Message* and passes to *PHY Layer*.
12	*PHY Layer* receives the *Message* and compares the *CRC* it calculated with the one sent to verify the ***Sink_Capabilities*** *Message*.	*PHY Layer* appends a *CRC* and sends the ***Sink_Capabilities*** *Message*. Starts ***CRCReceiveTimer***.
13	*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Sink_Capabilities*** *Message* information to the *Policy Engine* that consumes it.	
14	The *Policy Engine* stops the ***SenderResponseTimer***.	
15	*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.	
16	*PHY Layer* appends a *CRC* and sends the ***GoodCRC*** *Message*.	*PHY Layer* receives ***GoodCRC*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.

Table 8.93 Steps for a Source getting Sink Capabilities Sequence

Step	Source Port	Sink Port
17		*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.
18		*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Sink_Capabilities*** *Message* was successfully sent.
The *Sink* has informed the *Source* of its capabilities.		

8.3.2.11.3.1.4 Dual-Role Sink Get Sink Capabilities from a Dual-Role Source

Figure 8.67, "Dual-Role Sink Gets Dual-Role Source's Capabilities as a Sink" shows an example sequence between a *Dual-Role Power Source* and a *Dual-Role Power Sink* when the *Dual-Role Power Sink* gets the *Dual-Role Power Source Capabilities* as a *Sink*.

Figure 8.67 Dual-Role Sink Gets Dual-Role Source's Capabilities as a Sink

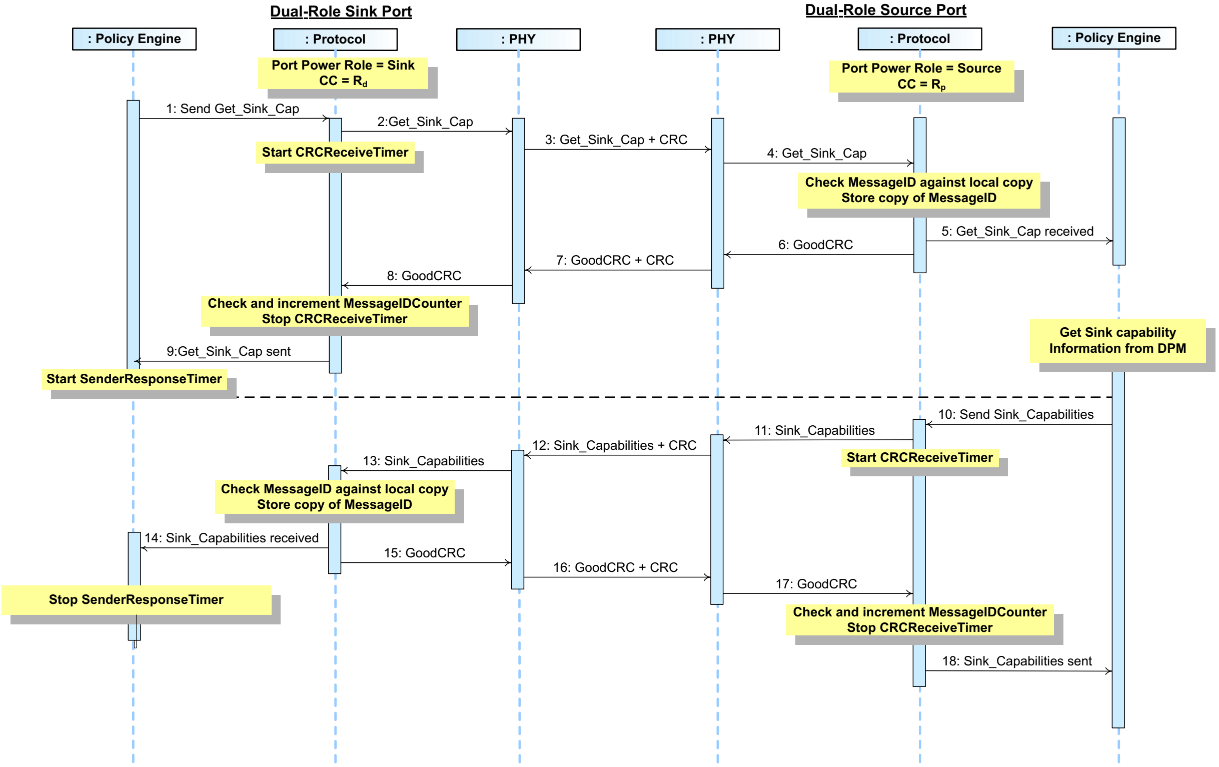


Table 8.94, "Steps for a Dual-Role Sink getting Dual-Role Source capabilities as a Sink Sequence" below provides a detailed explanation of what happens at each labeled step in *Figure 8.67, "Dual-Role Sink Gets Dual-Role Source's Capabilities as a Sink"* above.

Table 8.94 Steps for a Dual-Role Sink getting Dual-Role Source capabilities as a Sink Sequence

Step	Dual-Role Sink Port	Dual-Role Source Port
1	The *Port* has ***Port Power Role*** set to *Dual-Role Power Sink* with the R_d pull down on its *CC* wire. *Policy Engine* directs the *Protocol Layer* to send a ***Get_Sink_Cap*** *Message*.	The *Port* has ***Port Power Role*** set to *Dual-Role Power Source* and the R_p pull up on its *CC* wire.
2	*Protocol Layer* creates the *Message* and passes to *PHY Layer*.	
3	*PHY Layer* appends *CRC* and sends the ***Get_Sink_Cap*** *Message*. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the ***Get_Sink_Cap*** *Message* and checks the *CRC* to verify the *Message*.
4		*PHY Layer* removes the *CRC* and forwards the ***Get_Sink_Cap*** *Message* to the *Protocol Layer*.
5		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Get_Sink_Cap*** *Message* information to the *Policy Engine* that consumes it.
6		*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.
7	*PHY Layer* receives the ***GoodCRC*** *Message* and checks the *CRC* to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.
8	*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.	
9	*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Get_Sink_Cap*** *Message* was successfully sent. *Policy Engine* starts ***SenderResponseTimer***.	
10		*Policy Engine* requests the *DPM* for the present *Dual-Role Power Source Capabilities* which are provided. The *Policy Engine* tells the *Protocol Layer* to form a ***Sink_Capabilities*** *Message*.
11		*Protocol Layer* creates the *Message* and passes to *PHY Layer*.
12	*PHY Layer* receives the *Message* and compares the *CRC* it calculated with the one sent to verify the ***Sink_Capabilities*** *Message*.	*PHY Layer* appends a *CRC* and sends the ***Sink_Capabilities*** *Message*. Starts ***CRCReceiveTimer***.
13	*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Sink_Capabilities*** *Message* information to the *Policy Engine* that consumes it.	
14	The *Policy Engine* stops the ***SenderResponseTimer***.	
15	*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.	

Table 8.94 Steps for a Dual-Role Sink getting Dual-Role Source capabilities as a Sink Sequence

Step	Dual-Role Sink Port	Dual-Role Source Port
16	*PHY Layer* appends a *CRC* and sends the ***GoodCRC*** *Message*.	*PHY Layer* receives ***GoodCRC*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
17		*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.
18		*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Sink_Capabilities*** *Message* was successfully sent.
The *Dual-Role Power Source* has informed the *Dual-Role Power Sink* of its *Capabilities* as a *Sink*.		

8.3.2.11.3.2 EPR

8.3.2.11.3.2.1 Sink Gets EPR Source Capabilities

Figure 8.68, "Sink Gets Source's EPR Capabilities" shows an example sequence between a *Source* and a *Sink* when the *Sink* gets the *Source*'s *EPR Capabilities*.

Figure 8.68 Sink Gets Source's EPR Capabilities

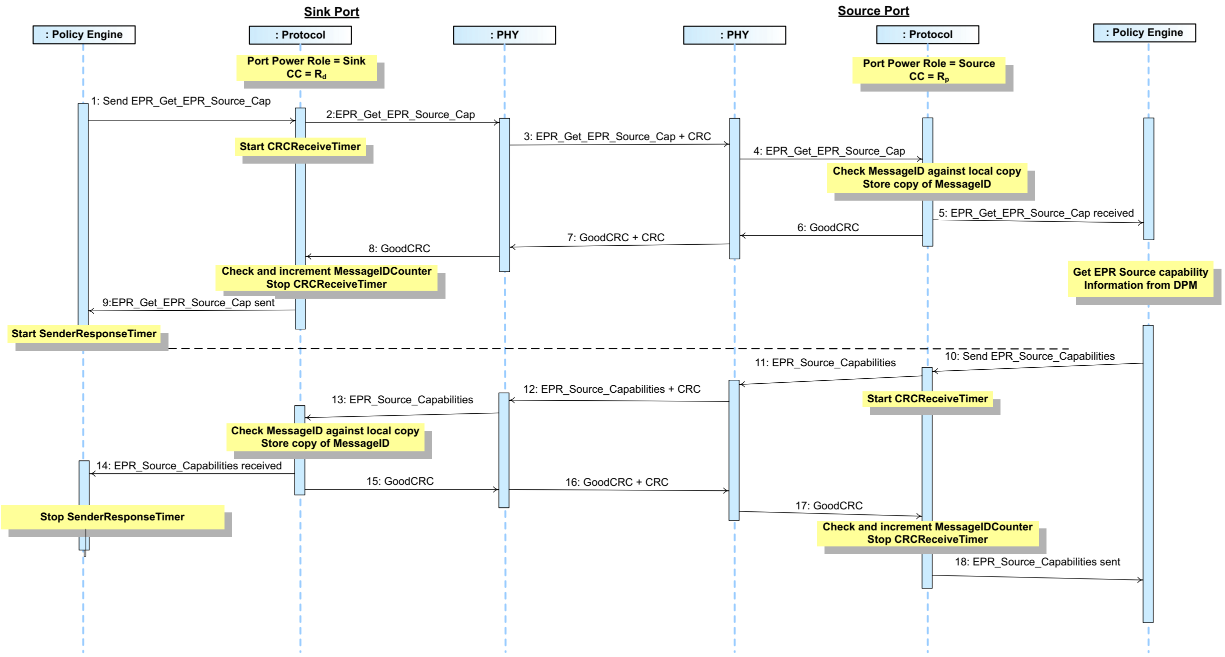

Sink Port
Source Port
: Policy Engine
: Protocol
: PHY
: PHY
: Protocol
: Policy Engine
Port Power Role = Sink
CC = R_d
Port Power Role = Source
CC = R_p
1: Send EPR_Get_EPR_Source_Cap
2:EPR_Get_EPR_Source_Cap
Start CRCReceiveTimer
3: EPR_Get_EPR_Source_Cap + CRC
4: EPR_Get_EPR_Source_Cap
Check MessageID against local copy
Store copy of MessageID
5: EPR_Get_EPR_Source_Cap received
6: GoodCRC
7: GoodCRC + CRC
8: GoodCRC
Check and increment MessageIDCounter
Stop CRCReceiveTimer
Get EPR Source capability
Information from DPM
9:EPR_Get_EPR_Source_Cap sent
Start SenderResponseTimer
10: Send EPR_Source_Capabilities
11: EPR_Source_Capabilities
12: EPR_Source_Capabilities + CRC
Start CRCReceiveTimer
13: EPR_Source_Capabilities
Check MessageID against local copy
Store copy of MessageID
14: EPR_Source_Capabilities received
15: GoodCRC
16: GoodCRC + CRC
Stop SenderResponseTimer
17: GoodCRC
Check and increment MessageIDCounter
Stop CRCReceiveTimer
18: EPR_Source_Capabilities sent

Table 8.95, "Steps for a Sink getting EPR Source Capabilities Sequence" below provides a detailed explanation of what happens at each labeled step in *Figure 8.68, "Sink Gets Source's EPR Capabilities"* above.

Table 8.95 Steps for a Sink getting EPR Source Capabilities Sequence

Step	Sink Port	Source Port
1	The *Port* has ***Port Power Role*** set to *Sink* with the R_d pull down on its *CC* wire. *Policy Engine* directs the *Protocol Layer* to send a ***EPR_Get_Source_Cap*** *Message*.	The *Port* has ***Port Power Role*** set to *Source* and the R_p pull up on its *CC* wire.
2	*Protocol Layer* creates the *Message* and passes to *PHY Layer*.	
3	*PHY Layer* appends *CRC* and sends the ***EPR_Get_Source_Cap*** *Message*. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the ***EPR_Get_Source_Cap*** *Message* and checks the *CRC* to verify the *Message*.
4		*PHY Layer* removes the *CRC* and forwards the ***EPR_Get_Source_Cap*** *Message* to the *Protocol Layer*.
5		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***EPR_Get_Source_Cap*** *Message* information to the *Policy Engine* that consumes it.
6		*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.
7	*PHY Layer* receives the ***GoodCRC*** *Message* and checks the *CRC* to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.
8	*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.	
9	*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***EPR_Get_Source_Cap*** *Message* was successfully sent. *Policy Engine* starts ***SenderResponseTimer***.	
10		*Policy Engine* requests the *DPM* for the present EPR *Source Capabilities* which are provided. The *Policy Engine* tells the *Protocol Layer* to form an ***EPR_Source_Capabilities*** *Message*.
11		*Protocol Layer* creates the *Message* and passes to *PHY Layer*.
12	*PHY Layer* receives the *Message* and compares the *CRC* it calculated with the one sent to verify the ***EPR_Source_Capabilities*** *Message*.	*PHY Layer* appends a *CRC* and sends the ***EPR_Source_Capabilities*** *Message*. Starts ***CRCReceiveTimer***.
13	*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***EPR_Source_Capabilities*** *Message* information to the *Policy Engine* that consumes it.	
14	The *Policy Engine* stops the ***SenderResponseTimer***.	
15	*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.	

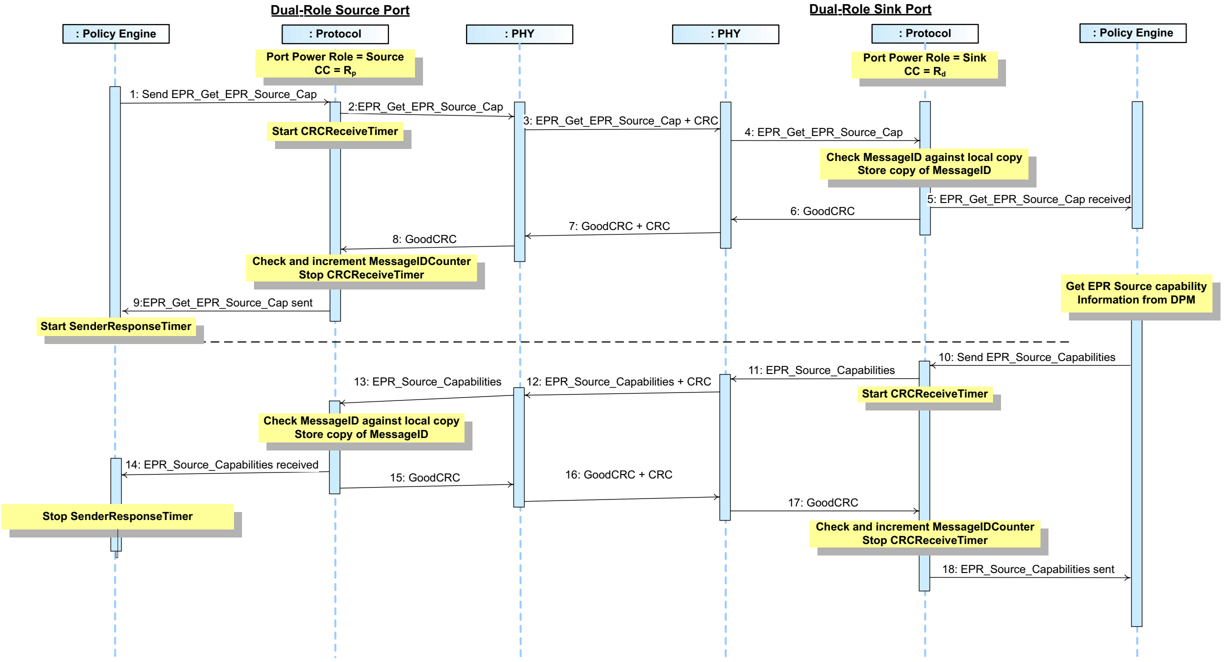
Table 8.95 Steps for a Sink getting EPR Source Capabilities Sequence

Step	Sink Port	Source Port
16	*PHY Layer* appends a *CRC* and sends the ***GoodCRC*** *Message*.	*PHY Layer* receives ***GoodCRC*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
17		*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.
18		*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Source_Capabilities*** *Message* was successfully sent.
The *Source* has informed the *Sink* of its *EPR Capabilities*.		

8.3.2.11.3.2.2 Dual-Role Source Gets Source Capabilities from a Dual-Role EPR Sink

Figure 8.69, "Dual-Role Source Gets Dual-Role Sink's Capabilities as an EPR Source" shows an example sequence between a *Dual-Role Power Source* and a *Dual-Role Power Sink* when the *Source* gets the *Sink Capabilities* as an *EPR Source*.

Figure 8.69 Dual-Role Source Gets Dual-Role Sink's Capabilities as an EPR Source



Dual-Role Source Port
Dual-Role Sink Port
: Policy Engine
: Protocol
: PHY
: PHY
: Protocol
: Policy Engine
Port Power Role = Source
CC = R$_p$
Port Power Role = Sink
CC = R$_d$
1: Send EPR_Get_EPR_Source_Cap
2:EPR_Get_EPR_Source_Cap
Start CRCReceiveTimer
3: EPR_Get_EPR_Source_Cap + CRC
4: EPR_Get_EPR_Source_Cap
Check MessageID against local copy
Store copy of MessageID
5: EPR_Get_EPR_Source_Cap received
6: GoodCRC
7: GoodCRC + CRC
8: GoodCRC
Check and increment MessageIDCounter
Stop CRCReceiveTimer
Get EPR Source capability Information from DPM
9:EPR_Get_EPR_Source_Cap sent
Start SenderResponseTimer
10: Send EPR_Source_Capabilities
11: EPR_Source_Capabilities
12: EPR_Source_Capabilities + CRC
13: EPR_Source_Capabilities
Start CRCReceiveTimer
Check MessageID against local copy
Store copy of MessageID
14: EPR_Source_Capabilities received
15: GoodCRC
16: GoodCRC + CRC
17: GoodCRC
Stop SenderResponseTimer
Check and increment MessageIDCounter
Stop CRCReceiveTimer
18: EPR_Source_Capabilities sent

Table 8.96, "Steps for a Dual-Role Source getting Dual-Role Sink's capabilities as an EPR Source Sequence" below provides a detailed explanation of what happens at each labeled step in *Figure 8.69, "Dual-Role Source Gets Dual-Role Sink's Capabilities as an EPR Source"* above.

Table 8.96 Steps for a Dual-Role Source getting Dual-Role Sink's capabilities as an EPR Source Sequence

Step	Dual-Role Source Port	Dual-Role Sink Port
1	The *Port* has ***Port Power Role*** set to *Source* and the R_p pull up on its *CC* wire. *Policy Engine* directs the *Protocol Layer* to send a ***EPR_Get_Source_Cap*** *Message*.	The *Port* has ***Port Power Role*** set to *Sink* with the R_d pull down on its *CC* wire.
2	*Protocol Layer* creates the *Message* and passes to *PHY Layer*.	
3	*PHY Layer* appends *CRC* and sends the ***EPR_Get_Source_Cap*** *Message*. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the ***EPR_Get_Source_Cap*** *Message* and checks the *CRC* to verify the *Message*.
4		*PHY Layer* removes the *CRC* and forwards the ***EPR_Get_Source_Cap*** *Message* to the *Protocol Layer*.
5		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***EPR_Get_Source_Cap*** *Message* information to the *Policy Engine* that consumes it.
6		*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.
7	*PHY Layer* receives the ***GoodCRC*** *Message* and checks the *CRC* to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.
8	*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.	
9	*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***EPR_Get_Source_Cap*** *Message* was successfully sent. *Policy Engine* starts ***SenderResponseTimer***.	
10		*Policy Engine* requests the *DPM* for the present *Source Capabilities* which are provided. The *Policy Engine* tells the *Protocol Layer* to form an ***EPR_Source_Capabilities*** *Message*.
11		*Protocol Layer* creates the *Message* and passes to *PHY Layer*.
12	*PHY Layer* receives the *Message* and compares the *CRC* it calculated with the one sent to verify the ***EPR_Source_Capabilities*** *Message*.	*PHY Layer* appends a *CRC* and sends the ***EPR_Source_Capabilities*** *Message*. Starts ***CRCReceiveTimer***.
13	*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***EPR_Source_Capabilities*** *Message* information to the *Policy Engine* that consumes it.	
14	The *Policy Engine* stops the ***SenderResponseTimer***.	
15	*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.	

Table 8.96 Steps for a Dual-Role Source getting Dual-Role Sink's capabilities as an EPR Source Sequence

Step	Dual-Role Source Port	Dual-Role Sink Port
16	*PHY Layer* appends a *CRC* and sends the ***GoodCRC*** *Message*.	*PHY Layer* receives ***GoodCRC*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
17		*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.
18		*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***EPR_Source_Capabilities*** *Message* was successfully sent.
The *Dual-Role Power Sink* has informed the *Dual-Role Power Source* of its *EPR Capabilities*.		

8.3.2.11.3.2.3 Source Gets Sink EPR Capabilities

Figure 8.70, "Source Gets Sink's EPR Capabilities" shows an example sequence between a *Source* and a *Sink* when the *Source* gets the *Sink*'s *EPR Capabilities*.

Figure 8.70 Source Gets Sink's EPR Capabilities

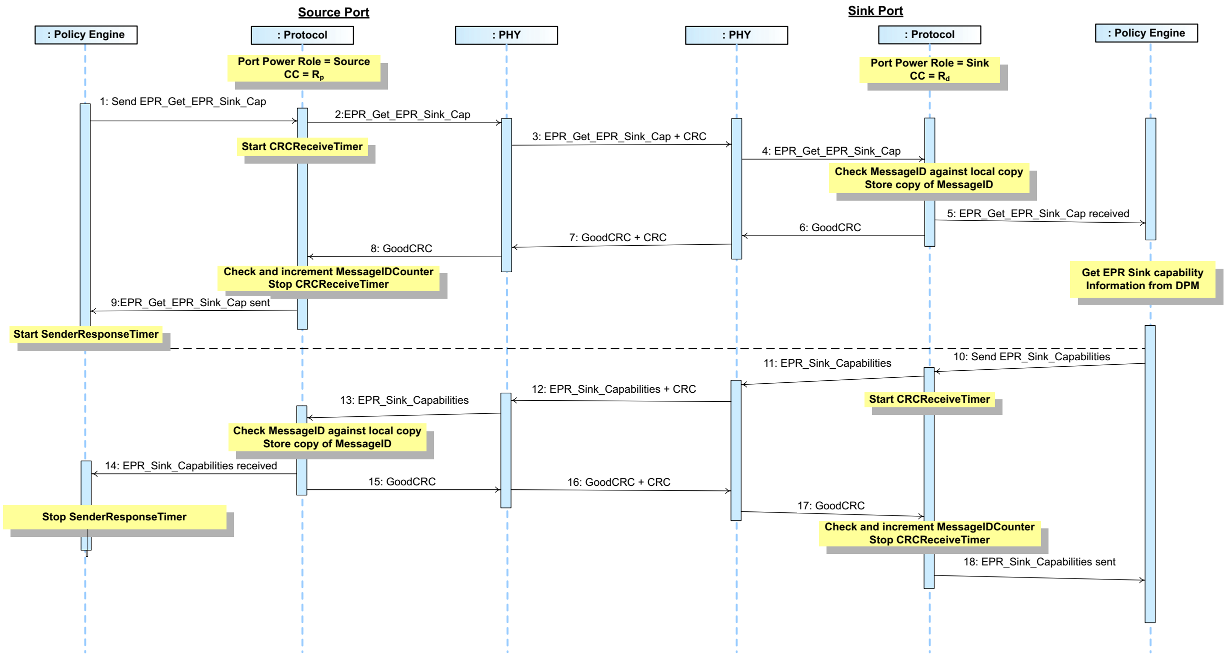


Table 8.97, "Steps for a Source getting Sink EPR Capabilities Sequence" below provides a detailed explanation of what happens at each labeled step in *Figure 8.70, "Source Gets Sink's EPR Capabilities"* above.

Table 8.97 Steps for a Source getting Sink EPR Capabilities Sequence

Step	Source Port	Sink Port
1	The *Port* has ***Port Power Role*** set to *Source* and the R_p pull up on its *CC* wire. *Policy Engine* directs the *Protocol Layer* to send a ***EPR_Get_Sink_Cap*** *Message*.	The *Port* has ***Port Power Role*** set to *Sink* with the R_d pull down on its *CC* wire.
2	*Protocol Layer* creates the *Message* and passes to *PHY Layer*.	
3	*PHY Layer* appends *CRC* and sends the ***EPR_Get_Sink_Cap*** *Message*. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the ***EPR_Get_Sink_Cap*** *Message* and checks the *CRC* to verify the *Message*.
4		*PHY Layer* removes the *CRC* and forwards the ***EPR_Get_Sink_Cap*** *Message* to the *Protocol Layer*.
5		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***EPR_Get_Sink_Cap*** *Message* information to the *Policy Engine* that consumes it.
6		*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.
7	*PHY Layer* receives the ***GoodCRC*** *Message* and checks the *CRC* to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.
8	*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.	
9	*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***EPR_Get_Sink_Cap*** *Message* was successfully sent. *Policy Engine* starts ***SenderResponseTimer***.	
10		*Policy Engine* requests the *DPM* for the present *Sink Capabilities* which are provided. The *Policy Engine* tells the *Protocol Layer* to form an ***EPR_Sink_Capabilities*** *Message*.
11		*Protocol Layer* creates the *Message* and passes to *PHY Layer*.
12	*PHY Layer* receives the *Message* and compares the *CRC* it calculated with the one sent to verify the ***EPR_Sink_Capabilities*** *Message*.	*PHY Layer* appends a *CRC* and sends the ***EPR_Sink_Capabilities*** *Message*. Starts ***CRCReceiveTimer***.
13	*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***EPR_Sink_Capabilities*** *Message* information to the *Policy Engine* that consumes it.	
14	The *Policy Engine* stops the ***SenderResponseTimer***.	
15	*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.	

Table 8.97 Steps for a Source getting Sink EPR Capabilities Sequence

Step	Source Port	Sink Port
16	*PHY Layer* appends a *CRC* and sends the ***GoodCRC*** *Message*.	*PHY Layer* receives ***GoodCRC*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
17		*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.
18		*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***EPR_Sink_Capabilities*** *Message* was successfully sent.
The *Sink* has informed the *Source* of its *EPR Capabilities*.		

8.3.2.11.3.2.4 Dual-Role Sink Get Sink EPR Capabilities from a Dual-Role Source

Figure 8.71, "Dual-Role Sink Gets Dual-Role Source's Capabilities as an EPR Sink" shows an example sequence between a *Dual-Role Power Source* and a *Dual-Role Power Sink* when the *Dual-Role Power Sink* gets the *Dual-Role Power Source Capabilities* as a *Sink*.

Figure 8.71 Dual-Role Sink Gets Dual-Role Source's Capabilities as an EPR Sink

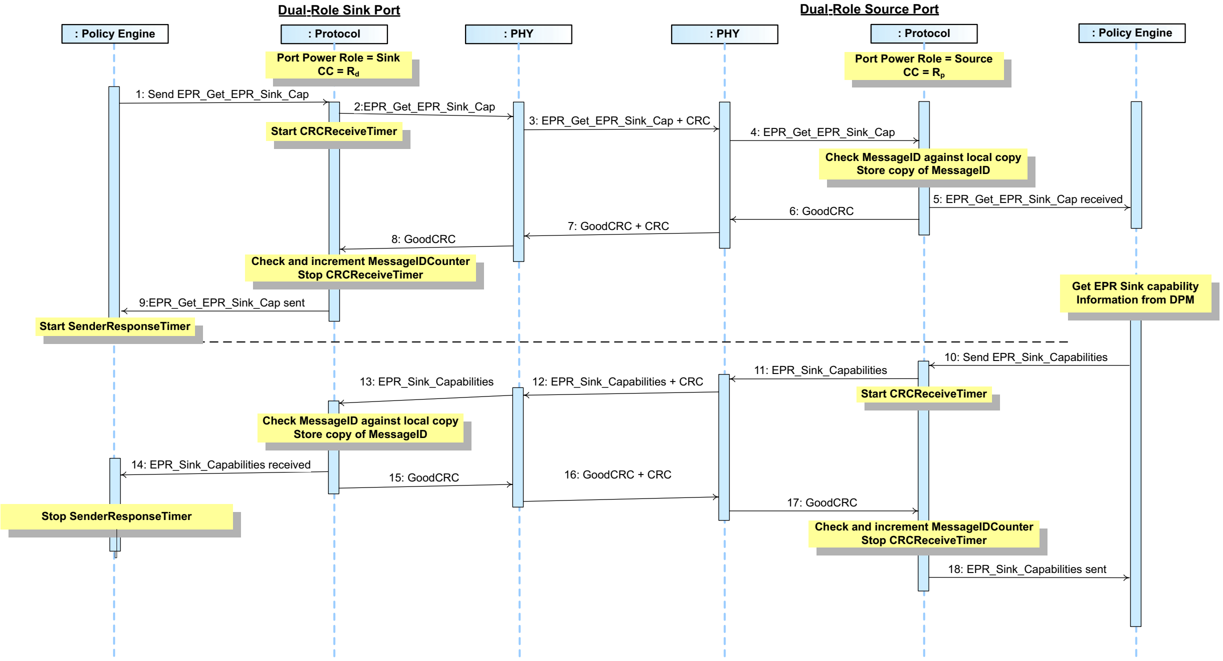


Table 8.98, "Steps for a Dual-Role Sink getting Dual-Role Source Capabilities as an EPR Sink Sequence" below provides a detailed explanation of what happens at each labeled step in *Figure 8.71, "Dual-Role Sink Gets Dual-Role Source's Capabilities as an EPR Sink"* above.

Table 8.98 Steps for a Dual-Role Sink getting Dual-Role Source Capabilities as an EPR Sink Sequence

Step	Dual-Role Sink Port	Dual-Role Source Port
1	The *Port* has ***Port Power Role*** set to *Dual-Role Power Sink* with the R_d pull down on its *CC* wire. *Policy Engine* directs the *Protocol Layer* to send a ***EPR_Get_Sink_Cap*** *Message*.	The *Port* has ***Port Power Role*** set to *Dual-Role Power Source* and the R_p pull up on its *CC* wire.
2	*Protocol Layer* creates the *Message* and passes to *PHY Layer*.	
3	*PHY Layer* appends *CRC* and sends the ***EPR_Get_Sink_Cap*** *Message*. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the ***EPR_Get_Sink_Cap*** *Message* and checks the *CRC* to verify the *Message*.
4		*PHY Layer* removes the *CRC* and forwards the ***EPR_Get_Sink_Cap*** *Message* to the *Protocol Layer*.
5		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***EPR_Get_Sink_Cap*** *Message* information to the *Policy Engine* that consumes it.
6		*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.
7	*PHY Layer* receives the ***GoodCRC*** *Message* and checks the *CRC* to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.
8	*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.	
9	*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***EPR_Get_Sink_Cap*** *Message* was successfully sent. *Policy Engine* starts ***SenderResponseTimer***.	
10		*Policy Engine* requests the *DPM* for the present *Dual-Role Power Source Capabilities* which are provided. The *Policy Engine* tells the *Protocol Layer* to form an ***EPR_Sink_Capabilities*** *Message*.
11		*Protocol Layer* creates the *Message* and passes to *PHY Layer*.
12	*PHY Layer* receives the *Message* and compares the *CRC* it calculated with the one sent to verify the ***EPR_Sink_Capabilities*** *Message*.	*PHY Layer* appends a *CRC* and sends the ***EPR_Sink_Capabilities*** *Message*. Starts ***CRCReceiveTimer***.
13	*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***EPR_Sink_Capabilities*** *Message* information to the *Policy Engine* that consumes it.	
14	The *Policy Engine* stops the ***SenderResponseTimer***.	
15	*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.	

Table 8.98 Steps for a Dual-Role Sink getting Dual-Role Source Capabilities as an EPR Sink Sequence

Step	Dual-Role Sink Port	Dual-Role Source Port
16	*PHY Layer* appends a *CRC* and sends the ***GoodCRC*** *Message*.	*PHY Layer* receives ***GoodCRC*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
17		*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.
18		*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***EPR_Sink_Capabilities*** *Message* was successfully sent.
The *Dual-Role Power Source* has informed the *Dual-Role Power Sink* of its *Capabilities* as an *EPR Sink*.		

8.3.2.11.4 Extended Capabilities

8.3.2.11.4.1 Sink Gets Source Extended Capabilities

Figure 8.72, "Sink Gets Source's Extended Capabilities" shows an example sequence between a *Source* and a *Sink* when the *Sink* gets the *Source*'s *Extended Capabilities*.

Figure 8.72 Sink Gets Source's Extended Capabilities

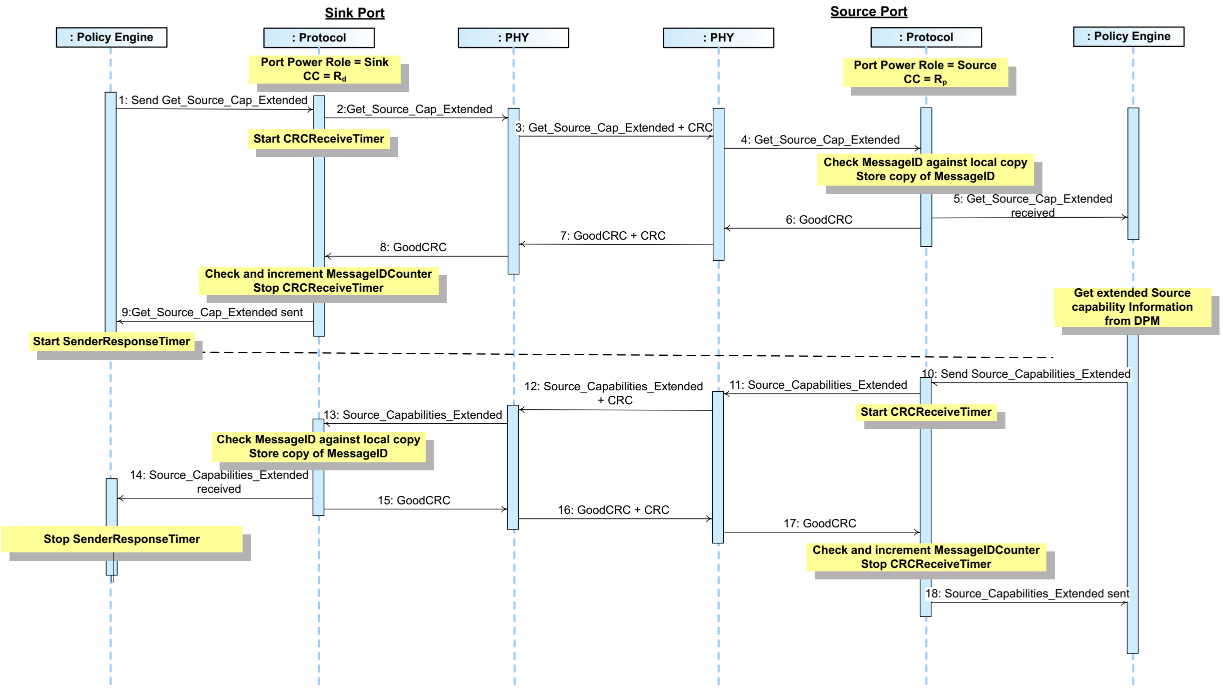

Sink Port
Source Port
: Policy Engine
: Protocol
: PHY
: PHY
: Protocol
: Policy Engine
Port Power Role = Sink
CC = R_d
Port Power Role = Source
CC = R_p
1: Send Get_Source_Cap_Extended
2:Get_Source_Cap_Extended
Start CRCReceiveTimer
3: Get_Source_Cap_Extended + CRC
4: Get_Source_Cap_Extended
Check MessageID against local copy
Store copy of MessageID
5: Get_Source_Cap_Extended received
6: GoodCRC
7: GoodCRC + CRC
8: GoodCRC
Check and increment MessageIDCounter
Stop CRCReceiveTimer
9:Get_Source_Cap_Extended sent
Get extended Source capability Information from DPM
Start SenderResponseTimer
10: Send Source_Capabilities_Extended
11: Source_Capabilities_Extended
12: Source_Capabilities_Extended + CRC
Start CRCReceiveTimer
13: Source_Capabilities_Extended
Check MessageID against local copy
Store copy of MessageID
14: Source_Capabilities_Extended received
15: GoodCRC
16: GoodCRC + CRC
17: GoodCRC
Stop SenderResponseTimer
Check and increment MessageIDCounter
Stop CRCReceiveTimer
18: Source_Capabilities_Extended sent

Table 8.99, "Steps for a Sink getting Source Extended Capabilities Sequence" below provides a detailed explanation of what happens at each labeled step in *Figure 8.72, "Sink Gets Source's Extended Capabilities"* above.

Table 8.99 Steps for a Sink getting Source Extended Capabilities Sequence

Step	Sink Port	Source Port
1	The *Port* has ***Port Power Role*** set to *Sink* with the R_d pull down on its *CC* wire. *Policy Engine* directs the *Protocol Layer* to send a ***Get_Source_Cap_Extended*** *Message*.	The *Port* has ***Port Power Role*** set to *Source* and the R_p pull up on its *CC* wire.
2	*Protocol Layer* creates the *Message* and passes to *PHY Layer*.	
3	*PHY Layer* appends *CRC* and sends the ***Get_Source_Cap_Extended*** *Message*. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the ***Get_Source_Cap_Extended*** *Message* and checks the *CRC* to verify the *Message*.
4		*PHY Layer* removes the *CRC* and forwards the ***Get_Source_Cap_Extended*** *Message* to the *Protocol Layer*.
5		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Get_Source_Cap_Extended*** *Message* information to the *Policy Engine* that consumes it.
6		*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.
7	*PHY Layer* receives the ***GoodCRC*** *Message* and checks the *CRC* to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.
8	*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.	
9	*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Get_Source_Cap_Extended*** *Message* was successfully sent. *Policy Engine* starts ***SenderResponseTimer***.	
10		*Policy Engine* requests the *DPM* for the present *Source Extended Capabilities* which are provided. The *Policy Engine* tells the *Protocol Layer* to form a ***Source_Capabilities_Extended*** *Message*.
11		*Protocol Layer* creates the *Message* and passes to *PHY Layer*.
12	*PHY Layer* receives the *Message* and compares the *CRC* it calculated with the one sent to verify the ***Source_Capabilities_Extended*** *Message*.	*PHY Layer* appends a *CRC* and sends the ***Source_Capabilities_Extended*** *Message*. Starts ***CRCReceiveTimer***.
13	*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Source_Capabilities_Extended*** *Message* information to the *Policy Engine* that consumes it.	
14	The *Policy Engine* stops the ***SenderResponseTimer***.	
15	*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.	

Table 8.99 Steps for a Sink getting Source Extended Capabilities Sequence

Step	Sink Port	Source Port
16	*PHY Layer* appends a *CRC* and sends the ***GoodCRC*** *Message*.	*PHY Layer* receives ***GoodCRC*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
17		*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.
18		*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Source_Capabilities_Extended*** *Message* was successfully sent.
The *Source* has informed the *Sink* of its *Extended Capabilities*.		

8.3.2.11.4.2 Dual-Role Source Gets Source Capabilities Extended from a Dual-Role Sink

Figure 8.73, "Dual-Role Source Gets Dual-Role Sink's Extended Capabilities" shows an example sequence between a *Source* and a *Sink* when the *Dual-Role Power Source* gets the *Dual-Role Power Sink*'s *Extended Capabilities* as a *Source*.

Figure 8.73 Dual-Role Source Gets Dual-Role Sink's Extended Capabilities

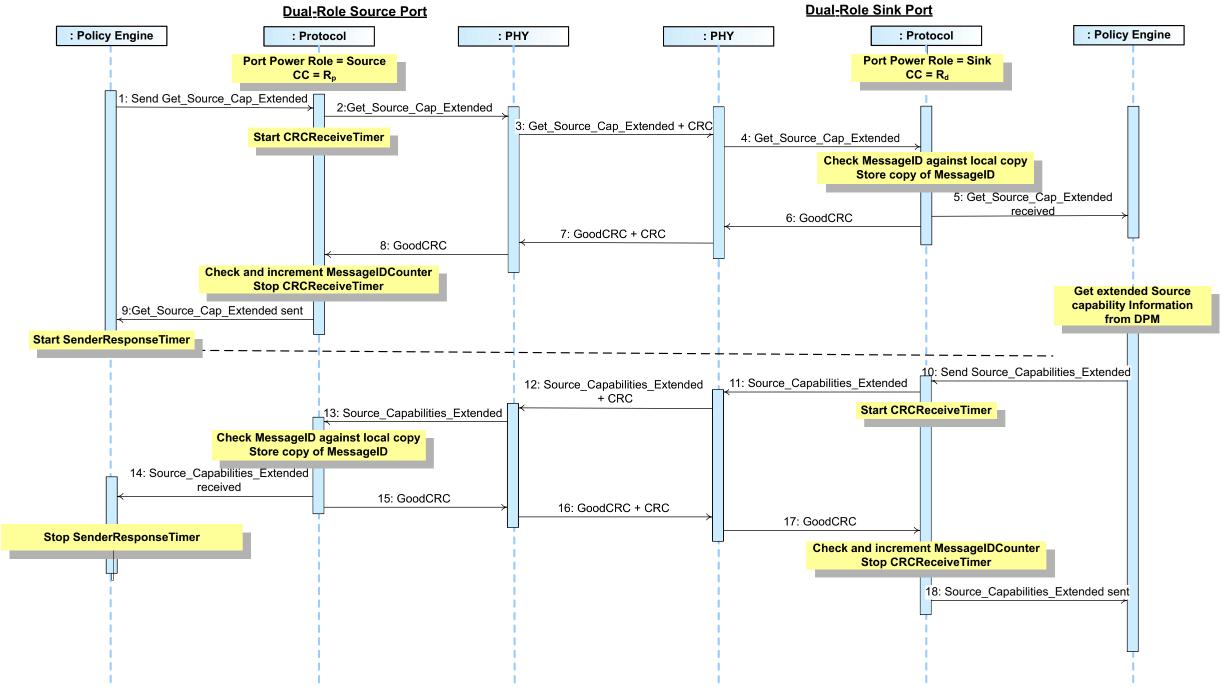

Dual-Role Source Port
Dual-Role Sink Port
: Policy Engine
: Protocol
: PHY
: PHY
: Protocol
: Policy Engine
Port Power Role = Source
CC = Rp
Port Power Role = Sink
CC = Rd
1: Send Get_Source_Cap_Extended
2:Get_Source_Cap_Extended
Start CRCReceiveTimer
3: Get_Source_Cap_Extended + CRC
4: Get_Source_Cap_Extended
Check MessageID against local copy
Store copy of MessageID
5: Get_Source_Cap_Extended received
6: GoodCRC
7: GoodCRC + CRC
8: GoodCRC
Check and increment MessageIDCounter
Stop CRCReceiveTimer
Get extended Source capability Information from DPM
9:Get_Source_Cap_Extended sent
Start SenderResponseTimer
10: Send Source_Capabilities_Extended
11: Source_Capabilities_Extended
12: Source_Capabilities_Extended + CRC
Start CRCReceiveTimer
13: Source_Capabilities_Extended
Check MessageID against local copy
Store copy of MessageID
14: Source_Capabilities_Extended received
15: GoodCRC
16: GoodCRC + CRC
17: GoodCRC
Stop SenderResponseTimer
Check and increment MessageIDCounter
Stop CRCReceiveTimer
18: Source_Capabilities_Extended sent

Table 8.100, "Steps for a Dual-Role Source getting Dual-Role Sink Extended Capabilities Sequence" below provides a detailed explanation of what happens at each labeled step in *Figure 8.73, "Dual-Role Source Gets Dual-Role Sink's Extended Capabilities"* above.

Table 8.100 Steps for a Dual-Role Source getting Dual-Role Sink Extended Capabilities Sequence

Step	Dual-Role Source Port	Dual-Role Sink Port
1	The *Port* has ***Port Power Role*** set to *Source* and the R_p pull up on its *CC* wire. *Policy Engine* directs the *Protocol Layer* to send a ***Get_Source_Cap_Extended*** *Message*.	The *Port* has ***Port Power Role*** set to *Sink* with the R_d pull down on its *CC* wire.
2	*Protocol Layer* creates the *Message* and passes to *PHY Layer*.	
3	*PHY Layer* appends *CRC* and sends the ***Get_Source_Cap_Extended*** *Message*. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the ***Get_Source_Cap_Extended*** *Message* and checks the *CRC* to verify the *Message*.
4		*PHY Layer* removes the *CRC* and forwards the ***Get_Source_Cap_Extended*** *Message* to the *Protocol Layer*.
5		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Get_Source_Cap_Extended*** *Message* information to the *Policy Engine* that consumes it.
6		*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.
7	*PHY Layer* receives the ***GoodCRC*** *Message* and checks the *CRC* to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.
8	*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.	
9	*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Get_Source_Cap_Extended*** *Message* was successfully sent. *Policy Engine* starts ***SenderResponseTimer***.	
10		*Policy Engine* requests the *DPM* for the *Extended Capabilities* as a *Source* which are provided. The *Policy Engine* tells the *Protocol Layer* to form a ***Source_Capabilities_Extended*** *Message*.
11		*Protocol Layer* creates the *Message* and passes to *PHY Layer*.
12	*PHY Layer* receives the *Message* and compares the *CRC* it calculated with the one sent to verify the ***Source_Capabilities_Extended*** *Message*.	*PHY Layer* appends a *CRC* and sends the ***Source_Capabilities_Extended*** *Message*. Starts ***CRCReceiveTimer***.
13	*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Source_Capabilities_Extended*** *Message* information to the *Policy Engine* that consumes it.	
14	The *Policy Engine* stops the ***SenderResponseTimer***.	

Table 8.100 Steps for a Dual-Role Source getting Dual-Role Sink Extended Capabilities Sequence

Step	Dual-Role Source Port	Dual-Role Sink Port
15	*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.	
16	*PHY Layer* appends a *CRC* and sends the ***GoodCRC*** *Message*.	*PHY Layer* receives ***GoodCRC*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
17		*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.
18		*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Source_Capabilities_Extended*** *Message* was successfully sent.
The *Dual-Role Power Sink* has informed the *Dual-Role Power Source* of its *Extended Capabilities* as a *Source*.		

8.3.2.11.4.3 Source Gets Sink Extended Capabilities

Figure 8.74, "Source Gets Sink's Extended Capabilities" shows an example sequence between a *Source* and a *Sink* when the *Source* gets the *Sink*'s *Extended Capabilities*.

Figure 8.74 Source Gets Sink's Extended Capabilities

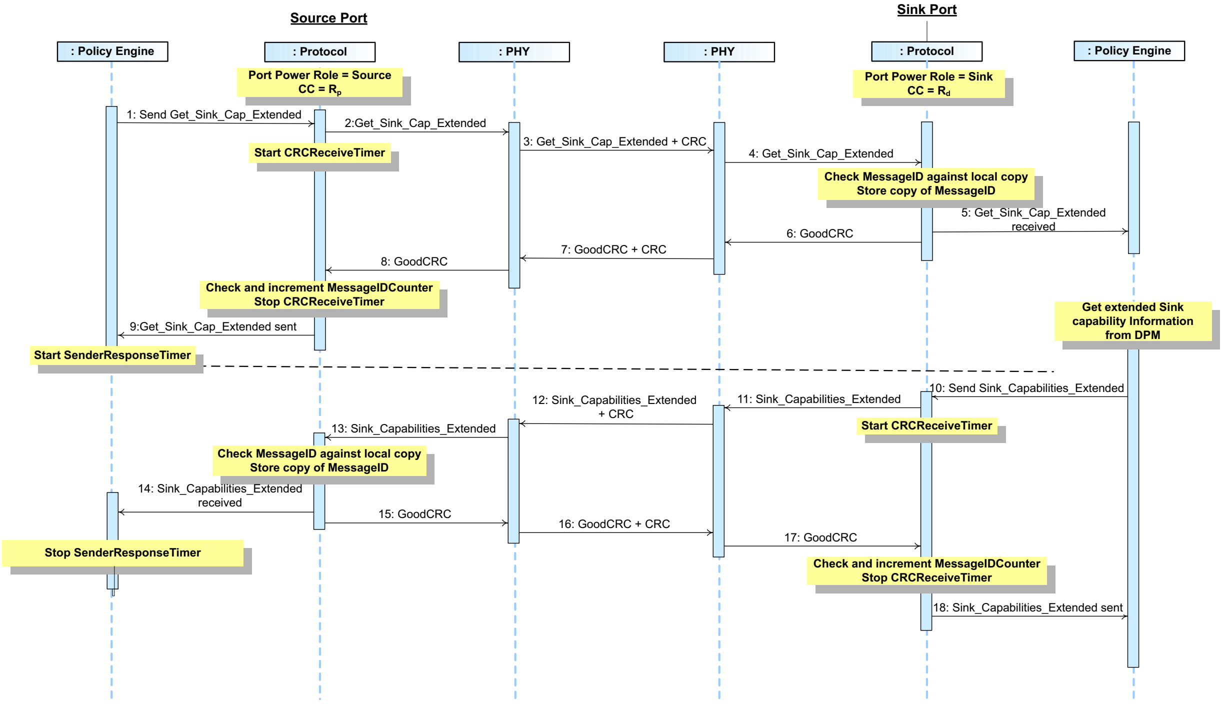

Source Port
Sink Port
: Policy Engine
: Protocol
: PHY
: PHY
: Protocol
: Policy Engine
Port Power Role = Source
CC = R_p
Port Power Role = Sink
CC = R_d
1: Send Get_Sink_Cap_Extended
2:Get_Sink_Cap_Extended
Start CRCReceiveTimer
3: Get_Sink_Cap_Extended + CRC
4: Get_Sink_Cap_Extended
Check MessageID against local copy
Store copy of MessageID
5: Get_Sink_Cap_Extended received
6: GoodCRC
7: GoodCRC + CRC
8: GoodCRC
Check and increment MessageIDCounter
Stop CRCReceiveTimer
9:Get_Sink_Cap_Extended sent
Get extended Sink capability Information from DPM
Start SenderResponseTimer
10: Send Sink_Capabilities_Extended
11: Sink_Capabilities_Extended
12: Sink_Capabilities_Extended + CRC
Start CRCReceiveTimer
13: Sink_Capabilities_Extended
Check MessageID against local copy
Store copy of MessageID
14: Sink_Capabilities_Extended received
15: GoodCRC
16: GoodCRC + CRC
17: GoodCRC
Stop SenderResponseTimer
Check and increment MessageIDCounter
Stop CRCReceiveTimer
18: Sink_Capabilities_Extended sent

Table 8.101, "Steps for a Source getting Sink Extended Capabilities Sequence" below provides a detailed explanation of what happens at each labeled step in *Figure 8.74, "Source Gets Sink's Extended Capabilities"* above.

Table 8.101 Steps for a Source getting Sink Extended Capabilities Sequence

Step	Sink Port	Source Port
1	The *Port* has ***Port Power Role*** set to *Source* and the R_p pull up on its *CC* wire. *Policy Engine* directs the *Protocol Layer* to send a ***Get_Sink_Cap_Extended*** *Message*.	The *Port* has ***Port Power Role*** set to *Sink* with the R_d pull down on its *CC* wire.
2	*Protocol Layer* creates the *Message* and passes to *PHY Layer*.	
3	*PHY Layer* appends *CRC* and sends the ***Get_Source_Cap_Extended*** *Message*. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the ***Get_Sink_Cap_Extended*** *Message* and checks the *CRC* to verify the *Message*.
4		*PHY Layer* removes the *CRC* and forwards the ***Get_Sink_Cap_Extended*** *Message* to the *Protocol Layer*.
5		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Get_Sink_Cap_Extended*** *Message* information to the *Policy Engine* that consumes it.
6		*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.
7	*PHY Layer* receives the ***GoodCRC*** *Message* and checks the *CRC* to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.
8	*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.	
9	*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Get_Sink_Cap_Extended*** *Message* was successfully sent. *Policy Engine* starts ***SenderResponseTimer***.	
10		*Policy Engine* requests the *DPM* for the present *Sink Extended Capabilities* which are provided. The *Policy Engine* tells the *Protocol Layer* to form a ***Sink_Capabilities_Extended*** *Message*.
11		*Protocol Layer* creates the *Message* and passes to *PHY Layer*.
12	*PHY Layer* receives the *Message* and compares the *CRC* it calculated with the one sent to verify the ***Sink_Capabilities_Extended*** *Message*.	*PHY Layer* appends a *CRC* and sends the ***Sink_Capabilities_Extended*** *Message*. Starts ***CRCReceiveTimer***.
13	*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Sink_Capabilities_Extended*** *Message* information to the *Policy Engine* that consumes it.	
14	The *Policy Engine* stops the ***SenderResponseTimer***.	
15	*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.	

Table 8.101 Steps for a Source getting Sink Extended Capabilities Sequence

Step	Sink Port	Source Port
16	*PHY Layer* appends a *CRC* and sends the ***GoodCRC*** *Message*.	*PHY Layer* receives ***GoodCRC*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
17		*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.
18		*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Sink_Capabilities_Extended*** *Message* was successfully sent.
The *Sink* has informed the *Source* of its *Extended Capabilities*.		

8.3.2.11.4.4 Dual-Role Sink Gets Sink Capabilities Extended from a Dual-Role Source

Figure 8.75, "Dual-Role Sink Gets Dual-Role Source's Extended Capabilities" shows an example sequence between a *Source* and a *Sink* when the *Dual-Role Power Sink* gets the *Dual-Role Power Source*'s *Extended Capabilities* as a *Sink*.

Figure 8.75 Dual-Role Sink Gets Dual-Role Source's Extended Capabilities

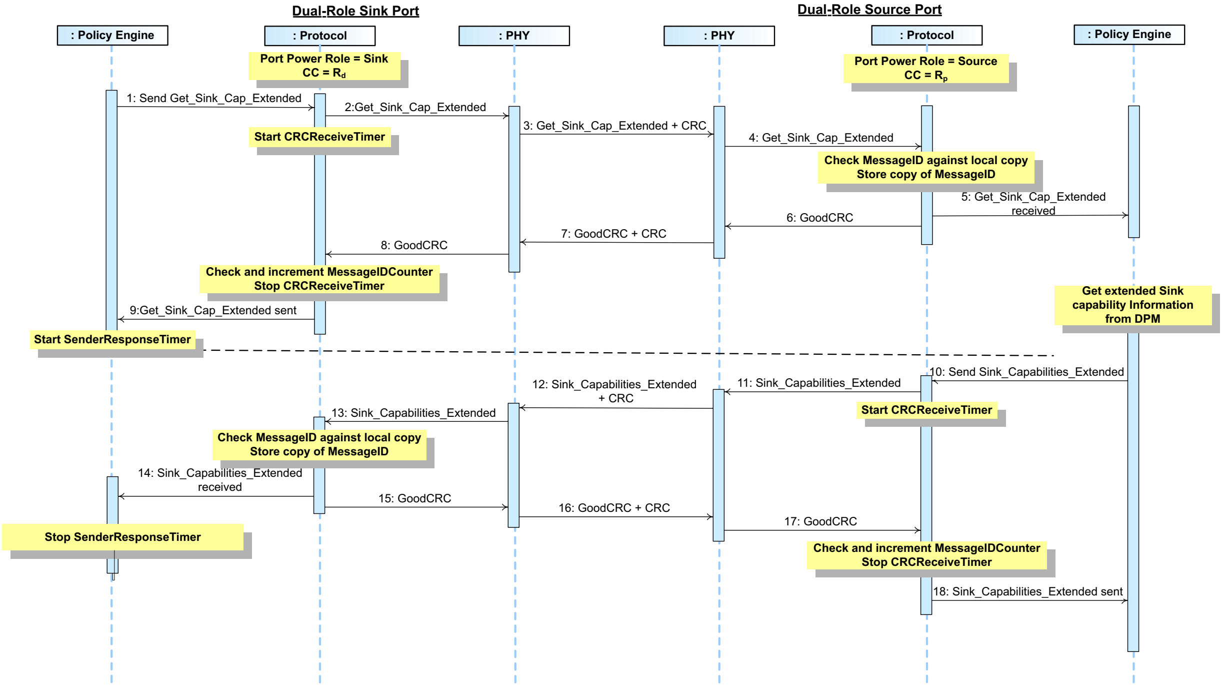

Dual-Role Sink Port
Dual-Role Source Port
: Policy Engine
: Protocol
: PHY
: PHY
: Protocol
: Policy Engine
Port Power Role = Sink
CC = R_d
Port Power Role = Source
CC = R_p
1: Send Get_Sink_Cap_Extended
2:Get_Sink_Cap_Extended
Start CRCReceiveTimer
3: Get_Sink_Cap_Extended + CRC
4: Get_Sink_Cap_Extended
Check MessageID against local copy
Store copy of MessageID
5: Get_Sink_Cap_Extended received
6: GoodCRC
7: GoodCRC + CRC
8: GoodCRC
Check and increment MessageIDCounter
Stop CRCReceiveTimer
Get extended Sink capability Information from DPM
9:Get_Sink_Cap_Extended sent
Start SenderResponseTimer
10: Send Sink_Capabilities_Extended
11: Sink_Capabilities_Extended
12: Sink_Capabilities_Extended + CRC
Start CRCReceiveTimer
13: Sink_Capabilities_Extended
Check MessageID against local copy
Store copy of MessageID
14: Sink_Capabilities_Extended received
15: GoodCRC
16: GoodCRC + CRC
17: GoodCRC
Stop SenderResponseTimer
Check and increment MessageIDCounter
Stop CRCReceiveTimer
18: Sink_Capabilities_Extended sent

Table 8.102, "Steps for a Dual-Role Sink getting Dual-Role Source Extended Capabilities Sequence" below provides a detailed explanation of what happens at each labeled step in *Figure 8.75, "Dual-Role Sink Gets Dual-Role Source's Extended Capabilities"* above.

Table 8.102 Steps for a Dual-Role Sink getting Dual-Role Source Extended Capabilities Sequence

Step	Dual-Role Source Port	Dual-Role Sink Port
1	The *Port* has ***Port Power Role*** set to *Sink* with the R_d pull down on its *CC* wire. *Policy Engine* directs the *Protocol Layer* to send a ***Get_Sink_Cap_Extended*** *Message*.	The *Port* has ***Port Power Role*** set to *Source* and the R_p pull up on its *CC* wire.
2	*Protocol Layer* creates the *Message* and passes to *PHY Layer*.	
3	*PHY Layer* appends *CRC* and sends the ***Get_Sink_Cap_Extended*** *Message*. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the ***Get_Sink_Cap_Extended*** *Message* and checks the *CRC* to verify the *Message*.
4		*PHY Layer* removes the *CRC* and forwards the ***Get_Sink_Cap_Extended*** *Message* to the *Protocol Layer*.
5		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Get_Sink_Cap_Extended*** *Message* information to the *Policy Engine* that consumes it.
6		*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.
7	*PHY Layer* receives the ***GoodCRC*** *Message* and checks the *CRC* to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.
8	*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.	
9	*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Get_Sink_Cap_Extended*** *Message* was successfully sent. *Policy Engine* starts ***SenderResponseTimer***.	
10		*Policy Engine* requests the *DPM* for the *Extended Capabilities* as a *Sink* which are provided. The *Policy Engine* tells the *Protocol Layer* to form a ***Sink_Capabilities_Extended*** *Message*.
11		*Protocol Layer* creates the *Message* and passes to *PHY Layer*.
12	*PHY Layer* receives the *Message* and compares the *CRC* it calculated with the one sent to verify the ***Sink_Capabilities_Extended*** *Message*.	*PHY Layer* appends a *CRC* and sends the ***Sink_Capabilities_Extended*** *Message*. Starts ***CRCReceiveTimer***.
13	*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Sink_Capabilities_Extended*** *Message* information to the *Policy Engine* that consumes it.	
14	The *Policy Engine* stops the ***SenderResponseTimer***.	
15	*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.	

Table 8.102 Steps for a Dual-Role Sink getting Dual-Role Source Extended Capabilities Sequence

Step	Dual-Role Source Port	Dual-Role Sink Port
16	*PHY Layer* appends a *CRC* and sends the ***GoodCRC*** *Message*.	*PHY Layer* receives ***GoodCRC*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
17		*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.
18		*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Sink_Capabilities_Extended*** *Message* was successfully sent.
The *Dual-Role Power Source* has informed the *Dual-Role Power Sink* of its *Extended Capabilities* as a *Sink*.		

8.3.2.11.5 Battery Capabilities and Status

8.3.2.11.5.1 Sink Gets Battery Capabilities

Figure 8.76, "Sink Gets Source's Battery Capabilities" shows an example sequence between a *Source* and a *Sink* when the *Sink* gets the *Source*'s *Battery* capabilities for a given *Battery*.

Figure 8.76 Sink Gets Source's Battery Capabilities

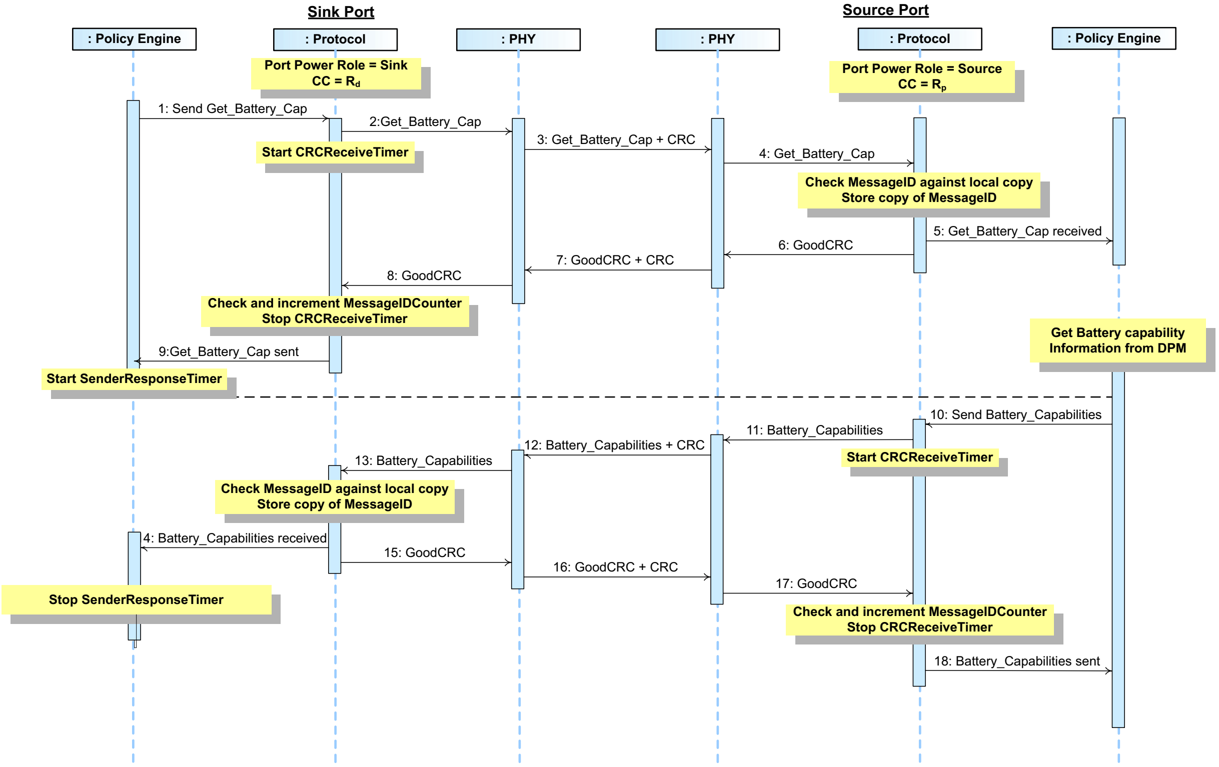


Table 8.103, "Steps for a Sink getting Source Battery capabilities Sequence" below provides a detailed explanation of what happens at each labeled step in *Figure 8.76, "Sink Gets Source's Battery Capabilities"* above.

Table 8.103 Steps for a Sink getting Source Battery capabilities Sequence

Step	Sink Port	Source Port
1	The *Port* has ***Port Power Role*** set to *Sink* with the R_d pull down on its *CC* wire. *Policy Engine* directs the *Protocol Layer* to send a ***Get_Battery_Cap*** *Message* containing the number of the *Battery* for which capabilities are being requested.	The *Port* has ***Port Power Role*** set to *Source* and the R_p pull up on its *CC* wire.
2	*Protocol Layer* creates the *Message* and passes to *PHY Layer*.	
3	*PHY Layer* appends *CRC* and sends the ***Get_Battery_Cap*** *Message*. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the ***Get_Battery_Cap*** *Message* and checks the *CRC* to verify the *Message*.
4		*PHY Layer* removes the *CRC* and forwards the ***Get_Battery_Cap*** *Message* to the *Protocol Layer*.
5		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Get_Battery_Cap*** *Message* information to the *Policy Engine* that consumes it.
6		*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.
7	*PHY Layer* receives the ***GoodCRC*** *Message* and checks the *CRC* to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.
8	*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.	
9	*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Get_Battery_Cap*** *Message* was successfully sent. *Policy Engine* starts ***SenderResponseTimer***.	
10		*Policy Engine* requests the *DPM* for the present *Source Battery* capabilities, for the requested *Battery* number, which are provided. The *Policy Engine* tells the *Protocol Layer* to form a ***Battery_Capabilities*** *Message*.
11		*Protocol Layer* creates the *Message* and passes to *PHY Layer*.
12	*PHY Layer* receives the *Message* and compares the *CRC* it calculated with the one sent to verify the ***Battery_Capabilities*** *Message*.	*PHY Layer* appends a *CRC* and sends the ***Battery_Capabilities*** *Message*. Starts ***CRCReceiveTimer***.
13	*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Battery_Capabilities*** *Message* information to the *Policy Engine* that consumes it.	
14	The *Policy Engine* stops the ***SenderResponseTimer***.	
15	*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.	

Table 8.103 Steps for a Sink getting Source Battery capabilities Sequence

Step	Sink Port	Source Port
16	*PHY Layer* appends a *CRC* and sends the ***GoodCRC*** *Message*.	*PHY Layer* receives ***GoodCRC*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
17		*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.
18		*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Battery_Capabilities*** *Message* was successfully sent.
The *Source* has informed the *Sink* of the *Battery* capabilities for the requested *Battery*.		

8.3.2.11.5.2 Source Gets Battery Capabilities

Figure 8.77, "Source Gets Sink's Battery Capabilities" shows an example sequence between a *Source* and a *Sink* when the *Source* gets the *Sink*'s *Battery* capabilities for a given *Battery*.

Figure 8.77 Source Gets Sink's Battery Capabilities

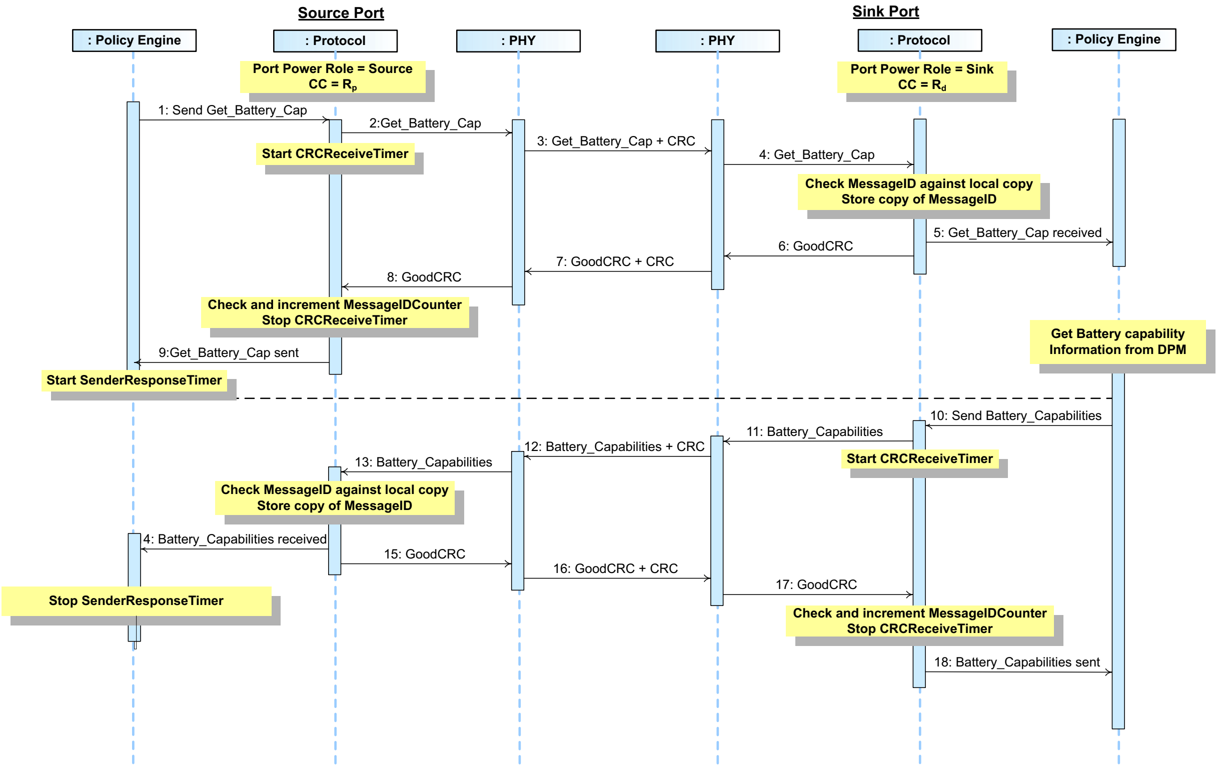


Table 8.104, "Steps for a Source getting Sink Battery capabilities Sequence" below provides a detailed explanation of what happens at each labeled step in *Figure 8.77, "Source Gets Sink's Battery Capabilities"* above.

Table 8.104 Steps for a Source getting Sink Battery capabilities Sequence

Step	Source Port	Sink Port
1	The *Port* has ***Port Power Role*** set to *Source* and the R_p pull up on its *CC* wire. *Policy Engine* directs the *Protocol Layer* to send a ***Get_Battery_Cap*** *Message* containing the number of the *Battery* for which capabilities are being requested.	The *Port* has ***Port Power Role*** set to *Sink* with the R_d pull down on its *CC* wire.
2	*Protocol Layer* creates the *Message* and passes to *PHY Layer*.	
3	*PHY Layer* appends *CRC* and sends the ***Get_Battery_Cap*** *Message*. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the ***Get_Battery_Cap*** *Message* and checks the *CRC* to verify the *Message*.
4		*PHY Layer* removes the *CRC* and forwards the ***Get_Battery_Cap*** *Message* to the *Protocol Layer*.
5		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Get_Battery_Cap*** *Message* information to the *Policy Engine* that consumes it.
6		*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.
7	*PHY Layer* receives the ***GoodCRC*** *Message* and checks the *CRC* to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.
8	*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.	
9	*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Get_Battery_Cap*** *Message* was successfully sent. *Policy Engine* starts ***SenderResponseTimer***.	
10		*Policy Engine* requests the *DPM* for the present *Source Battery* capabilities, for the requested *Battery* number, which are provided. The *Policy Engine* tells the *Protocol Layer* to form a ***Battery_Capabilities*** *Message*.
11		*Protocol Layer* creates the *Message* and passes to *PHY Layer*.
12	*PHY Layer* receives the *Message* and compares the *CRC* it calculated with the one sent to verify the ***Battery_Capabilities*** *Message*.	*PHY Layer* appends a *CRC* and sends the ***Battery_Capabilities*** *Message*. Starts ***CRCReceiveTimer***.
13	*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Battery_Capabilities*** *Message* information to the *Policy Engine* that consumes it.	
14	The *Policy Engine* stops the ***SenderResponseTimer***.	
15	*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.	

Table 8.104 Steps for a Source getting Sink Battery capabilities Sequence

Step	Source Port	Sink Port
16	*PHY Layer* appends a *CRC* and sends the ***GoodCRC*** *Message*.	*PHY Layer* receives ***GoodCRC*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
17		*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.
18		*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Battery_Capabilities*** *Message* was successfully sent.
The *Sink* has informed the *Source* of the *Battery* capabilities for the requested *Battery*.		

8.3.2.11.5.3 Sink Gets Battery Status

Figure 8.78, "Sink Gets Source's Battery Status" shows an example sequence between a *Source* and a *Sink* when the *Sink* gets the *Source*'s *Battery* status for a given *Battery*.

Figure 8.78 Sink Gets Source's Battery Status

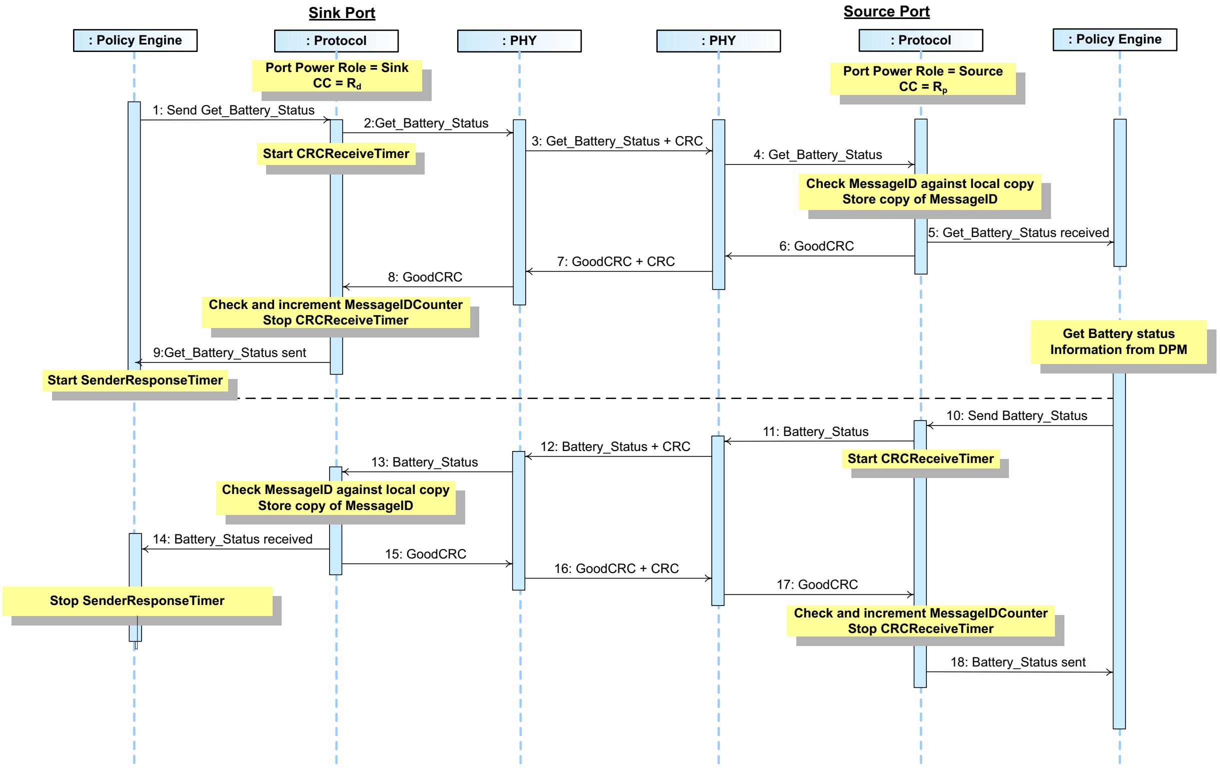


Table 8.105, "Steps for a Sink getting Source Battery status Sequence" below provides a detailed explanation of what happens at each labeled step in *Figure 8.78, "Sink Gets Source's Battery Status"* above.

Table 8.105 Steps for a Sink getting Source Battery status Sequence

Step	Sink Port	Source Port
1	The *Port* has ***Port Power Role*** set to *Sink* with the R_d pull down on its *CC* wire. *Policy Engine* directs the *Protocol Layer* to send a ***Get_Battery_Status*** *Message* containing the number of the *Battery* for which status is being requested.	The *Port* has ***Port Power Role*** set to *Source* and the R_p pull up on its *CC* wire.
2	*Protocol Layer* creates the *Message* and passes to *PHY Layer*.	
3	*PHY Layer* appends *CRC* and sends the ***Get_Battery_Status*** *Message*. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the ***Get_Battery_Status*** *Message* and checks the *CRC* to verify the *Message*.
4		*PHY Layer* removes the *CRC* and forwards the ***Get_Battery_Status*** *Message* to the *Protocol Layer*.
5		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Get_Battery_Status*** *Message* information to the *Policy Engine* that consumes it.
6		*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.
7	*PHY Layer* receives the ***GoodCRC*** *Message* and checks the *CRC* to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.
8	*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.	
9	*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Get_Battery_Status*** *Message* was successfully sent. *Policy Engine* starts ***SenderResponseTimer***.	
10		*Policy Engine* requests the *DPM* for the present *Source Battery* status, for the requested *Battery* number, which are provided. The *Policy Engine* tells the *Protocol Layer* to form a ***Battery_Status*** *Message*.
11		*Protocol Layer* creates the *Message* and passes to *PHY Layer*.
12	*PHY Layer* receives the *Message* and compares the *CRC* it calculated with the one sent to verify the ***Battery_Status*** *Message*.	*PHY Layer* appends a *CRC* and sends the ***Battery_Status*** *Message*. Starts ***CRCReceiveTimer***.
13	*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Battery_Status*** *Message* information to the *Policy Engine* that consumes it.	
14	The *Policy Engine* stops the ***SenderResponseTimer***.	
15	*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.	

Table 8.105 Steps for a Sink getting Source Battery status Sequence

Step	Sink Port	Source Port
16	*PHY Layer* appends a *CRC* and sends the ***GoodCRC*** *Message*.	*PHY Layer* receives ***GoodCRC*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
17		*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.
18		*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Battery_Status*** *Message* was successfully sent.
The *Source* has informed the *Sink* of the *Battery* status for the requested *Battery*.		

8.3.2.11.5.4 Source Gets Battery Status

Figure 8.79, "Source Gets Sink's Battery Status" shows an example sequence between a *Source* and a *Sink* when the *Source* gets the *Sink*'s *Battery* status for a given *Battery*.

Figure 8.79 Source Gets Sink's Battery Status

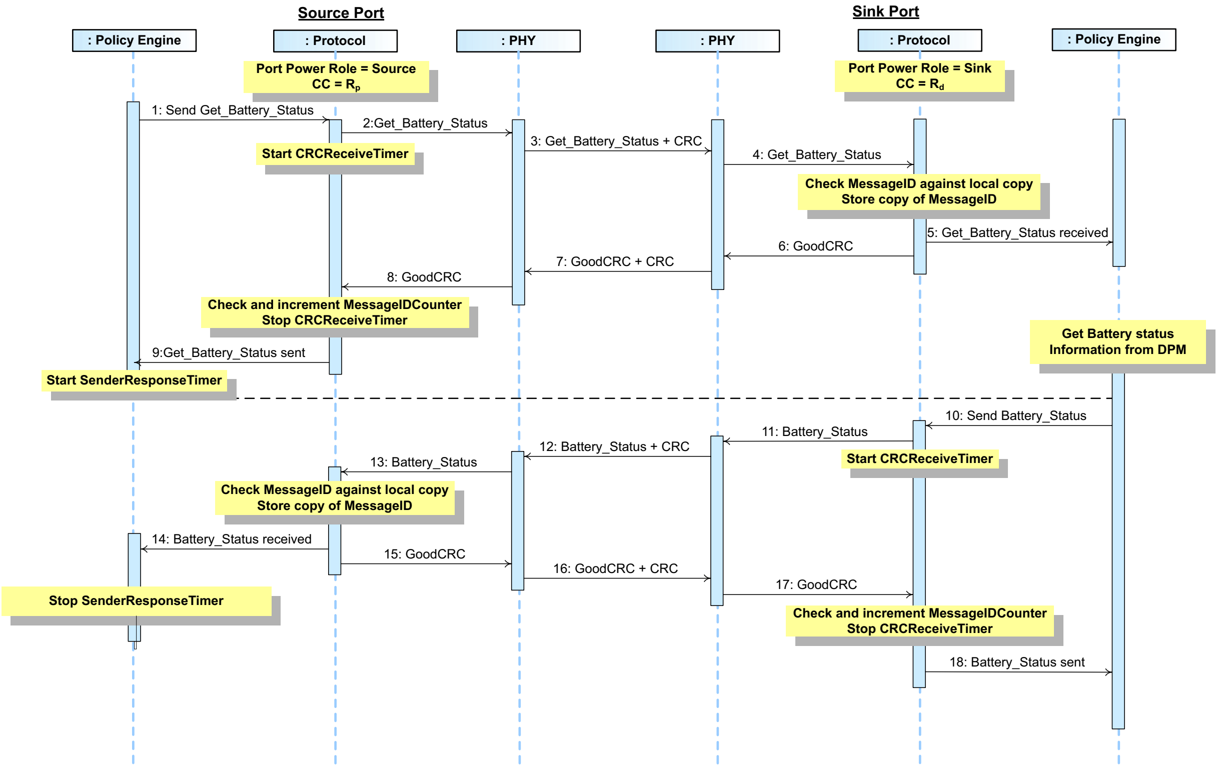


Table 8.106, "Steps for a Source getting Sink Battery status Sequence" below provides a detailed explanation of what happens at each labeled step in *Figure 8.79, "Source Gets Sink's Battery Status"* above.

Table 8.106 Steps for a Source getting Sink Battery status Sequence

Step	Source Port	Sink Port
1	The *Port* has ***Port Power Role*** set to *Source* and the R_p pull up on its *CC* wire. *Policy Engine* directs the *Protocol Layer* to send a ***Get_Battery_Status*** *Message* containing the number of the *Battery* for which status is being requested.	The *Port* has ***Port Power Role*** set to *Sink* with the R_d pull down on its *CC* wire.
2	*Protocol Layer* creates the *Message* and passes to *PHY Layer*.	
3	*PHY Layer* appends *CRC* and sends the ***Get_Battery_Status*** *Message*. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the ***Get_Battery_Status*** *Message* and checks the *CRC* to verify the *Message*.
4		*PHY Layer* removes the *CRC* and forwards the ***Get_Battery_Status*** *Message* to the *Protocol Layer*.
5		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Get_Battery_Status*** *Message* information to the *Policy Engine* that consumes it.
6		*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.
7	*PHY Layer* receives the ***GoodCRC*** *Message* and checks the *CRC* to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.
8	*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.	
9	*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Get_Battery_Status*** *Message* was successfully sent. *Policy Engine* starts ***SenderResponseTimer***.	
10		*Policy Engine* requests the *DPM* for the present *Source Battery* status, for the requested *Battery* number, which are provided. The *Policy Engine* tells the *Protocol Layer* to form a ***Battery_Status*** *Message*.
11		*Protocol Layer* creates the *Message* and passes to *PHY Layer*.
12	*PHY Layer* receives the *Message* and compares the *CRC* it calculated with the one sent to verify the ***Battery_Status*** *Message*.	*PHY Layer* appends a *CRC* and sends the ***Battery_Status*** *Message*. Starts ***CRCReceiveTimer***.
13	*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Battery_Status*** *Message* information to the *Policy Engine* that consumes it.	
14	The *Policy Engine* stops the ***SenderResponseTimer***.	
15	*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.	

Table 8.106 Steps for a Source getting Sink Battery status Sequence

Step	Source Port	Sink Port
16	*PHY Layer* appends a *CRC* and sends the ***GoodCRC*** *Message*.	*PHY Layer* receives ***GoodCRC*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
17		*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.
18		*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Battery_Status*** *Message* was successfully sent.
The *Sink* has informed the *Source* of the *Battery* status for the requested *Battery*.		

8.3.2.11.6 Manufacturer Information

8.3.2.11.6.1 Source Gets Port Manufacturer Information from a Sink

Figure 8.80, "Source Gets Sink's Port Manufacturer Information" shows an example sequence between a *Source* and a *Sink* when the *Source* gets the *Sink*'s Manufacturer information for the *Port*.

Figure 8.80 Source Gets Sink's Port Manufacturer Information

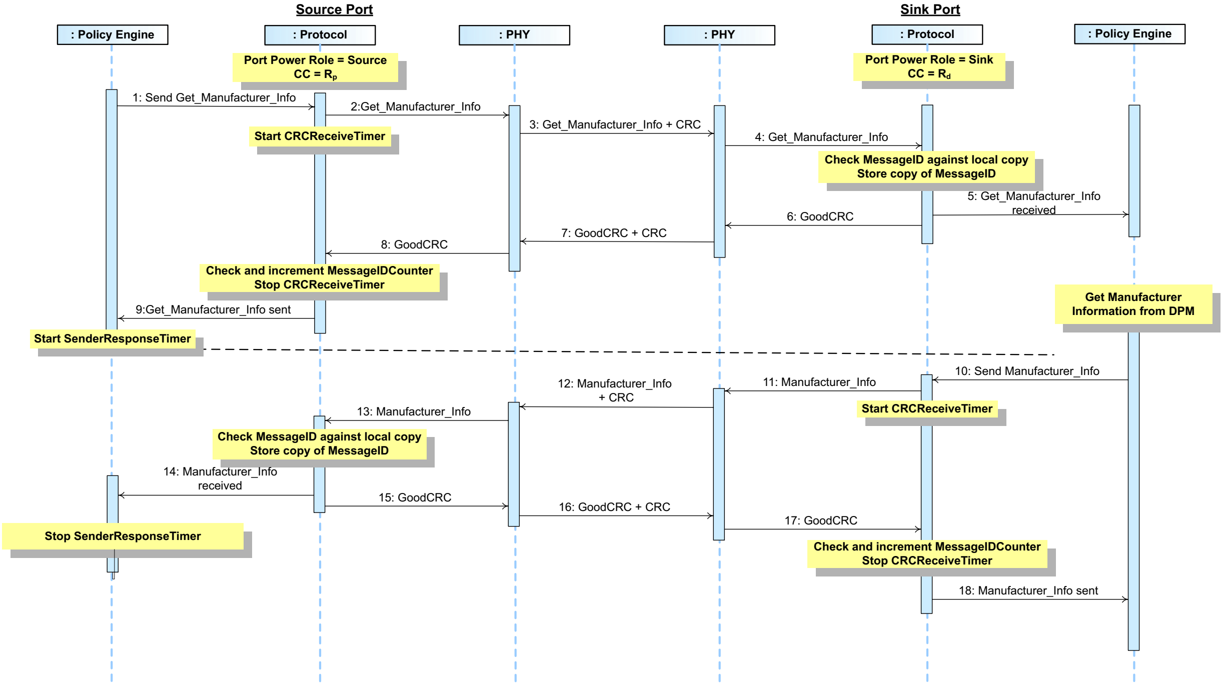


Table 8.107, "Steps for a Source getting Sink's Port Manufacturer Information Sequence" below provides a detailed explanation of what happens at each labeled step in *Figure 8.80, "Source Gets Sink's Port Manufacturer Information"* above.

Table 8.107 Steps for a Source getting Sink's Port Manufacturer Information Sequence

Step	Source Port	Sink Port
1	The *Port* has ***Port Power Role*** set to *Source* and the R_p pull up on its *CC* wire. *Policy Engine* directs the *Protocol Layer* to send a ***Get_Manufacturer_Info*** *Message* with a request for *Port* information.	The *Port* has ***Port Power Role*** set to *Sink* with the R_d pull down on its *CC* wire.
2	*Protocol Layer* creates the *Message* and passes to *PHY Layer*.	
3	*PHY Layer* appends *CRC* and sends the ***Get_Manufacturer_Info*** *Message*. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the ***Get_Manufacturer_Info*** *Message* and checks the *CRC* to verify the *Message*.
4		*PHY Layer* removes the *CRC* and forwards the ***Get_Manufacturer_Info*** *Message* to the *Protocol Layer*.
5		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Get_Manufacturer_Info*** *Message* information to the *Policy Engine* that consumes it.
6		*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.
7	*PHY Layer* receives the ***GoodCRC*** *Message* and checks the *CRC* to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.
8	*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.	
9	*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Get_Manufacturer_Info*** *Message* was successfully sent. *Policy Engine* starts ***SenderResponseTimer***.	
10		*Policy Engine* requests the *DPM* for the *Port*'s manufacturer information which is provided. The *Policy Engine* tells the *Protocol Layer* to form a ***Manufacturer_Info*** *Message*.
11		*Protocol Layer* creates the *Message* and passes to *PHY Layer*.
12	*PHY Layer* receives the *Message* and compares the *CRC* it calculated with the one sent to verify the ***Manufacturer_Info*** *Message*.	*PHY Layer* appends a *CRC* and sends the ***Manufacturer_Info*** *Message*. Starts ***CRCReceiveTimer***.
13	*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Manufacturer_Info*** *Message* information to the *Policy Engine* that consumes it.	
14	The *Policy Engine* stops the ***SenderResponseTimer***.	

Table 8.107 Steps for a Source getting Sink's Port Manufacturer Information Sequence

Step	Source Port	Sink Port
15	*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.	
16	*PHY Layer* appends a *CRC* and sends the ***GoodCRC*** *Message*.	*PHY Layer* receives ***GoodCRC*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
17		*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.
18		*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Manufacturer_Info*** *Message* was successfully sent.
The *Sink* has informed the *Source* of the manufacturer information for the *Port*.		

8.3.2.11.6.2 Sink Gets Port Manufacturer Information from a Source

Figure 8.81, "Sink Gets Source's Port Manufacturer Information" shows an example sequence between a *Source* and a *Sink* when the *Source* gets the *Sink*'s Manufacturer information for the *Port*.

Figure 8.81 Sink Gets Source's Port Manufacturer Information

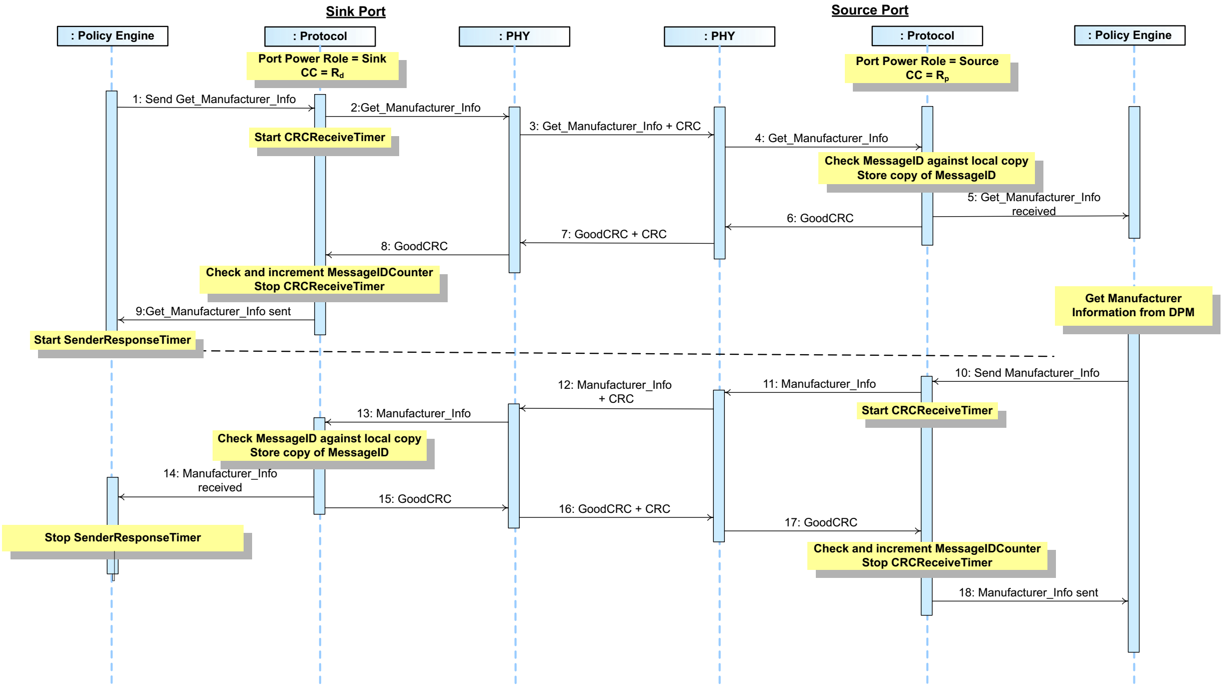


Table 8.108, "Steps for a Source getting Sink's Port Manufacturer Information Sequence" below provides a detailed explanation of what happens at each labeled step in *Figure 8.81, "Sink Gets Source's Port Manufacturer Information"* above.

Table 8.108 Steps for a Source getting Sink's Port Manufacturer Information Sequence

Step	Sink Port	Source Port
1	The *Port* has ***Port Power Role*** set to *Sink* with the R_d pull down on its *CC* wire. *Policy Engine* directs the *Protocol Layer* to send a ***Get_Manufacturer_Info*** *Message* with a request for *Port* information.	The *Port* has ***Port Power Role*** set to *Source* and the R_p pull up on its *CC* wire.
2	*Protocol Layer* creates the *Message* and passes to *PHY Layer*.	
3	*PHY Layer* appends *CRC* and sends the ***Get_Manufacturer_Info*** *Message*. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the ***Get_Manufacturer_Info*** *Message* and checks the *CRC* to verify the *Message*.
4		*PHY Layer* removes the *CRC* and forwards the ***Get_Manufacturer_Info*** *Message* to the *Protocol Layer*.
5		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Get_Manufacturer_Info*** *Message* information to the *Policy Engine* that consumes it.
6		*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.
7	*PHY Layer* receives the ***GoodCRC*** *Message* and checks the *CRC* to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.
8	*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.	
9	*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Get_Manufacturer_Info*** *Message* was successfully sent. *Policy Engine* starts ***SenderResponseTimer***.	
10		*Policy Engine* requests the *DPM* for the *Port*'s manufacturer information which is provided. The *Policy Engine* tells the *Protocol Layer* to form a ***Manufacturer_Info*** *Message*.
11		*Protocol Layer* creates the *Message* and passes to *PHY Layer*.
12	*PHY Layer* receives the *Message* and compares the *CRC* it calculated with the one sent to verify the ***Manufacturer_Info*** *Message*.	*PHY Layer* appends a *CRC* and sends the ***Manufacturer_Info*** *Message*. Starts ***CRCReceiveTimer***.
13	*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Manufacturer_Info*** *Message* information to the *Policy Engine* that consumes it.	
14	The *Policy Engine* stops the ***SenderResponseTimer***.	

Table 8.108 Steps for a Source getting Sink's Port Manufacturer Information Sequence

Step	Sink Port	Source Port
15	*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.	
16	*PHY Layer* appends a *CRC* and sends the ***GoodCRC*** *Message*.	*PHY Layer* receives ***GoodCRC*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
17		*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.
18		*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Manufacturer_Info*** *Message* was successfully sent.
The *Sink* has informed the *Source* of the manufacturer information for the *Port*.		

8.3.2.11.6.3 Source Gets Battery Manufacturer Information from a Sink

Figure 8.82, "Source Gets Sink's Battery Manufacturer Information" shows an example sequence between a *Source* and a *Sink* when the *Source* gets the *Sink*'s Manufacturer information for one of its Batteries.

Figure 8.82 Source Gets Sink's Battery Manufacturer Information

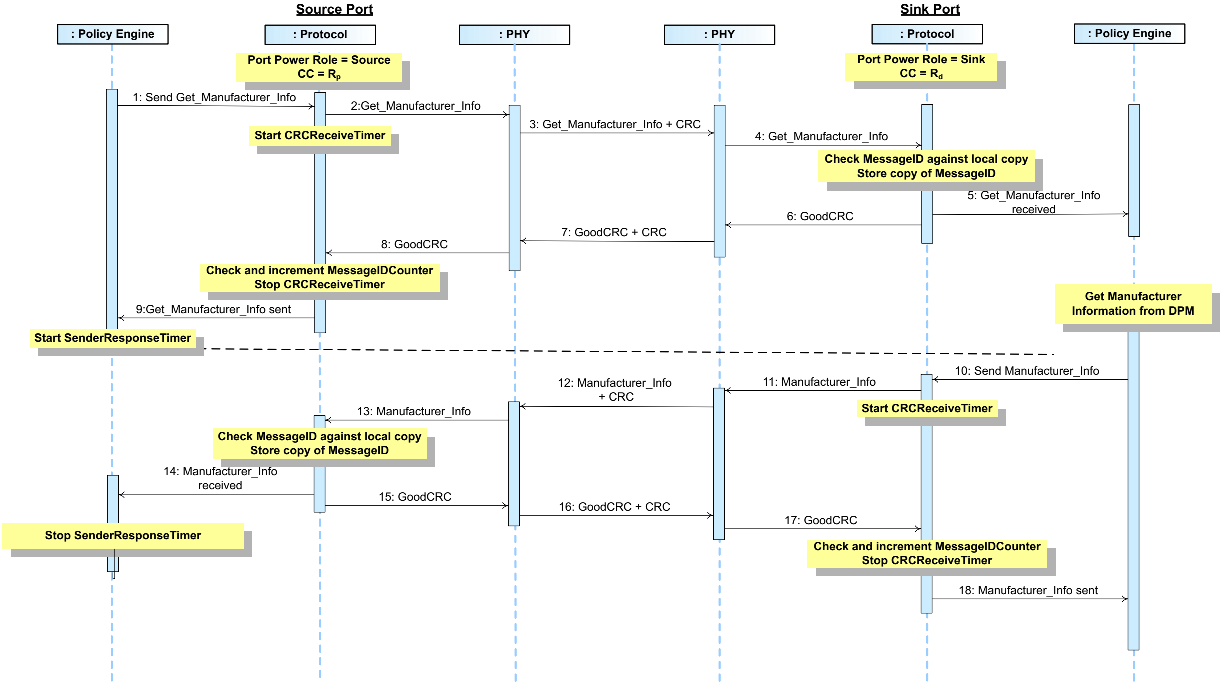


Table 8.109, "Steps for a Source getting Sink's Battery Manufacturer Information Sequence" below provides a detailed explanation of what happens at each labeled step in *Figure 8.82, "Source Gets Sink's Battery Manufacturer Information"* above.

Table 8.109 Steps for a Source getting Sink's Battery Manufacturer Information Sequence

Step	Source Port	Sink Port
1	The *Port* has ***Port Power Role*** set to *Source* and the R_p pull up on its *CC* wire. *Policy Engine* directs the *Protocol Layer* to send a ***Get_Manufacturer_Info*** *Message* with a request for *Battery* information for a given *Battery*.	The *Port* has ***Port Power Role*** set to *Sink* with the R_d pull down on its *CC* wire.
2	*Protocol Layer* creates the *Message* and passes to *PHY Layer*.	
3	*PHY Layer* appends *CRC* and sends the ***Get_Manufacturer_Info*** *Message*. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the ***Get_Manufacturer_Info*** *Message* and checks the *CRC* to verify the *Message*.
4		*PHY Layer* removes the *CRC* and forwards the ***Get_Manufacturer_Info*** *Message* to the *Protocol Layer*.
5		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Get_Manufacturer_Info*** *Message* information to the *Policy Engine* that consumes it.
6		*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.
7	*PHY Layer* receives the ***GoodCRC*** *Message* and checks the *CRC* to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.
8	*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.	
9	*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Get_Manufacturer_Info*** *Message* was successfully sent. *Policy Engine* starts ***SenderResponseTimer***.	
10		*Policy Engine* requests the *DPM* for the *Battery*'s manufacturer information for a given *Battery* which is provided. The *Policy Engine* tells the *Protocol Layer* to form a ***Manufacturer_Info*** *Message*.
11		*Protocol Layer* creates the *Message* and passes to *PHY Layer*.
12	*PHY Layer* receives the *Message* and compares the *CRC* it calculated with the one sent to verify the ***Manufacturer_Info*** *Message*.	*PHY Layer* appends a *CRC* and sends the ***Manufacturer_Info*** *Message*. Starts ***CRCReceiveTimer***.
13	*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Manufacturer_Info*** *Message* information to the *Policy Engine* that consumes it.	
14	The *Policy Engine* stops the ***SenderResponseTimer***.	

Table 8.109 Steps for a Source getting Sink's Battery Manufacturer Information Sequence

Step	Source Port	Sink Port
15	*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.	
16	*PHY Layer* appends a *CRC* and sends the ***GoodCRC*** *Message*.	*PHY Layer* receives ***GoodCRC*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
17		*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.
18		*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Manufacturer_Info*** *Message* was successfully sent.
The *Sink* has informed the *Source* of the manufacturer information for the requested *Battery*.		

8.3.2.11.6.4 Sink Gets Battery Manufacturer Information from a Source

Figure 8.83, "Sink Gets Source's Battery Manufacturer Information" shows an example sequence between a *Source* and a *Sink* when the *Source* gets the *Sink*'s Manufacturer information for the *Port*.

Figure 8.83 Sink Gets Source's Battery Manufacturer Information

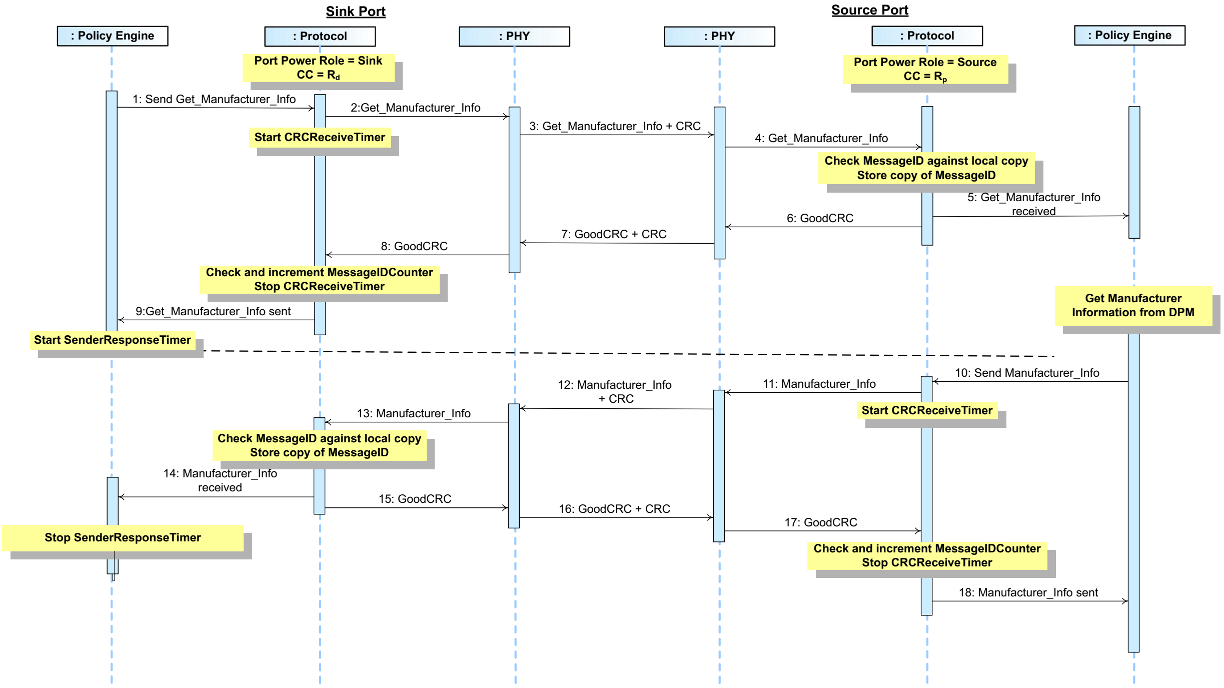


Table 8.110, "Steps for a Source getting Sink's Battery Manufacturer Information Sequence" below provides a detailed explanation of what happens at each labeled step in *Figure 8.83, "Sink Gets Source's Battery Manufacturer Information"* above.

Table 8.110 Steps for a Source getting Sink's Battery Manufacturer Information Sequence

Step	Sink Port	Source Port
1	The *Port* has ***Port Power Role*** set to *Sink* with the R_d pull down on its *CC* wire. *Policy Engine* directs the *Protocol Layer* to send a ***Get_Manufacturer_Info*** *Message* with a request for *Battery* information for a given *Battery*.	The *Port* has ***Port Power Role*** set to *Source* and the R_p pull up on its *CC* wire.
2	*Protocol Layer* creates the *Message* and passes to *PHY Layer*.	
3	*PHY Layer* appends *CRC* and sends the ***Get_Manufacturer_Info*** *Message*. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the ***Get_Manufacturer_Info*** *Message* and checks the *CRC* to verify the *Message*.
4		*PHY Layer* removes the *CRC* and forwards the ***Get_Manufacturer_Info*** *Message* to the *Protocol Layer*.
5		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Get_Manufacturer_Info*** *Message* information to the *Policy Engine* that consumes it.
6		*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.
7	*PHY Layer* receives the ***GoodCRC*** *Message* and checks the *CRC* to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.
8	*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.	
9	*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Get_Manufacturer_Info*** *Message* was successfully sent. *Policy Engine* starts ***SenderResponseTimer***.	
10		*Policy Engine* requests the *DPM* for the *Battery*'s manufacturer information for a given *Battery* which is provided. The *Policy Engine* tells the *Protocol Layer* to form a ***Manufacturer_Info*** *Message*.
11		*Protocol Layer* creates the *Message* and passes to *PHY Layer*.
12	*PHY Layer* receives the *Message* and compares the *CRC* it calculated with the one sent to verify the ***Manufacturer_Info*** *Message*.	*PHY Layer* appends a *CRC* and sends the ***Manufacturer_Info*** *Message*. Starts ***CRCReceiveTimer***.
13	*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Manufacturer_Info*** *Message* information to the *Policy Engine* that consumes it.	
14	The *Policy Engine* stops the ***SenderResponseTimer***.	

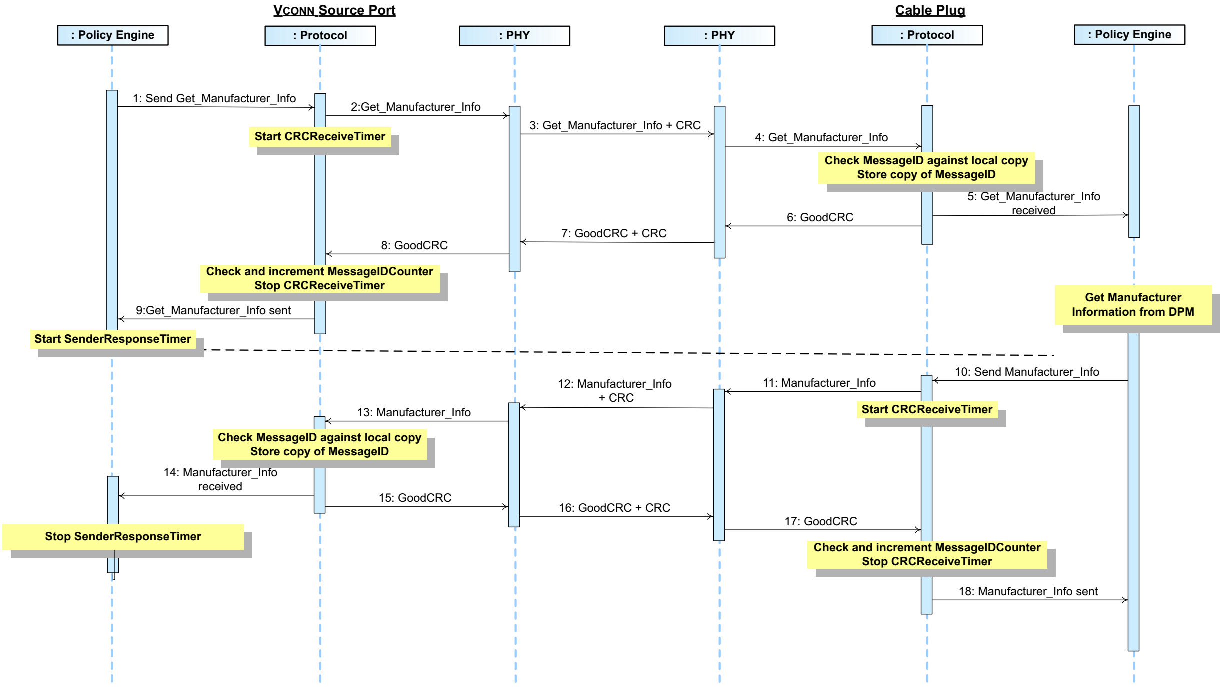
Table 8.110 Steps for a Source getting Sink's Battery Manufacturer Information Sequence

Step	Sink Port	Source Port
15	*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.	
16	*PHY Layer* appends a *CRC* and sends the ***GoodCRC*** *Message*.	*PHY Layer* receives ***GoodCRC*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
17		*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.
18		*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Manufacturer_Info*** *Message* was successfully sent.
The *Sink* has informed the *Source* of the manufacturer information for the requested *Battery*.		

8.3.2.11.6.5 VCONN Source Gets Manufacturer Information from a Cable Plug

Figure 8.84, "VCONN Source Gets Cable Plug's Manufacturer Information" shows an example sequence between a *VCONN Source* (*Source* or *Sink*) and a *Cable Plug* when the *VCONN Source* gets the *Cable Plug*'s Manufacturer information.

Figure 8.84 VCONN Source Gets Cable Plug's Manufacturer Information



VCONN Source Port
Cable Plug
: Policy Engine
: Protocol
: PHY
: PHY
: Protocol
: Policy Engine
1: Send Get_Manufacturer_Info
2:Get_Manufacturer_Info
Start CRCReceiveTimer
3: Get_Manufacturer_Info + CRC
4: Get_Manufacturer_Info
Check MessageID against local copy
Store copy of MessageID
5: Get_Manufacturer_Info received
6: GoodCRC
7: GoodCRC + CRC
8: GoodCRC
Check and increment MessageIDCounter
Stop CRCReceiveTimer
9:Get_Manufacturer_Info sent
Start SenderResponseTimer
Get Manufacturer Information from DPM
10: Send Manufacturer_Info
11: Manufacturer_Info
Start CRCReceiveTimer
12: Manufacturer_Info + CRC
13: Manufacturer_Info
Check MessageID against local copy
Store copy of MessageID
14: Manufacturer_Info received
15: GoodCRC
16: GoodCRC + CRC
17: GoodCRC
Stop SenderResponseTimer
Check and increment MessageIDCounter
Stop CRCReceiveTimer
18: Manufacturer_Info sent

Table 8.111, "Steps for a VCONN Source getting Sink's Port Manufacturer Information Sequence" below provides a detailed explanation of what happens at each labeled step in *Figure 8.84, "VCONN Source Gets Cable Plug's Manufacturer Information"* above.

Table 8.111 Steps for a VCONN Source getting Sink's Port Manufacturer Information Sequence

Step	VCONN Source	Cable Plug
1	The *Port* is currently acting as the *VCONN Source*. *Policy Engine* directs the *Protocol Layer* to send a ***Get_Manufacturer_Info*** *Message* with a request for *Port* information.	
2	*Protocol Layer* creates the *Message* and passes to *PHY Layer*.	
3	*PHY Layer* appends *CRC* and sends the ***Get_Manufacturer_Info*** *Message*. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the ***Get_Manufacturer_Info*** *Message* and checks the *CRC* to verify the *Message*.
4		*PHY Layer* removes the *CRC* and forwards the ***Get_Manufacturer_Info*** *Message* to the *Protocol Layer*.
5		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Get_Manufacturer_Info*** *Message* information to the *Policy Engine* that consumes it.
6		*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.
7	*PHY Layer* receives the ***GoodCRC*** *Message* and checks the *CRC* to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.
8	*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.	
9	*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Get_Manufacturer_Info*** *Message* was successfully sent. *Policy Engine* starts ***SenderResponseTimer***.	
10		*Policy Engine* requests the *DPM* for the *Cable Plug*'s manufacturer information which is provided. The *Policy Engine* tells the *Protocol Layer* to form a ***Manufacturer_Info*** *Message*.
11		*Protocol Layer* creates the *Message* and passes to *PHY Layer*.
12	*PHY Layer* receives the *Message* and compares the *CRC* it calculated with the one sent to verify the ***Manufacturer_Info*** *Message*.	*PHY Layer* appends a *CRC* and sends the ***Manufacturer_Info*** *Message*. Starts ***CRCReceiveTimer***.
13	*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Manufacturer_Info*** *Message* information to the *Policy Engine* that consumes it.	
14	The *Policy Engine* stops the ***SenderResponseTimer***.	
15	*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.	

Table 8.111 Steps for a VCONN Source getting Sink's Port Manufacturer Information Sequence

Step	VCONN Source	Cable Plug
16	*PHY Layer* appends a *CRC* and sends the ***GoodCRC*** *Message*.	*PHY Layer* receives ***GoodCRC*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
17		*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.
18		*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Manufacturer_Info*** *Message* was successfully sent.
The *Cable Plug* has informed the *Source* of its manufacturer information.		

8.3.2.11.7 Country Codes

8.3.2.11.7.1 8.3.2.12.7.1Source Gets Country Codes from a Sink

Figure 8.85, "Source Gets Sink's Country Codes" shows an example sequence between a *Source* and a *Sink* when the *Source* gets the *Sink*'s Country Codes.

Figure 8.85 Source Gets Sink's Country Codes

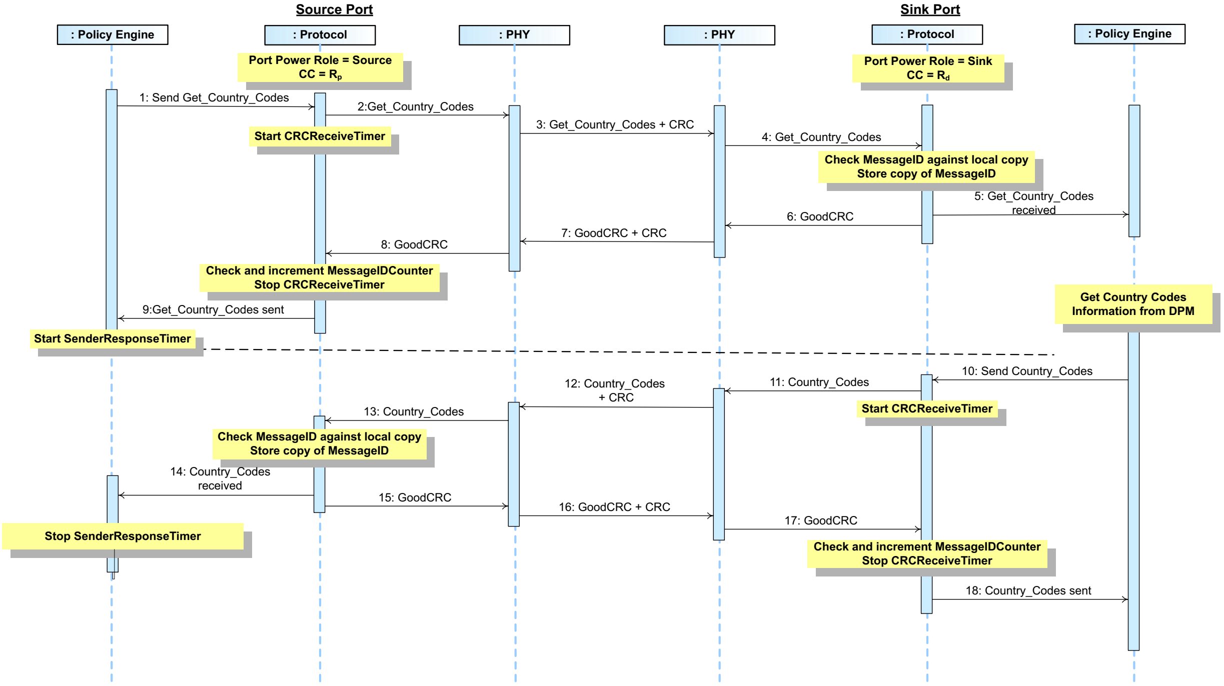


Table 8.112, "Steps for a Source getting Country Codes Sequence" below provides a detailed explanation of what happens at each labeled step in *Figure 8.85, "Source Gets Sink's Country Codes"* above.

Table 8.112 Steps for a Source getting Country Codes Sequence

Step	Source Port	Sink Port
1	The *Port* has ***Port Power Role*** set to *Source* and the R_p pull up on its *CC* wire. *Policy Engine* directs the *Protocol Layer* to send a ***Get_Country_Codes*** *Message* with a request for *Port* information.	The *Port* has ***Port Power Role*** set to *Sink* with the R_d pull down on its *CC* wire.
2	*Protocol Layer* creates the *Message* and passes to *PHY Layer*.	
3	*PHY Layer* appends *CRC* and sends the ***Get_Country_Codes*** *Message*. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the ***Get_Country_Codes*** *Message* and checks the *CRC* to verify the *Message*.
4		*PHY Layer* removes the *CRC* and forwards the ***Get_Country_Codes*** *Message* to the *Protocol Layer*.
5		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Get_Country_Codes*** *Message* information to the *Policy Engine* that consumes it.
6		*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.
7	*PHY Layer* receives the ***GoodCRC*** *Message* and checks the *CRC* to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.
8	*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.	
9	*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Get_Country_Codes*** *Message* was successfully sent. *Policy Engine* starts ***SenderResponseTimer***.	
10		*Policy Engine* requests the *DPM* for the *Port*'s manufacturer information which is provided. The *Policy Engine* tells the *Protocol Layer* to form a ***Country_Codes*** *Message*.
11		*Protocol Layer* creates the *Message* and passes to *PHY Layer*.
12	*PHY Layer* receives the *Message* and compares the *CRC* it calculated with the one sent to verify the ***Country_Codes*** *Message*.	*PHY Layer* appends a *CRC* and sends the ***Country_Codes*** *Message*. Starts ***CRCReceiveTimer***.
13	*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Country_Codes*** *Message* information to the *Policy Engine* that consumes it.	
14	The *Policy Engine* stops the ***SenderResponseTimer***.	
15	*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.	

Table 8.112 Steps for a Source getting Country Codes Sequence

Step	Source Port	Sink Port
16	*PHY Layer* appends a *CRC* and sends the ***GoodCRC*** *Message*.	*PHY Layer* receives ***GoodCRC*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
17		*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.
18		*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Country_Codes*** *Message* was successfully sent.
The *Sink* has informed the *Source* of the country codes.		

8.3.2.11.7.2 Sink Gets Country Codes from a Source

Figure 8.86, "Sink Gets Source's Country Codes" shows an example sequence between a *Source* and a *Sink* when the *Source* gets the *Sink*'s country codes.

Figure 8.86 Sink Gets Source's Country Codes

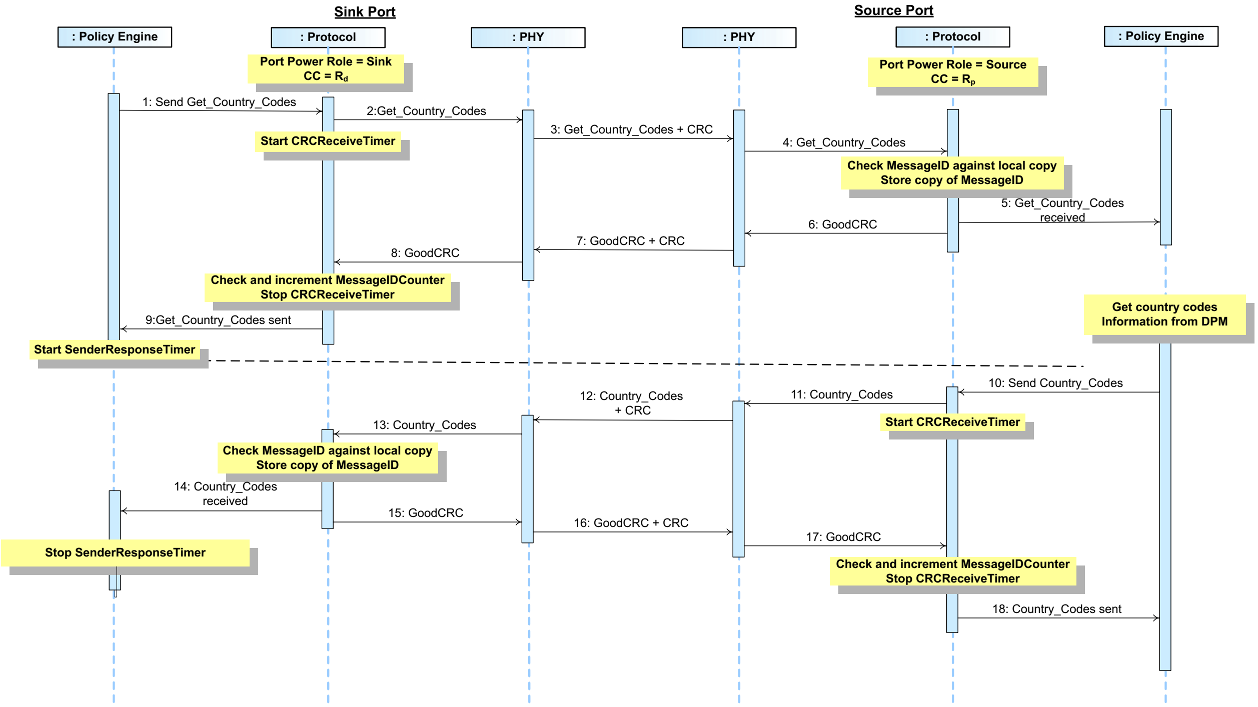


Table 8.113, "Steps for a Source getting Sink's Country Codes Sequence" below provides a detailed explanation of what happens at each labeled step in *Figure 8.86, "Sink Gets Source's Country Codes"* above.

Table 8.113 Steps for a Source getting Sink's Country Codes Sequence

Step	Sink Port	Source Port
1	The *Port* has ***Port Power Role*** set to *Sink* with the R_d pull down on its *CC* wire. *Policy Engine* directs the *Protocol Layer* to send a ***Get_Country_Codes*** *Message* with a request for *Port* information.	The *Port* has ***Port Power Role*** set to *Source* and the R_p pull up on its *CC* wire.
2	*Protocol Layer* creates the *Message* and passes to *PHY Layer*.	
3	*PHY Layer* appends *CRC* and sends the ***Get_Country_Codes*** *Message*. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the ***Get_Country_Codes*** *Message* and checks the *CRC* to verify the *Message*.
4		*PHY Layer* removes the *CRC* and forwards the ***Get_Country_Codes*** *Message* to the *Protocol Layer*.
5		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Get_Country_Codes*** *Message* information to the *Policy Engine* that consumes it.
6		*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.
7	*PHY Layer* receives the ***GoodCRC*** *Message* and checks the *CRC* to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.
8	*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.	
9	*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Get_Country_Codes*** *Message* was successfully sent. *Policy Engine* starts ***SenderResponseTimer***.	
10		*Policy Engine* requests the *DPM* for the *Port*'s manufacturer information which is provided. The *Policy Engine* tells the *Protocol Layer* to form a ***Country_Codes*** *Message*.
11		*Protocol Layer* creates the *Message* and passes to *PHY Layer*.
12	*PHY Layer* receives the *Message* and compares the *CRC* it calculated with the one sent to verify the ***Country_Codes*** *Message*.	*PHY Layer* appends a *CRC* and sends the ***Country_Codes*** *Message*. Starts ***CRCReceiveTimer***.
13	*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Country_Codes*** *Message* information to the *Policy Engine* that consumes it.	
14	The *Policy Engine* stops the ***SenderResponseTimer***.	
15	*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.	

Table 8.113 Steps for a Source getting Sink's Country Codes Sequence

Step	Sink Port	Source Port
16	*PHY Layer* appends a *CRC* and sends the ***GoodCRC*** *Message*.	*PHY Layer* receives ***GoodCRC*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
17		*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.
18		*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Country_Codes*** *Message* was successfully sent.
The *Sink* has informed the *Source* of the country codes.		

8.3.2.11.7.3 VCONN Source Gets Country Codes from a Cable Plug

Figure 8.87, "VCONN Source Gets Cable Plug's Country Codes" shows an example sequence between a *VCONN Source* (*Source* or *Sink*) and a *Cable Plug* when the *VCONN Source* gets the *Cable Plug*'s Country Codes.

Figure 8.87 VCONN Source Gets Cable Plug's Country Codes

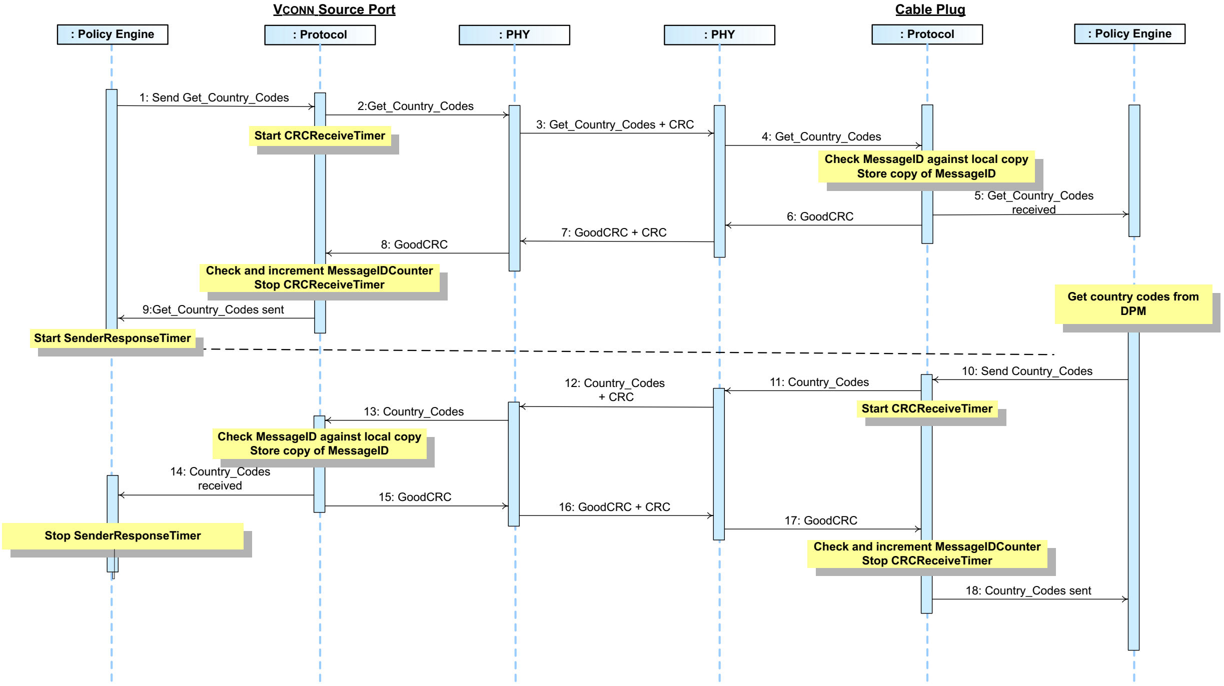


Table 8.114, "Steps for a VCONN Source getting Sink's Country Codes Sequence" below provides a detailed explanation of what happens at each labeled step in *Figure 8.87, "VCONN Source Gets Cable Plug's Country Codes"* above.

Table 8.114 Steps for a VCONN Source getting Sink's Country Codes Sequence

Step	VCONN Source	Cable Plug
1	The *Port* is currently acting as the *VCONN Source*. *Policy Engine* directs the *Protocol Layer* to send a ***Get_Country_Codes*** *Message* with a request for *Port* information.	
2	*Protocol Layer* creates the *Message* and passes to *PHY Layer*.	
3	*PHY Layer* appends *CRC* and sends the ***Get_Country_Codes*** *Message*. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the ***Get_Country_Codes*** *Message* and checks the *CRC* to verify the *Message*.
4		*PHY Layer* removes the *CRC* and forwards the ***Get_Country_Codes*** *Message* to the *Protocol Layer*.
5		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Get_Country_Codes*** *Message* information to the *Policy Engine* that consumes it.
6		*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.
7	*PHY Layer* receives the ***GoodCRC*** *Message* and checks the *CRC* to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.
8	*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.	
9	*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Get_Country_Codes*** *Message* was successfully sent. *Policy Engine* starts ***SenderResponseTimer***.	
10		*Policy Engine* requests the *DPM* for the *Cable Plug*'s manufacturer information which is provided. The *Policy Engine* tells the *Protocol Layer* to form a ***Country_Codes*** *Message*.
11		*Protocol Layer* creates the *Message* and passes to *PHY Layer*.
12	*PHY Layer* receives the *Message* and compares the *CRC* it calculated with the one sent to verify the ***Country_Codes*** *Message*.	*PHY Layer* appends a *CRC* and sends the ***Country_Codes*** *Message*. Starts ***CRCReceiveTimer***.
13	*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Country_Codes*** *Message* information to the *Policy Engine* that consumes it.	
14	The *Policy Engine* stops the ***SenderResponseTimer***.	
15	*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.	

Table 8.114 Steps for a VCONN Source getting Sink's Country Codes Sequence

Step	VCONN Source	Cable Plug
16	*PHY Layer* appends a *CRC* and sends the ***GoodCRC*** *Message*.	*PHY Layer* receives ***GoodCRC*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
17		*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.
18		*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Country_Codes*** *Message* was successfully sent.
The *Cable Plug* has informed the *Source* of its country codes.		

8.3.2.11.8 Country Information

8.3.2.11.8.1 Source Gets Country Information from a Sink

Figure 8.88, "Source Gets Sink's Country Information" shows an example sequence between a *Source* and a *Sink* when the *Source* gets the *Sink*'s country information.

Figure 8.88 Source Gets Sink's Country Information

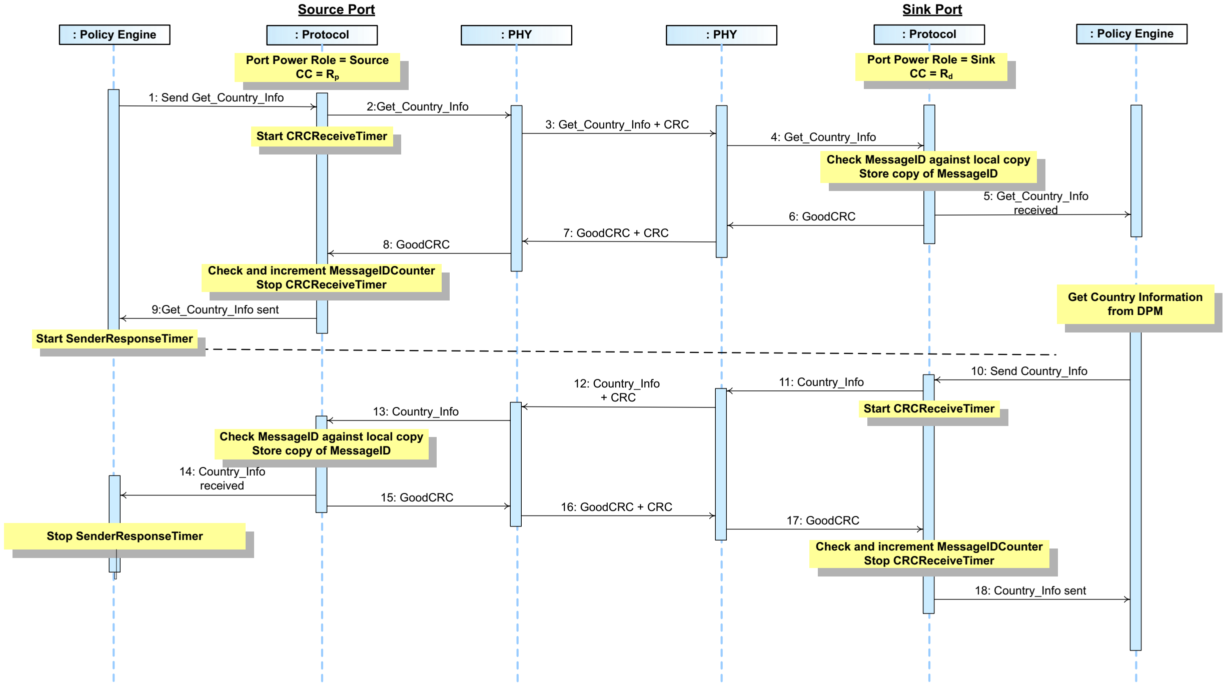


Table 8.115, "Steps for a Source getting Country Information Sequence" below provides a detailed explanation of what happens at each labeled step in *Figure 8.88, "Source Gets Sink's Country Information"* above.

Table 8.115 Steps for a Source getting Country Information Sequence

Step	Source Port	Sink Port
1	The *Port* has ***Port Power Role*** set to *Source* and the R_p pull up on its *CC* wire. *Policy Engine* directs the *Protocol Layer* to send a ***Get_Country_Info*** *Message* with a request for *Port* information for a specific Country Code.	The *Port* has ***Port Power Role*** set to *Sink* with the R_d pull down on its *CC* wire.
2	*Protocol Layer* creates the *Message* and passes to *PHY Layer*.	
3	*PHY Layer* appends *CRC* and sends the ***Get_Country_Info*** *Message*. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the ***Get_Country_Info*** *Message* and checks the *CRC* to verify the *Message*.
4		*PHY Layer* removes the *CRC* and forwards the ***Get_Country_Info*** *Message* to the *Protocol Layer*.
5		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Get_Country_Info*** *Message* information to the *Policy Engine* that consumes it.
6		*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.
7	*PHY Layer* receives the ***GoodCRC*** *Message* and checks the *CRC* to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.
8	*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.	
9	*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Get_Country_Info*** *Message* was successfully sent. *Policy Engine* starts ***SenderResponseTimer***.	
10		*Policy Engine* requests the *DPM* for the *Port*'s manufacturer information which is provided. The *Policy Engine* tells the *Protocol Layer* to form a ***Country_Info*** *Message*.
11		*Protocol Layer* creates the *Message* and passes to *PHY Layer*.
12	*PHY Layer* receives the *Message* and compares the *CRC* it calculated with the one sent to verify the ***Country_Info*** *Message*.	*PHY Layer* appends a *CRC* and sends the ***Country_Info*** *Message*. Starts ***CRCReceiveTimer***.
13	*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Country_Info*** *Message* information to the *Policy Engine* that consumes it.	
14	The *Policy Engine* stops the ***SenderResponseTimer***.	
15	*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.	

Table 8.115 Steps for a Source getting Country Information Sequence

Step	Source Port	Sink Port
16	*PHY Layer* appends a *CRC* and sends the ***GoodCRC*** *Message*.	*PHY Layer* receives ***GoodCRC*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
17		*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.
18		*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Country_Info*** *Message* was successfully sent.
The *Sink* has informed the *Source* of the country information.		

8.3.2.11.8.2 Sink Gets Country Information from a Source

Figure 8.89, "Sink Gets Source's Country Information" shows an example sequence between a *Source* and a *Sink* when the *Source* gets the *Sink*'s country codes.

Figure 8.89 Sink Gets Source's Country Information

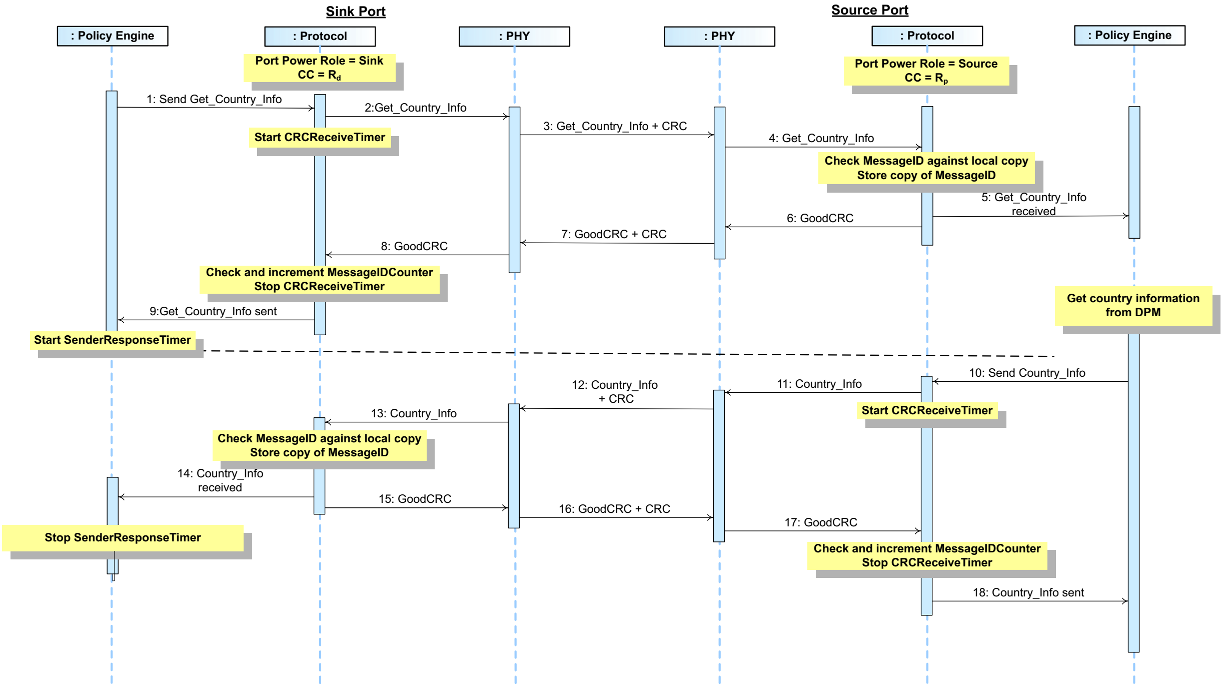


Table 8.116, "Steps for a Source getting Sink's Country Information Sequence" below provides a detailed explanation of what happens at each labeled step in *Figure 8.89, "Sink Gets Source's Country Information"* above.

Table 8.116 Steps for a Source getting Sink's Country Information Sequence

Step	Sink Port	Source Port
1	The *Port* has ***Port Power Role*** set to *Sink* with the R_d pull down on its *CC* wire. *Policy Engine* directs the *Protocol Layer* to send a ***Get_Country_Info*** *Message* with a request for *Port* information for a specific country code.	The *Port* has ***Port Power Role*** set to *Source* and the R_p pull up on its *CC* wire.
2	*Protocol Layer* creates the *Message* and passes to *PHY Layer*.	
3	*PHY Layer* appends *CRC* and sends the ***Get_Country_Info*** *Message*. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the ***Get_Country_Info*** *Message* and checks the *CRC* to verify the *Message*.
4		*PHY Layer* removes the *CRC* and forwards the ***Get_Country_Info*** *Message* to the *Protocol Layer*.
5		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Get_Country_Info*** *Message* information to the *Policy Engine* that consumes it.
6		*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.
7	*PHY Layer* receives the ***GoodCRC*** *Message* and checks the *CRC* to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.
8	*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.	
9	*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Get_Country_Info*** *Message* was successfully sent. *Policy Engine* starts ***SenderResponseTimer***.	
10		*Policy Engine* requests the *DPM* for the *Port*'s manufacturer information which is provided. The *Policy Engine* tells the *Protocol Layer* to form a ***Country_Info*** *Message*.
11		*Protocol Layer* creates the *Message* and passes to *PHY Layer*.
12	*PHY Layer* receives the *Message* and compares the *CRC* it calculated with the one sent to verify the ***Country_Info*** *Message*.	*PHY Layer* appends a *CRC* and sends the ***Country_Info*** *Message*. Starts ***CRCReceiveTimer***.
13	*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Country_Info*** *Message* information to the *Policy Engine* that consumes it.	
14	The *Policy Engine* stops the ***SenderResponseTimer***.	
15	*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.	

Table 8.116 Steps for a Source getting Sink's Country Information Sequence

Step	Sink Port	Source Port
16	*PHY Layer* appends a *CRC* and sends the ***GoodCRC*** *Message*.	*PHY Layer* receives ***GoodCRC*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
17		*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.
18		*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Country_Info*** *Message* was successfully sent.
The *Sink* has informed the *Source* of the country information.		

8.3.2.11.8.3 VCONN Source Gets Country Information from a Cable Plug

Figure 8.90, "VCONN Source Gets Cable Plug's Country Information" shows an example sequence between a *VCONN Source* (*Source* or *Sink*) and a *Cable Plug* when the *VCONN Source* gets the *Cable Plug*'s country information.

Figure 8.90 VCONN Source Gets Cable Plug's Country Information

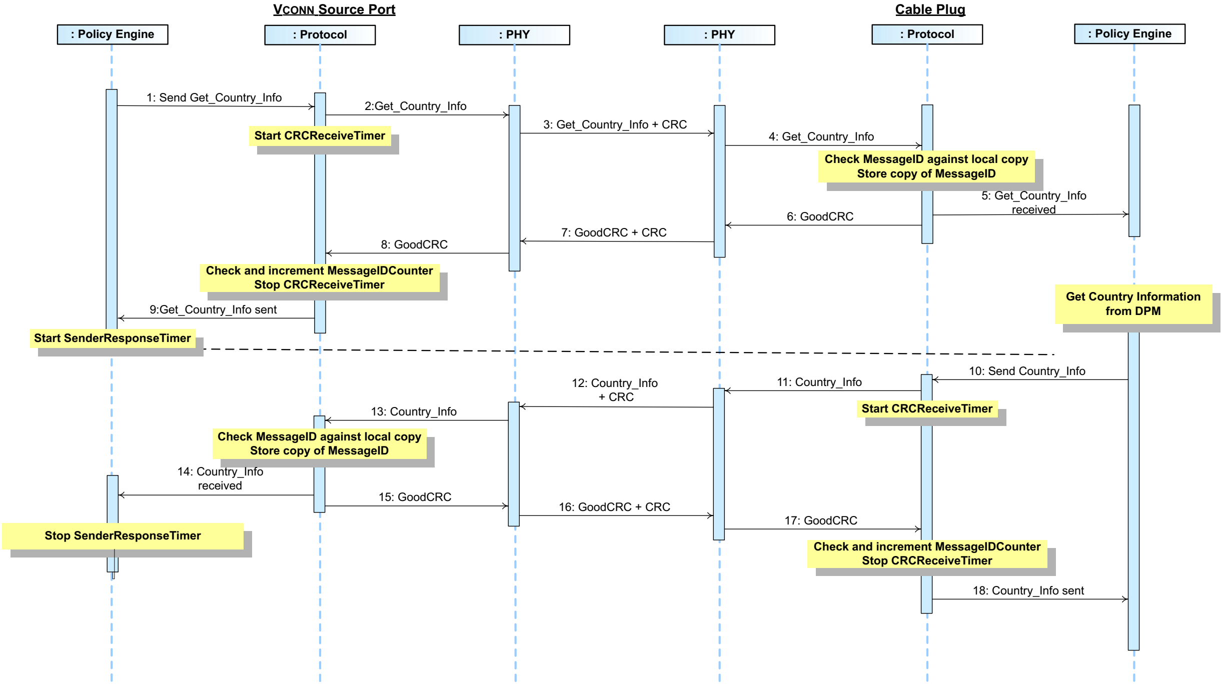


Table 8.117, "Steps for a VCONN Source getting Sink's Country Information Sequence" below provides a detailed explanation of what happens at each labeled step in *Figure 8.90, "VCONN Source Gets Cable Plug's Country Information"* above.

Table 8.117 Steps for a VCONN Source getting Sink's Country Information Sequence

Step	VCONN Source	Cable Plug
1	The *Port* is currently acting as the *VCONN Source*. *Policy Engine* directs the *Protocol Layer* to send a ***Get_Country_Info*** *Message* with a request for *Port* information for a specific country code.	
2	*Protocol Layer* creates the *Message* and passes to *PHY Layer*.	
3	*PHY Layer* appends *CRC* and sends the ***Get_Country_Info*** *Message*. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the ***Get_Country_Info*** *Message* and checks the *CRC* to verify the *Message*.
4		*PHY Layer* removes the *CRC* and forwards the ***Get_Country_Info*** *Message* to the *Protocol Layer*.
5		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Get_Country_Info*** *Message* information to the *Policy Engine* that consumes it.
6		*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.
7	*PHY Layer* receives the ***GoodCRC*** *Message* and checks the *CRC* to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.
8	*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.	
9	*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Get_Country_Info*** *Message* was successfully sent. *Policy Engine* starts ***SenderResponseTimer***.	
10		*Policy Engine* requests the *DPM* for the *Cable Plug*'s manufacturer information which is provided. The *Policy Engine* tells the *Protocol Layer* to form a ***Country_Info*** *Message*.
11		*Protocol Layer* creates the *Message* and passes to *PHY Layer*.
12	*PHY Layer* receives the *Message* and compares the *CRC* it calculated with the one sent to verify the ***Country_Info*** *Message*.	*PHY Layer* appends a *CRC* and sends the ***Country_Info*** *Message*. Starts ***CRCReceiveTimer***.
13	*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Country_Info*** *Message* information to the *Policy Engine* that consumes it.	
14	The *Policy Engine* stops the ***SenderResponseTimer***.	
15	*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.	

Table 8.117 Steps for a VCONN Source getting Sink's Country Information Sequence

Step	VCONN Source	Cable Plug
16	*PHY Layer* appends a *CRC* and sends the ***GoodCRC*** *Message*.	*PHY Layer* receives ***GoodCRC*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
17		*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.
18		*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Country_Info*** *Message* was successfully sent.
The *Cable Plug* has informed the *Source* of its country information.		

8.3.2.11.9 Revision Information

8.3.2.11.9.1 Source Gets Revision Information from a Sink

Figure 8.91, "Source Gets Sink's Revision Information" shows an example sequence between a *Source* and a *Sink* when the *Source* gets the *Sink*'s Revision information.

Figure 8.91 Source Gets Sink's Revision Information

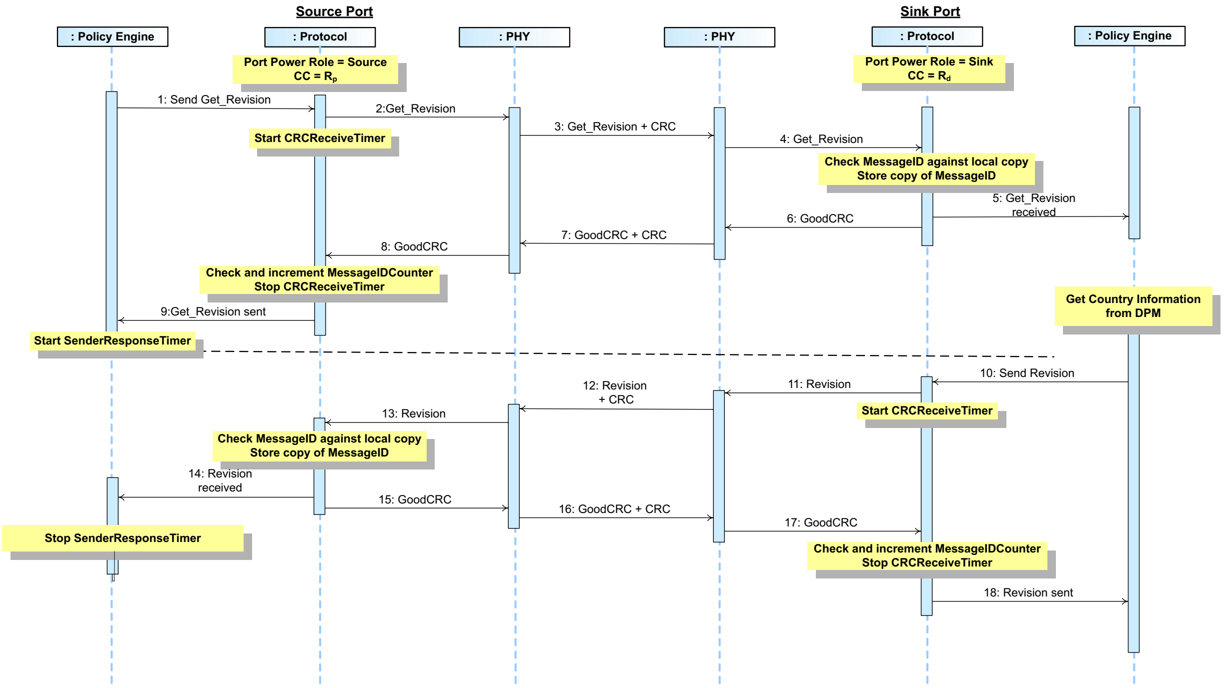


Table 8.118, "Steps for a Source getting Revision Information Sequence" below provides a detailed explanation of what happens at each labeled step in *Figure 8.91, "Source Gets Sink's Revision Information"* above.

Table 8.118 Steps for a Source getting Revision Information Sequence

Step	Source Port	Sink Port
1	The *Port* has ***Port Power Role*** set to *Source* and the R_p pull up on its *CC* wire. *Policy Engine* directs the *Protocol Layer* to send a ***Get_Revision*** *Message* with a request for *Port* information for a specific Revision Code.	The *Port* has ***Port Power Role*** set to *Sink* with the R_d pull down on its *CC* wire.
2	*Protocol Layer* creates the *Message* and passes to *PHY Layer*.	
3	*PHY Layer* appends *CRC* and sends the ***Get_Revision*** *Message*. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the ***Get_Revision*** *Message* and checks the *CRC* to verify the *Message*.
4		*PHY Layer* removes the *CRC* and forwards the ***Get_Revision*** *Message* to the *Protocol Layer*.
5		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Get_Revision*** *Message* information to the *Policy Engine* that consumes it.
6		*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.
7	*PHY Layer* receives the ***GoodCRC*** *Message* and checks the *CRC* to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.
8	*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.	
9	*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Get_Revision*** *Message* was successfully sent. *Policy Engine* starts ***SenderResponseTimer***.	
10		*Policy Engine* requests the *DPM* for the *Port*'s manufacturer information which is provided. The *Policy Engine* tells the *Protocol Layer* to form a ***Revision*** *Message*.
11		*Protocol Layer* creates the *Message* and passes to *PHY Layer*.
12	*PHY Layer* receives the *Message* and compares the *CRC* it calculated with the one sent to verify the ***Revision_Info*** *Message*.	*PHY Layer* appends a *CRC* and sends the ***Revision*** *Message*. Starts ***CRCReceiveTimer***.
13	*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Revision*** *Message* information to the *Policy Engine* that consumes it.	
14	The *Policy Engine* stops the ***SenderResponseTimer***.	
15	*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.	

Table 8.118 Steps for a Source getting Revision Information Sequence

Step	Source Port	Sink Port
16	*PHY Layer* appends a *CRC* and sends the ***GoodCRC*** *Message*.	*PHY Layer* receives ***GoodCRC*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
17		*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.
18		*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Revision*** *Message* was successfully sent.
The *Sink* has informed the *Source* of the Revision information.		

8.3.2.11.9.2 Sink Gets Revision Information from a Source

Figure 8.92, "Sink Gets Source's Revision Information" shows an example sequence between a *Source* and a *Sink* when the *Source* gets the *Sink*'s Revision codes.

Figure 8.92 Sink Gets Source's Revision Information

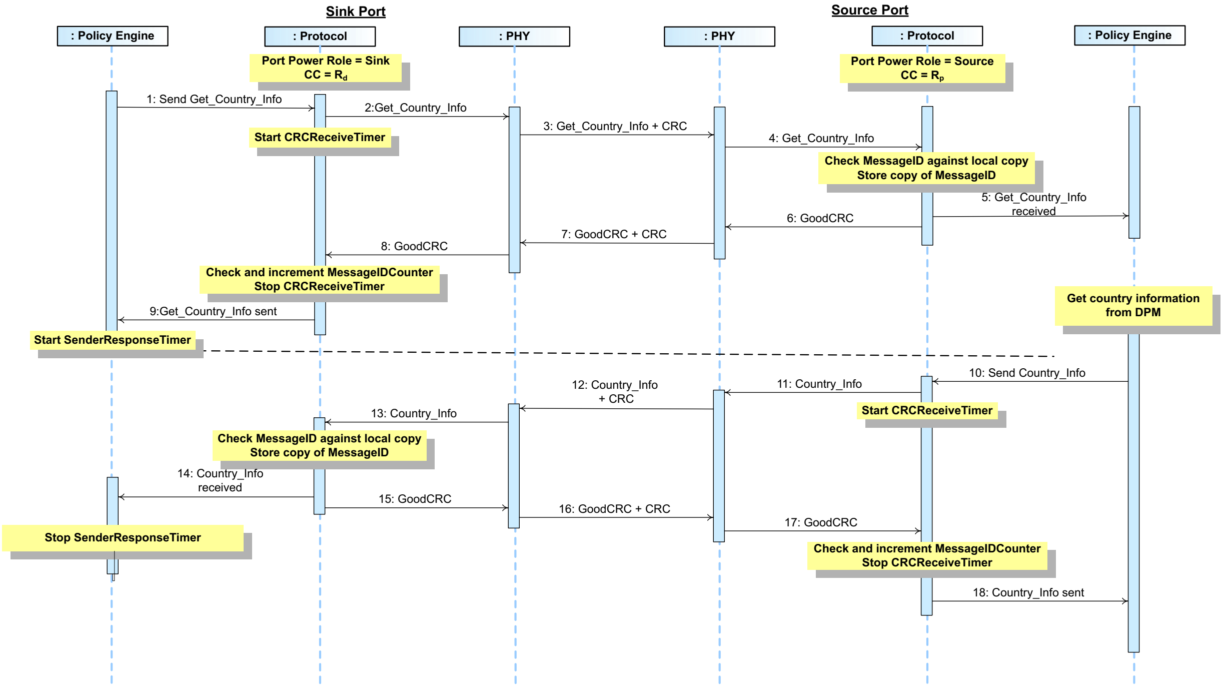


Table 8.119, "Steps for a Source getting Sink's Revision Information Sequence" below provides a detailed explanation of what happens at each labeled step in *Figure 8.92, "Sink Gets Source's Revision Information"* above.

Table 8.119 Steps for a Source getting Sink's Revision Information Sequence

Step	Sink Port	Source Port
1	The *Port* has ***Port Power Role*** set to *Sink* with the R_d pull down on its *CC* wire. *Policy Engine* directs the *Protocol Layer* to send a ***Get_Revision*** *Message* with a request for *Port* information for a specific Revision code.	The *Port* has ***Port Power Role*** set to *Source* and the R_p pull up on its *CC* wire.
2	*Protocol Layer* creates the *Message* and passes to *PHY Layer*.	
3	*PHY Layer* appends *CRC* and sends the ***Get_Revision*** *Message*. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the ***Get_Revision*** *Message* and checks the *CRC* to verify the *Message*.
4		*PHY Layer* removes the *CRC* and forwards the ***Get_Revision*** *Message* to the *Protocol Layer*.
5		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Get_Revision*** *Message* information to the *Policy Engine* that consumes it.
6		*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.
7	*PHY Layer* receives the ***GoodCRC*** *Message* and checks the *CRC* to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.
8	*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.	
9	*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Get_Revision*** *Message* was successfully sent. *Policy Engine* starts ***SenderResponseTimer***.	
10		*Policy Engine* requests the *DPM* for the *Port*'s manufacturer information which is provided. The *Policy Engine* tells the *Protocol Layer* to form a ***Revision*** *Message*.
11		*Protocol Layer* creates the *Message* and passes to *PHY Layer*.
12	*PHY Layer* receives the *Message* and compares the *CRC* it calculated with the one sent to verify the ***Revision_Info*** *Message*.	*PHY Layer* appends a *CRC* and sends the ***Revision*** *Message*. Starts ***CRCReceiveTimer***.
13	*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Revision*** *Message* information to the *Policy Engine* that consumes it.	
14	The *Policy Engine* stops the ***SenderResponseTimer***.	
15	*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.	

Table 8.119 Steps for a Source getting Sink's Revision Information Sequence

Step	Sink Port	Source Port
16	*PHY Layer* appends a *CRC* and sends the ***GoodCRC*** *Message*.	*PHY Layer* receives ***GoodCRC*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
17		*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.
18		*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Revision*** *Message* was successfully sent.
The *Sink* has informed the *Source* of the Revision information.		

8.3.2.11.9.3 VCONN Source Gets Revision Information from a Cable Plug

Figure 8.93, "VCONN Source Gets Cable Plug's Revision Information" shows an example sequence between a *VCONN Source* (*Source* or *Sink*) and a *Cable Plug* when the *VCONN Source* gets the *Cable Plug*'s Revision information.

Figure 8.93 VCONN Source Gets Cable Plug's Revision Information

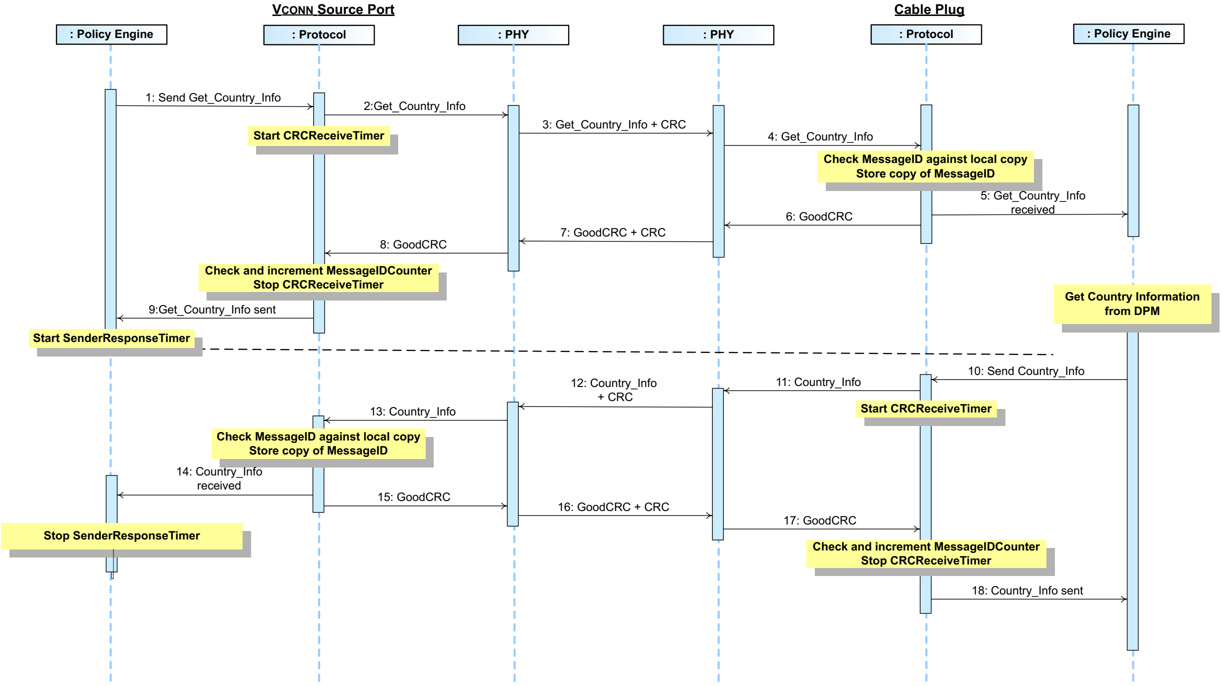


Table 8.120, "Steps for a VCONN Source getting Sink's Revision Information Sequence" below provides a detailed explanation of what happens at each labeled step in *Figure 8.93, "VCONN Source Gets Cable Plug's Revision Information"* above.

Table 8.120 Steps for a VCONN Source getting Sink's Revision Information Sequence

Step	VCONN Source	Cable Plug
1	The *Port* is currently acting as the *VCONN Source*. *Policy Engine* directs the *Protocol Layer* to send a ***Get_Revision*** *Message* with a request for *Port* information for a specific Revision code.	
2	*Protocol Layer* creates the *Message* and passes to *PHY Layer*.	
3	*PHY Layer* appends *CRC* and sends the ***Get_Revision*** *Message*. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the ***Get_Revision*** *Message* and checks the *CRC* to verify the *Message*.
4		*PHY Layer* removes the *CRC* and forwards the ***Get_Revision*** *Message* to the *Protocol Layer*.
5		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Get_Revision*** *Message* information to the *Policy Engine* that consumes it.
6		*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.
7	*PHY Layer* receives the ***GoodCRC*** *Message* and checks the *CRC* to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.
8	*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.	
9	*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Get_Revision*** *Message* was successfully sent. *Policy Engine* starts ***SenderResponseTimer***.	
10		*Policy Engine* requests the *DPM* for the *Cable Plug*'s manufacturer information which is provided. The *Policy Engine* tells the *Protocol Layer* to form a ***Revision*** *Message*.
11		*Protocol Layer* creates the *Message* and passes to *PHY Layer*.
12	*PHY Layer* receives the *Message* and compares the *CRC* it calculated with the one sent to verify the ***Revision*** *Message*.	*PHY Layer* appends a *CRC* and sends the ***Revision*** *Message*. Starts ***CRCReceiveTimer***.
13	*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Revision*** *Message* information to the *Policy Engine* that consumes it.	
14	The *Policy Engine* stops the ***SenderResponseTimer***.	
15	*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.	

Table 8.120 Steps for a VCONN Source getting Sink's Revision Information Sequence

Step	VCONN Source	Cable Plug
16	*PHY Layer* appends a *CRC* and sends the ***GoodCRC*** *Message*.	*PHY Layer* receives ***GoodCRC*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
17		*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.
18		*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Revision*** *Message* was successfully sent.
The *Cable Plug* has informed the *Source* of its Revision information.		

8.3.2.11.10 Source Information

8.3.2.11.10.1 Sink Gets Source Information

Figure 8.94, "Sink Gets Source's Information" shows an example sequence between a *Source* and a *Sink* when the *Sink* gets the *Source*'s information.

Figure 8.94 Sink Gets Source's Information

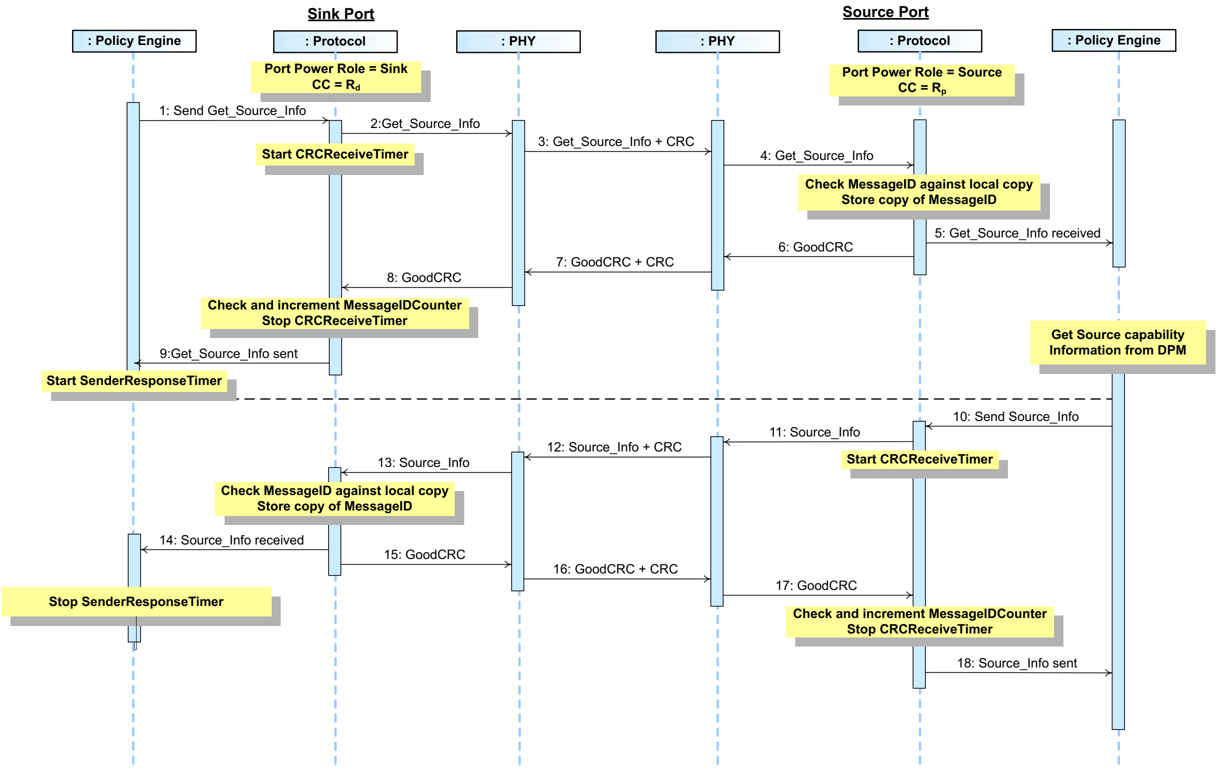


Table 8.121, "Steps for a Sink getting Source Information Sequence" below provides a detailed explanation of what happens at each labeled step in *Figure 8.94, "Sink Gets Source's Information"* above.

Table 8.121 Steps for a Sink getting Source Information Sequence

Step	Sink Port	Source Port
1	The *Port* has **Port Power Role** set to *Sink* with the R_d pull down on its *CC* wire. *Policy Engine* directs the *Protocol Layer* to send a ***Get_Source_Info*** *Message*.	The *Port* has **Port Power Role** set to *Source* and the R_p pull up on its *CC* wire.
2	*Protocol Layer* creates the *Message* and passes to *PHY Layer*.	
3	*PHY Layer* appends *CRC* and sends the ***Get_Source_Info*** *Message*. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the ***Get_Source_Info*** *Message* and checks the *CRC* to verify the *Message*.
4		*PHY Layer* removes the *CRC* and forwards the ***Get_Source_Info*** *Message* to the *Protocol Layer*.
5		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Get_Source_Info*** *Message* information to the *Policy Engine* that consumes it.
6		*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.
7	*PHY Layer* receives the ***GoodCRC*** *Message* and checks the *CRC* to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.
8	*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.	
9	*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Get_Source_Info*** *Message* was successfully sent. *Policy Engine* starts ***SenderResponseTimer***.	
10		*Policy Engine* requests the *DPM* for the present *Source* information which is provided. The *Policy Engine* tells the *Protocol Layer* to form a ***Source_Info*** *Message*.
11		*Protocol Layer* creates the *Message* and passes to *PHY Layer*.
12	*PHY Layer* receives the *Message* and compares the *CRC* it calculated with the one sent to verify the ***Source_Info*** *Message*.	*PHY Layer* appends a *CRC* and sends the ***Source_Info*** *Message*. Starts ***CRCReceiveTimer***.
13	*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Source_Info*** *Message* information to the *Policy Engine* that consumes it.	
14	The *Policy Engine* stops the ***SenderResponseTimer***.	
15	*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.	

Table 8.121 Steps for a Sink getting Source Information Sequence

Step	Sink Port	Source Port
16	*PHY Layer* appends a *CRC* and sends the ***GoodCRC*** *Message*.	*PHY Layer* receives ***GoodCRC*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
17		*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.
18		*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Source_Info*** *Message* was successfully sent.
The *Source* has provided the *Sink* with its information.		

8.3.2.11.10.2 Dual-Role Source Gets Source Information from a Dual-Role Sink

Figure 8.95, "Dual-Role Source Gets Dual-Role Sink's Information as a Source" shows an example sequence between a *Dual-Role Power Source* and a *Dual-Role Power Sink* when the *Source* gets the *Sink*'s Information as a *Source*.

Figure 8.95 Dual-Role Source Gets Dual-Role Sink's Information as a Source

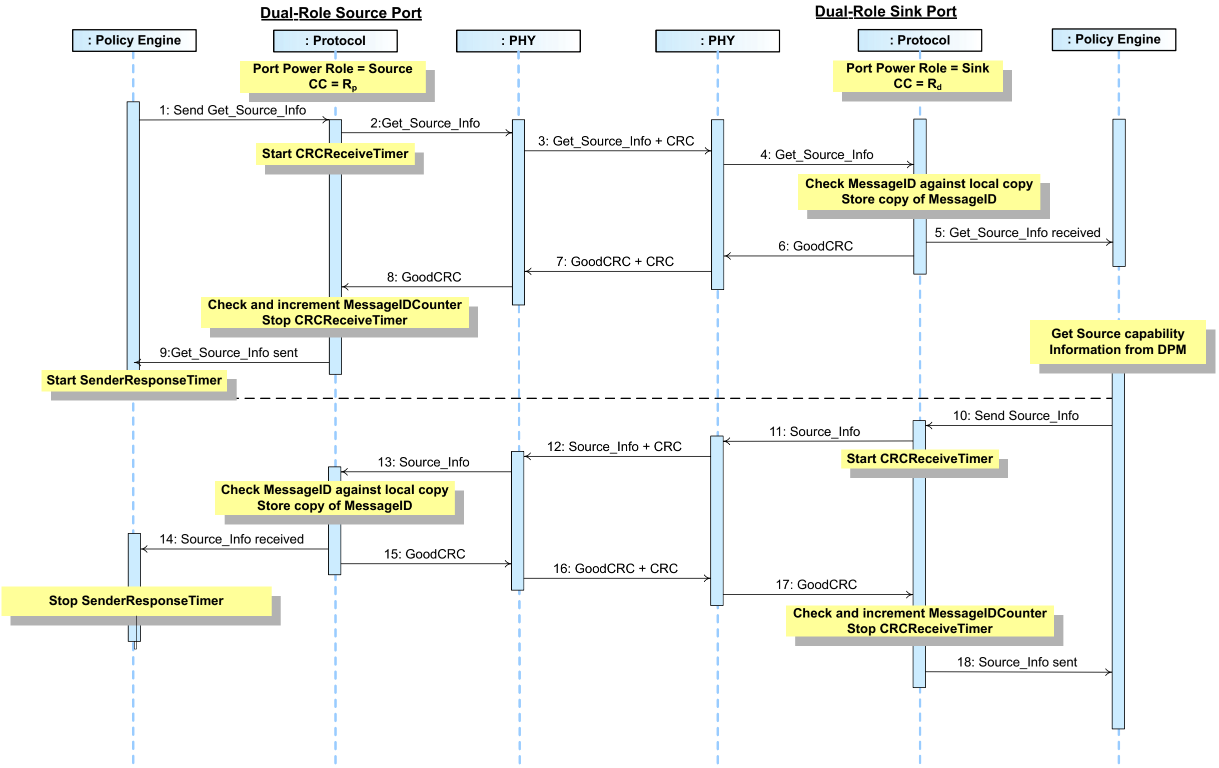


Table 8.122, "Steps for a Dual-Role Source getting Dual-Role Sink's Information as a Source Sequence" below provides a detailed explanation of what happens at each labeled step in *Figure 8.95, "Dual-Role Source Gets Dual-Role Sink's Information as a Source"* above.

Table 8.122 Steps for a Dual-Role Source getting Dual-Role Sink's Information as a Source Sequence

Step	Dual-Role Source Port	Dual-Role Sink Port
1	The *Port* has ***Port Power Role*** set to *Source* and the R_p pull up on its *CC* wire. *Policy Engine* directs the *Protocol Layer* to send a ***Get_Source_Info*** *Message*.	The *Port* has ***Port Power Role*** set to *Sink* with the R_d pull down on its *CC* wire.
2	*Protocol Layer* creates the *Message* and passes to *PHY Layer*.	
3	*PHY Layer* appends *CRC* and sends the ***Get_Source_Info*** *Message*. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the ***Get_Source_Info*** *Message* and checks the *CRC* to verify the *Message*.
4		*PHY Layer* removes the *CRC* and forwards the ***Get_Source_Info*** *Message* to the *Protocol Layer*.
5		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Get_Source_Info*** *Message* information to the *Policy Engine* that consumes it.
6		*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.
7	*PHY Layer* receives the ***GoodCRC*** *Message* and checks the *CRC* to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.
8	*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.	
9	*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Get_Source_Info*** *Message* was successfully sent. *Policy Engine* starts ***SenderResponseTimer***.	
10		*Policy Engine* requests the *DPM* for the present *Source* information which is provided. The *Policy Engine* tells the *Protocol Layer* to form a ***Source_Info*** *Message*.
11		*Protocol Layer* creates the *Message* and passes to *PHY Layer*.
12	*PHY Layer* receives the *Message* and compares the *CRC* it calculated with the one sent to verify the ***Source_Info*** *Message*.	*PHY Layer* appends a *CRC* and sends the ***Source_Info*** *Message*. Starts ***CRCReceiveTimer***.
13	*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Source_Info*** *Message* information to the *Policy Engine* that consumes it.	
14	The *Policy Engine* stops the ***SenderResponseTimer***.	
15	*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.	

Table 8.122 Steps for a Dual-Role Source getting Dual-Role Sink's Information as a Source Sequence

Step	Dual-Role Source Port	Dual-Role Sink Port
16	*PHY Layer* appends a *CRC* and sends the ***GoodCRC*** *Message*.	*PHY Layer* receives ***GoodCRC*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
17		*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.
18		*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Source_Info*** *Message* was successfully sent.
The *Dual-Role Power Sink* has provided the *Dual-Role Power Source* with its information.		

8.3.2.12 Security

8.3.2.12.1 Source requests security exchange with Sink

Figure 8.96, "Source requests security exchange with Sink" shows an example sequence for a security exchange between a *Source* and a *Sink*.

Figure 8.96 Source requests security exchange with Sink

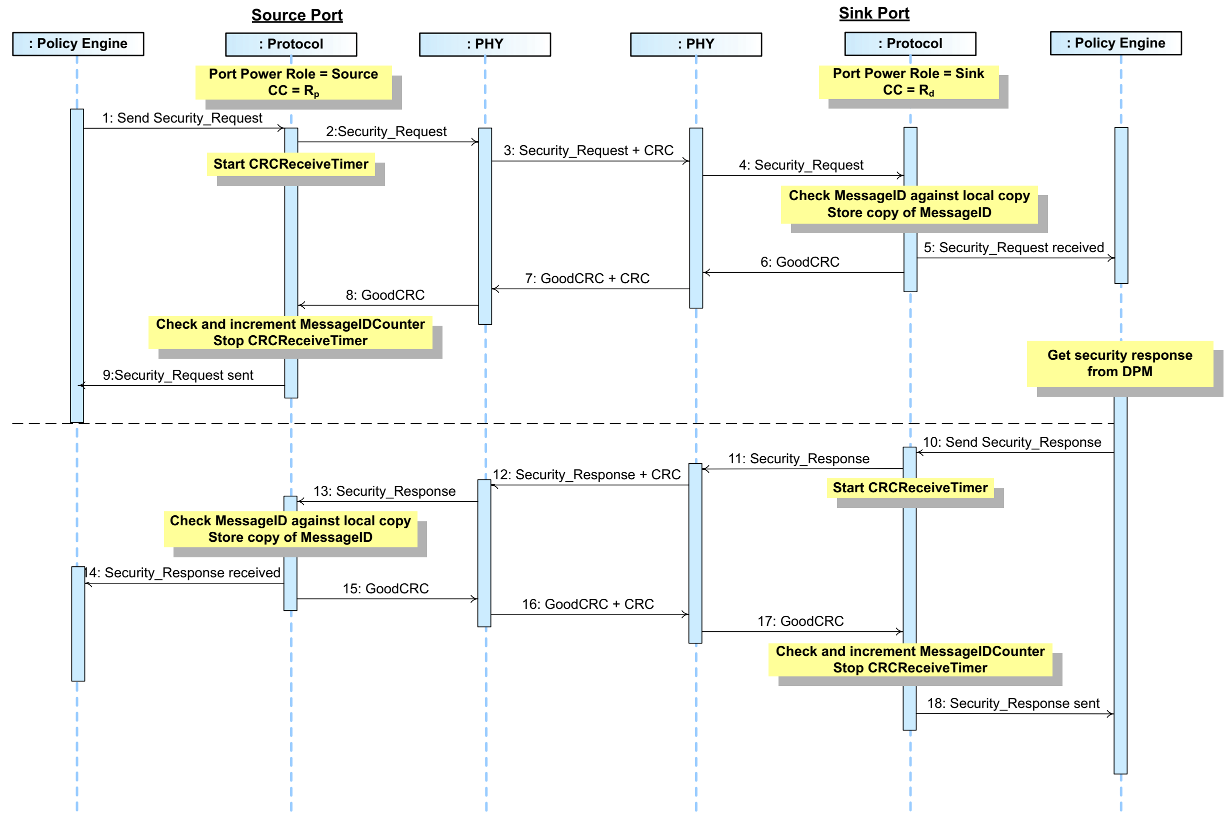


Table 8.123, "Steps for a Source requesting a security exchange with a Sink Sequence" below provides a detailed explanation of what happens at each labeled step in *Figure 8.96, "Source requests security exchange with Sink"* above.

Table 8.123 Steps for a Source requesting a security exchange with a Sink Sequence

Step	Source Port	Sink Port
1	The *Port* has ***Port Power Role*** set to *Source* and the R_p pull up on its *CC* wire. *Policy Engine* directs the *Protocol Layer* to send a ***Security_Request*** *Message* using a *Payload* supplied by the *DPM*.	The *Port* has ***Port Power Role*** set to *Sink* with the R_d pull down on its *CC* wire.
2	*Protocol Layer* creates the *Message* and passes to *PHY Layer*.	
3	*PHY Layer* appends *CRC* and sends the ***Security_Request*** *Message*. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the ***Security_Request*** *Message* and checks the *CRC* to verify the *Message*.
4		*PHY Layer* removes the *CRC* and forwards the ***Security_Request*** *Message* to the *Protocol Layer*.
5		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Security_Request*** *Message* information to the *Policy Engine* that consumes it.
6		*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.
7	*PHY Layer* receives the ***GoodCRC*** *Message* and checks the *CRC* to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.
8	*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.	
9	*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Security_Request*** *Message* was successfully sent.	
10		*Policy Engine* requests the *DPM* for the response to the security request which is provided. The *Policy Engine* tells the *Protocol Layer* to form a ***Security_Response*** *Message*.
11		*Protocol Layer* creates the *Message* and passes to *PHY Layer*.
12	*PHY Layer* receives the *Message* and compares the *CRC* it calculated with the one sent to verify the ***Security_Response*** *Message*.	*PHY Layer* appends a *CRC* and sends the ***Security_Response*** *Message*. Starts ***CRCReceiveTimer***.
13	*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Security_Response*** *Message* information to the *Policy Engine* that consumes it.	
14	*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.	
15	*PHY Layer* appends a *CRC* and sends the ***GoodCRC*** *Message*.	*PHY Layer* receives ***GoodCRC*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.

Table 8.123 Steps for a Source requesting a security exchange with a Sink Sequence

Step	Source Port	Sink Port
16		*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.
17		*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Security_Response*** *Message* was successfully sent.
The security exchange is complete.		

8.3.2.12.2 Sink requests security exchange with Source

Figure 8.97, "Sink requests security exchange with Source" shows an example sequence for a security exchange between a *Sink* and a *Source*.

Figure 8.97 Sink requests security exchange with Source

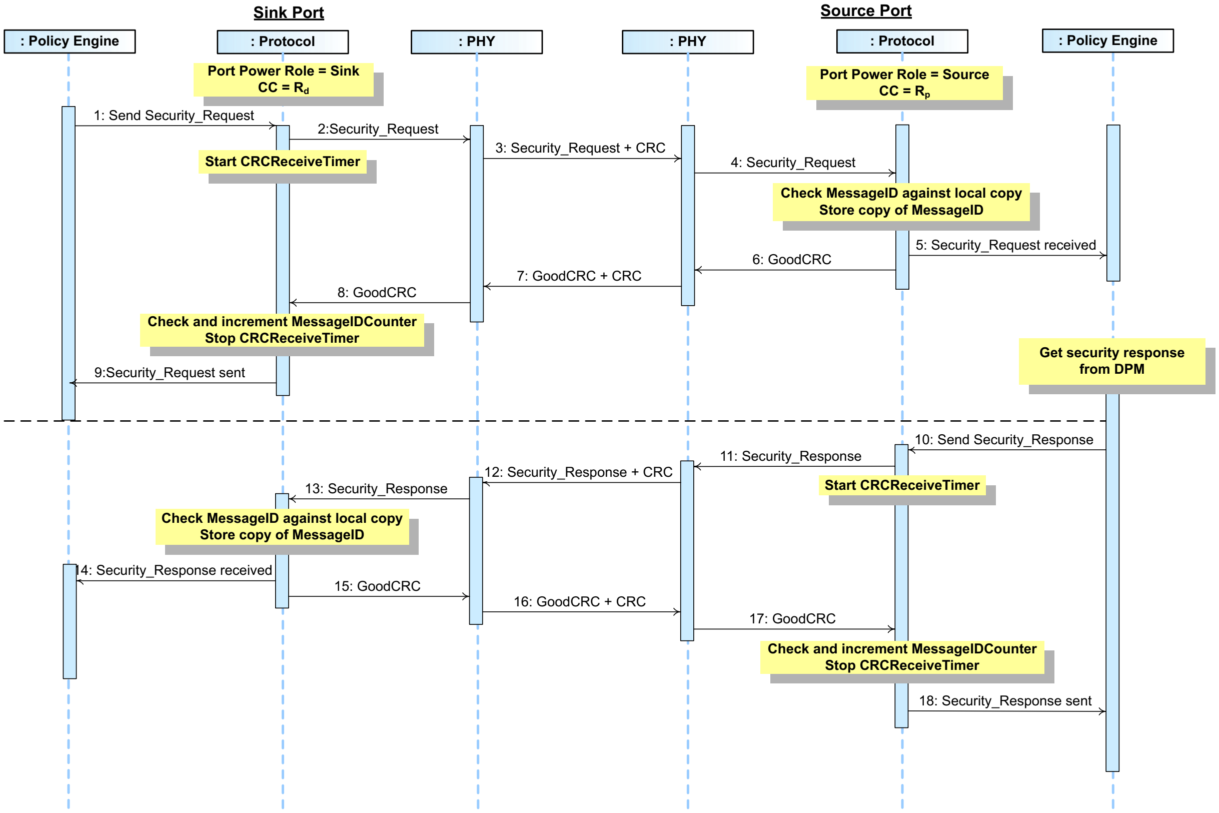


Table 8.124, "Steps for a Sink requesting a security exchange with a Source Sequence" below provides a detailed explanation of what happens at each labeled step in *Figure 8.97, "Sink requests security exchange with Source"* above.

Table 8.124 Steps for a Sink requesting a security exchange with a Source Sequence

Step	Sink Port	Source Port
1	The *Port* has ***Port Power Role*** set to Sink with the R_d pull down on its *CC* wire. *Policy Engine* directs the *Protocol Layer* to send a ***Security_Request*** *Message* using a *Payload* supplied by the *DPM*.	The *Port* has ***Port Power Role*** set to *Source* and the R_p pull up on its *CC* wire.
2	*Protocol Layer* creates the *Message* and passes to *PHY Layer*.	
3	*PHY Layer* appends *CRC* and sends the ***Security_Request*** *Message*. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the ***Security_Request*** *Message* and checks the *CRC* to verify the *Message*.
4		*PHY Layer* removes the *CRC* and forwards the ***Security_Request*** *Message* to the *Protocol Layer*.
5		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Security_Request*** *Message* information to the *Policy Engine* that consumes it.
6		*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.
7	*PHY Layer* receives the ***GoodCRC*** *Message* and checks the *CRC* to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.
8	*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.	
9	*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Security_Request*** *Message* was successfully sent.	
10		*Policy Engine* requests the *DPM* for the response to the security request which is provided. The *Policy Engine* tells the *Protocol Layer* to form a ***Security_Response*** *Message*.
11		*Protocol Layer* creates the *Message* and passes to *PHY Layer*.
12	*PHY Layer* receives the *Message* and compares the *CRC* it calculated with the one sent to verify the ***Security_Response*** *Message*.	*PHY Layer* appends a *CRC* and sends the ***Security_Response*** *Message*. Starts ***CRCReceiveTimer***.
13	*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Security_Response*** *Message* information to the *Policy Engine* that consumes it.	
14	*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.	

Table 8.124 Steps for a Sink requesting a security exchange with a Source Sequence

Step	Sink Port	Source Port
15	*PHY Layer* appends a *CRC* and sends the ***GoodCRC*** *Message*.	*PHY Layer* receives ***GoodCRC*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
16		*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.
17		*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Security_Response*** *Message* was successfully sent.
The security exchange is complete.		

8.3.2.12.3 VCONN Source requests security exchange with Cable Plug

[Figure 8.98, "VCONN Source requests security exchange with Cable Plug"](#) shows an example sequence for a security exchange between a *VCONN Source* and a *Cable Plug*.

Figure 8.98 VCONN Source requests security exchange with Cable Plug

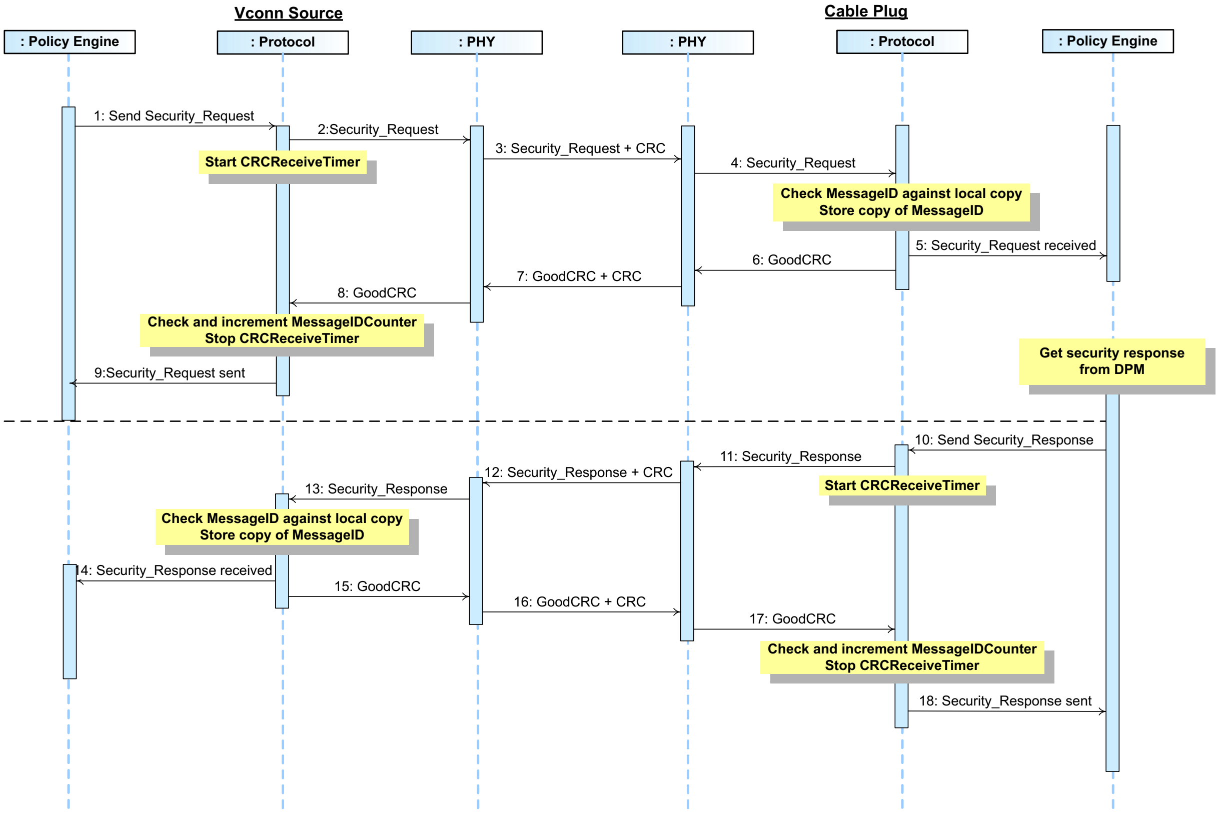


Table 8.125, "Steps for a VCONN Source requesting a security exchange with a Cable Plug Sequence" below provides a detailed explanation of what happens at each labeled step in *Figure 8.98, "VCONN Source requests security exchange with Cable Plug"* above.

Table 8.125 Steps for a VCONN Source requesting a security exchange with a Cable Plug Sequence

Step	VCONN Source	Cable Plug
1	*Policy Engine* directs the *Protocol Layer* to send a ***Security_Request*** *Message* using a *Payload* supplied by the *DPM*.	
2	*Protocol Layer* creates the *Message* and passes to *PHY Layer*.	
3	*PHY Layer* appends *CRC* and sends the ***Security_Request*** *Message*. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the ***Security_Request*** *Message* and checks the *CRC* to verify the *Message*.
4		*PHY Layer* removes the *CRC* and forwards the ***Security_Request*** *Message* to the *Protocol Layer*.
5		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Security_Request*** *Message* information to the *Policy Engine* that consumes it.
6		*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.
7	*PHY Layer* receives the ***GoodCRC*** *Message* and checks the *CRC* to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.
8	*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.	
9	*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Security_Request*** *Message* was successfully sent.	
10		*Policy Engine* requests the *DPM* for the response to the security request which is provided. The *Policy Engine* tells the *Protocol Layer* to form a ***Security_Response*** *Message*.
11		*Protocol Layer* creates the *Message* and passes to *PHY Layer*.
12	*PHY Layer* receives the *Message* and compares the *CRC* it calculated with the one sent to verify the ***Security_Response*** *Message*.	*PHY Layer* appends a *CRC* and sends the ***Security_Response*** *Message*. Starts ***CRCReceiveTimer***.
13	*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Security_Response*** *Message* information to the *Policy Engine* that consumes it.	
14	*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.	
15	*PHY Layer* appends a *CRC* and sends the ***GoodCRC*** *Message*.	*PHY Layer* receives ***GoodCRC*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.

Table 8.125 Steps for a VCONN Source requesting a security exchange with a Cable Plug Sequence

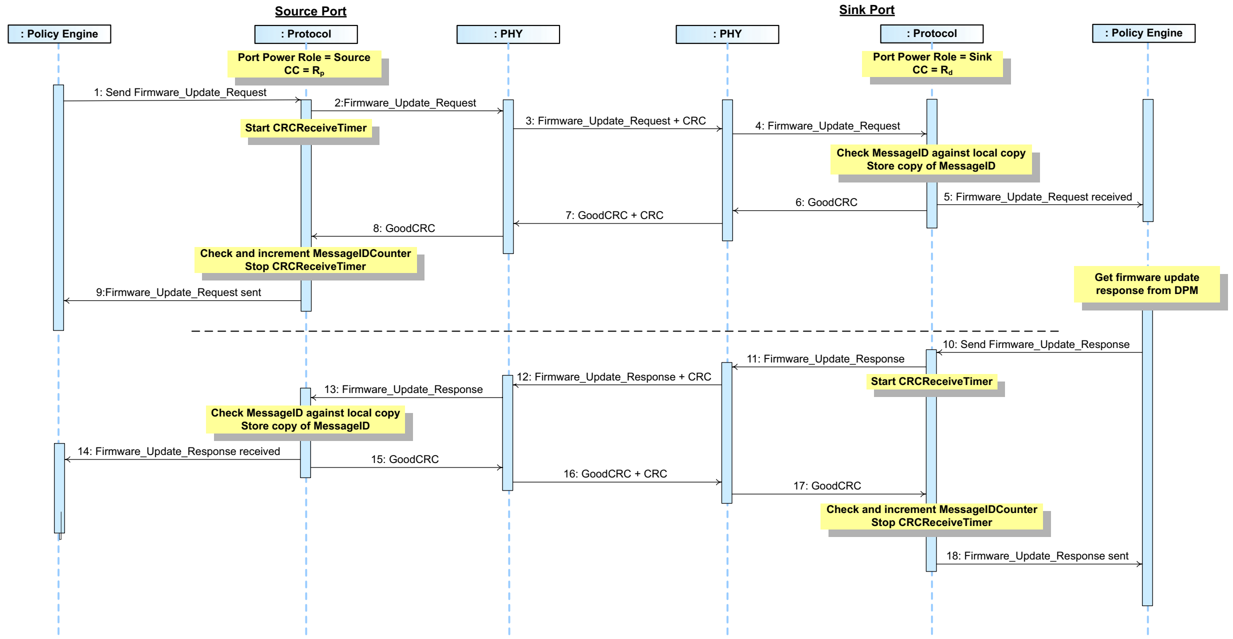
Step	VCONN Source	Cable Plug
16		*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.
17		*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Security_Response*** *Message* was successfully sent.
The security exchange is complete.		

8.3.2.13 Firmware Update

8.3.2.13.1 Source requests firmware update exchange with Sink

Figure 8.99, "Source requests firmware update exchange with Sink" shows an example sequence for a firmware update exchange between a *Source* and a *Sink*.

Figure 8.99 Source requests firmware update exchange with Sink



Source Port
Sink Port
: Policy Engine
: Protocol
: PHY
: PHY
: Protocol
: Policy Engine
Port Power Role = Source
CC = R_p
Port Power Role = Sink
CC = R_d
1: Send Firmware_Update_Request
2:Firmware_Update_Request
Start CRCReceiveTimer
3: Firmware_Update_Request + CRC
4: Firmware_Update_Request
Check MessageID against local copy
Store copy of MessageID
5: Firmware_Update_Request received
6: GoodCRC
7: GoodCRC + CRC
8: GoodCRC
Check and increment MessageIDCounter
Stop CRCReceiveTimer
9:Firmware_Update_Request sent
Get firmware update
response from DPM
10: Send Firmware_Update_Response
11: Firmware_Update_Response
Start CRCReceiveTimer
12: Firmware_Update_Response + CRC
13: Firmware_Update_Response
Check MessageID against local copy
Store copy of MessageID
14: Firmware_Update_Response received
15: GoodCRC
16: GoodCRC + CRC
17: GoodCRC
Check and increment MessageIDCounter
Stop CRCReceiveTimer
18: Firmware_Update_Response sent

Table 8.126, "Steps for a Source requesting a firmware update exchange with a Sink Sequence" below provides a detailed explanation of what happens at each labeled step in *Figure 8.99, "Source requests firmware update exchange with Sink"* above.

Table 8.126 Steps for a Source requesting a firmware update exchange with a Sink Sequence

Step	Source Port	Sink Port
1	The *Port* has ***Port Power Role*** set to *Source* and the R_p pull up on its *CC* wire. *Policy Engine* directs the *Protocol Layer* to send a ***Firmware_Update_Request*** *Message* using a *Payload* supplied by the *DPM*.	The *Port* has ***Port Power Role*** set to *Sink* with the R_d pull down on its *CC* wire.
2	*Protocol Layer* creates the *Message* and passes to *PHY Layer*.	
3	*PHY Layer* appends *CRC* and sends the ***Firmware_Update_Request*** *Message*. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the ***Firmware_Update_Request*** *Message* and checks the *CRC* to verify the *Message*.
4		*PHY Layer* removes the *CRC* and forwards the ***Firmware_Update_Request*** *Message* to the *Protocol Layer*.
5		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Firmware_Update_Request*** *Message* information to the *Policy Engine* that consumes it.
6		*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.
7	*PHY Layer* receives the ***GoodCRC*** *Message* and checks the *CRC* to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.
8	*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.	
9	*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Firmware_Update_Request*** *Message* was successfully sent.	
10		*Policy Engine* requests the *DPM* for the response to the firmware update request which is provided. The *Policy Engine* tells the *Protocol Layer* to form a ***Firmware_Update_Response*** *Message*.
11		*Protocol Layer* creates the *Message* and passes to *PHY Layer*.
12	*PHY Layer* receives the *Message* and compares the *CRC* it calculated with the one sent to verify the ***Firmware_Update_Response*** *Message*.	*PHY Layer* appends a *CRC* and sends the ***Firmware_Update_Response*** *Message*. Starts ***CRCReceiveTimer***.
13	*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Firmware_Update_Response*** *Message* information to the *Policy Engine* that consumes it.	

Table 8.126 Steps for a Source requesting a firmware update exchange with a Sink Sequence

Step	Source Port	Sink Port
14	*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.	
15	*PHY Layer* appends a *CRC* and sends the ***GoodCRC*** *Message*.	*PHY Layer* receives ***GoodCRC*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
16		*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.
17		*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Firmware_Update_Response*** *Message* was successfully sent.
The firmware update exchange is complete.		

8.3.2.13.2 Sink requests firmware update exchange with Source

Figure 8.100, "Sink requests firmware update exchange with Source" shows an example sequence for a firmware update exchange between a *Sink* and a *Source*.

Figure 8.100 Sink requests firmware update exchange with Source

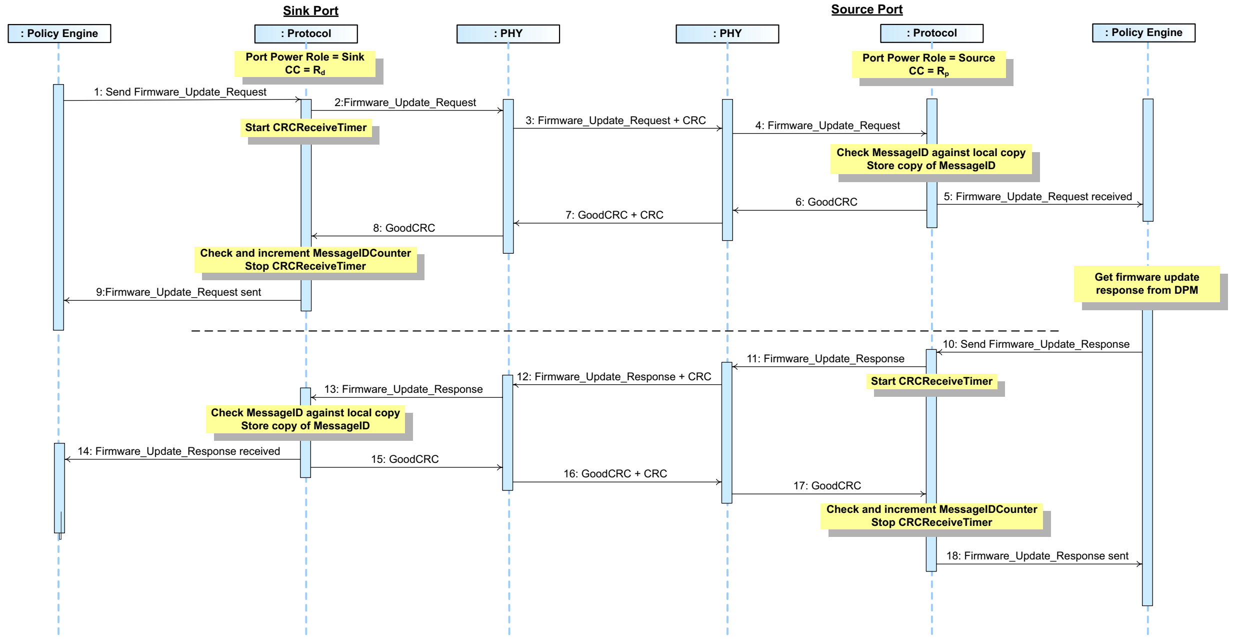

Sink Port
Source Port
: Policy Engine
: Protocol
: PHY
: PHY
: Protocol
: Policy Engine
Port Power Role = Sink
CC = R_d
Port Power Role = Source
CC = R_p
1: Send Firmware_Update_Request
2:Firmware_Update_Request
Start CRCReceiveTimer
3: Firmware_Update_Request + CRC
4: Firmware_Update_Request
Check MessageID against local copy
Store copy of MessageID
5: Firmware_Update_Request received
6: GoodCRC
7: GoodCRC + CRC
8: GoodCRC
Check and increment MessageIDCounter
Stop CRCReceiveTimer
9:Firmware_Update_Request sent
Get firmware update
response from DPM
10: Send Firmware_Update_Response
11: Firmware_Update_Response
Start CRCReceiveTimer
12: Firmware_Update_Response + CRC
13: Firmware_Update_Response
Check MessageID against local copy
Store copy of MessageID
14: Firmware_Update_Response received
15: GoodCRC
16: GoodCRC + CRC
17: GoodCRC
Check and increment MessageIDCounter
Stop CRCReceiveTimer
18: Firmware_Update_Response sent

Table 8.127, "Steps for a Sink requesting a firmware update exchange with a Source Sequence" below provides a detailed explanation of what happens at each labeled step in *Figure 8.100, "Sink requests firmware update exchange with Source"* above.

Table 8.127 Steps for a Sink requesting a firmware update exchange with a Source Sequence

Step	Sink Port	Source Port
1	The *Port* has ***Port Power Role*** set to *Sink* with the R_d pull down on its *CC* wire. *Policy Engine* directs the *Protocol Layer* to send a ***Firmware_Update_Request*** *Message* using a *Payload* supplied by the *DPM*.	The *Port* has ***Port Power Role*** set to *Source* and the R_p pull up on its *CC* wire.
2	*Protocol Layer* creates the *Message* and passes to *PHY Layer*.	
3	*PHY Layer* appends *CRC* and sends the ***Firmware_Update_Request*** *Message*. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the ***Firmware_Update_Request*** *Message* and checks the *CRC* to verify the *Message*.
4		*PHY Layer* removes the *CRC* and forwards the ***Firmware_Update_Request*** *Message* to the *Protocol Layer*.
5		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Firmware_Update_Request*** *Message* information to the *Policy Engine* that consumes it.
6		*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.
7	*PHY Layer* receives the ***GoodCRC*** *Message* and checks the *CRC* to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.
8	*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.	
9	*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Firmware_Update_Request*** *Message* was successfully sent.	
10		*Policy Engine* requests the *DPM* for the response to the firmware update request which is provided. The *Policy Engine* tells the *Protocol Layer* to form a ***Firmware_Update_Response*** *Message*.
11		*Protocol Layer* creates the *Message* and passes to *PHY Layer*.
12	*PHY Layer* receives the *Message* and compares the *CRC* it calculated with the one sent to verify the ***Firmware_Update_Response*** *Message*.	*PHY Layer* appends a *CRC* and sends the ***Firmware_Update_Response*** *Message*. Starts ***CRCReceiveTimer***.
13	*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Firmware_Update_Response*** *Message* information to the *Policy Engine* that consumes it.	

Table 8.127 Steps for a Sink requesting a firmware update exchange with a Source Sequence

Step	Sink Port	Source Port
14	*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.	
15	*PHY Layer* appends a *CRC* and sends the ***GoodCRC*** *Message*.	*PHY Layer* receives ***GoodCRC*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
16		*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.
17		*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Firmware_Update_Response*** *Message* was successfully sent.
The firmware update exchange is complete.		

8.3.2.13.3 VCONN Source requests firmware update exchange with Cable Plug

Figure 8.101, "VCONN Source requests firmware update exchange with Cable Plug" shows an example sequence for a firmware update exchange between a *VCONN Source* and a *Cable Plug*.

Figure 8.101 VCONN Source requests firmware update exchange with Cable Plug

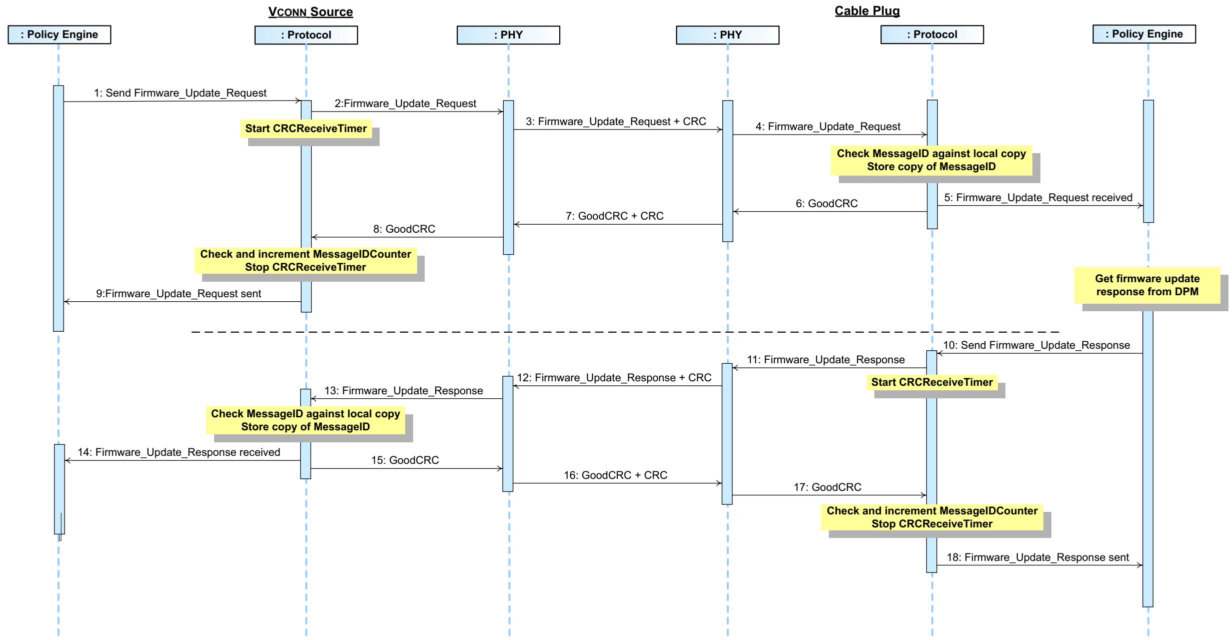

VCONN Source
Cable Plug
: Policy Engine
: Protocol
: PHY
: PHY
: Protocol
: Policy Engine
1: Send Firmware_Update_Request
2:Firmware_Update_Request
Start CRCReceiveTimer
3: Firmware_Update_Request + CRC
4: Firmware_Update_Request
Check MessageID against local copy
Store copy of MessageID
5: Firmware_Update_Request received
6: GoodCRC
7: GoodCRC + CRC
8: GoodCRC
Check and increment MessageIDCounter
Stop CRCReceiveTimer
9:Firmware_Update_Request sent
Get firmware update response from DPM
10: Send Firmware_Update_Response
11: Firmware_Update_Response
Start CRCReceiveTimer
12: Firmware_Update_Response + CRC
13: Firmware_Update_Response
Check MessageID against local copy
Store copy of MessageID
14: Firmware_Update_Response received
15: GoodCRC
16: GoodCRC + CRC
17: GoodCRC
Check and increment MessageIDCounter
Stop CRCReceiveTimer
18: Firmware_Update_Response sent

Table 8.128, "Steps for a VCONN Source requesting a firmware update exchange with a Cable Plug Sequence" below provides a detailed explanation of what happens at each labeled step in *Figure 8.101, "VCONN Source requests firmware update exchange with Cable Plug"* above.

Table 8.128 Steps for a VCONN Source requesting a firmware update exchange with a Cable Plug Sequence

Step	VCONN Source	Cable Plug
1	*Policy Engine* directs the *Protocol Layer* to send a ***Firmware_Update_Request*** *Message* using a *Payload* supplied by the *DPM*.	
2	*Protocol Layer* creates the *Message* and passes to *PHY Layer*.	
3	*PHY Layer* appends *CRC* and sends the ***Firmware_Update_Request*** *Message*. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the ***Firmware_Update_Request*** *Message* and checks the *CRC* to verify the *Message*.
4		*PHY Layer* removes the *CRC* and forwards the ***Firmware_Update_Request*** *Message* to the *Protocol Layer*.
5		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Firmware_Update_Request*** *Message* information to the *Policy Engine* that consumes it.
6		*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.
7	*PHY Layer* receives the ***GoodCRC*** *Message* and checks the *CRC* to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.
8	*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.	
9	*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Firmware_Update_Request*** *Message* was successfully sent.	
10		*Policy Engine* requests the *DPM* for the response to the firmware update request which is provided. The *Policy Engine* tells the *Protocol Layer* to form a ***Firmware_Update_Response*** *Message*.
11		*Protocol Layer* creates the *Message* and passes to *PHY Layer*.
12	*PHY Layer* receives the *Message* and compares the *CRC* it calculated with the one sent to verify the ***Firmware_Update_Response*** *Message*.	*PHY Layer* appends a *CRC* and sends the ***Firmware_Update_Response*** *Message*. Starts ***CRCReceiveTimer***.
13	*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Firmware_Update_Response*** *Message* information to the *Policy Engine* that consumes it.	
14	*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.	

Table 8.128 Steps for a VCONN Source requesting a firmware update exchange with a Cable Plug Sequence

Step	VCONN Source	Cable Plug
15	*PHY Layer* appends a *CRC* and sends the ***GoodCRC*** *Message*.	*PHY Layer* receives ***GoodCRC*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
16		*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.
17		*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Firmware_Update_Response*** *Message* was successfully sent.
The firmware update exchange is complete.		

8.3.2.14 Structured VDM

8.3.2.14.1 Discover Identity

8.3.2.14.1.1 Initiator to Responder Discover Identity (ACK)

Figure 8.102, "Initiator to Responder Discover Identity (ACK)" shows an example sequence between an *Initiator* and *Responder*, where both *Port Partners* are in an *Explicit Contract* and the *Initiator* discovers identity information from the *Responder*.

Figure 8.102 Initiator to Responder Discover Identity (ACK)

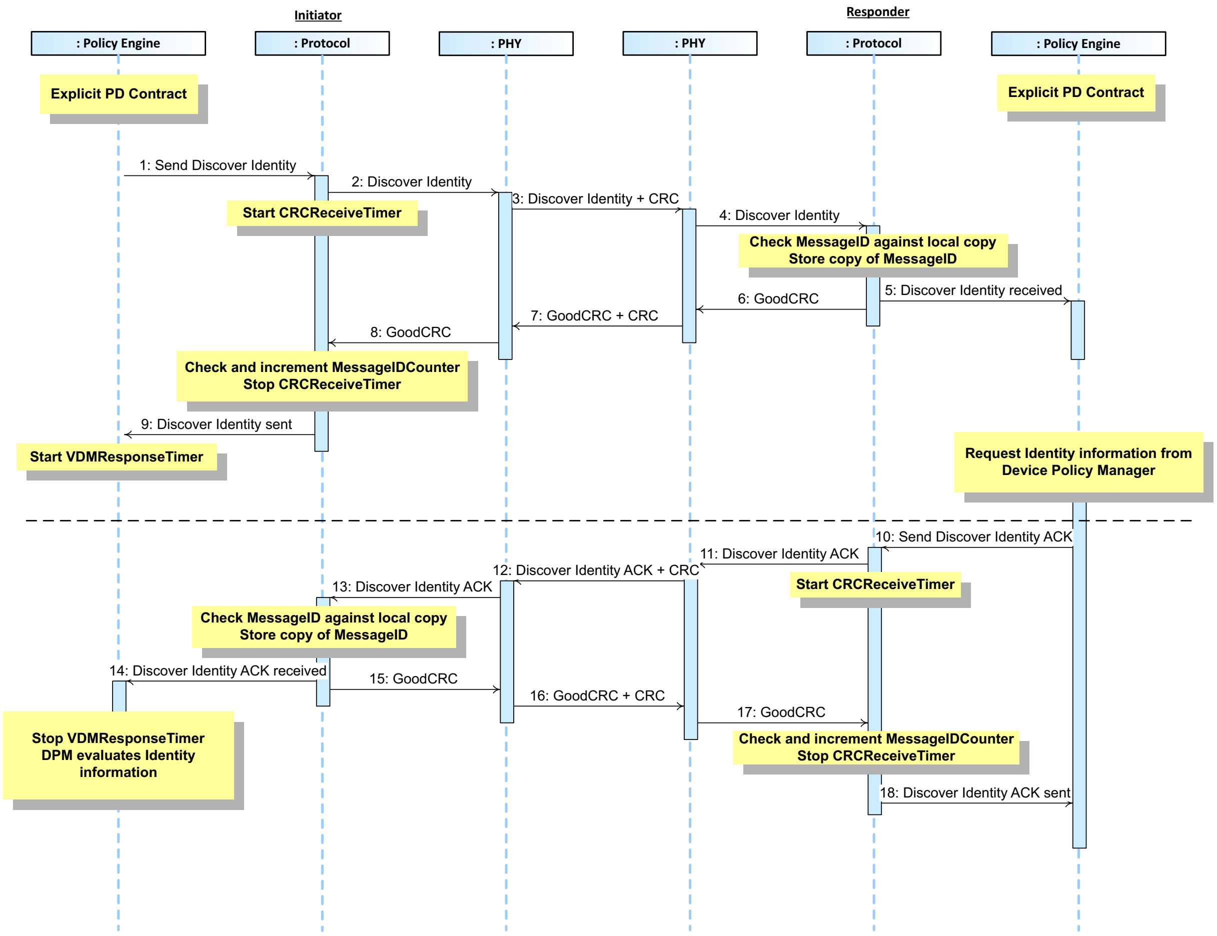


Table 8.129, "Steps for Initiator to UFP Discover Identity (ACK)" below provides a detailed explanation of what happens at each labeled step in *Figure 8.102, "Initiator to Responder Discover Identity (ACK)"* above.

Table 8.129 Steps for Initiator to UFP Discover Identity (ACK)

Step	Initiator	Responder
1	The *Initiator* has an *Explicit Contract*. The *Policy Engine* directs the *Protocol Layer* to send a ***Discover Identity*** *Command* request.	The *Responder* has an *Explicit Contract*.
2	*Protocol Layer* creates the ***Discover Identity*** *Command* request and passes to *PHY Layer*.	
3	*PHY Layer* appends *CRC* and sends the ***Discover Identity*** *Command* request. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the ***Discover Identity*** *Command* request and checks the *CRC* to verify the *Message*.
4		*PHY Layer* removes the *CRC* and forwards the ***Discover Identity*** *Command* request to the *Protocol Layer*.
5		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Discover Identity*** *Command* request information to the *Policy Engine* that consumes it.
6		*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.
7	*PHY Layer* receives the ***GoodCRC*** *Message* and checks the *CRC* to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.
8	*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.	
9	*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Discover Identity*** *Command* request was successfully sent. *Policy Engine* starts the ***VDMResponseTimer***.	
10		*Policy Engine* requests the identity information from the *DPM*. The *Policy Engine* tells the *Protocol Layer* to form a ***Discover Identity*** *Command* ***ACK*** response.
11		*Protocol Layer* creates the ***Discover Identity*** *Command* ***ACK*** response and passes to *PHY Layer*.
12	*PHY Layer* receives the ***Discover Identity*** *Command* ***ACK*** response and compares the *CRC* it calculated with the one sent to verify the *Message*.	*PHY Layer* appends a *CRC* and sends the ***Discover Identity*** *Command* ***ACK*** response. Starts ***CRCReceiveTimer***.
13	*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Discover Identity*** *Command* ***ACK*** response information to the *Policy Engine* that consumes it.	
14	The *Policy Engine* stops the ***VDMResponseTimer*** and passed the Identity information to the *DPM* for evaluation.	
15	*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.	

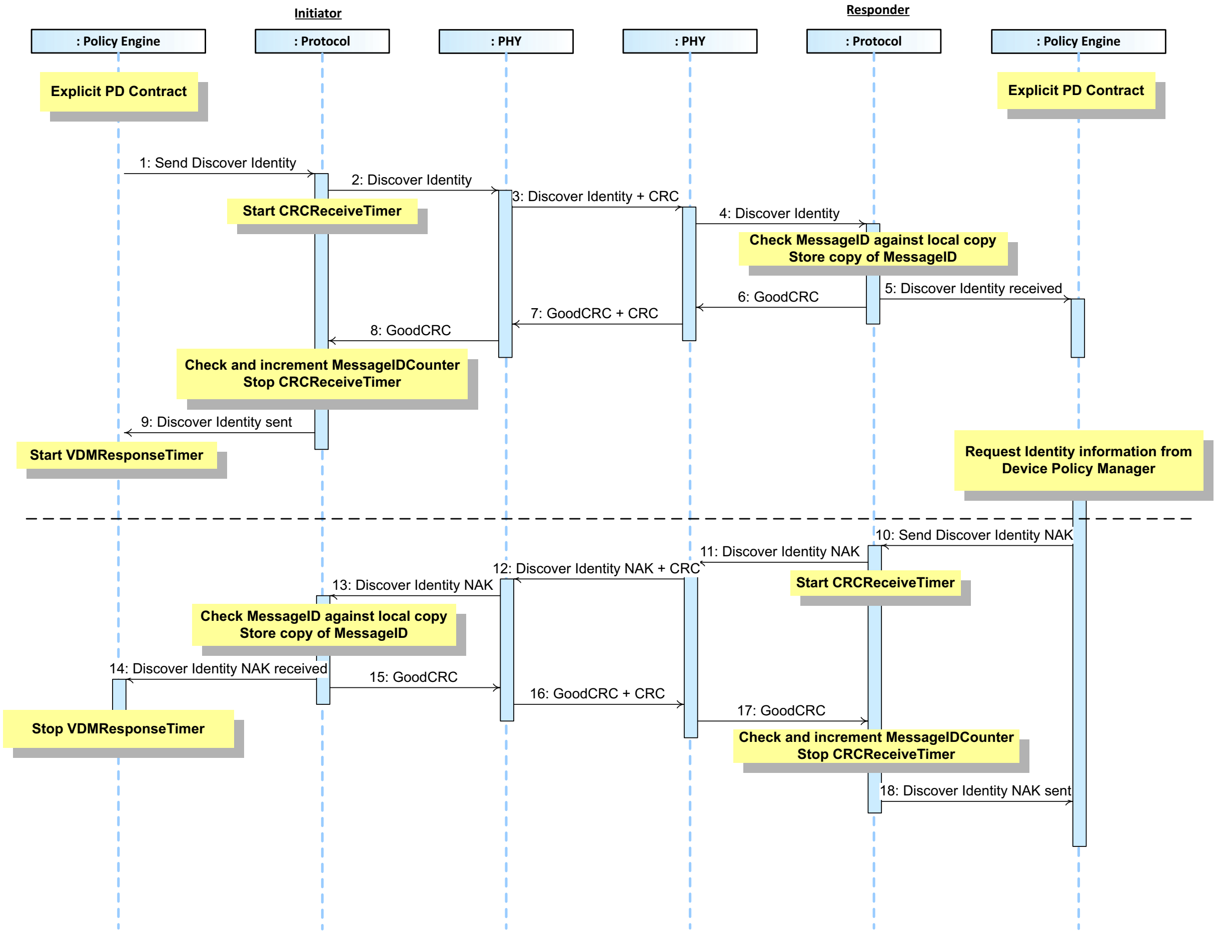
Table 8.129 Steps for Initiator to UFP Discover Identity (ACK)

Step	Initiator	Responder
16	*PHY Layer* appends a *CRC* and sends the ***GoodCRC*** *Message*.	*PHY Layer* receives ***GoodCRC*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
17		*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.
18		*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Discover Identity*** *Command* ***ACK*** response was successfully sent.

8.3.2.14.1.2 Initiator to Responder Discover Identity (NAK)

Figure 8.103, "Initiator to Responder Discover Identity (NAK)" shows an example sequence between an *Initiator* and *Responder*, where both *Port Partner*s are in an *Explicit Contract* and the *Initiator* attempts to discover identity information from the *Responder* but receives a ***NAK***.

Figure 8.103 Initiator to Responder Discover Identity (NAK)



Initiator
Responder
: Policy Engine
: Protocol
: PHY
: PHY
: Protocol
: Policy Engine
Explicit PD Contract
Explicit PD Contract
1: Send Discover Identity
2: Discover Identity
3: Discover Identity + CRC
4: Discover Identity
Start CRCReceiveTimer
Check MessageID against local copy
Store copy of MessageID
5: Discover Identity received
6: GoodCRC
7: GoodCRC + CRC
8: GoodCRC
Check and increment MessageIDCounter
Stop CRCReceiveTimer
9: Discover Identity sent
Start VDMResponseTimer
Request Identity information from
Device Policy Manager
10: Send Discover Identity NAK
11: Discover Identity NAK
12: Discover Identity NAK + CRC
13: Discover Identity NAK
Start CRCReceiveTimer
Check MessageID against local copy
Store copy of MessageID
14: Discover Identity NAK received
15: GoodCRC
16: GoodCRC + CRC
17: GoodCRC
Stop VDMResponseTimer
Check and increment MessageIDCounter
Stop CRCReceiveTimer
18: Discover Identity NAK sent

Table 8.130, "Steps for Initiator to UFP Discover Identity (NAK)" below provides a detailed explanation of what happens at each labeled step in *Figure 8.103, "Initiator to Responder Discover Identity (NAK)"* above.

Table 8.130 Steps for Initiator to UFP Discover Identity (NAK)

Step	Initiator	Responder
1	The *Initiator* has an *Explicit Contract*. The *Policy Engine* directs the *Protocol Layer* to send a ***Discover Identity*** *Command* request.	The *Responder* has an *Explicit Contract*.
2	*Protocol Layer* creates the ***Discover Identity*** *Command* request and passes to *PHY Layer*.	
3	*PHY Layer* appends *CRC* and sends the ***Discover Identity*** *Command* request. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the ***Discover Identity*** *Command* request and checks the *CRC* to verify the *Message*.
4		*PHY Layer* removes the *CRC* and forwards the ***Discover Identity*** *Command* request to the *Protocol Layer*.
5		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Discover Identity*** *Command* request information to the *Policy Engine* that consumes it.
6		*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.
7	*PHY Layer* receives the ***GoodCRC*** *Message* and checks the *CRC* to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.
8	*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.	
9	*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Discover Identity*** *Command* request was successfully sent. *Policy Engine* starts the ***VDMResponseTimer***.	
10		*Policy Engine* requests the identity information from the *DPM*. The *Policy Engine* tells the *Protocol Layer* to form a ***Discover Identity*** *Command* ***NAK*** response.
11		*Protocol Layer* creates the ***Discover Identity*** *Command* ***NAK*** response and passes to *PHY Layer*.
12	*PHY Layer* receives the ***Discover Identity*** *Command* ***NAK*** response and compares the *CRC* it calculated with the one sent to verify the *Message*.	*PHY Layer* appends a *CRC* and sends the ***Discover Identity*** *Command* ***NAK*** response. Starts ***CRCReceiveTimer***.
13	*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Discover Identity*** *Command* ***NAK*** response information to the *Policy Engine* that consumes it.	
14	The *Policy Engine* stops the ***VDMResponseTimer*** and passed the Identity information to the *DPM* for evaluation.	
15	*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.	

Table 8.130 Steps for Initiator to UFP Discover Identity (NAK)

Step	Initiator	Responder
16	*PHY Layer* appends a *CRC* and sends the ***GoodCRC*** *Message*.	*PHY Layer* receives ***GoodCRC*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
17		*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.
18		*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Discover Identity*** *Command* ***NAK*** response was successfully sent.

8.3.2.14.1.3 Initiator to Responder Discover Identity (BUSY)

Figure 8.104, "Initiator to Responder Discover Identity (BUSY)" shows an example sequence between an *Initiator* and *Responder*, where both *Port Partners* are in an *Explicit Contract* and the *Initiator* attempts to discover identity information from the *Responder* but receives a ***BUSY***.

Figure 8.104 Initiator to Responder Discover Identity (BUSY)

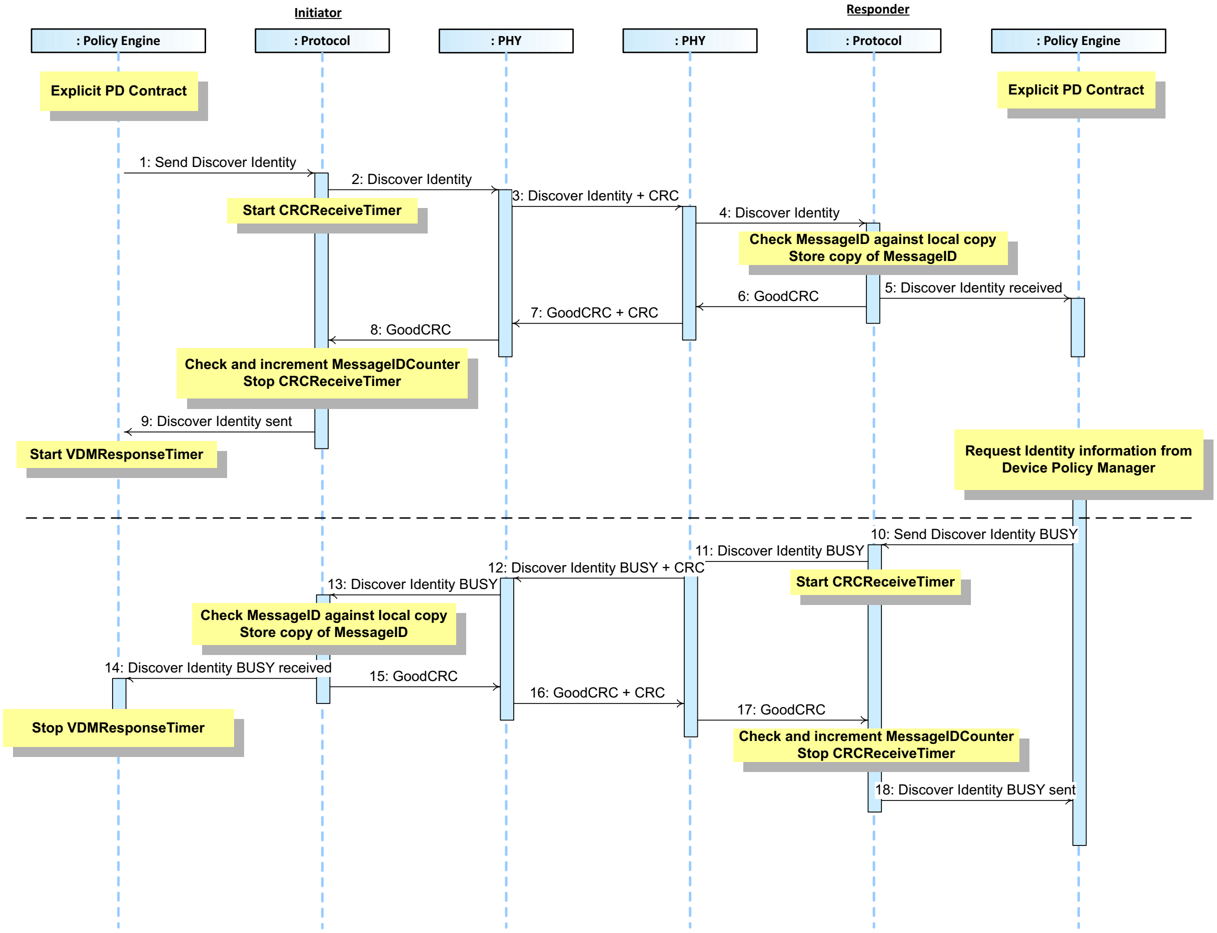

Initiator
Responder
: Policy Engine
: Protocol
: PHY
: PHY
: Protocol
: Policy Engine
Explicit PD Contract
Explicit PD Contract
1: Send Discover Identity
2: Discover Identity
Start CRCReceiveTimer
3: Discover Identity + CRC
4: Discover Identity
Check MessageID against local copy
Store copy of MessageID
5: Discover Identity received
6: GoodCRC
7: GoodCRC + CRC
8: GoodCRC
Check and increment MessageIDCounter
Stop CRCReceiveTimer
9: Discover Identity sent
Start VDMResponseTimer
Request Identity information from
Device Policy Manager
10: Send Discover Identity BUSY
11: Discover Identity BUSY
12: Discover Identity BUSY + CRC
Start CRCReceiveTimer
13: Discover Identity BUSY
Check MessageID against local copy
Store copy of MessageID
14: Discover Identity BUSY received
15: GoodCRC
16: GoodCRC + CRC
17: GoodCRC
Stop VDMResponseTimer
Check and increment MessageIDCounter
Stop CRCReceiveTimer
18: Discover Identity BUSY sent

Table 8.131, "Steps for Initiator to UFP Discover Identity (BUSY)" below provides a detailed explanation of what happens at each labeled step in *Figure 8.104, "Initiator to Responder Discover Identity (BUSY)"* above.

Table 8.131 Steps for Initiator to UFP Discover Identity (BUSY)

Step	Initiator	Responder
1	The *Initiator* has an *Explicit Contract*. The *Policy Engine* directs the *Protocol Layer* to send a ***Discover Identity*** *Command* request.	The *Responder* has an *Explicit Contract*.
2	*Protocol Layer* creates the ***Discover Identity*** *Command* request and passes to *PHY Layer*.	
3	*PHY Layer* appends *CRC* and sends the ***Discover Identity*** *Command* request. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the ***Discover Identity*** *Command* request and checks the *CRC* to verify the *Message*.
4		*PHY Layer* removes the *CRC* and forwards the ***Discover Identity*** *Command* request to the *Protocol Layer*.
5		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Discover Identity*** *Command* request information to the *Policy Engine* that consumes it.
6		*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.
7	*PHY Layer* receives the ***GoodCRC*** *Message* and checks the *CRC* to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.
8	*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.	
9	*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Discover Identity*** *Command* request was successfully sent. *Policy Engine* starts the ***VDMResponseTimer***.	
10		*Policy Engine* requests the identity information from the *DPM*. The *Policy Engine* tells the *Protocol Layer* to form a ***Discover Identity*** *Command* ***BUSY*** response.
11		*Protocol Layer* creates the ***Discover Identity*** *Command* ***BUSY*** response and passes to *PHY Layer*.
12	*PHY Layer* receives the ***Discover Identity*** *Command* ***BUSY*** response and compares the *CRC* it calculated with the one sent to verify the *Message*.	*PHY Layer* appends a *CRC* and sends the ***Discover Identity*** *Command* ***BUSY*** response. Starts ***CRCReceiveTimer***.
13	*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Discover Identity*** *Command* ***BUSY*** response information to the *Policy Engine* that consumes it.	
14	The *Policy Engine* stops the ***VDMResponseTimer*** and passed the Identity information to the *DPM* for evaluation.	
15	*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.	

Table 8.131 Steps for Initiator to UFP Discover Identity (BUSY)

Step	Initiator	Responder
16	*PHY Layer* appends a *CRC* and sends the ***GoodCRC*** *Message*.	*PHY Layer* receives ***GoodCRC*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
17		*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.
18		*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Discover Identity*** *Command* ***NAK*** response was successfully sent.

8.3.2.14.2 Discover SVIDs

8.3.2.14.2.1 Initiator to Responder Discover SVIDs (ACK)

Figure 8.105, "Initiator to Responder Discover SVIDs (ACK)" shows an example sequence between an *Initiator* and *Responder*, where both *Port Partners* are in an *Explicit Contract* and the *Initiator* discovers *SVID* information from the *Responder*.

Figure 8.105 Initiator to Responder Discover SVIDs (ACK)

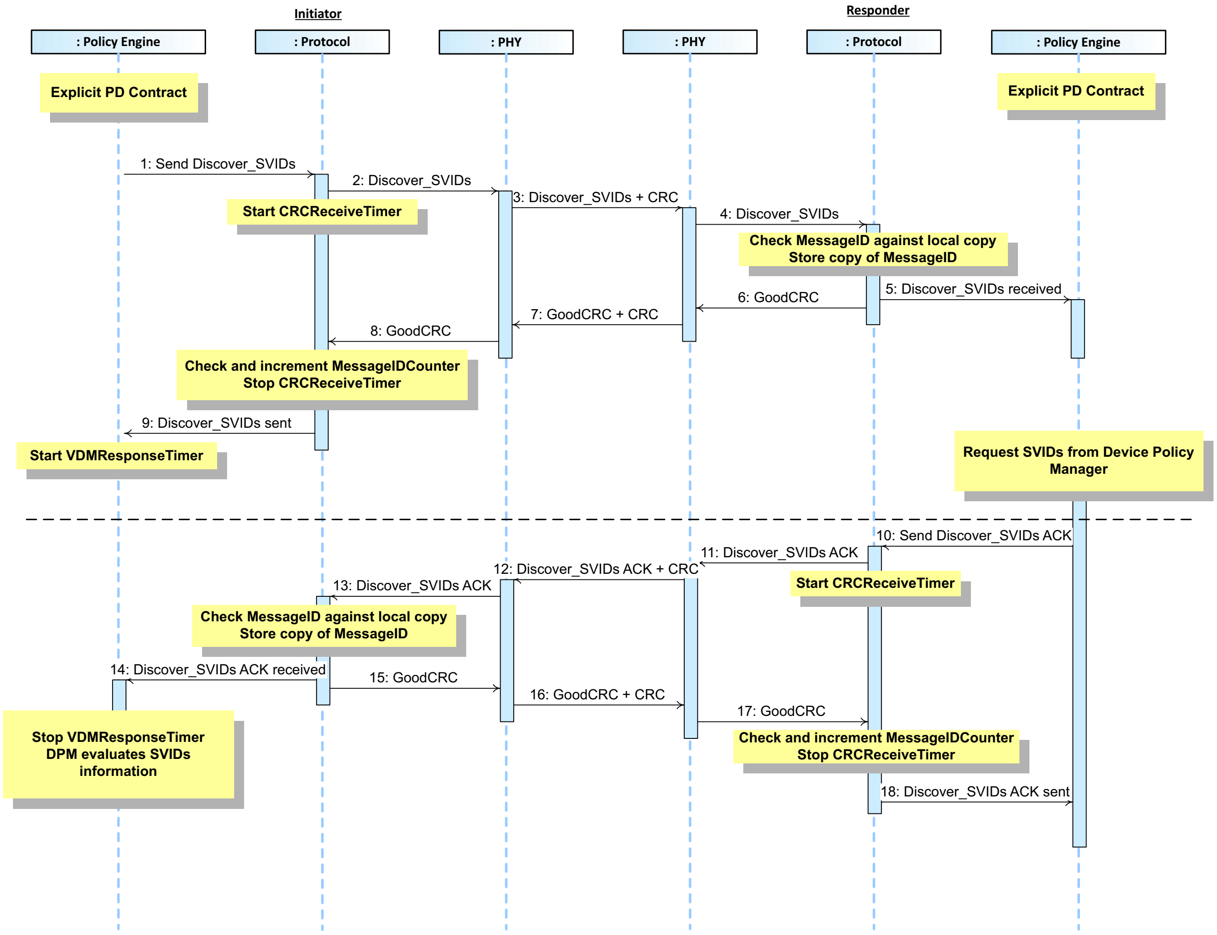


Table 8.132, "Steps for DFP to UFP Discover SVIDs (ACK)" below provides a detailed explanation of what happens at each labeled step in *Figure 8.105, "Initiator to Responder Discover SVIDs (ACK)"* above.

Table 8.132 Steps for DFP to UFP Discover SVIDs (ACK)

Step	Initiator	Responder
1	The *Initiator* has an *Explicit Contract*. The *Policy Engine* directs the *Protocol Layer* to send a ***Discover SVIDs*** *Command* request.	The *Responder* has an *Explicit Contract*.
2	*Protocol Layer* creates the ***Discover SVIDs*** *Command* request and passes to *PHY Layer*.	
3	*PHY Layer* appends *CRC* and sends the ***Discover SVIDs*** *Command* request. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the ***Discover SVIDs*** *Command* request and checks the *CRC* to verify the *Message*.
4		*PHY Layer* removes the *CRC* and forwards the ***Discover SVIDs*** *Command* request to the *Protocol Layer*.
5		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Discover SVIDs*** *Command* request information to the *Policy Engine* that consumes it.
6		*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.
7	*PHY Layer* receives the ***GoodCRC*** *Message* and checks the *CRC* to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.
8	*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.	
9	*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Discover SVIDs*** *Command* request was successfully sent. *Policy Engine* starts the ***VDMResponseTimer***.	
10		*Policy Engine* requests the identity information from the *DPM*. The *Policy Engine* tells the *Protocol Layer* to form a ***Discover SVIDs*** *Command* ***ACK*** response.
11		*Protocol Layer* creates the ***Discover SVIDs*** *Command* ***ACK*** response and passes to *PHY Layer*.
12	*PHY Layer* receives the ***Discover SVIDs*** *Command* ***ACK*** response and compares the *CRC* it calculated with the one sent to verify the *Message*.	*PHY Layer* appends a *CRC* and sends the ***Discover SVIDs*** *Command* ***ACK*** response. Starts ***CRCReceiveTimer***.
13	*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Discover SVIDs*** *Command* ***ACK*** response information to the *Policy Engine* that consumes it.	
14	The *Policy Engine* stops the ***VDMResponseTimer*** and passed the Identity information to the *DPM* for evaluation.	
15	*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.	

Table 8.132 Steps for DFP to UFP Discover SVIDs (ACK)

Step	Initiator	Responder
16	*PHY Layer* appends a *CRC* and sends the ***GoodCRC*** *Message*.	*PHY Layer* receives ***GoodCRC*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
17		*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.
18		*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Discover SVIDs*** *Command* ***ACK*** response was successfully sent.

8.3.2.14.2.2 Initiator to Responder Discover SVIDs (NAK)

Figure 8.106, "Initiator to Responder Discover SVIDs (NAK)" shows an example sequence between an *Initiator* and *Responder*, where both *Port Partner*s are in an *Explicit Contract* and the *Initiator* attempts to discover *SVID* information from the *Responder* but receives a ***NAK***.

Figure 8.106 Initiator to Responder Discover SVIDs (NAK)

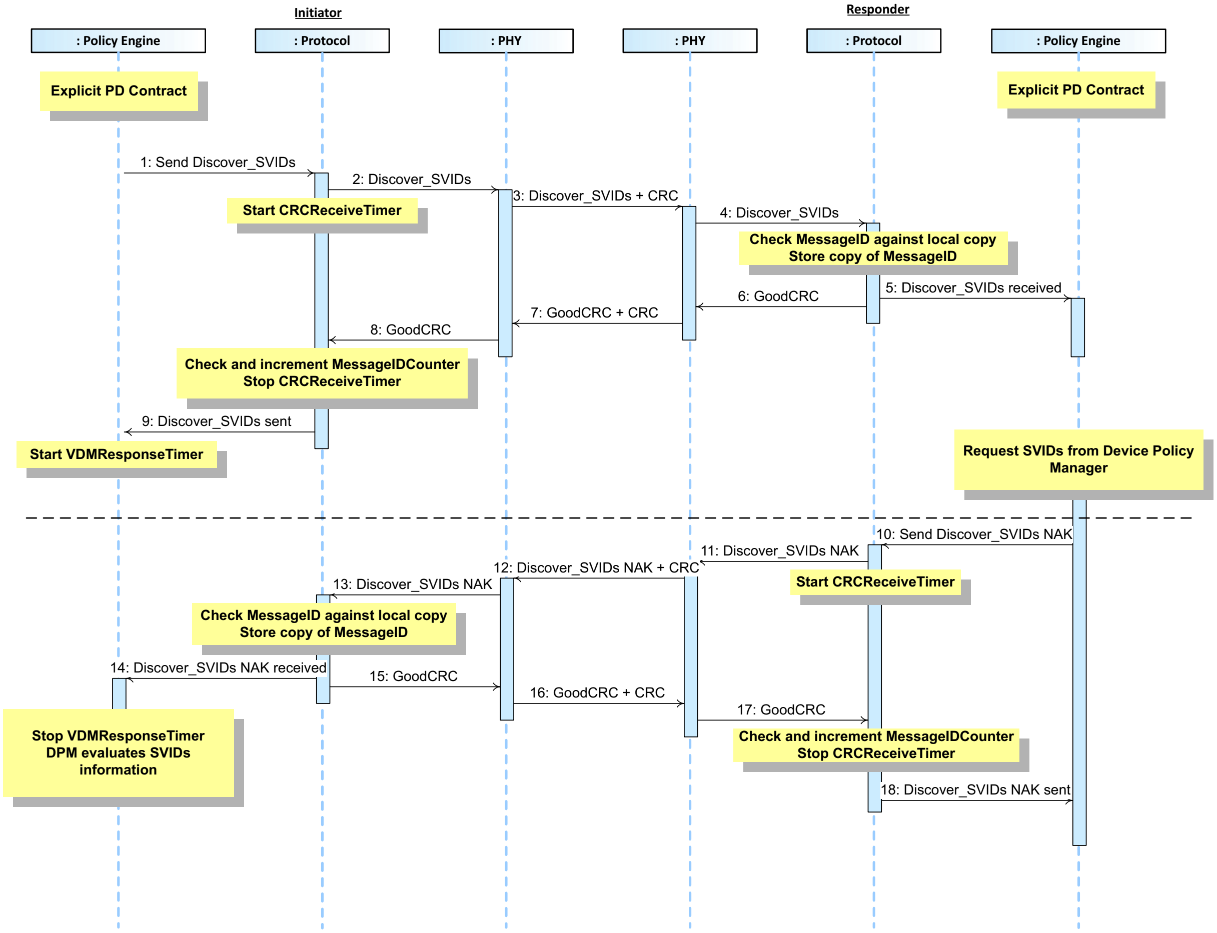


Table 8.133, "Steps for DFP to UFP Discover SVIDs (NAK)" below provides a detailed explanation of what happens at each labeled step in *Figure 8.106, "Initiator to Responder Discover SVIDs (NAK)"* above.

Table 8.133 Steps for DFP to UFP Discover SVIDs (NAK)

Step	Initiator	Responder
1	The *Initiator* has an *Explicit Contract*. The *Policy Engine* directs the *Protocol Layer* to send a ***Discover SVIDs*** *Command* request.	The *Responder* has an *Explicit Contract*.
2	*Protocol Layer* creates the ***Discover SVIDs*** *Command* request and passes to *PHY Layer*.	
3	*PHY Layer* appends *CRC* and sends the ***Discover SVIDs*** *Command* request. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the ***Discover SVIDs*** *Command* request and checks the *CRC* to verify the *Message*.
4		*PHY Layer* removes the *CRC* and forwards the ***Discover SVIDs*** *Command* request to the *Protocol Layer*.
5		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Discover SVIDs*** *Command* request information to the *Policy Engine* that consumes it.
6		*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.
7	*PHY Layer* receives the ***GoodCRC*** *Message* and checks the *CRC* to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.
8	*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.	
9	*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Discover SVIDs*** *Command* request was successfully sent. *Policy Engine* starts the ***VDMResponseTimer***.	
10		*Policy Engine* requests the identity information from the *DPM*. The *Policy Engine* tells the *Protocol Layer* to form a ***Discover SVIDs*** *Command* ***NAK*** response.
11		*Protocol Layer* creates the ***Discover SVIDs*** *Command* ***NAK*** response and passes to *PHY Layer*.
12	*PHY Layer* receives the ***Discover SVIDs*** *Command* ***NAK*** response and compares the *CRC* it calculated with the one sent to verify the *Message*.	*PHY Layer* appends a *CRC* and sends the ***Discover SVIDs*** *Command* ***NAK*** response. Starts ***CRCReceiveTimer***.
13	*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Discover SVIDs*** *Command* ***NAK*** response information to the *Policy Engine* that consumes it.	
14	The *Policy Engine* stops the ***VDMResponseTimer*** and passed the Identity information to the *DPM* for evaluation.	
15	*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.	
16	*PHY Layer* appends a *CRC* and sends the ***GoodCRC*** *Message*.	*PHY Layer* receives ***GoodCRC*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.

Table 8.133 Steps for DFP to UFP Discover SVIDs (NAK)

Step	Initiator	Responder
17		*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.
18		*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Discover SVIDs*** *Command* ***NAK*** response was successfully sent.

8.3.2.14.2.3 Initiator to Responder Discover SVIDs (BUSY)

Figure 8.107, "Initiator to Responder Discover SVIDs (BUSY)" shows an example sequence between an *Initiator* and *Responder*, where both *Port Partners* are in an *Explicit Contract* and the *Initiator* attempts to discover *SVID* information from the *Responder* but receives a ***BUSY***.

Figure 8.107 Initiator to Responder Discover SVIDs (BUSY)

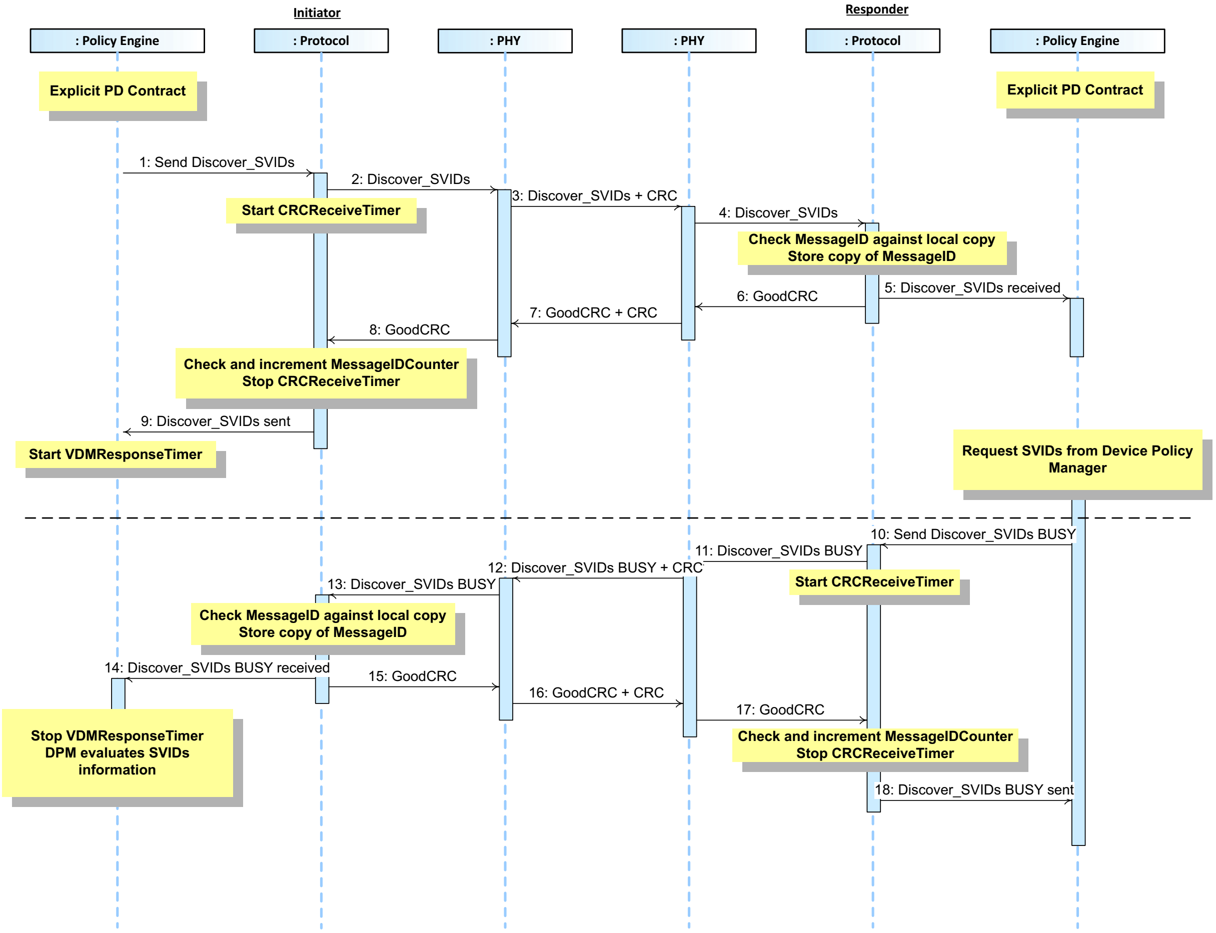


Table 8.134, "Steps for DFP to UFP Discover SVIDs (BUSY)" below provides a detailed explanation of what happens at each labeled step in *Figure 8.107, "Initiator to Responder Discover SVIDs (BUSY)"* above.

Table 8.134 Steps for DFP to UFP Discover SVIDs (BUSY)

Step	Initiator	Responder
1	The *Initiator* has an *Explicit Contract*. The *Policy Engine* directs the *Protocol Layer* to send a ***Discover SVIDs*** *Command* request.	The *Responder* has an *Explicit Contract*.
2	*Protocol Layer* creates the ***Discover SVIDs*** *Command* request and passes to *PHY Layer*.	
3	*PHY Layer* appends *CRC* and sends the ***Discover SVIDs*** *Command* request. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the ***Discover SVIDs*** *Command* request and checks the *CRC* to verify the *Message*.
4		*PHY Layer* removes the *CRC* and forwards the ***Discover SVIDs*** *Command* request to the *Protocol Layer*.
5		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Discover SVIDs*** *Command* request information to the *Policy Engine* that consumes it.
6		*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.
7	*PHY Layer* receives the ***GoodCRC*** *Message* and checks the *CRC* to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.
8	*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.	
9	*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Discover SVIDs*** *Command* request was successfully sent. *Policy Engine* starts the ***VDMResponseTimer***.	
10		*Policy Engine* requests the identity information from the *DPM*. The *Policy Engine* tells the *Protocol Layer* to form a ***Discover SVIDs*** *Command* ***BUSY*** response.
11		*Protocol Layer* creates the ***Discover SVIDs*** *Command* ***BUSY*** response and passes to *PHY Layer*.
12	*PHY Layer* receives the ***Discover SVIDs*** *Command* ***BUSY*** response and compares the *CRC* it calculated with the one sent to verify the *Message*.	*PHY Layer* appends a *CRC* and sends the ***Discover SVIDs*** *Command* ***BUSY*** response. Starts ***CRCReceiveTimer***.
13	*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Discover SVIDs*** *Command* ***BUSY*** response information to the *Policy Engine* that consumes it.	
14	The *Policy Engine* stops the ***VDMResponseTimer*** and passed the Identity information to the *DPM* for evaluation.	
15	*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.	

Table 8.134 Steps for DFP to UFP Discover SVIDs (BUSY)

Step	Initiator	Responder
16	*PHY Layer* appends a *CRC* and sends the ***GoodCRC*** *Message*.	*PHY Layer* receives ***GoodCRC*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
17		*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.
18		*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Discover SVIDs*** *Command* ***BUSY*** response was successfully sent.

8.3.2.14.3 Discover Modes

8.3.2.14.3.1 Initiator to Responder Discover Modes (ACK)

Figure 8.108, "Initiator to Responder Discover Modes (ACK)" shows an example sequence between an *Initiator* and *Responder*, where both *Port Partner*s are in an *Explicit Contract* and the *Initiator* discovers Mode information from the *Responder*.

Figure 8.108 Initiator to Responder Discover Modes (ACK)

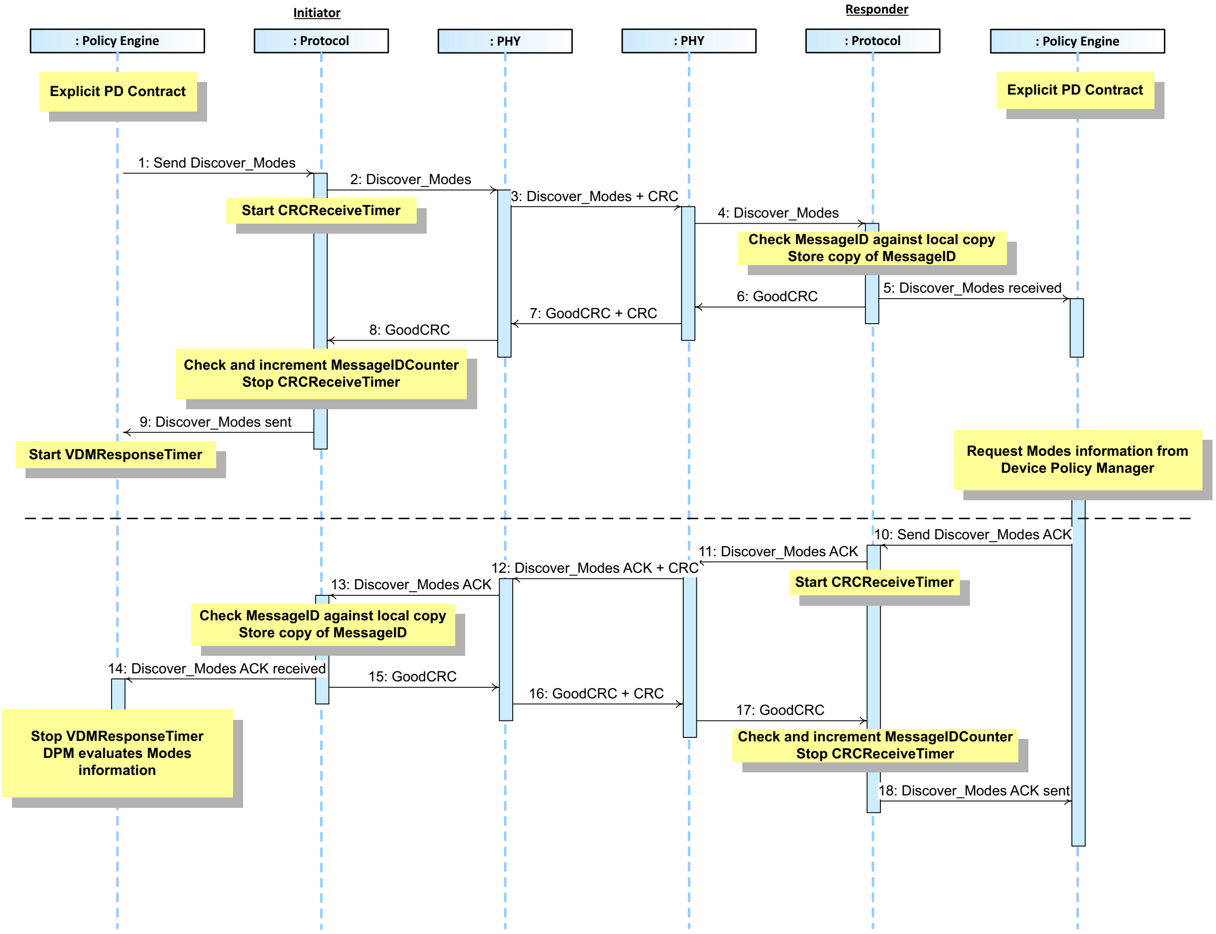


Table 8.135, "Steps for DFP to UFP Discover Modes (ACK)" below provides a detailed explanation of what happens at each labeled step in *Figure 8.108, "Initiator to Responder Discover Modes (ACK)"*.

Table 8.135 Steps for DFP to UFP Discover Modes (ACK)

Step	DFP	UFP
1	The *DFP* has an *Explicit Contract*. The *Policy Engine* directs the *Protocol Layer* to send a ***Discover Modes*** *Command* request.	The *UFP* has an *Explicit Contract*.
2	*Protocol Layer* creates the ***Discover Modes*** *Command* request and passes to *PHY Layer*.	
3	*PHY Layer* appends *CRC* and sends the ***Discover Modes*** *Command* request. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the ***Discover Modes*** *Command* request and checks the *CRC* to verify the *Message*.
4		*PHY Layer* removes the *CRC* and forwards the ***Discover Modes*** *Command* request to the *Protocol Layer*.
5		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Discover Modes*** *Command* request information to the *Policy Engine* that consumes it.
6		*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.
7	*PHY Layer* receives the ***GoodCRC*** *Message* and checks the *CRC* to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.
8	*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.	
9	*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Discover Modes*** *Command* request was successfully sent. *Policy Engine* starts the ***VDMResponseTimer***.	
10		*Policy Engine* requests the identity information from the *DPM*. The *Policy Engine* tells the *Protocol Layer* to form a ***Discover Modes*** *Command* ***ACK*** response.
11		*Protocol Layer* creates the ***Discover Modes*** *Command* ***ACK*** response and passes to *PHY Layer*.
12	*PHY Layer* receives the ***Discover Modes*** *Command* ***ACK*** response and compares the *CRC* it calculated with the one sent to verify the *Message*.	*PHY Layer* appends a *CRC* and sends the ***Discover Modes*** *Command* ***ACK*** response. Starts ***CRCReceiveTimer***.
13	*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Discover Modes*** *Command* ***ACK*** response information to the *Policy Engine* that consumes it.	
14	The *Policy Engine* stops the ***VDMResponseTimer*** and passed the Identity information to the *DPM* for evaluation.	
15	*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.	

Table 8.135 Steps for DFP to UFP Discover Modes (ACK)

Step	DFP	UFP
16	*PHY Layer* appends a *CRC* and sends the ***GoodCRC*** *Message*.	*PHY Layer* receives ***GoodCRC*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
17		*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.
18		*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Discover Modes*** *Command* ***ACK*** response was successfully sent.

8.3.2.14.3.2 Initiator to Responder Discover Modes (NAK)

Figure 8.109, "Initiator to Responder Discover Modes (NAK)" shows an example sequence between an *Initiator* and *Responder*, where both *Port Partner*s are in an *Explicit Contract* and the *Initiator* attempts to discover Mode information from the *Responder* but receives a ***NAK***.

Figure 8.109 Initiator to Responder Discover Modes (NAK)

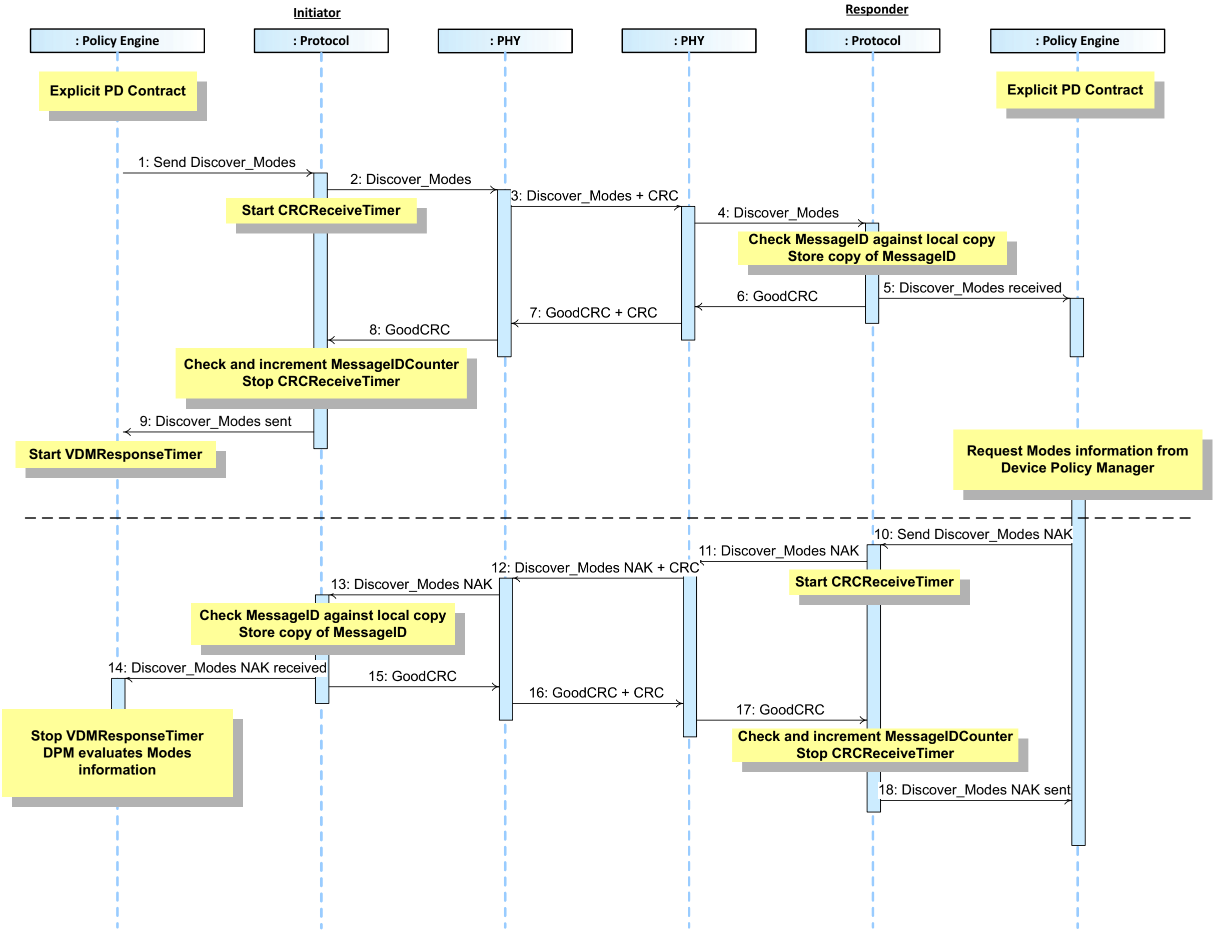


Table 8.136, "Steps for DFP to UFP Discover Modes (NAK)" below provides a detailed explanation of what happens at each labeled step in *Figure 8.109, "Initiator to Responder Discover Modes (NAK)"*.

Table 8.136 Steps for DFP to UFP Discover Modes (NAK)

Step	DFP	UFP
1	The *DFP* has an *Explicit Contract*. The *Policy Engine* directs the *Protocol Layer* to send a ***Discover Modes*** *Command* request.	The *UFP* has an *Explicit Contract*.
2	*Protocol Layer* creates the ***Discover Modes*** *Command* request and passes to *PHY Layer*.	
3	*PHY Layer* appends *CRC* and sends the ***Discover Modes*** *Command* request. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the ***Discover Modes*** *Command* request and checks the *CRC* to verify the *Message*.
4		*PHY Layer* removes the *CRC* and forwards the ***Discover Modes*** *Command* request to the *Protocol Layer*.
5		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Discover Modes*** *Command* request information to the *Policy Engine* that consumes it.
6		*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.
7	*PHY Layer* receives the ***GoodCRC*** *Message* and checks the *CRC* to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.
8	*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.	
9	*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Discover Modes*** *Command* request was successfully sent. *Policy Engine* starts the ***VDMResponseTimer***.	
10		*Policy Engine* requests the identity information from the *DPM*. The *Policy Engine* tells the *Protocol Layer* to form a ***Discover Modes*** *Command* ***NAK*** response.
11		*Protocol Layer* creates the ***Discover Modes*** *Command* ***NAK*** response and passes to *PHY Layer*.
12	*PHY Layer* receives the ***Discover Modes*** *Command* ***NAK*** response and compares the *CRC* it calculated with the one sent to verify the *Message*.	*PHY Layer* appends a *CRC* and sends the ***Discover Modes*** *Command* ***NAK*** response. Starts ***CRCReceiveTimer.***
13	*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Discover Modes*** *Command* ***NAK*** response information to the *Policy Engine* that consumes it.	
14	The *Policy Engine* stops the ***VDMResponseTimer*** and passed the Identity information to the *DPM* for evaluation.	
15	*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.	

Table 8.136 Steps for DFP to UFP Discover Modes (NAK)

Step	DFP	UFP
16	*PHY Layer* appends a *CRC* and sends the ***GoodCRC*** *Message*.	*PHY Layer* receives ***GoodCRC*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
17		*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.
18		*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Discover Modes*** *Command* ***NAK*** response was successfully sent.

8.3.2.14.3.3 Initiator to Responder Discover Modes (BUSY)

Figure 8.110, "Initiator to Responder Discover Modes (BUSY)" shows an example sequence between an *Initiator* and *Responder*, where both *Port Partner*s are in an *Explicit Contract* and the *Initiator* attempts to discover Mode information from the *Responder* but receives a ***BUSY***.

Figure 8.110 Initiator to Responder Discover Modes (BUSY)

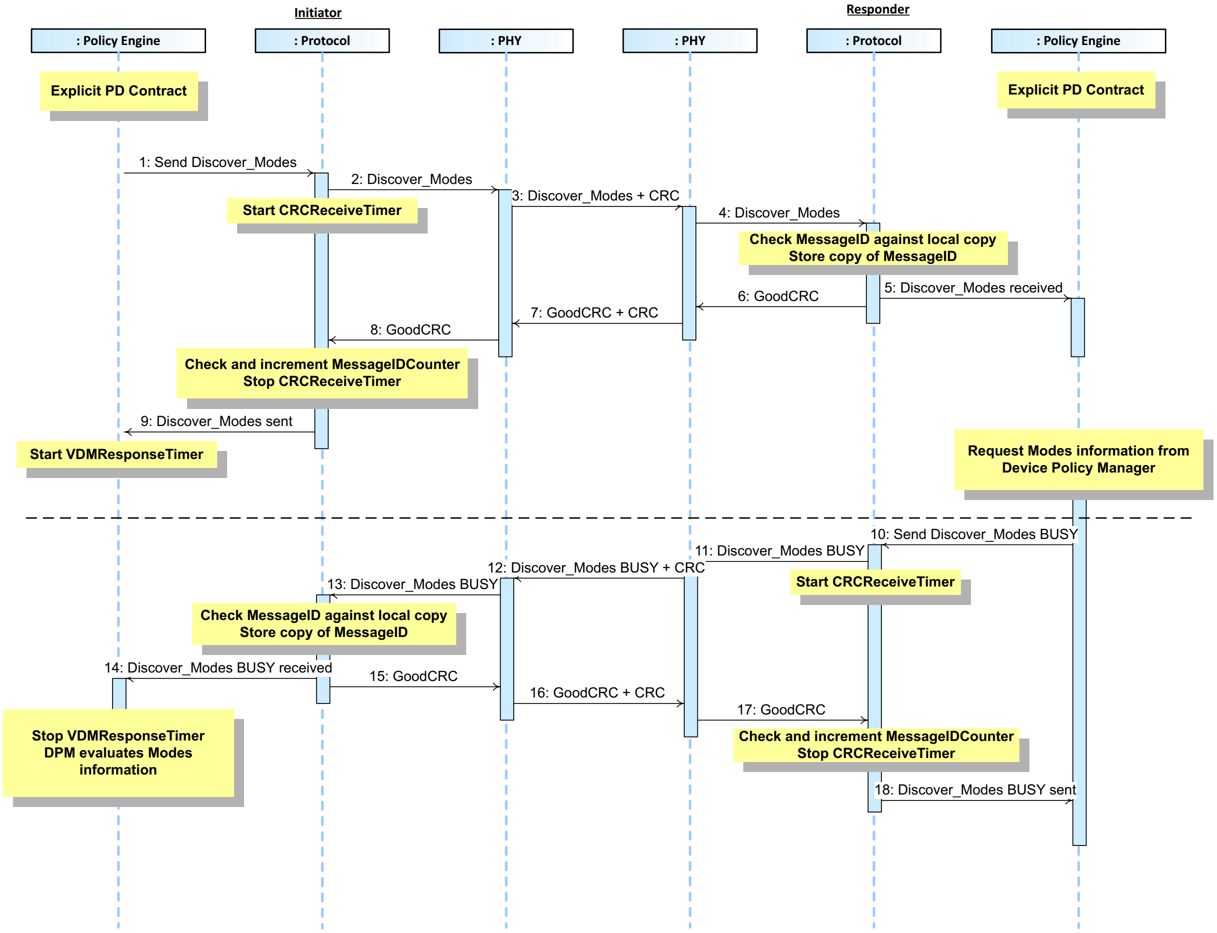


Table 8.137, "Steps for DFP to UFP Discover Modes (BUSY)" below provides a detailed explanation of what happens at each labeled step in *Figure 8.110, "Initiator to Responder Discover Modes (BUSY)"*.

Table 8.137 Steps for DFP to UFP Discover Modes (BUSY)

Step	DFP	UFP
1	The *DFP* has an *Explicit Contract*. The *Policy Engine* directs the *Protocol Layer* to send a ***Discover Modes*** *Command* request.	The *UFP* has an *Explicit Contract*.
2	*Protocol Layer* creates the ***Discover Modes*** *Command* request and passes to *PHY Layer*.	
3	*PHY Layer* appends *CRC* and sends the ***Discover Modes*** *Command* request. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the ***Discover Modes*** *Command* request and checks the *CRC* to verify the *Message*.
4		*PHY Layer* removes the *CRC* and forwards the ***Discover Modes*** *Command* request to the *Protocol Layer*.
5		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Discover Modes*** *Command* request information to the *Policy Engine* that consumes it.
6		*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.
7	*PHY Layer* receives the ***GoodCRC*** *Message* and checks the *CRC* to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.
8	*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.	
9	*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Discover Modes*** *Command* request was successfully sent. *Policy Engine* starts the ***VDMResponseTimer***.	
10		*Policy Engine* requests the identity information from the *DPM*. The *Policy Engine* tells the *Protocol Layer* to form a ***Discover Modes*** *Command* ***NAK*** response.
11		*Protocol Layer* creates the ***Discover Modes*** *Command* ***NAK*** response and passes to *PHY Layer*.
12	*PHY Layer* receives the ***Discover Modes*** *Command* ***NAK*** response and compares the *CRC* it calculated with the one sent to verify the *Message*.	*PHY Layer* appends a *CRC* and sends the ***Discover Modes*** *Command* ***NAK*** response. Starts ***CRCReceiveTimer***.
13	*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Discover Modes*** *Command* ***NAK*** response information to the *Policy Engine* that consumes it.	
14	The *Policy Engine* stops the ***VDMResponseTimer*** and passed the Identity information to the *DPM* for evaluation.	
15	*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.	

Table 8.137 Steps for DFP to UFP Discover Modes (BUSY)

Step	DFP	UFP
16	*PHY Layer* appends a *CRC* and sends the ***GoodCRC*** *Message*.	*PHY Layer* receives ***GoodCRC*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
17		*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.
18		*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Discover Modes*** *Command* ***NAK*** response was successfully sent.

8.3.2.14.4 Enter/Exit Mode

8.3.2.14.4.1 DFP to UFP Enter Mode

Figure 8.111, "DFP to UFP Enter Mode" shows an example sequence between a *DFP* and a *UFP* that occurs after the *DFP* has discovered supported *SVIDs* and Modes at which point it selects and enters a Mode.

Figure 8.111 DFP to UFP Enter Mode

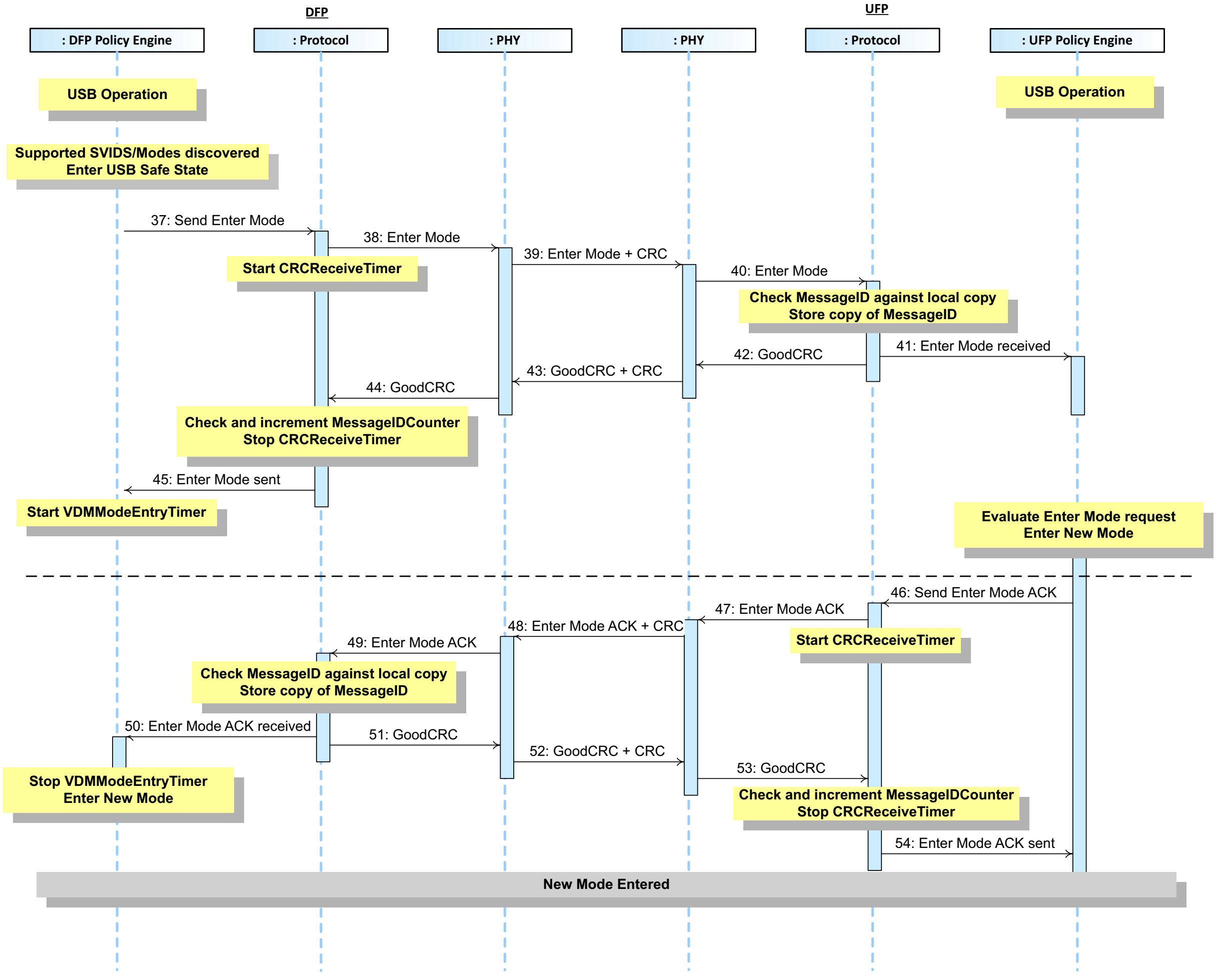


Table 8.138, "Steps for DFP to UFP Enter Mode" below provides a detailed explanation of what happens at each labeled step in *Figure 8.111, "DFP to UFP Enter Mode"* above.

Table 8.138 Steps for DFP to UFP Enter Mode

Step	DFP	UFP
1	The *DFP* has an *Explicit Contract* The *DFP* has discovered the supported *SVIDS* using the ***Discover SVIDs*** *Command* request and the supported Modes using the ***Discover Modes*** *Command* request The *DFP* goes to *USB Safe State*. The *DPM* requests the *Policy Engine* to enter a Mode. The *Policy Engine* directs the *Protocol Layer* to send an ***Enter Mode*** *Command* request.	The *UFP* has an *Explicit Contract*.
2	*Protocol Layer* creates the ***Enter Mode*** *Command* request and passes to *PHY Layer*.	
3	*PHY Layer* appends *CRC* and sends the ***Enter Mode*** *Command* request. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the ***Enter Mode*** *Command* request and checks the *CRC* to verify the *Message*.
4		*PHY Layer* removes the *CRC* and forwards the ***Enter Mode*** *Command* request to the *Protocol Layer*.
5		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Enter Mode*** *Command* request information to the *Policy Engine* that consumes it.
6		*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.
7	*PHY Layer* receives the ***GoodCRC*** *Message* and checks the *CRC* to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.
8	*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.	
9	*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Enter Mode*** *Command* request was successfully sent. *Policy Engine* starts the ***VDMModeEntryTimer***.	
10		*Policy Engine* requests the *DPM* to enter the new Mode. The *Policy Engine* tells the *Protocol Layer* to form an ***Enter Mode*** *Command* ***ACK*** response.
11		*Protocol Layer* creates the ***Enter Mode*** *Command* ***ACK*** response and passes to *PHY Layer*.
12	*PHY Layer* receives the ***Enter Mode*** *Command* ***ACK*** response and compares the *CRC* it calculated with the one sent to verify the *Message*.	*PHY Layer* appends a *CRC* and sends the ***Enter Mode*** *Command* ***ACK*** response. Starts ***CRCReceiveTimer***.
13	*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Enter Mode*** *Command* ***ACK*** response information to the *Policy Engine* that consumes it.	
14	The *Policy Engine* stops the ***VDMModeEntryTimer*** and requests the *DPM* to enter the new Mode.	

Table 8.138 Steps for DFP to UFP Enter Mode

Step	DFP	UFP
15	*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.	
16	*PHY Layer* appends a *CRC* and sends the ***GoodCRC*** *Message*.	*PHY Layer* receives ***GoodCRC*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
17		*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.
18		*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Enter Mode*** *Command* ***ACK*** response was successfully sent.
DFP and *UFP* are operating in the new Mode		

8.3.2.14.4.2 DFP to UFP Exit Mode

Figure 8.112, "DFP to UFP Exit Mode" shows an example sequence between a *DFP* and a *UFP*, where the *DFP* commands the *UFP* to exit the only *Active Mode*.

Figure 8.112 DFP to UFP Exit Mode

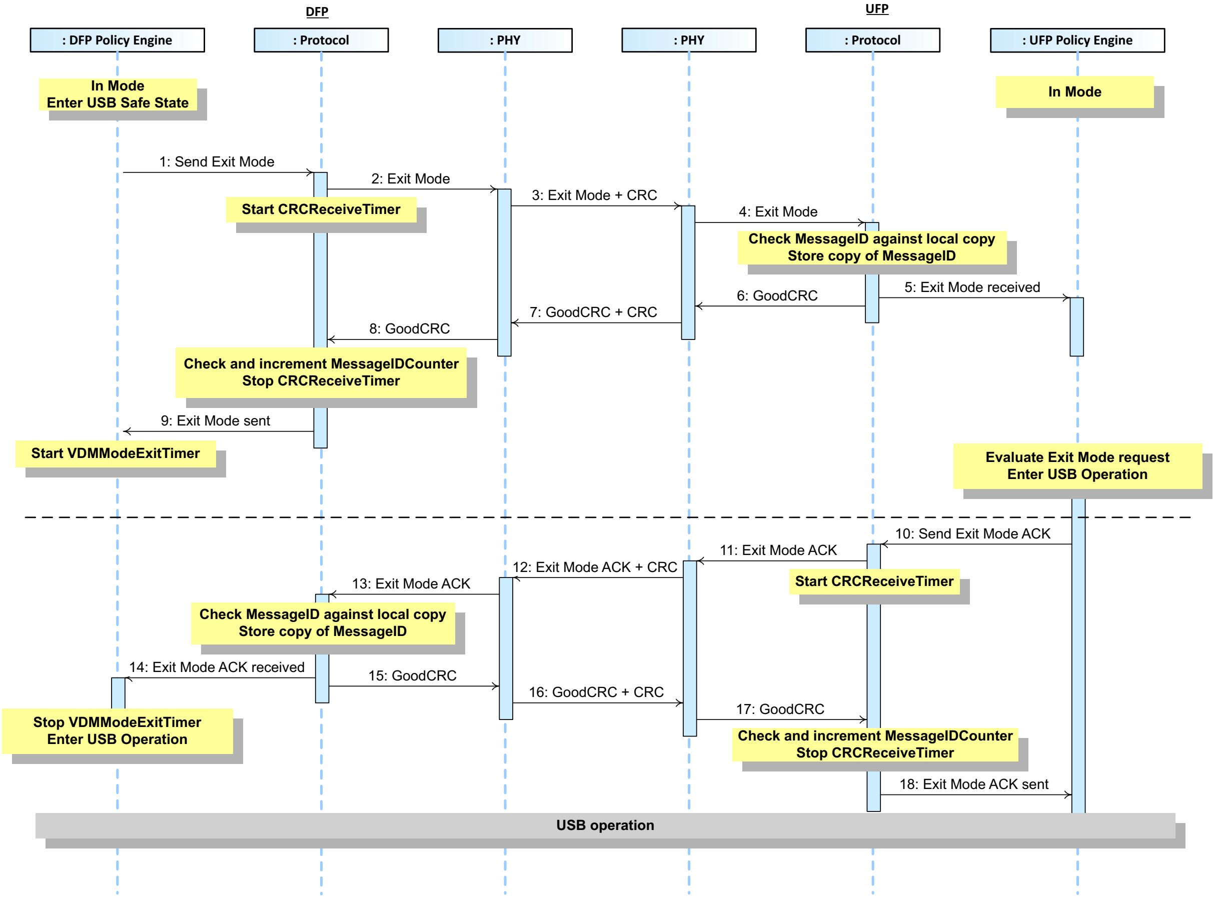


Table 8.139, "Steps for DFP to UFP Exit Mode" below provides a detailed explanation of what happens at each labeled step in *Figure 8.112, "DFP to UFP Exit Mode"* above.

Table 8.139 Steps for DFP to UFP Exit Mode

Step	DFP	UFP
1	The *DFP* is in a Mode and then enters *USB Safe State*. The *Policy Engine* directs the *Protocol Layer* to send an ***Exit Mode*** *Command* request.	The *UFP* is in a Mode.
2	*Protocol Layer* creates the ***Exit Mode*** *Command* request and passes to *PHY Layer*.	
3	*PHY Layer* appends *CRC* and sends the ***Exit Mode*** *Command* request. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the ***Exit Mode*** *Command* request and checks the *CRC* to verify the *Message*.
4		*PHY Layer* removes the *CRC* and forwards the ***Exit Mode*** *Command* request to the *Protocol Layer*.
5		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Exit Mode*** *Command* request information to the *Policy Engine* that consumes it.
6		*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.
7	*PHY Layer* receives the ***GoodCRC*** *Message* and checks the *CRC* to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.
8	*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.	
9	*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Exit Mode*** *Command* request was successfully sent. *Policy Engine* starts the ***VDMModeExitTimer***.	
10		*Policy Engine* requests the *DPM* to enter USB operation. The *Policy Engine* tells the *Protocol Layer* to form an ***Exit Mode*** *Command* ***ACK*** response.
11		*Protocol Layer* creates the ***Exit Mode*** *Command* ***ACK*** response and passes to *PHY Layer*.
12	*PHY Layer* receives the ***Exit Mode*** *Command* ***ACK*** response and compares the *CRC* it calculated with the one sent to verify the *Message*.	*PHY Layer* appends a *CRC* and sends the ***Exit Mode*** *Command* ***ACK*** response. Starts ***CRCReceiveTimer***.
13	*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Exit Mode*** *Command* ***ACK*** response information to the *Policy Engine* that consumes it.	
14	The *Policy Engine* stops the ***VDMModeExitTimer*** and requests the *DPM* to enter USB Operation.	
15	*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.	
16	*PHY Layer* appends a *CRC* and sends the ***GoodCRC*** *Message*.	*PHY Layer* receives ***GoodCRC*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.

Table 8.139 Steps for DFP to UFP Exit Mode

Step	DFP	UFP
17		*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.
18		*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Exit Mode*** *Command* ***ACK*** response was successfully sent.
Both *DFP* and *UFP* are in USB Operation		

8.3.2.14.4.3 DFP to Cable Plug Enter Mode

Figure 8.113, "DFP to Cable Plug Enter Mode" shows an example sequence between a *DFP* and a *Cable Plug* that occurs after the *DFP* has discovered supported *SVID*s and Modes at which point it selects and enters a Mode.

Figure 8.113 DFP to Cable Plug Enter Mode

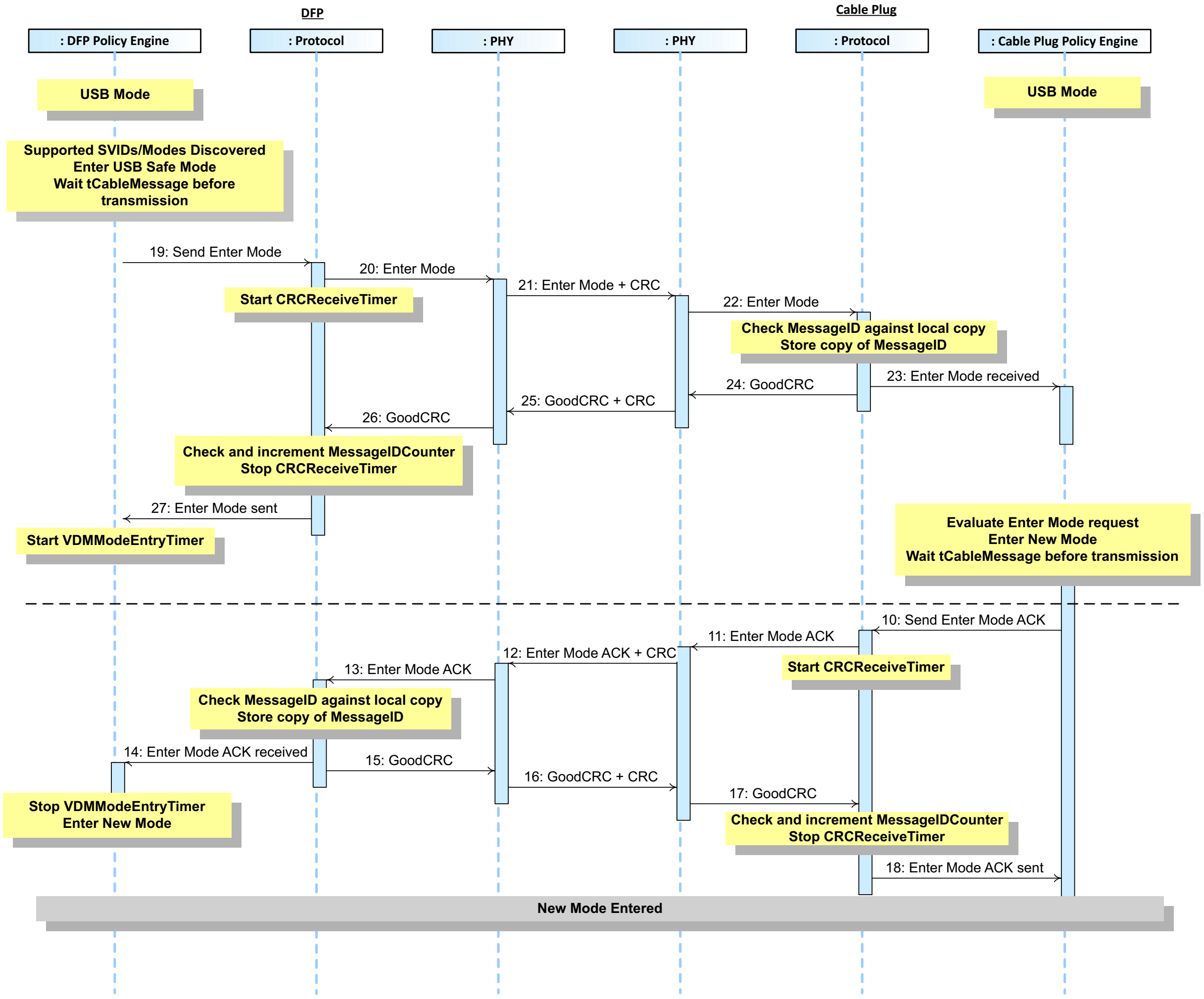


Table 8.140, "Steps for DFP to Cable Plug Enter Mode" below provides a detailed explanation of what happens at each labeled step in *Figure 8.113, "DFP to Cable Plug Enter Mode"* above.

Table 8.140 Steps for DFP to Cable Plug Enter Mode

Step	DFP	Cable Plug
1	The *DFP* has an *Explicit Contract* The *DFP* has discovered the supported *SVIDS* using the ***Discover SVIDs*** *Command* request and the supported Modes using the ***Discover Modes*** *Command* request The *DFP* goes to *USB Safe State*. The *DPM* requests the *Policy Engine* to enter a Mode. ***tCableMessage*** after the last ***GoodCRC*** *Message* was sent the *Policy Engine* directs the *Protocol Layer* to send an ***Enter Mode*** *Command* request.	
2	*Protocol Layer* creates the ***Enter Mode*** *Command* request and passes to *PHY Layer*.	
3	*PHY Layer* appends *CRC* and sends the ***Enter Mode*** *Command* request. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the ***Enter Mode*** *Command* request and checks the *CRC* to verify the *Message*.
4		*PHY Layer* removes the *CRC* and forwards the ***Enter Mode*** *Command* request to the *Protocol Layer*.
5		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Enter Mode*** *Command* request information to the *Policy Engine* that consumes it.
6		*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.
7	*PHY Layer* receives the ***GoodCRC*** *Message* and checks the *CRC* to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.
8	*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.	
9	*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Enter Mode*** *Command* request was successfully sent. *Policy Engine* starts the ***VDMModeEntryTimer***.	
10		*Policy Engine* requests the *DPM* to enter the new Mode. ***tCableMessage*** after the ***GoodCRC*** *Message* was sent the *Policy Engine* tells the *Protocol Layer* to form an ***Enter Mode*** *Command* ***ACK*** response.
11		*Protocol Layer* creates the ***Enter Mode*** *Command* ***ACK*** response and passes to *PHY Layer*.
12	*PHY Layer* receives the ***Enter Mode*** *Command* ***ACK*** response and compares the *CRC* it calculated with the one sent to verify the *Message*.	*PHY Layer* appends a *CRC* and sends the ***Enter Mode*** *Command* ***ACK*** response. Starts ***CRCReceiveTimer***.
13	*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Enter Mode*** *Command* ***ACK*** response information to the *Policy Engine* that consumes it.	

Table 8.140 Steps for DFP to Cable Plug Enter Mode

Step	DFP	Cable Plug
14	The *Policy Engine* stops the ***VDMModeEntryTimer*** and requests the *DPM* to enter the new Mode.	
15	*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.	
16	*PHY Layer* appends a *CRC* and sends the ***GoodCRC*** *Message*.	*PHY Layer* receives ***GoodCRC*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
17		*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.
18		*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Enter Mode*** *Command* ***ACK*** response was successfully sent.
DFP and *Cable Plug* are operating in the new Mode		

8.3.2.14.4.4 DFP to Cable Plug Exit Mode

Figure 8.114, "DFP to Cable Plug Exit Mode" shows an example sequence between a *USB Type-C*® *DFP* and a *Cable Plug*, where the *DFP* commands the *Cable Plug* to exit an *Active Mode*.

Figure 8.114 DFP to Cable Plug Exit Mode

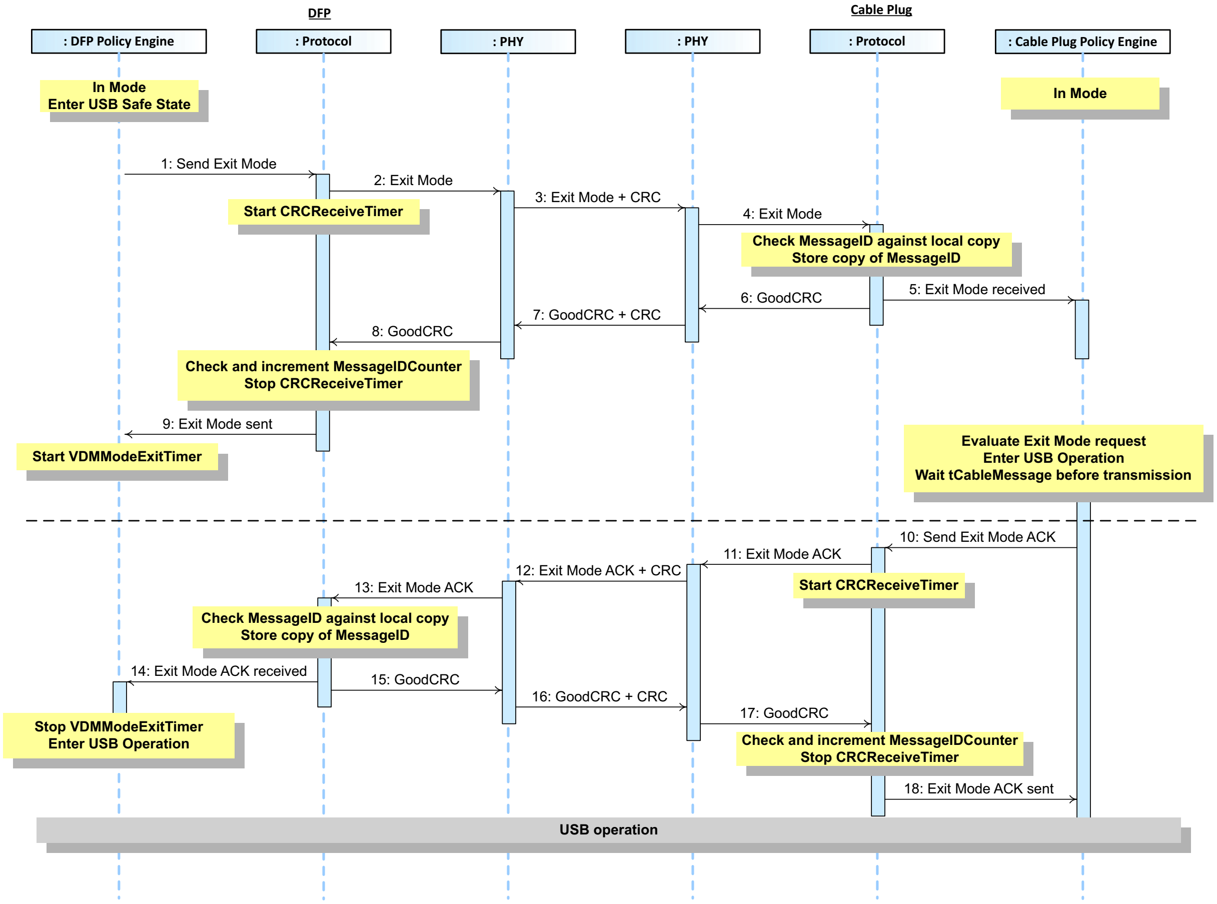


Table 8.141, "Steps for DFP to Cable Plug Exit Mode" below provides a detailed explanation of what happens at each labeled step in *Figure 8.114, "DFP to Cable Plug Exit Mode"* above.

Table 8.141 Steps for DFP to Cable Plug Exit Mode

Step	DFP	Cable Plug
1	The *DFP* is in a Mode and then enters *USB Safe State*. The *Policy Engine* directs the *Protocol Layer* to send an ***Exit Mode*** *Command* request.	The *Cable Plug* is in a Mode.
2	*Protocol Layer* creates the ***Exit Mode*** *Command* request and passes to *PHY Layer*.	
3	*PHY Layer* appends *CRC* and sends the ***Exit Mode*** *Command* request. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the ***Exit Mode*** *Command* request and checks the *CRC* to verify the *Message*.
4		*PHY Layer* removes the *CRC* and forwards the ***Exit Mode*** *Command* request to the *Protocol Layer*.
5		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Exit Mode*** *Command* request information to the *Policy Engine* that consumes it.
6		*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.
7	*PHY Layer* receives the ***GoodCRC*** *Message* and checks the *CRC* to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.
8	*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.	
9	*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Exit Mode*** *Command* request was successfully sent. *Policy Engine* starts the ***VDMModeExitTimer***.	
10		*Policy Engine* requests the *DPM* to enter USB operation. ***tCableMessage*** after the ***GoodCRC*** *Message* was sent the *Policy Engine* tells the *Protocol Layer* to form an ***Exit Mode*** *Command* ***ACK*** response.
11		*Protocol Layer* creates the ***Exit Mode*** *Command* ***ACK*** response and passes to *PHY Layer*.
12	*PHY Layer* receives the ***Exit Mode*** *Command* ***ACK*** response and compares the *CRC* it calculated with the one sent to verify the *Message*.	*PHY Layer* appends a *CRC* and sends the ***Exit Mode*** *Command* ***ACK*** response. Starts ***CRCReceiveTimer***.
13	*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Exit Mode*** *Command* ***ACK*** response information to the *Policy Engine* that consumes it.	
14	The *Policy Engine* stops the ***VDMModeExitTimer*** and requests the *DPM* to enter USB Operation.	
15	*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.	

Table 8.141 Steps for DFP to Cable Plug Exit Mode

Step	DFP	Cable Plug
16	*PHY Layer* appends a *CRC* and sends the ***GoodCRC*** *Message*.	*PHY Layer* receives ***GoodCRC*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
17		*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.
18		*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Exit Mode*** *Command* ***ACK*** response was successfully sent.
Both *DFP* and *Cable Plug* are in USB Operation		

8.3.2.14.4.5 Initiator to Responder Attention

Figure 8.115, "Initiator to Responder Attention" shows an example sequence between an *Initiator* and a *Responder*, where the *Initiator* requests attention from the *Responder*.

Figure 8.115 Initiator to Responder Attention

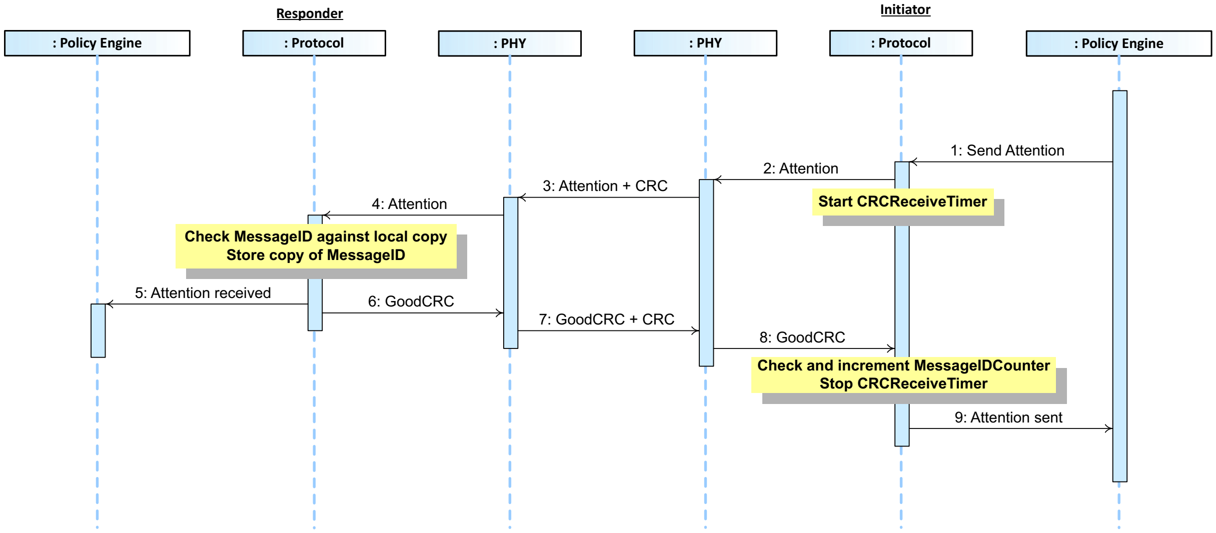


Table 8.142, "Steps for Initiator to Responder Attention" below provides a detailed explanation of what happens at each labeled step in *Figure 8.115, "Initiator to Responder Attention"* above.

Table 8.142 Steps for Initiator to Responder Attention

Step	Responder	Initiator
1		The *DPM* requests attention. The *Policy Engine* tells the *Protocol Layer* to form an ***Attention*** *Command* request.
2		*Protocol Layer* creates the ***Attention*** *Command* request and passes to *PHY Layer*.
3	*PHY Layer* receives the ***Attention*** *Command* request and compares the *CRC* it calculated with the one sent to verify the *Message*.	*PHY Layer* appends a *CRC* and sends the ***Attention*** *Command* request. Starts ***CRCReceiveTimer***.
4	*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Attention*** *Command* request information to the *Policy Engine* that consumes it.	
5	The *Policy Engine* informs the *DPM*	
6	*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.	
7	*PHY Layer* appends a *CRC* and sends the ***GoodCRC*** *Message*.	*PHY Layer* receives ***GoodCRC*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
8		*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.
9		*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Attention*** *Command* request was successfully sent.

8.3.2.15 Built in Self-Test (BIST)

8.3.2.15.1 BIST Carrier Mode

The following is an example of a *BIST Carrier Mode* test between a *Tester* and a *UUT*. When the *UUT* is connected to the *Tester* the sequence below is executed.

Figure 8.116, "BIST Carrier Mode Test" shows the *Messages* as they flow across the bus and within the devices. This test enables the measurement of power supply noise and frequency drift.

1) Connection is established and stable.
2) *Tester* sends a ***BIST*** *Message* with a ***BIST Carrier Mode*** *BIST Data Object*.
3) *UUT* answers with a ***GoodCRC*** *Message*.
4) *UUT* starts sending the *Test Pattern*.
5) Operator does the measurements.
6) The test ends after ***tBISTContMode***.

See also *Section 5.9.1, "BIST Carrier Mode"* and *Section 6.4.3.1, "BIST Carrier Mode"*.

Figure 8.116 BIST Carrier Mode Test

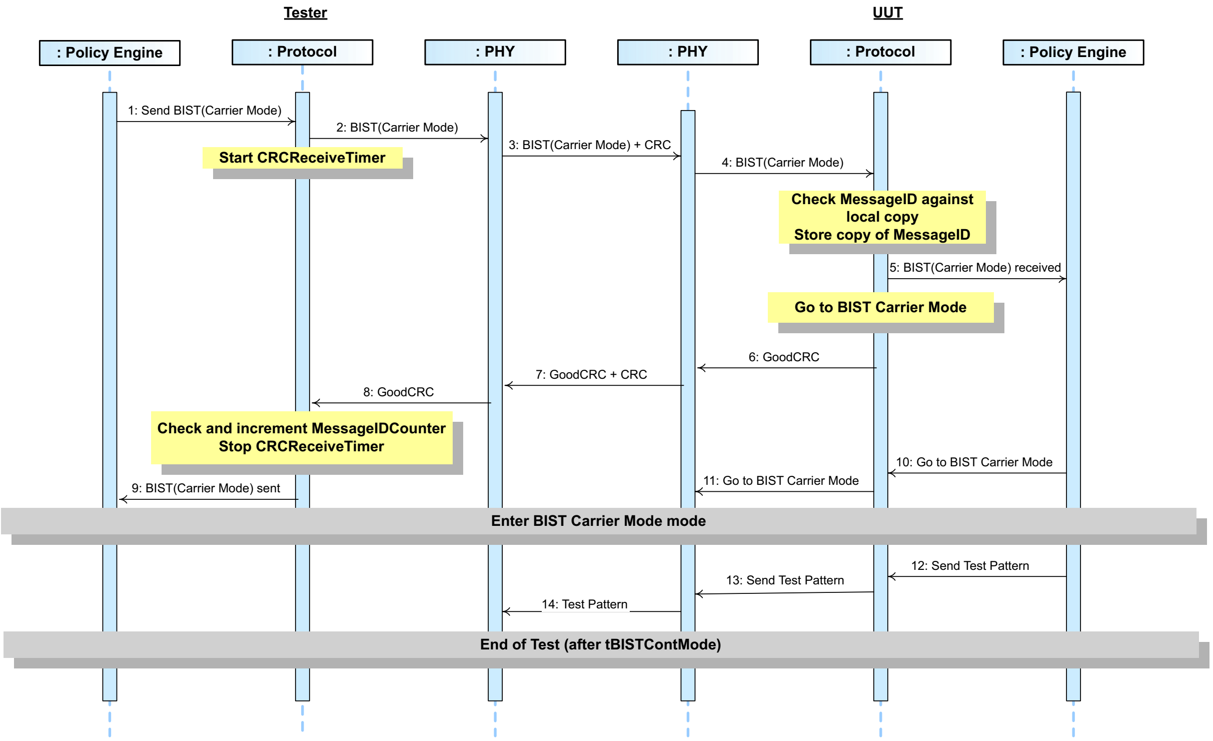

Tester
UUT
: Policy Engine
: Protocol
: PHY
: PHY
: Protocol
: Policy Engine
1: Send BIST(Carrier Mode)
2: BIST(Carrier Mode)
3: BIST(Carrier Mode) + CRC
Start CRCReceiveTimer
4: BIST(Carrier Mode)
Check MessageID against local copy
Store copy of MessageID
5: BIST(Carrier Mode) received
Go to BIST Carrier Mode
6: GoodCRC
7: GoodCRC + CRC
8: GoodCRC
Check and increment MessageIDCounter
Stop CRCReceiveTimer
10: Go to BIST Carrier Mode
11: Go to BIST Carrier Mode
9: BIST(Carrier Mode) sent
Enter BIST Carrier Mode mode
12: Send Test Pattern
13: Send Test Pattern
14: Test Pattern
End of Test (after tBISTContMode)

Table 8.143, "Steps for BIST Carrier Mode Test" below provides a detailed explanation of what happens at each labeled step in *Figure 8.116, "BIST Carrier Mode Test"* above.

Table 8.143 Steps for BIST Carrier Mode Test

Step	Tester	UUT
1	The *Policy Engine* directs the *Protocol Layer* to generate a ***BIST*** *Message*, with a *BIST Data Object* of ***BIST Carrier Mode***, to put the *UUT* into *BIST Carrier Mode*.	
2	*Protocol Layer* creates the *Message* and passes to *PHY Layer*.	
3	*PHY Layer* appends *CRC* and sends the ***BIST*** *Message*. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the ***BIST*** *Message* and checks the *CRC* to verify the *Message*.
4		*PHY Layer* removes the *CRC* and forwards the ***BIST*** *Message* to the *Protocol Layer*.
5		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***BIST*** *Message* information to the *Policy Engine* that consumes it.
6		*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.
7	*PHY Layer* receives the ***GoodCRC*** and checks the *CRC* to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.
8	*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.	
9	*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***BIST*** *Message* was successfully sent.	
10		*Policy Engine* tells *Protocol Layer* to go into *BIST Carrier Mode*. The *Policy Engine* goes to *BIST Carrier Mode*.
11		*Protocol Layer* tells *PHY Layer* to go into *BIST Carrier Mode*.
	UUT enters *BIST Carrier Mode*.	
12		The *Policy Engine* directs the *Protocol Layer* to start generation of the *Test Pattern*.
13		*Protocol Layer* directs the *PHY Layer* to generate the *Test Pattern*.
14	*PHY Layer* receives the *Test Pattern* stream.	*PHY Layer* generates a continuous *Test Pattern* stream.
	The *UUT* exits *BIST Carrier Mode* after ***tBISTContMode***.	

8.3.2.15.2 BIST Test Data Mode

The following is an example of a *BIST Test Data Mode* test between a *Tester* and a *UUT*. When the *UUT* is connected to the *Tester* the sequence below is executed.

Figure 8.117, "BIST Test Data Test" shows the *Message*s as they flow across the bus and within the devices.

1) Connection is established and stable.

2) *Tester* sends a ***BIST*** *Message* with a ***BIST Test Data*** *BIST Data Object*.

3) *UUT* answers with a ***GoodCRC*** *Message*.

4) Steps 2and 3 are repeated any number of times.

5) The test ends after ***Hard Reset*** *Signaling* is issued.

See also *Section 5.9.2, "BIST Test Data Mode"* and *Section 6.4.3.2, "BIST Test Data Mode"*.

Figure 8.117 BIST Test Data Test

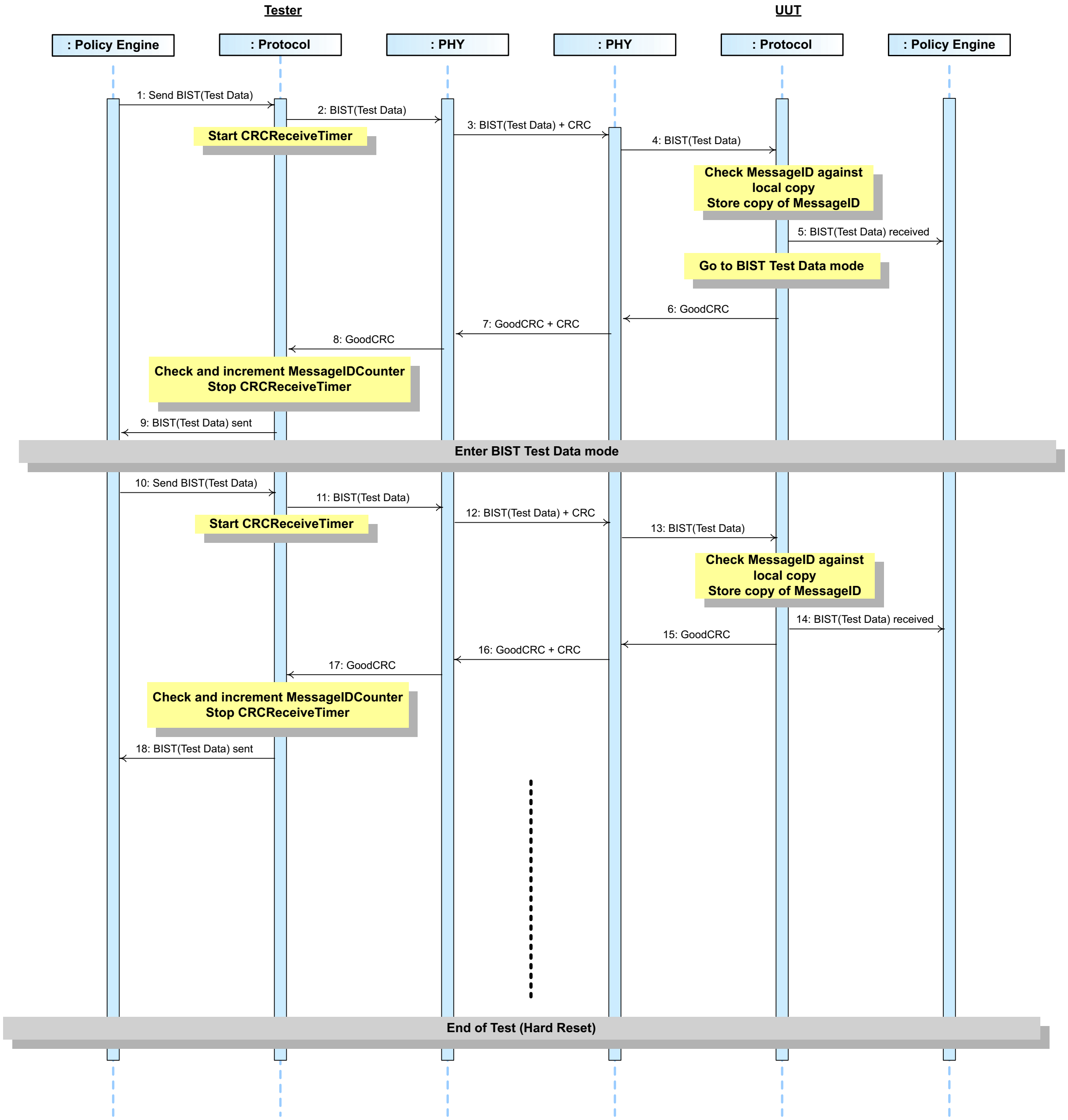


Table 8.144, "Steps for BIST Test Data Test" below provides a detailed explanation of what happens at each labeled step in *Figure 8.117, "BIST Test Data Test"* above.

Table 8.144 Steps for BIST Test Data Test

Step	Tester	UUT
1	The *Policy Engine* directs the *Protocol Layer* to generate a ***BIST*** *Message*, with a *BIST Data Object* of ***BIST Test Data***, to put the *UUT* into *BIST Test Data Mode*.	
2	*Protocol Layer* creates the *Message* and passes to *PHY Layer*.	
3	*PHY Layer* appends *CRC* and sends the ***BIST*** *Message*. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the ***BIST*** *Message* and checks the *CRC* to verify the *Message*.
4		*PHY Layer* removes the *CRC* and forwards the ***BIST*** *Message* to the *Protocol Layer*.
5		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***BIST*** *Message* information to the *Policy Engine* that consumes it. The *Policy Engine* goes into *BIST Test Data Mode* Mode where it sends no further *Messages* except for ***GoodCRC*** *Messages* in response to received *Messages* (see *Section 6.4.3.2, "BIST Test Data Mode"*).
6		*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.
7	*PHY Layer* receives the ***GoodCRC*** and checks the *CRC* to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.
8	*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.	
9	*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***BIST*** *Message* was successfully sent.	
	UUT enters *BIST Test Data Mode*.	
10	The *Policy Engine* directs the *Protocol Layer* to generate a ***BIST*** *Message*, with a *BIST Data Object* of ***BIST Test Data***, to put the *UUT* into *BIST Test Data Mode*.	
11	*Protocol Layer* creates the *Message* and passes to *PHY Layer*.	
12	*PHY Layer* appends *CRC* and sends the ***BIST*** *Message*. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the ***BIST*** *Message* and checks the *CRC* to verify the *Message*.
13		*PHY Layer* removes the *CRC* and forwards the ***BIST*** *Message* to the *Protocol Layer*.

Table 8.144 Steps for BIST Test Data Test

Step	Tester	UUT
14		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***BIST*** *Message* information to the *Policy Engine* that consumes it. The *Policy Engine* goes into *BIST Test Data Mode* Mode where it sends no further *Messages* except for ***GoodCRC*** *Messages* in response to received *Messages* (see *Section 6.4.3.2, "BIST Test Data Mode"*).
15		*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.
16	*PHY Layer* receives the ***GoodCRC*** and checks the *CRC* to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.
17	*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.	
18	*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***BIST*** *Message* was successfully sent.	
	Repeat steps 10-18 any number of times	
The *UUT* exits *BIST Test Data Mode* after a *Hard Reset*		

8.3.2.15.3 BIST Shared Capacity Test Mode

The following is an example of a *BIST Shared Capacity Test Mode* test between a *Tester* and a *UUT*. When the *UUT* is connected to the *Tester* the sequence below is executed.

Figure 8.118, "BIST Share Capacity Mode Test" shows the *Messages* as they flow across the bus and within the devices. This test places the *UUT* in a compliance test mode where the maximum *Source* capability is always offered on every *Port*, regardless of the availability of shared power i.e., all shared power management is disabled.

1) Connection is established and stable.
2) *Tester* sends a ***BIST*** *Message* with a ***BIST Shared Test Mode Entry*** *BIST Data Object*.
3) *UUT* answers with a ***GoodCRC*** *Message*.
4) *UUT* enters *BIST Shared Capacity Test Mode*.
5) Operator does the measurements.
6) *Tester* sends a ***BIST*** *Message* with a ***BIST Shared Test Mode Exit*** *BIST Data Object*.
7) *UUT* answers with a ***GoodCRC*** *Message*.
8) *UUT* exits *BIST Shared Capacity Test Mode*.

See also *Section 5.9.1, "BIST Carrier Mode"* and *Section 6.4.3.3, "BIST Shared Capacity Test Mode"*.

Figure 8.118 BIST Share Capacity Mode Test

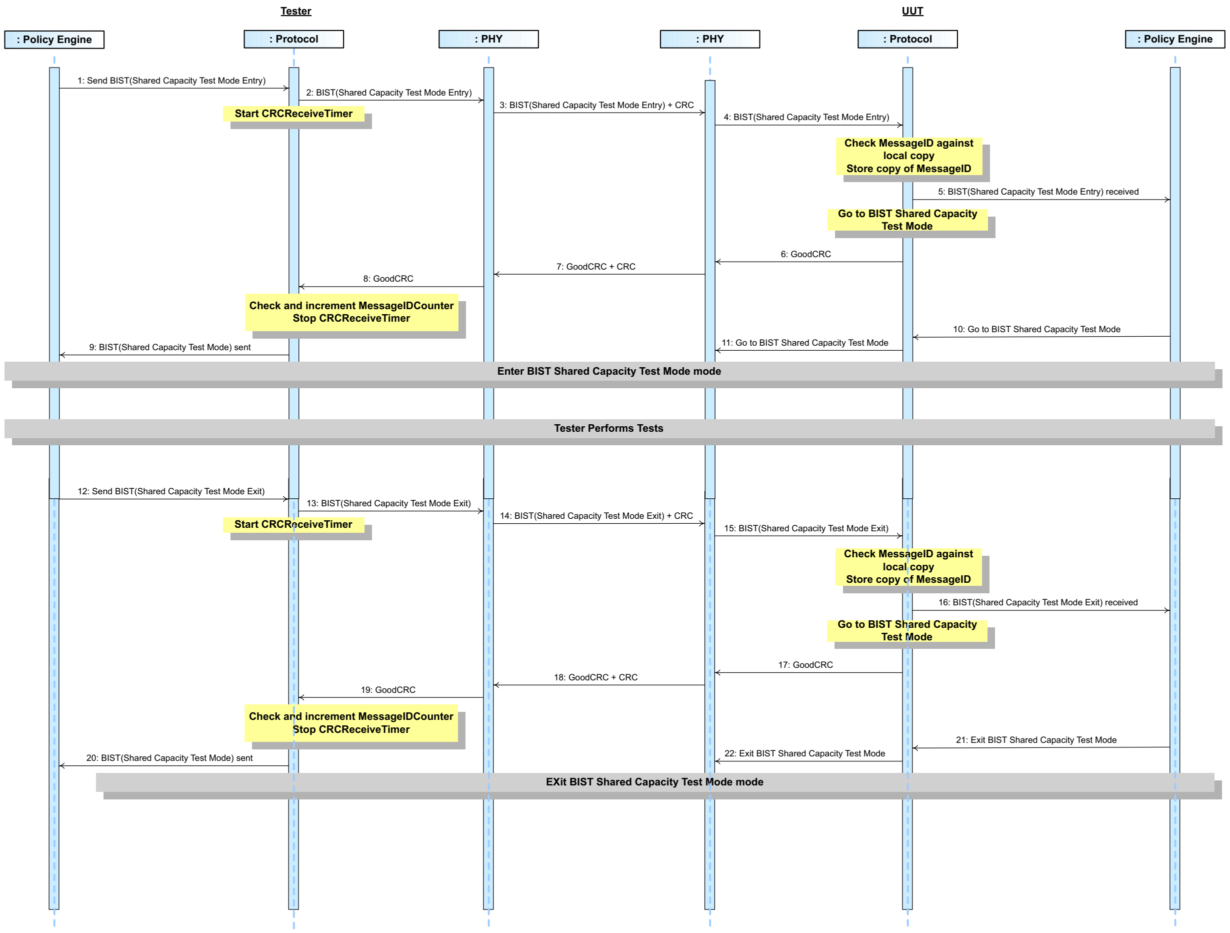

Tester
UUT
: Policy Engine
: Protocol
: PHY
: PHY
: Protocol
: Policy Engine
1: Send BIST(Shared Capacity Test Mode Entry)
2: BIST(Shared Capacity Test Mode Entry)
Start CRCReceiveTimer
3: BIST(Shared Capacity Test Mode Entry) + CRC
4: BIST(Shared Capacity Test Mode Entry)
Check MessageID against local copy
Store copy of MessageID
5: BIST(Shared Capacity Test Mode Entry) received
Go to BIST Shared Capacity Test Mode
6: GoodCRC
7: GoodCRC + CRC
8: GoodCRC
Check and increment MessageIDCounter
Stop CRCReceiveTimer
10: Go to BIST Shared Capacity Test Mode
11: Go to BIST Shared Capacity Test Mode
9: BIST(Shared Capacity Test Mode) sent
Enter BIST Shared Capacity Test Mode mode
Tester Performs Tests
12: Send BIST(Shared Capacity Test Mode Exit)
13: BIST(Shared Capacity Test Mode Exit)
Start CRCReceiveTimer
14: BIST(Shared Capacity Test Mode Exit) + CRC
15: BIST(Shared Capacity Test Mode Exit)
Check MessageID against local copy
Store copy of MessageID
16: BIST(Shared Capacity Test Mode Exit) received
Go to BIST Shared Capacity Test Mode
17: GoodCRC
18: GoodCRC + CRC
19: GoodCRC
Check and increment MessageIDCounter
Stop CRCReceiveTimer
21: Exit BIST Shared Capacity Test Mode
22: Exit BIST Shared Capacity Test Mode
20: BIST(Shared Capacity Test Mode) sent
EXit BIST Shared Capacity Test Mode mode

Table 8.145, "Steps for BIST Shared Capacity Test Mode Test" below provides a detailed explanation of what happens at each labeled step in *Figure 8.118, "BIST Share Capacity Mode Test"* above.

Table 8.145 Steps for BIST Shared Capacity Test Mode Test

Step	Tester	UUT
1	The *Policy Engine* directs the *Protocol Layer* to generate a ***BIST*** *Message*, with a *BIST Data Object* of ***BIST Shared Test Mode Entry***, to put the *UUT* into *BIST Shared Capacity Test Mode*.	
2	*Protocol Layer* creates the *Message* and passes to *PHY Layer*.	
3	*PHY Layer* appends *CRC* and sends the ***BIST*** *Message*. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the ***BIST*** *Message* and checks the *CRC* to verify the *Message*.
4		*PHY Layer* removes the *CRC* and forwards the ***BIST*** *Message* to the *Protocol Layer*.
5		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***BIST*** *Message* information to the *Policy Engine* that consumes it.
6		*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.
7	*PHY Layer* receives the ***GoodCRC*** and checks the *CRC* to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.
8	*PHY LayerPHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.	
9	*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***BIST*** *Message* was successfully sent.	
10		*Policy Engine* tells *Protocol Layer* to go into *BIST Shared Capacity Test Mode*. The *Policy Engine* goes to *BIST Shared Capacity Test Mode*.
11		*Protocol Layer* tells *PHY Layer* to go into *BIST Shared Capacity Test Mode*.
UUT enters *BIST Shared Capacity Test Mode*. *Tester* performs tests.		
12	The *Policy Engine* directs the *Protocol Layer* to generate a ***BIST*** *Message*, with a *BIST Data Object* of ***BIST Shared Test Mode Exit***, to take the *UUT* out of *BIST Shared Capacity Test Mode*.	
13	*Protocol Layer* creates the *Message* and passes to *PHY Layer*.	
14	*PHY Layer* appends *CRC* and sends the ***BIST*** *Message*. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the ***BIST*** *Message* and checks the *CRC* to verify the *Message*.
15		*PHY Layer* removes the *CRC* and forwards the ***BIST*** *Message* to the *Protocol Layer*.
16		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***BIST*** *Message* information to the *Policy Engine* that consumes it.

Table 8.145 Steps for BIST Shared Capacity Test Mode Test

Step	Tester	UUT
17		*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.
18	*PHY Layer* receives the ***GoodCRC*** and checks the *CRC* to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.
19	*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.	
20	*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***BIST*** *Message* was successfully sent.	
21		*Policy Engine* tells *Protocol Layer* to exit *BIST Shared Capacity Test Mode*. The *Policy Engine* exits to *BIST Shared Capacity Test Mode*.
22		*Protocol Layer* tells *PHY Layer* to exit *BIST Shared Capacity Test Mode*.
UUT exits *BIST Shared Capacity Test Mode*.		

8.3.2.16 Enter USB

8.3.2.16.1 UFP Entering USB4 Mode

8.3.2.16.1.1 UFP Entering USB4 Mode (Accept)

This is an example of an Enter USB operation where the *DFP* requests ***[USB4]*** mode when this is a ***Valid*** mode of operation for the *UFP*. *Figure 8.119, "UFP Entering USB4 Mode (Accept)"* shows the *Messages* as they flow across the bus and within the devices to accomplish the Enter USB process.

Figure 8.119 UFP Entering USB4 Mode (Accept)

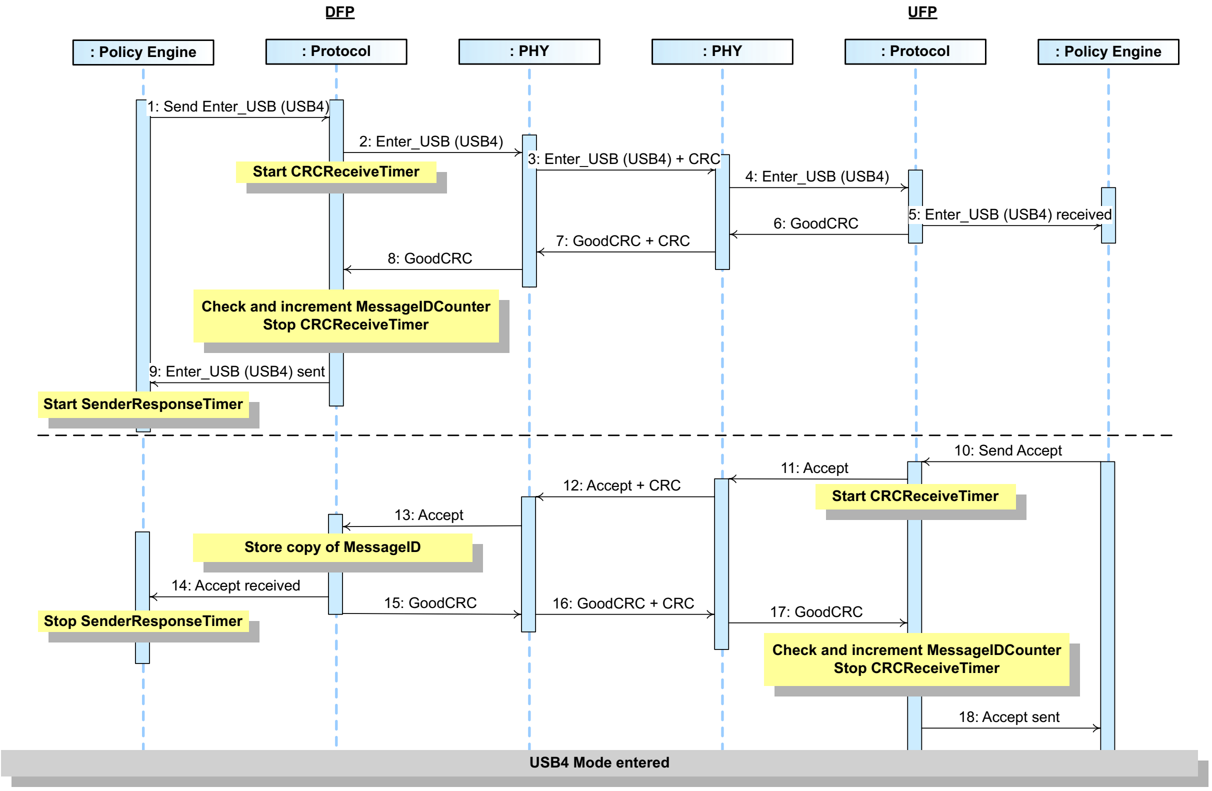


Table 8.146, "Steps for UFP USB4 Mode Entry (Accept)" below provides a detailed explanation of what happens at each labeled step in *Figure 8.119, "UFP Entering USB4 Mode (Accept)"* above.

Table 8.146 Steps for UFP USB4 Mode Entry (Accept)

Step	DFP	UFP
1	The *Policy Engine* directs the *Protocol Layer* to generate an ***Enter_USB*** *Message* to request entry to ***[USB4]*** mode.	
2	*Protocol Layer* creates the *Message* and passes to *PHY Layer*.	
3	*PHY Layer* appends *CRC* and sends the ***Enter_USB*** *Message*. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the ***Enter_USB*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
4		*PHY Layer* removes the *CRC* and forwards the ***Enter_USB*** *Message* to the *Protocol Layer*.
5		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Enter_USB*** *Message* information to the *Policy Engine* that consumes it.
6		*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.
7	*PHY Layer* receives the ***GoodCRC*** and checks the *CRC* to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.
8	*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.	
9	*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Enter_USB*** *Message* was successfully sent. *Policy Engine* starts ***SenderResponseTimer***.	
10		*Policy Engine* tells the *Protocol Layer* to form an ***Accept*** *Message*.
11		*Protocol Layer* creates the *Message* and passes to *PHY Layer*.
12	*PHY Layer* receives the *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.	*PHY Layer* appends a *CRC* and sends the *Message*. Starts ***CRCReceiveTimer***.
13	*Protocol Layer* stores the ***MessageID*** of the incoming *Message*.	
14	The *Protocol Layer* forwards the received ***Accept*** *Message* information to the *Policy Engine* that consumes it.	
15	*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.	
16	*PHY Layer* appends a *CRC* and sends the ***GoodCRC*** *Message*.	*PHY Layer* receives ***GoodCRC*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
17		*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.

Table 8.146 Steps for UFP USB4 Mode Entry (Accept)

Step	DFP	UFP
18		*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Accept*** *Message* was successfully sent.
Both *Port Partner*s enter ***[USB4]*** operation.		

8.3.2.16.1.2 UFP Entering USB4 Mode (Reject)

This is an example of an Enter USB operation where the *DFP* requests ***[USB4]*** mode when this is an ***Invalid*** mode of operation for the *UFP*. *Figure 8.120, "UFP Entering USB4 Mode (Reject)"* shows the *Messages* as they flow across the bus and within the devices to accomplish the Enter USB process.

Figure 8.120 UFP Entering USB4 Mode (Reject)

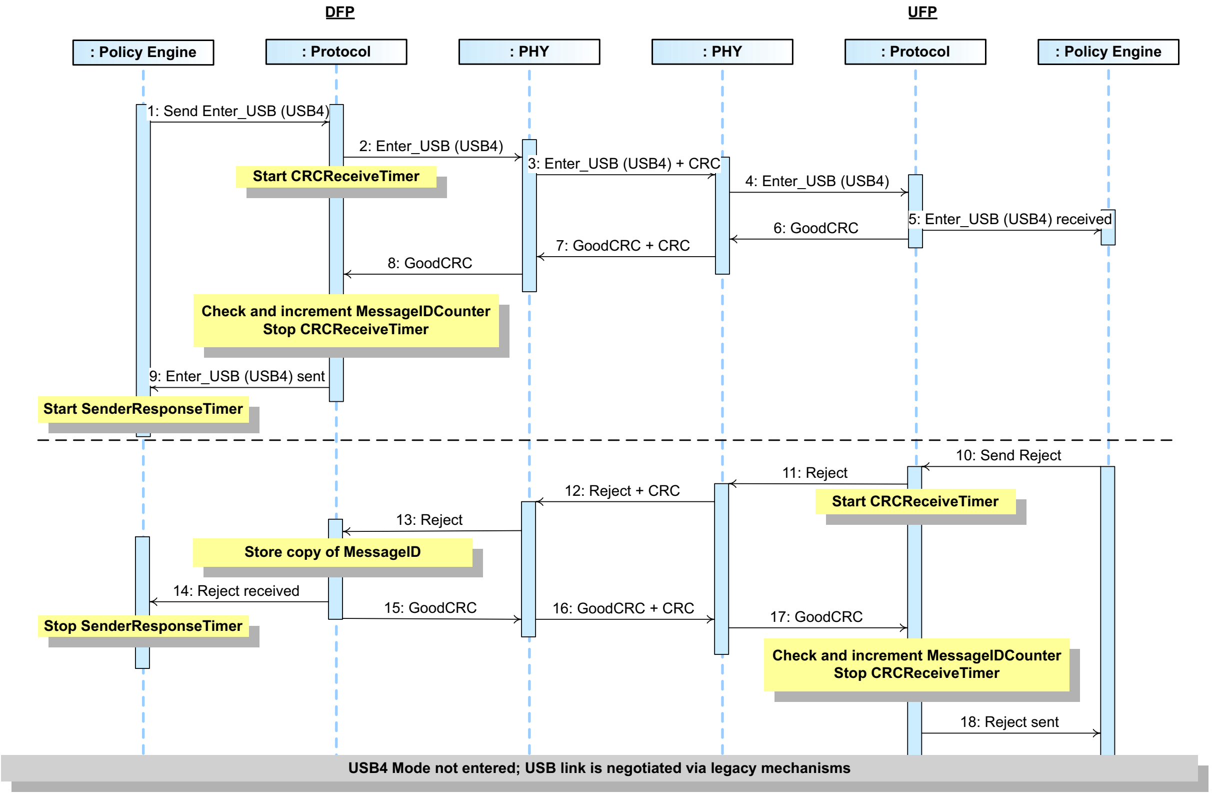


Table 8.147, "Steps for UFP USB4 Mode Entry (Reject)" below provides a detailed explanation of what happens at each labeled step in *Figure 8.120, "UFP Entering USB4 Mode (Reject)"* above.

Table 8.147 Steps for UFP USB4 Mode Entry (Reject)

Step	DFP	UFP
1	The *Policy Engine* directs the *Protocol Layer* to generate an ***Enter_USB*** *Message* to request entry to ***[USB4]*** mode.	
2	*Protocol Layer* creates the *Message* and passes to *PHY Layer*.	
3	*PHY Layer* appends *CRC* and sends the ***Enter_USB*** *Message*. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the ***Enter_USB*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
4		*PHY Layer* removes the *CRC* and forwards the ***Enter_USB*** *Message* to the *Protocol Layer*.
5		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Enter_USB*** *Message* information to the *Policy Engine* that consumes it.
6		*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.
7	*PHY Layer* receives the ***GoodCRC*** and checks the *CRC* to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.
8	*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.	
9	*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Enter_USB*** *Message* was successfully sent. *Policy Engine* starts ***SenderResponseTimer***.	
10		*Policy Engine* tells the *Protocol Layer* to form an ***Reject*** *Message*.
11		*Protocol Layer* creates the *Message* and passes to *PHY Layer*.
12	*PHY Layer* receives the *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.	*PHY Layer* appends a *CRC* and sends the *Message*. Starts ***CRCReceiveTimer***.
13	*Protocol Layer* stores the ***MessageID*** of the incoming *Message*.	
14	The *Protocol Layer* forwards the received ***Reject*** *Message* information to the *Policy Engine* that consumes it.	
15	*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.	
16	*PHY Layer* appends a *CRC* and sends the ***GoodCRC*** *Message*.	*PHY Layer* receives ***GoodCRC*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
17		*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.

Table 8.147 Steps for UFP USB4 Mode Entry (Reject)

Step	DFP	UFP
18		*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Reject*** *Message* was successfully sent.
Port Partners do not enter ***[USB4]*** operation.		

8.3.2.16.1.3 UFP Entering USB4 Mode (Wait)

This is an example of an Enter USB operation where the *DFP* requests ***[USB4]*** mode when this is not possible for the *UFP* at this time. *Figure 8.121, "UFP Entering USB4 Mode (Wait)"* shows the *Messages* as they flow across the bus and within the devices to accomplish the Enter USB process.

Figure 8.121 UFP Entering USB4 Mode (Wait)

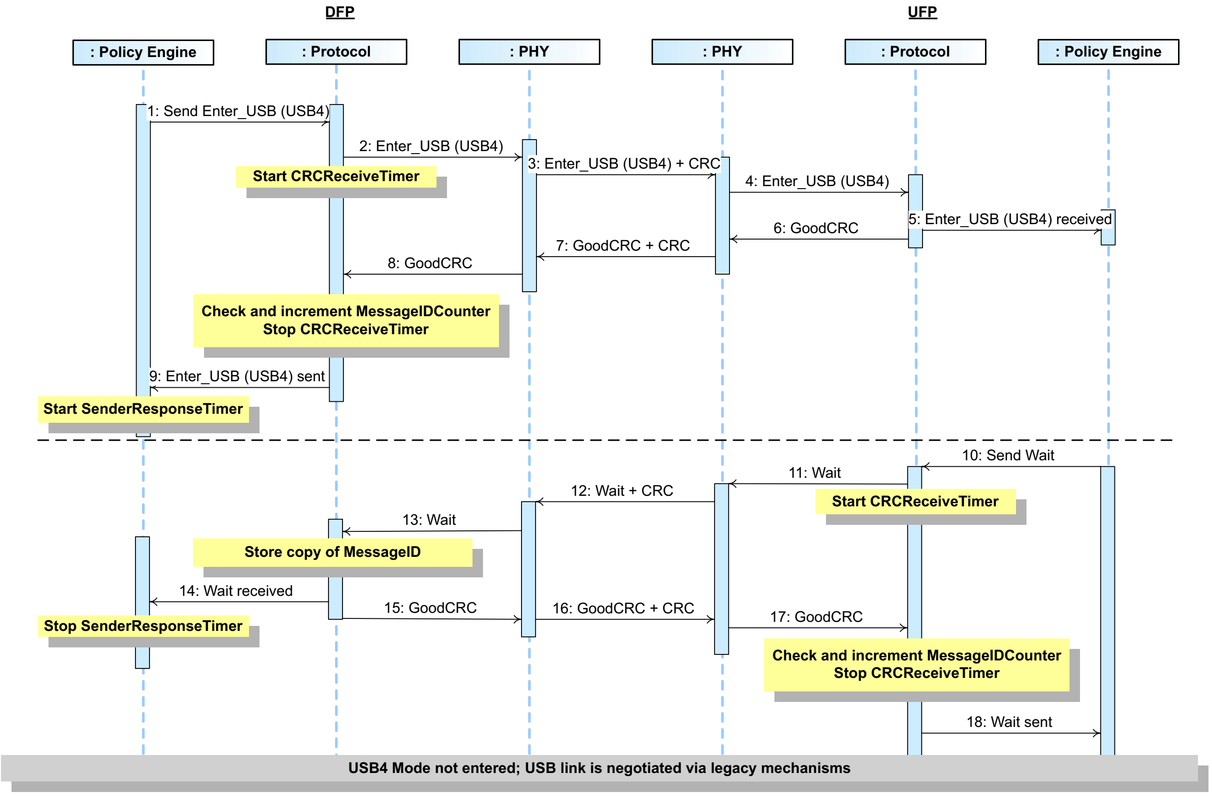


Table 8.148, "Steps for UFP USB4 Mode Entry (Wait)" below provides a detailed explanation of what happens at each labeled step in *Figure 8.121, "UFP Entering USB4 Mode (Wait)"* above.

Table 8.148 Steps for UFP USB4 Mode Entry (Wait)

Step	DFP	UFP
1	The *Policy Engine* directs the *Protocol Layer* to generate an ***Enter_USB*** *Message* to request entry to ***[USB4]*** mode.	
2	*Protocol Layer* creates the *Message* and passes to *PHY Layer*.	
3	*PHY Layer* appends *CRC* and sends the ***Enter_USB*** *Message*. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the ***Enter_USB*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
4		*PHY Layer* removes the *CRC* and forwards the ***Enter_USB*** *Message* to the *Protocol Layer*.
5		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Enter_USB*** *Message* information to the *Policy Engine* that consumes it.
6		*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.
7	*PHY Layer* receives the ***GoodCRC*** and checks the *CRC* to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.
8	*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.	
9	*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Enter_USB*** *Message* was successfully sent. *Policy Engine* starts ***SenderResponseTimer***.	
10		*Policy Engine* tells the *Protocol Layer* to form an ***Wait*** *Message*.
11		*Protocol Layer* creates the *Message* and passes to *PHY Layer*.
12	*PHY Layer* receives the *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.	*PHY Layer* appends a *CRC* and sends the *Message*. Starts ***CRCReceiveTimer***.
13	*Protocol Layer* stores the ***MessageID*** of the incoming *Message*.	
14	The *Protocol Layer* forwards the received ***Wait*** *Message* information to the *Policy Engine* that consumes it.	
15	*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.	
16	*PHY Layer* appends a *CRC* and sends the ***GoodCRC*** *Message*.	*PHY Layer* receives ***GoodCRC*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
17		*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.

Table 8.148 Steps for UFP USB4 Mode Entry (Wait)

Step	DFP	UFP
18		*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Wait*** *Message* was successfully sent.
Port Partners do not enter ***[USB4]*** operation.		

8.3.2.16.2 Cable Plug Entering USB4 Mode

8.3.2.16.2.1 Cable Plug Entering USB4 Mode (Accept)

This is an example of an Enter USB operation where the *DFP* requests ***[USB4]*** mode when this is a ***Valid*** mode of operation for the *Cable Plug*. *Figure 8.122, "Cable Plug Entering USB4 Mode (Accept)"* shows the *Messages* as they flow across the bus and within the devices to accomplish the Enter USB process.

Figure 8.122 Cable Plug Entering USB4 Mode (Accept)

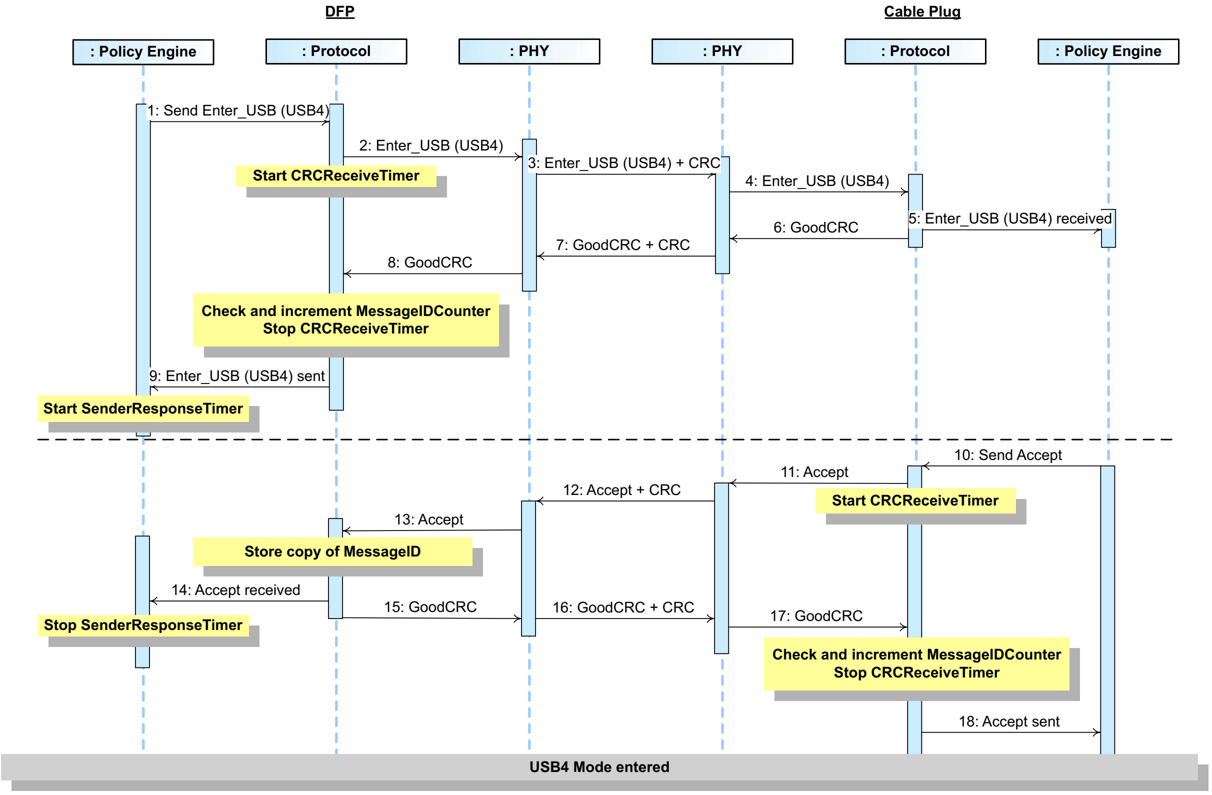


Table 8.149, "Steps for Cable Plug USB4 Mode Entry (Accept)" below provides a detailed explanation of what happens at each labeled step in *Figure 8.122, "Cable Plug Entering USB4 Mode (Accept)"* above.

Table 8.149 Steps for Cable Plug USB4 Mode Entry (Accept)

Step	DFP	Cable Plug
1	The *Policy Engine* directs the *Protocol Layer* to generate an ***Enter_USB*** *Message* to request entry to ***[USB4]*** mode.	
2	*Protocol Layer* creates the *Message* and passes to *PHY Layer*.	
3	*PHY Layer* appends *CRC* and sends the ***Enter_USB*** *Message*. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the ***Enter_USB*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
4		*PHY Layer* removes the *CRC* and forwards the ***Enter_USB*** *Message* to the *Protocol Layer*.
5		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Enter_USB*** *Message* information to the *Policy Engine* that consumes it.
6		*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.
7	*PHY Layer* receives the ***GoodCRC*** and checks the *CRC* to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.
8	*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.	
9	*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Enter_USB*** *Message* was successfully sent. *Policy Engine* starts ***SenderResponseTimer***.	
10		*Policy Engine* tells the *Protocol Layer* to form an ***Accept*** *Message*.
11		*Protocol Layer* creates the *Message* and passes to *PHY Layer*.
12	*PHY Layer* receives the *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.	*PHY Layer* appends a *CRC* and sends the *Message*. Starts ***CRCReceiveTimer***.
13	*Protocol Layer* stores the ***MessageID*** of the incoming *Message*.	
14	The *Protocol Layer* forwards the received ***Accept*** *Message* information to the *Policy Engine* that consumes it.	
15	*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.	
16	*PHY Layer* appends a *CRC* and sends the ***GoodCRC*** *Message*.	*PHY Layer* receives ***GoodCRC*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
17		*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.

Table 8.149 Steps for Cable Plug USB4 Mode Entry (Accept)

Step	DFP	Cable Plug
18		*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Accept*** *Message* was successfully sent.
Cable Plug enters ***[USB4]*** operation.		

8.3.2.16.2.2 Cable Plug Entering USB4 Mode (Reject)

This is an example of an Enter USB operation where the *DFP* requests *[USB4]* mode when this is an ***Invalid*** mode of operation for the *Cable Plug*. *Figure 8.123, "Cable Plug Entering USB4 Mode (Reject)"* shows the *Message*s as they flow across the bus and within the devices to accomplish the Enter USB process.

Figure 8.123 Cable Plug Entering USB4 Mode (Reject)

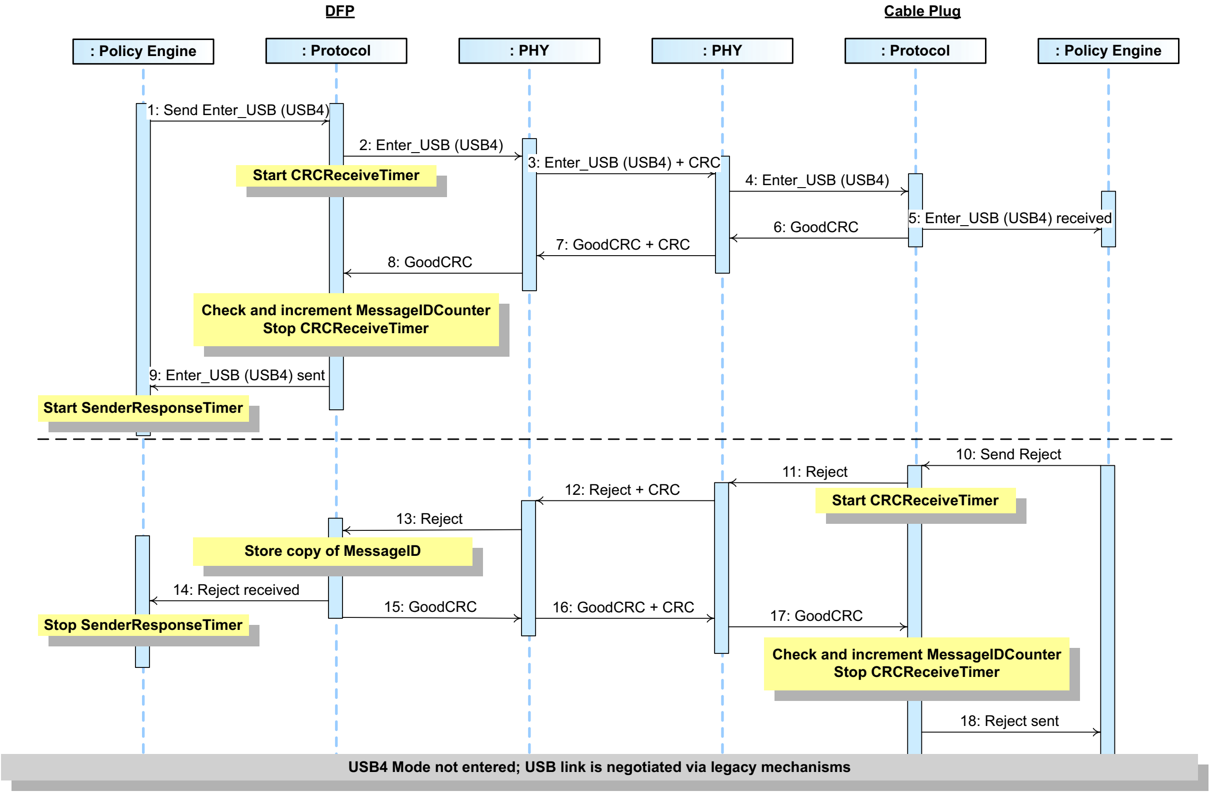


Table 8.150, "Steps for Cable Plug USB4 Mode Entry (Reject)" below provides a detailed explanation of what happens at each labeled step in *Figure 8.123, "Cable Plug Entering USB4 Mode (Reject)"* above.

Table 8.150 Steps for Cable Plug USB4 Mode Entry (Reject)

Step	DFP	Cable Plug
1	The *Policy Engine* directs the *Protocol Layer* to generate an ***Enter_USB*** *Message* to request entry to ***[USB4]*** mode.	
2	*Protocol Layer* creates the *Message* and passes to *PHY Layer*.	
3	*PHY Layer* appends *CRC* and sends the ***Enter_USB*** *Message*. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the ***Enter_USB*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
4		*PHY Layer* removes the *CRC* and forwards the ***Enter_USB*** *Message* to the *Protocol Layer*.
5		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Enter_USB*** *Message* information to the *Policy Engine* that consumes it.
6		*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.
7	*PHY Layer* receives the ***GoodCRC*** and checks the *CRC* to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.
8	*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.	
9	*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Enter_USB*** *Message* was successfully sent. *Policy Engine* starts ***SenderResponseTimer***.	
10		*Policy Engine* tells the *Protocol Layer* to form an ***Reject*** *Message*.
11		*Protocol Layer* creates the *Message* and passes to *PHY Layer*.
12	*PHY Layer* receives the *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.	*PHY Layer* appends a *CRC* and sends the *Message*. Starts ***CRCReceiveTimer***.
13	*Protocol Layer* stores the ***MessageID*** of the incoming *Message*.	
14	The *Protocol Layer* forwards the received ***Reject*** *Message* information to the *Policy Engine* that consumes it.	
15	*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.	
16	*PHY Layer* appends a *CRC* and sends the ***GoodCRC*** *Message*.	*PHY Layer* receives ***GoodCRC*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
17		*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.

Table 8.150 Steps for Cable Plug USB4 Mode Entry (Reject)

Step	DFP	Cable Plug
18		*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Reject*** *Message* was successfully sent.
Cable Plug does not enter ***[USB4]*** operation.		

8.3.2.16.2.3 Cable Plug Entering USB4 Mode (Wait)

This is an example of an Enter USB operation where the *DFP* requests ***[USB4]*** mode when this is not possible for the *Cable Plug* at this time. *Figure 8.124, "Cable Plug Entering USB4 Mode (Wait)"* shows the *Messages* as they flow across the bus and within the devices to accomplish the Enter USB process.

Figure 8.124 Cable Plug Entering USB4 Mode (Wait)

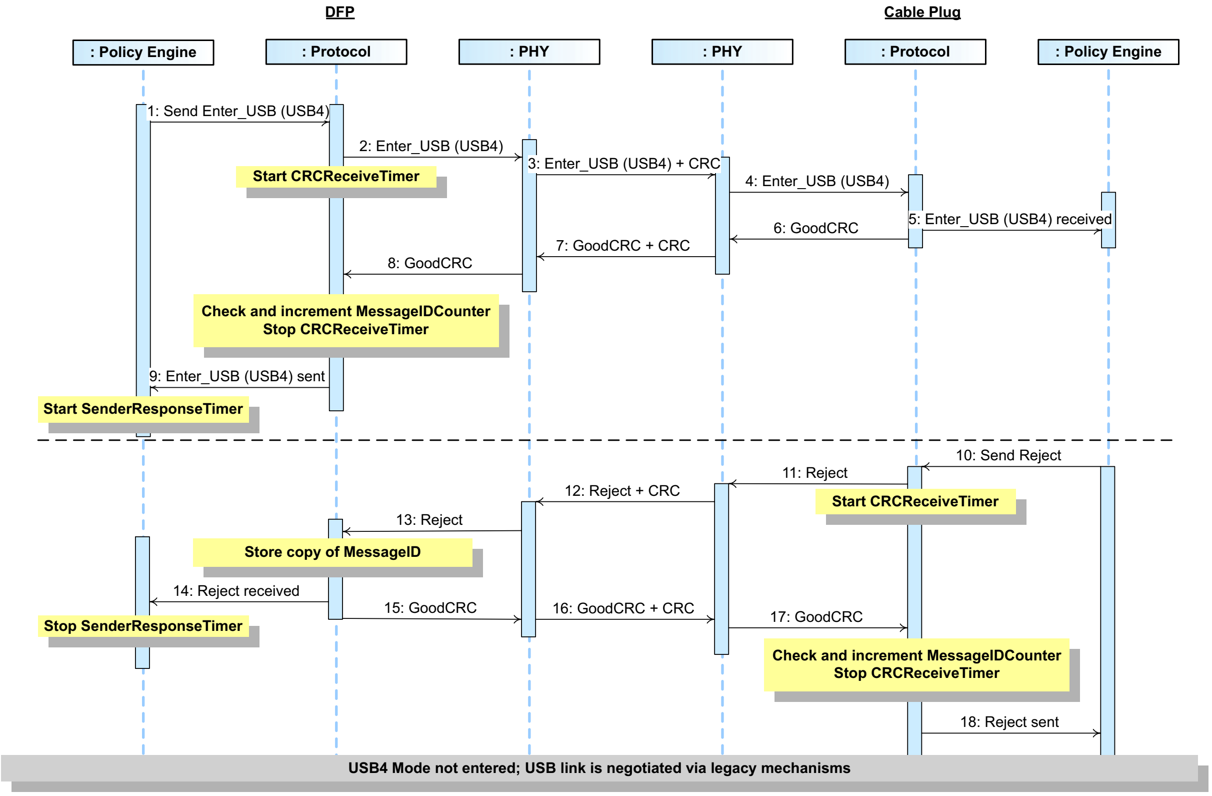


Table 8.151, "Steps for Cable Plug USB4 Mode Entry (Wait)" below provides a detailed explanation of what happens at each labeled step in *Figure 8.124, "Cable Plug Entering USB4 Mode (Wait)"* above.

Table 8.151 Steps for Cable Plug USB4 Mode Entry (Wait)

Step	DFP	Cable Plug
1	The *Policy Engine* directs the *Protocol Layer* to generate an ***Enter_USB*** *Message* to request entry to ***[USB4]*** mode.	
2	*Protocol Layer* creates the *Message* and passes to *PHY Layer*.	
3	*PHY Layer* appends *CRC* and sends the ***Enter_USB*** *Message*. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the ***Enter_USB*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
4		*PHY Layer* removes the *CRC* and forwards the ***Enter_USB*** *Message* to the *Protocol Layer*.
5		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the received ***Enter_USB*** *Message* information to the *Policy Engine* that consumes it.
6		*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.
7	*PHY Layer* receives the ***GoodCRC*** and checks the *CRC* to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.
8	*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.	
9	*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Enter_USB*** *Message* was successfully sent. *Policy Engine* starts ***SenderResponseTimer***.	
10		*Policy Engine* tells the *Protocol Layer* to form an ***Wait*** *Message*.
11		*Protocol Layer* creates the *Message* and passes to *PHY Layer*.
12	*PHY Layer* receives the *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.	*PHY Layer* appends a *CRC* and sends the *Message*. Starts ***CRCReceiveTimer***.
13	*Protocol Layer* stores the ***MessageID*** of the incoming *Message*.	
14	The *Protocol Layer* forwards the received ***Wait*** *Message* information to the *Policy Engine* that consumes it.	
15	*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.	
16	*PHY Layer* appends a *CRC* and sends the ***GoodCRC*** *Message*.	*PHY Layer* receives ***GoodCRC*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
17		*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.

Table 8.151 Steps for Cable Plug USB4 Mode Entry (Wait)

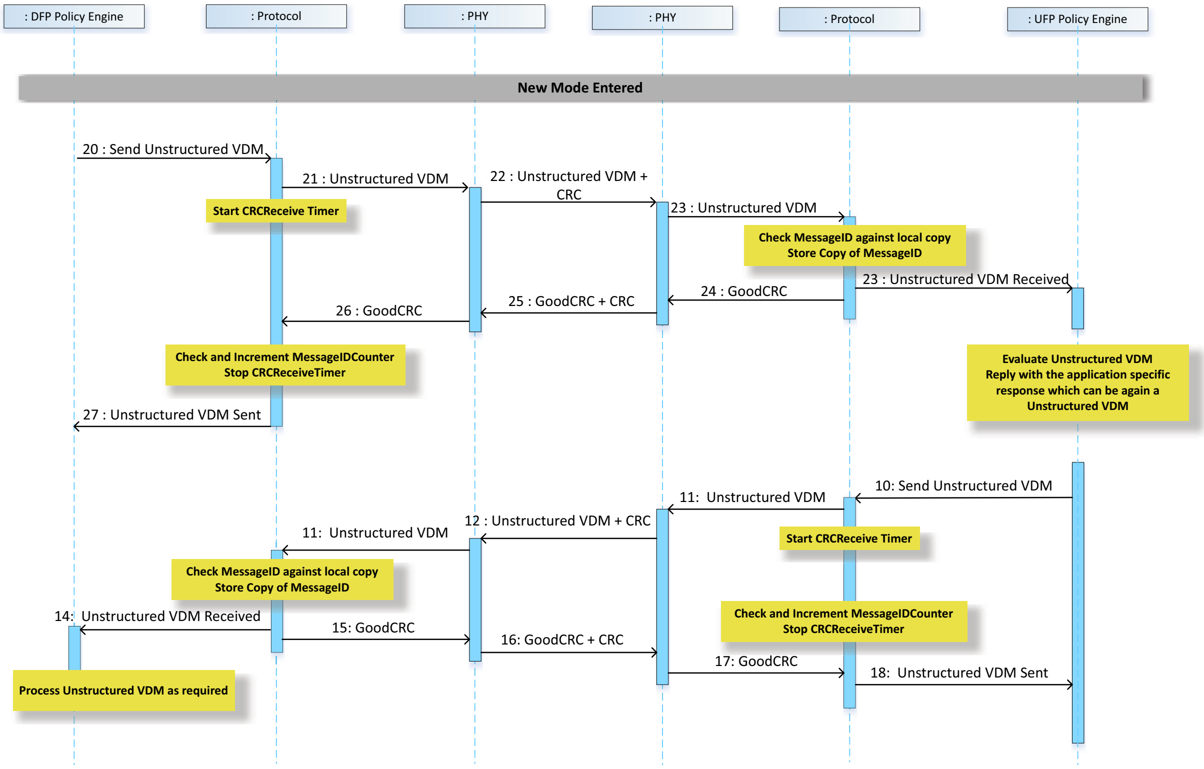
Step	DFP	Cable Plug
18		*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Wait*** *Message* was successfully sent.
Cable Plug does not enter ***[USB4]*** operation.		

8.3.2.17 Unstructured Vendor Defined Messages

8.3.2.17.1 Unstructured VDM

Figure 8.125, "Unstructured VDM Message Sequence" shows an example sequence of an *Unstructured VDM* Transaction between a *DFP* and *UFP*. The figure below shows the *Messages* as they flow across the bus after *UFP* Enters into *Modal Operation*.

Figure 8.125 Unstructured VDM Message Sequence



: DFP Policy Engine
: Protocol
: PHY
: PHY
: Protocol
: UFP Policy Engine
New Mode Entered
20 : Send Unstructured VDM
21 : Unstructured VDM
22 : Unstructured VDM + CRC
23 : Unstructured VDM
Start CRCReceive Timer
Check MessageID against local copy
Store Copy of MessageID
23 : Unstructured VDM Received
24 : GoodCRC
25 : GoodCRC + CRC
26 : GoodCRC
Check and Increment MessageIDCounter
Stop CRCReceiveTimer
Evaluate Unstructured VDM
Reply with the application specific response which can be again a Unstructured VDM
27 : Unstructured VDM Sent
10: Send Unstructured VDM
11: Unstructured VDM
12 : Unstructured VDM + CRC
11: Unstructured VDM
Start CRCReceive Timer
Check MessageID against local copy
Store Copy of MessageID
14: Unstructured VDM Received
15: GoodCRC
16: GoodCRC + CRC
Check and Increment MessageIDCounter
Stop CRCReceiveTimer
17: GoodCRC
18: Unstructured VDM Sent
Process Unstructured VDM as required

Table 8.152, "Steps for Unstructured VDM Message Sequence" below provides a detailed explanation of what happens at each labeled step in *Figure 8.125, "Unstructured VDM Message Sequence"* above.

Table 8.152 Steps for Unstructured VDM Message Sequence

Step	DFP	UFP
1	The *DFP* has an *Explicit Contract* and has entered an *Active Mode* with the *UFP*. The *Policy Engine* directs the *Protocol Layer* to send an Unstructured ***Vendor_Defined*** *Message*.	The *UFP* has an *Explicit Contract* and has entered an *Active Mode* with the *UFP*
2	*Protocol Layer* creates the Unstructured ***Vendor_Defined*** *Message* and passes to *PHY Layer*.	
3	*PHY Layer* appends *CRC* and sends the Unstructured ***Vendor_Defined*** *Message*. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the Unstructured ***Vendor_Defined*** *Message* and checks the *CRC* to verify the *Message*.
4		*PHY Layer* removes the *CRC* and forwards the Unstructured ***Vendor_Defined*** *Message* to the *Protocol Layer*.
5		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the Unstructured ***Vendor_Defined*** *Message* information to the *Policy Engine* that consumes it.
6		*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.
7	*PHY Layer* receives the ***GoodCRC*** *Message* and checks the *CRC* to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.
8	*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.	
9	*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the Unstructured ***Vendor_Defined*** *Message* was successfully sent.	
10		In this example the Vendor protocol requires a response. The *Policy Engine* tells the *Protocol Layer* to form an Unstructured ***Vendor_Defined*** *Message*.
11		*Protocol Layer* creates the Unstructured ***Vendor_Defined*** *Message* and passes to *PHY Layer*.
12	*PHY Layer* receives the Unstructured ***Vendor_Defined*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.	*PHY Layer* appends a *CRC* and sends the Unstructured ***Vendor_Defined*** *Message*. Starts ***CRCReceiveTimer***.
13	*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the Unstructured ***Vendor_Defined*** *Message* information to the *Policy Engine* that consumes it.	
14	*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.	

Table 8.152 Steps for Unstructured VDM Message Sequence

Step	DFP	UFP
15	*PHY Layer* appends a *CRC* and sends the ***GoodCRC*** *Message*.	*PHY Layer* receives ***GoodCRC*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.
16		*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.
17		*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the Unstructured ***Vendor_Defined*** *Message* was successfully sent.

8.3.2.17.2 VDEM

Figure 8.126, "VDEM Message Sequence" shows an example sequence of an *VDEM* transaction between a *DFP* and *UFP*. The figure below shows the *Messages* as they flow across the bus after *UFP* Enters into *Modal Operation*.

Figure 8.126 VDEM Message Sequence

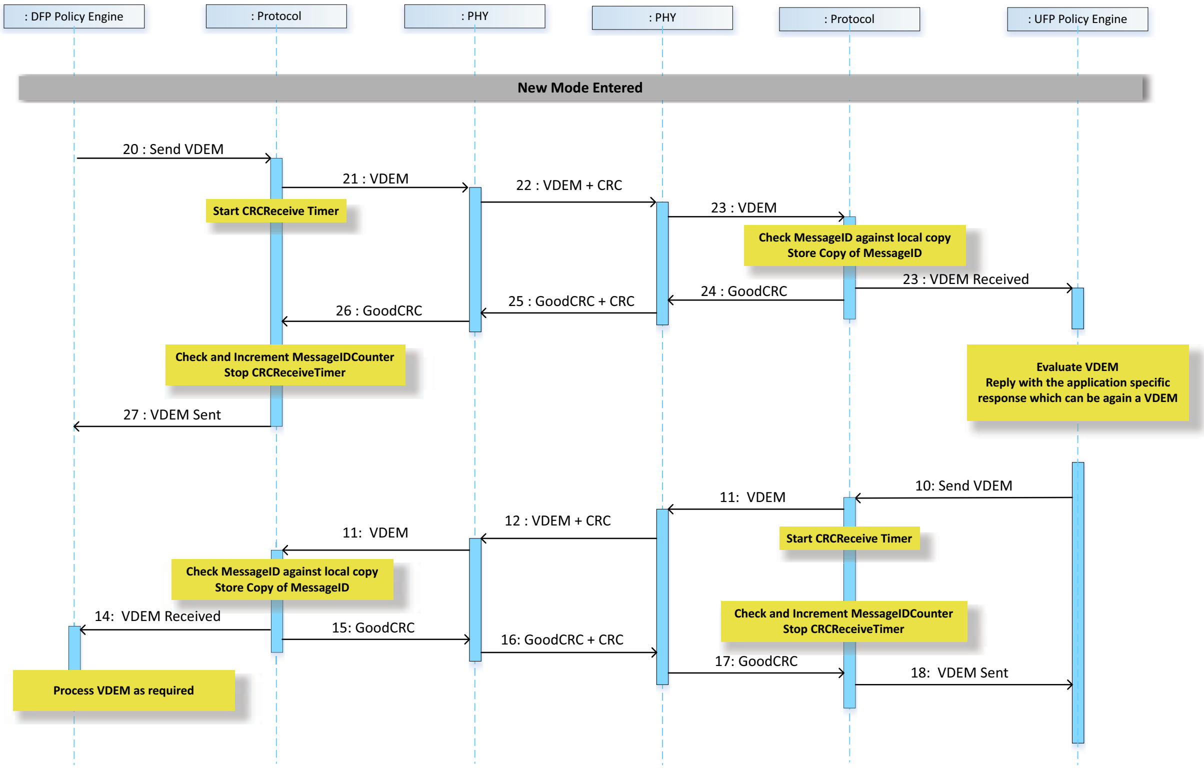


Table 8.153, "Steps for VDEM Message Sequence" below provides a detailed explanation of what happens at each labeled step in *Figure 8.126, "VDEM Message Sequence"* above.

Table 8.153 Steps for VDEM Message Sequence

Step	DFP	UFP
1	The *DFP* has an *Explicit Contract* and has entered an *Active Mode* with the *UFP*. The *Policy Engine* directs the *Protocol Layer* to send a ***Vendor_Defined_Extended*** *Message*.	The *UFP* has an *Explicit Contract* and has entered an *Active Mode* with the *UFP*
2	*Protocol Layer* creates the ***Vendor_Defined_Extended*** *Message* and passes to *PHY Layer*.	
3	*PHY Layer* appends *CRC* and sends the ***Vendor_Defined_Extended*** *Message*. Starts ***CRCReceiveTimer***.	*PHY Layer* receives the ***Vendor_Defined_Extended*** *Message* and checks the *CRC* to verify the *Message*.
4		*PHY Layer* removes the *CRC* and forwards the ***Vendor_Defined_Extended*** *Message* to the *Protocol Layer*.
5		*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the ***Vendor_Defined_Extended*** *Message* information to the *Policy Engine* that consumes it.
6		*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.
7	*PHY LayerPHY Layer* receives the ***GoodCRC*** *Message* and checks the *CRC* to verify the *Message*.	*PHY Layer* appends *CRC* and sends the ***GoodCRC*** *Message*.
8	*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.	
9	*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. *Protocol Layer* informs the *Policy Engine* that the ***Vendor_Defined_Extended*** *Message* was successfully sent.	
10		In this example the Vendor protocol requires a response. The *Policy Engine* tells the *Protocol Layer* to form a ***Vendor_Defined_Extended*** *Message*.
11		*Protocol Layer* creates the ***Vendor_Defined_Extended*** *Message* and passes to *PHY Layer*.
12	*PHY Layer* receives the ***Vendor_Defined_Extended*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.	*PHY Layer* appends a *CRC* and sends the ***Vendor_Defined_Extended*** *Message*. Starts ***CRCReceiveTimer***.
13	*Protocol Layer* checks the ***MessageID*** in the incoming *Message* is different from the previously stored value and then stores a copy of the new value. The *Protocol Layer* forwards the ***Vendor_Defined_Extended*** *Message* information to the *Policy Engine* that consumes it.	
14	*Protocol Layer* generates a ***GoodCRC*** *Message* and passes it *PHY Layer*.	
15	*PHY Layer* appends a *CRC* and sends the ***GoodCRC*** *Message*.	*PHY Layer* receives ***GoodCRC*** *Message* and compares the *CRC* it calculated with the one sent to verify the *Message*.

Table 8.153 Steps for VDEM Message Sequence

Step	DFP	UFP
16		*PHY Layer* removes the *CRC* and forwards the ***GoodCRC*** *Message* to the *Protocol Layer*.
17		*Protocol Layer* verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer.*** *Protocol Layer* informs the *Policy Engine* that the ***Vendor_Defined_Extended*** *Message* was successfully sent.

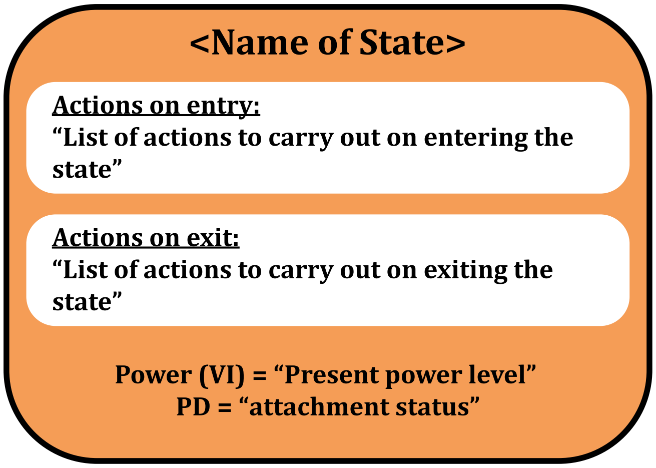
8.3.3 State Diagrams

8.3.3.1 Introduction to state diagrams used in Chapter 8

The state diagrams defined in [Section 8.3.3, "State Diagrams"] are ***Normative*** and ***Shall*** define the operation of the Power Delivery *Policy Engine*.

Note: These state diagrams are not intended to replace a well written and robust design.

Figure 8.127 Outline of States



<Name of State>
Actions on entry:
"List of actions to carry out on entering the state"
Actions on exit:
"List of actions to carry out on exiting the state"
Power (VI) = "Present power level"
PD = "attachment status"

Figure 8.127, "Outline of States" shows an outline of the states defined in the following sections. At the top there is the name of the state. This is followed by "Actions on entry" a list of actions carried out on entering the state. If there are also "Actions on exit" a list of actions carried out on exiting the state, then these are listed as well; otherwise, this box is omitted from the state. At the bottom the status of PD is listed:

- "Power" which indicates the present output power for a *Source Port* or input power for a *Sink Port*.
- "PD" which indicates the present *Attachment* status either "*Attached*", "*Detached*", or "unknown".

Transitions from one state to another are indicated by arrows with the conditions listed on the arrow. Where there are multiple conditions, these are connected using either a logical OR "|" or a logical AND "&".

In some cases, there are transitions which can occur from any state to a particular state. These are indicated by an arrow which is unconnected to a state at one end, but with the other end (the point) connected to the final state.

In some state diagrams it is necessary to enter or exit from states in other diagrams (e.g., *Source Port* or *Sink Port* state diagrams). *Figure 8.128, "References to states"* indicates how such references are made. The reference is indicated with a hatched box. The box contains the name of the state and whether the state is a *DFP* or *UFP*. It has also been necessary to indicate conditional entry to either *Source Port* or *Sink Port* state diagrams. This is achieved by the use of a bulleted list indicating the preconditions (see example in *Figure 8.129, "Example of state reference with conditions"*). It is also possible that the entry and return states are the same. *Figure 8.130, "Example of state reference with the same entry and exit"* indicates a state reference where each referenced state corresponds to either the entry state or the exit state.

Figure 8.128 References to states

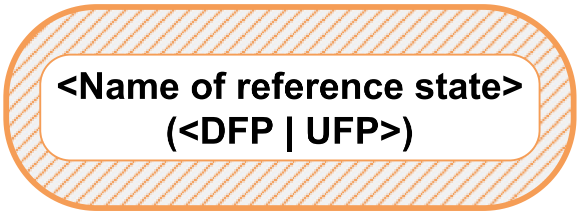


Figure 8.129 Example of state reference with conditions

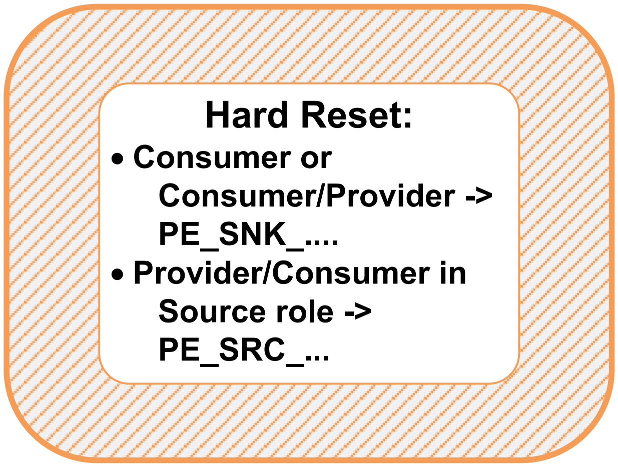
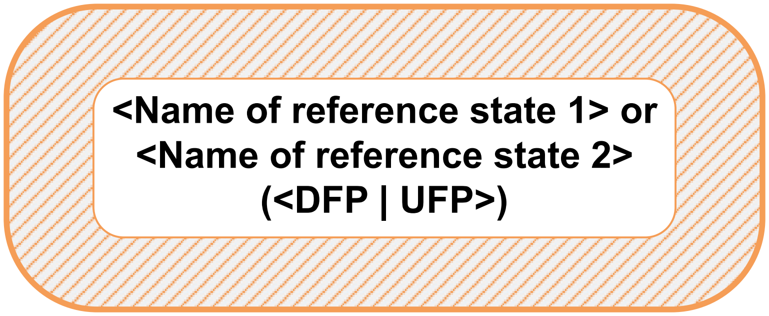

Hard Reset:
• Consumer or Consumer/Provider -> PE_SNK_....
• Provider/Consumer in Source role -> PE_SRC_...

Figure 8.130 Example of state reference with the same entry and exit



Timers are included in many of the states. Timers are initialized (set to their starting condition) and run (timer is counting) in the particular state it is referenced. As soon as the state is exited then the timer is no longer active. Where the timers continue to run outside of the state (such as the ***NoResponseTimer***), this is called out in the text. Timeouts of the timers are listed as conditions on state transitions.

The ***SenderResponseTimer*** is a special case, as it ***May*** be stopped and started from outside the states in which it is used. To allow this to be done without over-complicating the state diagrams, the ***SenderResponseTimer*** is described with its own state diagram (*Figure 8.131, "SenderResponseTimer Policy Engine State Diagram"*). The control of this Timer is shared between the *Policy Engine* and the *Chunking Layer*.

Conditions listed on state transitions will come from one of three sources and, when there is a conflict, ***Should*** be serviced in the following order:

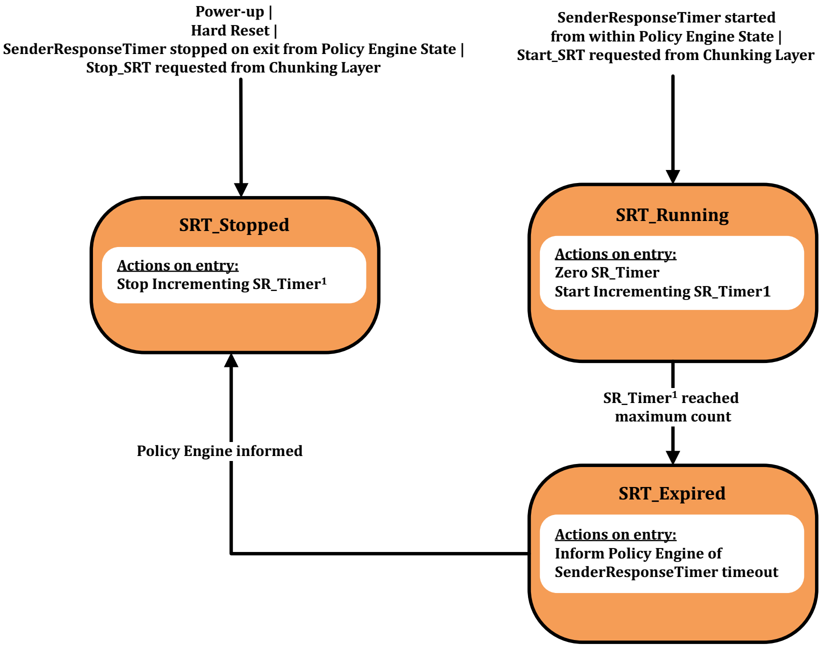
1) *Message* and related indications passed up to the *Policy Engine* from the *Protocol Layer* (*Message* sent; *Message* received etc.).
2) Events triggered within the *Policy Engine* e.g., timer timeouts.
3) Information and requests coming from the *Device Policy Manager* relating either to *Local Policy*, or to other modules which the *Device Policy Manager* controls such as power supply and *USB-C®* *Port Control*.

Note: The following state diagrams are not intended to cover all possible corner cases that could be encountered. For example, where an outgoing *Message* is ***Discarded***, due to an incoming *Message* by the *Protocol Layer* (see *Section 6.12.2.3, "Protocol Layer Message Reception"*) it will be necessary for the higher layers of the system to handle a retry of the *AMS* that was being initiated, after first handling the incoming *Message*.

8.3.3.1.1 SenderResponseTimer State Diagram

Figure 8.131, "SenderResponseTimer Policy Engine State Diagram" below shows the state diagram for the *Policy Engine* in a *Source Port* or a *Sink Port*. The following sections describe operation in each of the states.

Figure 8.131 SenderResponseTimer Policy Engine State Diagram


Power-up |
Hard Reset |
SenderResponseTimer stopped on exit from Policy Engine State |
Stop_SRT requested from Chunking Layer
SenderResponseTimer started
from within Policy Engine State |
Start_SRT requested from Chunking Layer
SRT_Stopped
Actions on entry:
Stop Incrementing SR_Timer¹
SRT_Running
Actions on entry:
Zero SR_Timer
Start Incrementing SR_Timer1
SR_Timer¹ reached
maximum count
Policy Engine informed
SRT_Expired
Actions on entry:
Inform Policy Engine of
SenderResponseTimer timeout

1) The SR_Timer is regarded as the mechanism within the ***SenderResponseTimer*** state diagram that implements the ***SenderResponseTimer***.

8.3.3.1.1.1 SRT_Stopped State

The ***SRT_Stopped*** State ***Shall*** be the starting state for the ***SenderResponseTimer*** either on power up or after a *Hard Reset*. On entry to this state the *Policy Engine* ***Shall*** stop incrementing the SR_Timer.

The *Policy Engine* ***Shall*** transition to the ***SRT_Running*** State:

- When the ***SenderResponseTimer*** is started from within a *Policy Engine* state, or
- When a Start_SRT is requested from the *Chunking Layer*.

8.3.3.1.1.2 SRT_Running State

On entry to the ***SRT_Running*** State the ***SenderResponseTimer*** state machine ***Shall***:

- Set the SR_Timer to zero
- Start running SR_Timer.

The ***SenderResponseTimer*** state machine ***Shall*** transition to the ***SRT_Expired*** State:

- When the SR_Timer reaches its maximum count

The ***SenderResponseTimer*** state machine ***Shall*** transition to the ***SRT_Stopped*** State:

- When the ***SenderResponseTimer*** is stopped by exiting a *Policy Engine* state, or
- When a Stop_SRT is requested from the *Chunking Layer*

8.3.3.1.1.3 SRT_Expired State

On entry to the ***SRT_Running*** State the ***SenderResponseTimer*** state machine ***Shall*** Inform *Policy Engine* of ***SenderResponseTimer*** timeout

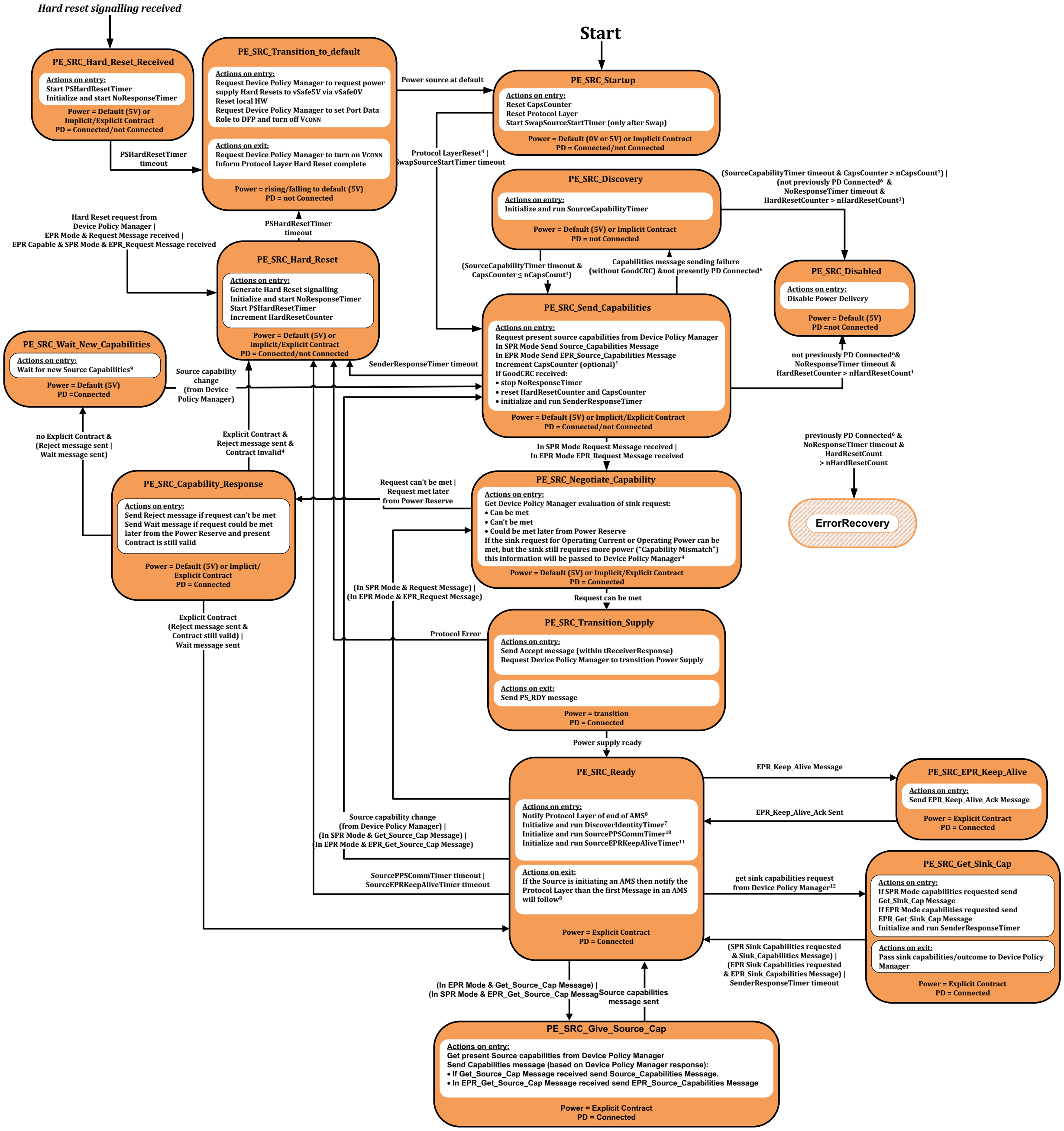
The *Policy Engine* ***Shall*** then transition to the ***SRT_Stopped*** state:

- When the *Policy Engine* has been informed.

8.3.3.2 Policy Engine Source Port State Diagram

Figure 8.132, "Source Port State Diagram" below shows the state diagram for the *Policy Engine* in a *Source Port*. The following sections describe operation in each of the states.

Figure 8.132 Source Port State Diagram



Hard reset signalling received
Start
PE_SRC_Hard_Reset_Received
Actions on entry:
Start PSHardResetTimer
Initialize and start NoResponseTimer
Power = Default (5V) or Implicit/Explicit Contract
PD = Connected/not Connected
PSHardResetTimer timeout
PE_SRC_Transition_to_default
Actions on entry:
Request Device Policy Manager to request power supply Hard Resets to vSafe5V via vSafe0V
Reset local HW
Request Device Policy Manager to set Port Data Role to DFP and turn off VCONN
Actions on exit:
Request Device Policy Manager to turn on VCONN
Inform Protocol Layer Hard Reset complete
Power = rising/falling to default (5V)
PD = not Connected
Power source at default
PE_SRC_Startup
Actions on entry:
Reset CapsCounter
Reset Protocol Layer
Start SwapSourceStartTimer (only after Swap)
Power = Default (0V or 5V) or Implicit Contract
PD = Connected/not Connected
Protocol LayerReset[4] | SwapSourceStartTimer timeout
PE_SRC_Discovery
Actions on entry:
Initialize and run SourceCapabilityTimer
Power = Default (5V) or Implicit Contract
PD = not Connected
(SourceCapabilityTimer timeout & CapsCounter > nCapsCount[1]) | (not previously PD Connected[6] & NoResponseTimer timeout & HardResetCounter > nHardResetCount[1])
Hard Reset request from Device Policy Manager | EPR Mode & Request Message received | EPR Capable & SPR Mode & EPR_Request Message received
PSHardResetTimer timeout
PE_SRC_Hard_Reset
Actions on entry:
Generate Hard Reset signalling
Initialize and start NoResponseTimer
Start PSHardResetTimer
Increment HardResetCounter
Power = Default (5V) or Implicit/Explicit Contract
PD = Connected/not Connected
(SourceCapabilityTimer timeout & CapsCounter ≤ nCapsCount[1])
Capabilities message sending failure (without GoodCRC) &not presently PD Connected[6]
PE_SRC_Disabled
Actions on entry:
Disable Power Delivery
Power = Default (5V)
PD =not Connected
PE_SRC_Send_Capabilities
Actions on entry:
Request present source capabilities from Device Policy Manager
In SPR Mode Send Source_Capabilities Message
In EPR Mode Send EPR_Source_Capabilities Message
Increment CapsCounter (optional)[1]
If GoodCRC received:
• stop NoResponseTimer
• reset HardResetCounter and CapsCounter
• initialize and run SenderResponseTimer
Power = Default (5V) or Implicit/Explicit Contract
PD = Connected/not Connected
SenderResponseTimer timeout
not previously PD Connected[6]& NoResponseTimer timeout & HardResetCounter > nHardResetCount[1]
PE_SRC_Wait_New_Capabilities
Actions on entry:
Wait for new Source Capabilities[9]
Power = Default (5V)
PD =Connected
Source capability change (from Device Policy Manager)
no Explicit Contract & (Reject message sent | Wait message sent)
Explicit Contract & Reject message sent & Contract Invalid[4]
In SPR Mode Request Message received | In EPR Mode EPR_Request Message received
previously PD Connected[6] & NoResponseTimer timeout & HardResetCount > nHardResetCount
ErrorRecovery
PE_SRC_Capability_Response
Actions on entry:
Send Reject message if request can't be met
Send Wait message if request could be met later from the Power Reserve and present Contract is still valid
Power = Default (5V) or Implicit/ Explicit Contract
PD = Connected
Request can't be met | Request met later from Power Reserve
PE_SRC_Negotiate_Capability
Actions on entry:
Get Device Policy Manager evaluation of sink request:
• Can be met
• Can't be met
• Could be met later from Power Reserve
If the sink request for Operating Current or Operating Power can be met, but the sink still requires more power ("Capability Mismatch") this information will be passed to Device Policy Manager[4]
Power = Default (5V) or Implicit/Explicit Contract
PD = Connected
(In SPR Mode & Request Message) | (In EPR Mode & EPR_Request Message)
Request can be met
Explicit Contract (Reject message sent & Contract still valid) | Wait message sent
Protocol Error
PE_SRC_Transition_Supply
Actions on entry:
Send Accept message (within tReceiverResponse)
Request Device Policy Manager to transition Power Supply
Actions on exit:
Send PS_RDY message
Power = transition
PD = Connected
Power supply ready
PE_SRC_Ready
Actions on entry:
Notify Protocol Layer of end of AMS[8]
Initialize and run DiscoverIdentityTimer[7]
Initialize and run SourcePPSCommTimer[10]
Initialize and run SourceEPRKeepAliveTimer[11]
Actions on exit:
If the Source is initiating an AMS then notify the Protocol Layer than the first Message in an AMS will follow[8]
Power = Explicit Contract
PD = Connected
Source capability change (from Device Policy Manager) | (In SPR Mode & Get_Source_Cap Message) | (In EPR Mode & EPR_Get_Source_Cap Message)
SourcePPSCommTimer timeout | SourceEPRKeepAliveTimer timeout
EPR_Keep_Alive Message
PE_SRC_EPR_Keep_Alive
Actions on entry:
Send EPR_Keep_Alive_Ack Message
Power = Explicit Contract
PD = Connected
EPR_Keep_Alive_Ack Sent
get sink capabilities request from Device Policy Manager[12]
PE_SRC_Get_Sink_Cap
Actions on entry:
If SPR Mode capabilities requested send Get_Sink_Cap Message
If EPR Mode capabilities requested send EPR_Get_Sink_Cap Message
Initialize and run SenderResponseTimer
Actions on exit:
Pass sink capabilities/outcome to Device Policy Manager
Power = Explicit Contract
PD = Connected
(SPR Sink Capabilities requested & Sink_Capabilities Message) | (EPR Sink Capabilities requested & EPR_Sink_Capabilities Message) | SenderResponseTimer timeout
(In EPR Mode & Get_Source_Cap Message) | (In SPR Mode & EPR_Get_Source_Cap Messag
Source capabilities message sent
PE_SRC_Give_Source_Cap
Actions on entry:
Get present Source capabilities from Device Policy Manager
Send Capabilities message (based on Device Policy Manager response):
• If Get_Source_Cap Message received send Source_Capabilities Message.
• In EPR_Get_Source_Cap Message received send EPR_Source_Capabilities Message
Power = Explicit Contract
PD = Connected

1) Implementation of the ***CapsCounter*** is ***Optional***. In the case where this is not implemented the *Source* ***Shall*** continue to send ***Source_Capabilities*** *Messages* each time the ***SourceCapabilityTimer*** times out.

2) Since the *Sink* is required to make a ***Valid*** request from the offered capabilities the expected transition is via "Request can be met" unless the *Source Capabilities* have changed since the last offer.

3) “Contract Invalid" means that the previously *Negotiated* voltage and Current values are no longer included in the *Source*'s new Capabilities. If the *Sink* fails to make a ***Valid*** Request in this case, then Power Delivery operation is no longer possible and Power Delivery mode is exited with a *Hard Reset*.

4) After a Power Swap the *New Source* is required to wait an additional ***tSwapSourceStart*** before sending a ***Source_Capabilities*** *Message*. This delay is not required when first starting up a system.

5) PD *Connected* is defined as a situation when the *Port Partner*s are actively communicating. The *Port Partner*s remain PD *Connected* after a Swap until there is a transition to Disabled or the connector is able to identify a *Detach*.

6) *Port Partners* are no longer PD *Connected* after a *Hard Reset*, but consideration needs to be given as to whether there has been a PD Connection while the Ports have been *Attached* to prevent unnecessary *USB Type-C Error Recovery*.

7) The ***DiscoverIdentityTimer*** is run when this is a *VCONN Source* and a PD Connection with a *Cable Plug* needs to be established i.e. no ***GoodCRC*** *Message* has yet been received in response to a ***Discover Identity*** *Command*.

8) See *Section 5.7, "Collision Avoidance"*, *Section 6.6.16, "Collision Avoidance Timers"* and *Section 6.10, "Collision Avoidance"*.

9) In the ***PE_SRC_Wait_New_Capabilities*** State the *Device Policy Manager* ***Should*** either decide to send no further *Source Capabilities* or ***Should*** send a different set of *Source Capabilities*. Continuing to send the same set of *Source Capabilities* could result in a live lock situation.

10) The ***SourcePPSCommTimer*** is only initialized and run when the present *Explicit Contract* is for an *SPR PPS APDO*. *Sources* that do not support *SPR PPS* do not need to implement the ***SourcePPSCommTimer***.

11) The ***SourceEPRKeepAliveTimer*** is only initialized and run when the *Source* is in *EPR Mode*; Sources that do not support *EPR Mode* do not need to implement the ***SourceEPRKeepAliveTimer***.

12) Either SPR or EPR *Sink Capabilities* ***May*** be requested, regardless of whether or not the *Source* is currently operating in SPR or *EPR Mode*.

8.3.3.2.1 PE_SRC_Startup State

PE_SRC_Startup ***Shall*** be the starting state for a *Source Policy Engine* either on power up or after a *Hard Reset*. On entry to this state the *Policy Engine* ***Shall*** reset the ***CapsCounter*** and reset the *Protocol Layer*.

Note: Resetting the *Protocol Layer* will also reset the ***MessageIDCounter*** and stored ***MessageID*** (see *Section 6.12.2.3, "Protocol Layer Message Reception"*).

The *Policy Engine* ***Shall*** transition to the ***PE_SRC_Send_Capabilities*** state:

- When the *Protocol Layer* reset has completed if the ***PE_SRC_Startup*** state was entered due to the system first starting up.
- When the ***SwapSourceStartTimer*** times out if the ***PE_SRC_Startup*** state was entered as the result of a *Power Role Swap*.

Note: Sources ***Shall*** remain in the ***PE_SRC_Startup*** state, without sending any ***Source_Capabilities*** *Message*s until a plug is *Attached*.

8.3.3.2.2 PE_SRC_Discovery State

On entry to the ***PE_SRC_Discovery*** state the *Policy Engine* ***Shall*** initialize and run the ***SourceCapabilityTimer*** in order to trigger sending a ***Source_Capabilities*** *Message*.

The *Policy Engine* ***Shall*** transition to the ***PE_SRC_Send_Capabilities*** state when:

- The ***SourceCapabilityTimer*** times out and ***CapsCounter*** ≤ ***nCapsCount***.

The *Policy Engine* ***May Optionally*** go to the ***PE_SRC_Disabled*** state when:

- The *Port Partner*s are not presently PD *Connected*
- And the ***SourceCapabilityTimer*** times out
- And ***CapsCounter*** > ***nCapsCount***.

The *Policy Engine* ***Shall*** go to the ***PE_SRC_Disabled*** state when:

- The *Port Partner*s have not been PD *Connected* (the *Source Port* remains *Attached* to a Port it has not had a PD Connection with during this *Attachment*)

- And the ***NoResponseTimer*** times out
- And the ***HardResetCounter*** > ***nHardResetCount***.

Note: In the ***PE_SRC_Disabled*** state the *Attached* device is assumed to be unresponsive. The *Policy Engine* operates as if the device is *Detached* until such time as a *Detach*/*Re-attach* is detected.

8.3.3.2.3 PE_SRC_Send_Capabilities State

Note: This state can be entered from the ***PE_SRC_Soft_Reset*** state.

On entry to the ***PE_SRC_Send_Capabilities*** state the *Policy Engine* ***Shall*** request the present Port capabilities from the *Device Policy Manager*. The *Policy Engine* ***Shall*** then request the *Protocol Layer* to send a capabilities *Message* containing these capabilities. The *Policy Engine* ***Shall*** request:

- A ***Source_Capabilities*** *Message* if the *Source* is in *SPR Mode* or
- An ***EPR_Source_Capabilities*** *Message* if the *Source* is in *EPR Mode*.

The *Policy Engine* ***Shall*** then increment the ***CapsCounter*** (if implemented).

If a ***GoodCRC*** *Message* is received, then the *Policy Engine* ***Shall***:

- Stop the ***NoResponseTimer***.
- Reset the ***HardResetCounter*** and ***CapsCounter*** to zero.

Note: The ***HardResetCounter*** ***Shall*** only be set to zero in this state and at power up; its value ***Shall*** be maintained during a *Hard Reset*.

- Initialize and run the ***SenderResponseTimer***.

Once a ***Source_Capabilities*** *Message* has been received and acknowledged by a ***GoodCRC*** *Message*, the *Sink* is required to then send a ***Request*** *Message* within ***tSenderResponse***.

The *Policy Engine* ***Shall*** transition to the ***PE_SRC_Negotiate_Capability*** state when:

- A ***Request*** *Message* is received from the *Sink* and the *Source* is operating in *SPR Mode* or
- An ***EPR_Request*** *Message* is received from the *Sink* and the *Source* is operating in *EPR Mode*.

The *Policy Engine* ***Shall*** transition to the ***PE_SRC_Discovery*** state when:

- The *Protocol Layer* indicates that the *Message* has not been sent and we are presently not *Connected*. This is part of the Capabilities sending process whereby successful *Message* sending indicates connection to a PD *Sink Port*.

The *Policy Engine* ***Shall*** transition to the ***PE_SRC_Hard_Reset*** state when:

- The ***SenderResponseTimer*** times out. In this case a transition back to *USB Default Operation* is required.

When:

- The *Port Partner*s have not been PD *Connected* (the *Source Port* remains *Attached* to a Port it has not had a PD Connection with during this *Attachment*)
- And the ***NoResponseTimer*** times out
- And the ***HardResetCounter*** > ***nHardResetCount***.

The *Policy Engine* ***Shall*** do one of the following:

- Transition to the ***PE_SRC_Discovery*** state.
- Transition to the ***PE_SRC_Disabled*** state.

Note: That in either case the *Attached* device is assumed to be unresponsive. The *Policy Engine* ***Should*** operate as if the device is *Detached* until such time as a *Detach*/*Re-attach* is detected.

The *Policy Engine* ***Shall*** go to the ***ErrorRecovery*** state when:

- The *Port Partner*s have previously been PD *Connected* (the *Source Port* remains *Attached* to a Port it has had a PD Connection with during this *Attachment*)
- And the ***NoResponseTimer*** times out.
- And the ***HardResetCounter*** > ***nHardResetCount***.

8.3.3.2.4 PE_SRC_Negotiate_Capability State

On entry to the ***PE_SRC_Negotiate_Capability*** state the *Policy Engine* ***Shall*** ask the *Device Policy Manager* to evaluate the Request from the *Attached Sink*. The response from the *Device Policy Manager* ***Shall*** be one of the following:

- The Request can be met.
- The Request cannot be met
- The Request could be met later from the Power Reserve.

The *Policy Engine* ***Shall*** transition to the ***PE_SRC_Transition_Supply*** state when:

- The Request can be met.

The *Policy Engine* ***Shall*** transition to the ***PE_SRC_Capability_Response*** state when:

- The Request cannot be met.
- Or the Request can be met later from the Power Reserve.

8.3.3.2.5 PE_SRC_Transition_Supply State

The *Policy Engine* ***Shall*** be in the ***PE_SRC_Transition_Supply*** state while the power supply is transitioning from one power to another.

On entry to the ***PE_SRC_Transition_Supply*** state, the *Policy Engine* ***Shall*** request the *Protocol Layer* to send an ***Accept*** *Message* and inform the *Device Policy Manager* that it ***Shall*** transition the power supply to the Requested power level.

Note: If the power supply is currently operating at the requested power no change will be necessary.

On exit from the ***PE_SRC_Transition_Supply*** state the *Policy Engine* ***Shall*** request the *Protocol Layer* to send a ***PS_RDY*** *Message*.

The *Policy Engine* ***Shall*** transition to the ***PE_SRC_Ready*** state when:

- The *Device Policy Manager* informs the *Policy Engine* that the power supply is ready.

The *Policy Engine* ***Shall*** transition to the ***PE_SRC_Hard_Reset*** state when:

- A *Protocol Error* occurs.

8.3.3.2.6 PE_SRC_Ready State

In the ***PE_SRC_Ready*** state the PD *Source* ***Shall*** be operating at a stable power with no ongoing *Negotiation*. It ***Shall*** respond to requests from the *Sink*, events from the *Device Policy Manager*.

On entry to the ***PE_SRC_Ready*** state the *Source* ***Shall*** notify the *Protocol Layer* of the end of the *Atomic Message Sequence* (*AMS*). If the transition into ***PE_SRC_Ready*** is the result of *Protocol Error* that has not caused a *Soft Reset* (see *Section 8.3.3.4.1, "SOP Source Port Soft Reset and Protocol Error State Diagram"*) then the notification to the *Protocol Layer* of the end of the *AMS* ***Shall Not*** be sent since there is a *Message* to be processed.

On entry to the ***PE_SRC_Ready*** state if this is a *VCONN Source* which needs to establish communication with a *Cable Plug*, the *Policy Engine* ***Shall***:

- Initialize and run the ***DiscoverIdentityTimer*** (no ***GoodCRC*** *Message* response yet received to ***Discover Identity*** *Message*).

On entry to the ***PE_SRC_Ready*** state if the current *Explicit Contract* is for an *SPR PPS APDO*, then the *Policy Engine* ***Shall*** do the following:

- Initialize and run the ***SourcePPSCommTimer***.

On entry to the ***PE_SRC_Ready*** state if the current *Explicit Contract* is for *EPR Mode*, then the *Policy Engine* ***Shall*** do the following:

- Initialize and run the ***SourceEPRKeepAliveTimer***.

On exit from the ***PE_SRC_Ready***, if the *Source* is initiating an *AMS*, then the *Policy Engine* ***Shall*** notify the *Protocol Layer* that the first *Message* in an *AMS* will follow.

The *Policy Engine* ***Shall*** transition to the ***PE_SRC_Send_Capabilities*** state when:

- The *Device Policy Manager* indicates that *Source Capabilities* have changed or
- A ***Get_Source_Cap*** *Message* is received, and the *Source* is in *SPR Mode* or
- An ***EPR_Get_Source_Cap*** *Message* is received, and the *Source* is in *EPR Mode*.

The *Policy Engine* ***Shall*** transition to the ***PE_SRC_Negotiate_Capability*** state when:

- A ***Request*** *Message* is received, and the *Source* is in *SPR Mode* or
- An ***EPR_Request*** *Message* is received, and the *Source* is in *EPR Mode*.

The *Policy Engine* ***Shall*** transition to the ***PE_SRC_Get_Sink_Cap*** state when:

- The *Device Policy Manager* asks for the *Sink Capabilities*.

The *Policy Engine* ***Shall*** transition to the ***PE_SRC_Hard_Reset*** state when:

- The *Source* is operating as an *SPR PPS* and the ***SourcePPSCommTimer*** Timer times-out or
- The *Source* is in *EPR Mode* and the ***SourceEPRKeepAliveTimer*** Timer times-out.

The *Policy Engine* ***Shall*** transition to the ***PE_SRC_EPR_Keep_Alive*** state when:

- An ***EPR_KeepAlive*** *Message* is received.

The *Policy Engine* ***Shall*** transition to the ***PE_SRC_Give_Source_Cap*** State when:

- In *EPR Mode* and a ***Get_Source_Cap*** *Message* is received or
- In *SPR Mode* and an ***EPR_Get_Source_Cap*** *Message* is received.

8.3.3.2.7 PE_SRC_Disabled State

In the ***PE_SRC_Disabled*** state the PD *Source* supplies default power and is unresponsive to USB Power Delivery messaging, but not to ***Hard Reset*** *Signaling*.

8.3.3.2.8 PE_SRC_Capability_Response State

The *Policy Engine* ***Shall*** enter the ***PE_SRC_Capability_Response*** state if there is a Request received from the *Sink* that cannot be met based on the present capabilities. When the present *Explicit Contract* is not within the present capabilities it is regarded as ***Invalid*** and a *Hard Reset* will be triggered.

On entry to the ***PE_SRC_Hard_Reset*** state the *Policy Engine* ***Shall*** request the *Protocol Layer* to send one of the following:

- ***Reject*** *Message* **-** if the request cannot be met or the present *Explicit Contract* is ***Invalid***.
- ***Wait*** *Message* **-** if the request could be met later from the Power Reserve. A ***Wait*** *Message* ***Shall Not*** be sent if the present *Explicit Contract* is ***Invalid***.

The *Policy Engine* ***Shall*** transition to the ***PE_SRC_Ready*** state when:

- There is an *Explicit Contract* and
- A ***Reject*** *Message* has been sent and the present *Explicit Contract* is still ***Valid*** or
- A ***Wait*** *Message* has been sent.

The *Policy Engine* ***Shall*** transition to the ***PE_SRC_Hard_Reset*** state when:

- There is an *Explicit Contract* and
- The ***Reject*** *Message* has been sent and the present *Explicit Contract* is ***Invalid*** (i.e., the *Sink* had to request a new value so instead we will return to *USB Default Operation*).

The *Policy Engine* ***Shall*** transition to the ***PE_SRC_Wait_New_Capabilities*** state when:

- There is no *Explicit Contract* and
- A ***Reject*** *Message* has been sent or
- A ***Wait*** *Message* has been sent.

8.3.3.2.9 PE_SRC_Hard_Reset State

The *Policy Engine* ***Shall*** transition to the ***PE_SRC_Hard_Reset*** state from any state when:

- *Hard Reset* request from *Device Policy Manager* or
- In *EPR Mode* and a ***Request*** *Message* is received or
- *EPR Capable* and in *SPR Mode* and an ***EPR_Request*** *Message* is received.

On entry to the ***PE_SRC_Hard_Reset*** state the *Policy Engine* ***Shall***:

- request the generation of ***Hard Reset*** *Signaling* by the PHY Layer
- initialize and run the ***NoResponseTimer***.

Note: The ***NoResponseTimer*** ***Shall*** continue to run in every state until it is stopped or times out.

- initialize and run the ***PSHardResetTimer*** and increment the ***HardResetCounter***.

The *Policy Engine* ***Shall*** transition to the ***PE_SRC_Transition_to_default*** state when:

- The ***PSHardResetTimer*** times out.

8.3.3.2.10 PE_SRC_Hard_Reset_Received State

The *Policy Engine* ***Shall*** transition from any state to the ***PE_SRC_Hard_Reset_Received*** state when:

- ***Hard Reset*** *Signaling* is detected.

On entry to the ***PE_SRC_Hard_Reset_Received*** state the *Policy Engine* ***Shall***:

- initialize and run the ***PSHardResetTimer***
- initialize and run the ***NoResponseTimer***.

Note: The ***NoResponseTimer*** ***Shall*** continue to run in every state until it is stopped or times out.

The *Policy Engine* ***Shall*** transition to the ***PE_SRC_Transition_to_default*** state when:

- The ***PSHardResetTimer*** times out.

8.3.3.2.11 PE_SRC_Transition_to_default State

On entry to the ***PE_SRC_Transition_to_default*** state the *Policy Engine* ***Shall***:

- indicate to the *Device Policy Manager* that the power supply ***Shall*** *Hard Reset* (see *Section 7.1.5, "Response to Hard Resets"*).
- request a reset of the local hardware
- request the *Device Policy Manager* to set the ***Port Data Role*** to *DFP* and turn off *VCONN*.

On exit from the ***PE_SRC_Transition_to_default*** state the *Policy Engine* ***Shall***:

- request the *Device Policy Manager* to turn on *VCONN*
- inform the *Protocol Layer* that the *Hard Reset* is complete.

The *Policy Engine* ***Shall*** transition to the ***PE_SRC_Startup*** state when:

- The *Device Policy Manager* indicates that the power supply has reached the default level.

8.3.3.2.12 PE_SRC_Get_Sink_Cap State

In this state the *Policy Engine*, due to a request from the *Device Policy Manager*, ***Shall*** request the capabilities from the *Attached Sink*.

On entry to the ***PE_SRC_Get_Sink_Cap*** state the *Policy Engine* ***Shall*** request the *Protocol Layer* to send a ***Get_Sink_Cap*** *Message* in order to retrieve the *Sink Capabilities*. The *Policy Engine* ***Shall*** send:

- A ***Get_Sink_Cap*** *Message* when the *Device Policy Manager* requests SPR capabilities or
- An ***EPR_Get_Sink_Cap*** *Message* when the *Device Policy Manager* requests *EPR Capabilities*.

The *Policy Engine* ***Shall*** then start the ***SenderResponseTimer***.

On exit from the ***PE_SRC_Get_Sink_Cap*** state the *Policy Engine* ***Shall*** inform the *Device Policy Manager* of the outcome (capabilities or response timeout).

The *Policy Engine* ***Shall*** transition to the ***PE_SRC_Ready*** state when:

- SPR *Sink Capabilities* were requested and a ***Sink_Capabilities*** *Message* is received or
- EPR *Sink Capabilities* were requested and an ***EPR_Sink_Capabilities*** *Message* is received or
- The ***SenderResponseTimer*** times out.

8.3.3.2.13 PE_SRC_Wait_New_Capabilities State

In this state the *Policy Engine* has been unable to *Negotiate* an *Explicit Contract* and is waiting for new Capabilities from the *Device Policy Manager*.

The *Policy Engine* ***Shall*** transition to the ***PE_SRC_Send_Capabilities*** state when:

- The *Device Policy Manager* indicates that *Source Capabilities* have changed.

8.3.3.2.14 PE_SRC_EPR_Keep_Alive State

On entry to the ***PE_SRC_EPR_Keep_Alive*** State the *Policy Engine* ***Shall*** send a ***EPR_KeepAlive_Ack*** *Message*.

The *Policy Engine* ***Shall*** transition to the ***PE_SRC_Ready*** state when:

- The ***EPR_KeepAlive_Ack*** *Message* has been sent.

8.3.3.2.15 8.3.3.2.15PE_SRC_Give_Source_Cap State

- On entry to the ***PE_SRC_Give_Source_Cap*** State the *Policy Engine* ***Shall*** request the *Device Policy Manager* for the current system capabilities.

The *Policy Engine* ***Shall*** then request the *Protocol Layer* to send a *Source Capabilities Message* containing these capabilities.

The *Policy Engine* ***Shall*** send:

- A ***Source_Capabilities*** *Message* when a ***Get_Source_Cap*** *Message* is received or
- An ***EPR_Source_Capabilities*** *Message* when a ***EPR_Get_Source_Cap*** *Message* is received.

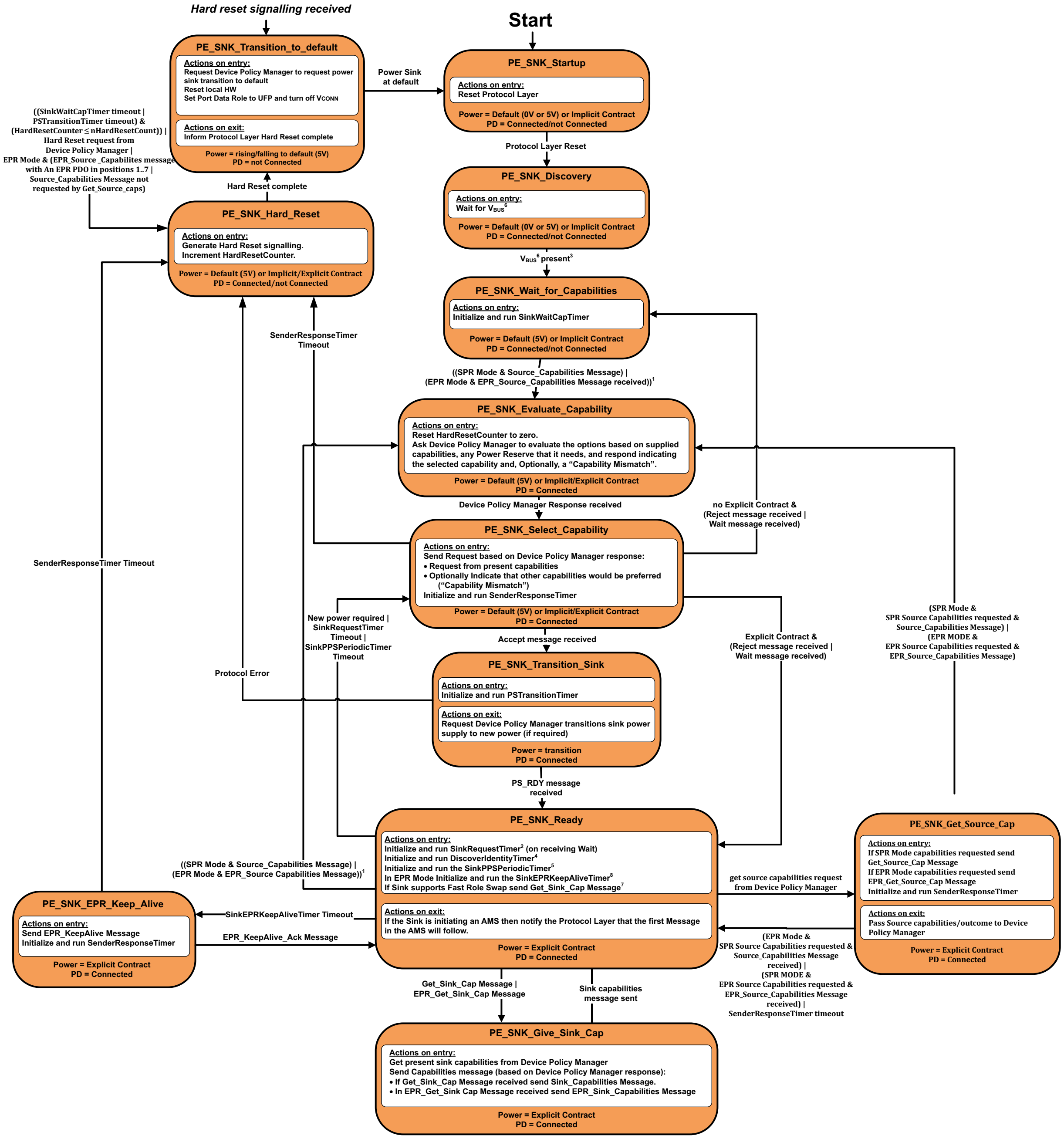
The *Policy Engine* ***Shall*** transition to the ***PE_SNK_Ready*** state when:

- The *Source Capabilities Message* has been successfully sent.

8.3.3.3 Policy Engine Sink Port State Diagram

[*Figure 8.133, "Sink Port State Diagram"*](#) below shows the state diagram for the *Policy Engine* in a *Sink Port*. The following sections describe operation in each of the states.

Figure 8.133 Sink Port State Diagram


Hard reset signalling received
Start
PE_SNK_Transition_to_default
Actions on entry:
Request Device Policy Manager to request power sink transition to default
Reset local HW
Set Port Data Role to UFP and turn off VCONN
Actions on exit:
Inform Protocol Layer Hard Reset complete
Power = rising/falling to default (5V)
PD = not Connected
Power Sink at default
PE_SNK_Startup
Actions on entry:
Reset Protocol Layer
Power = Default (0V or 5V) or Implicit Contract
PD = Connected/not Connected
Protocol Layer Reset
((SinkWaitCapTimer timeout | PSTransitionTimer timeout) & (HardResetCounter ≤ nHardResetCount)) | Hard Reset request from Device Policy Manager | EPR Mode & (EPR_Source _Capabilites message with An EPR PDO in positions 1..7 | Source_Capabilities Message not requested by Get_Source_caps)
Hard Reset complete
PE_SNK_Hard_Reset
Actions on entry:
Generate Hard Reset signalling.
Increment HardResetCounter.
Power = Default (5V) or Implicit/Explicit Contract
PD = Connected/not Connected
PE_SNK_Discovery
Actions on entry:
Wait for V_{BUS}[6]
Power = Default (0V or 5V) or Implicit Contract
PD = Connected/not Connected
V_{BUS}[6] present[3]
PE_SNK_Wait_for_Capabilities
Actions on entry:
Initialize and run SinkWaitCapTimer
Power = Default (5V) or Implicit Contract
PD = Connected/not Connected
SenderResponseTimer Timeout
((SPR Mode & Source_Capabilities Message) | (EPR Mode & EPR_Source_Capabilities Message received))[1]
PE_SNK_Evaluate_Capability
Actions on entry:
Reset HardResetCounter to zero.
Ask Device Policy Manager to evaluate the options based on supplied capabilities, any Power Reserve that it needs, and respond indicating the selected capability and, Optionally, a “Capability Mismatch”.
Power = Default (5V) or Implicit/Explicit Contract
PD = Connected
Device Policy Manager Response received
no Explicit Contract & (Reject message received | Wait message received)
PE_SNK_Select_Capability
Actions on entry:
Send Request based on Device Policy Manager response:
• Request from present capabilities
• Optionally Indicate that other capabilities would be preferred (“Capability Mismatch”)
Initialize and run SenderResponseTimer
Power = Default (5V) or Implicit/Explicit Contract
PD = Connected
SenderResponseTimer Timeout
New power required | SinkRequestTimer Timeout | SinkPPSPeriodicTimer Timeout
Accept message received
Explicit Contract & (Reject message received | Wait message received)
(SPR Mode & SPR Source Capabilities requested & Source_Capabilities Message) | (EPR MODE & EPR Source Capabilities requested & EPR_Source_Capabilities Message)
Protocol Error
PE_SNK_Transition_Sink
Actions on entry:
Initialize and run PSTransitionTimer
Actions on exit:
Request Device Policy Manager transitions sink power supply to new power (if required)
Power = transition
PD = Connected
PS_RDY message received
PE_SNK_Ready
Actions on entry:
Initialize and run SinkRequestTimer[2] (on receiving Wait)
Initialize and run DiscoverIdentityTimer[4]
Initialize and run the SinkPPSPeriodicTimer[5]
In EPR Mode Initialize and run the SinkEPRKeepAliveTimer[8]
If Sink supports Fast Role Swap send Get_Sink_Cap Message[7]
Actions on exit:
If the Sink is initiating an AMS then notify the Protocol Layer that the first Message in the AMS will follow.
Power = Explicit Contract
PD = Connected
((SPR Mode & Source_Capabilities Message) | (EPR Mode & EPR_Source Capabilities Message))[1]
PE_SNK_EPR_Keep_Alive
Actions on entry:
Send EPR_KeepAlive Message
Initialize and run SenderResponseTimer
Power = Explicit Contract
PD = Connected
SinkEPRKeepAliveTimer Timeout
EPR_KeepAlive_Ack Message
get source capabilities request from Device Policy Manager
(EPR Mode & SPR Source Capabilities requested & Source_Capabilities Message received) | (SPR MODE & EPR Source Capabilities requested & EPR_Source_Capabilities Message received) | SenderResponseTimer timeout
PE_SNK_Get_Source_Cap
Actions on entry:
If SPR Mode capabilities requested send Get_Source_Cap Message
If EPR Mode capabilities requested send EPR_Get_Source_Cap Message
Initialize and run SenderResponseTimer
Actions on exit:
Pass Source capabilities/outcome to Device Policy Manager
Power = Explicit Contract
PD = Connected
Get_Sink_Cap Message | EPR_Get_Sink_Cap Message
Sink capabilities message sent
PE_SNK_Give_Sink_Cap
Actions on entry:
Get present sink capabilities from Device Policy Manager
Send Capabilities message (based on Device Policy Manager response):
• If Get_Sink_Cap Message received send Sink_Capabilities Message.
• In EPR_Get_Sink Cap Message received send EPR_Sink_Capabilities Message
Power = Explicit Contract
PD = Connected

1) *Source Capabilities Messages* received in States other than *PE_SNK_Wait_for_Capabilities*, *PE_SNK_Ready* or *PE_SNK_Get_Source_Cap* constitute a *Protocol Error*.

2) The ***SinkRequestTimer*** ***Should Not*** be stopped if a ***Ping*** **(*Deprecated*)** *Message* is received in the *PE_SNK_Ready* state since it represents the maximum time between requests after a ***Wait*** *Message* which is not reset by a ***Ping*** **(*Deprecated*)** *Message*.

3) During a *Hard Reset* the *Source* voltage will transition to ***vSafe0V*** and then transition to ***vSafe5V***. *Sinks* need to ensure that *VBUS* present is not indicated until after the *Source* has completed the *Hard Reset* process by detecting both of these transitions.

4) The ***DiscoverIdentityTimer*** is run when this is a *VCONN Source* and a PD Connection with a *Cable Plug* needs to be established i.e. no ***GoodCRC*** *Message* has yet been received in response to a ***Discover Identity*** *Command*.

5) The ***SinkPPSPeriodicTimer*** is only initialized and run when the present *Explicit Contract* is for an *SPR PPS APDO*. *Sink*s that do not support PPS do not need to implement the ***SinkPPSPeriodicTimer***.

6) A *Sink* that is a *VPD* ***May*** use *VCONN* as a proxy for *VBUS*.

7) To be sent once, and only required if *Fast Role Swap* is supported by the *Sink*.

8.3.3.3.1 PE_SNK_Startup State

PE_SNK_Startup ***Shall*** be the starting state for a *Sink Policy Engine* either on power up or after a *Hard Reset*. On entry to this state the *Policy Engine* ***Shall*** reset the *Protocol Layer*.

Note: Resetting the *Protocol Layer* will also reset the ***MessageIDCounter*** and stored ***MessageID*** (see *Section 6.12.2.3, "Protocol Layer Message Reception"*).

Once the reset process completes, the *Policy Engine* ***Shall*** transition to the ***PE_SNK_Discovery*** state.

8.3.3.3.2 PE_SNK_Discovery State

In the ***PE_SNK_Discovery*** state the *Sink Policy Engine* waits for *VBUS* to be present.

The *Policy Engine* ***Shall*** transition to the ***PE_SNK_Wait_for_Capabilities*** state when:

- The *Device Policy Manager* indicates that *VBUS* has been detected.

8.3.3.3.3 PE_SNK_Wait_for_Capabilities State

On entry to the ***PE_SNK_Wait_for_Capabilities*** state the *Policy Engine* ***Shall*** initialize and start the ***SinkWaitCapTimer***.

The *Policy Engine* ***Shall*** transition to the ***PE_SNK_Evaluate_Capability*** state when:

- The *Sink* is in *SPR Mode* and a ***Source_Capabilities*** *Message* is received or
- The *Sink* is in *EPR Mode* and an ***EPR_Source_Capabilities*** *Message* is received.

When the ***SinkWaitCapTimer*** times out, the *Policy Engine* will perform a *Hard Reset*.

8.3.3.3.4 PE_SNK_Evaluate_Capability State

The ***PE_SNK_Evaluate_Capability*** state is first entered when the *Sink* receives its first ***Source_Capabilities*** *Message* from the *Source*. At this point the *Sink* knows that it is *Attached* to and communicating with a PD capable *Source*.

On entry to the ***PE_SNK_Evaluate_Capability*** state the *Policy Engine* ***Shall*** request the *Device Policy Manager* to evaluate the supplied *Source Capabilities* based on *Local Policy*. The *Device Policy Manager* ***Shall*** indicate to the *Policy Engine* the new power level required, selected from the present offered capabilities. The *Device Policy Manager* ***Shall*** also indicate to the *Policy Engine* a *Capabilities Mismatch* if the offered power does not meet the device's requirements.

The *Policy Engine* ***Shall*** transition to the ***PE_SNK_Select_Capability*** state when:

- A response is received from the *Device Policy Manager*.

8.3.3.3.5 PE_SNK_Select_Capability State

On entry to the ***PE_SNK_Select_Capability*** state the *Policy Engine* ***Shall*** request the *Protocol Layer* to send a response *Message*, based on the evaluation from the *Device Policy Manager*. The *Message* ***Shall*** be one of the following:

- A Request from the offered *Source Capabilities*.

- A Request from the offered *Source Capabilities* with an indication that another power level would be preferred (***Capability Mismatch*** bit set).

When in *SPR Mode* a ***Request*** *Message* ***Shall*** be sent.

When in *EPR Mode* an ***EPR_Request*** *Message* ***Shall*** be sent.

The *Policy Engine* ***Shall*** initialize and run the ***SenderResponseTimer***.

The *Policy Engine* ***Shall*** transition to the ***PE_SNK_Transition_Sink*** state when:

- An ***Accept*** *Message* is received from the *Source*.

The *Policy Engine* ***Shall*** transition to the ***PE_SNK_Wait_for_Capabilities*** state when:

- There is no *Explicit Contract* in place and
- A ***Reject*** *Message* is received from the *Source* or
- A ***Wait*** *Message* is received from the *Source*.

The *Policy Engine* ***Shall*** transition to the ***PE_SNK_Ready*** state when:

- There is an *Explicit Contract* in place and
- A ***Reject*** *Message* is received from the *Source* or
- A ***Wait*** *Message* is received from the *Source*.

The *Policy Engine* ***Shall*** transition to the ***PE_SNK_Hard_Reset*** state when:

- A ***SenderResponseTimer*** timeout occurs.

8.3.3.3.6 PE_SNK_Transition_Sink State

On entry to the ***PE_SNK_Transition_Sink*** state the *Policy Engine* ***Shall*** initialize and run the ***PSTransitionTimer*** (timeout will lead to a *Hard Reset* see *Section 8.3.3.3.8, "PE_SNK_Hard_Reset State"* and ***Shall*** then request the *Device Policy Manager* to transition the *Sink*'s power supply to the new power level.

Note: If there is no power level change the *Device Policy Manager* ***Should Not*** affect any change to the power supply.

On exit from the ***PE_SNK_Transition_Sink*** state the *Policy Engine* ***Shall*** request the *Device Policy Manager* to transition the *Sink*'s power supply to the new power level.

The *Policy Engine* ***Shall*** transition to the ***PE_SNK_Ready*** state when:

- A ***PS_RDY*** *Message* is received from the *Source*.

The *Policy Engine* ***Shall*** transition to the ***PE_SNK_Hard_Reset*** state when:

- A *Protocol Error* occurs.

8.3.3.3.7 PE_SNK_Ready State

In the ***PE_SNK_Ready*** state the PD *Sink* ***Shall*** be operating at a stable power level with no ongoing *Negotiation*. It ***Shall*** respond to requests from the *Source*, events from the *Device Policy Manager*.

On entry to the ***PE_SNK_Ready*** state as the result of a wait the *Policy Engine* ***Should*** do the following:

- Initialize and run the ***SinkRequestTimer***.

On entry to the ***PE_SNK_Ready*** state if this is a *VCONN Source* which needs to establish communication with a *Cable Plug*, then the *Policy Engine* ***Shall*** do the following:

- Initialize and run the ***DiscoverIdentityTimer*** (no ***GoodCRC*** *Message* response yet received to ***Discover Identity*** *Message*).

On entry to the ***PE_SNK_Ready*** state if the current *Explicit Contract* is for an *SPR PPS APDO*, then the *Policy Engine* ***Shall*** do the following:

- Initialize and run the ***SinkPPSPeriodicTimer***.

On entry to the ***PE_SNK_Ready*** state if the *Sink* supports *Fast Role Swap*, then the *Policy Engine* ***Shall*** do the following:

- Send a ***Get_Sink_Cap*** *Message*.

On exit from the ***PE_SNK_Ready*** state, if the transition is as a result of a DPM request to start a new *Atomic Message Sequence* (*AMS*) then the *Policy Engine* ***Shall*** notify the *Protocol Layer* that the first *Message* in an *AMS* will follow.

The *Policy Engine* ***Shall*** transition to the ***PE_SNK_Evaluate_Capability*** state when:

- In *SPR Mode* and a ***Source_Capabilities*** *Message* is received or
- In *EPR Mode* and an ***EPR_Source_Capabilities*** *Message* is received.

The *Policy Engine* ***Shall*** transition to the ***PE_SNK_Select_Capability*** state when:

- A new power level is requested by the *Device Policy Manager* or
- A ***SinkRequestTimer*** timeout occurs or
- A ***SinkPPSPeriodicTimer*** timeout occurs.

The *Policy Engine* ***Shall*** transition to the ***PE_SNK_Give_Sink_Cap*** state when:

- ***Get_Sink_Cap*** *Message* is received or
- ***EPR_Get_Sink_Cap*** *Message* is received.

The *Policy Engine* ***Shall*** transition to the ***PE_SNK_Get_Source_Cap*** state when:

- The *Device Policy Manager* requests an update of the remote *Source Capabilities*.

The *Policy Engine* ***Shall*** transition to the ***PE_SNK_EPR_Keep_Alive*** state when:

- The ***SinkEPRKeepAliveTimer*** timeouts out.

8.3.3.3.8 PE_SNK_Hard_Reset State

The *Policy Engine* ***Shall*** transition to the ***PE_SNK_Hard_Reset*** state from any state when:

- (***PSTransitionTimer*** times out) and
- (***HardResetCounter*** ≤ ***nHardResetCount***)) |
- *Hard Reset* request from *Device Policy Manager* or
- In *EPR Mode* and
  - An ***EPR_Source_Capabilities*** *Message* is received with an *EPR (A)PDO* in object positions 1…7 or
  - A ***Source_Capabilities*** *Message* is received that has not been requested using a ***Get_Source_Cap*** *Message*.

The *Policy Engine* ***May*** transition to the ***PE_SNK_Hard_Reset*** state from any state when:

- ***SinkWaitCapTimer*** times out

Note: If the ***SinkWaitCapTimer*** times out and the ***HardResetCounter*** is greater than ***nHardResetCount*** the *Sink* ***Shall*** assume that the *Source* is non-responsive.

Note: The ***HardResetCounter*** is reset on a power cycle or *Detach*.

On entry to the *PE_SNK_Hard_Reset* state the *Policy Engine* ***Shall*** request the generation of ***Hard Reset*** *Signaling* by the PHY Layer and increment the ***HardResetCounter***.

The *Policy Engine* ***Shall*** transition to the *PE_SNK_Transition_to_default* state when:

- The *Hard Reset* is complete.

8.3.3.3.9 PE_SNK_Transition_to_default State

The *Policy Engine* ***Shall*** transition from any state to *PE_SNK_Transition_to_default* state when:

- ***Hard Reset*** *Signaling* is detected.

When ***Hard Reset*** *Signaling* is received or transmitted then the *Policy Engine* ***Shall*** transition from any state to *PE_SNK_Transition_to_default*. This state can also be entered from the *PE_SNK_Hard_Reset* state.

On entry to the *PE_SNK_Transition_to_default* state the *Policy Engine* ***Shall***:

  - indicate to the *Device Policy Manager* that the *Sink* ***Shall*** transition to default
  - request a reset of the local hardware
  - request the *Device Policy Manager* that the ***Port Data Role*** is set to *UFP*.

The *Policy Engine* ***Shall*** transition to the *PE_SNK_Startup* state when:

- The *Device Policy Manager* indicates that the *Sink* has reached the default level.

8.3.3.3.10 PE_SNK_Give_Sink_Cap State

- On entry to the *PE_SNK_Give_Sink_Cap* state the *Policy Engine* ***Shall*** request the *Device Policy Manager* for the current system capabilities. The *Policy Engine* ***Shall*** then request the *Protocol Layer* to send a ***Sink_Capabilities*** *Message* containing these capabilities. The *Policy Engine* ***Shall*** send:
- A ***Sink_Capabilities*** *Message* when a ***Get_Sink_Cap*** *Message* is received or
- An ***EPR_Sink_Capabilities*** *Message* when a ***EPR_Get_Sink_Cap*** *Message* is received.

The *Policy Engine* ***Shall*** transition to the *PE_SNK_Ready* state when:

- The ***Sink_Capabilities*** *Message* has been successfully sent.

8.3.3.3.11 PE_SNK_EPR_Keep_Alive

On entry to the *PE_SNK_EPR_Keep_Alive* State the *Policy Engine* ***Shall*** send an ***EPR_KeepAlive*** *Message* and initialize and run the ***SenderResponseTimer***.

The *Policy Engine* ***Shall*** transition to the *PE_SNK_Ready* state when:

- A ***EPR_KeepAlive_Ack*** *Message* is received.

The *Policy Engine* ***Shall*** transition to the *PE_SNK_Hard_Reset* state when:

- The ***SenderResponseTimer*** times out.

8.3.3.3.12 PE_SNK_Get_Source_Cap State

- On entry to the *PE_SNK_Get_Source_Cap* state the *Policy Engine* ***Shall*** request the *Protocol Layer* to send a get *Source Capabilities Message* in order to retrieve the *Source Capabilities*. The *Policy Engine* ***Shall*** send:
- A ***Get_Source_Cap*** *Message* when the *Device Policy Manager* requests SPR capabilities or
- An ***EPR_Get_Source_Cap*** *Message* when the *Device Policy Manager* requests *EPR Capabilities*.

The *Policy Engine* ***Shall*** then start the ***SenderResponseTimer***.

On exit from the ***PE_SNK_Get_Source_Cap*** State the *Policy Engine* ***Shall*** inform the *Device Policy Manager* of the outcome (capabilities or response timeout).

The *Policy Engine* ***Shall*** transition to the ***PE_SNK_Ready*** state when:

- In *EPR Mode* and SPR *Source Capabilities* were requested and a ***Source_Capabilities*** *Message* is received or
- In *SPR Mode* and EPR *Source Capabilities* were requested and an ***EPR_Source_Capabilities*** *Message* is received or
- The ***SenderResponseTimer*** times out.

The *Policy Engine* ***Shall*** transition to the ***PE_SNK_Evaluate_Capability*** State when:

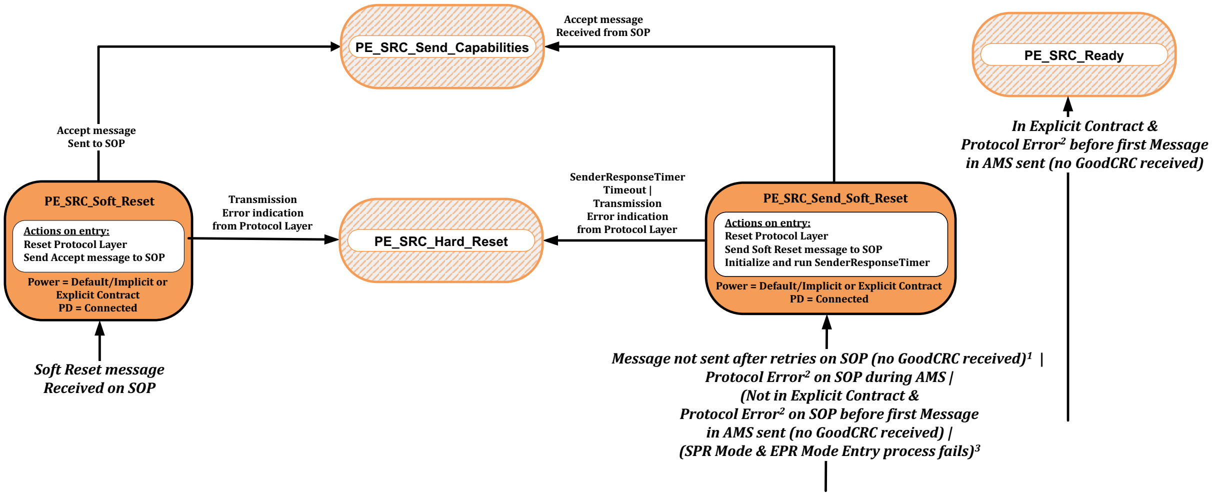
- In *SPR Mode* and SPR *Source Capabilities* were requested and a ***Source_Capabilities*** *Message* is received or
- In *EPR Mode* and EPR *Source Capabilities* were requested and an ***EPR_Source_Capabilities*** *Message* is received.

8.3.3.4 SOP Soft Reset and Protocol Error State Diagrams

8.3.3.4.1 SOP Source Port Soft Reset and Protocol Error State Diagram

Figure 8.134, "SOP Source Port Soft Reset and Protocol Error State Diagram" below shows the state diagram for the *Policy Engine* in a *Source Port* when performing a *Soft Reset* of its *Port Partner* i.e., using *SOP*. The following sections describe operation in each of the states.

Figure 8.134 SOP Source Port Soft Reset and Protocol Error State Diagram



PE_SRC_Send_Capabilities
Accept message Received from SOP
PE_SRC_Ready
Accept message Sent to SOP
In Explicit Contract & Protocol Error² before first Message in AMS sent (no GoodCRC received)
PE_SRC_Soft_Reset
Actions on entry:
Reset Protocol Layer
Send Accept message to SOP
Power = Default/Implicit or Explicit Contract
PD = Connected
Transmission Error indication from Protocol Layer
PE_SRC_Hard_Reset
SenderResponseTimer Timeout | Transmission Error indication from Protocol Layer
PE_SRC_Send_Soft_Reset
Actions on entry:
Reset Protocol Layer
Send Soft Reset message to SOP
Initialize and run SenderResponseTimer
Power = Default/Implicit or Explicit Contract
PD = Connected
Soft Reset message Received on SOP
Message not sent after retries on SOP (no GoodCRC received)¹ | Protocol Error² on SOP during AMS | (Not in Explicit Contract & Protocol Error² on SOP before first Message in AMS sent (no GoodCRC received) | (SPR Mode & EPR Mode Entry process fails)³

[1] Excludes the ***Soft_Reset*** Message itself.

[2] An Unrecognized or Unsupported Message received on ***SOP*** will result in a ***Not_Supported*** Message response being generated on ***SOP*** (see ***Section 6.3.16 "Not_Supported Message"***).

[3] See ***Section 6.4.10.1 "Process to enter EPR Mode"*** for the conditions when a ***Soft_Reset*** Message ***Shall*** be sent by the Source during the EPR Mode entry process.

8.3.3.4.1.1 PE_SRC_Send_Soft_Reset State

The ***PE_SRC_Send_Soft_Reset*** state ***Shall*** be entered from any state when:

- A *Protocol Error* on *SOP* is detected by the *Protocol Layer* during a *Non-interruptible AMS* (see *Section 6.8.1, "Soft Reset and Protocol Error"*) or
- A *Message* has not been sent after retries to the *Sink* or
- When not in an *Explicit Contract* and *Protocol Error*s occurred on *SOP* during any *AMS* where the first *Message* in the *AMS* has not yet been sent i.e., an unexpected *Message* is received instead of the expected ***GoodCRC*** *Message* response or
- When in *SPR Mode* and the *EPR Mode* entry process fails.

The main exceptions to this rule are when:

- The *Source* is in the ***PE_SRC_Send_Capabilities*** state, there is a ***Source_Capabilities*** *Message* sending failure on *SOP* (without a ***GoodCRC*** *Message*) and the *Source* is not presently *Attached* (as indicated in *Figure 8.132, "Source Port State Diagram"*). In this case, the ***PE_SRC_Discovery*** state is entered (see *Section 8.3.3.2.2, "PE_SRC_Discovery State"*).
- When the voltage is in transition due to a new *Explicit Contract* being *Negotiated* (see *Section 8.3.3.2, "Policy Engine Source Port State Diagram"*). In this case ***Hard Reset*** *Signaling* will be generated.
- During a *Power Role Swap* when the power supply is in transition (see *Section 8.3.3.19.3, "Policy Engine in Source to Sink Power Role Swap State Diagram"* and *Section 8.3.3.19.4, "Policy Engine in Sink to Source Power Role Swap State Diagram"*). In this case *USB Type-C Error Recovery* will be triggered directly.
- During a *Data Role Swap* when there is a mismatch in the ***Port Data Role*** field (see *Section 6.2.1.1.6, "Port Data Role"*). In this case *USB Type-C Error Recovery* will be triggered directly.

*Protocol Error*s occurring in the following situations ***Shall Not*** lead to a *Soft Reset*, but ***Shall*** result in a transition to the ***PE_SRC_Ready*** state where the *Message* received will be handled as if it had been received in the ***PE_SRC_Ready*** state:

- When in an *Explicit Contract* and *Protocol Error*s occurred on *SOP* during any *AMS* where the first *Message* in the *AMS* has not yet been sent i.e., an unexpected *Message* is received instead of the expected ***GoodCRC*** *Message* response.

On entry to the ***PE_SRC_Send_Soft_Reset*** state the *Policy Engine* ***Shall*** request the *SOP Protocol Layer* to perform a *Soft Reset*, then ***Shall*** send a ***Soft_Reset*** *Message* to the *Sink* on *SOP*, and initialize and run the ***SenderResponseTimer***.

The *Policy Engine* ***Shall*** transition to the ***PE_SRC_Send_Capabilities*** state when:

- An ***Accept*** *Message* has been received on *SOP*.

The *Policy Engine* ***Shall*** transition to the ***PE_SRC_Hard_Reset*** state when:

- A ***SenderResponseTimer*** timeout occurs.
- Or the *Protocol Layer* indicates that a transmission error has occurred.

8.3.3.4.1.2 PE_SRC_Soft_Reset State

The ***PE_SRC_Soft_Reset*** state ***Shall*** be entered from any state when a ***Soft_Reset*** *Message* is received on *SOP* from the *Protocol Layer*.

On entry to the ***PE_SRC_Soft_Reset*** state the *Policy Engine* ***Shall*** reset the *SOP Protocol Layer* and ***Shall*** then request the *Protocol Layer* to send an ***Accept*** *Message* on *SOP*.

The *Policy Engine* ***Shall*** transition to the ***PE_SRC_Send_Capabilities*** state (see *Section 8.3.3.2.3, "PE_SRC_Send_Capabilities State"*) when:

- The ***Accept*** *Message* has been sent on *SOP*.

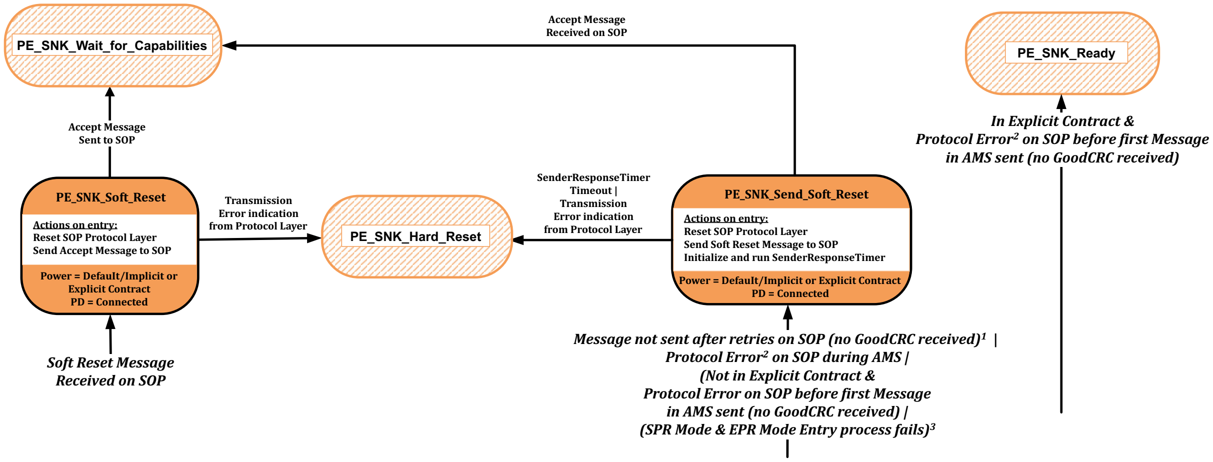
The *Policy Engine* ***Shall*** transition to the ***PE_SRC_Hard_Reset*** state when:

- The *Protocol Layer* indicates that a transmission error has occurred.

8.3.3.4.2 SOP Sink Port Soft Reset and Protocol Error State Diagram

Figure 8.135, "Sink Port Soft Reset and Protocol Error Diagram" below shows the state diagram for the *Policy Engine* in a *Sink Port* when performing a *Soft Reset* of its *Port Partner* i.e., using *SOP*. The following sections describe operation in each of the states.

Figure 8.135 Sink Port Soft Reset and Protocol Error Diagram



PE_SNK_Wait_for_Capabilities
Accept Message Received on SOP
PE_SNK_Ready
Accept Message Sent to SOP
In Explicit Contract & Protocol Error[2] on SOP before first Message in AMS sent (no GoodCRC received)
PE_SNK_Soft_Reset
Actions on entry:
Reset SOP Protocol Layer
Send Accept Message to SOP
Power = Default/Implicit or Explicit Contract
PD = Connected
Transmission Error indication from Protocol Layer
PE_SNK_Hard_Reset
SenderResponseTimer Timeout | Transmission Error indication from Protocol Layer
PE_SNK_Send_Soft_Reset
Actions on entry:
Reset SOP Protocol Layer
Send Soft Reset Message to SOP
Initialize and run SenderResponseTimer
Power = Default/Implicit or Explicit Contract
PD = Connected
Soft Reset Message Received on SOP
Message not sent after retries on SOP (no GoodCRC received)[1] |
Protocol Error[2] on SOP during AMS |
(Not in Explicit Contract &
Protocol Error on SOP before first Message
in AMS sent (no GoodCRC received) |
(SPR Mode & EPR Mode Entry process fails)[3]

[1] Excludes the *Soft_Reset* Message itself.
[2] An Unrecognized or Unsupported Message will result in a *Not_Supported* Message response being generated (see *Section 6.3.16 "Not_Supported Message"*).
[3] See *Section 6.4.10.1 "Process to enter EPR Mode"* for the conditions when a *Soft_Reset* Message ***Shall*** be sent by the Sink during the EPR Mode entry process.

8.3.3.4.2.1 PE_SNK_Send_Soft_Reset State

The *PE_SNK_Send_Soft_Reset* state ***Shall*** be entered from any state when:

- A *Protocol Error* on *SOP* is detected by the *Protocol Layer* during an *AMS* (see *Section 6.8.1, "Soft Reset and Protocol Error"*) or
- A *Message* has not been sent after retries to the *Sink* or
- When not in an *Explicit Contract* and *Protocol Error*s occurred on *SOP* during any *AMS* where the first *Message* in the *AMS* has not yet been sent i.e., an unexpected *Message* is received instead of the expected ***GoodCRC*** *Message* response.
- When in *SPR Mode* and the *EPR Mode* entry process fails.

The main exceptions to this rule are when:

- When the voltage is in transition due to a new *Explicit Contract* being *Negotiated* (see *Section 8.3.3.3, "Policy Engine Sink Port State Diagram"*). In this case a *Hard Reset* will be generated.
- During a *Power Role Swap* when the power supply is in transition (see *Section 8.3.3.19.3, "Policy Engine in Source to Sink Power Role Swap State Diagram"* and *Section 8.3.3.19.4, "Policy Engine in Sink to Source Power Role Swap State Diagram"*). In this case a *Hard Reset* will be triggered directly.
- During a *Data Role Swap* when the *DFP*/*UFP Data Roles* are changing. In this case *USB Type-C Error Recovery* will be triggered directly.

Note: *Protocol Error*s occurring in the following situations ***Shall Not*** lead to a *Soft Reset*, but ***Shall*** result in a transition to the *PE_SNK_Ready* state where the *Message* received will be handled as if it had been received in the *PE_SNK_Ready* state:

- When in an *Explicit Contract* and *Protocol Error*s occurred on *SOP* during any *AMS* where the first *Message* in the *AMS* has not yet been sent i.e., an unexpected *Message* is received instead of the expected ***GoodCRC*** *Message* response.

On entry to the ***PE_SNK_Send_Soft_Reset*** state the *Policy Engine* ***Shall*** request the *SOP Protocol Layer* to perform a *Soft Reset*, then ***Shall*** send a ***Soft_Reset*** *Message* on *SOP* to the *Source*, and initialize and run the ***SenderResponseTimer***.

The *Policy Engine* ***Shall*** transition to the ***PE_SNK_Wait_for_Capabilities*** state when:

- An ***Accept*** *Message* has been received on *SOP*.

The *Policy Engine* ***Shall*** transition to the ***PE_SNK_Hard_Reset*** state when:

- A ***SenderResponseTimer*** timeout occurs.
- Or the *Protocol Layer* indicates that a transmission error has occurred.

8.3.3.4.2.2 PE_SNK_Soft_Reset State

The ***PE_SNK_Soft_Reset*** state ***Shall*** be entered from any state when a ***Soft_Reset*** *Message* is received on *SOP* from the *Protocol Layer*.

On entry to the ***PE_SNK_Soft_Reset*** state the *Policy Engine* ***Shall*** reset the *SOP Protocol Layer* and ***Shall*** then request the *Protocol Layer* to send an ***Accept*** *Message* on *SOP*.

The *Policy Engine* ***Shall*** transition to the ***PE_SNK_Wait_for_Capabilities*** state when:

- The ***Accept*** *Message* has been sent on *SOP*.

The *Policy Engine* ***Shall*** transition to the ***PE_SNK_Hard_Reset*** state when:

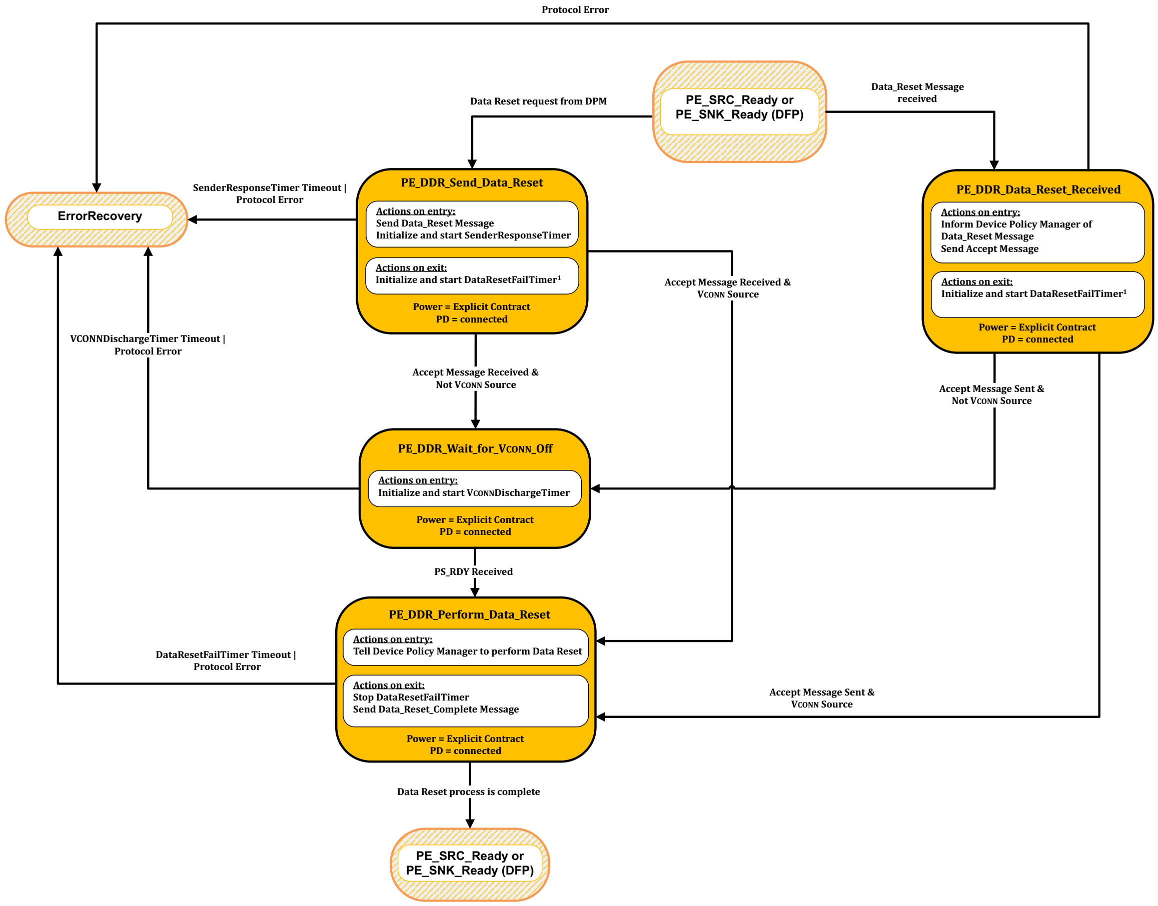
- The *Protocol Layer* indicates that a transmission error has occurred.

8.3.3.5 Data Reset State Diagrams

8.3.3.5.1 DFP Data_Reset Message State Diagrams

Figure 8.136, "DFP Data_Reset Message State Diagram" shows the state diagram for a ***Data_Reset*** *Message* sent or received by a *DFP*.

Figure 8.136 DFP Data_Reset Message State Diagram


Protocol Error
Data Reset request from DPM
PE_SRC_Ready or PE_SNK_Ready (DFP)
Data_Reset Message received
SenderResponseTimer Timeout | Protocol Error
ErrorRecovery
PE_DDR_Send_Data_Reset
Actions on entry:
Send Data_Reset Message
Initialize and start SenderResponseTimer
Actions on exit:
Initialize and start DataResetFailTimer¹
Power = Explicit Contract
PD = connected
PE_DDR_Data_Reset_Received
Actions on entry:
Inform Device Policy Manager of Data_Reset Message
Send Accept Message
Actions on exit:
Initialize and start DataResetFailTimer¹
Power = Explicit Contract
PD = connected
Accept Message Received & VCONN Source
VCONNDischargeTimer Timeout | Protocol Error
Accept Message Received & Not VCONN Source
Accept Message Sent & Not VCONN Source
PE_DDR_Wait_for_VCONN_Off
Actions on entry:
Initialize and start VCONNDischargeTimer
Power = Explicit Contract
PD = connected
PS_RDY Received
PE_DDR_Perform_Data_Reset
Actions on entry:
Tell Device Policy Manager to perform Data Reset
Actions on exit:
Stop DataResetFailTimer
Send Data_Reset_Complete Message
Power = Explicit Contract
PD = connected
DataResetFailTimer Timeout | Protocol Error
Accept Message Sent & VCONN Source
Data Reset process is complete
PE_SRC_Ready or PE_SNK_Ready (DFP)

[1] Note that the ***DataResetFailTimer*** ***Shall*** continue to run in every state until it is stopped or times out.

8.3.3.5.1.1 PE_DDR_Send_Data_Reset State

The ***PE_DDR_Send_Data_Reset*** State ***Shall*** be entered from the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** State when requested by the *Device Policy Manager*.

On entry to the ***PE_DDR_Send_Data_Reset*** State the *Policy Engine* ***Shall*** request the *Protocol Layer* to send a ***Data_Reset*** *Message* and then initialize and start the ***SenderResponseTimer***.

On exit from the ***PE_DDR_Send_Data_Reset*** State the *Policy Engine* ***Shall*** initialize and start the ***DataResetFailTimer***.

The *Policy Engine* ***Shall*** transition to the ***PE_DDR_Perform_Data_Reset*** State when:

- An ***Accept*** *Message* has been received and
- The *DFP* is presently the *VCONN Source*.

The *Policy Engine* ***Shall*** transition to the ***PE_DDR_Wait_For_VCONN_Off*** State when:

- An ***Accept*** *Message* has been received and

- The *DFP* is not presently the *VCONN Source*.

The *Policy Engine* ***Shall*** transition to ***ErrorRecovery*** when:

- A ***SenderResponseTimer*** timeout occurs or
- A *Protocol Error* occurs.

8.3.3.5.1.2 PE_DDR_Data_Reset_Received State

The ***PE_DDR_Data_Reset_Received*** State ***Shall*** be entered from the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** State when a ***Data_Reset*** *Message* is received.

On entry to the ***PE_DDR_Data_Reset_Received*** State the *Policy Engine* ***Shall*** inform the *Device Policy Manager* and then ***Shall*** send an ***Accept*** *Message*.

On exit from the ***PE_DDR_Data_Reset_Received*** State the *Policy Engine* ***Shall*** initialize and start the ***DataResetFailTimer***.

The *Policy Engine* ***Shall*** transition to the ***PE_DDR_Perform_Data_Reset*** State when:

- An ***Accept*** *Message* has been sent and
- The *DFP* is presently the *VCONN Source*.

The *Policy Engine* ***Shall*** transition to the ***PE_DDR_Wait_For_VCONN_Off*** State when:

- An ***Accept*** *Message* has been sent and
- The *DFP* is not presently the *VCONN Source*.

The *Policy Engine* ***Shall*** transition to ***ErrorRecovery*** when:

- A *Protocol Error* occurs.

8.3.3.5.1.3 PE_DDR_Wait_For_VCONN_Off State

On entry to the ***PE_DDR_Wait_For_VCONN_Off*** State the *Policy Engine* ***Shall*** initialize and start the ***VCONNDischargeTimer***.

The *Policy Engine* ***Shall*** transition to the ***PE_DDR_Perform_Data_Reset*** State when:

- A ***PS_RDY*** *Message* is received.

The *Policy Engine* ***Shall*** transition to ***ErrorRecovery*** when:

- The ***VCONNDischargeTimer*** has timed out or
- A *Protocol Error* occurs.

8.3.3.5.1.4 PE_DDR_Perform_Data_Reset State

On entry to the ***PE_DDR_Perform_Data_Reset*** State the *Policy Engine* ***Shall*** request the *Device Policy Manager* to complete the *Data Reset* process as defined in *Section 6.3.14, "Data_Reset Message"*.

On exit from the ***PE_DDR_Perform_Data_Reset*** State the *Policy Engine* ***Shall*** stop the ***DataResetFailTimer*** and send a ***Data_Reset_Complete*** *Message*.

The *Policy Engine* ***Shall*** transition back to either the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** State depending on the *DFP*'s *Power Role* when:

- The DPM indicates that *Data Reset* process is complete (see *Section 6.3.14, "Data_Reset Message"*).

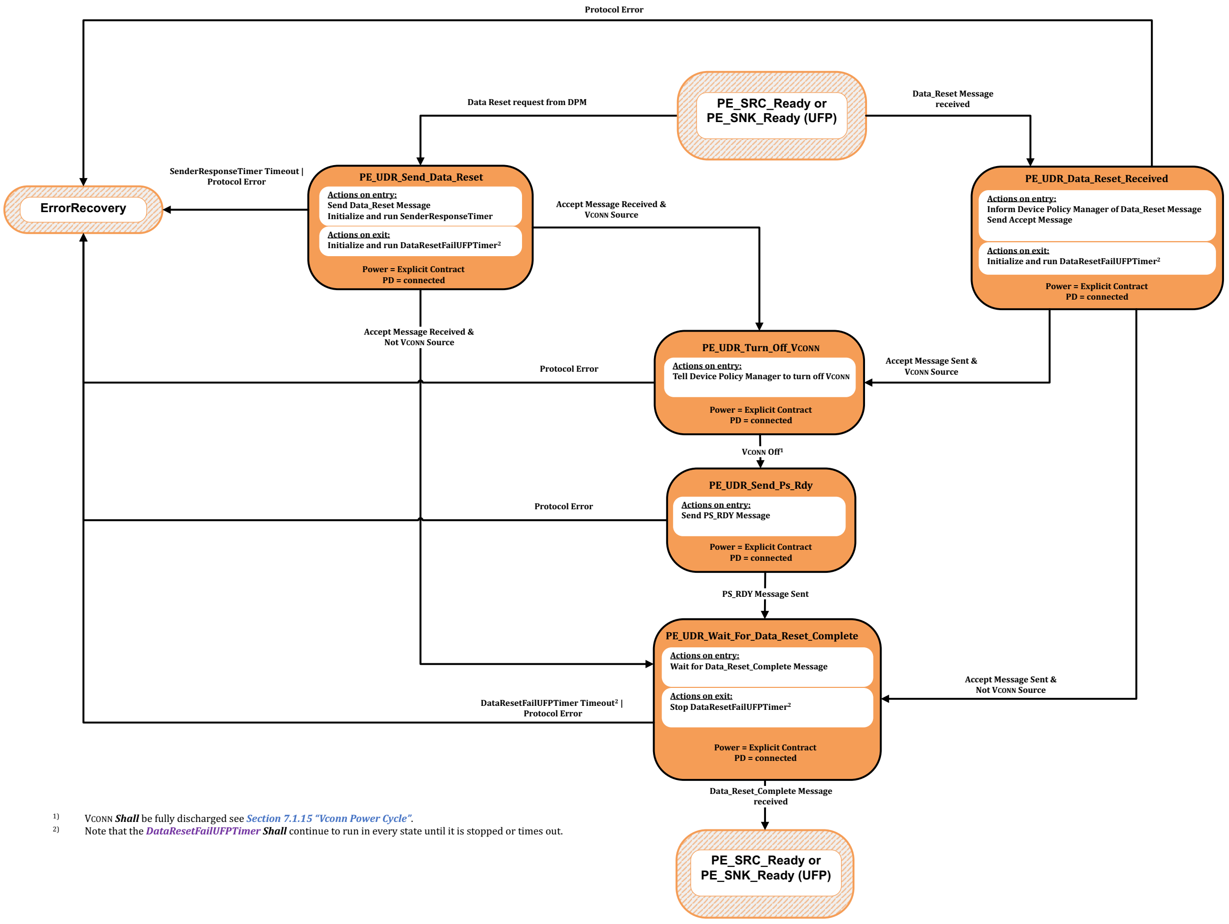
The *Policy Engine* ***Shall*** transition to ***ErrorRecovery*** when:

- The ***DataResetFailTimer*** times out
- A *Protocol Error* occurs.

8.3.3.5.2 UFP Data_Reset Message State Diagrams

Figure 8.137, "UFP Data_Reset Message State Diagram" shows the state diagram for a ***Data_Reset*** *Message* sent or received by a *UFP*.

Figure 8.137 UFP Data_Reset Message State Diagram



1) VCONN ***Shall*** be fully discharged see *Section 7.1.15 "Vconn Power Cycle"*.

2) Note that the ***DataResetFailUFPTimer*** ***Shall*** continue to run in every state until it is stopped or times out.

8.3.3.5.2.1 PE_UDR_Send_Data_Reset State

The *PE_UDR_Send_Data_Reset* State ***Shall*** be entered from the *PE_SRC_Ready* or *PE_SNK_Ready* State when requested by the *Device Policy Manager*.

On entry to the *PE_UDR_Send_Data_Reset* State the *Policy Engine* ***Shall*** request the *Protocol Layer* to send a ***Data_Reset*** *Message* and then initialize and run the ***SenderResponseTimer***.

On exit from the *PE_UDR_Send_Data_Reset* State the *Policy Engine* ***Shall*** initialize and run the ***DataResetFailUFPTimer***.

The *Policy Engine* ***Shall*** transition to the *PE_UDR_Turn_Off_VCONN* State when:

- An ***Accept*** *Message* has been received and
- The *UFP* is presently the *VCONN Source*.

The *Policy Engine* ***Shall*** transition to the *PE_UDR_Wait_For_Data_Reset_Complete* State when:

- An ***Accept*** *Message* has been received and
- The *UFP* is not presently the *VCONN Source*.

The *Policy Engine* ***Shall*** transition to *ErrorRecovery* when:

- The ***SenderResponseTimer*** has timed out or
- A *Protocol Error* occurs.

8.3.3.5.2.2 PE_UDR_Data_Reset_Received State

The ***PE_UDR_Data_Reset_Received*** State ***Shall*** be entered from either the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** State when a ***Data_Reset*** *Message* is received.

On entry to the ***PE_UDR_Data_Reset_Received*** State the *Policy Engine* ***Shall*** inform the *Device Policy Manager* and then ***Shall*** send an ***Accept*** *Message*.

On exit from the ***PE_UDR_Data_Reset_Received*** State the *Policy Engine* ***Shall*** initialize and run the ***DataResetFailUFPTimer***.

The *Policy Engine* ***Shall*** transition to the ***PE_UDR_Turn_Off_VCONN*** State when:

- An ***Accept*** *Message* has been sent and
- The *UFP* is presently the *VCONN Source*.

The *Policy Engine* ***Shall*** transition to the ***PE_UDR_Wait_For_Data_Reset_Complete*** State when:

- An ***Accept*** *Message* has been sent and
- The *UFP* is not presently the *VCONN Source*.

The *Policy Engine* ***Shall*** transition to ***ErrorRecovery*** when:

- A *Protocol Error* occurs.

8.3.3.5.2.3 PE_UDR_Turn_Off_VCONN State

On entry to the ***PE_UDR_Turn_Off_VCONN*** State the *Policy Engine* ***Shall*** request the *Device Policy Manager* to turn off *VCONN*.

The *Policy Engine* ***Shall*** transition to the ***PE_UDR_Send_Ps_Rdy*** State when:

- The DPM indicates that *VCONN* has been turned off (*VCONN* below vRaReconnect see ***[USB Type-C 2.4]***).

The *Policy Engine* ***Shall*** transition to ***ErrorRecovery*** when:

- A *Protocol Error* occurs.

8.3.3.5.2.4 PE_UDR_Send_Ps_Rdy State

On entry to the ***PE_UDR_Send_Ps_Rdy*** State the *Policy Engine* ***Shall*** send a ***PS_RDY*** *Message*.

The *Policy Engine* ***Shall*** transition to the ***PE_UDR_Wait_For_Data_Reset_Complete*** State when:

- The ***PS_RDY*** *Message* has been sent.

The *Policy Engine* ***Shall*** transition to ***ErrorRecovery*** when:

- A *Protocol Error* occurs.

8.3.3.5.2.5 PE_UDR_Wait_For_Data_Reset_Complete State

On entry to the ***PE_UDR_Wait_For_Data_Reset_Complete*** State the *Policy Engine* ***Shall*** wait for the ***Data_Reset_Complete*** *Message*.

On exit from the ***PE_UDR_Wait_For_Data_Reset_Complete*** State the *Policy Engine* ***Shall*** stop the ***DataResetFailUFPTimer***.

The *Policy Engine* ***Shall*** transition back to either the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** State depending on the *UFP*'s *Power Role* when:

- The ***Data_Reset_Complete*** *Message* is received.

The *Policy Engine* ***Shall*** transition to ***ErrorRecovery*** when:

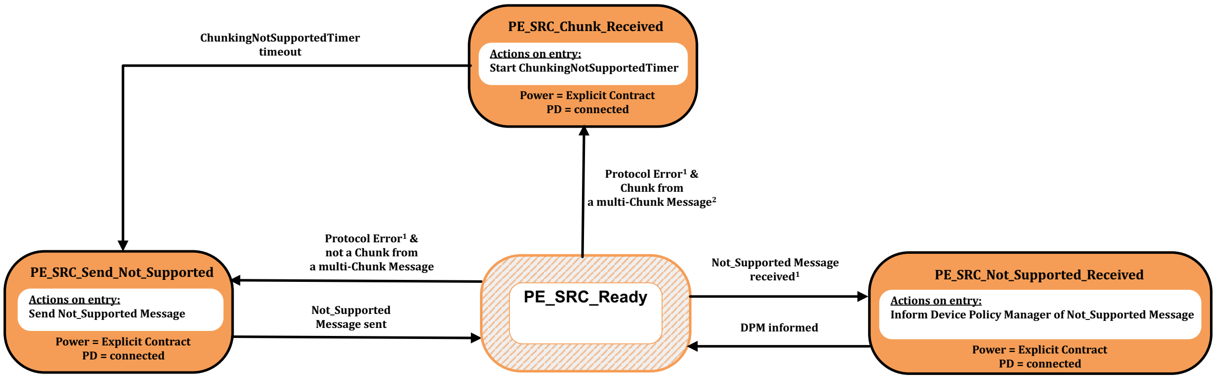
- The ***DataResetFailUFPTimer*** times out or
- A *Protocol Error* occurs.

8.3.3.6 Not Supported Message State Diagrams

8.3.3.6.1 Source Port Not Supported Message State Diagram

Figure 8.138, "Source Port Not Supported Message State Diagram" shows the state diagram for a ***Not_Supported*** *Message* sent or received by a *Source Port*.

Figure 8.138 Source Port Not Supported Message State Diagram


ChunkingNotSupportedTimer timeout
PE_SRC_Chunk_Received
Actions on entry:
Start ChunkingNotSupportedTimer
Power = Explicit Contract
PD = connected
Protocol Error¹ & Chunk from a multi-Chunk Message²
PE_SRC_Send_Not_Supported
Actions on entry:
Send Not_Supported Message
Power = Explicit Contract
PD = connected
Protocol Error¹ & not a Chunk from a multi-Chunk Message
Not_Supported Message sent
PE_SRC_Ready
Not_Supported Message received¹
DPM informed
PE_SRC_Not_Supported_Received
Actions on entry:
Inform Device Policy Manager of Not_Supported Message
Power = Explicit Contract
PD = connected

1) Transition as a result of an unsupported Message being received in the *PE_SRC_Ready* state directly (see also *Section 8.3.3.4.1 "SOP Source Port Soft Reset and Protocol Error State Diagram"*).

2) Transition can only occur where a manufacturer has opted not to implement a Chunking state machine (see *Section 6.12.2.1 "Protocol Layer Chunking"*) and is communicating with a system which is attempting to send it Chunks.

8.3.3.6.1.1 PE_SRC_Send_Not_Supported State

The ***PE_SRC_Send_Not_Supported*** state ***Shall*** be entered from the ***PE_SRC_Ready*** state either as the result of a *Protocol Error* received during an interruptible *AMS* or as a result of an *Unsupported Message* being received in the ***PE_SRC_Ready*** state directly except for the first *Chunk* in a multi-*Chunk Message* (see also *Section 6.12.2.1, "Protocol Layer Chunking"* and *Section 8.3.3.4.1, "SOP Source Port Soft Reset and Protocol Error State Diagram"*).

On entry to the ***PE_SRC_Send_Not_Supported*** state (from the ***PE_SRC_Ready*** state) the *Policy Engine* ***Shall*** request the *Protocol Layer* to send a ***Not_Supported*** *Message*.

The *Policy Engine* ***Shall*** transition back to the previous state (***PE_SRC_Ready*** see *Figure 8.132, "Source Port State Diagram"*) when:

- The ***Not_Supported*** *Message* has been successfully sent.

8.3.3.6.1.2 PE_SRC_Not_Supported_Received State

The ***PE_SRC_Not_Supported_Received*** state ***Shall*** be entered from the ***PE_SRC_Ready*** state when a ***Not_Supported*** *Message* is received.

On entry to the ***PE_SRC_Not_Supported_Received*** state the *Policy Engine* ***Shall*** inform the *Device Policy Manager*.

The *Policy Engine* ***Shall*** transition back to the previous state (***PE_SRC_Ready*** see *Figure 8.132, "Source Port State Diagram"*) when:

- The *Device Policy Manager* has been informed.

8.3.3.6.1.3 PE_SRC_Chunk_Received State

The ***PE_SRC_Chunk_Received*** state ***Shall*** be entered from the ***PE_SRC_Ready*** state as a result of an *Unsupported Message* being received in the ***PE_SRC_Ready*** state directly where the *Message* is a *Chunk* in a multi-*Chunk Message* (see also *Section 6.12.2.1, "Protocol Layer Chunking"* and *Section 8.3.3.4.1, "SOP Source Port Soft Reset and Protocol Error State Diagram"*).

On entry to the ***PE_SRC_Chunk_Received*** state (from the ***PE_SRC_Ready*** state) the *Policy Engine* ***Shall*** initialize and run the ***ChunkingNotSupportedTimer***.

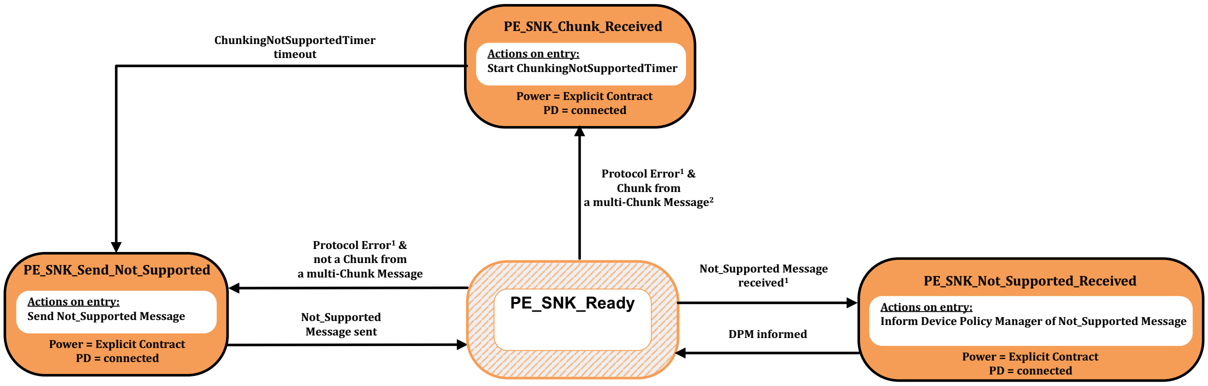
The *Policy Engine* ***Shall*** transition to ***PE_SRC_Send_Not_Supported*** when:

- The ***ChunkingNotSupportedTimer*** has timed out.

8.3.3.6.2 Sink Port Not Supported Message State Diagram

Figure 8.139, "Sink Port Not Supported Message State Diagram" shows the state diagram for a ***Not_Supported*** *Message* sent or received by a *Sink Port*.

Figure 8.139 Sink Port Not Supported Message State Diagram


PE_SNK_Chunk_Received
Actions on entry:
Start ChunkingNotSupportedTimer
Power = Explicit Contract
PD = connected
ChunkingNotSupportedTimer timeout
Protocol Error[1] & Chunk from a multi-Chunk Message[2]
PE_SNK_Send_Not_Supported
Actions on entry:
Send Not_Supported Message
Power = Explicit Contract
PD = connected
Protocol Error[1] & not a Chunk from a multi-Chunk Message
Not_Supported Message sent
PE_SNK_Ready
Not_Supported Message received[1]
DPM informed
PE_SNK_Not_Supported_Received
Actions on entry:
Inform Device Policy Manager of Not_Supported Message
Power = Explicit Contract
PD = connected

[1] Transition as a result of an unsupported Message being received in the *PE_SNK_Ready* state directly (see also *Section 8.3.3.4.2 "SOP Sink Port Soft Reset and Protocol Error State Diagram"*).

[2] Transition can only occur where a manufacturer has opted not to implement a Chunking state machine (see *Section 6.12.2.1 "Protocol Layer Chunking"*) and is communicating with a system which is attempting to send it Chunks.

8.3.3.6.2.1 PE_SNK_Send_Not_Supported State

The ***PE_SNK_Send_Not_Supported*** state ***Shall*** be entered from the ***PE_SNK_Ready*** state either as the result of a *Protocol Error* received during an interruptible *AMS* or as a result of an *Unsupported Message* being received in the ***PE_SNK_Ready*** state directly except for the first *Chunk* in a multi-*Chunk Message* (see also *Section 6.12.2.1, "Protocol Layer Chunking"* and *Section 8.3.3.4.1, "SOP Source Port Soft Reset and Protocol Error State Diagram"*).

On entry to the ***PE_SNK_Send_Not_Supported*** state (from the ***PE_SNK_Ready*** state) the *Policy Engine* ***Shall*** request the *Protocol Layer* to send a ***Not_Supported*** *Message*.

The *Policy Engine* ***Shall*** transition back to the previous state (***PE_SNK_Ready*** see *Figure 8.133, "Sink Port State Diagram"*) when:

- The ***Not_Supported*** *Message* has been successfully sent.

8.3.3.6.2.2 PE_SNK_Not_Supported_Received State

The ***PE_SNK_Not_Supported_Received*** state ***Shall*** be entered from the ***PE_SNK_Ready*** state when a ***Not_Supported*** *Message* is received.

On entry to the ***PE_SNK_Not_Supported_Received*** state the *Policy Engine* ***Shall*** inform the *Device Policy Manager*.

The *Policy Engine* ***Shall*** transition back to the previous state (***PE_SNK_Ready*** see *Figure 8.133, "Sink Port State Diagram"*) when:

- The *Device Policy Manager* has been informed.

8.3.3.6.2.3 PE_SNK_Chunk_Received State

The ***PE_SNK_Chunk_Received*** state ***Shall*** be entered from the ***PE_SNK_Ready*** state as a result of an *Unsupported Message* being received in the ***PE_SNK_Ready*** state directly where the *Message* is a *Chunk* in a multi-*Chunk Message* (see also *Section 6.12.2.1, "Protocol Layer Chunking"* and *Section 8.3.3.4.1, "SOP Source Port Soft Reset and Protocol Error State Diagram"*).

On entry to the ***PE_SNK_Chunk_Received*** state (from the ***PE_SNK_Ready*** state) the *Policy Engine* ***Shall*** initialize and run the ***ChunkingNotSupportedTimer***.

The *Policy Engine* ***Shall*** transition to ***PE_SNK_Send_Not_Supported*** when:

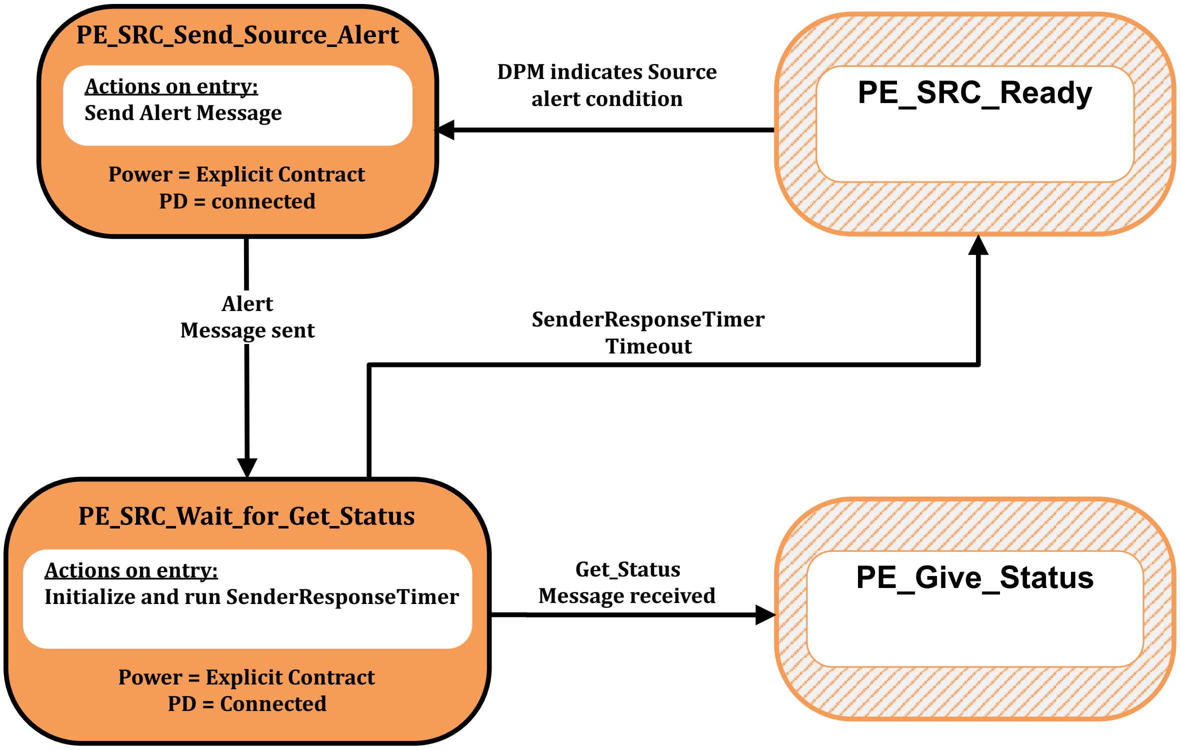
- The ***ChunkingNotSupportedTimer*** has timed out.

8.3.3.7 Alert State Diagrams

8.3.3.7.1 Source Port Source Alert State Diagram

Figure 8.140, "Source Port Source Alert State Diagram" shows the state diagram for an ***Alert*** *Message* sent by a *Source Port*.

Figure 8.140 Source Port Source Alert State Diagram


PE_SRC_Send_Source_Alert
Actions on entry:
Send Alert Message
Power = Explicit Contract
PD = connected
DPM indicates Source alert condition
PE_SRC_Ready
Alert Message sent
SenderResponseTimer Timeout
PE_SRC_Wait_for_Get_Status
Actions on entry:
Initialize and run SenderResponseTimer
Power = Explicit Contract
PD = Connected
Get_Status Message received
PE_Give_Status

8.3.3.7.1.1 PE_SRC_Send_Source_Alert State

The ***PE_SRC_Send_Source_Alert*** state ***Shall*** be entered from the ***PE_SRC_Ready*** state when the *Device Policy Manager* indicates that there is a *Source* alert condition to be reported.

On entry to the ***PE_SRC_Send_Source_Alert*** state the *Policy Engine* ***Shall*** request the *Protocol Layer* to send an ***Alert*** *Message*.

The *Policy Engine* ***Shall*** transition to the ***PE_SRC_Wait_for_Get_Status*** State when:

- The ***Alert*** *Message* has been successfully sent.

8.3.3.7.1.2 PE_SRC_Wait_for_Get_Status State

On entry to the ***PE_SRC_Wait_for_Get_Status*** State the *Policy Engine* ***Shall*** initialize and run the ***SenderResponseTimer***.

The *Policy Engine* ***Shall*** transition back to the ***PE_Give_Status*** State (see *Figure 8.151, "Give Status State Diagram"*) when:

- A ***Get_Status*** *Message* is received.

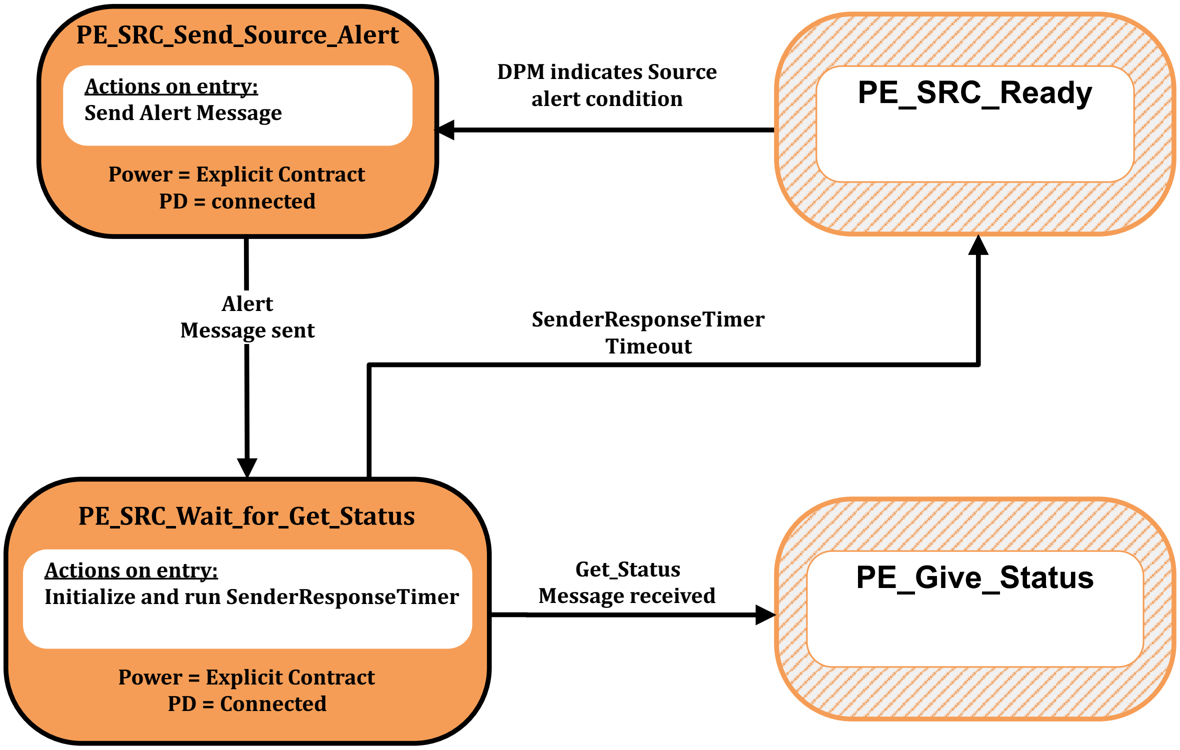
The *Policy Engine* ***Shall*** transition back to ***PE_SRC_Ready*** (see *Figure 8.132, "Source Port State Diagram"*) when:

- The ***SenderResponseTimer*** times out.

8.3.3.7.2 Sink Port Source Alert State Diagram

Figure 8.141, "Sink Port Source Alert State Diagram" shows the state diagram for an ***Alert*** *Message* received by a *Sink Port*.

Figure 8.141 Sink Port Source Alert State Diagram



8.3.3.7.2.1 PE_SNK_Source_Alert_Received State

The ***PE_SNK_Source_Alert_Received*** state ***Shall*** be entered from the ***PE_SNK_Ready*** state when an ***Alert*** *Message* is received.

On entry to the ***PE_SNK_Source_Alert_Received*** state the *Policy Engine* ***Shall*** inform the *Device Policy Manager* of the details of the *Source* alert.

The *Policy Engine* ***Shall*** transition to the ***PE_Get_Status*** State (see *Figure 8.150, "Get Status State Diagram"*) when:

- The DPM requests status.

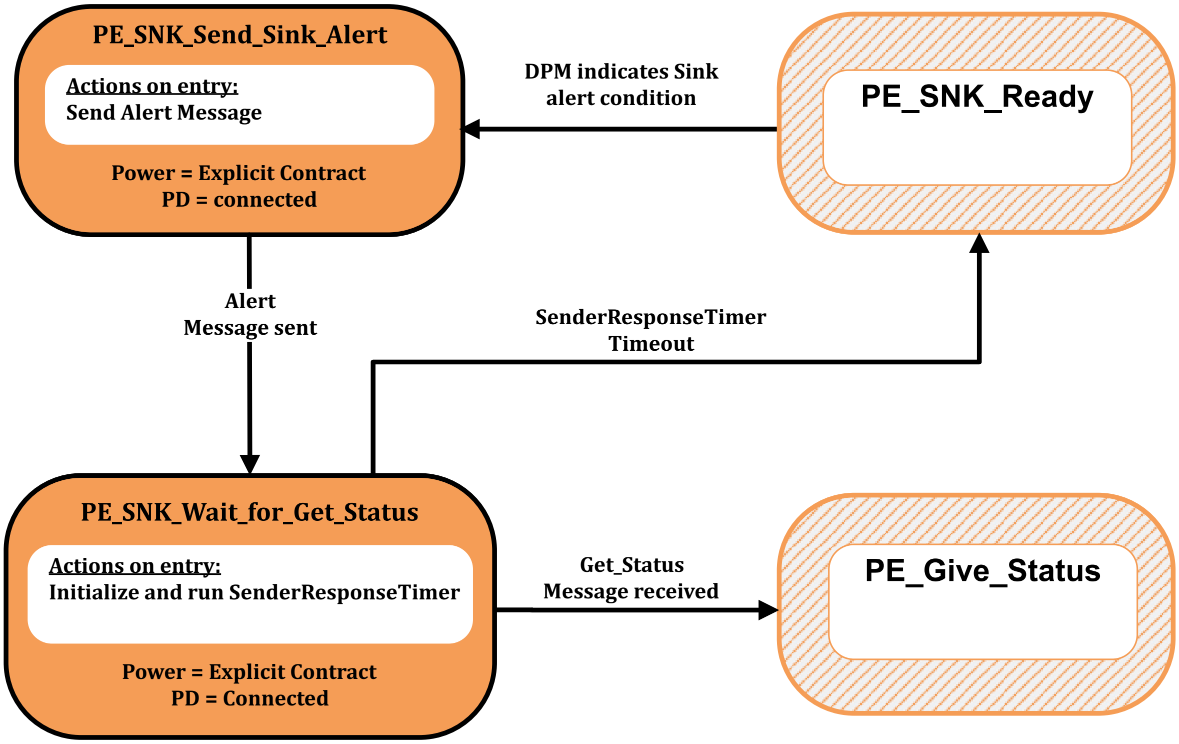
The *Policy Engine* ***Shall*** transition back to the ***PE_SNK_Ready*** State (see *Figure 8.133, "Sink Port State Diagram"*) when:

- The DPM does not request status.

8.3.3.7.3 Sink Port Sink Alert State Diagram

Figure 8.142, "Sink Port Sink Alert State Diagram" shows the state diagram for an ***Alert*** *Message* sent by a *Sink Port*.

Figure 8.142 Sink Port Sink Alert State Diagram


PE_SNK_Send_Sink_Alert
Actions on entry:
Send Alert Message
Power = Explicit Contract
PD = connected
DPM indicates Sink alert condition
PE_SNK_Ready
Alert Message sent
SenderResponseTimer Timeout
PE_SNK_Wait_for_Get_Status
Actions on entry:
Initialize and run SenderResponseTimer
Power = Explicit Contract
PD = Connected
Get_Status Message received
PE_Give_Status

8.3.3.7.3.1 PE_SNK_Send_Sink_Alert State

The ***PE_SNK_Send_Sink_Alert*** state ***Shall*** be entered from the ***PE_SNK_Ready*** state when the *Device Policy Manager* indicates that there is a *Source* alert condition to be reported.

On entry to the ***PE_SNK_Send_Sink_Alert*** state the *Policy Engine* ***Shall*** request the *Protocol Layer* to send an ***Alert*** *Message*.

The *Policy Engine* ***Shall*** transition to the ***PE_SNK_Wait_for_Get_Status*** State when:

- The ***Alert*** *Message* has been successfully sent.

8.3.3.7.3.2 PE_SNK_Wait_for_Get_Status State

On entry to the ***PE_SNK_Wait_for_Get_Status*** State the *Policy Engine* ***Shall*** initialize and run the ***SenderResponseTimer***.

The *Policy Engine* ***Shall*** transition back to the ***PE_Give_Status*** State (see *Figure 8.151, "Give Status State Diagram"*) when:

- A ***Get_Status*** *Message* is received.

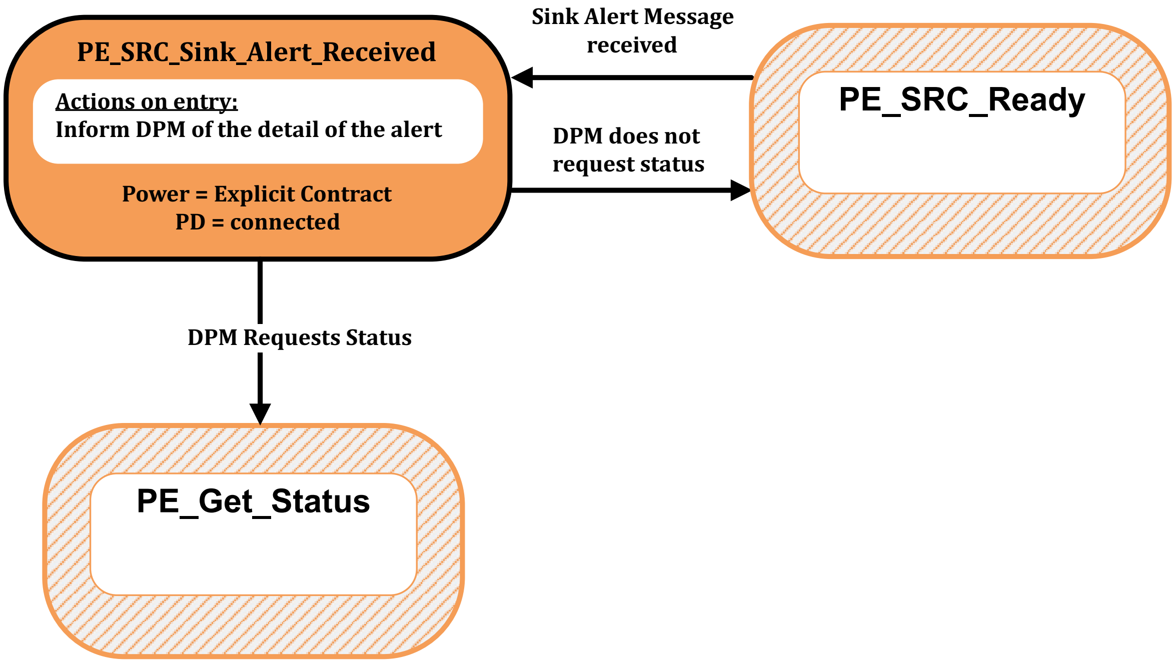
The *Policy Engine* ***Shall*** transition back to the ***PE_SNK_Ready*** (see *Figure 8.133, "Sink Port State Diagram"*) when:

- The ***SenderResponseTimer*** times out.

8.3.3.7.4 Source Port Sink Alert State Diagram

Figure 8.143, "Source Port Sink Alert State Diagram" shows the state diagram for an ***Alert*** *Message* received by a *Source Port*.

Figure 8.143 Source Port Sink Alert State Diagram


PE_SRC_Sink_Alert_Received
Actions on entry:
Inform DPM of the detail of the alert
Power = Explicit Contract
PD = connected
Sink Alert Message received
DPM does not request status
PE_SRC_Ready
DPM Requests Status
PE_Get_Status

8.3.3.7.4.1 PE_SRC_Sink_Alert_Received State

The ***PE_SRC_Sink_Alert_Received*** state ***Shall*** be entered from the ***PE_SRC_Ready*** state when an ***Alert*** *Message* is received.

On entry to the ***PE_SRC_Sink_Alert_Received*** state the *Policy Engine* ***Shall*** inform the *Device Policy Manager* of the details of the *Source* alert.

The *Policy Engine* ***Shall*** transition to the ***PE_Get_Status*** State (see *Figure 8.150, "Get Status State Diagram"*) when:

- The DPM requests status.

The *Policy Engine* ***Shall*** transition back to the ***PE_SRC_Ready*** (see *Figure 8.132, "Source Port State Diagram"*) when:

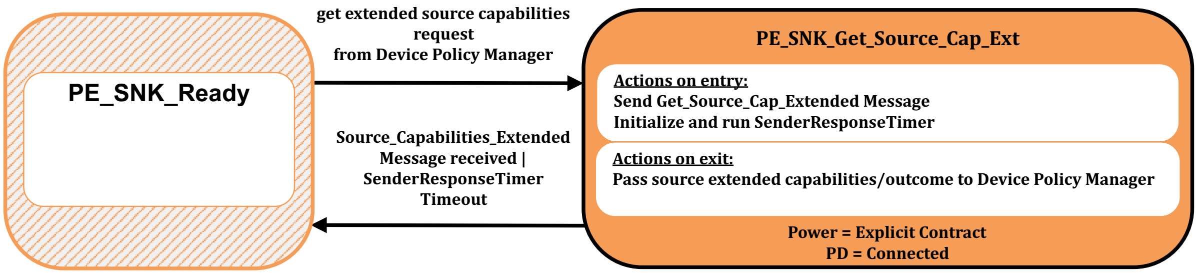
- The DPM does not request status.

8.3.3.8 Source/Sink Capabilities Extended State Diagrams

8.3.3.8.1 Sink Port Get Source Capabilities Extended State Diagram

Figure 8.144, "Sink Port Get Source Capabilities Extended State Diagram" shows the state diagram for a *Sink* on receiving a request from the *Device Policy Manager* to get the *Port Partner*'s extended *Source Capabilities*. See also *Section 6.5.1, "Source_Capabilities_Extended Message"*.

Figure 8.144 Sink Port Get Source Capabilities Extended State Diagram


PE_SNK_Ready
get extended source capabilities request from Device Policy Manager
Source_Capabilities_Extended Message received | SenderResponseTimer Timeout
PE_SNK_Get_Source_Cap_Ext
Actions on entry:
Send Get_Source_Cap_Extended Message
Initialize and run SenderResponseTimer
Actions on exit:
Pass source extended capabilities/outcome to Device Policy Manager
Power = Explicit Contract
PD = Connected

8.3.3.8.1.1 PE_SNK_Get_Source_Cap_Ext State

The *Policy Engine **Shall*** transition to the ***PE_SNK_Get_Source_Cap_Ext*** state, from the ***PE_SNK_Ready*** state, due to a request to get the remote extended *Source Capabilities* from the *Device Policy Manager*.

On entry to the ***PE_SNK_Get_Source_Cap_Ext*** state the *Policy Engine **Shall*** send a ***Get_Source_Cap_Extended*** *Message* and initialize and run the ***SenderResponseTimer***.

On exit from the ***PE_SNK_Get_Source_Cap_Ext*** state the *Policy Engine **Shall*** inform the *Device Policy Manager* of the outcome (capabilities or response timeout).

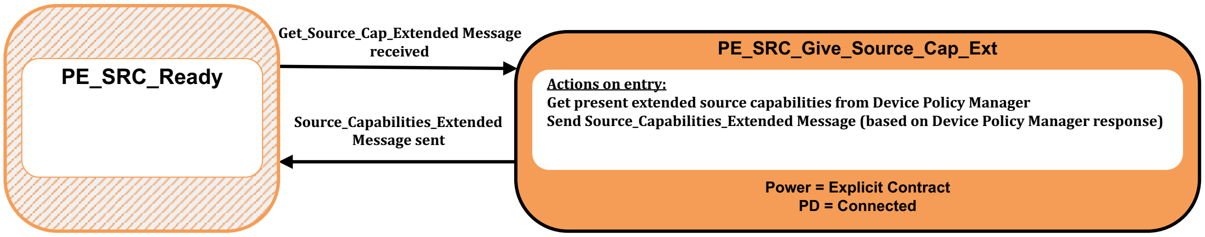
The *Policy Engine **Shall*** transition back to the ***PE_SNK_Ready*** state (see *Figure 8.133, "Sink Port State Diagram"*) when:

- A ***Source_Capabilities_Extended*** *Message* is received
- Or ***SenderResponseTimer*** times out.

8.3.3.8.2 Source Give Source Capabilities Extended State Diagram

Figure 8.145, "Source Give Source Capabilities Extended State Diagram" shows the state diagram for a *Source* on receiving a ***Get_Source_Cap_Extended*** *Message*. See also *Section 6.5.1, "Source_Capabilities_Extended Message"*.

Figure 8.145 Source Give Source Capabilities Extended State Diagram


PE_SRC_Ready
Get_Source_Cap_Extended Message received
Source_Capabilities_Extended Message sent
PE_SRC_Give_Source_Cap_Ext
Actions on entry:
Get present extended source capabilities from Device Policy Manager
Send Source_Capabilities_Extended Message (based on Device Policy Manager response)
Power = Explicit Contract
PD = Connected

8.3.3.8.2.1 PE_SRC_Give_Source_Cap_Ext State

The *Policy Engine* ***Shall*** transition to the ***PE_SRC_Give_Source_Cap_Ext*** state, from the ***PE_SRC_Ready*** state, when a ***Get_Source_Cap_Extended*** *Message* is received.

On entry to the ***PE_SRC_Give_Source_Cap_Ext*** state the *Policy Engine* ***Shall*** request the present extended *Source Capabilities* from the *Device Policy Manager* and then send a ***Source_Capabilities_Extended*** *Message* based on these capabilities.

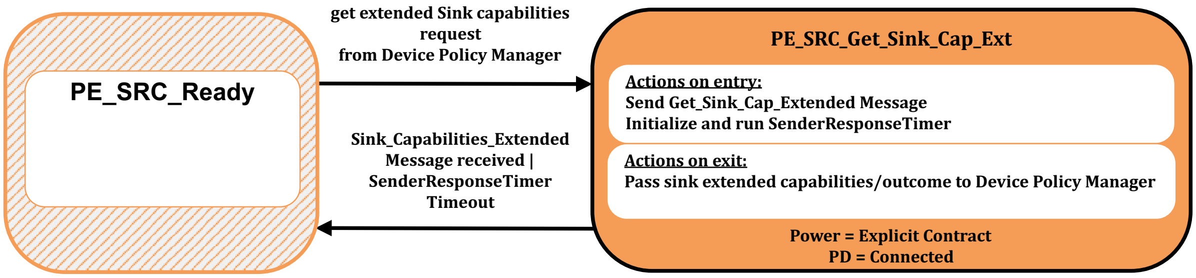
The *Policy Engine* ***Shall*** transition back to the ***PE_SRC_Ready*** state (see *Figure 8.132, "Source Port State Diagram"*) when:

- The ***Source_Capabilities_Extended*** *Message* has been successfully sent.

8.3.3.8.3 Source Port Get Sink Capabilities Extended State Diagram

Figure 8.146, "Source Port Get Sink Capabilities Extended State Diagram" shows the state diagram for a *Source* on receiving a request from the *Device Policy Manager* to get the *Port Partner*'s extended *Sink Capabilities*. See also *Section 6.5.13, "Sink_Capabilities_Extended Message"*.

Figure 8.146 Source Port Get Sink Capabilities Extended State Diagram


PE_SRC_Ready
get extended Sink capabilities request from Device Policy Manager
Sink_Capabilities_Extended Message received | SenderResponseTimer Timeout
PE_SRC_Get_Sink_Cap_Ext
Actions on entry:
Send Get_Sink_Cap_Extended Message
Initialize and run SenderResponseTimer
Actions on exit:
Pass sink extended capabilities/outcome to Device Policy Manager
Power = Explicit Contract
PD = Connected

8.3.3.8.3.1 PE_SRC_Get_Sink_Cap_Ext State

The *Policy Engine* ***Shall*** transition to the ***PE_SRC_Get_Sink_Cap_Ext*** state, from the ***PE_SRC_Ready*** state, due to a request to get the remote extended *Source Capabilities* from the *Device Policy Manager*.

On entry to the ***PE_SRC_Get_Sink_Cap_Ext*** state the *Policy Engine* ***Shall*** send a ***Get_Sink_Cap_Extended*** *Message* and initialize and run the ***SenderResponseTimer***.

On exit from the ***PE_SRC_Get_Sink_Cap_Ext*** state the *Policy Engine* ***Shall*** inform the *Device Policy Manager* of the outcome (capabilities or response timeout).

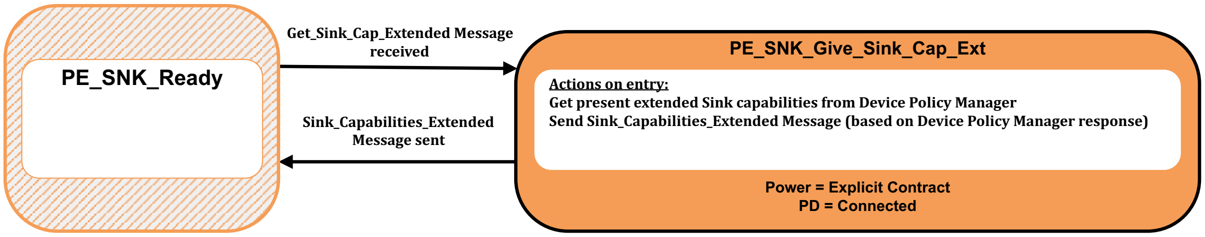
The *Policy Engine* ***Shall*** transition back to the ***PE_SRC_Ready*** state (see *Figure 8.132, "Source Port State Diagram"*) when:

- A ***Sink_Capabilities_Extended*** *Message* is received
- Or ***SenderResponseTimer*** times out.

8.3.3.8.4 Sink Give Sink Capabilities Extended State Diagram

Figure 8.147, "Sink Give Sink Capabilities Extended State Diagram" shows the state diagram for a *Source* on receiving a ***Get_Sink_Cap_Extended*** *Message*. See also *Section 6.5.13, "Sink_Capabilities_Extended Message"*.

Figure 8.147 Sink Give Sink Capabilities Extended State Diagram



PE_SNK_Ready
Get_Sink_Cap_Extended Message received
Sink_Capabilities_Extended Message sent
PE_SNK_Give_Sink_Cap_Ext
Actions on entry:
Get present extended Sink capabilities from Device Policy Manager
Send Sink_Capabilities_Extended Message (based on Device Policy Manager response)
Power = Explicit Contract
PD = Connected

8.3.3.8.4.1 PE_SNK_Give_Sink_Cap_Ext State

The *Policy Engine* ***Shall*** transition to the ***PE_SNK_Give_Sink_Cap_Ext*** state, from the ***PE_SNK_Ready*** state, when a ***Get_Sink_Cap_Extended*** *Message* is received.

On entry to the ***PE_SNK_Give_Sink_Cap_Ext*** state the *Policy Engine* ***Shall*** request the present extended *Source Capabilities* from the *Device Policy Manager* and then send a ***Sink_Capabilities_Extended*** *Message* based on these capabilities.

The *Policy Engine* ***Shall*** transition back to the ***PE_SNK_Ready*** state (see *Figure 8.133, "Sink Port State Diagram"*) when:

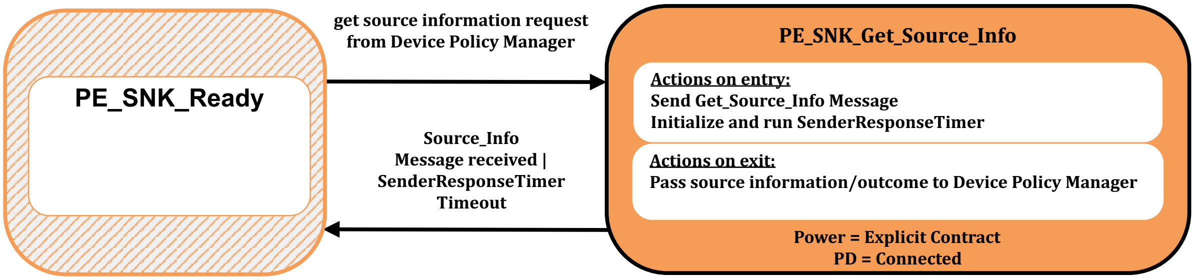
- The ***Sink_Capabilities_Extended*** *Message* has been successfully sent.

8.3.3.9 Source Information State Diagrams

8.3.3.9.1 Sink Port Get Source Information State Diagram

Figure 8.148, "Sink Port Get Source Information State Diagram" shows the state diagram for a *Sink* on receiving a request from the *Device Policy Manager* to get the *Port Partner*'s *Source* information. See also *Section 6.3.23, "Get_Source_Info Message"* and *Section 6.4.11, "Source_Info Message"*.

Figure 8.148 Sink Port Get Source Information State Diagram


PE_SNK_Ready
get source information request
from Device Policy Manager
Source_Info
Message received |
SenderResponseTimer
Timeout
PE_SNK_Get_Source_Info
Actions on entry:
Send Get_Source_Info Message
Initialize and run SenderResponseTimer
Actions on exit:
Pass source information/outcome to Device Policy Manager
Power = Explicit Contract
PD = Connected

8.3.3.9.1.1 PE_SNK_Get_Source_Info State

The *Policy Engine* ***Shall*** transition to the ***PE_SNK_Get_Source_Info*** state, from the ***PE_SNK_Ready*** state, due to a request to get the remote *Source* information from the *Device Policy Manager*.

On entry to the ***PE_SNK_Get_Source_Info*** state the *Policy Engine* ***Shall*** send a ***Get_Source_Info*** *Message* and initialize and run the ***SenderResponseTimer***.

On exit from the ***PE_SNK_Get_Source_Info*** state the *Policy Engine* ***Shall*** inform the *Device Policy Manager* of the outcome (information or response timeout).

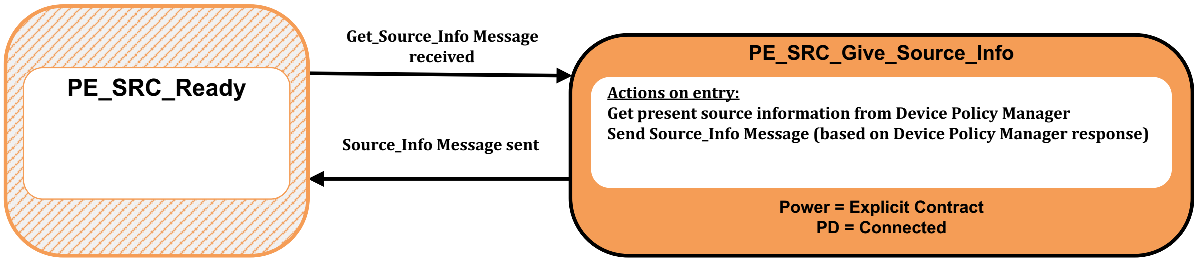
The *Policy Engine* ***Shall*** transition back to the ***PE_SNK_Ready*** state (see *Figure 8.133, "Sink Port State Diagram"*) when:

- A ***Source_Info*** *Message* is received
- Or ***SenderResponseTimer*** times out.

8.3.3.9.2 Source Give Source Information State Diagram

Figure 8.149, "Source Give Source Information State Diagram" shows the state diagram for a *Source* on receiving a ***Get_Source_Info*** *Message*. See also *Section 6.3.23, "Get_Source_Info Message"* and *Section 6.4.11, "Source_Info Message"*.

Figure 8.149 Source Give Source Information State Diagram


PE_SRC_Ready
Get_Source_Info Message received
Source_Info Message sent
PE_SRC_Give_Source_Info
Actions on entry:
Get present source information from Device Policy Manager
Send Source_Info Message (based on Device Policy Manager response)
Power = Explicit Contract
PD = Connected

8.3.3.9.2.1 PE_SRC_Give_Source_Info State

The *Policy Engine* ***Shall*** transition to the ***PE_SRC_Give_Source_Info*** state, from the ***PE_SRC_Ready*** state, when a ***Get_Source_Info*** *Message* is received.

On entry to the ***PE_SRC_Give_Source_Info*** state the *Policy Engine* ***Shall*** request the present *Source* information from the *Device Policy Manager* and then send a ***Source_Info*** *Message* based on this information.

The *Policy Engine* ***Shall*** transition back to the ***PE_SRC_Ready*** state (see *Figure 8.132, "Source Port State Diagram"*) when:

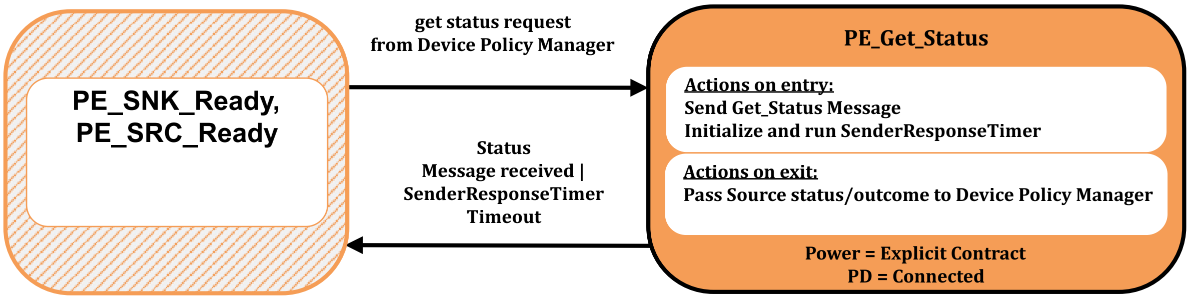
- The ***Source_Info*** *Message* has been successfully sent.

8.3.3.10 Status State Diagrams

8.3.3.10.1 Get Status State Diagram

Figure 8.150, "Get Status State Diagram" shows the state diagram for a Port on receiving a request from the *Device Policy Manager* to get the *Port Partner* or *Cable Plug*'s Status. See also *Section 6.5.2, "Status Message"*.

Figure 8.150 Get Status State Diagram


PE_SNK_Ready,
PE_SRC_Ready
get status request from Device Policy Manager
Status Message received | SenderResponseTimer Timeout
PE_Get_Status
Actions on entry:
Send Get_Status Message
Initialize and run SenderResponseTimer
Actions on exit:
Pass Source status/outcome to Device Policy Manager
Power = Explicit Contract
PD = Connected

8.3.3.10.1.1 PE_Get_Status State

The *Policy Engine* ***Shall*** transition to the ***PE_Get_Status*** state, from the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** States, due to a request to get the *Port Partner* or *Cable Plug*'s status from the *Device Policy Manager*.

On entry to the ***PE_Get_Status*** state the *Policy Engine* ***Shall*** send a ***Get_Status*** *Message* and initialize and run the ***SenderResponseTimer***.

On exit from the ***PE_Get_Status*** state the *Policy Engine* ***Shall*** inform the *Device Policy Manager* of the outcome (status or response timeout).

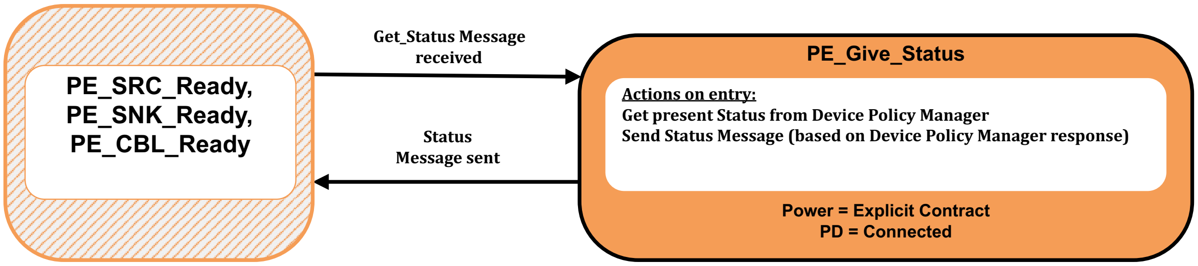
The *Policy Engine* ***Shall*** transition back to the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** States as appropriate (see *Figure 8.132, "Source Port State Diagram"* or *Figure 8.133, "Sink Port State Diagram"*) when:

- A ***Status*** *Message* is received
- Or ***SenderResponseTimer*** times out.

8.3.3.10.2 Give Status State Diagram

Figure 8.151, "Give Status State Diagram" shows the state diagram for a *Source* on receiving a ***Get_Status*** *Message*. See also *Section 6.5.2, "Status Message"*.

Figure 8.151 Give Status State Diagram


PE_SRC_Ready,
PE_SNK_Ready,
PE_CBL_Ready
Get_Status Message received
Status Message sent
PE_Give_Status
Actions on entry:
Get present Status from Device Policy Manager
Send Status Message (based on Device Policy Manager response)
Power = Explicit Contract
PD = Connected

8.3.3.10.2.1 PE_Give_Status State

The *Policy Engine* ***Shall*** transition to the ***PE_Give_Status*** state, from the ***PE_SRC_Ready***, ***PE_SNK_Ready*** or ***PE_CBL_Ready*** States, when a ***Get_Status*** *Message* is received.

On entry to the ***PE_Give_Status*** state the *Policy Engine* ***Shall*** request the present *Source* status from the *Device Policy Manager* and then send a ***Status*** *Message* based on these capabilities.

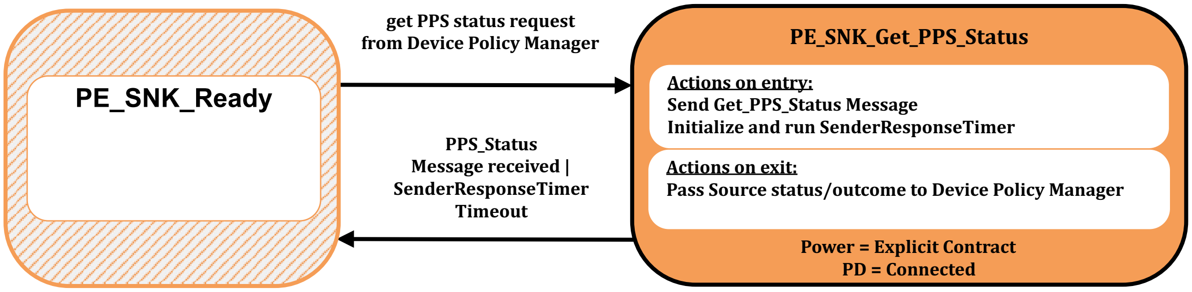
The *Policy Engine* ***Shall*** transition back to the ***PE_SRC_Ready***, ***PE_SNK_Ready*** or ***PE_CBL_Ready*** States as appropriate (see *Figure 8.132, "Source Port State Diagram"*, *Figure 8.133, "Sink Port State Diagram"*and *Figure 8.203, "Cable Ready State Diagram"*) when:

- The ***Status*** *Message* has been successfully sent.

8.3.3.10.3 Sink Port Get Source PPS Status State Diagram

Figure 8.152, "Sink Port Get Source PPS Status State Diagram" shows the state diagram for a *Sink* on receiving a request from the *Device Policy Manager* to get the *Port Partner*'s *Source* status when operating as a PPS. See also *Section 6.5.10, "PPS_Status Message"*.

Figure 8.152 Sink Port Get Source PPS Status State Diagram


PE_SNK_Ready
get PPS status request from Device Policy Manager
PPS_Status Message received | SenderResponseTimer Timeout
PE_SNK_Get_PPS_Status
Actions on entry:
Send Get_PPS_Status Message
Initialize and run SenderResponseTimer
Actions on exit:
Pass Source status/outcome to Device Policy Manager
Power = Explicit Contract
PD = Connected

8.3.3.10.3.1 PE_SNK_Get_PPS_Status State

The *Policy Engine* ***Shall*** transition to the ***PE_SNK_Get_PPS_Status*** state, from the ***PE_SNK_Ready*** state, due to a request to get the remote *Source* PPS status from the *Device Policy Manager*.

On entry to the ***PE_SNK_Get_PPS_Status*** state the *Policy Engine* ***Shall*** send a ***Get_PPS_Status*** *Message* and initialize and run the ***SenderResponseTimer***.

On exit from the ***PE_SNK_Get_PPS_Status*** state the *Policy Engine* ***Shall*** inform the *Device Policy Manager* of the outcome (status or response timeout).

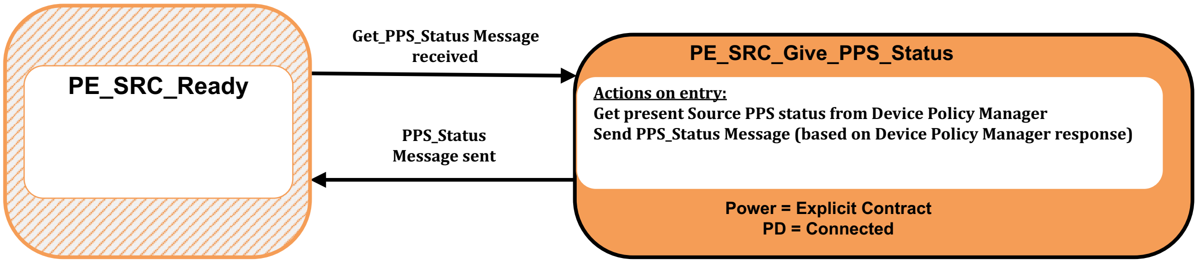
The *Policy Engine* ***Shall*** transition back to the ***PE_SNK_Ready*** state (see *Figure 8.133, "Sink Port State Diagram"*) when:

- A ***PPS_Status*** *Message* is received
- Or ***SenderResponseTimer*** times out.

8.3.3.10.4 Source Give Source PPS Status State Diagram

Figure 8.153, "Source Give Source PPS Status State Diagram" shows the state diagram for a *Source* on receiving a ***Get_PPS_Status*** *Message*. See also *Section 6.5.10, "PPS_Status Message"*.

Figure 8.153 Source Give Source PPS Status State Diagram


PE_SRC_Ready
Get_PPS_Status Message received
PPS_Status Message sent
PE_SRC_Give_PPS_Status
Actions on entry:
Get present Source PPS status from Device Policy Manager
Send PPS_Status Message (based on Device Policy Manager response)
Power = Explicit Contract
PD = Connected

8.3.3.10.4.1 PE_SRC_Give_PPS_Status State

The *Policy Engine* ***Shall*** transition to the ***PE_SRC_Give_PPS_Status*** state, from the ***PE_SRC_Ready*** state, when a ***Get_PPS_Status*** *Message* is received.

On entry to the ***PE_SRC_Give_PPS_Status*** state the *Policy Engine* ***Shall*** request the present *Source* PPS status from the *Device Policy Manager* and then send a ***PPS_Status*** *Message* based on these capabilities.

The *Policy Engine* ***Shall*** transition back to the ***PE_SRC_Ready*** state (see *Figure 8.132, "Source Port State Diagram"*) when:

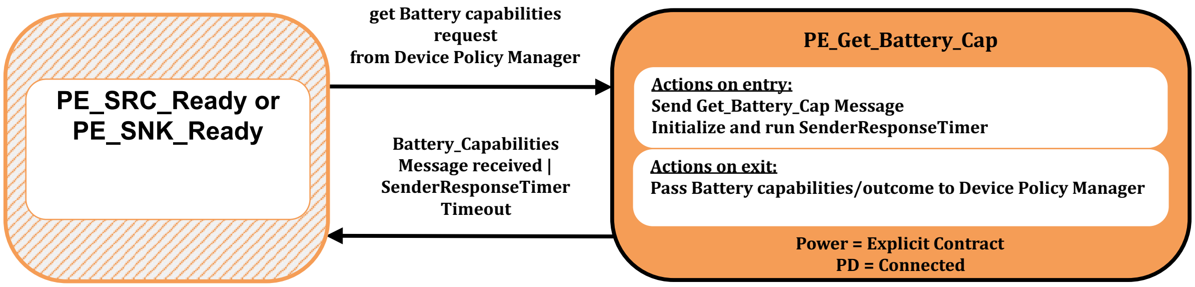
- The ***PPS_Status*** *Message* has been successfully sent.

8.3.3.11 Battery Capabilities State Diagrams

8.3.3.11.1 Get Battery Capabilities State Diagram

Figure 8.154, "Get Battery Capabilities State Diagram" shows the state diagram for a *Source* or *Sink* on receiving a request from the *Device Policy Manager* to get the *Port Partner*'s *Battery* capabilities for a specified *Battery*. See also *Section 6.5.5, "Battery_Capabilities Message"*.

Figure 8.154 Get Battery Capabilities State Diagram


PE_SRC_Ready or PE_SNK_Ready
get Battery capabilities request from Device Policy Manager
Battery_Capabilities Message received | SenderResponseTimer Timeout
PE_Get_Battery_Cap
Actions on entry:
Send Get_Battery_Cap Message
Initialize and run SenderResponseTimer
Actions on exit:
Pass Battery capabilities/outcome to Device Policy Manager
Power = Explicit Contract
PD = Connected

8.3.3.11.1.1 PE_Get_Battery_Cap State

The *Policy Engine* ***Shall*** transition to the ***PE_Get_Battery_Cap*** state, from either the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** state, due to a request to get the remote *Battery* capabilities, for a specified *Battery*, from the *Device Policy Manager*.

On entry to the ***PE_Get_Battery_Cap*** state the *Policy Engine* ***Shall*** send a ***Get_Battery_Cap*** *Message* and initialize and run the ***SenderResponseTimer***.

On exit from the ***PE_Get_Battery_Cap*** state the *Policy Engine* ***Shall*** inform the *Device Policy Manager* of the outcome (capabilities or response timeout).

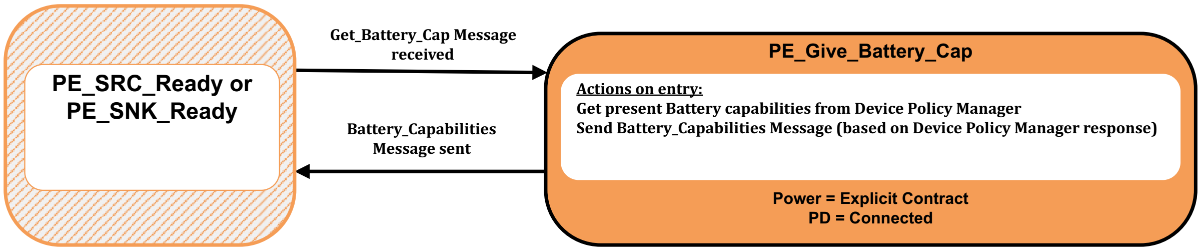
The *Policy Engine* ***Shall*** transition back to either the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** state as appropriate (see *Figure 8.132, "Source Port State Diagram"* and *Figure 8.133, "Sink Port State Diagram"*) when:

- A ***Battery_Capabilities*** *Message* is received
- Or ***SenderResponseTimer*** times out.

8.3.3.11.2 Give Battery Capabilities State Diagram

Figure 8.155, "Give Battery Capabilities State Diagram" shows the state diagram for a *Source* or *Sink* on receiving a ***Get_Battery_Cap*** *Message*. See also *Section 6.5.5, "Battery Capabilities Message"*.

Figure 8.155 Give Battery Capabilities State Diagram



PE_SRC_Ready or PE_SNK_Ready
Get_Battery_Cap Message received
Battery_Capabilities Message sent
PE_Give_Battery_Cap
Actions on entry:
Get present Battery capabilities from Device Policy Manager
Send Battery_Capabilities Message (based on Device Policy Manager response)
Power = Explicit Contract
PD = Connected

8.3.3.11.2.1 PE_Give_Battery_Cap State

The *Policy Engine* ***Shall*** transition to the ***PE_Give_Battery_Cap*** state, from either the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** state, when a ***Get_Battery_Cap*** *Message* is received.

On entry to the ***PE_Give_Battery_Cap*** state the *Policy Engine* ***Shall*** request the present *Battery* capabilities, for the requested *Battery*, from the *Device Policy Manager* and then send a ***Battery_Capabilities*** *Message* based on these capabilities.

The *Policy Engine* ***Shall*** transition back to either the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** state as appropriate (see *Figure 8.132, "Source Port State Diagram"* and *Figure 8.133, "Sink Port State Diagram"*) when:

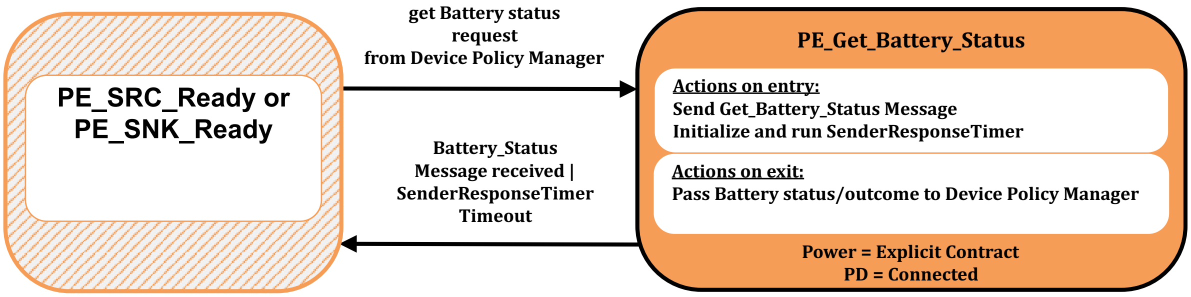
- The ***Battery_Capabilities*** *Message* has been successfully sent.

8.3.3.12 Battery Status State Diagrams

8.3.3.12.1 Get Battery Status State Diagram

Figure 8.156, "Get Battery Status State Diagram" shows the state diagram for a *Source* or *Sink* on receiving a request from the *Device Policy Manager* to get the *Port Partner*'s *Battery* status for a specified *Battery*. See also *Section 6.5.4, "Get_Battery_Status Message"*.

Figure 8.156 Get Battery Status State Diagram


PE_SRC_Ready or PE_SNK_Ready
get Battery status request from Device Policy Manager
Battery_Status Message received | SenderResponseTimer Timeout
PE_Get_Battery_Status
Actions on entry:
Send Get_Battery_Status Message
Initialize and run SenderResponseTimer
Actions on exit:
Pass Battery status/outcome to Device Policy Manager
Power = Explicit Contract
PD = Connected

8.3.3.12.1.1 PE_Get_Battery_Status State

The *Policy Engine* ***Shall*** transition to the ***PE_Get_Battery_Status*** state, from either the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** state, due to a request to get the remote *Battery* status, for a specified *Battery*, from the *Device Policy Manager*.

On entry to the ***PE_Get_Battery_Status*** state the *Policy Engine* ***Shall*** send a ***Get_Battery_Status*** *Message* and initialize and run the ***SenderResponseTimer***.

On exit from the ***PE_Get_Battery_Status*** state the *Policy Engine* ***Shall*** inform the *Device Policy Manager* of the outcome (status or response timeout).

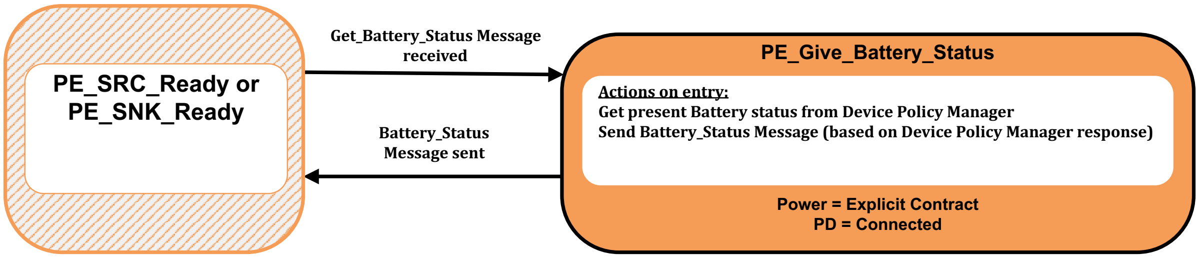
The *Policy Engine* ***Shall*** transition back to either the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** state as appropriate (see *Figure 8.132, "Source Port State Diagram"* and *Figure 8.133, "Sink Port State Diagram"*) when:

- A ***Battery_Status*** *Message* is received
- Or ***SenderResponseTimer*** times out.

8.3.3.12.2 Give Battery Status State Diagram

Figure 8.157, "Give Battery Status State Diagram" shows the state diagram for a *Source* or *Sink* on receiving a ***Get_Battery_Status*** *Message*. See also *Section 6.5.4, "Get_Battery_Status Message"*.

Figure 8.157 Give Battery Status State Diagram



PE_SRC_Ready or PE_SNK_Ready
Get_Battery_Status Message received
Battery_Status Message sent
PE_Give_Battery_Status
Actions on entry:
Get present Battery status from Device Policy Manager
Send Battery_Status Message (based on Device Policy Manager response)
Power = Explicit Contract
PD = Connected

8.3.3.12.2.1 PE_Give_Battery_Status State

The *Policy Engine* ***Shall*** transition to the ***PE_Give_Battery_Status*** state, from either the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** state, when a ***Get_Battery_Status*** *Message* is received.

On entry to the ***PE_Give_Battery_Status*** state the *Policy Engine* ***Shall*** request the present *Battery* status, for the requested *Battery*, from the *Device Policy Manager* and then send a ***Battery_Status*** *Message* based on this status.

The *Policy Engine* ***Shall*** transition back to either the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** state as appropriate (see *Figure 8.132, "Source Port State Diagram"* and *Figure 8.133, "Sink Port State Diagram"*) when:

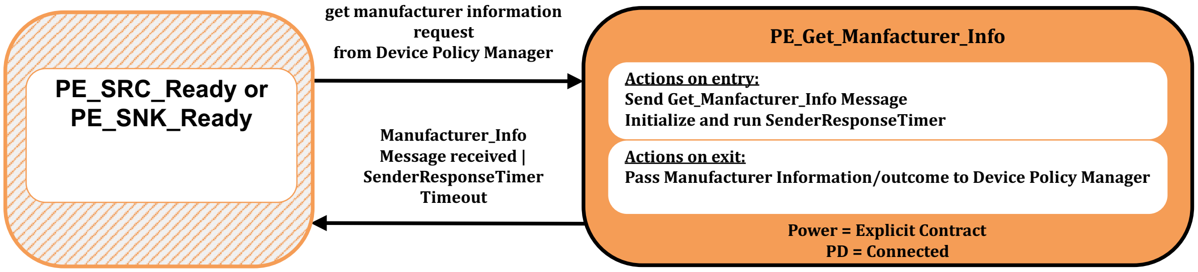
- The ***Battery_Status*** *Message* has been successfully sent.

8.3.3.13 Manufacturer Information State Diagrams

8.3.3.13.1 Get Manufacturer Information State Diagram

Figure 8.158, "Get Manufacturer Information State Diagram" shows the state diagram for a *Source* or *Sink* on receiving a request from the *Device Policy Manager* to get the *Port Partner* or *Cable Plug*'s Manufacturer Information. See also *Section 6.5.6, "Get_Manufacturer_Info Message"*.

Figure 8.158 Get Manufacturer Information State Diagram


PE_SRC_Ready or
PE_SNK_Ready
get manufacturer information request from Device Policy Manager
Manufacturer_Info Message received | SenderResponseTimer Timeout
PE_Get_Manfacturer_Info
Actions on entry:
Send Get_Manfacturer_Info Message
Initialize and run SenderResponseTimer
Actions on exit:
Pass Manufacturer Information/outcome to Device Policy Manager
Power = Explicit Contract
PD = Connected

8.3.3.13.1.1 PE_Get_Manufacturer_Info State

The *Policy Engine **Shall*** transition to the ***PE_Get_Manufacturer_Info*** state, from either the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** state, due to a request to get the remote Manufacturer Information from the *Device Policy Manager*.

On entry to the ***PE_Get_Manufacturer_Info*** state the *Policy Engine **Shall*** send a ***Get_Manufacturer_Info** Message* and initialize and run the ***SenderResponseTimer***.

On exit from the ***PE_Get_Manufacturer_Info*** state the *Policy Engine **Shall*** inform the *Device Policy Manager* of the outcome (information or response timeout).

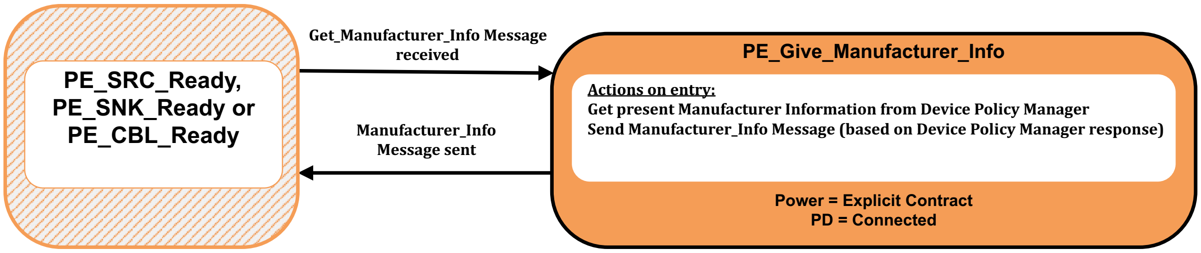
The *Policy Engine **Shall*** transition back to either the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** state as appropriate (see *Figure 8.132, "Source Port State Diagram"* and *Figure 8.133, "Sink Port State Diagram"*) when:

- A ***Manufacturer_Info** Message* is received
- Or ***SenderResponseTimer*** times out.

8.3.3.13.2 Give Manufacturer Information State Diagram

Figure 8.159, "Give Manufacturer Information State Diagram" shows the state diagram for a *Source*, *Sink* or *Cable Plug* on receiving a ***Get_Manufacturer_Info*** *Message*. See also Section 6.5.6, "Get_Manufacturer_Info Message".

Figure 8.159 Give Manufacturer Information State Diagram


PE_SRC_Ready, PE_SNK_Ready or PE_CBL_Ready
Get_Manufacturer_Info Message received
Manufacturer_Info Message sent
PE_Give_Manufacturer_Info
Actions on entry:
Get present Manufacturer Information from Device Policy Manager
Send Manufacturer_Info Message (based on Device Policy Manager response)
Power = Explicit Contract
PD = Connected

8.3.3.13.2.1 PE_Give_Manufacturer_Info State

The *Policy Engine* ***Shall*** transition to the ***PE_Give_Manufacturer_Info*** state, from either the ***PE_SRC_Ready***, ***PE_SNK_Ready*** or ***PE_CBL_Ready*** state, when a ***Get_Manufacturer_Info*** *Message* is received.

On entry to the ***PE_Give_Manufacturer_Info*** state the *Policy Engine* ***Shall*** request the manufacturer information from the *Device Policy Manager* and then send a ***Manufacturer_Info*** *Message* based on this status.

The *Policy Engine* ***Shall*** transition back to either the ***PE_SRC_Ready***, ***PE_SNK_Ready*** or ***PE_CBL_Ready*** state as appropriate (see Figure 8.132, "Source Port State Diagram", Figure 8.133, "Sink Port State Diagram" and Figure 8.203, "Cable Ready State Diagram") when:

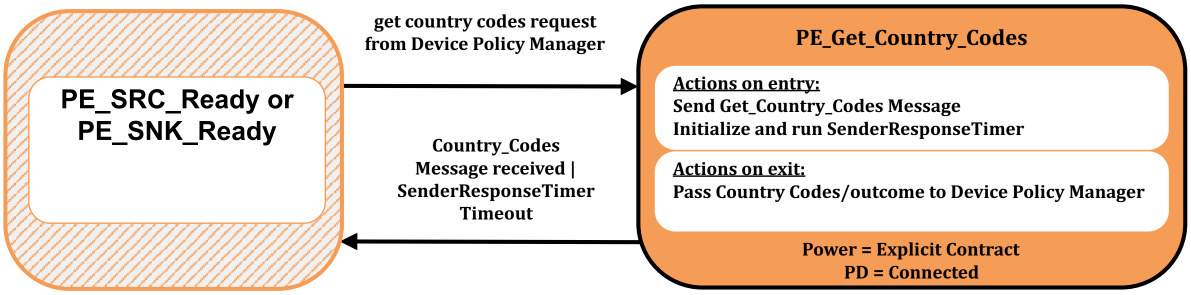
- The ***Manufacturer_Info*** *Message* has been successfully sent.

8.3.3.14 Country Codes and Information State Diagrams

8.3.3.14.1 Get Country Codes State Diagram

Figure 8.160, "Get Country Codes State Diagram" shows the state diagram for a *Source* or *Sink* on receiving a request from the *Device Policy Manager* to get the *Port Partner* or *Cable Plug*'s Country Codes. See also *Section 6.5.11, "Country_Codes Message"*.

Figure 8.160 Get Country Codes State Diagram


PE_SRC_Ready or PE_SNK_Ready
get country codes request from Device Policy Manager
Country_Codes Message received | SenderResponseTimer Timeout
PE_Get_Country_Codes
Actions on entry:
Send Get_Country_Codes Message
Initialize and run SenderResponseTimer
Actions on exit:
Pass Country Codes/outcome to Device Policy Manager
Power = Explicit Contract
PD = Connected

8.3.3.14.1.1 PE_Get_Country_Codes State

The *Policy Engine* ***Shall*** transition to the ***PE_Get_Country_Codes*** state, from either the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** state, due to a request to get the remote Country Codes from the *Device Policy Manager*.

On entry to the ***PE_Get_Country_Codes*** state the *Policy Engine* ***Shall*** send a ***Get_Country_Codes*** *Message* and initialize and run the ***SenderResponseTimer***.

On exit from the ***PE_Get_Country_Codes*** state the *Policy Engine* ***Shall*** inform the *Device Policy Manager* of the outcome (Country Codes or response timeout).

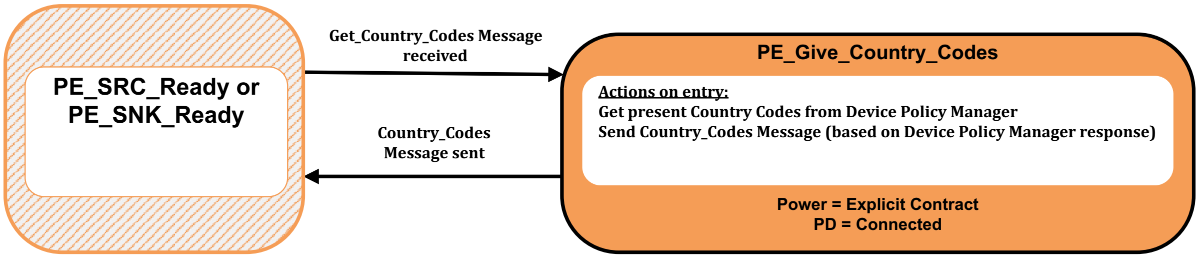
The *Policy Engine* ***Shall*** transition back to either the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** state as appropriate (see *Figure 8.132, "Source Port State Diagram"* and *Figure 8.133, "Sink Port State Diagram"*) when:

- A ***Country_Codes*** *Message* is received
- Or ***SenderResponseTimer*** times out.

8.3.3.14.2 Give Country Codes State Diagram

Figure 8.161, "Give Country Codes State Diagram" shows the state diagram for a *Source* or *Sink* on receiving a ***Get_Country_Codes*** *Message*. See also *Section 6.5.11, "Country_Codes Message"*.

Figure 8.161 Give Country Codes State Diagram


PE_SRC_Ready or PE_SNK_Ready
Get_Country_Codes Message received
Country_Codes Message sent
PE_Give_Country_Codes
Actions on entry:
Get present Country Codes from Device Policy Manager
Send Country_Codes Message (based on Device Policy Manager response)
Power = Explicit Contract
PD = Connected

8.3.3.14.2.1 PE_Give_Country_Codes State

The *Policy Engine* ***Shall*** transition to the ***PE_Give_Country_Codes*** state, from either the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** State, when a ***Get_Country_Codes*** *Message* is received.

On entry to the ***PE_Give_Country_Codes*** state the *Policy Engine* ***Shall*** request the country codes from the *Device Policy Manager* and then send a ***Country_Codes*** *Message* containing these codes.

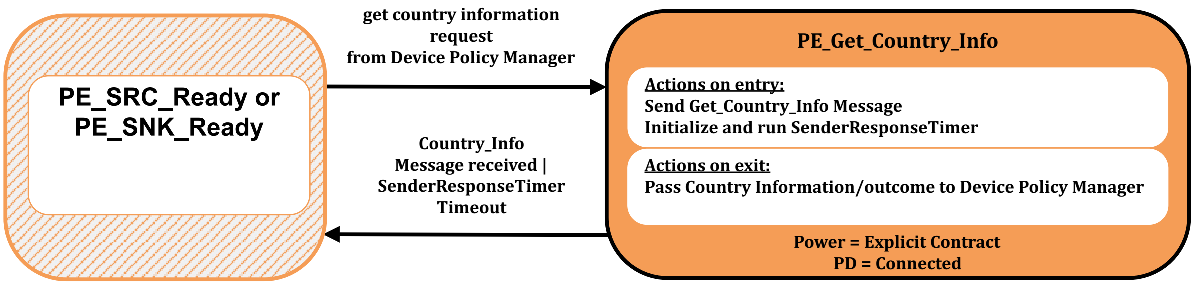
The *Policy Engine* ***Shall*** transition back to either the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** State as appropriate (see *Figure 8.132, "Source Port State Diagram"* and *Figure 8.133, "Sink Port State Diagram"*) when:

- The ***Country_Codes*** *Message* has been successfully sent.

8.3.3.14.3 Get Country Information State Diagram

Figure 8.162, "Get Country Information State Diagram" shows the state diagram for a *Source* or *Sink* on receiving a request from the *Device Policy Manager* to get the *Port Partner* or *Cable Plug*'s Country Information. See also *Section 6.5.12, "Country_Info Message"*.

Figure 8.162 Get Country Information State Diagram


PE_SRC_Ready or PE_SNK_Ready
get country information request from Device Policy Manager
Country_Info Message received | SenderResponseTimer Timeout
PE_Get_Country_Info
Actions on entry:
Send Get_Country_Info Message
Initialize and run SenderResponseTimer
Actions on exit:
Pass Country Information/outcome to Device Policy Manager
Power = Explicit Contract
PD = Connected

8.3.3.14.3.1 PE_Get_Country_Info State

The *Policy Engine* ***Shall*** transition to the ***PE_Get_Country_Info*** state, from either the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** state, due to a request to get the remote Manufacturer Information from the *Device Policy Manager*.

On entry to the ***PE_Get_Country_Info*** state the *Policy Engine* ***Shall*** send a ***Get_Manufacturer_Info*** *Message* and initialize and run the ***SenderResponseTimer***.

On exit from the ***PE_Get_Country_Info*** state the *Policy Engine* ***Shall*** inform the *Device Policy Manager* of the outcome (country information or response timeout).

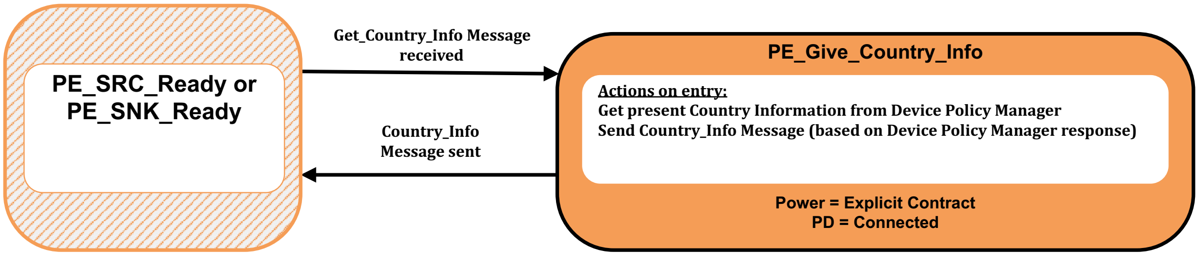
The *Policy Engine* ***Shall*** transition back to either the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** state as appropriate (see *Figure 8.132, "Source Port State Diagram"* and *Figure 8.133, "Sink Port State Diagram"*) when:

- A ***Country_Info*** *Message* is received
- Or ***SenderResponseTimer*** times out.

8.3.3.14.4 Give Country Information State Diagram

Figure 8.163, "Give Country Information State Diagram" shows the state diagram for a *Source* or *Sink* on receiving a ***Get_Country_Info*** *Message*. See also *Section 6.5.12, "Country_Info Message"*.

Figure 8.163 Give Country Information State Diagram



PE_SRC_Ready or PE_SNK_Ready
Get_Country_Info Message received
Country_Info Message sent
PE_Give_Country_Info
Actions on entry:
Get present Country Information from Device Policy Manager
Send Country_Info Message (based on Device Policy Manager response)
Power = Explicit Contract
PD = Connected

8.3.3.14.4.1 PE_Give_Country_Info State

The *Policy Engine* ***Shall*** transition to the ***PE_Give_Country_Info*** state, from either the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** State, when a ***Get_Country_Info*** *Message* is received.

On entry to the ***PE_Give_Country_Info*** state the *Policy Engine* ***Shall*** request the country information from the *Device Policy Manager* and then send a ***Country_Info*** *Message* containing this country information.

The *Policy Engine* ***Shall*** transition back to either the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** State as appropriate (see *Figure 8.132, "Source Port State Diagram"* and *Figure 8.133, "Sink Port State Diagram"*) when:

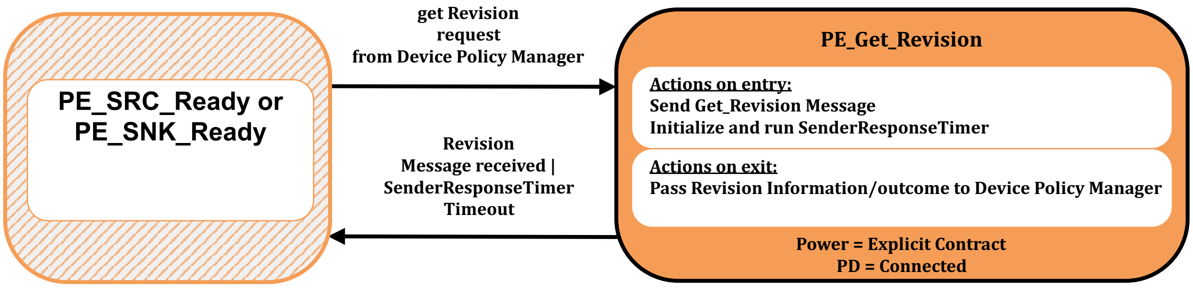
- The ***Country_Info*** *Message* has been successfully sent.

8.3.3.15 Revision State Diagrams

8.3.3.15.1 Get Revision State Diagram

Figure 8.164, "Get Revision State Diagram" shows the state diagram for a *Source* or *Sink* on receiving a request from the *Device Policy Manager* to get the *Port Partner* or *Cable Plug*'s Revision Information. See also *Section 6.3.24, "Get_Revision Message"* and *Section 6.4.12, "Revision Message"*.

Figure 8.164 Get Revision State Diagram


PE_SRC_Ready or
PE_SNK_Ready
get Revision
request
from Device Policy Manager
Revision
Message received |
SenderResponseTimer
Timeout
PE_Get_Revision
Actions on entry:
Send Get_Revision Message
Initialize and run SenderResponseTimer
Actions on exit:
Pass Revision Information/outcome to Device Policy Manager
Power = Explicit Contract
PD = Connected

8.3.3.15.1.1 PE_Get_Revision State

The *Policy Engine* ***Shall*** transition to the ***PE_Get_Revision*** state, from either the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** state, due to a request to get the remote Revision Information from the *Device Policy Manager*.

On entry to the ***PE_Get_Revision*** state the *Policy Engine* ***Shall*** send a ***Get_Revision*** *Message* and initialize and run the ***SenderResponseTimer***.

On exit from the ***PE_Get_Revision*** state the *Policy Engine* ***Shall*** inform the *Device Policy Manager* of the outcome (Revision information or response timeout).

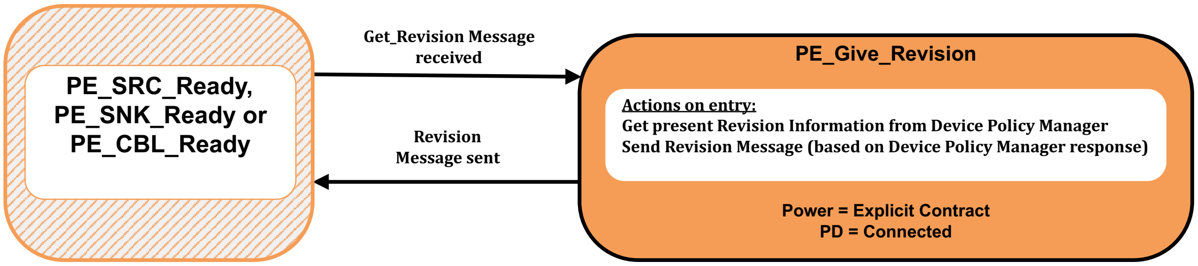
The *Policy Engine* ***Shall*** transition back to either the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** state as appropriate (see *Figure 8.132, "Source Port State Diagram"* and *Figure 8.133, "Sink Port State Diagram"*) when:

- A ***Revision*** *Message* is received
- Or ***SenderResponseTimer*** times out.

8.3.3.15.2 Give Revision State Diagram

Figure 8.165, "Give Revision State Diagram" shows the state diagram for a *Source*, *Sink* or *Cable Plug* on receiving a ***Get_Revision*** *Message*. See also *Section 6.3.24, "Get_Revision Message"* and *Section 6.4.12, "Revision Message"*.

Figure 8.165 Give Revision State Diagram


PE_SRC_Ready,
PE_SNK_Ready or
PE_CBL_Ready
Get_Revision Message received
Revision Message sent
PE_Give_Revision
Actions on entry:
Get present Revision Information from Device Policy Manager
Send Revision Message (based on Device Policy Manager response)
Power = Explicit Contract
PD = Connected

8.3.3.15.2.1 PE_Give_Revision State

The *Policy Engine* ***Shall*** transition to the ***PE_Give_Revision*** state, from either the ***PE_SRC_Ready***, ***PE_SNK_Ready*** or ***PE_CBL_Ready*** state, when a ***Get_Revision*** *Message* is received.

On entry to the ***PE_Give_Revision*** state the *Policy Engine* ***Shall*** request the Revision information from the *Device Policy Manager* and then send a ***Revision*** *Message* based on this information.

The *Policy Engine* ***Shall*** transition back to either the ***PE_SRC_Ready***, ***PE_SNK_Ready*** or ***PE_CBL_Ready*** state as appropriate (see *Figure 8.132, "Source Port State Diagram"*, *Figure 8.133, "Sink Port State Diagram"* and *Figure 8.203, "Cable Ready State Diagram"*) when:

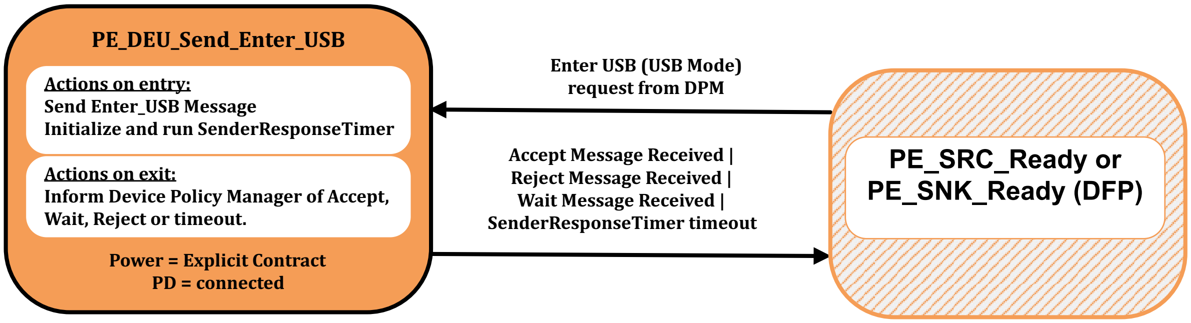
- The ***Revision*** *Message* has been successfully sent.

8.3.3.16 Enter_USB Message State Diagrams

8.3.3.16.1 DFP Enter_USB Message State Diagrams

Figure 8.166, "DFP Enter_USB Message State Diagram" shows the state diagram for an ***Enter_USB*** *Message* sent by a *DFP*.

Figure 8.166 DFP Enter_USB Message State Diagram


PE_DEU_Send_Enter_USB
Actions on entry:
Send Enter_USB Message
Initialize and run SenderResponseTimer
Actions on exit:
Inform Device Policy Manager of Accept, Wait, Reject or timeout.
Power = Explicit Contract
PD = connected
Enter USB (USB Mode) request from DPM
Accept Message Received | Reject Message Received | Wait Message Received | SenderResponseTimer timeout
PE_SRC_Ready or PE_SNK_Ready (DFP)

8.3.3.16.1.1 PE_DEU_Send_Enter_USB State

The ***PE_DEU_Send_Enter_USB*** State ***Shall*** be entered from the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** State when requested by the *Device Policy Manager* and the Port is operating as a *DFP*.

On entry to the ***PE_DEU_Send_Enter_USB*** State the *Policy Engine* ***Shall*** request the *Protocol Layer* to send an ***Enter_USB*** *Message* and then initialize and run the ***SenderResponseTimer***.

On exit from the ***PE_DEU_Send_Enter_USB*** state the *Policy Engine* ***Shall*** inform the *Device Policy Manager* of the outcome: ***Accept*** *Message* received, ***Reject*** *Message* received, ***SenderResponseTimer*** timeout.

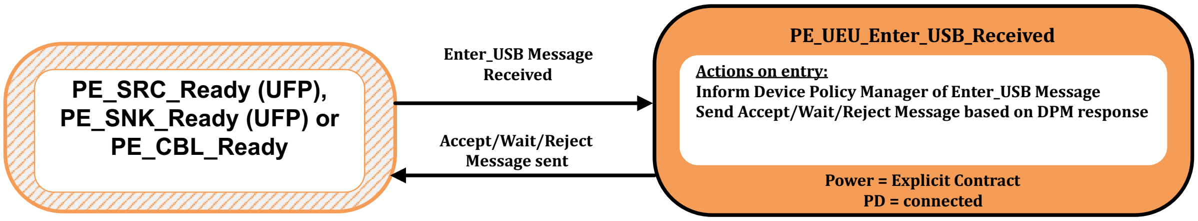
The *Policy Engine* ***Shall*** transition back to the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** State depending on the Ports *Power Role* when:

- An ***Accept*** *Message* has been received or
- A ***Wait*** *Message* has been received or
- A ***Reject*** *Message* has been received
- There is a ***SenderResponseTimer*** timeout.

8.3.3.16.2 UFP or Cable Plug Enter_USB Message State Diagrams

Figure 8.167, "UFP Enter_USB Message State Diagram" shows the state diagram for an ***Enter_USB*** Message received by a *UFP* or *Cable Plug*.

Figure 8.167 UFP Enter_USB Message State Diagram


PE_SRC_Ready (UFP), PE_SNK_Ready (UFP) or PE_CBL_Ready
Enter_USB Message Received
Accept/Wait/Reject Message sent
PE_UEU_Enter_USB_Received
Actions on entry:
Inform Device Policy Manager of Enter_USB Message
Send Accept/Wait/Reject Message based on DPM response
Power = Explicit Contract
PD = connected

8.3.3.16.2.1 PE_UEU_Enter_USB_Received State

The ***PE_UEU_Enter_USB_Received*** state ***Shall*** be entered from the ***PE_SRC_Ready***, ***PE_SNK_Ready*** or ***PE_CBL_Ready*** state as appropriate (see *Figure 8.132, "Source Port State Diagram"*, *Figure 8.133, "Sink Port State Diagram"* and *Figure 8.203, "Cable Ready State Diagram"*) when an ***Enter_USB*** *Message* is received and the Port is operating as a *UFP* or is a *Cable Plug*.

On entry to the ***PE_UEU_Enter_USB_Received*** state the *Policy Engine* ***Shall*** inform the *Device Policy Manager*. The *Device Policy Manager* responds with an indication of whether the ***Enter_USB*** *Message* is to be accepted or rejected. The *Policy Engine* ***Shall*** send either an ***Accept*** *Message*, a ***Wait*** *Message* or a ***Reject*** *Message* as appropriate.

The *Policy Engine* ***Shall*** transition back to the ***PE_SRC_Ready***, ***PE_SNK_Ready*** or ***PE_CBL_Ready*** state as appropriate when:

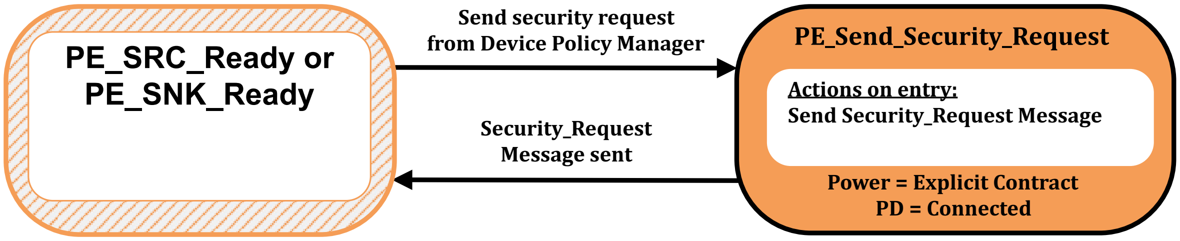
- Either an ***Accept*** *Message*, a ***Wait*** *Message* or a ***Reject*** *Message* has been sent.

8.3.3.17 Security State Diagrams

8.3.3.17.1 Send Security Request State Diagram

Figure 8.168, "Send security request State Diagram" shows the state diagram for a *Source* or *Sink* on receiving a request from the *Device Policy Manager* to send a security request. See also *Section 6.5.8, "Security Messages"*.

Figure 8.168 Send security request State Diagram



8.3.3.17.1.1 PE_Send_Security_Request State

The *Policy Engine* ***Shall*** transition to the ***PE_Send_Security_Request*** state, from either the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** state, due to a request to send a security request from the *Device Policy Manager*.

On entry to the ***PE_Send_Security_Request*** state the *Policy Engine* ***Shall*** send a ***Security_Request*** *Message*.

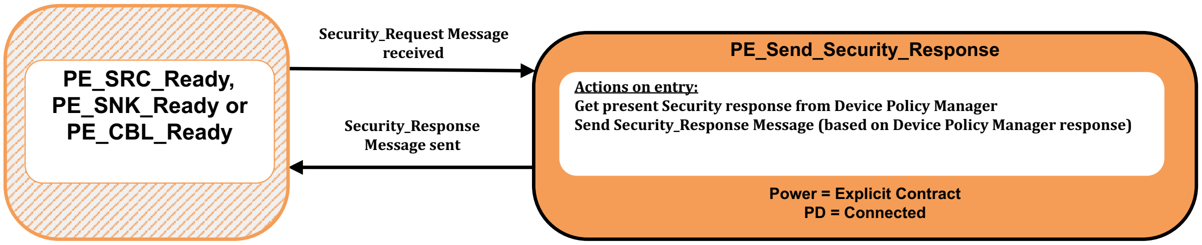
The *Policy Engine* ***Shall*** transition back to either the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** state as appropriate (see *Figure 8.132, "Source Port State Diagram"* and *Figure 8.133, "Sink Port State Diagram"*) when:

- The ***Security_Request*** *Message* has been sent.

8.3.3.17.2 Send Security Response State Diagram

Figure 8.169, "Send security response State Diagram" shows the state diagram for a *Source*, *Sink* or *Cable Plug* on receiving a ***Security_Request*** *Message*. See also *Section 6.5.8, "Security Messages"*.

Figure 8.169 Send security response State Diagram


PE_SRC_Ready, PE_SNK_Ready or PE_CBL_Ready
Security_Request Message received
Security_Response Message sent
PE_Send_Security_Response
Actions on entry:
Get present Security response from Device Policy Manager
Send Security_Response Message (based on Device Policy Manager response)
Power = Explicit Contract
PD = Connected

8.3.3.17.2.1 PE_Send_Security_Response State

The *Policy Engine* ***Shall*** transition to the ***PE_Send_Security_Response*** state, from either the ***PE_SRC_Ready***, ***PE_SNK_Ready*** or ***PE_CBL_Ready*** state, when a ***Security_Request*** *Message* is received.

On entry to the ***PE_Send_Security_Response*** state the *Policy Engine* ***Shall*** request the appropriate response from the *Device Policy Manager* and then send a ***Security_Response*** *Message* based on this status.

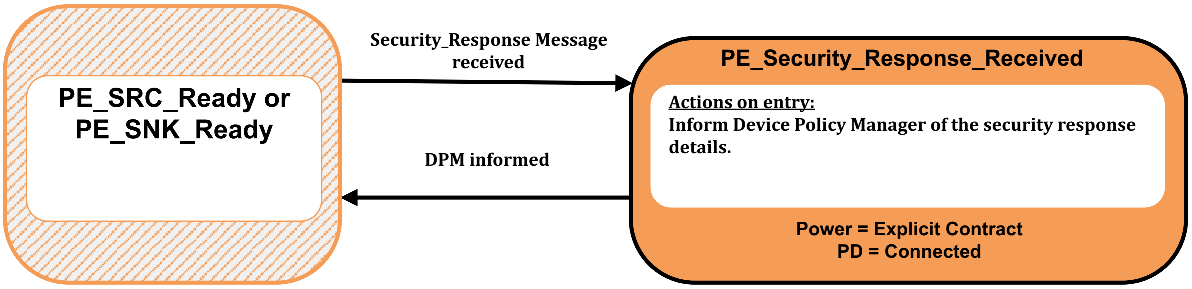
The *Policy Engine* ***Shall*** transition back to either the ***PE_SRC_Ready***, ***PE_SNK_Ready*** or ***PE_CBL_Ready*** state as appropriate (see *Figure 8.132, "Source Port State Diagram"*, *Figure 8.133, "Sink Port State Diagram"* and *Figure 8.203, "Cable Ready State Diagram"*) when:

- The ***Security_Response*** *Message* has been successfully sent.

8.3.3.17.3 Security Response Received State Diagram

Figure 8.170, "Security response received State Diagram" shows the state diagram for a *Source* or *Sink* on receiving a ***Security_Response*** *Message*. See also *Section 6.5.8, "Security Messages"*.

Figure 8.170 Security response received State Diagram


PE_SRC_Ready or PE_SNK_Ready
Security_Response Message received
DPM informed
PE_Security_Response_Received
Actions on entry:
Inform Device Policy Manager of the security response details.
Power = Explicit Contract
PD = Connected

8.3.3.17.3.1 PE_Security_Response_Received State

The *Policy Engine* ***Shall*** transition to the ***PE_Security_Response_Received*** state, from either the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** when a ***Security_Response*** *Message* is received.

On entry to the ***PE_Security_Response_Received*** state the *Policy Engine* ***Shall*** inform the *Device Policy Manager* of the details of the security response.

The *Policy Engine* ***Shall*** transition back to either the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** state as appropriate (see *Figure 8.132, "Source Port State Diagram"*, *Figure 8.133, "Sink Port State Diagram"* and *Figure 8.203, "Cable Ready State Diagram"*) when:

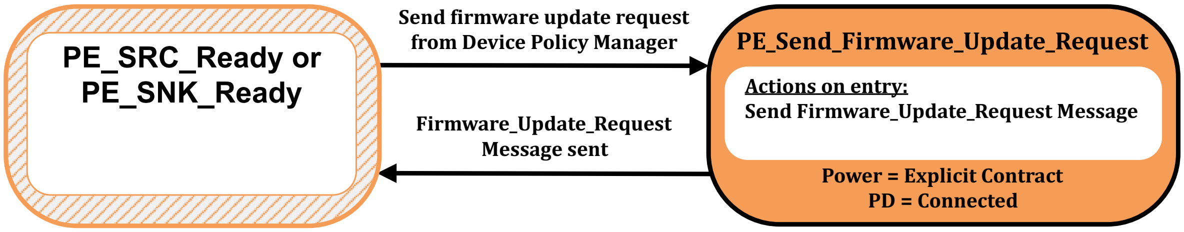
- The *Device Policy Manager* has been informed.

8.3.3.18 Firmware Update State Diagrams

8.3.3.18.1 Send Firmware Update Request State Diagram

Figure 8.171, "Send firmware update request State Diagram" shows the state diagram for a *Source* or *Sink* on receiving a request from the *Device Policy Manager* to send a firmware update request. See also *Section 6.5.9, "Firmware Update Messages"*.

Figure 8.171 Send firmware update request State Diagram


PE_SRC_Ready or PE_SNK_Ready
Send firmware update request from Device Policy Manager
Firmware_Update_Request Message sent
PE_Send_Firmware_Update_Request
Actions on entry:
Send Firmware_Update_Request Message
Power = Explicit Contract
PD = Connected

8.3.3.18.1.1 PE_Send_Firmware_Update_Request State

The *Policy Engine* ***Shall*** transition to the ***PE_Send_Firmware_Update_Request*** state, from either the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** state, due to a request to send a firmware update request from the *Device Policy Manager*.

On entry to the ***PE_Send_Firmware_Update_Request*** state the *Policy Engine* ***Shall*** send a ***Firmware_Update_Request*** *Message*.

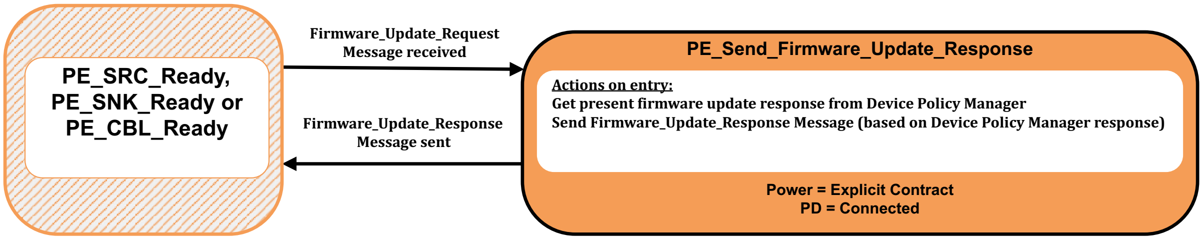
The *Policy Engine* ***Shall*** transition back to either the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** state as appropriate (see *Figure 8.132, "Source Port State Diagram"* and *Figure 8.133, "Sink Port State Diagram"*) when:

- The ***Firmware_Update_Request*** *Message* has been sent.

8.3.3.18.2 Send Firmware Update Response State Diagram

[Figure 8.172, "Send firmware update response State Diagram"](#) shows the state diagram for a *Source*, *Sink* or *Cable Plug* on receiving a ***Firmware_Update_Request*** *Message*. See also [Section 6.5.9, "Firmware Update Messages"](#).

Figure 8.172 Send firmware update response State Diagram


PE_SRC_Ready,
PE_SNK_Ready or
PE_CBL_Ready
Firmware_Update_Request
Message received
Firmware_Update_Response
Message sent
PE_Send_Firmware_Update_Response
Actions on entry:
Get present firmware update response from Device Policy Manager
Send Firmware_Update_Response Message (based on Device Policy Manager response)
Power = Explicit Contract
PD = Connected

8.3.3.18.2.1 PE_Send_Firmware_Update_Response State

The *Policy Engine* ***Shall*** transition to the ***PE_Send_Firmware_Update_Response*** state, from either the ***PE_SRC_Ready***, ***PE_SNK_Ready*** or ***PE_CBL_Ready*** state, when a ***Firmware_Update_Request*** *Message* is received.

On entry to the ***PE_Send_Firmware_Update_Response*** state the *Policy Engine* ***Shall*** request the appropriate response from the *Device Policy Manager* and then send a ***Firmware_Update_Response*** *Message* based on this status.

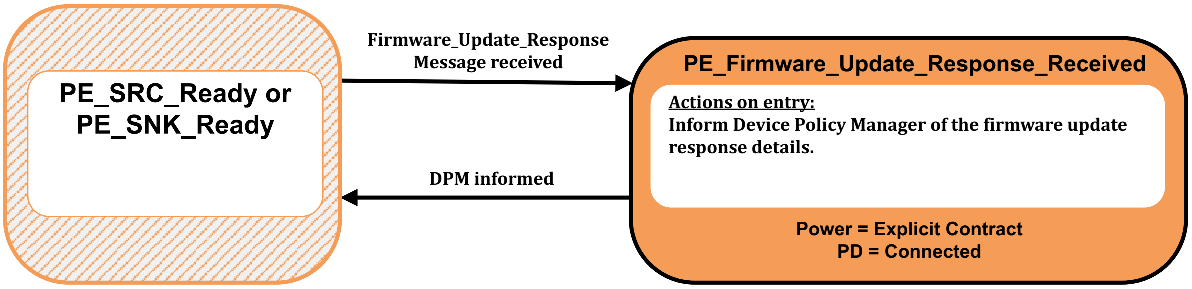
The *Policy Engine* ***Shall*** transition back to either the ***PE_SRC_Ready***, ***PE_SNK_Ready*** or ***PE_CBL_Ready*** state as appropriate (see [Figure 8.132, "Source Port State Diagram"](#), [Figure 8.133, "Sink Port State Diagram"](#) and [Figure 8.203, "Cable Ready State Diagram"](#)) when:

- The ***Firmware_Update_Response*** *Message* has been successfully sent.

8.3.3.18.3 Firmware Update Response Received State Diagram

Figure 8.173, "Firmware update response received State Diagram" shows the state diagram for a *Source* or *Sink* on receiving a ***Firmware_Update_Response*** *Message*. See also *Section 6.5.9, "Firmware Update Messages"*.

Figure 8.173 Firmware update response received State Diagram



PE_SRC_Ready or PE_SNK_Ready
Firmware_Update_Response Message received
DPM informed
PE_Firmware_Update_Response_Received
Actions on entry:
Inform Device Policy Manager of the firmware update response details.
Power = Explicit Contract
PD = Connected

8.3.3.18.3.1 PE_Firmware_Update_Response_Received State

The *Policy Engine* ***Shall*** transition to the ***PE_Firmware_Update_Response_Received*** state, from either the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** when a ***Firmware_Update_Response*** *Message* is received.

On entry to the ***PE_Firmware_Update_Response_Received*** state the *Policy Engine* ***Shall*** inform the *Device Policy Manager* of the details of the firmware update response.

The *Policy Engine* ***Shall*** transition back to either the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** state as appropriate (see *Figure 8.132, "Source Port State Diagram"*, *Figure 8.133, "Sink Port State Diagram"* and *Figure 8.203, "Cable Ready State Diagram"*) when:

- The *Device Policy Manager* has been informed.

8.3.3.19 Dual-Role Port State Diagrams

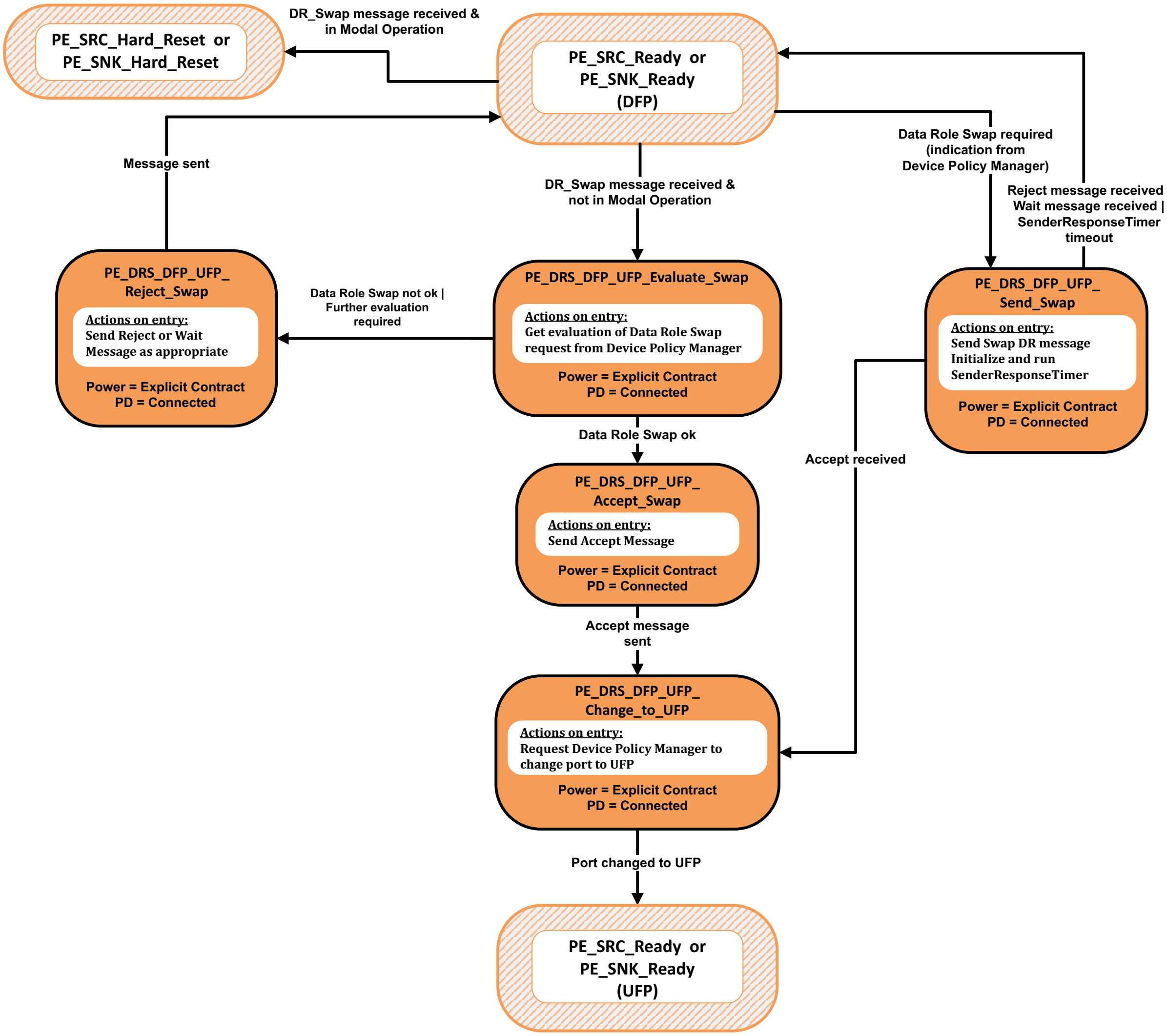
Dual-Role Ports that combine *Source* and *Sink* functionality ***Shall*** comprise *Source* and *Sink Policy Engine* state machines. In addition they ***Shall*** have the capability to perform a *Power Role Swap* from the *PE_SRC_Ready* or *PE_SNK_Ready* states and ***Shall*** return to *USB Default Operation* on a *Hard Reset*.

The State Diagrams in this section ***Shall*** apply to every ***[USB Type-C 2.4]*** *DRP*.

8.3.3.19.1 DFP to UFP Data Role Swap State Diagram

Figure 8.174, "DFP to UFP Data Role Swap State Diagram" shows the additional state diagram required to perform a *Data Role Swap* from *DFP* to *UFP* operation and the changes that ***Shall*** be followed for error and *Hard Reset* handling.

Figure 8.174 DFP to UFP Data Role Swap State Diagram



8.3.3.19.1.1 PE_SRC_Ready or PE_SNK_Ready State

The *Data Role Swap* process ***Shall*** start only from either the *PE_SRC_Ready* or *PE_SNK_Ready* state where power is stable.

The *Policy Engine* ***Shall*** transition to the *PE_DRS_DFP_UFP_Evaluate_Swap* state when:

- A *DR_Swap Message* is received and

- There are no *Active Modes* (not in *Modal Operation*).

The *Policy Engine* ***Shall*** transition to either the ***PE_SRC_Hard_Reset*** or ***PE_SNK_Hard_Reset*** states when:

- A ***DR_Swap*** *Message* is received and
- There are one or more *Active Modes* (*Modal Operation*).

The *Policy Engine* ***Shall*** transition to the ***PE_DRS_DFP_UFP_Send_Swap*** state when:

- The *Device Policy Manager* indicates that a *Data Role Swap* is required.

8.3.3.19.1.2 PE_DRS_DFP_UFP_Evaluate_Swap State

On entry to the ***PE_DRS_DFP_UFP_Evaluate_Swap*** state the *Policy Engine* ***Shall*** ask the *Device Policy Manager* whether a *Data Role Swap* can be made.

The *Policy Engine* ***Shall*** transition to the ***PE_DRS_DFP_UFP_Accept_Swap*** state when:

- The *Device Policy Manager* indicates that a *Data Role Swap* is OK.

The *Policy Engine* ***Shall*** transition to the ***PE_DRS_DFP_UFP_Reject_Swap*** state when:

- The *Device Policy Manager* indicates that a *Data Role Swap* is not OK.
- Or further evaluation of the *Data Role Swap* request is needed.

8.3.3.19.1.3 PE_DRS_DFP_UFP_Accept_Swap State

On entry to the ***PE_DRS_DFP_UFP_Accept_Swap*** state the *Policy Engine* ***Shall*** request the *Protocol Layer* to send an ***Accept*** *Message*.

The *Policy Engine* ***Shall*** transition to the ***PE_DRS_DFP_UFP_Change_to_UFP*** state when:

- The ***Accept*** *Message* has been sent.

8.3.3.19.1.4 PE_DRS_DFP_UFP_Change_to_UFP State

On entry to the ***PE_DRS_DFP_UFP_Change_to_UFP*** state the *Policy Engine* ***Shall*** request the *Device Policy Manager* to change the Port from a *DFP* to a *UFP*.

The *Policy Engine* ***Shall*** transition to either the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** state when:

- The *Device Policy Manager* indicates that the Port has been changed to a *UFP*.

8.3.3.19.1.5 PE_DRS_DFP_UFP_Send_Swap State

On entry to the ***PE_DRS_DFP_UFP_Send_Swap*** state the *Policy Engine* ***Shall*** request the *Protocol Layer* to send a ***DR_Swap*** *Message* and ***Shall*** start the ***SenderResponseTimer***.

On exit from the ***PE_DRS_DFP_UFP_Send_Swap*** state the *Policy Engine* ***Shall*** stop the ***SenderResponseTimer***.

The *Policy Engine* ***Shall*** continue as a *DFP* and ***Shall*** transition to either the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** state when:

- A ***Reject*** *Message* is received.
- Or a ***Wait*** *Message* is received.
- Or the ***SenderResponseTimer*** times out.

The *Policy Engine* ***Shall*** transition to the ***PE_DRS_DFP_UFP_Change_to_UFP*** state when:

- An ***Accept*** *Message* is received.

8.3.3.19.1.6 PE_DRS_DFP_UFP_Reject_Swap State

On entry to the ***PE_DRS_DFP_UFP_Reject_Swap*** state the *Policy Engine* ***Shall*** request the *Protocol Layer* to send:

- A ***Reject*** *Message* if the device is unable to perform a *Data Role Swap* at this time.
- A ***Wait*** *Message* if further evaluation of the *Data Role Swap* request is required.

Note: In this case it is expected that one of the *Port Partner*s will send a ***DR_Swap*** *Message* at a later time (see *Section 6.3.12.3, "Wait in response to a DR_Swap Message"*).

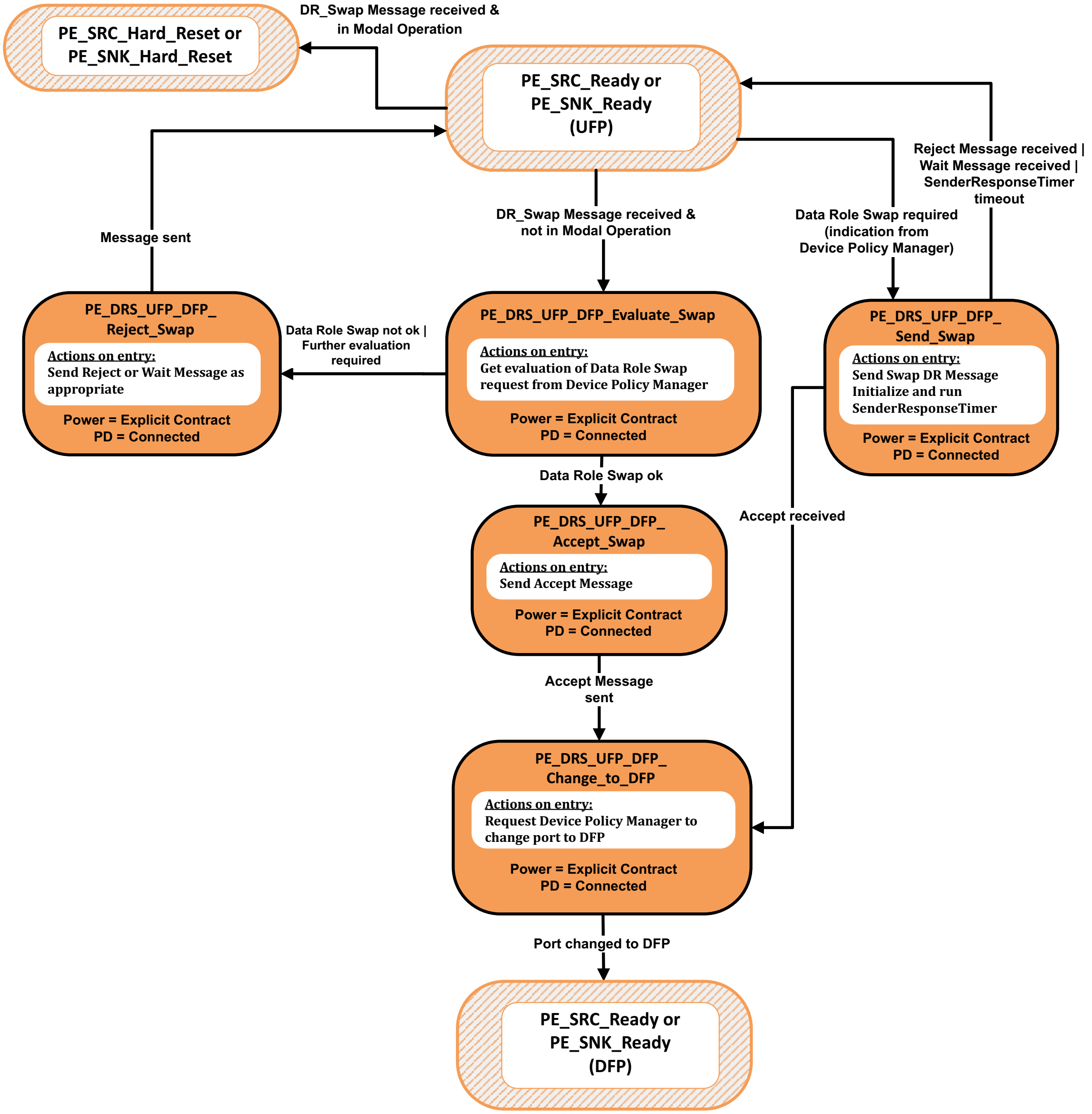
The *Policy Engine* ***Shall*** continue as a *DFP* and ***Shall*** transition to either the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** state when:

- The ***Reject*** or ***Wait*** *Message* has been sent.

8.3.3.19.2 UFP to DFP Data Role Swap State Diagram

Figure 8.175, "UFP to DFP Data Role Swap State Diagram" shows the additional state diagram required to perform a *Data Role Swap* from *DRP UFP* to *DFP* operation and the changes that ***Shall*** be followed for error and *Hard Reset* handling.

Figure 8.175 UFP to DFP Data Role Swap State Diagram



PE_SRC_Hard_Reset or PE_SNK_Hard_Reset
DR_Swap Message received & in Modal Operation
PE_SRC_Ready or PE_SNK_Ready (UFP)
Message sent
DR_Swap Message received & not in Modal Operation
Data Role Swap required (indication from Device Policy Manager)
Reject Message received | Wait Message received | SenderResponseTimer timeout
PE_DRS_UFP_DFP_Reject_Swap
Actions on entry:
Send Reject or Wait Message as appropriate
Power = Explicit Contract
PD = Connected
Data Role Swap not ok | Further evaluation required
PE_DRS_UFP_DFP_Evaluate_Swap
Actions on entry:
Get evaluation of Data Role Swap request from Device Policy Manager
Power = Explicit Contract
PD = Connected
PE_DRS_UFP_DFP_Send_Swap
Actions on entry:
Send Swap DR Message
Initialize and run SenderResponseTimer
Power = Explicit Contract
PD = Connected
Data Role Swap ok
Accept received
PE_DRS_UFP_DFP_Accept_Swap
Actions on entry:
Send Accept Message
Power = Explicit Contract
PD = Connected
Accept Message sent
PE_DRS_UFP_DFP_Change_to_DFP
Actions on entry:
Request Device Policy Manager to change port to DFP
Power = Explicit Contract
PD = Connected
Port changed to DFP
PE_SRC_Ready or PE_SNK_Ready (DFP)

8.3.3.19.2.1 PE_SRC_Ready or PE_SNK_Ready State

The *Data Role Swap* process ***Shall*** start only from the either the *PE_SRC_Ready* or *PE_SNK_Ready* state where power is stable.

The *Policy Engine* ***Shall*** transition to the *PE_DRS_UFP_DFP_Evaluate_Swap* state when:

- A ***DR_Swap*** *Message* is received and
- There are no *Active Modes* (not in *Modal Operation*).

The *Policy Engine* ***Shall*** transition to either the ***PE_SRC_Hard_Reset*** or ***PE_SNK_Hard_Reset*** states when:

- A ***DR_Swap*** *Message* is received and
- There are one or more *Active Modes* (*Modal Operation*).

The *Policy Engine* ***Shall*** transition to the ***PE_DRS_UFP_DFP_Send_Swap*** state when:

- The *Device Policy Manager* indicates that a *Data Role Swap* is required.

8.3.3.19.2.2 PE_DRS_UFP_DFP_Evaluate_Swap State

On entry to the ***PE_DRS_UFP_DFP_Evaluate_Swap*** state the *Policy Engine* ***Shall*** ask the *Device Policy Manager* whether a *Data Role Swap* can be made.

The *Policy Engine* ***Shall*** transition to the ***PE_DRS_UFP_DFP_Accept_Swap*** state when:

- The *Device Policy Manager* indicates that a *Data Role Swap* is OK.

The *Policy Engine* ***Shall*** transition to the ***PE_DRS_UFP_DFP_Reject_Swap*** state when:

- The *Device Policy Manager* indicates that a *Data Role Swap* is not OK.
- Or further evaluation of the *Data Role Swap* request is needed.

8.3.3.19.2.3 PE_DRS_UFP_DFP_Accept_Swap State

On entry to the ***PE_DRS_UFP_DFP_Accept_Swap*** state the *Policy Engine* ***Shall*** request the *Protocol Layer* to send an ***Accept*** *Message*.

The *Policy Engine* ***Shall*** transition to the ***PE_DRS_UFP_DFP_Change_to_DFP*** state when:

- The ***Accept*** *Message* has been sent.

8.3.3.19.2.4 PE_DRS_UFP_DFP_Change_to_DFP State

On entry to the ***PE_DRS_UFP_DFP_Change_to_DFP*** state the *Policy Engine* ***Shall*** request the *Device Policy Manager* to change the Port from a *UFP* to a *DFP*.

The *Policy Engine* ***Shall*** transition to either the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** state when:

- The *Device Policy Manager* indicates that the Port has been changed to a *DFP*.

8.3.3.19.2.5 PE_DRS_UFP_DFP_Send_Swap State

On entry to the ***PE_DRS_UFP_DFP_Send_Swap*** state the *Policy Engine* ***Shall*** request the *Protocol Layer* to send a ***DR_Swap*** *Message* and ***Shall*** start the ***SenderResponseTimer***.

On exit from the ***PE_DRS_UFP_DFP_Send_Swap*** state the *Policy Engine* ***Shall*** stop the ***SenderResponseTimer***.

The *Policy Engine* ***Shall*** continue as a *UFP* and ***Shall*** transition to either the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** state when:

- A ***Reject*** *Message* is received.
- Or a ***Wait*** *Message* is received.
- Or the ***SenderResponseTimer*** times out.

The *Policy Engine* ***Shall*** transition to the ***PE_DRS_UFP_DFP_Change_to_DFP*** state when:

- An ***Accept*** *Message* is received.

8.3.3.19.2.6 PE_DRS_UFP_DFP_Reject_Swap State

On entry to the ***PE_DRS_UFP_DFP_Reject_Swap*** state the *Policy Engine* ***Shall*** request the *Protocol Layer* to send:

- A ***Reject*** *Message* if the device is unable to perform a *Data Role Swap* at this time.

- A ***Wait*** *Message* if further evaluation of the *Data Role Swap* request is required.

Note: In this case it is expected that one of the *Port Partner*s will send a ***DR_Swap*** *Message* at a later time (see *Section 6.3.12.3, "Wait in response to a DR_Swap Message"*).

The *Policy Engine* ***Shall*** continue as a *UFP* and ***Shall*** transition to the either the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** state when:

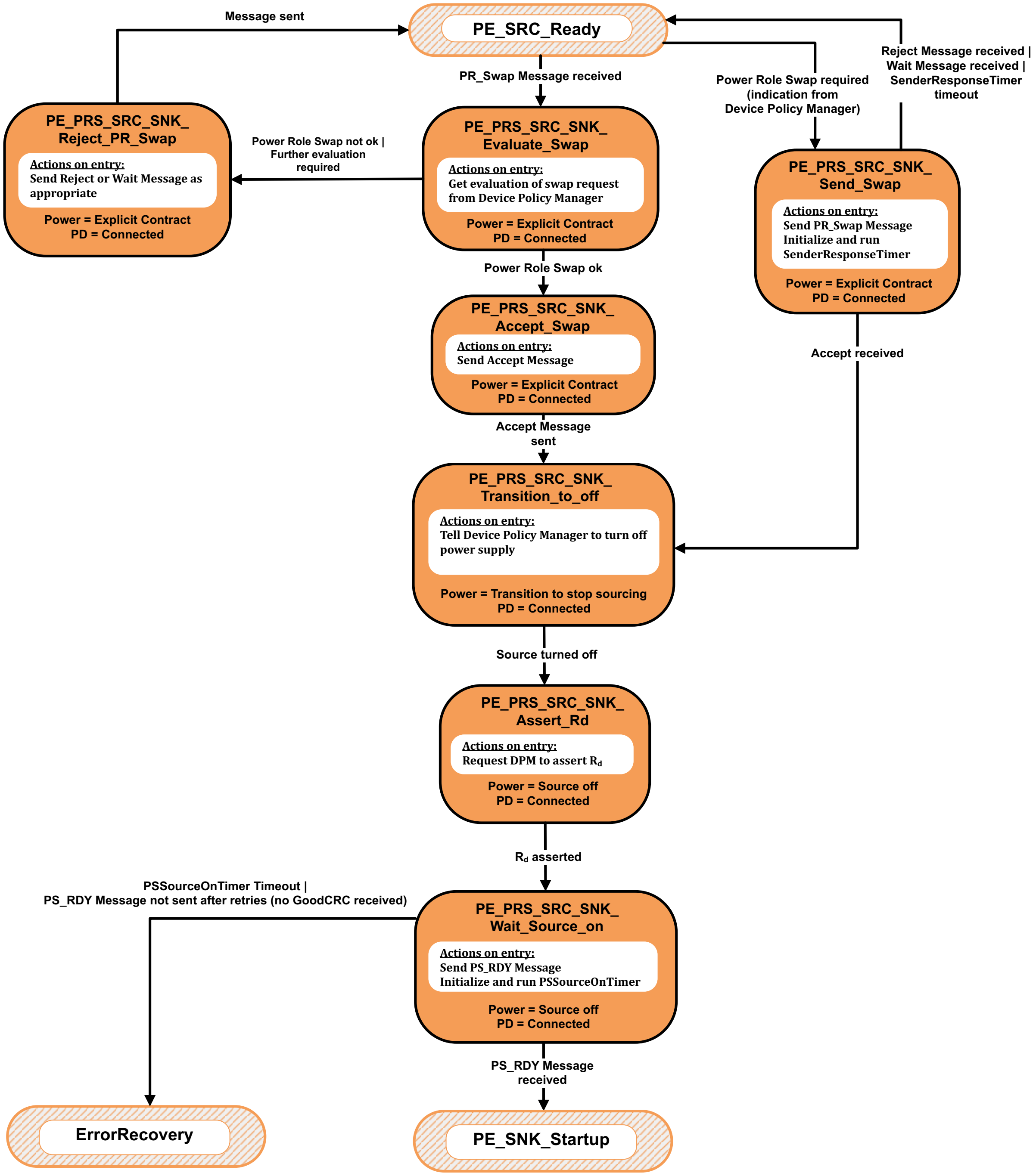
- The ***Reject*** or ***Wait*** *Message* has been sent.

8.3.3.19.3 Policy Engine in Source to Sink Power Role Swap State Diagram

Dual-Role Ports that combine *Source* and *Sink* functionality ***Shall*** comprise *Source* and *Sink Policy Engine* state machines. In addition, they ***Shall*** have the capability to do a *Power Role Swap* from the *PE_SRC_Ready* state and ***Shall*** return to *USB Default Operation* on a *Hard Reset*.

Figure 8.176, "Dual-Role Port in Source to Sink Power Role Swap State Diagram" shows the additional state diagram required to perform a *Power Role Swap* from *Source* to *Sink Power Roles* and the changes that ***Shall*** be followed for error handling.

Figure 8.176 Dual-Role Port in Source to Sink Power Role Swap State Diagram



PE_SRC_Ready
Message sent
PR_Swap Message received
Power Role Swap required (indication from Device Policy Manager)
Reject Message received | Wait Message received | SenderResponseTimer timeout
PE_PRS_SRC_SNK_ Reject_PR_Swap
Actions on entry:
Send Reject or Wait Message as appropriate
Power = Explicit Contract
PD = Connected
Power Role Swap not ok | Further evaluation required
PE_PRS_SRC_SNK_ Evaluate_Swap
Actions on entry:
Get evaluation of swap request from Device Policy Manager
Power = Explicit Contract
PD = Connected
PE_PRS_SRC_SNK_ Send_Swap
Actions on entry:
Send PR_Swap Message
Initialize and run SenderResponseTimer
Power = Explicit Contract
PD = Connected
Power Role Swap ok
PE_PRS_SRC_SNK_ Accept_Swap
Actions on entry:
Send Accept Message
Power = Explicit Contract
PD = Connected
Accept received
Accept Message sent
PE_PRS_SRC_SNK_ Transition_to_off
Actions on entry:
Tell Device Policy Manager to turn off power supply
Power = Transition to stop sourcing
PD = Connected
Source turned off
PE_PRS_SRC_SNK_ Assert_Rd
Actions on entry:
Request DPM to assert R_d
Power = Source off
PD = Connected
R_d asserted
PSSourceOnTimer Timeout | PS_RDY Message not sent after retries (no GoodCRC received)
PE_PRS_SRC_SNK_ Wait_Source_on
Actions on entry:
Send PS_RDY Message
Initialize and run PSSourceOnTimer
Power = Source off
PD = Connected
PS_RDY Message received
ErrorRecovery
PE_SNK_Startup

8.3.3.19.3.1 PE_SRC_Ready State

The *Power Role Swap* process ***Shall*** start only from the ***PE_SRC_Ready*** state where power is stable.

The *Policy Engine* ***Shall*** transition to the ***PE_PRS_SRC_SNK_Evaluate_Swap*** state when:

- A ***PR_Swap*** *Message* is received.

The *Policy Engine* ***Shall*** transition to the ***PE_PRS_SRC_SNK_Send_Swap*** state when:

- The *Device Policy Manager* indicates that a *Power Role Swap* is required.

8.3.3.19.3.2 PE_PRS_SRC_SNK_Evaluate_Swap State

On entry to the ***PE_PRS_SRC_SNK_Evaluate_Swap*** state the *Policy Engine* ***Shall*** ask the *Device Policy Manager* whether a *Power Role Swap* can be made.

The *Policy Engine* ***Shall*** transition to the ***PE_PRS_SRC_SNK_Accept_Swap*** state when:

- The *Device Policy Manager* indicates that a *Power Role Swap* is OK.

The *Policy Engine* ***Shall*** transition to the ***PE_PRS_SRC_SNK_Reject_Swap*** state when:

- The *Device Policy Manager* indicates that a *Power Role Swap* is not OK.
- Or further evaluation of the *Power Role Swap* request is needed.

8.3.3.19.3.3 PE_PRS_SRC_SNK_Accept_Swap State

On entry to the ***PE_PRS_SRC_SNK_Accept_Swap*** state the *Policy Engine* ***Shall*** request the *Protocol Layer* to send an ***Accept*** *Message*.

The *Policy Engine* ***Shall*** transition to the ***PE_PRS_SRC_SNK_Transition_to_off*** state when:

- The ***Accept*** *Message* has been sent.

8.3.3.19.3.4 PE_PRS_SRC_SNK_Transition_to_off State

On entry to the ***PE_PRS_SRC_SNK_Transition_to_off*** state the *Policy Engine* ***Shall*** request the *Device Policy Manager* to turn off the *Source*.

The *Policy Engine* ***Shall*** transition to the ***PE_PRS_SRC_SNK_Assert_Rd*** state when:

- The *Device Policy Manager* indicates that the *Source* has been turned off.

8.3.3.19.3.5 PE_PRS_SRC_SNK_Assert_Rd State

On entry to the ***PE_PRS_SRC_SNK_Assert_Rd*** state the *Policy Engine* ***Shall*** request the *Device Policy Manager* to change the resistor asserted on the *CC* wire from R_p to R_d.

The *Policy Engine* ***Shall*** transition to the ***PE_PRS_SRC_SNK_Wait_Source_on*** state when:

- The *Device Policy Manager* indicates that R_d is asserted.

8.3.3.19.3.6 PE_PRS_SRC_SNK_Wait_Source_on State

On entry to the ***PE_PRS_SRC_SNK_Wait_Source_on*** state the *Policy Engine* ***Shall*** request the *Protocol Layer* to send a ***PS_RDY*** *Message* and ***Shall*** start the ***PSSourceOnTimer***.

On exit from the *Source* off state the *Policy Engine* ***Shall*** stop the ***PSSourceOnTimer***.

The *Policy Engine* ***Shall*** transition to the ***PE_SNK_Startup*** when:

- A ***PS_RDY*** *Message* is received indicating that the remote *Source* is now supplying power.

The *Policy Engine* ***Shall*** transition to the ***ErrorRecovery*** state when:

- The ***PSSourceOnTimer*** times out or
- The ***PS_RDY*** *Message* is not sent after retries (a ***GoodCRC*** *Message* has not been received).

Note: A *Soft Reset* ***Shall Not*** be initiated in this case.

8.3.3.19.3.7 PE_PRS_SRC_SNK_Send_Swap State

On entry to the ***PE_PRS_SRC_SNK_Send_Swap*** state the *Policy Engine* ***Shall*** request the *Protocol Layer* to send a ***PR_Swap*** *Message* and ***Shall*** start the ***SenderResponseTimer***.

On exit from the ***PE_PRS_SRC_SNK_Send_Swap*** state the *Policy Engine* ***Shall*** stop the ***SenderResponseTimer***.

The *Policy Engine* ***Shall*** transition to the ***PE_SRC_Ready*** state when:

- A ***Reject*** *Message* is received.
- Or a ***Wait*** *Message* is received.
- Or the ***SenderResponseTimer*** times out.

The *Policy Engine* ***Shall*** transition to the ***PE_PRS_SRC_SNK_Transition_to_off*** state when:

- An ***Accept*** *Message* is received.

8.3.3.19.3.8 PE_PRS_SRC_SNK_Reject_Swap State

On entry to the ***PE_PRS_SRC_SNK_Reject_Swap*** state the *Policy Engine* ***Shall*** request the *Protocol Layer* to send:

- A ***Reject*** *Message* if the device is unable to perform a *Power Role Swap* at this time.
- A ***Wait*** *Message* if further evaluation of the *Power Role Swap* request is required.

Note: In this case it is expected that one of the *Port Partner*s will send a ***PR_Swap*** *Message* at a later time (see *Section 6.3.12.2, "Wait in response to a PR_Swap Message"*).

The *Policy Engine* ***Shall*** transition to the ***PE_SRC_Ready*** when:

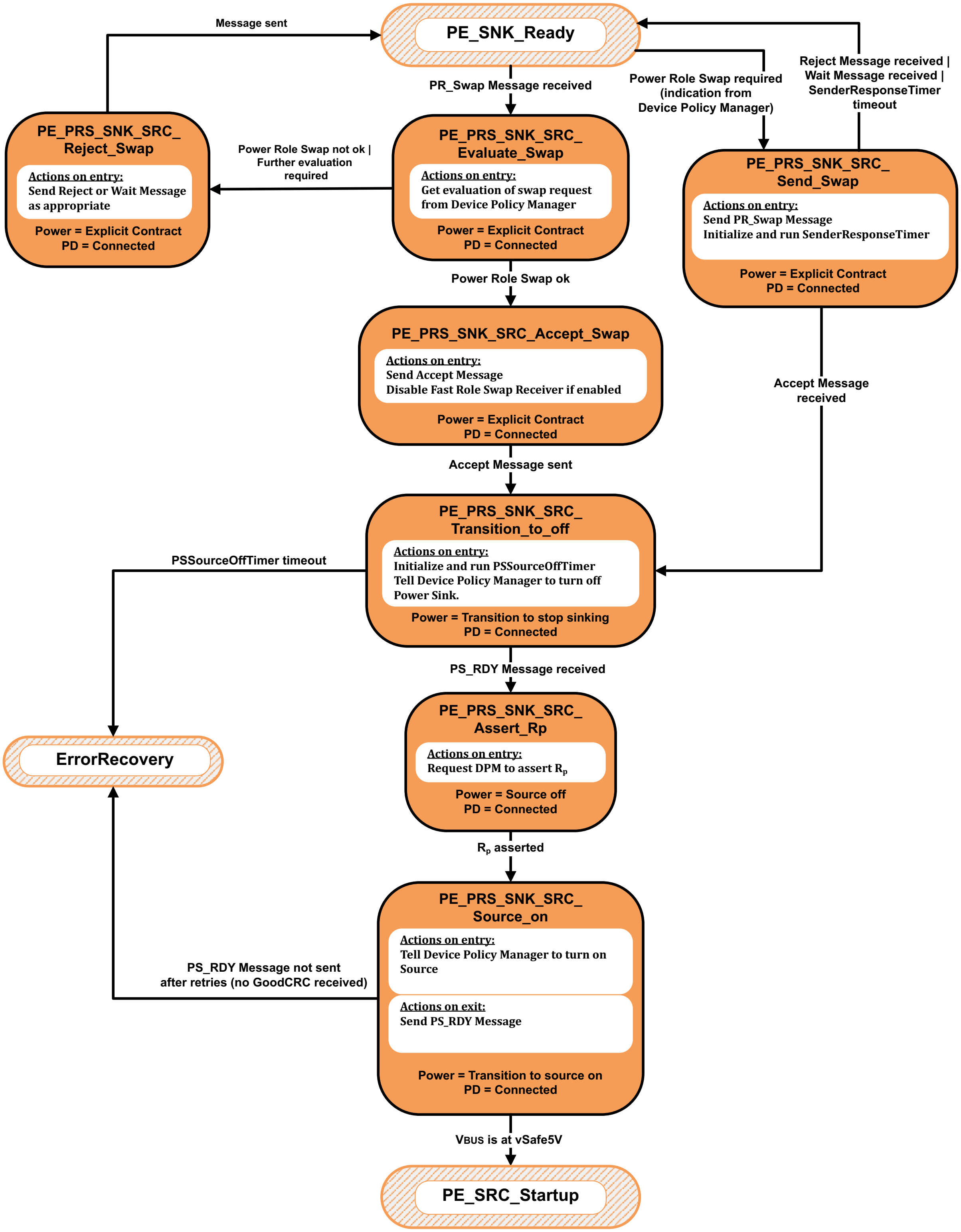
- The ***Reject*** or ***Wait*** *Message* has been sent.

8.3.3.19.4 Policy Engine in Sink to Source Power Role Swap State Diagram

Dual-Role Ports that combine *Sink* and *Source* functionality ***Shall*** comprise *Sink* and *Source Policy Engine* state machines. In addition, they ***Shall*** have the capability to do a *Power Role Swap* from the ***PE_SNK_Ready*** state and ***Shall*** return to *USB Default Operation* on a *Hard Reset*.

Figure 8.177, "Dual-role Port in Sink to Source Power Role Swap State Diagram" shows the additional state diagram required to perform a *Power Role Swap* from *Sink* to *Source Role*s and the changes that ***Shall*** be followed for error handling.

Figure 8.177 Dual-role Port in Sink to Source Power Role Swap State Diagram



Message sent
PE_SNK_Ready
PR_Swap Message received
Power Role Swap required (indication from Device Policy Manager)
Reject Message received | Wait Message received | SenderResponseTimer timeout
PE_PRS_SNK_SRC_Reject_Swap
Actions on entry:
Send Reject or Wait Message as appropriate
Power = Explicit Contract
PD = Connected
Power Role Swap not ok | Further evaluation required
PE_PRS_SNK_SRC_Evaluate_Swap
Actions on entry:
Get evaluation of swap request from Device Policy Manager
Power = Explicit Contract
PD = Connected
PE_PRS_SNK_SRC_Send_Swap
Actions on entry:
Send PR_Swap Message
Initialize and run SenderResponseTimer
Power = Explicit Contract
PD = Connected
Power Role Swap ok
PE_PRS_SNK_SRC_Accept_Swap
Actions on entry:
Send Accept Message
Disable Fast Role Swap Receiver if enabled
Power = Explicit Contract
PD = Connected
Accept Message received
Accept Message sent
PE_PRS_SNK_SRC_Transition_to_off
Actions on entry:
Initialize and run PSSourceOffTimer
Tell Device Policy Manager to turn off Power Sink.
Power = Transition to stop sinking
PD = Connected
PSSourceOffTimer timeout
PS_RDY Message received
ErrorRecovery
PE_PRS_SNK_SRC_Assert_Rp
Actions on entry:
Request DPM to assert R_p
Power = Source off
PD = Connected
R_p asserted
PE_PRS_SNK_SRC_Source_on
Actions on entry:
Tell Device Policy Manager to turn on Source
Actions on exit:
Send PS_RDY Message
Power = Transition to source on
PD = Connected
PS_RDY Message not sent after retries (no GoodCRC received)
VBUS is at vSafe5V
PE_SRC_Startup

8.3.3.19.4.1 PE_SNK_Ready State

The *Power Role Swap* process ***Shall*** start only from the *PE_SNK_Ready* state where power is stable.

The *Policy Engine* ***Shall*** transition to the *PE_PRS_SNK_SRC_Evaluate_Swap* state when:

- A ***PR_Swap*** *Message* is received.

The *Policy Engine* ***Shall*** transition to the ***PE_PRS_SNK_SRC_Send_Swap*** state when:

- The *Device Policy Manager* indicates that a *Power Role Swap* is required.

8.3.3.19.4.2 PE_PRS_SNK_SRC_Evaluate_Swap State

On entry to the ***PE_PRS_SNK_SRC_Send_Swap*** state the *Policy Engine* ***Shall*** ask the *Device Policy Manager* whether a *Power Role Swap* can be made.

The *Policy Engine* ***Shall*** transition to the ***PE_PRS_SNK_SRC_Accept_Swap*** state when:

- The *Device Policy Manager* indicates that a *Power Role Swap* is OK.

The *Policy Engine* ***Shall*** transition to the ***PE_PRS_SNK_SRC_Reject_Swap*** state when:

- The *Device Policy Manager* indicates that a *Power Role Swap* is not OK.

8.3.3.19.4.3 PE_PRS_SNK_SRC_Accept_Swap State

On entry to the ***PE_PRS_SNK_SRC_Accept_Swap*** state the *Policy Engine* ***Shall*** request the *Protocol Layer* to send an ***Accept*** *Message* and ***Shall*** disable the *Fast Role Swap* receiver if this is enabled.

The *Policy Engine* ***Shall*** transition to the ***PE_PRS_SNK_SRC_Transition_to_off*** state when:

- The ***Accept*** *Message* has been sent.

8.3.3.19.4.4 PE_PRS_SNK_SRC_Transition_to_off State

On entry to the ***PE_PRS_SNK_SRC_Transition_to_off*** state the *Policy Engine* ***Shall*** initialize and run the ***PSSourceOffTimer*** and then request the *Device Policy Manager* to turn off the *Sink*.

The *Policy Engine* ***Shall*** transition to the ***ErrorRecovery*** state when:

- The ***PSSourceOffTimer*** times out.

The *Policy Engine* ***Shall*** transition to the ***PE_PRS_SNK_SRC_Assert_Rp*** state when:

- A ***PS_RDY*** *Message* is received.

8.3.3.19.4.5 PE_PRS_SNK_SRC_Assert_Rp State

On entry to the ***PE_PRS_SNK_SRC_Assert_Rp*** state the *Policy Engine* ***Shall*** request the *Device Policy Manager* to change the resistor asserted on the *CC* wire from R_d to R_p.

The *Policy Engine* ***Shall*** transition to the ***PE_PRS_SNK_SRC_Source_on*** state when:

- The *Device Policy Manager* indicates that R_d is asserted.

8.3.3.19.4.6 PE_PRS_SNK_SRC_Source_on State

On entry to the ***PE_PRS_SNK_SRC_Source_on*** state the *Policy Engine* ***Shall*** request the *Device Policy Manager* to turn on the *Source*.

On exit from the ***PE_PRS_SNK_SRC_Source_on*** state the *Policy Engine* ***Shall*** send a ***PS_RDY*** *Message*.

The *Policy Engine* ***Shall*** transition to the ***PE_SRC_Startup*** state when:

- The *Source Port VBUS* is at ***vSafe5V***.

The *Policy Engine* ***Shall*** transition to the ***ErrorRecovery*** state when:

- The ***PS_RDY*** *Message* is not sent after retries (a ***GoodCRC*** *Message* has not been received). A *Soft Reset* ***Shall Not*** be initiated in this case.

8.3.3.19.4.7 PE_PRS_SNK_SRC_Send_Swap State

On entry to the *PE_PRS_SNK_SRC_Send_Swap* state the *Policy Engine* ***Shall*** request the *Protocol Layer* to send a ***PR_Swap*** *Message* and ***Shall*** initialize and run the ***SenderResponseTimer***.

The *Policy Engine* ***Shall*** transition to the *PE_SNK_Ready* state when:

- A ***Reject*** *Message* is received.
- Or a ***Wait*** *Message* is received.
- Or the ***SenderResponseTimer*** times out.

The *Policy Engine* ***Shall*** transition to the *PE_PRS_SNK_SRC_Transition_to_off* state when:

- An ***Accept*** *Message* is received.

8.3.3.19.4.8 PE_PRS_SNK_SRC_Reject_Swap State

On entry to the *PE_PRS_SNK_SRC_Reject_Swap* state the *Policy Engine* ***Shall*** request the *Protocol Layer* to send:

- A ***Reject*** *Message* if the device is unable to perform a *Power Role Swap* at this time.
- A ***Wait*** *Message* if further evaluation of the *Power Role Swap* request is required.

Note: In this case it is expected that one of the *Port Partner*s will send a ***PR_Swap*** *Message* at a later time (see *Section 6.3.12.2, "Wait in response to a PR_Swap Message"*).

The *Policy Engine* ***Shall*** transition to the *PE_SNK_Ready* state when:

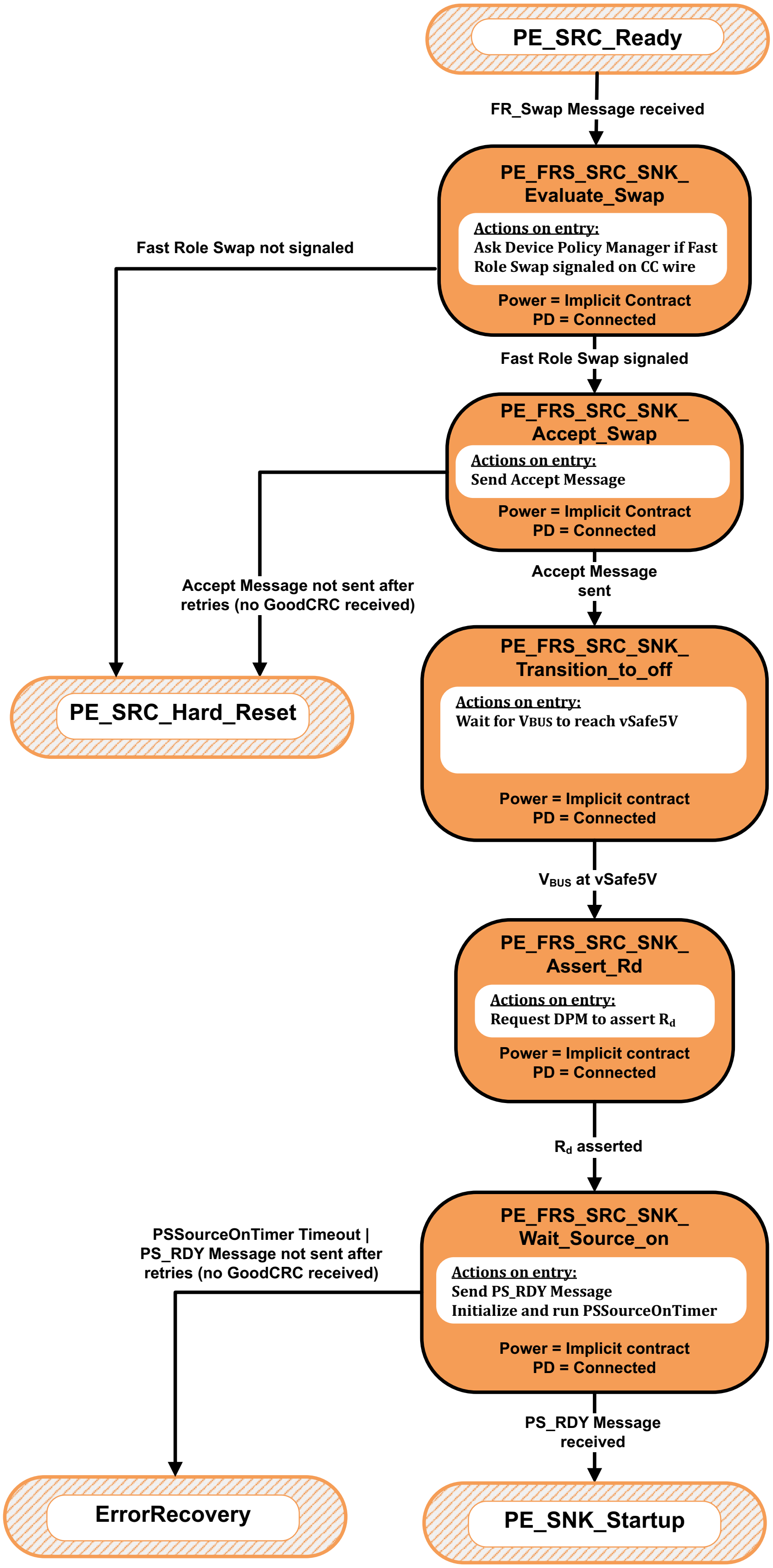
- The ***Reject*** or ***Wait*** *Message* has been sent.

8.3.3.19.5 Policy Engine in Source to Sink Fast Role Swap State Diagram

Dual-Role Ports that combine *Source* and *Sink* functionality ***Shall*** comprise *Source* and *Sink Policy Engine* state machines. In addition, they ***Should*** have the capability to do a *Fast Role Swap* from the ***PE_SRC_Ready*** state and ***Shall*** return to *USB Default Operation* on a *Hard Reset*.

Figure 8.178, "Dual-Role Port in Source to Sink Fast Role Swap State Diagram" shows the additional state diagram required to perform a *Fast Role Swap* from *Source* to *Sink Power Role*s and the changes that ***Shall*** be followed for error handling.

Figure 8.178 Dual-Role Port in Source to Sink Fast Role Swap State Diagram



PE_SRC_Ready
FR_Swap Message received
PE_FRS_SRC_SNK_ Evaluate_Swap
Actions on entry:
Ask Device Policy Manager if Fast Role Swap signaled on CC wire
Power = Implicit Contract
PD = Connected
Fast Role Swap not signaled
Fast Role Swap signaled
PE_FRS_SRC_SNK_ Accept_Swap
Actions on entry:
Send Accept Message
Power = Implicit Contract
PD = Connected
Accept Message not sent after retries (no GoodCRC received)
Accept Message sent
PE_SRC_Hard_Reset
PE_FRS_SRC_SNK_ Transition_to_off
Actions on entry:
Wait for VBUS to reach vSafe5V
Power = Implicit contract
PD = Connected
VBUS at vSafe5V
PE_FRS_SRC_SNK_ Assert_Rd
Actions on entry:
Request DPM to assert Rd
Power = Implicit contract
PD = Connected
Rd asserted
PE_FRS_SRC_SNK_ Wait_Source_on
Actions on entry:
Send PS_RDY Message
Initialize and run PSSourceOnTimer
Power = Implicit contract
PD = Connected
PSSourceOnTimer Timeout | PS_RDY Message not sent after retries (no GoodCRC received)
PS_RDY Message received
ErrorRecovery
PE_SNK_Startup

8.3.3.19.5.1 PE_SRC_Ready State

The *Fast Role Swap* process ***Shall*** start only from the ***PE_SRC_Ready*** state where power is stable.

The *Policy Engine* ***Shall*** transition to the ***PE_FRS_SRC_SNK_Evaluate_Swap*** state when:

- An ***FR_Swap*** *Message* is received.

8.3.3.19.5.2 PE_FRS_SRC_SNK_Evaluate_Swap State

On entry to the ***PE_FRS_SRC_SNK_Evaluate_Swap*** state the *Policy Engine* ***Shall*** ask the *Device Policy Manager* whether *Fast Role Swap* has been signaled on the *CC* wire.

The *Policy Engine* ***Shall*** transition to the ***PE_FRS_SRC_SNK_Accept_Swap*** state when:

- The *Device Policy Manager* indicates that a *Fast Role Swap* has been signaled.

The *Policy Engine* ***Shall*** transition to the ***PE_SRC_Hard_Reset*** state when:

- The *Device Policy Manager* indicates that a *Fast Role Swap* is not being signaled.

8.3.3.19.5.3 PE_FRS_SRC_SNK_Accept_Swap State

On entry to the ***PE_FRS_SRC_SNK_Accept_Swap*** state the *Policy Engine* ***Shall*** request the *Protocol Layer* to send an ***Accept*** *Message*.

The *Policy Engine* ***Shall*** transition to the ***PE_FRS_SRC_SNK_Transition_to_off*** state when:

- The ***Accept*** *Message* has been sent.

The *Policy Engine* ***Shall*** transition to the ***PE_SRC_Hard_Reset*** state when:

- The ***Accept*** *Message* is not sent after retries (a ***GoodCRC*** *Message* has not been received).

Note: A *Soft Reset* ***Shall Not*** be initiated in this case.

8.3.3.19.5.4 PE_FRS_SRC_SNK_Transition_to_off State

On entry to the ***PE_FRS_SRC_SNK_Transition_to_off*** state the *Policy Engine* ***Shall*** wait until *VBUS* has discharged to ***vSafe5V***.

The *Policy Engine* ***Shall*** transition to the ***PE_FRS_SRC_SNK_Assert_Rd*** state when:

- The *Device Policy Manager* indicates that *VBUS* has discharged to ***vSafe5V***.

8.3.3.19.5.5 PE_FRS_SRC_SNK_Assert_Rd State

On entry to the ***PE_FRS_SRC_SNK_Assert_Rd*** state the *Policy Engine* ***Shall*** request the *Device Policy Manager* to change the resistor asserted on the *CC* wire from R_p to R_d.

The *Policy Engine* ***Shall*** transition to the ***PE_FRS_SRC_SNK_Wait_Source_on*** state when:

- The *Device Policy Manager* indicates that R_d is asserted.

8.3.3.19.5.6 PE_FRS_SRC_SNK_Wait_Source_on State

On entry to the ***PE_FRS_SRC_SNK_Wait_Source_on*** state the *Policy Engine* ***Shall*** request the *Protocol Layer* to send a ***PS_RDY*** *Message* and ***Shall*** start the ***PSSourceOnTimer***.

On exit from the *Source* off state the *Policy Engine* ***Shall*** stop the ***PSSourceOnTimer***.

The *Policy Engine* ***Shall*** transition to the ***PE_SNK_Startup*** when:

- A ***PS_RDY*** *Message* is received indicating that the *New Source* is now applying R_p.

The *Policy Engine* ***Shall*** transition to the ***ErrorRecovery*** state when:

- The ***PSSourceOnTimer*** times out or
- The ***PS_RDY*** *Message* is not sent after retries (a ***GoodCRC*** *Message* has not been received).

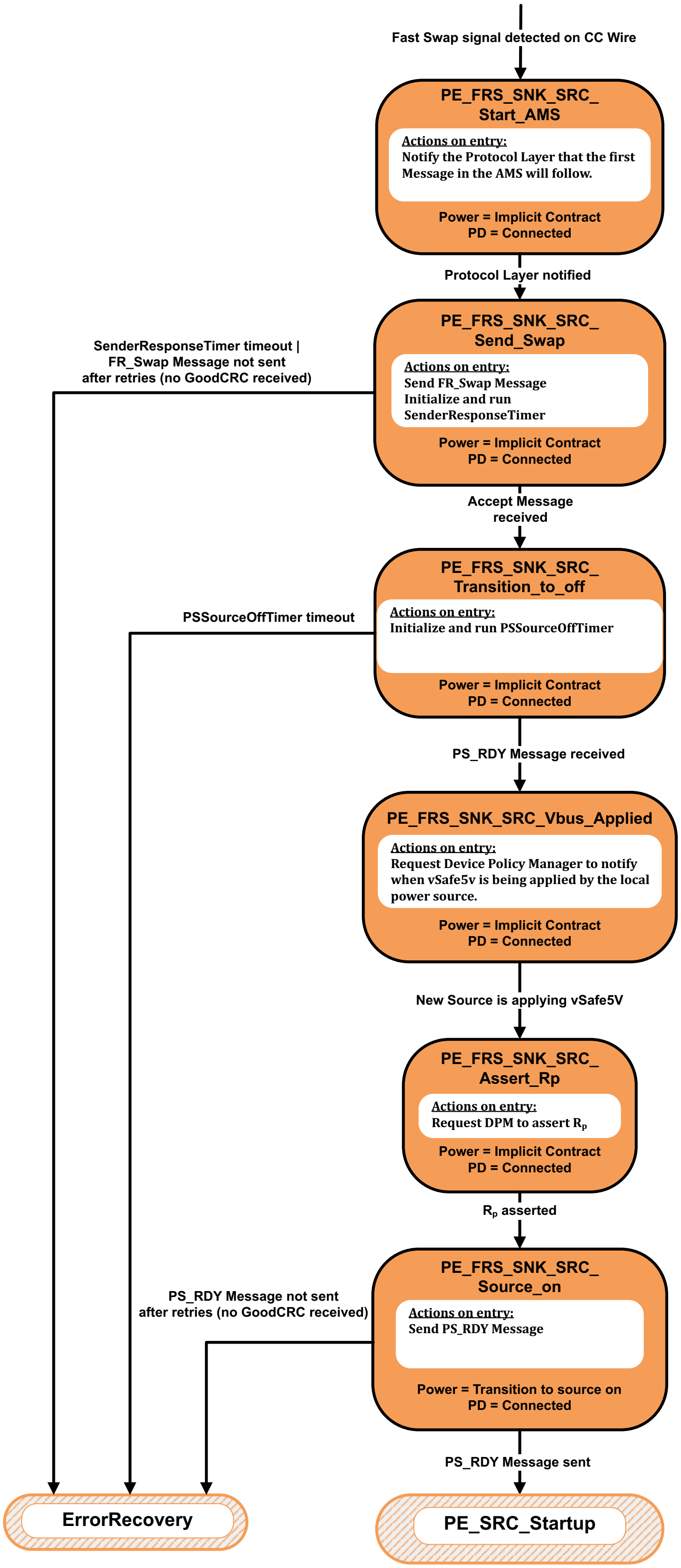
Note: A *Soft Reset* ***Shall Not*** be initiated in this case.

8.3.3.19.6 Policy Engine in Sink to Source Fast Role Swap State Diagram

Dual-Role Ports that combine *Sink* and *Source* functionality ***Shall*** comprise *Sink* and *Source Policy Engine* state machines. In addition, they ***Should*** have the capability to do a *Fast Role Swap* from the ***PE_SNK_Ready*** state and ***Shall*** return to *USB Default Operation* on a *Hard Reset*.

Figure 8.179, "Dual-role Port in Sink to Source Fast Role Swap State Diagram" shows the additional state diagram required to perform a *Fast Role Swap* from *Sink* to *Source Power Role*s and the changes that ***Shall*** be followed for error handling.

Figure 8.179 Dual-role Port in Sink to Source Fast Role Swap State Diagram


Fast Swap signal detected on CC Wire
PE_FRS_SNK_SRC_
Start_AMS
Actions on entry:
Notify the Protocol Layer that the first Message in the AMS will follow.
Power = Implicit Contract
PD = Connected
Protocol Layer notified
PE_FRS_SNK_SRC_
Send_Swap
Actions on entry:
Send FR_Swap Message
Initialize and run SenderResponseTimer
Power = Implicit Contract
PD = Connected
SenderResponseTimer timeout |
FR_Swap Message not sent
after retries (no GoodCRC received)
Accept Message received
PE_FRS_SNK_SRC_
Transition_to_off
Actions on entry:
Initialize and run PSSourceOffTimer
Power = Implicit Contract
PD = Connected
PSSourceOffTimer timeout
PS_RDY Message received
PE_FRS_SNK_SRC_Vbus_Applied
Actions on entry:
Request Device Policy Manager to notify when vSafe5v is being applied by the local power source.
Power = Implicit Contract
PD = Connected
New Source is applying vSafe5V
PE_FRS_SNK_SRC_
Assert_Rp
Actions on entry:
Request DPM to assert R_p
Power = Implicit Contract
PD = Connected
R_p asserted
PE_FRS_SNK_SRC_
Source_on
Actions on entry:
Send PS_RDY Message
Power = Transition to source on
PD = Connected
PS_RDY Message not sent
after retries (no GoodCRC received)
PS_RDY Message sent
ErrorRecovery
PE_SRC_Startup

8.3.3.19.6.1 PE_FRS_SNK_SRC_Start_AMS State

The *Policy Engine* ***Shall*** transition to the ***PE_FRS_SNK_SRC_Start_AMS*** state from any other state provided there is an *Explicit Contract* in place when:

- The *Sink Capabilities* received from the *Initial Source* by the *Policy Engine* has at least one of the *Fast Role Swap* bits set.
- The system has sufficient reserve power to provide the requested current to the *Initial Source*, as requested in the *Fast Role Swap* bits in the *Sink Capabilities*, and is willing to dedicate it to the Port
- The *Device Policy Manager* indicates that a *Fast Role Swap* signal has been detected on the *CC* wire.

On entry to the ***PE_FRS_SNK_SRC_Start_AMS*** state the *Policy Engine* ***Shall*** notify the *Protocol Layer* that the first *Message* in an *AMS* will follow.

The *Policy Engine* ***Shall*** transition to the ***PE_FRS_SNK_SRC_Send_Swap*** state when:

- The *Protocol Layer* has been notified.

8.3.3.19.6.2 PE_FRS_SNK_SRC_Send_Swap State

On entry to the ***PE_FRS_SNK_SRC_Send_Swap*** state the *Policy Engine* ***Shall*** request the *Protocol Layer* to send an ***FR_Swap*** *Message* and ***Shall*** initialize and run the ***SenderResponseTimer***.

The *Policy Engine* ***Shall*** transition to the ***PE_FRS_SNK_SRC_Transition_to_off*** state when:

- An ***Accept*** *Message* is received.

The *Policy Engine* ***Shall*** transition to the ***ErrorRecovery*** state when:

- The ***SenderResponseTimer*** times out or
- The ***FR_Swap*** *Message* is not sent after retries (a ***GoodCRC*** *Message* has not been received). A *Soft Reset* ***Shall Not*** be initiated in this case.

8.3.3.19.6.3 PE_FRS_SNK_SRC_Transition_to_off State

On entry to the ***PE_FRS_SNK_SRC_Transition_to_off*** state the *Policy Engine* ***Shall*** initialize and run the ***PSSourceOffTimer*** and then request the *Device Policy Manager* to turn off the *Sink*.

The *Policy Engine* ***Shall*** transition to the ***ErrorRecovery*** state when:

- The ***PSSourceOffTimer*** times out.

The *Policy Engine* ***Shall*** transition to the ***PE_FRS_SNK_SRC_VBUS_Applied*** state when:

- A ***PS_RDY*** *Message* is received.

8.3.3.19.6.4 PE_FRS_SNK_SRC_VBUS_Applied State

On entry to the ***PE_FRS_SNK_SRC_VBUS_Applied*** state the *Policy Engine* waits for a notification from the *Device Policy Manager* that the local power source has applied ***vSafe5V*** to *VBUS* (see [Section 5.8.6.3, "Fast Role Swap Detection"](#)).

Note: This could have already been applied prior to entering this state or could be applied while waiting in this state.

The *Policy Engine* ***Shall*** transition to the ***PE_FRS_SNK_SRC_Assert_Rp*** state when:

- The *Device Policy Manager* indicates that ***vSafe5V*** is being applied.

8.3.3.19.6.5 PE_FRS_SNK_SRC_Assert_Rp State

On entry to the ***PE_FRS_SNK_SRC_Assert_Rp*** state the *Policy Engine* ***Shall*** request the *Device Policy Manager* to change the resistor asserted on the *CC* wire from R_d to R_p.

The *Policy Engine* ***Shall*** transition to the ***PE_FRS_SNK_SRC_Source_on*** state when:

- The *Device Policy Manager* indicates that R_p is asserted.

8.3.3.19.6.6 PE_FRS_SNK_SRC_Source_on State

On entry to the ***PE_FRS_SNK_SRC_Source_on*** state the *Policy Engine* ***Shall*** request the *Device Policy Manager* to turn on the *Source*.

On exit from the ***PE_FRS_SNK_SRC_Source_on*** state the *Policy Engine* ***Shall*** send a ***PS_RDY*** *Message*.

The *Policy Engine* ***Shall*** transition to the ***PE_SRC_Startup*** state when:

- The ***PS_RDY*** *Message* has been sent.

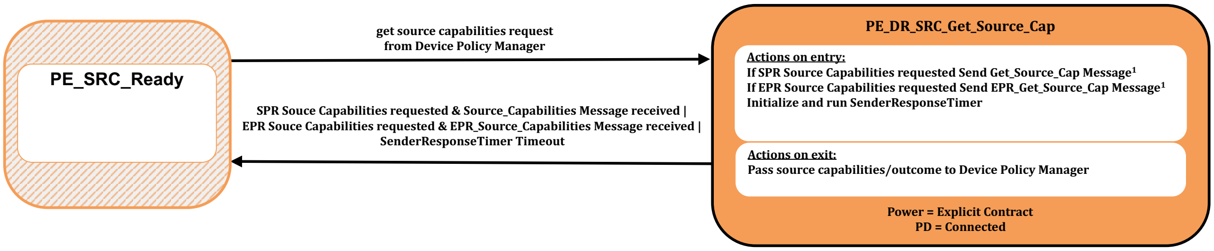
The *Policy Engine* ***Shall*** transition to the ***ErrorRecovery*** state when:

- The ***PS_RDY*** *Message* is not sent after retries (a ***GoodCRC*** *Message* has not been received). A *Soft Reset* ***Shall Not*** be initiated in this case.

8.3.3.19.7 Dual-Role (Source Port) Get Source Capabilities State Diagram

Figure 8.180, "Dual-Role (Source) Get Source Capabilities diagram" shows the state diagram for a Dual-Role device, presently operating as a *Source*, on receiving a request from the *Device Policy Manager* to get the *Port Partner*'s *Source Capabilities*. See also *Section , "A Source Port **Shall** report its Capabilities in a series of 32-bit Power Data Objects (see Table 6.7, "Power Data Object") as part of a **Source_Capabilities** Message (see Figure 6.13, "Example Capabilities Message with 2 Power Data Objects"). Power Data Objects are used to convey a Source Port's Capabilities to provide power including Dual-Role Power ports presently operating as a Sink."*.

Figure 8.180 Dual-Role (Source) Get Source Capabilities diagram


PE_SRC_Ready
get source capabilities request
from Device Policy Manager
SPR Souce Capabilities requested & Source_Capabilities Message received |
EPR Souce Capabilities requested & EPR_Source_Capabilities Message received |
SenderResponseTimer Timeout
PE_DR_SRC_Get_Source_Cap
Actions on entry:
If SPR Source Capabilities requested Send Get_Source_Cap Message[1]
If EPR Source Capabilities requested Send EPR_Get_Source_Cap Message[1]
Initialize and run SenderResponseTimer
Actions on exit:
Pass source capabilities/outcome to Device Policy Manager
Power = Explicit Contract
PD = Connected

[1] Either SPR or EPR Source Capabilities ***May*** be requested, regardless of whether or not the Source is currently operating in SPR or EPR Mode.

8.3.3.19.7.1 PE_DR_SRC_Get_Source_Cap State

The *Policy Engine* ***Shall*** transition to the ***PE_DR_SRC_Get_Source_Cap*** state, from the ***PE_SRC_Ready*** state, due to a request to get the remote *Source Capabilities* from the *Device Policy Manager*.

- On entry to the ***PE_DR_SRC_Get_Source_Cap*** state the *Policy Engine* ***Shall*** request the *Protocol Layer* to send a get *Source Capabilities Message* in order to retrieve the *Source Capabilities*. The *Policy Engine* ***Shall*** send:
- A ***Get_Source_Cap*** *Message* when the *Device Policy Manager* requests SPR capabilities or
- An ***EPR_Get_Source_Cap*** *Message* when the *Device Policy Manager* requests *EPR Capabilities*.

The *Policy Engine* ***Shall*** then start the ***SenderResponseTimer***.

On exit from the ***PE_DR_SRC_Get_Source_Cap*** state the *Policy Engine* ***Shall*** inform the *Device Policy Manager* of the outcome (capabilities or response timeout).

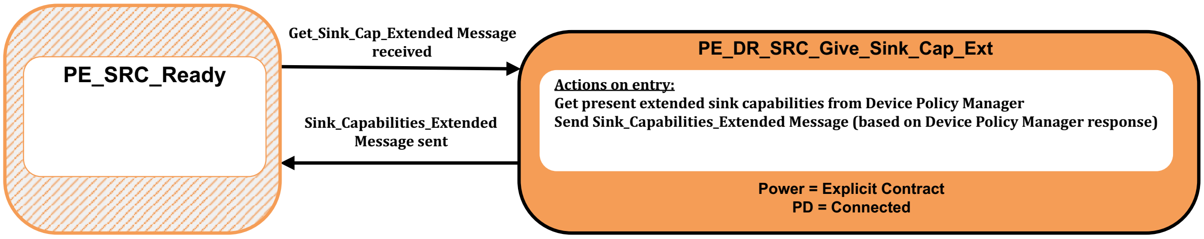
The *Policy Engine* ***Shall*** transition back to the ***PE_SRC_Ready*** State (see *Figure 8.132, "Source Port State Diagram"*) when:

- In *SPR Mode* and SPR *Source Capabilities* were requested and a ***Source_Capabilities*** *Message* is received or
- In *EPR Mode* and EPR *Source Capabilities* were requested and an ***EPR_Source_Capabilities*** *Message* is received or
- The ***SenderResponseTimer*** times out.

8.3.3.19.8 Dual-Role (Source Port) Give Sink Capabilities State Diagram

Figure 8.181, "Dual-Role (Source) Give Sink Capabilities diagram" shows the state diagram for a Dual-Role device, presently operating as a *Source*, on receiving a ***Get_Sink_Cap*** *Message*. See also *Section , "A Source Port **Shall** report its Capabilities in a series of 32-bit Power Data Objects (see Table 6.7, "Power Data Object") as part of a **Source_Capabilities** Message (see Figure 6.13, "Example Capabilities Message with 2 Power Data Objects"). Power Data Objects are used to convey a Source Port's Capabilities to provide power including Dual-Role Power ports presently operating as a Sink."*.

Figure 8.181 Dual-Role (Source) Give Sink Capabilities diagram


PE_SRC_Ready
Get_Sink_Cap_Extended Message received
Sink_Capabilities_Extended Message sent
PE_DR_SRC_Give_Sink_Cap_Ext
Actions on entry:
Get present extended sink capabilities from Device Policy Manager
Send Sink_Capabilities_Extended Message (based on Device Policy Manager response)
Power = Explicit Contract
PD = Connected

8.3.3.19.8.1 PE_DR_SRC_Give_Sink_Cap State

The *Policy Engine* ***Shall*** transition to the ***PE_DR_SRC_Give_Sink_Cap*** state, from the ***PE_SRC_Ready*** state, when a ***Get_Sink_Cap*** *Message* or ***EPR_Get_Sink_Cap*** *Message* is received.

- On entry to the ***PE_DR_SRC_Give_Sink_Cap*** state the *Policy Engine* ***Shall*** request the *Device Policy Manager* for the current system capabilities. The *Policy Engine* ***Shall*** then request the *Protocol Layer* to send a ***Sink_Capabilities*** *Message* containing these capabilities. The *Policy Engine* ***Shall*** send:
- A ***Sink_Capabilities*** *Message* when a ***Get_Sink_Cap*** *Message* is received or
- An ***EPR_Sink_Capabilities*** *Message* when a ***EPR_Get_Sink_Cap*** *Message* is received.

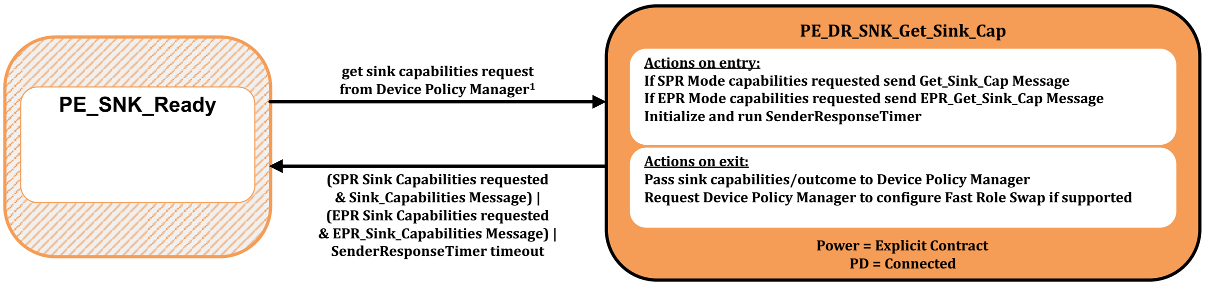
The *Policy Engine* ***Shall*** transition back to the ***PE_SRC_Ready*** state (see *Figure 8.132, "Source Port State Diagram"*) when:

- The ***Sink_Capabilities*** *Message* has been successfully sent.

8.3.3.19.9 Dual-Role (Sink Port) Get Sink Capabilities State Diagram

Figure 8.182, "Dual-Role (Sink) Get Sink Capabilities State Diagram" shows the state diagram for a Dual-Role device, presently operating as a *Sink*, on receiving a request from the *Device Policy Manager* to get the *Port Partner*'s *Sink Capabilities*. See also *Section , "A Source Port **Shall** report its Capabilities in a series of 32-bit Power Data Objects (see Table 6.7, "Power Data Object") as part of a **Source_Capabilities** Message (see Figure 6.13, "Example Capabilities Message with 2 Power Data Objects"). Power Data Objects are used to convey a Source Port's Capabilities to provide power including Dual-Role Power ports presently operating as a Sink."*.

Figure 8.182 Dual-Role (Sink) Get Sink Capabilities State Diagram


PE_SNK_Ready
get sink capabilities request from Device Policy Manager1
(SPR Sink Capabilities requested & Sink_Capabilities Message) | (EPR Sink Capabilities requested & EPR_Sink_Capabilities Message) | SenderResponseTimer timeout
PE_DR_SNK_Get_Sink_Cap
Actions on entry:
If SPR Mode capabilities requested send Get_Sink_Cap Message
If EPR Mode capabilities requested send EPR_Get_Sink_Cap Message
Initialize and run SenderResponseTimer
Actions on exit:
Pass sink capabilities/outcome to Device Policy Manager
Request Device Policy Manager to configure Fast Role Swap if supported
Power = Explicit Contract
PD = Connected

[1] Either SPR or EPR Sink Capabilities ***May*** be requested, regardless of whether or not the Sink is currently operating in SPR or EPR Mode.

8.3.3.19.9.1 PE_DR_SNK_Get_Sink_Cap State

The *Policy Engine **Shall*** transition to the ***PE_DR_SNK_Get_Sink_Cap*** state, from the ***PE_SNK_Ready*** state, due to a request to get the remote *Source Capabilities* from the *Device Policy Manager*.

- On entry to the ***PE_DR_SNK_Get_Sink_Cap*** state the *Policy Engine **Shall*** request the *Protocol Layer* to send a ***Get_Sink_Cap*** *Message* in order to retrieve the *Sink Capabilities*. The *Policy Engine **Shall*** send:
- A ***Get_Sink_Cap*** *Message* when the *Device Policy Manager* requests SPR capabilities or
- An ***EPR_Get_Sink_Cap*** *Message* when the *Device Policy Manager* requests *EPR Capabilities*.

The *Policy Engine **Shall*** then start the ***SenderResponseTimer***.

On exit from the ***PE_SRC_Get_Sink_Cap*** state the *Policy Engine **Shall*** inform the *Device Policy Manager* of the outcome (capabilities or response timeout). If *Fast Role Swap* is supported, request *Device Policy Manager* prepare or disable 5V source and configure the *Fast Role Swap* receiver based on the ***Fast Role Swap required USB Type-C Current*** bits in the received *Sink Capabilities*.

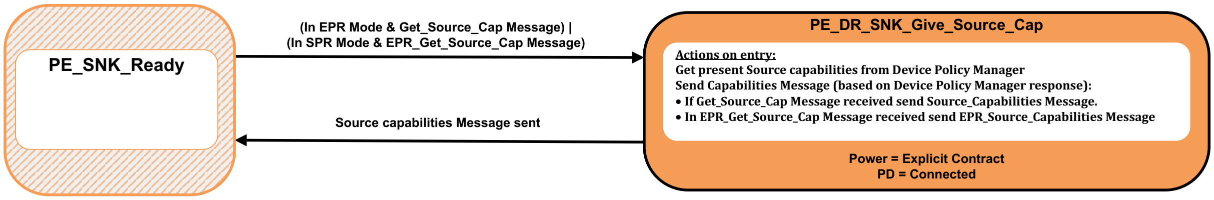
The *Policy Engine **Shall*** transition to the ***PE_SNK_Ready*** state (see *Figure 8.133, "Sink Port State Diagram"*) when:

- SPR *Sink Capabilities* were requested and a ***Sink_Capabilities*** *Message* is received or
- EPR *Sink Capabilities* were requested and an ***EPR_Sink_Capabilities*** *Message* is received or
- The ***SenderResponseTimer*** times out.

8.3.3.19.10 Dual-Role (Sink Port) Give Source Capabilities State Diagram

Figure 8.182, "Dual-Role (Sink) Get Sink Capabilities State Diagram" shows the state diagram for a Dual-Role device, presently operating as a *Sink*, on receiving a ***Get_Source_Cap*** *Message*. See also *Section , "A Source Port **Shall** report its Capabilities in a series of 32-bit Power Data Objects (see Table 6.7, "Power Data Object") as part of a **Source_Capabilities** Message (see Figure 6.13, "Example Capabilities Message with 2 Power Data Objects"). Power Data Objects are used to convey a Source Port's Capabilities to provide power including Dual-Role Power ports presently operating as a Sink."*.

Figure 8.183 Dual-Role (Sink) Give Source Capabilities State Diagram


PE_SNK_Ready
(In EPR Mode & Get_Source_Cap Message) |
(In SPR Mode & EPR_Get_Source_Cap Message)
Source capabilities Message sent
PE_DR_SNK_Give_Source_Cap
Actions on entry:
Get present Source capabilities from Device Policy Manager
Send Capabilities Message (based on Device Policy Manager response):
• If Get_Source_Cap Message received send Source_Capabilities Message.
• In EPR_Get_Source_Cap Message received send EPR_Source_Capabilities Message
Power = Explicit Contract
PD = Connected

8.3.3.19.10.1 PE_DR_SNK_Give_Source_Cap State

The *Policy Engine* ***Shall*** transition to the ***PE_DR_SNK_Give_Source_Cap*** state, from the ***PE_SNK_Ready*** state, when a ***Get_Source_Cap*** *Message* is received.

- On entry to the ***PE_DR_SNK_Give_Source_Cap*** State the *Policy Engine* ***Shall*** request the *Device Policy Manager* for the current system capabilities. The *Policy Engine* ***Shall*** then request the *Protocol Layer* to send a *Source Capabilities Message* containing these capabilities.
- The *Policy Engine* ***Shall*** send:
- A ***Source_Capabilities*** *Message* when a ***Get_Source_Cap*** *Message* is received or
- An ***EPR_Source_Capabilities*** *Message* when a ***EPR_Get_Source_Cap*** *Message* is received.

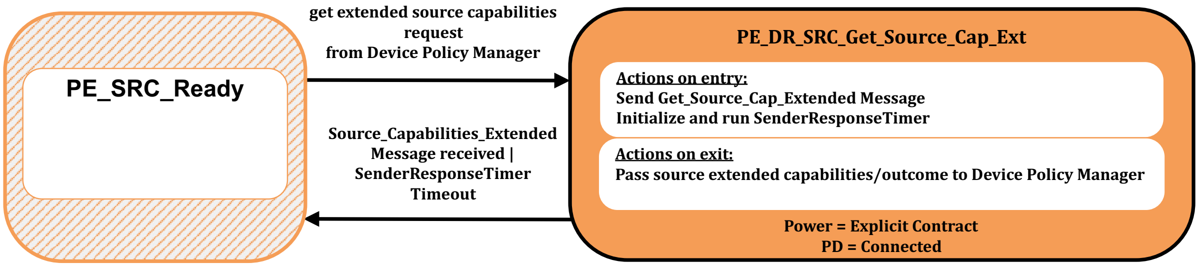
The *Policy Engine* ***Shall*** transition to the ***PE_SNK_Ready*** state (see *Figure 8.133, "Sink Port State Diagram"*) when:

- The *Source Capabilities Message* has been successfully sent.

8.3.3.19.11 Dual-Role (Source Port) Get Source Capabilities Extended State Diagram

Figure 8.184, "Dual-Role (Source) Get Source Capabilities Extended State Diagram" shows the state diagram for a Dual-Role device, presently operating as a *Source*, on receiving a request from the *Device Policy Manager* to get the *Port Partner*'s extended *Source Capabilities*. See also *Section 6.5.1, "Source_Capabilities_Extended Message"*.

Figure 8.184 Dual-Role (Source) Get Source Capabilities Extended State Diagram


PE_SRC_Ready
get extended source capabilities request from Device Policy Manager
Source_Capabilities_Extended Message received | SenderResponseTimer Timeout
PE_DR_SRC_Get_Source_Cap_Ext
Actions on entry:
Send Get_Source_Cap_Extended Message
Initialize and run SenderResponseTimer
Actions on exit:
Pass source extended capabilities/outcome to Device Policy Manager
Power = Explicit Contract
PD = Connected

8.3.3.19.11.1 PE_DR_SRC_Get_Source_Cap_Ext State

The *Policy Engine* ***Shall*** transition to the ***PE_DR_SRC_Get_Source_Cap_Ext*** state, from the ***PE_SRC_Ready*** state, due to a request to get the remote extended *Source Capabilities* from the *Device Policy Manager*.

On entry to the ***PE_DR_SRC_Get_Source_Cap_Ext*** state the *Policy Engine* ***Shall*** send a ***Get_Source_Cap_Extended*** *Message* and initialize and run the ***SenderResponseTimer***.

On exit from the ***PE_DR_SRC_Get_Source_Cap_Ext*** state the *Policy Engine* ***Shall*** inform the *Device Policy Manager* of the outcome (capabilities or response timeout).

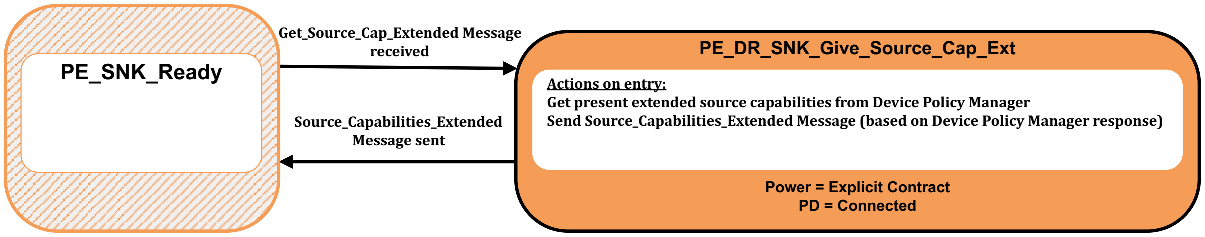
The *Policy Engine* ***Shall*** transition back to the ***PE_SRC_Ready*** state (see *Figure 8.132, "Source Port State Diagram"*) when:

- A ***Source_Capabilities_Extended*** *Message* is received
- Or ***SenderResponseTimer*** times out.

8.3.3.19.12 Dual-Role (Sink Port) Give Source Capabilities Extended State Diagram

Figure 8.185, "Dual-Role (Sink) Give Source Capabilities Extended diagram" shows the state diagram for a Dual-Role device, presently operating as a *Sink*, on receiving a ***Get_Source_Cap_Extended*** *Message*. See also *Section 6.5.1, "Source_Capabilities_Extended Message"*.

Figure 8.185 Dual-Role (Sink) Give Source Capabilities Extended diagram


PE_SNK_Ready
Get_Source_Cap_Extended Message received
Source_Capabilities_Extended Message sent
PE_DR_SNK_Give_Source_Cap_Ext
Actions on entry:
Get present extended source capabilities from Device Policy Manager
Send Source_Capabilities_Extended Message (based on Device Policy Manager response)
Power = Explicit Contract
PD = Connected

8.3.3.19.12.1 PE_DR_SNK_Give_Source_Cap_Ext State

The *Policy Engine* ***Shall*** transition to the ***PE_DR_SNK_Give_Source_Cap_Ext*** state, from the ***PE_SNK_Ready*** state, when a ***Get_Source_Cap_Extended*** *Message* is received.

On entry to the ***PE_DR_SNK_Give_Source_Cap_Ext*** state the *Policy Engine* ***Shall*** request the present extended *Source Capabilities* from the *Device Policy Manager* and then send a ***Source_Capabilities_Extended*** *Message* based on these capabilities.

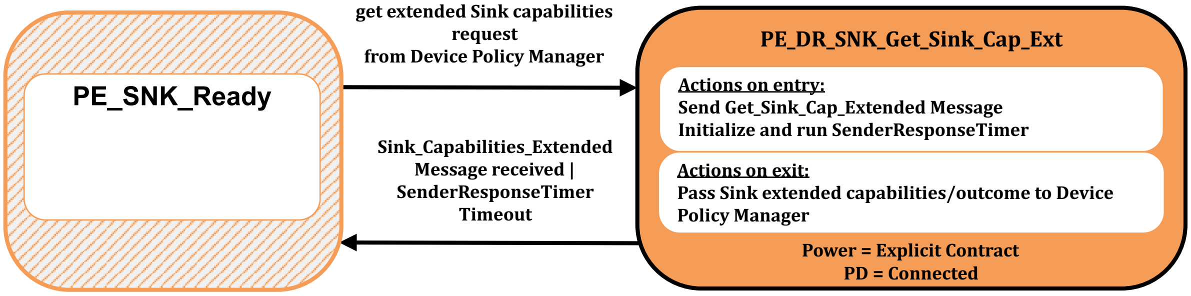
The *Policy Engine* ***Shall*** transition back to the ***PE_SNK_Ready*** state (see *Figure 8.133, "Sink Port State Diagram"*) when:

- The ***Source_Capabilities_Extended*** *Message* has been successfully sent.

8.3.3.19.13 Dual-Role (Sink Port) Get Sink Capabilities Extended State Diagram

Figure 8.186, "Dual-Role (Sink) Get Sink Capabilities Extended State Diagram" shows the state diagram for a Dual-Role device, presently operating as a *Sink*, on receiving a request from the *Device Policy Manager* to get the *Port Partner*'s extended *Sink Capabilities*. See also *Section 6.5.13, "Sink_Capabilities_Extended Message"*.

Figure 8.186 Dual-Role (Sink) Get Sink Capabilities Extended State Diagram


PE_SNK_Ready
get extended Sink capabilities request from Device Policy Manager
Sink_Capabilities_Extended Message received | SenderResponseTimer Timeout
PE_DR_SNK_Get_Sink_Cap_Ext
Actions on entry:
Send Get_Sink_Cap_Extended Message
Initialize and run SenderResponseTimer
Actions on exit:
Pass Sink extended capabilities/outcome to Device Policy Manager
Power = Explicit Contract
PD = Connected

8.3.3.19.13.1 PE_DR_SNK_Get_Sink_Cap_Ext State

The *Policy Engine* ***Shall*** transition to the ***PE_DR_SNK_Get_Sink_Cap_Ext*** state, from the ***PE_SNK_Ready*** state, due to a request to get the remote extended *Source Capabilities* from the *Device Policy Manager*.

On entry to the ***PE_DR_SNK_Get_Sink_Cap_Ext*** state the *Policy Engine* ***Shall*** send a ***Get_Sink_Cap_Extended*** *Message* and initialize and run the ***SenderResponseTimer***.

On exit from the ***PE_DR_SNK_Get_Sink_Cap_Ext*** state the *Policy Engine* ***Shall*** inform the *Device Policy Manager* of the outcome (capabilities or response timeout).

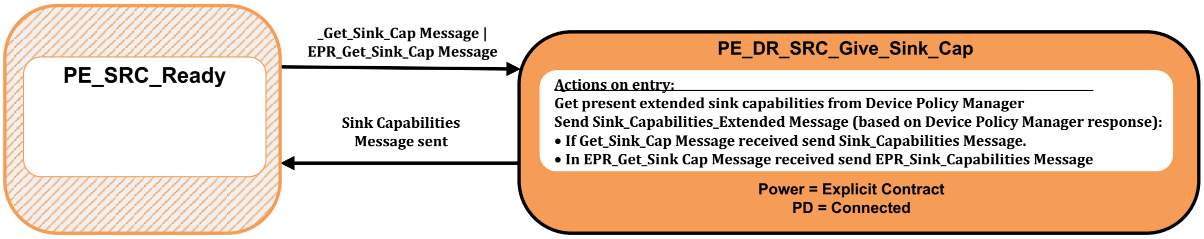
The *Policy Engine* ***Shall*** transition back to the ***PE_SNK_Ready*** state (see *Figure 8.133, "Sink Port State Diagram"*) when:

- A ***Sink_Capabilities_Extended*** *Message* is received.
- Or ***SenderResponseTimer*** times out.

8.3.3.19.14 Dual-Role (Source Port) Give Sink Capabilities Extended State Diagram

Figure 8.187, "Dual-Role (Source) Give Sink Capabilities Extended diagram" shows the state diagram for a Dual-Role device, presently operating as a *Sink*, on receiving a ***Get_Sink_Cap_Extended*** *Message*. See also *Section 6.5.13, "Sink_Capabilities_Extended Message"*.

Figure 8.187 Dual-Role (Source) Give Sink Capabilities Extended diagram


PE_SRC_Ready
_Get_Sink_Cap Message |
EPR_Get_Sink_Cap Message
Sink Capabilities
Message sent
PE_DR_SRC_Give_Sink_Cap
Actions on entry:
Get present extended sink capabilities from Device Policy Manager
Send Sink_Capabilities_Extended Message (based on Device Policy Manager response):
• If Get_Sink_Cap Message received send Sink_Capabilities Message.
• In EPR_Get_Sink Cap Message received send EPR_Sink_Capabilities Message
Power = Explicit Contract
PD = Connected

8.3.3.19.14.1 PE_DR_SRC_Give_Sink_Cap_Ext State

The *Policy Engine* ***Shall*** transition to the ***PE_DR_SRC_Give_Sink_Cap_Ext*** state, from the ***PE_SRC_Ready*** state, when a ***Get_Sink_Cap_Extended*** *Message* is received.

On entry to the ***PE_DR_SRC_Give_Sink_Cap_Ext*** state the *Policy Engine* ***Shall*** request the present extended *Sink Capabilities* from the *Device Policy Manager* and then send a ***Sink_Capabilities_Extended*** *Message* based on these capabilities.

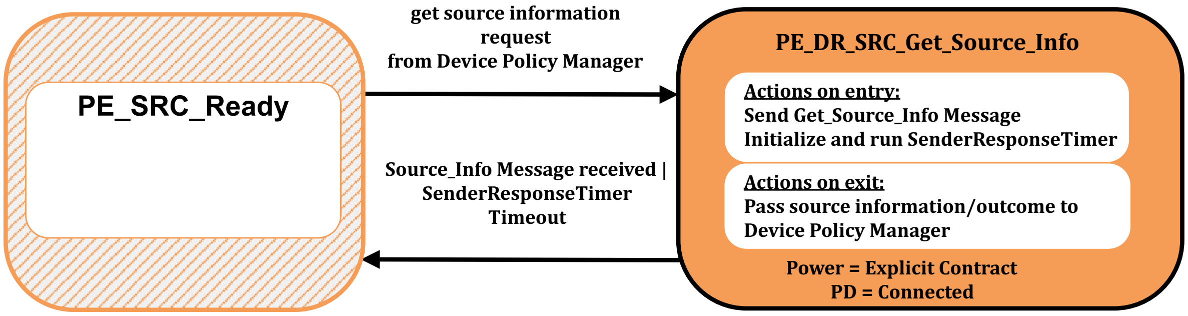
The *Policy Engine* ***Shall*** transition back to the ***PE_SRC_Ready*** state (see *Figure 8.132, "Source Port State Diagram"*)when:

- The ***Sink_Capabilities_Extended*** *Message* has been successfully sent.

8.3.3.19.15 Dual-Role (Source Port) Get Source Information State Diagram

Figure 8.188, "Dual-Role (Source) Get Source Information State Diagram" shows the state diagram for a Dual-Role device, presently operating as a *Source*, on receiving a request from the *Device Policy Manager* to get the *Port Partner*'s *Source* information. See also *Section 6.3.23, "Get_Source_Info Message"* and *Section 6.4.11, "Source_Info Message"*.

Figure 8.188 Dual-Role (Source) Get Source Information State Diagram



PE_SRC_Ready
get source information request from Device Policy Manager
Source_Info Message received | SenderResponseTimer Timeout
PE_DR_SRC_Get_Source_Info
Actions on entry:
Send Get_Source_Info Message
Initialize and run SenderResponseTimer
Actions on exit:
Pass source information/outcome to Device Policy Manager
Power = Explicit Contract
PD = Connected

8.3.3.19.15.1 PE_DR_SRC_Get_Source_Info State

The *Policy Engine* ***Shall*** transition to the ***PE_DR_SRC_Get_Source_Info*** state, from the ***PE_SRC_Ready*** state, due to a request to get the remote *Source* information from the *Device Policy Manager*.

On entry to the ***PE_DR_SRC_Get_Source_Info*** state the *Policy Engine* ***Shall*** send a ***Get_Source_Info*** *Message* and initialize and run the ***SenderResponseTimer***.

On exit from the ***PE_DR_SRC_Get_Source_Info*** state the *Policy Engine* ***Shall*** inform the *Device Policy Manager* of the outcome (information or response timeout).

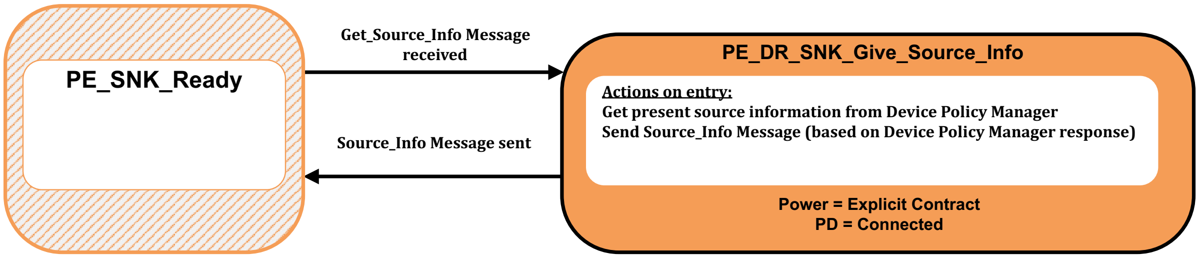
The *Policy Engine* ***Shall*** transition back to the ***PE_SRC_Ready*** state (see *Figure 8.132, "Source Port State Diagram"*) when:

- A ***Source_Info*** *Message* is received.
- Or ***SenderResponseTimer*** times out.

8.3.3.19.16 Dual-Role (Sink Port) Give Source Information State Diagram

Figure 8.189, "Dual-Role (Source) Give Source Information diagram" shows the state diagram for a Dual-Role device, presently operating as a *Sink*, on receiving a ***Get_Source_Info*** *Message*. See also *Section 6.3.23, "Get_Source_Info Message"* and *Section 6.4.11, "Source_Info Message"*.

Figure 8.189 Dual-Role (Source) Give Source Information diagram


PE_SNK_Ready
Get_Source_Info Message received
Source_Info Message sent
PE_DR_SNK_Give_Source_Info
Actions on entry:
Get present source information from Device Policy Manager
Send Source_Info Message (based on Device Policy Manager response)
Power = Explicit Contract
PD = Connected

8.3.3.19.16.1 PE_DR_SNK_Give_Source_Info State

The *Policy Engine* ***Shall*** transition to the ***PE_DR_SNK_Give_Source_Info*** state, from the ***PE_SNK_Ready*** state, when a ***Get_Source_Info*** *Message* is received.

On entry to the ***PE_DR_SNK_Give_Source_Info*** state the *Policy Engine* ***Shall*** request the present *Source* information from the *Device Policy Manager* and then send a ***Source_Info*** *Message* based on this information.

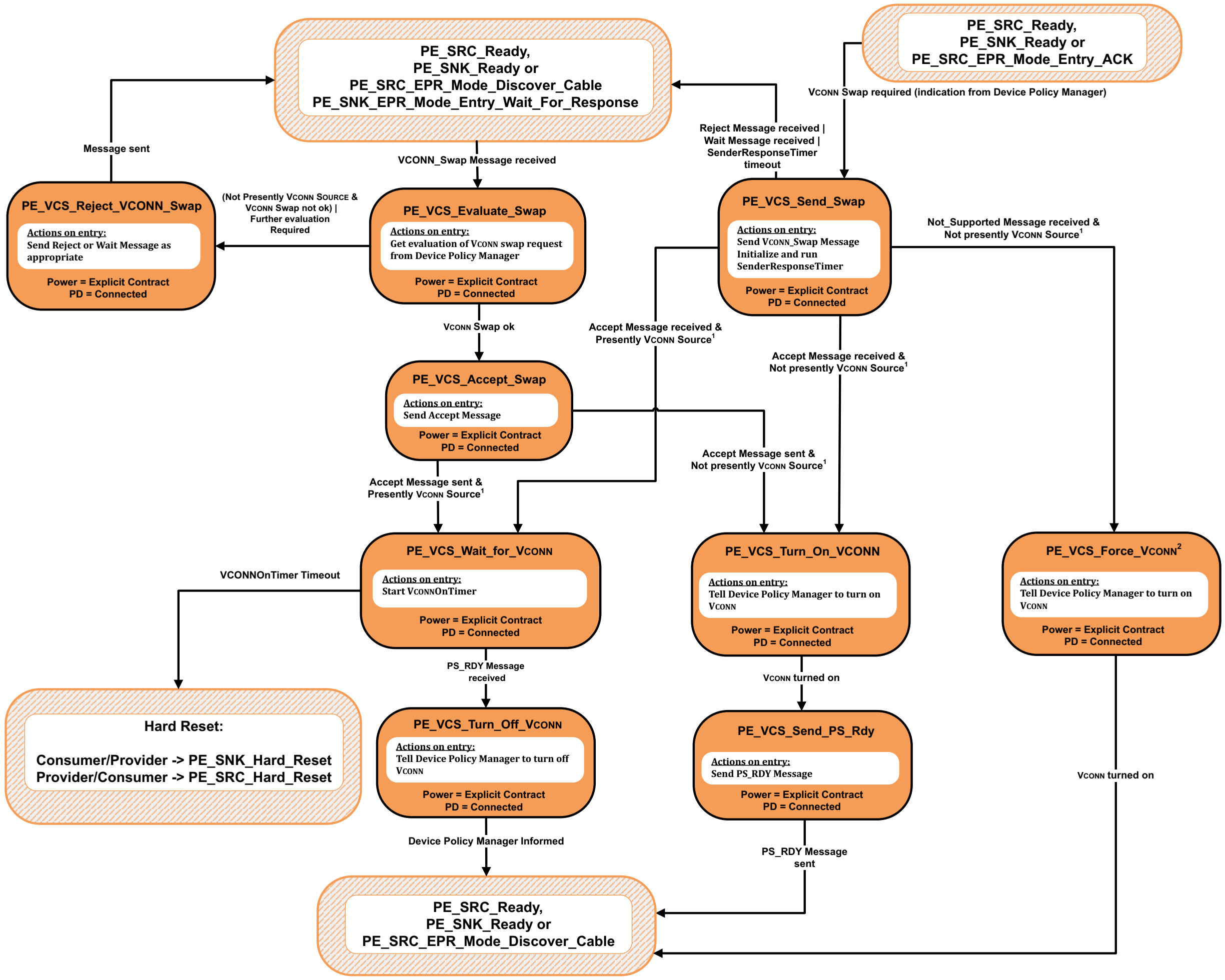
The *Policy Engine* ***Shall*** transition back to the ***PE_SNK_Ready*** state (see *Figure 8.133, "Sink Port State Diagram"*) when:

- The ***Source_Info*** *Message* has been successfully sent.

8.3.3.20 VCONN Swap State Diagram

The State Diagram in this section ***Shall*** apply to Ports that supply *VCONN*. [Figure 8.190, "VCONN Swap State Diagram"] shows the state operation for a Port on sending or receiving a *VCONN Swap* request.

Figure 8.190 VCONN Swap State Diagram



PE_SRC_Ready,
PE_SNK_Ready or
PE_SRC_EPR_Mode_Discover_Cable
PE_SNK_EPR_Mode_Entry_Wait_For_Response
PE_SRC_Ready,
PE_SNK_Ready or
PE_SRC_EPR_Mode_Entry_ACK
VCONN Swap required (indication from Device Policy Manager)
Message sent
VCONN_Swap Message received
Reject Message received |
Wait Message received |
SenderResponseTimer
timeout
PE_VCS_Reject_VCONN_Swap
Actions on entry:
Send Reject or Wait Message as appropriate
Power = Explicit Contract
PD = Connected
(Not Presently VCONN SOURCE &
VCONN Swap not ok) |
Further evaluation
Required
PE_VCS_Evaluate_Swap
Actions on entry:
Get evaluation of VCONN swap request from Device Policy Manager
Power = Explicit Contract
PD = Connected
PE_VCS_Send_Swap
Actions on entry:
Send VCONN_Swap Message
Initialize and run SenderResponseTimer
Power = Explicit Contract
PD = Connected
Not_Supported Message received &
Not presently VCONN Source[1]
VCONN Swap ok
Accept Message received &
Presently VCONN Source[1]
Accept Message received &
Not presently VCONN Source[1]
PE_VCS_Accept_Swap
Actions on entry:
Send Accept Message
Power = Explicit Contract
PD = Connected
Accept Message sent &
Not presently VCONN Source[1]
Accept Message sent &
Presently VCONN Source[1]
PE_VCS_Wait_for_VCONN
Actions on entry:
Start VCONNOnTimer
Power = Explicit Contract
PD = Connected
VCONNOnTimer Timeout
PE_VCS_Turn_On_VCONN
Actions on entry:
Tell Device Policy Manager to turn on VCONN
Power = Explicit Contract
PD = Connected
PE_VCS_Force_VCONN[2]
Actions on entry:
Tell Device Policy Manager to turn on VCONN
Power = Explicit Contract
PD = Connected
PS_RDY Message
received
VCONN turned on
Hard Reset:
Consumer/Provider -> PE_SNK_Hard_Reset
Provider/Consumer -> PE_SRC_Hard_Reset
PE_VCS_Turn_Off_VCONN
Actions on entry:
Tell Device Policy Manager to turn off VCONN
Power = Explicit Contract
PD = Connected
PE_VCS_Send_PS_Rdy
Actions on entry:
Send PS_RDY Message
Power = Explicit Contract
PD = Connected
VCONN turned on
Device Policy Manager Informed
PS_RDY Message
sent
PE_SRC_Ready,
PE_SNK_Ready or
PE_SRC_EPR_Mode_Discover_Cable

[1] A Port is presently the VCONN Source if it has the responsibility for supplying VCONN even if VCONN has been turned off.

[2] The ***PE_VCS_Force_VCONN*** state is ***Optional***.

8.3.3.20.1 PE_VCS_Send_Swap State

The ***PE_VCS_Send_Swap*** state is entered from either the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** state when the *Policy Engine* receives a request from the *Device Policy Manager* to perform a *VCONN Swap*.

On entry to the ***PE_VCS_Send_Swap*** state the *Policy Engine* ***Shall*** send a ***VCONN_Swap*** *Message* and start the ***SenderResponseTimer***.

The *Policy Engine* ***Shall*** transition to the ***PE_VCS_Wait_For_VCONN*** state when:

- An ***Accept*** *Message* is received and
- The Port is presently the *VCONN Source*.

The *Policy Engine* ***Shall*** transition to the ***PE_VCS_Turn_On_VCONN*** state when:

- An ***Accept*** *Message* is received and
- The Port is not presently the *VCONN Source*.

The *Policy Engine* ***Shall*** transition back to either the ***PE_SRC_Ready***, ***PE_SNK_Ready*** or ***PE_SRC_EPR_Mode_Discover_Cable*** state when:

- A ***Reject*** *Message* is received or
- A ***Wait*** *Message* is received or
- The ***SenderResponseTimer*** times out.

The *Policy Engine* ***May*** transition to the ***PE_VCS_Force_VCONN*** state when:

- A ***Not_Supported*** *Message* is received and
- The Port is not presently the *VCONN Source*.

8.3.3.20.2 PE_VCS_Evaluate_Swap State

The ***PE_VCS_Evaluate_Swap*** state is entered from either the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** state when the *Policy Engine* receives a ***VCONN_Swap*** *Message*.

On entry to the ***PE_VCS_Evaluate_Swap*** state the *Policy Engine* ***Shall*** request the *Device Policy Manager* for an evaluation of the *VCONN Swap* request.

The *Policy Engine* ***Shall*** transition to the ***PE_VCS_Accept_Swap*** state when:

- The *Device Policy Manager* indicates that a *VCONN Swap* is OK.

The *Policy Engine* ***Shall*** transition to the ***PE_VCS_Reject_Swap*** state when:

- The Port is not presently the *VCONN Source* and the *Device Policy Manager* indicates that a *VCONN Swap* is not OK or
- The *Device Policy Manager* indicates that a *VCONN Swap* cannot be done at this time.

8.3.3.20.3 PE_VCS_Accept_Swap State

On entry to the ***PE_VCS_Accept_Swap*** state the *Policy Engine* ***Shall*** send an ***Accept*** *Message*.

The *Policy Engine* ***Shall*** transition to the ***PE_VCS_Wait_For_VCONN*** state when:

- The ***Accept*** *Message* has been sent and
- The Port's *VCONN* is on.

The *Policy Engine* ***Shall*** transition to the ***PE_VCS_Turn_On_VCONN*** state when:

- The ***Accept*** *Message* has been sent and
- The Port's *VCONN* is off.

8.3.3.20.4 PE_VCS_Reject_Swap State

On entry to the ***PE_VCS_Reject_Swap*** state the *Policy Engine* ***Shall*** request the *Protocol Layer* to send:

- A ***Reject*** *Message* if the device is unable to perform a *VCONN Swap* at this time.
- A ***Wait*** *Message* if further evaluation of the *VCONN Swap* request is required.

Note: In this case it is expected that the Port will send a ***VCONN_Swap*** *Message* at a later time.

The *Policy Engine* ***Shall*** transition back to either the ***PE_SRC_Ready***, ***PE_SNK_Ready*** or ***PE_SRC_EPR_Mode_Discover_Cable*** state when:

- The ***Reject*** or ***Wait*** *Message* has been sent.

8.3.3.20.5 PE_VCS_Wait_for_VCONN State

On entry to the ***PE_VCS_Wait_For_VCONN*** state the *Policy Engine* ***Shall*** start the ***VCONNOnTimer***.

The *Policy Engine* ***Shall*** transition to the ***PE_VCS_Turn_Off_VCONN*** state when:

- A ***PS_RDY*** *Message* is received.

The *Policy Engine* ***Shall*** transition to either the ***PE_SRC_Hard_Reset*** or ***PE_SNK_Hard_Reset*** state when:

- The ***VCONNOnTimer*** times out.

8.3.3.20.6 PE_VCS_Turn_Off_VCONN State

On entry to the ***PE_VCS_Turn_Off_VCONN*** state the *Policy Engine* ***Shall*** tell the *Device Policy Manager* to turn off *VCONN*.

The *Policy Engine* ***Shall*** transition back to either the ***PE_SRC_Ready***, ***PE_SNK_Ready*** or ***PE_SRC_EPR_Mode_Discover_Cable*** state when:

- The *Device Policy Manager* has been informed.

8.3.3.20.7 PE_VCS_Turn_On_VCONN State

On entry to the ***PE_VCS_Turn_On_VCONN*** state the *Policy Engine* ***Shall*** tell the *Device Policy Manager* to turn on *VCONN*.

The *Policy Engine* ***Shall*** transition to the ***PE_VCS_Send_Ps_Rdy*** state when:

- The Port's *VCONN* is on.

8.3.3.20.8 PE_VCS_Send_PS_Rdy State

On entry to the ***PE_VCS_Send_Ps_Rdy*** state the *Policy Engine* ***Shall*** send a ***PS_RDY*** *Message*.

The *Policy Engine* ***Shall*** transition back to either the ***PE_SRC_Ready***, ***PE_SNK_Ready*** or ***PE_SRC_EPR_Mode_Discover_Cable*** state when:

- The ***PS_RDY*** *Message* has been sent.

8.3.3.20.9 PE_VCS_Force_VCONN State

On entry to the ***PE_VCS_Force_VCONN*** state the *Policy Engine* ***Shall*** tell the *Device Policy Manager* to turn on *VCONN*.

The *Policy Engine* ***Shall*** transition back to either the ***PE_SRC_Ready***, ***PE_SNK_Ready*** or ***PE_SRC_EPR_Mode_Discover_Cable*** state when:

- The Port's *VCONN* is on.

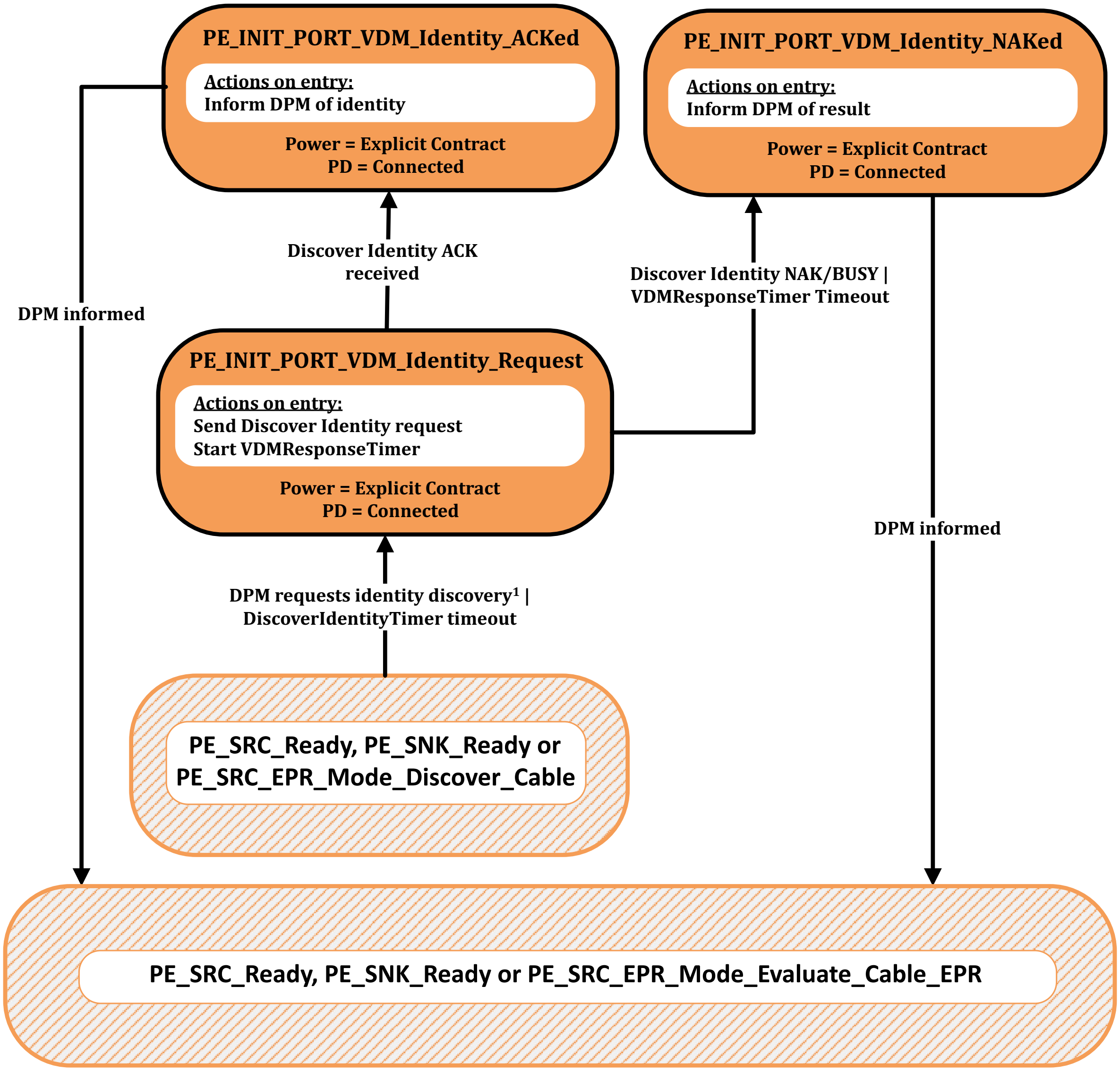
8.3.3.21 Initiator Structured VDM State Diagrams

The State Diagrams in this section ***Shall*** apply to all *Initiators*.

8.3.3.21.1 Initiator Structured VDM Discover Identity State Diagram

Figure 8.191, "Initiator to Port VDM Discover Identity State Diagram" shows the state diagram for an *Initiator* when discovering the identity of its *Port Partner* or *Cable Plug*.

Figure 8.191 Initiator to Port VDM Discover Identity State Diagram


PE_INIT_PORT_VDM_Identity_ACKed
Actions on entry:
Inform DPM of identity
Power = Explicit Contract
PD = Connected
PE_INIT_PORT_VDM_Identity_NAKed
Actions on entry:
Inform DPM of result
Power = Explicit Contract
PD = Connected
Discover Identity ACK received
Discover Identity NAK/BUSY | VDMResponseTimer Timeout
DPM informed
PE_INIT_PORT_VDM_Identity_Request
Actions on entry:
Send Discover Identity request
Start VDMResponseTimer
Power = Explicit Contract
PD = Connected
DPM informed
DPM requests identity discovery¹ | DiscoverIdentityTimer timeout
PE_SRC_Ready, PE_SNK_Ready or PE_SRC_EPR_Mode_Discover_Cable
PE_SRC_Ready, PE_SNK_Ready or PE_SRC_EPR_Mode_Evaluate_Cable_EPR

[1] The DPM in an EPR Source ***Shall*** request the discovery of the identity of the Cable Plug at startup.

8.3.3.21.1.1 PE_INIT_PORT_VDM_Identity_Request State

The *Policy Engine* transitions to the ***PE_INIT_PORT_VDM_Identity_Request*** state from either the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** state when:

- The *Device Policy Manager* requests the discovery of the identity of the *Port Partner* or *Cable Plug* or
- The ***DiscoverIdentityTimer*** times out.

The *Policy Engine* transitions to the ***PE_INIT_PORT_VDM_Identity_Request*** state from the ***PE_SRC_EPR_Mode_Discover_Cable*** state when:

- The *Cable Plug Discovery Process* has been initiated.

On entry to the ***PE_INIT_PORT_VDM_Identity_Request*** state the *Policy Engine* ***Shall*** send a *Structured VDM* ***Discover Identity*** *Command* request and ***Shall*** start the ***VDMResponseTimer***.

The *Policy Engine* ***Shall*** transition to the ***PE_INIT_PORT_VDM_Identity_ACKed*** state when:

- A *Structured VDM* ***Discover Identity ACK*** *Command* response is received.

The *Policy Engine* ***Shall*** transition to the ***PE_INIT_PORT_VDM_Identity_NAKed*** state when:

- A *Structured VDM* ***Discover Identity NAK*** or ***BUSY*** *Command* response is received or
- The ***VDMResponseTimer*** times out.

8.3.3.21.1.2 PE_INIT_PORT_VDM_Identity_ACKed State

On entry to the ***PE_INIT_PORT_VDM_Identity_ACKed*** state the *Policy Engine* ***Shall*** inform the *Device Policy Manager* of the Identity information.

The *Policy Engine* ***Shall*** transition to either the ***PE_SRC_Ready***, ***PE_SNK_Ready*** or ***PE_SRC_EPR_Mode_Evaluate_Cable_EPR*** state when:

- The *Device Policy Manager* has been informed.

8.3.3.21.1.3 PE_INIT_PORT_VDM_Identity_NAKed State

On entry to the ***PE_INIT_PORT_VDM_Identity_NAKed*** state the *Policy Engine* ***Shall*** inform the *Device Policy Manager* of the result (***NAK***, ***BUSY*** or timeout).

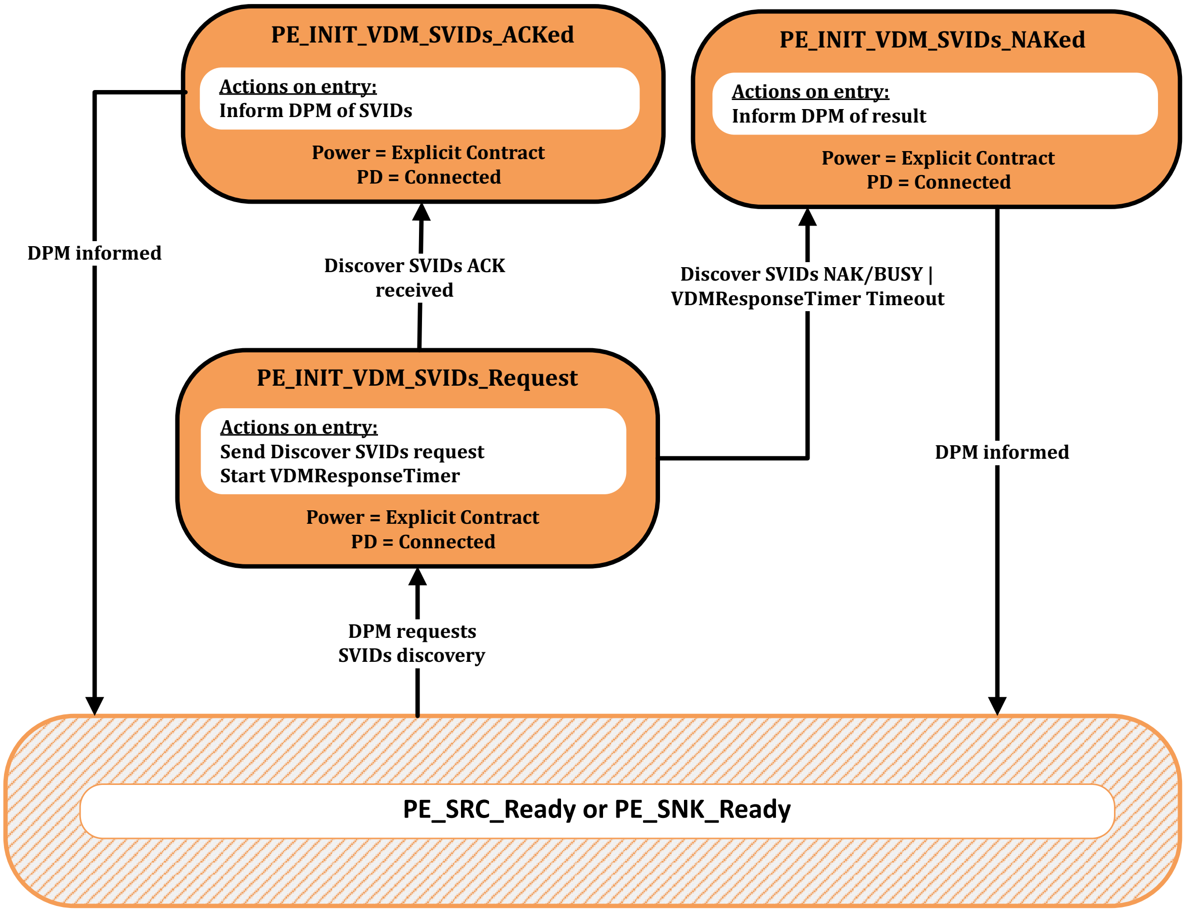
The *Policy Engine* ***Shall*** transition to either the ***PE_SRC_Ready***, ***PE_SNK_Ready*** or ***PE_SRC_EPR_Mode_Evaluate_Cable_EPR*** state when:

- The *Device Policy Manager* has been informed.

8.3.3.21.2 Initiator Structured VDM Discover SVIDs State Diagram

Figure 8.192, "Initiator VDM Discover SVIDs State Diagram" shows the state diagram for an *Initiator* when discovering *SVIDs* of its *Port Partner* or *Cable Plug*.

Figure 8.192 Initiator VDM Discover SVIDs State Diagram


PE_INIT_VDM_SVIDs_ACKed
Actions on entry:
Inform DPM of SVIDs
Power = Explicit Contract
PD = Connected
PE_INIT_VDM_SVIDs_NAKed
Actions on entry:
Inform DPM of result
Power = Explicit Contract
PD = Connected
DPM informed
Discover SVIDs ACK received
Discover SVIDs NAK/BUSY | VDMResponseTimer Timeout
PE_INIT_VDM_SVIDs_Request
Actions on entry:
Send Discover SVIDs request
Start VDMResponseTimer
Power = Explicit Contract
PD = Connected
DPM informed
DPM requests SVIDs discovery
PE_SRC_Ready or PE_SNK_Ready

8.3.3.21.2.1 PE_INIT_VDM_SVIDs_Request State

The *Policy Engine* transitions to the ***PE_INIT_VDM_SVIDs_Request*** state from either the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** state when:

- The *Device Policy Manager* requests the discovery of the *SVIDs* of the *Port Partner* or a *Cable Plug*.

On entry to the ***PE_INIT_VDM_SVIDs_Request*** state the *Policy Engine* ***Shall*** send a *Structured VDM* ***Discover SVIDs*** *Command* request and ***Shall*** start the ***VDMResponseTimer***.

The *Policy Engine* ***Shall*** transition to the ***PE_INIT_VDM_SVIDs_ACKed*** state when:

- A *Structured VDM* ***Discover SVIDs ACK*** *Command* response is received.

The *Policy Engine* ***Shall*** transition to the ***PE_INIT_VDM_SVIDs_NAKed*** state when:

- A *Structured VDM* ***Discover SVIDs NAK*** or ***BUSY*** *Command* response is received or
- The ***VDMResponseTimer*** times out.

8.3.3.21.2.2 PE_INIT_VDM_SVIDs_ACKed State

On entry to the ***PE_INIT_VDM_SVIDs_ACKed*** state the *Policy Engine* ***Shall*** inform the *Device Policy Manager* of the *SVIDs* information.

The *Policy Engine* ***Shall*** transition to either the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** state when:

- The *Device Policy Manager* has been informed.

8.3.3.21.2.3 PE_INIT_VDM_SVIDs_NAKed State

On entry to the ***PE_INIT_VDM_SVIDs_NAKed*** state the *Policy Engine* ***Shall*** inform the *Device Policy Manager* of the result (***NAK***, ***BUSY*** or timeout).

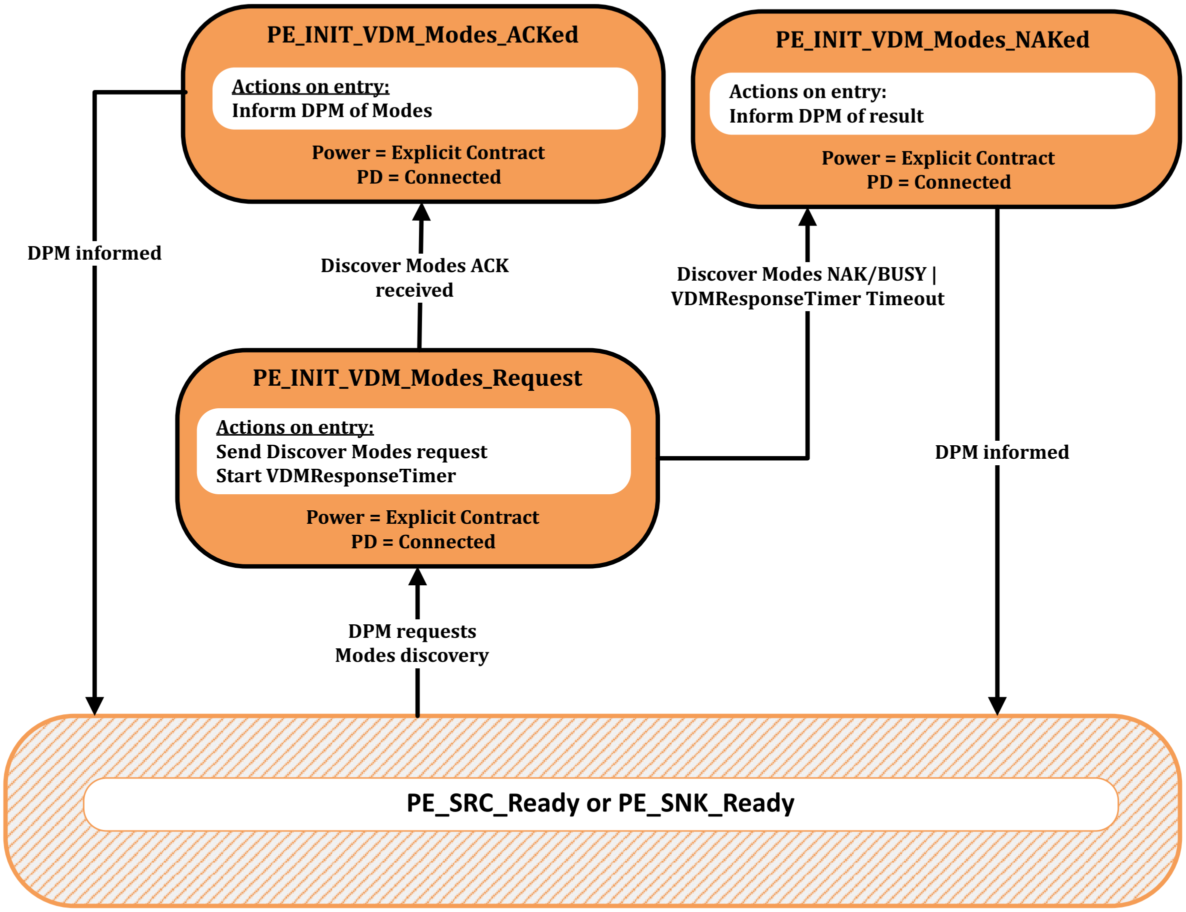
The *Policy Engine* ***Shall*** transition to either the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** state when:

- The *Device Policy Manager* has been informed.

8.3.3.21.3 Initiator Structured VDM Discover Modes State Diagram

Figure 8.193, "Initiator VDM Discover Modes State Diagram" shows the state diagram for an *Initiator* when discovering Modes of its *Port Partner* or *Cable Plug*.

Figure 8.193 Initiator VDM Discover Modes State Diagram


PE_INIT_VDM_Modes_ACKed
Actions on entry:
Inform DPM of Modes
Power = Explicit Contract
PD = Connected
PE_INIT_VDM_Modes_NAKed
Actions on entry:
Inform DPM of result
Power = Explicit Contract
PD = Connected
DPM informed
Discover Modes ACK received
Discover Modes NAK/BUSY | VDMResponseTimer Timeout
PE_INIT_VDM_Modes_Request
Actions on entry:
Send Discover Modes request
Start VDMResponseTimer
Power = Explicit Contract
PD = Connected
DPM informed
DPM requests Modes discovery
PE_SRC_Ready or PE_SNK_Ready

8.3.3.21.3.1 PE_INIT_VDM_Modes_Request State

The *Policy Engine* transitions to the *PE_INIT_VDM_Modes_Request* state from either the *PE_SRC_Ready* or *PE_SNK_Ready* state when:

- The *Device Policy Manager* requests the discovery of the Modes of the *Port Partner* or a *Cable Plug*.

On entry to the *PE_INIT_VDM_Modes_Request* state the *Policy Engine* ***Shall*** send a *Structured VDM* ***Discover Modes*** *Command* request and ***Shall*** start the ***VDMResponseTimer***.

The *Policy Engine* ***Shall*** transition to the *PE_INIT_VDM_Modes_ACKed* state when:

- A *Structured VDM* ***Discover Modes ACK*** *Command* response is received.

The *Policy Engine* ***Shall*** transition to the *PE_INIT_VDM_Modes_NAKed* state when:

- A *Structured VDM* ***Discover Modes NAK*** or ***BUSY*** *Command* response is received or
- The ***VDMResponseTimer*** times out.

8.3.3.21.3.2 PE_INIT_VDM_Modes_ACKed State

On entry to the ***PE_INIT_VDM_Modes_ACKed*** state the *Policy Engine* ***Shall*** inform the *Device Policy Manager* of the Modes information.

The *Policy Engine* ***Shall*** transition to either the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** state for a *DFP* when:

- The *Device Policy Manager* has been informed.

8.3.3.21.3.3 PE_INIT_VDM_Modes_NAKed State

On entry to the ***PE_INIT_VDM_Modes_NAKed*** state the *Policy Engine* ***Shall*** inform the *Device Policy Manager* of the result (***NAK***, ***BUSY*** or timeout).

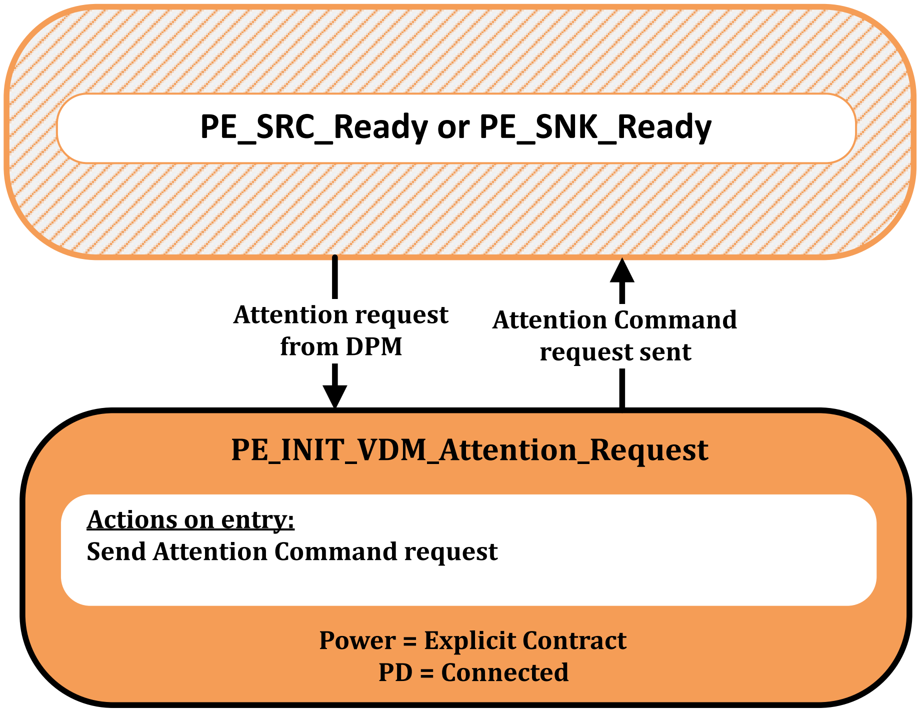
The *Policy Engine* ***Shall*** transition to either the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** state for a *DFP* when:

- The *Device Policy Manager* has been informed.

8.3.3.21.4 Initiator Structured VDM Attention State Diagram

Figure 8.194, "Initiator VDM Attention State Diagram" shows the state diagram for an *Initiator* when sending an ***Attention*** *Command* request.

Figure 8.194 Initiator VDM Attention State Diagram


PE_SRC_Ready or PE_SNK_Ready
Attention request from DPM
Attention Command request sent
PE_INIT_VDM_Attention_Request
Actions on entry:
Send Attention Command request
Power = Explicit Contract
PD = Connected

8.3.3.21.4.1 PE_INIT_VDM_Attention_Request State

The *Policy Engine* transitions to the ***PE_INIT_VDM_Attention_Request*** state from either the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** state when:

- When the *Device Policy Manager* requests attention from its *Port Partner*.

On entry to the ***PE_INIT_VDM_Attention_Request*** state the *Policy Engine* ***Shall*** send an ***Attention*** *Command* request.

The *Policy Engine* ***Shall*** transition to either the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** state when:

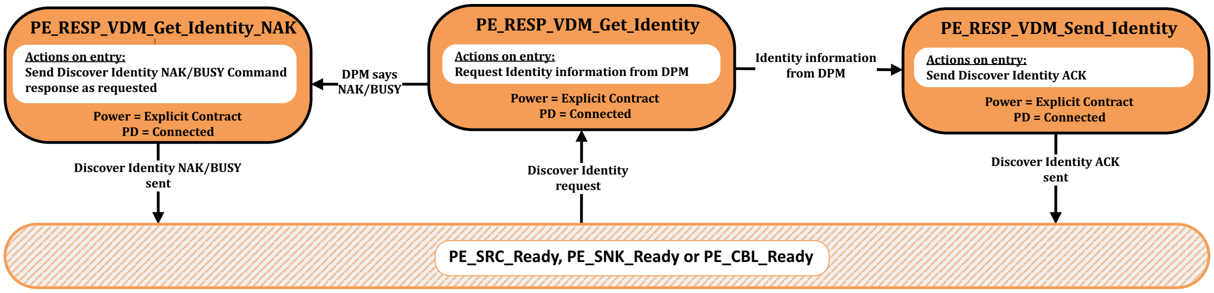
- The ***Attention*** *Command* request has been sent.

8.3.3.22 Responder Structured VDM State Diagrams

8.3.3.22.1 Responder Structured VDM Discover Identity State Diagram

Figure 8.195, "Responder Structured VDM Discover Identity State Diagram" shows the state diagram for a *Responder* receiving a ***Discover Identity*** *Command* request.

Figure 8.195 Responder Structured VDM Discover Identity State Diagram



PE_RESP_VDM_Get_Identity_NAK
Actions on entry:
Send Discover Identity NAK/BUSY Command response as requested
Power = Explicit Contract
PD = Connected
DPM says NAK/BUSY
PE_RESP_VDM_Get_Identity
Actions on entry:
Request Identity information from DPM
Power = Explicit Contract
PD = Connected
Identity information from DPM
PE_RESP_VDM_Send_Identity
Actions on entry:
Send Discover Identity ACK
Power = Explicit Contract
PD = Connected
Discover Identity NAK/BUSY sent
Discover Identity request
Discover Identity ACK sent
PE_SRC_Ready, PE_SNK_Ready or PE_CBL_Ready

8.3.3.22.1.1 PE_RESP_VDM_Get_Identity State

The *Policy Engine* transitions to the *PE_RESP_VDM_Get_Identity* state from either the *PE_SRC_Ready*, *PE_SNK_Ready* or *PE_CBL_Ready* state when:

- A *Structured VDM* ***Discover Identity*** *Command* request is received.

On entry to the *PE_RESP_VDM_Get_Identity* state the *Responder* ***Shall*** request identity information from the *Device Policy Manager*.

The *Policy Engine* ***Shall*** transition to the *PE_RESP_VDM_Send_Identity* state when:

- Identity information is received from the *Device Policy Manager*.

The *Policy Engine* ***Shall*** transition to the *PE_RESP_VDM_Get_Identity_NAK* state when:

- The *Device Policy Manager* indicates that the response to the ***Discover Identity*** *Command* request is ***NAK*** or ***BUSY***.

8.3.3.22.1.2 PE_RESP_VDM_Send_Identity State

On entry to the *PE_RESP_VDM_Send_Identity* state the *Responder* ***Shall*** send the *Structured VDM* ***Discover Identity ACK*** *Command* response.

The *Policy Engine* ***Shall*** transition to either the *PE_SRC_Ready* or *PE_SNK_Ready* state for a *UFP* when:

- The *Structured VDM* ***Discover Identity ACK*** *Command* response has been sent.

8.3.3.22.1.3 PE_RESP_VDM_Get_Identity_NAK State

On entry to the *PE_RESP_VDM_Get_Identity_NAK* state the *Policy Engine* ***Shall*** send a *Structured VDM* ***Discover Identity NAK*** or ***BUSY*** *Command* response as indicated by the *Device Policy Manager*.

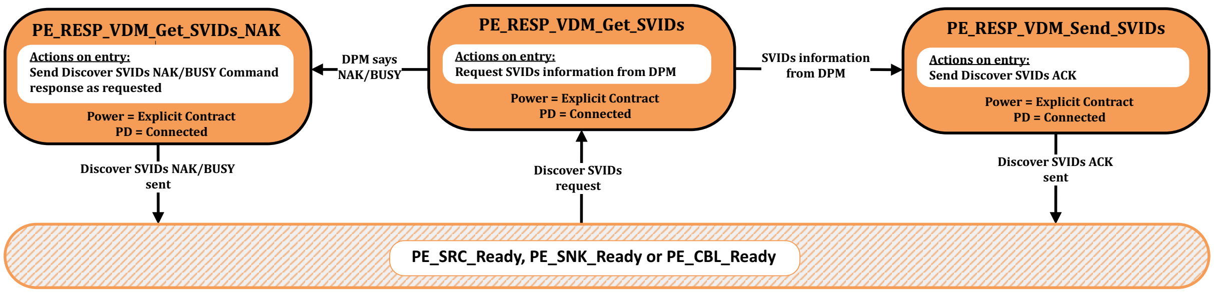
The *Policy Engine* ***Shall*** transition to either the *PE_SRC_Ready*, *PE_SNK_Ready* or *PE_CBL_Ready* state when:

- The *Structured VDM* ***Discover Identity NAK*** or ***BUSY*** *Command* response has been sent.

8.3.3.22.2 Responder Structured VDM Discover SVIDs State Diagram

Figure 8.196, "Responder Structured VDM Discover SVIDs State Diagram" shows the state diagram for a *Responder* when receiving a ***Discover SVIDs*** *Command*.

Figure 8.196 Responder Structured VDM Discover SVIDs State Diagram



PE_RESP_VDM_Get_SVIDs_NAK
Actions on entry:
Send Discover SVIDs NAK/BUSY Command response as requested
Power = Explicit Contract
PD = Connected
DPM says NAK/BUSY
PE_RESP_VDM_Get_SVIDs
Actions on entry:
Request SVIDs information from DPM
Power = Explicit Contract
PD = Connected
SVIDs information from DPM
PE_RESP_VDM_Send_SVIDs
Actions on entry:
Send Discover SVIDs ACK
Power = Explicit Contract
PD = Connected
Discover SVIDs NAK/BUSY sent
Discover SVIDs request
Discover SVIDs ACK sent
PE_SRC_Ready, PE_SNK_Ready or PE_CBL_Ready

8.3.3.22.2.1 PE_RESP_VDM_Get_SVIDs State

The *Policy Engine* transitions to the ***PE_RESP_VDM_Get_SVIDs*** state from either the ***PE_SRC_Ready***, ***PE_SNK_Ready*** or ***PE_CBL_Ready*** state when:

- A *Structured VDM* ***Discover SVIDs*** *Command* request is received.

On entry to the ***PE_RESP_VDM_Get_SVIDs*** state the *Responder* ***Shall*** request *SVIDs* information from the *Device Policy Manager*.

The *Policy Engine* ***Shall*** transition to the ***PE_RESP_VDM_Send_SVIDs*** state when:

- *SVIDs* information is received from the *Device Policy Manager*.

The *Policy Engine* ***Shall*** transition to the ***PE_RESP_VDM_Get_SVIDs_NAK*** state when:

- The *Device Policy Manager* indicates that the response to the ***Discover SVIDs*** *Command* request is ***NAK*** or ***BUSY***.

8.3.3.22.2.2 PE_UFP_VDM_Send_SVIDs State

On entry to the ***PE_RESP_VDM_Send_SVIDs*** state the *Responder* ***Shall*** send the *Structured VDM* ***Discover SVIDs ACK*** *Command* response.

The *Policy Engine* ***Shall*** transition to either the ***PE_SRC_Ready***, ***PE_SNK_Ready*** or ***PE_CBL_Ready*** state when:

- The *Structured VDM* ***Discover SVIDs ACK*** *Command* response has been sent.

8.3.3.22.2.3 PE_UFP_VDM_Get_SVIDs_NAK State

On entry to the ***PE_RESP_VDM_Get_SVIDs_NAK*** state the *Policy Engine* ***Shall*** send a *Structured VDM* ***Discover SVIDs NAK*** or ***BUSY*** *Command* response as indicated by the *Device Policy Manager*.

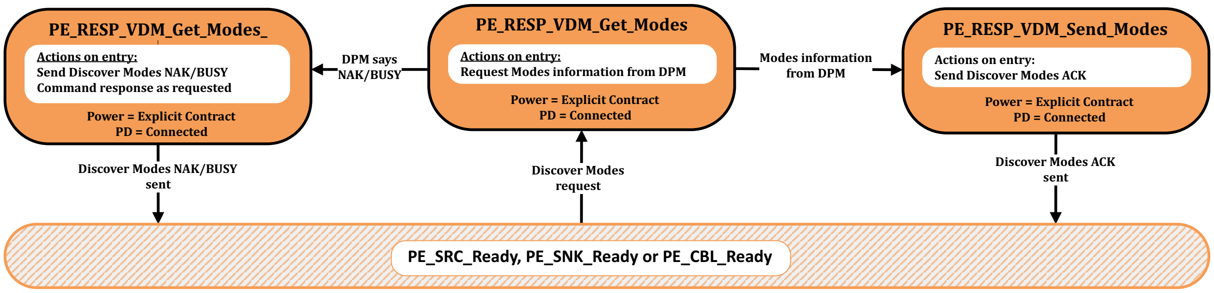
The *Policy Engine* ***Shall*** transition to either the ***PE_SRC_Ready***, ***PE_SNK_Ready*** or ***PE_CBL_Ready*** state when:

- The *Structured VDM* ***Discover SVIDs NAK*** or ***BUSY*** *Command* response has been sent.

8.3.3.22.3 Responder Structured VDM Discover Modes State Diagram

Figure 8.197, "Responder Structured VDM Discover Modes State Diagram" shows the state diagram for a *Responder* on receiving a ***Discover Modes*** *Command*.

Figure 8.197 Responder Structured VDM Discover Modes State Diagram



8.3.3.22.3.1 PE_RESP_VDM_Get_Modes State

The *Policy Engine* transitions to the ***PE_RESP_VDM_Get_Modes*** state from either the ***PE_SRC_Ready***, ***PE_SNK_Ready*** or ***PE_CBL_Ready*** state when:

- A *Structured VDM* ***Discover Modes*** *Command* request is received.

On entry to the ***PE_RESP_VDM_Get_Modes*** state the *Responder* ***Shall*** request Modes information from the *Device Policy Manager*.

The *Policy Engine* ***Shall*** transition to the ***PE_RESP_VDM_Send_Modes*** state when:

- Modes information is received from the *Device Policy Manager*.

The *Policy Engine* ***Shall*** transition to the ***PE_RESP_VDM_Get_Modes_NAK*** state when:

- The *Device Policy Manager* indicates that the response to the ***Discover Modes*** *Command* request is ***NAK*** or ***BUSY***.

8.3.3.22.3.2 PE_RESP_VDM_Send_Modes State

On entry to the ***PE_RESP_VDM_Send_Modes*** state the *Responder* ***Shall*** send the *Structured VDM* ***Discover Modes ACK*** *Command* response.

The *Policy Engine* ***Shall*** transition to either the ***PE_SRC_Ready***, ***PE_SNK_Ready*** or ***PE_CBL_Ready*** state when:

- The *Structured VDM* ***Discover Modes ACK*** *Command* response has been sent.

8.3.3.22.3.3 PE_RESP_VDM_Get_Modes_NAK State

On entry to the ***PE_RESP_VDM_Get_Modes_NAK*** state the *Policy Engine* ***Shall*** send a *Structured VDM* ***Discover Modes NAK*** or ***BUSY*** *Command* response as indicated by the *Device Policy Manager*.

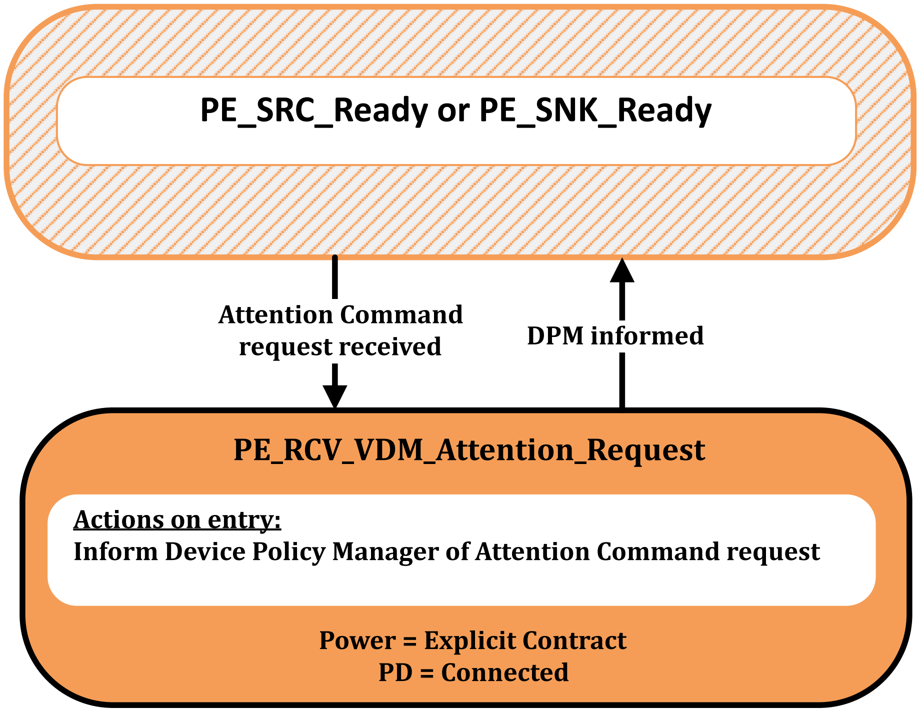
The *Policy Engine* ***Shall*** transition to either the ***PE_SRC_Ready***, ***PE_SNK_Ready*** or ***PE_CBL_Ready*** state when:

- The *Structured VDM* ***Discover Modes NAK*** or ***BUSY*** *Command* response has been sent.

8.3.3.22.4 Receiving a Structured VDM Attention State Diagram

Figure 8.198, "Receiving a Structured VDM Attention State Diagram" shows the state diagram when receiving an ***Attention*** *Command* request.

Figure 8.198 Receiving a Structured VDM Attention State Diagram


PE_SRC_Ready or PE_SNK_Ready
Attention Command request received
DPM informed
PE_RCV_VDM_Attention_Request
Actions on entry:
Inform Device Policy Manager of Attention Command request
Power = Explicit Contract
PD = Connected

8.3.3.22.4.1 PE_RCV_VDM_Attention_Request State

The *Policy Engine* transitions to the ***PE_RCV_VDM_Attention_Request*** state from either the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** state when:

- An ***Attention*** *Command* request is received.

On entry to the ***PE_RCV_VDM_Attention_Request*** state the *Policy Engine* ***Shall*** inform the *Device Policy Manager* of the ***Attention*** *Command* request.

The *Policy Engine* ***Shall*** transition to either the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** state when:

- The *Device Policy Manager* has been informed.

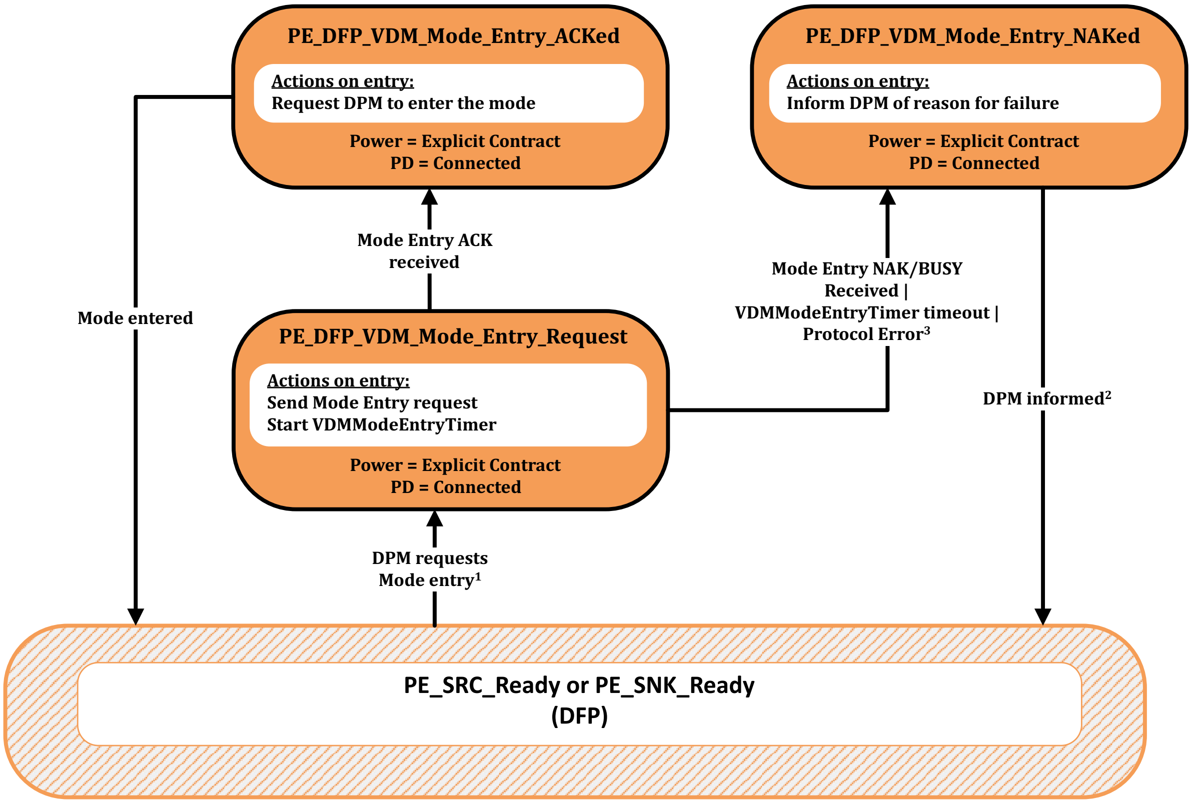
8.3.3.23 DFP Structured VDM State Diagrams

The State Diagrams in this section ***Shall*** apply to all *DFP*s that support *Structured VDM*s.

8.3.3.23.1 DFP Structured VDM Mode Entry State Diagram

Figure 8.199, "DFP VDM Mode Entry State Diagram" shows the state operation for a *DFP* when entering a Mode.

Figure 8.199 DFP VDM Mode Entry State Diagram



PE_DFP_VDM_Mode_Entry_ACKed
Actions on entry:
Request DPM to enter the mode
Power = Explicit Contract
PD = Connected
PE_DFP_VDM_Mode_Entry_NAKed
Actions on entry:
Inform DPM of reason for failure
Power = Explicit Contract
PD = Connected
Mode Entry ACK received
Mode entered
Mode Entry NAK/BUSY Received | VDMModeEntryTimer timeout | Protocol Error³
DPM informed²
PE_DFP_VDM_Mode_Entry_Request
Actions on entry:
Send Mode Entry request
Start VDMModeEntryTimer
Power = Explicit Contract
PD = Connected
DPM requests Mode entry¹
PE_SRC_Ready or PE_SNK_Ready
(DFP)

1) The Device Policy Manager ***Shall*** have placed the system into USB Safe State before issuing this request when entering Modal operation.

2) The Device Policy Manager ***Shall*** have returned the system to USB operation if not in Modal operation at this point.

3) Protocol Errors are handled by informing the DPM, returning to USB Safe State and then processing the Message once the *PE_SRC_Ready* or *PE_SNK_Ready* state has been entered.

8.3.3.23.1.1 PE_DFP_VDM_Mode_Entry_Request State

The *Policy Engine* transitions to the *PE_DFP_VDM_Mode_Entry_Request* state from either the *PE_SRC_Ready* or *PE_SNK_Ready* state for a *DFP* when:

- The *Device Policy Manager* requests that the *Port Partner* or a *Cable Plug* enter a Mode.

On entry to the *PE_DFP_VDM_Mode_Entry_Request* state the *Policy Engine* ***Shall*** send a *Structured VDM* ***Enter Mode*** *Command* request and ***Shall*** start the *VDMModeEntryTimer*.

The *Policy Engine* ***Shall*** transition to the *PE_DFP_VDM_Mode_Entry_ACKed* state when:

- A *Structured VDM* ***Enter Mode ACK*** *Command* response is received.

The *Policy Engine* ***Shall*** transition to the *PE_DFP_VDM_Mode_Entry_NAKed* state when:

- A *Structured VDM* ***Enter Mode NAK*** or ***BUSY*** *Command* response is received or
- The *VDMModeEntryTimer* times out.

8.3.3.23.1.2 PE_DFP_VDM_Mode_Entry_ACKed State

On entry to the ***PE_DFP_VDM_Mode_Entry_ACKed*** state the *Policy Engine* ***Shall*** request the *Device Policy Manager* to enter the Mode.

The *Policy Engine* ***Shall*** transition to either the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** state for a *DFP* when:

- The Mode has been entered.

8.3.3.23.1.3 PE_DFP_VDM_Mode_Entry_NAKed State

On entry to the ***PE_DFP_VDM_Mode_Entry_NAKed*** state the *Policy Engine* ***Shall*** inform the *Device Policy Manager* of the reason for failure (***NAK***, ***BUSY***, timeout or *Protocol Error*).

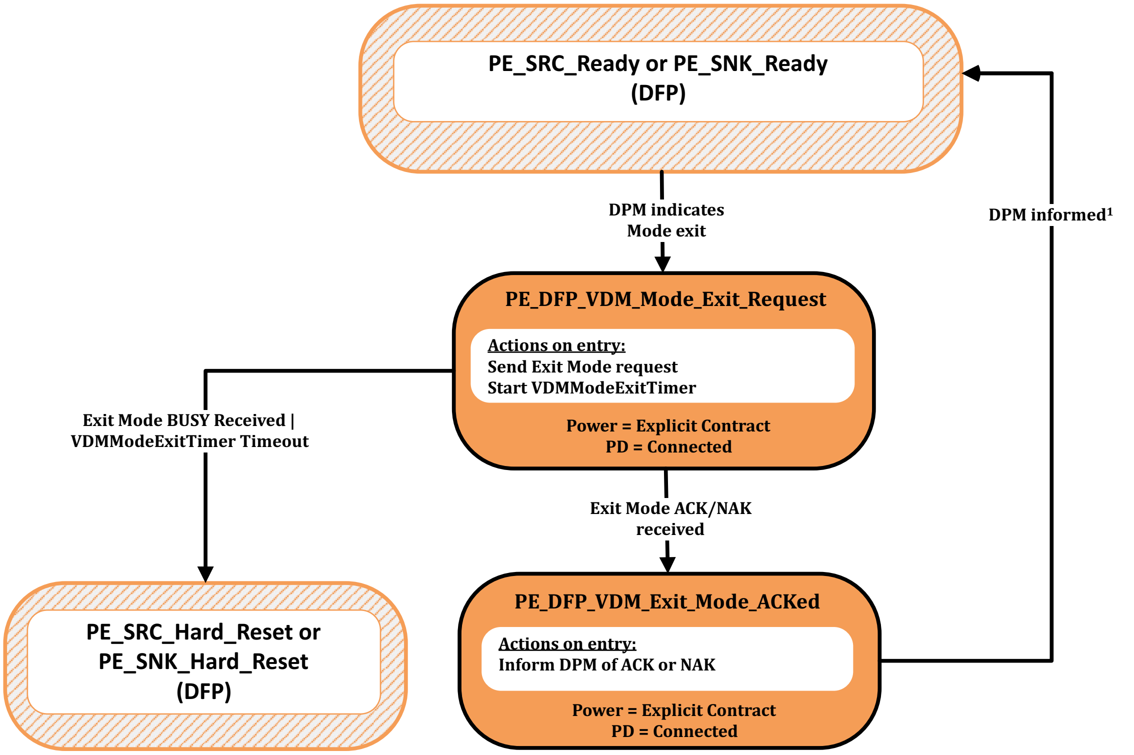
The *Policy Engine* ***Shall*** transition to either the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** state for a *DFP* when:

- The *Device Policy Manager* has been informed.

8.3.3.23.2 DFP Structured VDM Mode Exit State Diagram

Figure 8.200, "DFP VDM Mode Exit State Diagram" shows the state diagram for a *DFP* when exiting a Mode.

Figure 8.200 DFP VDM Mode Exit State Diagram



[1] The Device Policy Manager is required to return the system to USB operation at this point when exiting Modal Operation.

8.3.3.23.2.1 PE_DFP_VDM_Mode_Exit_Request State

The *Policy Engine* transitions to the ***PE_DFP_VDM_Mode_Exit_Request*** state from either the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** state for a *DFP* when:

- The *Device Policy Manager* requests that the *Port Partner* or a *Cable Plug* exit a Mode.

On entry to the ***PE_DFP_VDM_Mode_Exit_Request*** state the *Policy Engine* ***Shall*** send a *Structured VDM* ***Exit Mode*** *Command* request and ***Shall*** start the ***VDMModeExitTimer***.

The *Policy Engine* ***Shall*** transition to the ***PE_DFP_VDM_Mode_Entry_ACKed*** state when:

- A *Structured VDM* ***Exit Mode ACK*** or ***NAK*** *Command* response is received.

The *Policy Engine* ***Shall*** transition to either the ***PE_SRC_Hard_Reset*** or ***PE_SNK_Hard_Reset*** state depending on the present *Power Role* when:

- A *Structured VDM* ***Exit Mode BUSY*** *Command* response is received or
- The ***VDMModeExitTimer*** times out.

8.3.3.23.2.2 PE_DFP_VDM_DFP_Mode_Exit_ACKed State

On Exit to the ***PE_DFP_VDM_Mode_Entry_ACKed*** state the *Policy Engine* ***Shall*** inform the *Device Policy Manager* Of the result: ***ACK*** or ***NAK***.

The *Policy Engine* ***Shall*** transition to either the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** state for a *DFP* when:

- The *Device Policy Manager* has been informed.

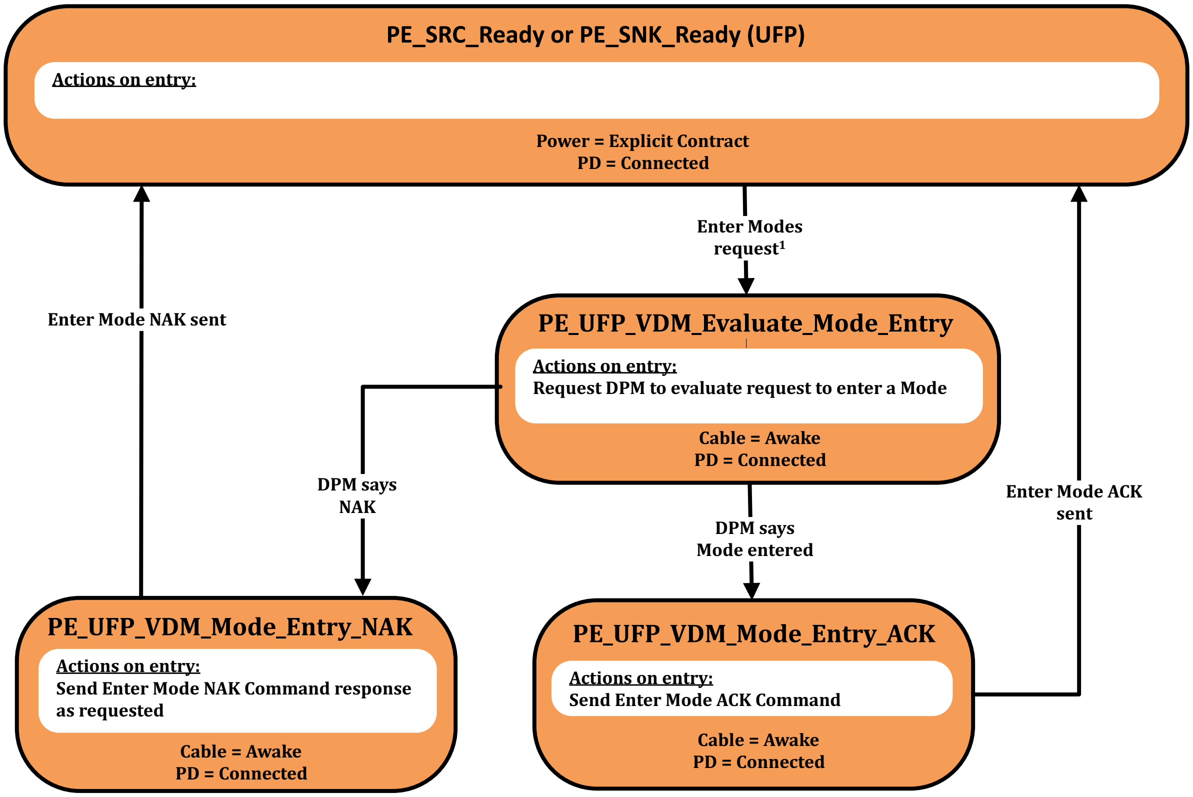
8.3.3.24 UFP Structured VDM State Diagrams

The State Diagrams in this section ***Shall*** apply to all *UFPs* that support *Structured VDMs*.

8.3.3.24.1 UFP Structured VDM Enter Mode State Diagram

Figure 8.201, "UFP Structured VDM Enter Mode State Diagram" shows the state diagram for a *UFP* in response to an ***Enter Mode*** *Command*.

Figure 8.201 UFP Structured VDM Enter Mode State Diagram



PE_SRC_Ready or PE_SNK_Ready (UFP)
Actions on entry:
Power = Explicit Contract
PD = Connected
Enter Modes request[1]
PE_UFP_VDM_Evaluate_Mode_Entry
Actions on entry:
Request DPM to evaluate request to enter a Mode
Cable = Awake
PD = Connected
Enter Mode NAK sent
DPM says NAK
DPM says Mode entered
Enter Mode ACK sent
PE_UFP_VDM_Mode_Entry_NAK
Actions on entry:
Send Enter Mode NAK Command response as requested
Cable = Awake
PD = Connected
PE_UFP_VDM_Mode_Entry_ACK
Actions on entry:
Send Enter Mode ACK Command
Cable = Awake
PD = Connected

[1] The UFP is required to be in USB operation or USB Safe State at this point.

8.3.3.24.1.1 PE_UFP_VDM_Evaluate_Mode_Entry State

The *Policy Engine* transitions to the ***PE_UFP_VDM_Evaluate_Mode_Entry*** state from either the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** state for a *UFP* when:

- A *Structured VDM* ***Enter Mode*** *Command* request is received from the *DFP*.

On Entry to the ***PE_UFP_VDM_Evaluate_Mode_Entry*** state the *Policy Engine* ***Shall*** request the *Device Policy Manager* to evaluate the ***Enter Mode*** *Command* request and enter the Mode indicated in the *Command* request if the request is acceptable.

The *Policy Engine* ***Shall*** transition to the ***PE_UFP_VDM_Mode_Entry_ACK*** state when:

- The *Device Policy Manager* indicates that the Mode has been entered.

The *Policy Engine* ***Shall*** transition to the ***PE_UFP_VDM_Mode_Entry_NAK*** state when:

- The *Device Policy Manager* indicates that the response to the Mode request is ***NAK***.

8.3.3.24.1.2 PE_UFP_VDM_Mode_Entry_ACK State

On entry to the ***PE_UFP_VDM_Mode_Entry_ACK*** state the *Policy Engine* ***Shall*** send a *Structured VDM* ***Enter Mode ACK*** *Command* response.

The *Policy Engine* ***Shall*** transition to either the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** state for a *UFP* when:

- The *Structured VDM* ***Enter Mode ACK*** *Command* response has been sent.

8.3.3.24.1.3 PE_UFP_VDM_Mode_Entry_NAK State

On entry to the ***PE_UFP_VDM_Mode_Entry_NAK*** state the *Policy Engine* ***Shall*** send a *Structured VDM* ***Enter Mode NAK*** *Command* response as indicated by the *Device Policy Manager*.

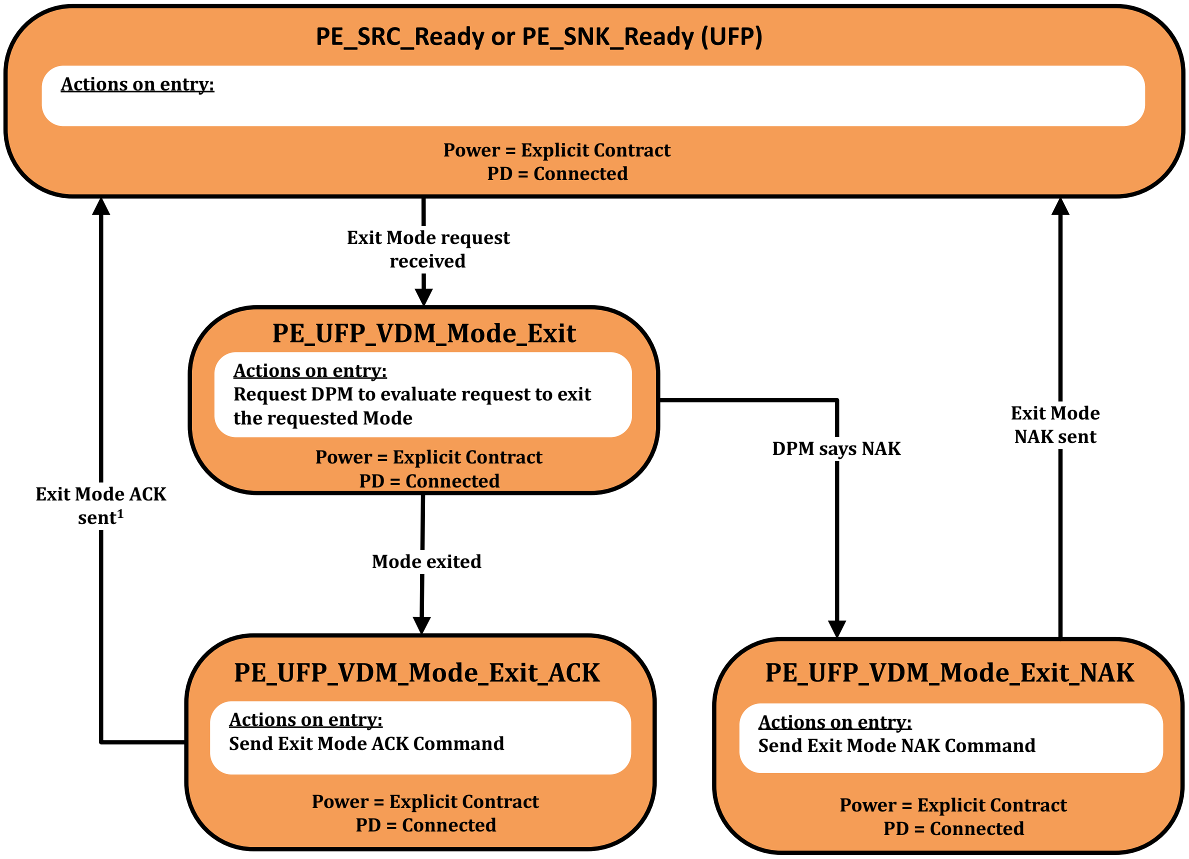
The *Policy Engine* ***Shall*** transition to either the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** state for a *UFP* when:

- The *Structured VDM* ***Enter Mode NAK*** *Command* response has been sent.

8.3.3.24.2 UFP Structured VDM Exit Mode State Diagram

Figure 8.202, "UFP Structured VDM Exit Mode State Diagram" shows the state diagram for a *UFP* in response to an ***Exit Mode*** *Command*.

Figure 8.202 UFP Structured VDM Exit Mode State Diagram


PE_SRC_Ready or PE_SNK_Ready (UFP)
Actions on entry:
Power = Explicit Contract
PD = Connected
Exit Mode request received
PE_UFP_VDM_Mode_Exit
Actions on entry:
Request DPM to evaluate request to exit the requested Mode
Power = Explicit Contract
PD = Connected
DPM says NAK
Exit Mode NAK sent
Exit Mode ACK sent¹
Mode exited
PE_UFP_VDM_Mode_Exit_ACK
Actions on entry:
Send Exit Mode ACK Command
Power = Explicit Contract
PD = Connected
PE_UFP_VDM_Mode_Exit_NAK
Actions on entry:
Send Exit Mode NAK Command
Power = Explicit Contract
PD = Connected

1) The UFP is required to be in USB operation or USB Safe State at this point.

8.3.3.24.2.1 PE_UFP_VDM_Mode_Exit State

The *Policy Engine* transitions to the *PE_UFP_VDM_Mode_Exit* state from either the *PE_SRC_Ready* or *PE_SNK_Ready* state for a *UFP* when:

- A *Structured VDM* ***Exit Mode*** *Command* request is received from the *DFP*.

On entry to the *PE_UFP_VDM_Mode_Exit* state the *Policy Engine* ***Shall*** request the *Device Policy Manager* to exit the Mode indicated in the *Command*.

The *Policy Engine* ***Shall*** transition to the *PE_UFP_VDM_Mode_Exit_ACK* state when:

- The *Device Policy Manager* indicates that the Mode has been exited.

The *Policy Engine* ***Shall*** transition to the *PE_UFP_VDM_Mode_Exit_NAK* state when:

- The *Device Policy Manager* indicates that the *Command* response to the ***Exit Mode*** *Command* request is ***NAK***.

8.3.3.24.2.2 PE_UFP_VDM_Mode_Exit_ACK State

On entry to the ***PE_UFP_VDM_Mode_Exit_ACK*** state the *Policy Engine* ***Shall*** send a *Structured VDM* ***Exit Mode ACK*** *Command* response.

The *Policy Engine* ***Shall*** transition to either the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** state for a *UFP* when:

- The *Structured VDM* ***Exit Mode ACK*** *Command* response has been sent.

8.3.3.24.2.3 PE_UFP_VDM_Mode_Exit_NAK State

On entry to the ***PE_UFP_VDM_Mode_Exit_NAK*** state the *Policy Engine* ***Shall*** send a *Structured VDM* ***Exit Mode NAK*** *Command* response as indicated by the *Device Policy Manager*.

The *Policy Engine* ***Shall*** transition to either the either the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** state for a *UFP* when:

- The *Structured VDM* ***Exit Mode NAK*** *Command* response has been sent.

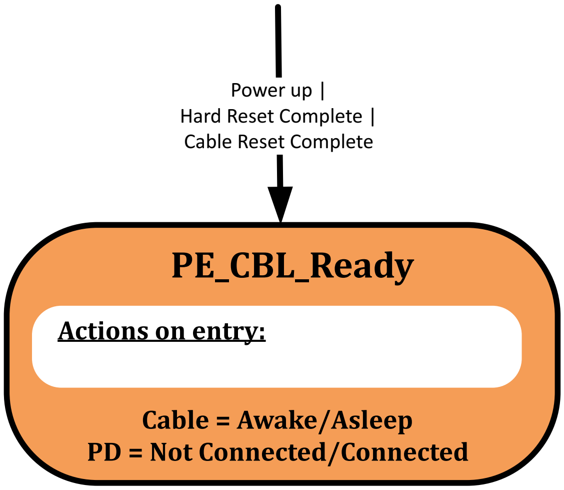
8.3.3.25 Cable Plug Specific State Diagrams

The State Diagrams in this section ***Shall*** apply to all *Cable Plugs* that support *Structured VDMs*.

8.3.3.25.1 Cable Plug Cable Ready State Diagram

Figure 8.203, "Cable Ready State Diagram" shows the Cable Ready state diagram for a *Cable Plug*.

Figure 8.203 Cable Ready State Diagram



8.3.3.25.1.1 PE_CBL_Ready State

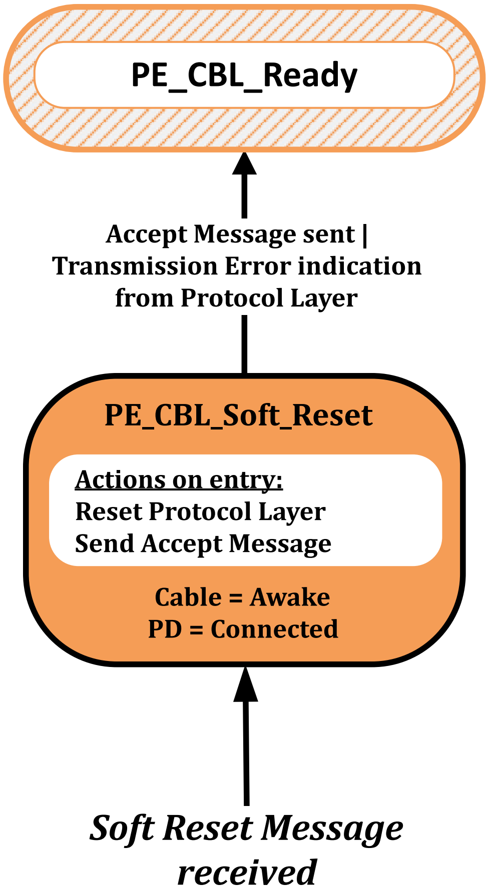
The *PE_CBL_Ready* state shown in the following sections is the normal operational state for a *Cable Plug* and where it starts after power up or a Hard/*Cable Reset*.

8.3.3.25.2 Soft/Hard/Cable Reset

8.3.3.25.2.1 Cable Plug Soft Reset State Diagram

Figure 8.204, "Cable Plug Soft Reset State Diagram" shows the *Cable Plug* state diagram on reception of a ***Soft_Reset*** *Message*.

Figure 8.204 Cable Plug Soft Reset State Diagram



8.3.3.25.2.1.1 PE_CBL_Soft_Reset State

The ***PE_CBL_Soft_Reset*** state ***Shall*** be entered from any state when a ***Soft_Reset*** *Message* is received from the *Protocol Layer*.

On entry to the ***PE_CBL_Soft_Reset*** state the *Policy Engine* ***Shall*** reset the *Protocol Layer* in the *Cable Plug* and ***Shall*** then request the *Protocol Layer* to send an ***Accept*** *Message*.

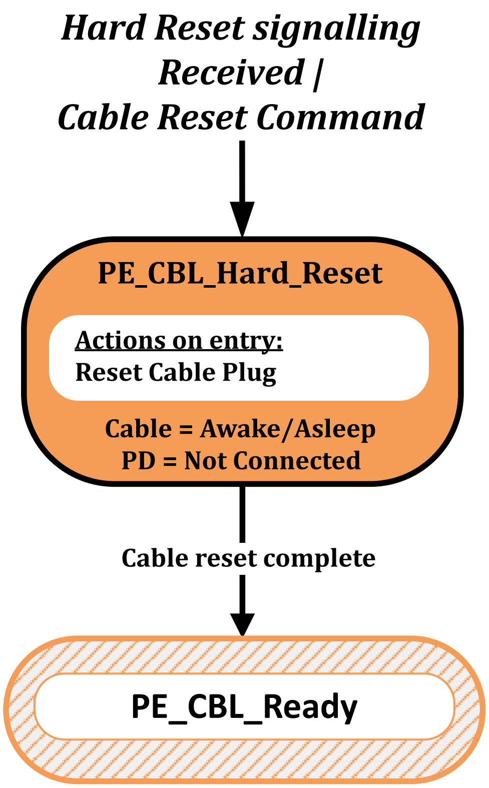
The *Policy Engine* ***Shall*** transition to the ***PE_CBL_Ready*** state when:

- The ***Accept*** *Message* has been sent or
- The *Protocol Layer* indicates that a transmission error has occurred.

8.3.3.25.2.2 Cable Plug Hard Reset State Diagram

Figure 8.205, "Cable Plug Hard Reset State Diagram" shows the *Cable Plug* state diagram for a *Hard Reset* or *Cable Reset*.

Figure 8.205 Cable Plug Hard Reset State Diagram



8.3.3.25.2.2.1 PE_CBL_Hard_Reset State

The ***PE_CBL_Hard_Reset*** state ***Shall*** be entered from any state when either ***Hard Reset*** *Signaling* or ***Cable Reset*** *Signaling* is detected.

On entry to the ***PE_CBL_Hard_Reset*** state the *Policy Engine* ***Shall*** reset the *Cable Plug* (equivalent to a power cycle).

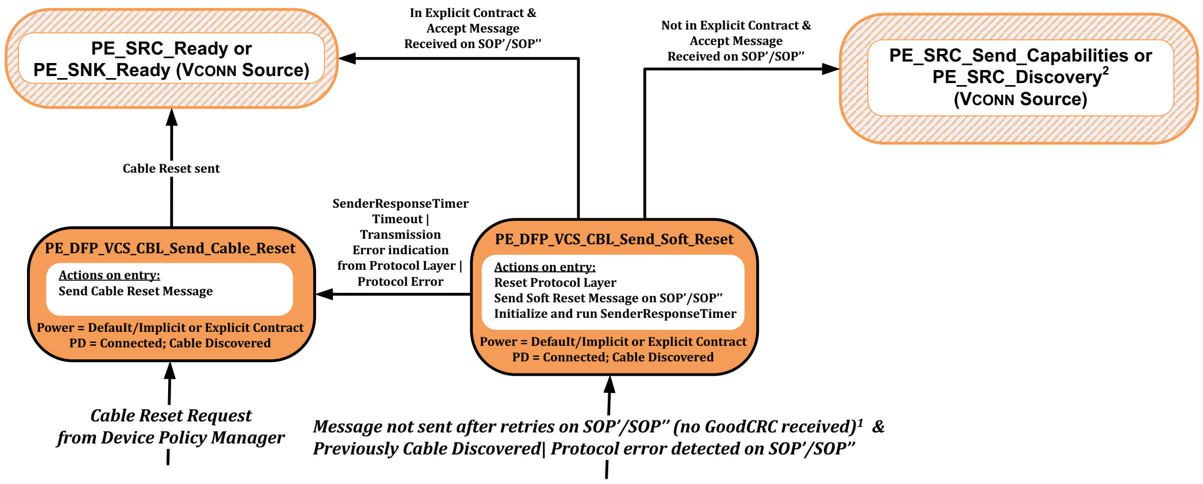
The *Policy Engine* ***Shall*** transition to the ***PE_CBL_Ready*** state when:

- The *Cable Plug* reset is complete.

8.3.3.25.2.3 DFP/VCONN Source SOP'/SOP'' Soft Reset or Cable Reset of a Cable Plug or VPD State Diagram

[Figure 8.206, "DFP/VCONN Source Soft Reset or Cable Reset of a Cable Plug or VPD State Diagram"](#) below shows the state diagram for the *Policy Engine* in a *VCONN Source* when performing a *Soft Reset* or *Cable Reset* of a *Cable Plug* or *VPD* on *SOP'/SOP''*. The following sections describe operation in each of the states.

Figure 8.206 DFP/VCONN Source Soft Reset or Cable Reset of a Cable Plug or VPD State Diagram



PE_SRC_Ready or PE_SNK_Ready (VCONN Source)
In Explicit Contract & Accept Message Received on SOP'/SOP''
Not in Explicit Contract & Accept Message Received on SOP'/SOP''
PE_SRC_Send_Capabilities or PE_SRC_Discovery2 (VCONN Source)
Cable Reset sent
SenderResponseTimer Timeout | Transmission Error indication from Protocol Layer | Protocol Error
PE_DFP_VCS_CBL_Send_Cable_Reset
Actions on entry:
Send Cable Reset Message
Power = Default/Implicit or Explicit Contract
PD = Connected; Cable Discovered
PE_DFP_VCS_CBL_Send_Soft_Reset
Actions on entry:
Reset Protocol Layer
Send Soft Reset Message on SOP'/SOP''
Initialize and run SenderResponseTimer
Power = Default/Implicit or Explicit Contract
PD = Connected; Cable Discovered
Cable Reset Request from Device Policy Manager
Message not sent after retries on SOP'/SOP'' (no GoodCRC received)1 & Previously Cable Discovered| Protocol error detected on SOP'/SOP''

[1] Excludes the *Soft_Reset* Message itself.

[2] Sink only communicates with the Cable Plug when in an Explicit Contract. If the *Discover Identity* Command is being sent at startup, then the Policy Engine will subsequently transition to the *PE_SRC_Send_Capabilities* state as normal. Otherwise, the Policy Engine will transition to the *PE_SRC_Discovery* state.

8.3.3.25.2.3.1 PE_DFP_VCS_CBL_Send_Soft_Reset State

The ***PE_DFP_VCS_CBL_Send_Soft_Reset*** state ***Shall*** be entered from any state when a *Protocol Error* is detected on *SOP'/SOP''* by the *Protocol Layer* (see [Section 6.8.1, "Soft Reset and Protocol Error"](#)) or when a *Message* has not been sent after retries on *SOP'/SOP''* while communicating with a *Cable Plug/VPD* and when there was previous communication with the *Cable Plug* that did not result in a Transmission Error or whenever the *Device Policy Manager* directs a *Soft Reset* on *SOP'/SOP''*.

On entry to the ***PE_DFP_VCS_CBL_Send_Soft_Reset*** state the *DFP Policy Engine* ***Shall*** request the *SOP'/SOP'' Protocol Layer* to perform a *Soft Reset*, then ***Shall*** send a ***Soft_Reset*** *Message* on *SOP'/SOP''* to the *Cable Plug/VPD*, and initialize and run the ***SenderResponseTimer***.

The *Policy Engine* ***Shall*** transition to either the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** state, depending on the *DFP VCONN Source*'s *Power Role*, when:

- There is no *Explicit Contract* in place and
- An ***Accept*** *Message* has been received on *SOP'/SOP''*.

The *Policy Engine* ***Shall*** transition to either the ***PE_SRC_Send_Capabilities*** state or ***PE_SRC_Discovery*** state, depending on the *DFP*'s *VCONN Source*'s *Power Role*, when:

- There is an *Explicit Contract* in place and
- An ***Accept*** *Message* has been received on *SOP'/SOP''*.

The *Policy Engine* ***Shall*** transition to the ***PE_DFP_VCS_CBL_Send_Cable_Reset*** state when:

- A ***SenderResponseTimer*** timeout occurs
- Or the *Protocol Layer* indicates that a transmission error has occurred
- Or when a *Protocol Error* is detected on *SOP'/SOP''* by the *Protocol Layer*.

8.3.3.25.2.3.2 PE_DFP_VCS_CBL_Send_Cable_Reset State

The ***PE_DFP_VCS_CBL_Send_Cable_Reset*** state ***Shall*** be entered from any state when the *Device Policy Manager* requests a *Cable Reset*.

On entry to the ***PE_DFP_VCS_CBL_Send_Cable_Reset*** state the *DFP Policy Engine* ***Shall*** request the *Protocol Layer* to send ***Cable Reset*** *Signaling*.

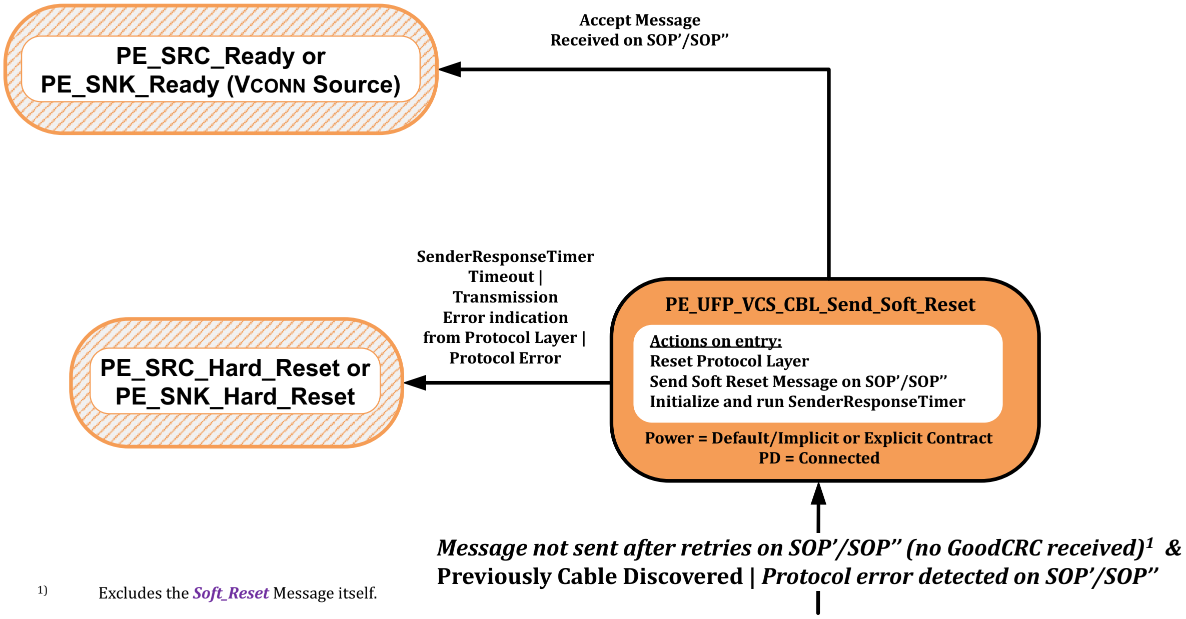
The *Policy Engine* ***Shall*** transition to either the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** state, depending on the *VCONN Source*'s *Power Role*, when:

- ***Cable Reset*** *Signaling* has been sent.

8.3.3.25.2.4 UFP/VCONN Source SOP'/SOP'' Soft Reset of a Cable Plug or VPD State Diagram

Figure 8.207, "UFP/VCONN Source Soft Reset of a Cable Plug or VPD State Diagram" below shows the state diagram for the *UFP Policy Engine* in a *VCONN Source* when performing a *Soft Reset* of a *Cable Plug* or *VPD* on *SOP'/SOP''*. The following sections describe operation in each of the states.

Figure 8.207 UFP/VCONN Source Soft Reset of a Cable Plug or VPD State Diagram


Accept Message
Received on SOP'/SOP''
PE_SRC_Ready or
PE_SNK_Ready (VCONN Source)
SenderResponseTimer
Timeout |
Transmission
Error indication
from Protocol Layer |
Protocol Error
PE_SRC_Hard_Reset or
PE_SNK_Hard_Reset
PE_UFP_VCS_CBL_Send_Soft_Reset
Actions on entry:
Reset Protocol Layer
Send Soft Reset Message on SOP'/SOP''
Initialize and run SenderResponseTimer
Power = Default/Implicit or Explicit Contract
PD = Connected
Message not sent after retries on SOP'/SOP'' (no GoodCRC received)1 &
Previously Cable Discovered | Protocol error detected on SOP'/SOP''

[1] Excludes the *Soft_Reset* Message itself.

8.3.3.25.2.4.1 PE_UFP_VCS_CBL_Send_Soft_Reset State

The *PE_UFP_VCS_CBL_Send_Soft_Reset* state ***Shall*** be entered from any state when a *Protocol Error* is detected on *SOP'/SOP''* by the *Protocol Layer* (see *Section 6.8.1, "Soft Reset and Protocol Error"*) or when a *Message* has not been sent after retries on *SOP'/SOP''* while communicating with a *Cable Plug/VPD* and when there was previous communication with the *Cable Plug* that did not result in a Transmission Error or whenever the *Device Policy Manager* directs a *Soft Reset* on *SOP'/SOP''*.

On entry to the *PE_UFP_VCS_CBL_Send_Soft_Reset* state the *Policy Engine* ***Shall*** request the *SOP'/SOP'' Protocol Layer* to perform a *Soft Reset*, then ***Shall*** send a ***Soft_Reset*** *Message* on *SOP'/SOP''* to the *Cable Plug*, and initialize and run the ***SenderResponseTimer***.

The *Policy Engine* ***Shall*** transition to either the *PE_SRC_Ready* or *PE_SNK_Ready* state, depending on the *UFP VCONN Source*'s *Power Role*, when:

- An ***Accept*** *Message* has been received on *SOP'/SOP''*.

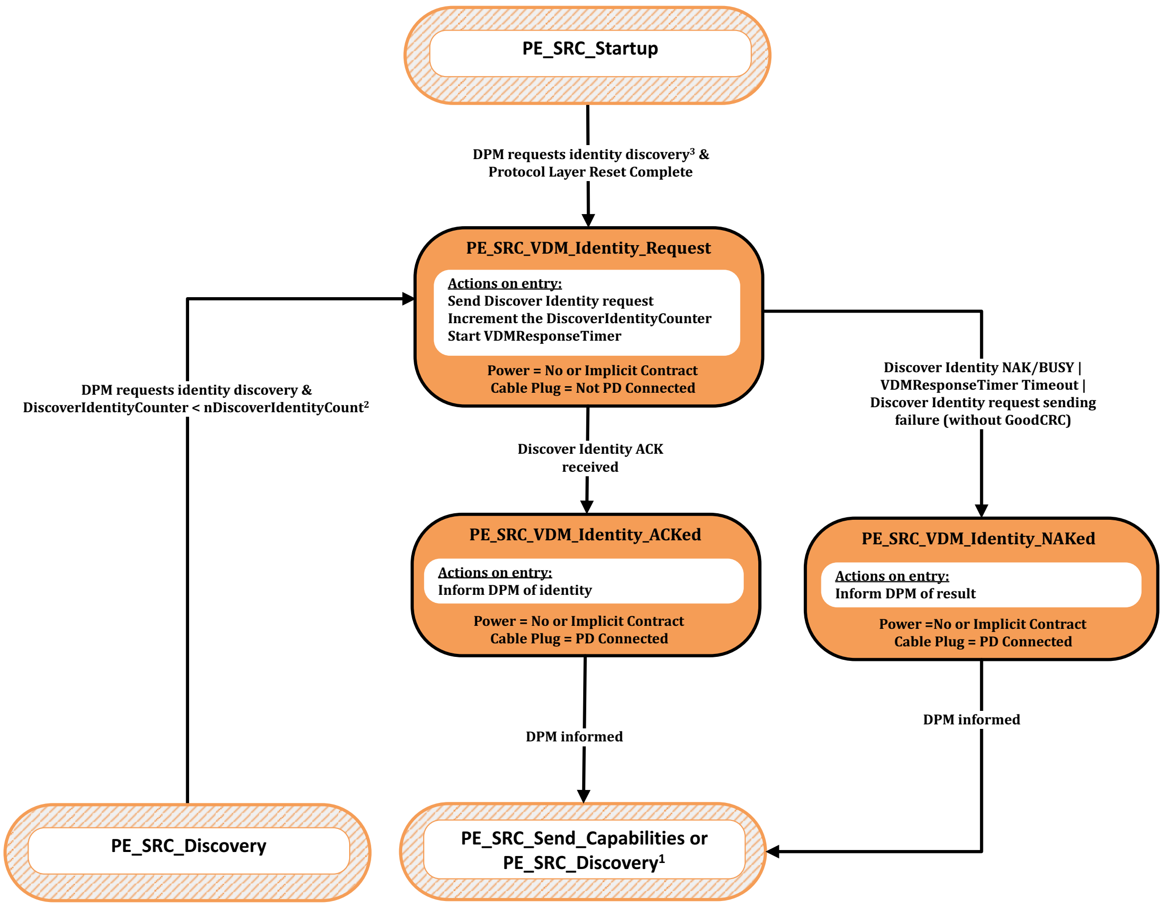
The *Policy Engine* ***Shall*** transition to either the *PE_SRC_Hard_Reset* or *PE_SNK_Hard_Reset* state, depending on the *UFP VCONN Source*'s *Power Role*, when:

- A ***SenderResponseTimer*** timeout occurs
- Or the *Protocol Layer* indicates that a transmission error has occurred
- Or when a *Protocol Error* is detected on *SOP'/SOP''* by the *Protocol Layer*.

8.3.3.25.3 Source Startup Structured VDM Discover Identity of a Cable Plug State Diagram

Figure 8.208, "Source Startup Structured VDM Discover Identity State Diagram" shows the state diagram for *Source* discovery of identity information from a *Cable Plug* during the startup sequence.

Figure 8.208 Source Startup Structured VDM Discover Identity State Diagram


PE_SRC_Startup
DPM requests identity discovery3 &
Protocol Layer Reset Complete
PE_SRC_VDM_Identity_Request
Actions on entry:
Send Discover Identity request
Increment the DiscoverIdentityCounter
Start VDMResponseTimer
Power = No or Implicit Contract
Cable Plug = Not PD Connected
DPM requests identity discovery &
DiscoverIdentityCounter < nDiscoverIdentityCount2
Discover Identity NAK/BUSY |
VDMResponseTimer Timeout |
Discover Identity request sending
failure (without GoodCRC)
Discover Identity ACK
received
PE_SRC_VDM_Identity_ACKed
Actions on entry:
Inform DPM of identity
Power = No or Implicit Contract
Cable Plug = PD Connected
PE_SRC_VDM_Identity_NAKed
Actions on entry:
Inform DPM of result
Power =No or Implicit Contract
Cable Plug = PD Connected
DPM informed
DPM informed
PE_SRC_Discovery
PE_SRC_Send_Capabilities or
PE_SRC_Discovery1

[1] If the ***Discover Identity*** Command is being sent at startup, then the Policy Engine will subsequently transition to the ***PE_SRC_Send_Capabilities*** state as normal. Otherwise, the Policy Engine will transition to the ***PE_SRC_Discovery*** state.

[2] The ***SourceCapabilityTimer*** continues to run during the states defined in this diagram even though there has been an exit from the ***PE_SRC_Discovery*** state. This ensures that ***Source_Capabilities*** Messages are sent out at a regular rate.

[3] The DPM in an EPR Source Shall request the discovery of the identity of the Cable Plug at startup.

8.3.3.25.3.1 PE_SRC_VDM_Identity_Request State

The *Policy Engine* ***Shall*** transition to the ***PE_SRC_VDM_Identity_Request*** state from the ***PE_SRC_Startup*** state when:

- The *Device Policy Manager* requests the discovery of the identity of the *Cable Plug*.

The *Policy Engine* ***Shall*** transition to the ***PE_SRC_VDM_Identity_Request*** state from the ***PE_SRC_Discovery*** state when:

- The *Device Policy Manager* requests the discovery of the identity of the *Cable Plug* and
- The ***DiscoverIdentityCounter*** < ***nDiscoverIdentityCount***.

Even though there has been a transition out of the ***PE_SRC_Discovery*** state the ***SourceCapabilityTimer Shall*** continue to run during the states shown in *Figure 8.208, "Source Startup Structured VDM Discover Identity State Diagram"* and ***Shall Not*** be initialized on re-entry to ***PE_SRC_Discovery***.

Note: An *EPR Source* is required to discover the identity of the *Cable Plug* prior to entering the *First Explicit Contract* (see *Section 6.4.10.1, "Process to enter EPR Mode"*)

On entry to the ***PE_SRC_VDM_Identity_Request*** state the *Policy Engine* ***Shall*** send a *Structured VDM* ***Discover Identity*** *Command* request, ***Shall*** increment the ***DiscoverIdentityCounter*** and ***Shall*** start the ***VDMResponseTimer***.

The *Policy Engine* ***Shall*** transition to the ***PE_SRC_VDM_Identity_ACKed*** state when:

- A *Structured VDM* ***Discover Identity ACK*** *Command* response is received.

The *Policy Engine* ***Shall*** transition to the ***PE_SRC_VDM_Identity_NAKed*** state when:

- A *Structured VDM* ***Discover Identity NAK*** or ***BUSY*** *Command* response is received or
- The ***VDMResponseTimer*** times out or
- The *Structured VDM* ***Discover Identity*** *Command* request *Message* sending fails (no ***GoodCRC*** *Message* received after retries).

8.3.3.25.3.2 PE_SRC_VDM_Identity_ACKed State

On entry to the ***PE_SRC_VDM_Identity_ACKed*** state the *Policy Engine* ***Shall*** inform the *Device Policy Manager* of the Identity information.

The *Policy Engine* ***Shall*** transition back to either the ***PE_SRC_Send_Capabilities*** or ***PE_SRC_Discovery*** state when:

- The *Device Policy Manager* has been informed.

8.3.3.25.3.3 PE_SRC_VDM_Identity_NAKed State

On entry to the ***PE_SRC_VDM_Identity_NAKed*** state the *Policy Engine* ***Shall*** inform the *Device Policy Manager* of the result (***NAK***, ***BUSY*** or timeout).

The *Policy Engine* ***Shall*** transition back to either the ***PE_SRC_Send_Capabilities*** or ***PE_SRC_Discovery*** state when:

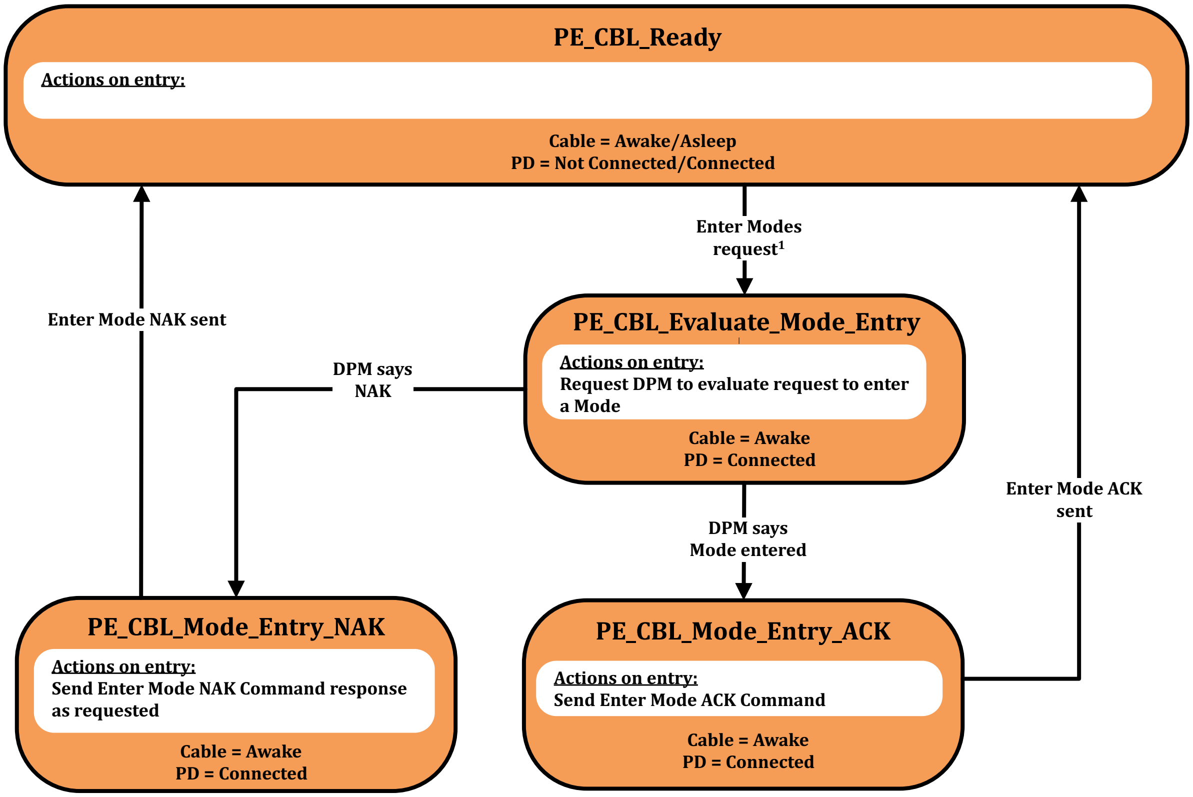
- The *Device Policy Manager* has been informed.

8.3.3.25.4 Cable Plug Mode Entry/Exit

8.3.3.25.4.1 Cable Plug Structured VDM Enter Mode State Diagram

Figure 8.209, "Cable Plug Structured VDM Enter Mode State Diagram" shows the state diagram for a *Cable Plug* in response to an ***Enter Mode*** *Command*.

Figure 8.209 Cable Plug Structured VDM Enter Mode State Diagram



1) The Cable is required to be in USB operation or USB Safe State at this point.

8.3.3.25.4.1.1 PE_CBL_Evaluate_Mode_Entry State

The *Policy Engine* transitions to the *PE_CBL_Evaluate_Mode_Entry* state from the *PE_CBL_Ready* state when:

- A *Structured VDM* ***Enter Mode*** *Command* request is received from the *DFP*.

On Entry to the *PE_CBL_Evaluate_Mode_Entry* state the *Policy Engine* ***Shall*** request the *Device Policy Manager* to evaluate the ***Enter Mode*** *Command* request and enter the Mode indicated in the *Command* request if the request is acceptable.

The *Policy Engine* ***Shall*** transition to the *PE_CBL_Mode_Entry_ACK* state when:

- The *Device Policy Manager* indicates that the Mode has been entered.

The *Policy Engine* ***Shall*** transition to the *PE_CBL_Mode_Entry_NAK* state when:

- The *Device Policy Manager* indicates that the response to the Mode request is ***NAK***.

8.3.3.25.4.1.2 PE_CBL_Mode_Entry_ACK State

On entry to the *PE_CBL_Mode_Entry_ACK* state the *Policy Engine* ***Shall*** send a *Structured VDM* ***Enter Mode ACK*** *Command* response.

The *Policy Engine* ***Shall*** transition to the ***PE_CBL_Ready*** state when:

- The *Structured VDM* ***Enter Mode ACK*** *Command* response has been sent.

8.3.3.25.4.1.3 PE_CBL_Mode_Entry_NAK State

On entry to the ***PE_CBL_Mode_Entry_NAK*** state the *Policy Engine* ***Shall*** send a *Structured VDM* ***Enter Mode NAK*** *Command* response as indicated by the *Device Policy Manager*.

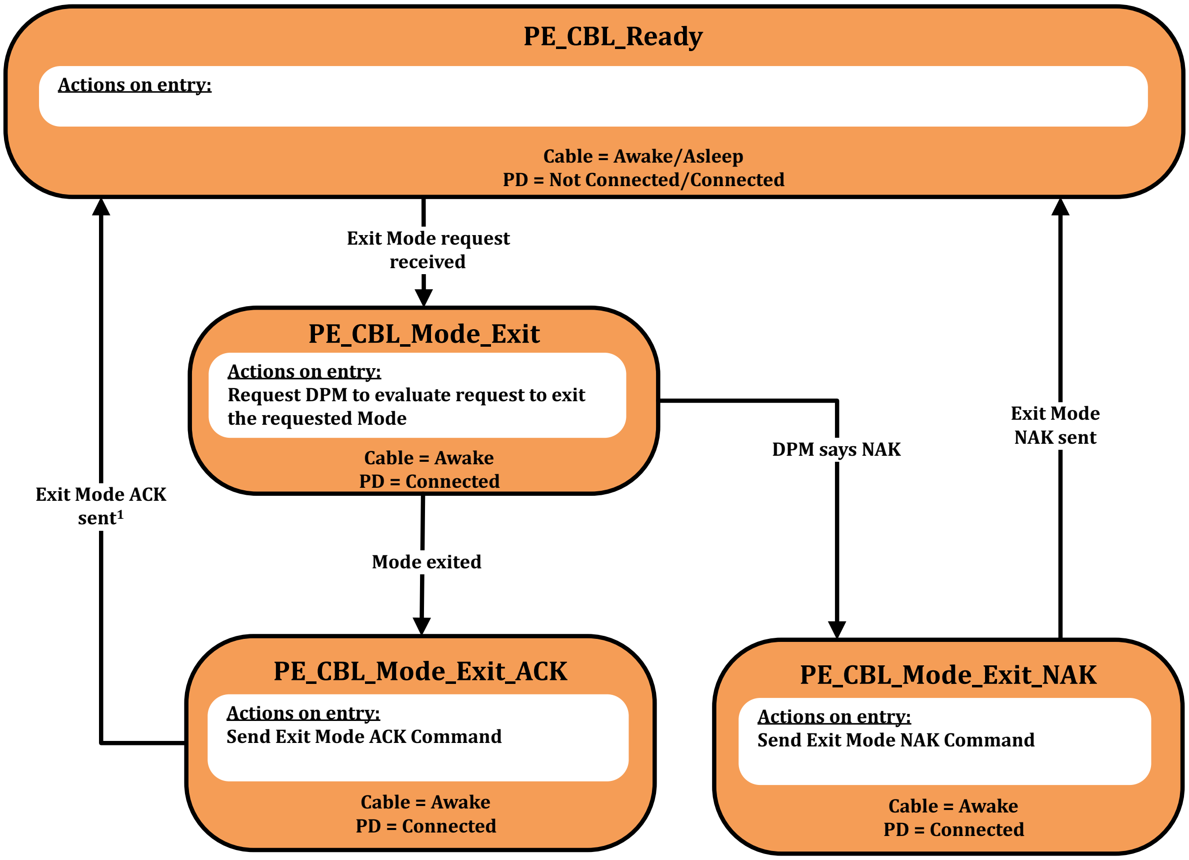
The *Policy Engine* ***Shall*** transition to the ***PE_CBL_Ready*** state when:

- The *Structured VDM* ***Enter Mode NAK*** *Command* response has been sent.

8.3.3.25.4.2 Cable Plug Structured VDM Exit Mode State Diagram

Figure 8.210, "Cable Plug Structured VDM Exit Mode State Diagram" shows the state diagram for a *Cable Plug* in response to an ***Exit Mode*** *Command*.

Figure 8.210 Cable Plug Structured VDM Exit Mode State Diagram



[1] The Cable is required to be in USB operation or USB Safe State at this point.

8.3.3.25.4.2.1 PE_CBL_Mode_Exit State

The *Policy Engine* transitions to the ***PE_CBL_Mode_Exit*** state from the ***PE_CBL_Ready*** state when:

- A *Structured VDM* ***Exit Mode*** *Command* request is received from the *DFP*.

On entry to the ***PE_CBL_Mode_Exit*** state the *Policy Engine* ***Shall*** request the *Device Policy Manager* to exit the Mode indicated in the *Command*.

The *Policy Engine* ***Shall*** transition to the ***PE_CBL_Mode_Exit_ACK*** state when:

- The *Device Policy Manager* indicates that the Mode has been exited.

The *Policy Engine* ***Shall*** transition to the ***PE_CBL_Mode_Exit_NAK*** state when:

- The *Device Policy Manager* indicates that the *Command* response to the ***Exit Mode*** *Command* request is ***NAK***.

8.3.3.25.4.2.2 PE_CBL_Mode_Exit_ACK State

On entry to the ***PE_CBL_Mode_Exit_ACK*** state the *Policy Engine* ***Shall*** send a *Structured VDM* ***Exit Mode ACK*** *Command* response.

The *Policy Engine* ***Shall*** transition to the ***PE_CBL_Ready*** state when:

- The *Structured VDM* ***Exit Mode ACK*** *Command* response has been sent.

8.3.3.25.4.2.3 PE_CBL_Mode_Exit_NAK State

On entry to the ***PE_CBL_Mode_Exit_NAK*** state the *Policy Engine* ***Shall*** send a *Structured VDM* ***Exit Mode NAK*** *Command* response as indicated by the *Device Policy Manager*.

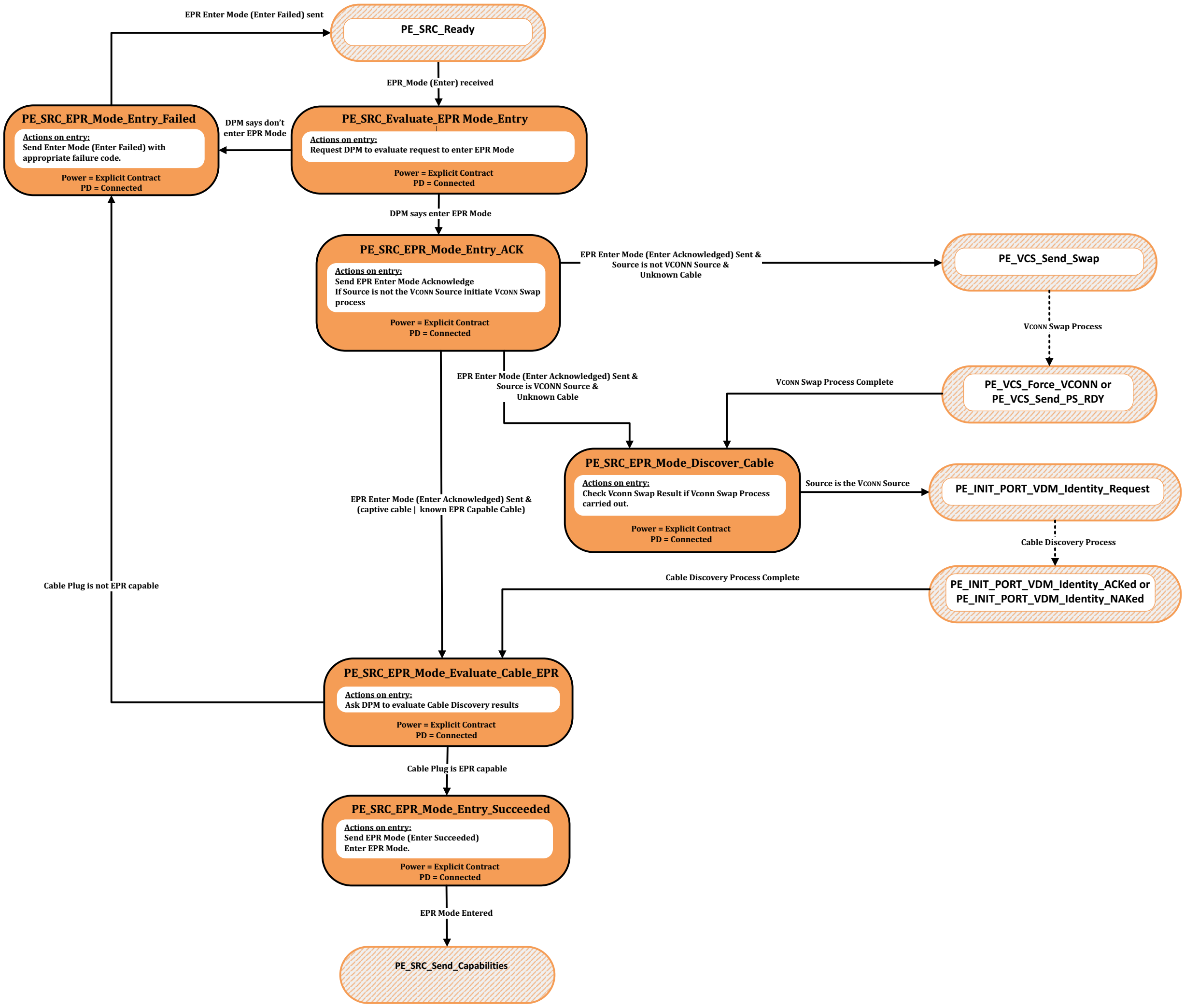
The *Policy Engine* ***Shall*** transition to the ***PE_CBL_Ready*** state when:

- The *Structured VDM* ***Exit Mode NAK*** *Command* response has been sent.

8.3.3.26 EPR Mode State Diagrams

8.3.3.26.1 Source EPR Mode Entry State Diagram

Figure 8.211, "Source EPR Mode Entry State Diagram" shows the state diagram for an *EPR Source* in response to an ***EPR_Mode*** *Message*.



PE_SRC_Ready
EPR Enter Mode (Enter Failed) sent
EPR_Mode (Enter) received
PE_SRC_EPR_Mode_Entry_Failed
Actions on entry:
Send Enter Mode (Enter Failed) with appropriate failure code.
Power = Explicit Contract
PD = Connected
DPM says don't enter EPR Mode
PE_SRC_Evaluate_EPR Mode_Entry
Actions on entry:
Request DPM to evaluate request to enter EPR Mode
Power = Explicit Contract
PD = Connected
DPM says enter EPR Mode
PE_SRC_EPR_Mode_Entry_ACK
Actions on entry:
Send EPR Enter Mode Acknowledge
If Source is not the VCONN Source initiate VCONN Swap process
Power = Explicit Contract
PD = Connected
EPR Enter Mode (Enter Acknowledged) Sent & Source is not VCONN Source & Unknown Cable
PE_VCS_Send_Swap
VCONN Swap Process
PE_VCS_Force_VCONN or PE_VCS_Send_PS_RDY
VCONN Swap Process Complete
EPR Enter Mode (Enter Acknowledged) Sent & Source is VCONN Source & Unknown Cable
PE_SRC_EPR_Mode_Discover_Cable
Actions on entry:
Check Vconn Swap Result if Vconn Swap Process carried out.
Power = Explicit Contract
PD = Connected
Source is the VCONN Source
PE_INIT_PORT_VDM_Identity_Request
Cable Discovery Process
PE_INIT_PORT_VDM_Identity_ACKed or PE_INIT_PORT_VDM_Identity_NAKed
Cable Discovery Process Complete
EPR Enter Mode (Enter Acknowledged) Sent & (captive cable | known EPR Capable Cable)
Cable Plug is not EPR capable
PE_SRC_EPR_Mode_Evaluate_Cable_EPR
Actions on entry:
Ask DPM to evaluate Cable Discovery results
Power = Explicit Contract
PD = Connected
Cable Plug is EPR capable
PE_SRC_EPR_Mode_Entry_Succeeded
Actions on entry:
Send EPR Mode (Enter Succeeded)
Enter EPR Mode.
Power = Explicit Contract
PD = Connected
EPR Mode Entered
PE_SRC_Send_Capabilities

Figure 8.211 Source EPR Mode Entry State Diagram

8.3.3.26.1.1 PE_SRC_Evaluate_EPR_Mode_Entry State

The *Policy Engine* transitions to the *PE_SRC_Evaluate_EPR_Mode_Entry* state from the *PE_SRC_Ready* state when:

- An ***EPR_Mode*** (Enter) *Message* is received from the *Sink*.

On Entry to the *PE_SRC_Evaluate_EPR_Mode_Entry* state the *Policy Engine* ***Shall*** request the *Device Policy Manager* to evaluate the ***EPR_Mode*** (Enter) *Message*.

The *Policy Engine* ***Shall*** transition to the *PE_SRC_EPR_Mode_Entry_Ack* state when:

- The *Device Policy Manager* indicates that *EPR Mode* can be entered.

The *Policy Engine* ***Shall*** transition to the *PE_SRC_EPR_Mode_Entry_Failed* state when:

- The *Device Policy Manager* indicates that the *EPR Mode* is not to be entered.

8.3.3.26.1.2 PE_SRC_EPR_Mode_Entry_Ack State

On entry to the ***PE_SRC_EPR_Mode_Entry_Ack*** state the *Policy Engine* ***Shall*** send a ***EPR_Mode*** (Enter Acknowledged) *Message*.

The *Policy Engine* ***Shall*** transition to the ***PE_SRC_EPR_Mode_Evaluate_Cable_EPR*** state when:

- The ***EPR_Mode*** (Enter Acknowledged) *Message* has been sent and
- The *Source* is not the *VCONN Source* and
- The cable is a captive cable or a known *EPR Cable*.

The *Policy Engine* ***Shall*** transition to the ***PE_VCS_Send_Swap*** state when:

- The ***EPR_Mode*** (Enter Acknowledged) *Message* has been sent and
- The *Source* is not the *VCONN Source* and
- The cable is unknown.

The *Policy Engine* ***Shall*** transition to the ***PE_SRC_EPR_Mode_Discover_Cable*** state when:

- The ***EPR_Mode*** (Enter Acknowledged) *Message* has been sent and
- The *Source* is the *VCONN Source* and
- The cable is unknown.

8.3.3.26.1.3 PE_SRC_EPR_Mode_Discover_Cable State

The *Policy Engine* transitions to the ***PE_SRC_EPR_Mode_Discover_Cable*** state from the ***PE_VCS_Force_VCONN*** state or ***PE_VCS_Send_Ps_Rdy*** state when:

- A *Source* initiated *VCONN Swap* process has completed.

The *Policy Engine* ***Shall*** transition to the ***PE_INIT_PORT_VDM_Identity_Request*** state in order to perform *Cable Plug* discovery when:

- The *Source* is the *VCONN Source*.

The *Policy Engine* ***Shall*** transition to the ***PE_SRC_EPR_Mode_Entry_Failed*** state when:

- The *VCONN Swap* process failed (the *Source* is not the *VCONN Source*).

8.3.3.26.1.4 PE_SRC_EPR_Mode_Evaluate_Cable_EPR State

In the ***PE_SRC_EPR_Mode_Evaluate_Cable_EPR*** state the *Policy Engine* requests the DPM to evaluate the *Cable Discovery* results.

The *Policy Engine* ***Shall*** transition to the ***PE_SRC_EPR_Mode_Entry_Succeeded*** state when:

- The *Cable Plug* is capable of *EPR Mode*.

The *Policy Engine* ***Shall*** transition to the ***PE_SRC_EPR_Mode_Entry_Failed*** state when:

- The *Cable Plug* is not capable of *EPR Mode*.

8.3.3.26.1.5 PE_SRC_EPR_Mode_Entry_Succeeded State

On entry to the ***PE_SRC_EPR_Mode_Entry_Succeeded*** state the *Policy Engine* ***Shall*** send a ***EPR_Mode*** (Enter Succeeded) *Message* and enter *EPR Mode*.

The *Policy Engine* ***Shall*** transition to the ***PE_SRC_Send_Capabilities*** state when:

- *EPR Mode* has been entered.

8.3.3.26.1.6 PE_SRC_EPR_Mode_Entry_Failed State

On entry to the ***PE_SRC_EPR_Mode_Entry_Failed*** state the *Policy Engine* ***Shall*** send a ***EPR_Mode*** (Enter Failed) *Message*.

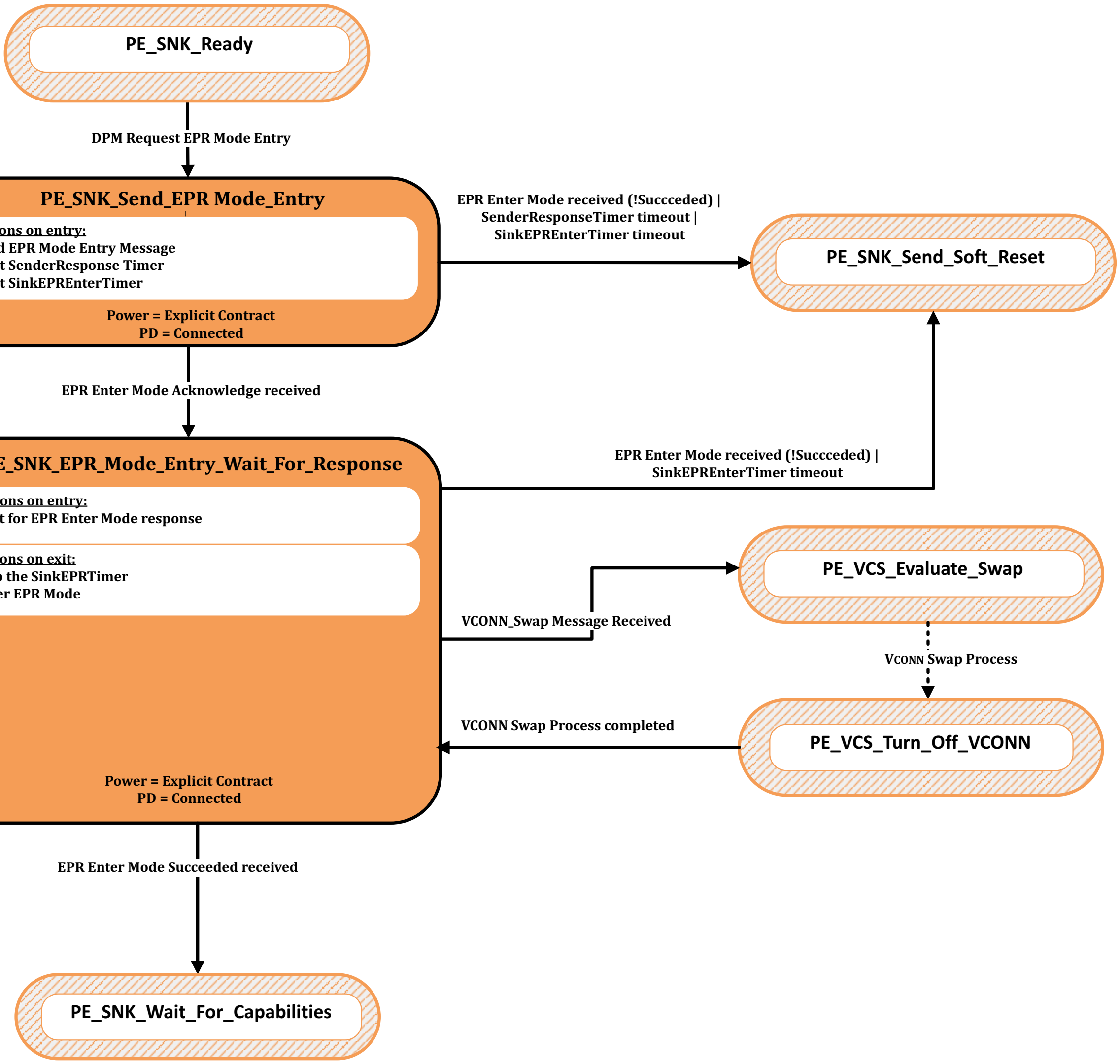
The *Policy Engine* ***Shall*** transition to the ***PE_SRC_Ready*** state when:

- The ***EPR_Mode*** (Enter Failed) *Message* has been sent.

8.3.3.26.2 Sink EPR Mode Entry State Diagram

Figure 8.212, "Sink EPR Mode Entry State Diagram" shows the state diagram for an *EPR Sink* initiating the *EPR Mode* Entry process.

Figure 8.212 Sink EPR Mode Entry State Diagram


PE_SNK_Ready
DPM Request EPR Mode Entry
PE_SNK_Send_EPR Mode_Entry
Actions on entry:
Send EPR Mode Entry Message
Start SenderResponse Timer
Start SinkEPREnterTimer
Power = Explicit Contract
PD = Connected
EPR Enter Mode received (!Succceded) |
SenderResponseTimer timeout |
SinkEPREnterTimer timeout
PE_SNK_Send_Soft_Reset
EPR Enter Mode Acknowledge received
PE_SNK_EPR_Mode_Entry_Wait_For_Response
Actions on entry:
Wait for EPR Enter Mode response
Actions on exit:
Stop the SinkEPRTimer
Enter EPR Mode
Power = Explicit Contract
PD = Connected
EPR Enter Mode received (!Succceded) |
SinkEPREnterTimer timeout
PE_VCS_Evaluate_Swap
VCONN_Swap Message Received
VCONN Swap Process
PE_VCS_Turn_Off_VCONN
VCONN Swap Process completed
EPR Enter Mode Succeeded received
PE_SNK_Wait_For_Capabilities

8.3.3.26.2.1 PE_SNK_Send_EPR_Mode_Entry State

The *Policy Engine* transitions to the *PE_SNK_Send_EPR_Mode_Entry* state from the *PE_SNK_Ready* state when:

- The DPM requests entry into *EPR Mode*.

On Entry to the *PE_SNK_Send_EPR_Mode_Entry* state the *Policy Engine **Shall*** send an ***EPR_Mode*** (Enter) *Message* and starts the ***SenderResponseTimer*** and the ***SinkEPREnterTimer***.

Note: The ***SinkEPREnterTimer Shall*** continue to run in every state until it is stopped or times out.

The *Policy Engine **Shall*** transition to the *PE_SNK_EPR_Mode_Wait_For_Response* state when:

- An ***EPR_Mode*** (Enter Acknowledge) *Message* is received.

The *Policy Engine **Shall*** transition to the *PE_SNK_Send_Soft_Reset* state when:

- An ***EPR_Mode*** *Message* is received which is not Enter Succeeded or

- The ***SenderResponseTimer*** times out or
- The ***SinkEPREnterTimer*** times out.

8.3.3.26.2.2 PE_SNK_EPR_Mode_Wait_For_Response State

In the State the *Policy Engine* waits for a confirmation that the *EPR Mode* entry request has succeeded.

On exit from the ***PE_SNK_EPR_Mode_Wait_For_Response*** state the *Policy Engine* ***Shall*** stop the ***SinkEPREnterTimer*** and enter *EPR Mode*.

The *Policy Engine* ***Shall*** transition to the ***PE_SNK_Send_Soft_Reset*** state when:

- An ***EPR_Mode*** *Message* is received which is not Enter Succeeded or
- The ***SinkEPREnterTimer*** times out.

The *Policy Engine* ***Shall*** transition to the ***PE_VCS_Evaluate_Swap*** State when:

- A ***VCONN_Swap*** *Message* is received.

The *Policy Engine* ***Shall*** transition back from the ***PE_VCS_Turn_Off_VCONN*** State to the ***PE_SNK_EPR_Mode_Wait_For_Response*** State when:

- The *VCONN Swap* process has completed.

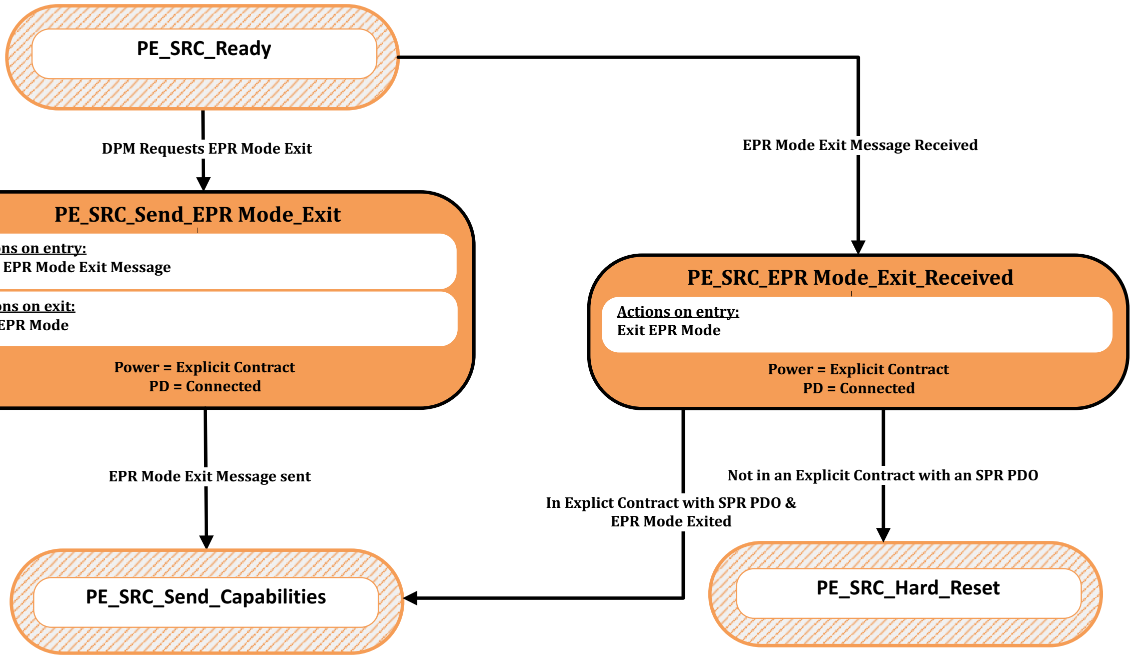
The *Policy Engine* ***Shall*** transition to the ***PE_SNK_Wait_for_Capabilities*** state when:

- An ***EPR_Mode*** (Enter Succeeded) *Message* has been received.

8.3.3.26.3 Source EPR Mode Exit State Diagram

Figure 8.213, "Source EPR Mode Exit State Diagram" shows the state diagram for an *EPR Source* initiating the *EPR Mode* exit process.

Figure 8.213 Source EPR Mode Exit State Diagram


PE_SRC_Ready
DPM Requests EPR Mode Exit
EPR Mode Exit Message Received
PE_SRC_Send_EPR Mode_Exit
Actions on entry:
Send EPR Mode Exit Message
Actions on exit:
Exit EPR Mode
Power = Explicit Contract
PD = Connected
PE_SRC_EPR Mode_Exit_Received
Actions on entry:
Exit EPR Mode
Power = Explicit Contract
PD = Connected
EPR Mode Exit Message sent
Not in an Explicit Contract with an SPR PDO
In Explicit Contract with SPR PDO &
EPR Mode Exited
PE_SRC_Send_Capabilities
PE_SRC_Hard_Reset

8.3.3.26.3.1 PE_SRC_Send_EPR_Mode_Exit State

The *Policy Engine* transitions to the *PE_SRC_Send_EPR_Mode_Exit* state from the *PE_SRC_Ready* state when:

- The DPM requests exit from *EPR Mode*.

On Entry to the *PE_SRC_Send_EPR_Mode_Exit* state the *Policy Engine* ***Shall*** send an ***EPR_Mode*** (Exit) *Message*.

On Exit from the *PE_SRC_Send_EPR_Mode_Exit* state the *Policy Engine* ***Shall*** exit *EPR Mode*.

The *Policy Engine* ***Shall*** transition to the *PE_SRC_Send_Capabilities* state when:

- The ***EPR_Mode*** (Exit) *Message* has been sent.

8.3.3.26.3.2 PE_SRC_EPR_Mode_Exit_Received State

The *Policy Engine* transitions to the *PE_SRC_EPR_Mode_Exit_Received* state from the *PE_SRC_Ready* state when:

- An ***EPR_Mode*** (Exit) *Message* is received.

On Entry to the *PE_SRC_EPR_Mode_Exit_Received* state the *Policy Engine* ***Shall*** exit *EPR Mode*.

The *Policy Engine* ***Shall*** transition to the *PE_SRC_Send_Capabilities* state when:

- In an *Explicit Contract* with an *SPR (A)PDO* and
- *EPR Mode* has been exited.

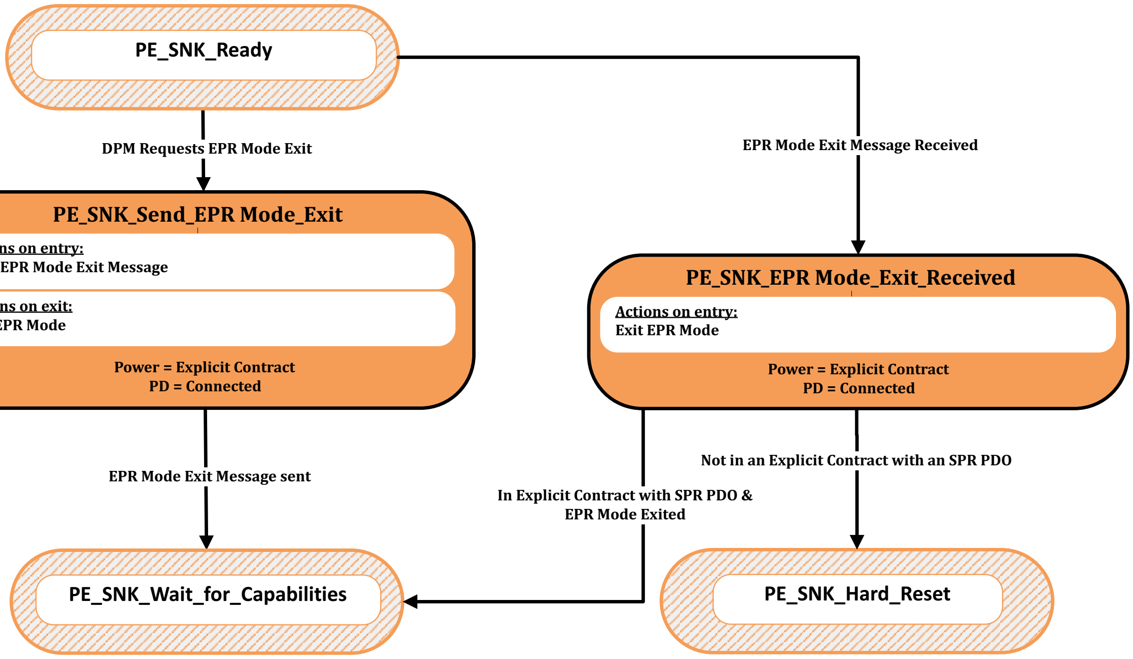
The *Policy Engine* ***Shall*** transition to the *PE_SRC_Hard_Reset* state when:

- Not in an *Explicit Contract* with an *SPR (A)PDO*.

8.3.3.26.4 Sink EPR Mode Exit State Diagram

Figure 8.214, "Sink EPR Mode Exit State Diagram" shows the state diagram for an *EPR Sink* initiating the *EPR Mode* exit process.

Figure 8.214 Sink EPR Mode Exit State Diagram


PE_SNK_Ready
DPM Requests EPR Mode Exit
EPR Mode Exit Message Received
PE_SNK_Send_EPR Mode_Exit
Actions on entry:
Send EPR Mode Exit Message
Actions on exit:
Exit EPR Mode
Power = Explicit Contract
PD = Connected
PE_SNK_EPR Mode_Exit_Received
Actions on entry:
Exit EPR Mode
Power = Explicit Contract
PD = Connected
EPR Mode Exit Message sent
Not in an Explicit Contract with an SPR PDO
In Explicit Contract with SPR PDO &
EPR Mode Exited
PE_SNK_Wait_for_Capabilities
PE_SNK_Hard_Reset

8.3.3.26.4.1 PE_SNK_Send_EPR_Mode_Exit State

The *Policy Engine* transitions to the ***PE_SNK_Send_EPR_Mode_Exit*** state from the ***PE_SNK_Ready*** state when:

- The DPM requests exit from *EPR Mode*.

On Entry to the ***PE_SNK_Send_EPR_Mode_Exit*** state the *Policy Engine* ***Shall*** send an ***EPR_Mode*** (Exit) *Message*.

On Exit from the ***PE_SNK_Send_EPR_Mode_Exit*** state the *Policy Engine* ***Shall*** exit *EPR Mode*.

The *Policy Engine* ***Shall*** transition to the ***PE_SNK_Wait_for_Capabilities*** state when:

- The ***EPR_Mode*** (Exit) *Message* has been sent.

8.3.3.26.4.2 PE_SNK_EPR_Mode_Exit_Received State

The *Policy Engine* transitions to the ***PE_SNK_EPR_Mode_Exit_Received*** state from the ***PE_SNK_Ready*** state when:

- An ***EPR_Mode*** (Exit) *Message* is received.

On Entry to the ***PE_SNK_EPR_Mode_Exit_Received*** state the *Policy Engine* ***Shall*** exit *EPR Mode*.

The *Policy Engine* ***Shall*** transition to the ***PE_SNK_Wait_for_Capabilities*** state when:

- In an *Explicit Contract* with an *SPR (A)PDO* and
- *EPR Mode* has been exited.

The *Policy Engine* ***Shall*** transition to the ***PE_SNK_Hard_Reset*** state when:

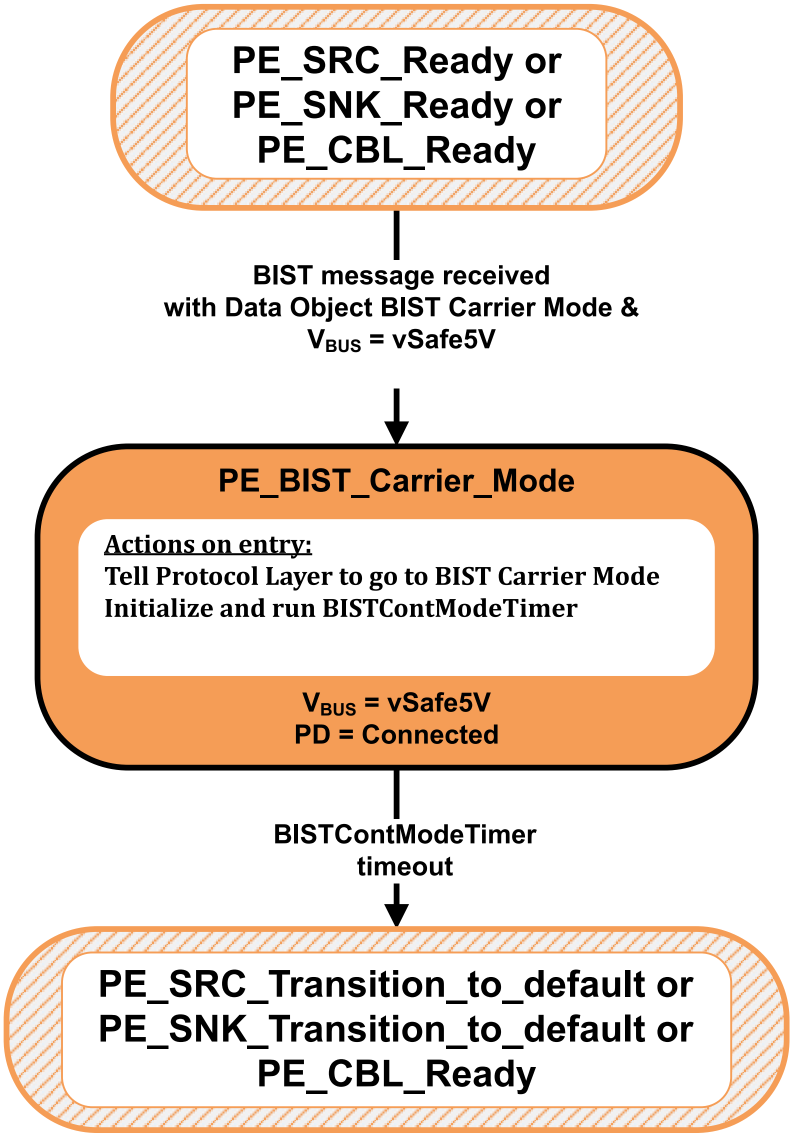
- Not in an *Explicit Contract* with an *SPR (A)PDO*.

8.3.3.27 BIST State diagrams

8.3.3.27.1 BIST Carrier Mode State Diagram

Figure 8.215, "BIST Carrier Mode State Diagram" shows the state diagram required by a *UUT*, which can be either a *Source*, *Sink* or *Cable Plug*, when operating in *BIST Carrier Mode*. Transitions ***Shall*** be from either the *PE_SRC_Ready*, *PE_SNK_Ready* or *PE_CBL_Ready* states.

Figure 8.215 BIST Carrier Mode State Diagram



8.3.3.27.1.1 PE_BIST_Carrier_Mode State

The *Source*, *Sink* or *Cable Plug* ***Shall*** enter the *PE_BIST_Carrier_Mode* state from either the *PE_SRC_Ready*, *PE_SNK_Ready* or *PE_CBL_Ready* state when:

- A ***BIST*** *Message* is received with a ***BIST Carrier Mode*** *BIST Data Object* and
- *VBUS* is at ***vSafe5V***.

On entry to the *PE_BIST_Carrier_Mode* state the *Policy Engine* ***Shall*** tell the *Protocol Layer* to go to *BIST Carrier Mode* (see *Section 6.4.3.1, "BIST Carrier Mode"*) and ***Shall*** initialize and run the ***BISTContModeTimer***.

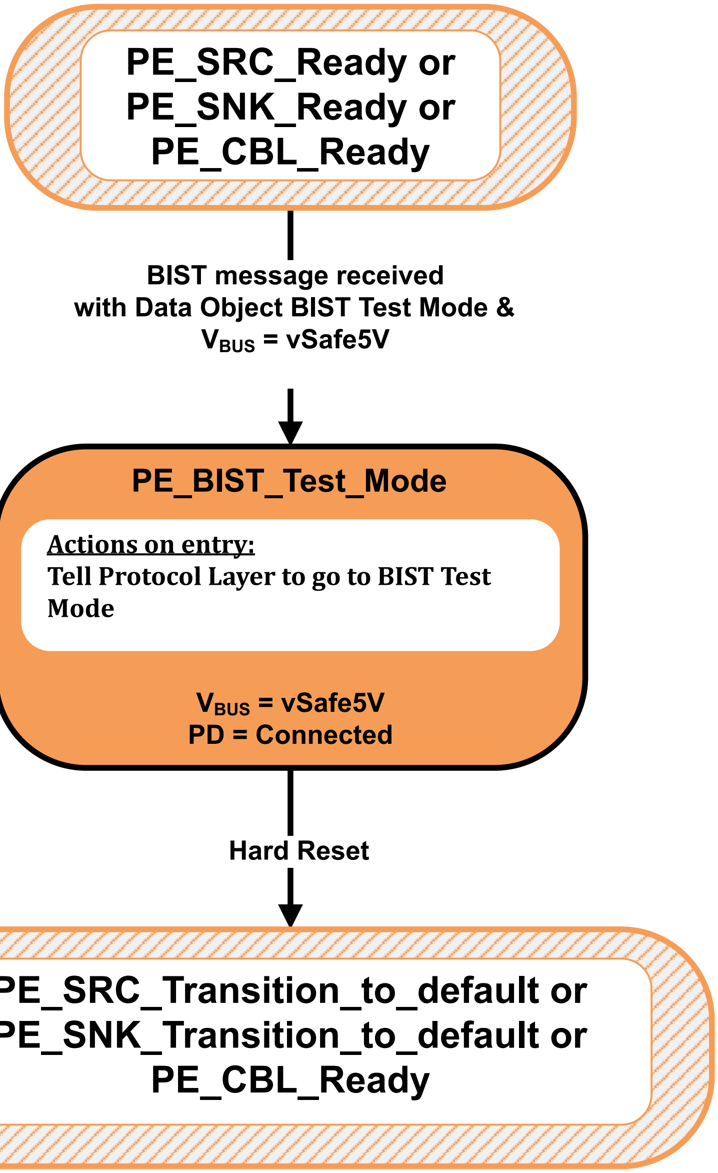
The *Policy Engine* ***Shall*** transition to either the ***PE_SRC_Transition_to_default*** state, ***PE_SNK_Transition_to_default*** state or ***PE_CBL_Ready*** state (as appropriate) when:

- The ***BISTContModeTimer*** times out.

8.3.3.27.2 BIST Test Data Mode State Diagram

Figure 8.216, "BIST Test Data Mode State Diagram" shows the state diagram required by a *UUT*, which can be either a *Source*, *Sink* or *Cable Plug*, when operating in *BIST Test Data Mode*. Transitions ***Shall*** be from either the ***PE_SRC_Ready***, ***PE_SNK_Ready*** or ***PE_CBL_Ready*** states.

Figure 8.216 BIST Test Data Mode State Diagram



8.3.3.27.2.1 PE_BIST_Test_Mode State

The *Source*, *Sink* or *Cable Plug* ***Shall*** enter the ***PE_BIST_Test_Mode*** state from either the ***PE_SRC_Ready***, ***PE_SNK_Ready*** or ***PE_CBL_Ready*** state when:

- A ***BIST*** *Message* is received with a ***BIST Test Data*** *BIST Data Object* and
- *VBUS* is at ***vSafe5V***.

On entry to the ***PE_BIST_Test_Mode*** state the *Policy Engine* ***Shall*** tell the *Protocol Layer* to go into *BIST Test Data Mode* where it sends no further *Message*s except for ***GoodCRC*** *Message*s in response to received *Message*s (see *Section 6.4.3.2, "BIST Test Data Mode"*).

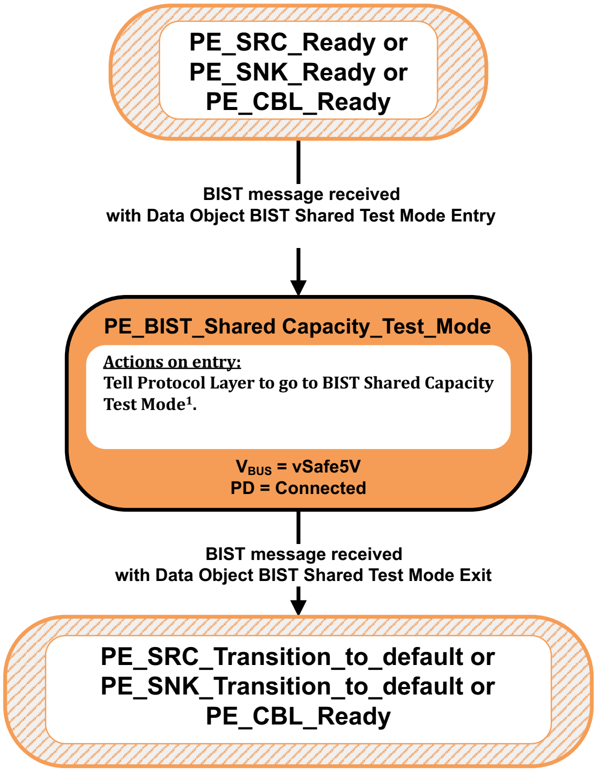
The *Policy Engine* ***Shall*** transition to either the ***PE_SRC_Transition_to_default*** state, ***PE_SNK_Transition_to_default*** state or ***PE_CBL_Ready*** state (as appropriate) when:

- A *Hard Reset* occurs.

8.3.3.27.3 BIST Shared Capacity Test Mode State Diagram

Figure 8.217, "BIST Shared Capacity Test Mode State Diagram" shows the state diagram required by a *UUT*, which can be either a *Source*, *Sink* or *Cable Plug*, when operating in *BIST Shared Capacity Test Mode*. Transitions ***Shall*** be from either the ***PE_SRC_Ready***, ***PE_SNK_Ready*** or ***PE_CBL_Ready*** states.

Figure 8.217 BIST Shared Capacity Test Mode State Diagram


PE_SRC_Ready or
PE_SNK_Ready or
PE_CBL_Ready
BIST message received
with Data Object BIST Shared Test Mode Entry
PE_BIST_Shared Capacity_Test_Mode
Actions on entry:
Tell Protocol Layer to go to BIST Shared Capacity Test Mode[1].
V_{BUS} = vSafe5V
PD = Connected
BIST message received
with Data Object BIST Shared Test Mode Exit
PE_SRC_Transition_to_default or
PE_SNK_Transition_to_default or
PE_CBL_Ready

[1] The UUT ***Shall*** exit BIST Shared Capacity Test Mode when It is powered off. The UUT ***Shall*** remain in BIST Shared Capacity Test Mode for any PD event (except when a ***BIST Shared Test Mode Exit*** BIST Data Object, is received); specifically the UUT ***Shall*** remain in BIST Shared Capacity Test Mode when any of the following PD events occurs: Hard Reset, Cable Reset, Soft Reset, Data Role Swap, Power Role Swap, Fast Role Swap, VCONN Swap. The UUT ***May*** leave test mode if the tester makes a request that exceeds the capabilities of the UUT.

8.3.3.27.3.1 PE_BIST_Shared_Capacity_Test_Mode State

The *Source*, *Sink* or *Cable Plug* ***Shall*** enter the ***PE_BIST_Shared_Capacity_Test_Mode*** state from either the ***PE_SRC_Ready***, ***PE_SNK_Ready*** or ***PE_CBL_Ready*** state when:

- A ***BIST*** *Message* is received with a ***BIST Shared Test Mode Entry*** *BIST Data Object* and
- *VBUS* is at ***vSafe5V***.

On entry to the ***PE_BIST_Shared_Capacity_Test_Mode*** state the *Policy Engine* ***Shall*** tell the *Protocol Layer* to go to *BIST Shared Capacity Test Mode* (see *Section 6.4.3.3, "BIST Shared Capacity Test Mode"*).

The *Policy Engine* ***Shall*** transition to either the ***PE_SRC_Transition_to_default*** state, ***PE_SNK_Transition_to_default*** state or ***PE_CBL_Ready*** state (as appropriate) when:

- A ***BIST*** *Message* is received with a ***BIST Shared Test Mode Exit*** *BIST Data Object*.

8.3.3.28 USB Type-C Referenced States

This section contains states cross-referenced from the ***[USB Type-C 2.4]*** specification.

8.3.3.28.1 ErrorRecovery state

The ***ErrorRecovery*** state is used to electronically disconnect *Port Partner*s using the *USB Type-C* connector. The ***ErrorRecovery*** state ***Shall*** be entered when there are errors on *USB Type-C* Ports which cannot be recovered by *Hard Reset*. The ***ErrorRecovery*** state ***Shall*** map to *USB Type-C* ***ErrorRecovery*** state operation as defined in the ***[USB Type-C 2.4]*** specification. Bus powered Sinks ***Shall Not*** be required to meet this requirement as removal of their power will serve the same purpose.

On entry to the ***ErrorRecovery*** state the *Explicit Contract* and PD Connection ***Shall*** be ended.

On exit from the ***ErrorRecovery*** state a new *Explicit Contract* ***Should*** be established once the *Port Partner*s have re-connected over the *CC* wire.

8.3.3.29 Policy Engine States

Table 8.154, "Policy Engine States" lists the states used by the various state machines.

Table 8.154 Policy Engine States

State name	Reference
SenderResponseTimer	
SRT_Stopped	*Section 8.3.3.1.1.1*
SRT_Running	*Section 8.3.3.1.1.2*
SRT_Expired	*Section 8.3.3.1.1.3*
Source Port	
PE_SRC_Startup	*Section 8.3.3.2.1*
PE_SRC_Discovery	*Section 8.3.3.2.2*
PE_SRC_Send_Capabilities	*Section 8.3.3.2.3*
PE_SRC_Negotiate_Capability	*Section 8.3.3.2.4*
PE_SRC_Transition_Supply	*Section 8.3.3.2.5*
PE_SRC_Ready	*Section 8.3.3.2.6*
PE_SRC_Disabled	*Section 8.3.3.2.7*
PE_SRC_Capability_Response	*Section 8.3.3.2.8*
PE_SRC_Hard_Reset	*Section 8.3.3.2.9*
PE_SRC_Hard_Reset_Received	*Section 8.3.3.2.10*
PE_SRC_Transition_to_default	*Section 8.3.3.2.11*
PE_SRC_Give_Source_Cap	*Section 8.3.3.2.15*
PE_SRC_Get_Sink_Cap	*Section 8.3.3.2.12*
PE_SRC_Wait_New_Capabilities	*Section 8.3.3.2.13*
PE_SRC_EPR_Keep_Alive	*Section 8.3.3.2.14*
Sink Port	
PE_SNK_Startup	*Section 8.3.3.3.1*
PE_SNK_Discovery	*Section 8.3.3.3.2*
PE_SNK_Wait_for_Capabilities	*Section 8.3.3.3.3*
PE_SNK_Evaluate_Capability	*Section 8.3.3.3.4*
PE_SNK_Select_Capability	*Section 8.3.3.3.5*
PE_SNK_Transition_Sink	*Section 8.3.3.3.6*
PE_SNK_Ready	*Section 8.3.3.3.7*
PE_SNK_Hard_Reset	*Section 8.3.3.3.8*
PE_SNK_Transition_to_default	*Section 8.3.3.3.9*
PE_SNK_Give_Sink_Cap	*Section 8.3.3.3.10*
PE_SNK_Get_Source_Cap	*Section 8.3.3.3.12*
PE_SNK_EPR_Keep_Alive	*Section 8.3.3.3.11*

Table 8.154 Policy Engine States

State name	Reference
Soft Reset and Protocol Error	
Source Port Soft Reset	
PE_SRC_Send_Soft_Reset	Section 8.3.3.4.1.1
PE_SRC_Soft_Reset	Section 8.3.3.4.1.2
Sink Port Soft Reset	
PE_SNK_Send_Soft_Reset	Section 8.3.3.4.2.1
PE_SNK_Soft_Reset	Section 8.3.3.4.2.2
Data Reset	
DFP Data Reset	
PE_DDR_Send_Data_Reset	Section 8.3.3.5.1.1
PE_DDR_Data_Reset_Received	Section 8.3.3.5.1.2
PE_DDR_Wait_For_VCONN_Off	Section 8.3.3.5.1.3
PE_DDR_Perform_Data_Reset	Section 8.3.3.5.1.4
UFP Data Reset	
PE_UDR_Send_Data_Reset	Section 8.3.3.5.2.1
PE_UDR_Data_Reset_Received	Section 8.3.3.5.2.2
PE_UDR_Turn_Off_VCONN	Section 8.3.3.5.2.3
PE_UDR_Send_Ps_Rdy	Section 8.3.3.5.2.4
PE_UDR_Wait_For_Data_Reset_Complete	Section 8.3.3.5.2.5
Not Supported Message	
Source Port Not Supported	
PE_SRC_Send_Not_Supported	Section 8.3.3.6.1.1
PE_SRC_Not_Supported_Received	Section 8.3.3.6.1.2
PE_SRC_Chunk_Received	Section 8.3.3.6.1.3
Sink Port Not Supported	
PE_SNK_Send_Not_Supported	Section 8.3.3.6.2.1
PE_SNK_Not_Supported_Received	Section 8.3.3.6.2.2
PE_SNK_Chunk_Received	Section 8.3.3.6.2.3
Source Alert	
Source Port Source Alert	
PE_SRC_Send_Source_Alert	Section 8.3.3.7.1.1
PE_SRC_Wait_for_Get_Status	Section 8.3.3.7.1.2
Sink Port Source Alert	
PE_SNK_Source_Alert_Received	Section 8.3.3.7.2.1
Sink Port Sink Alert	
PE_SNK_Send_Sink_Alert	Section 8.3.3.7.3.1
PE_SNK_Wait_for_Get_Status	Section 8.3.3.7.3.2
Source Port Sink Alert	
PE_SRC_Sink_Alert_Received	Section 8.3.3.7.4.1

Table 8.154 Policy Engine States

State name	Reference
Source/Sink Extended Capabilities	
Sink Port Get Source Capabilities Extended	
PE_SNK_Get_Source_Cap_Ext	Section 8.3.3.8.1.1
Source Port Give Source Capabilities Extended	
PE_SRC_Give_Source_Cap_Ext	Section 8.3.3.8.2.1
Source Port Get Sink Capabilities Extended	
PE_SRC_Get_Sink_Cap_Ext	Section 8.3.3.8.3.1
Source Port Give Source Capabilities Extended	
PE_SNK_Give_Sink_Cap_Ext	Section 8.3.3.8.4.1
Source Information	
Sink Port Get Source Information	
PE_SNK_Get_Source_Info	Section 8.3.3.9.1.1
Source Port Give Source Information	
PE_SRC_Give_Source_Info	Section 8.3.3.9.2.1
Status	
Get Status	
PE_Get_Status	Section 8.3.3.10.1.1
Give Status	
PE_Give_Status	Section 8.3.3.10.1.1
Sink Port Get PPS Status	
PE_SNK_Get_PPS_Status	Section 8.3.3.10.3.1
Source Port Give PPS Status	
PE_SRC_Give_PPS_Status	Section 8.3.3.10.4.1
Battery Capabilities	
Get Battery Capabilities	
PE_Get_Battery_Cap	Section 8.3.3.11.1.1
Give Battery Capabilities	
PE_Give_Battery_Cap	Section 8.3.3.11.2.1
Battery Status	
Get Battery Status	
PE_Get_Battery_Status	Section 8.3.3.12.1.1
Give Battery Status	
PE_Give_Battery_Status	Section 8.3.3.12.2.1
Manufacturer Information	
Get Manufacturer Information	
PE_Get_Manufacturer_Info	Section 8.3.3.13.1.1
Give Manufacturer Information	
PE_Give_Manufacturer_Info	Section 8.3.3.13.2.1
Country Codes and Information	
Get Country Codes	
PE_Get_Country_Codes	Section 8.3.3.14.1.1

Table 8.154 Policy Engine States

State name	Reference
Give Country Codes	
PE_Give_Country_Codes	*Section 8.3.3.14.2.1*
Get Country Information	
PE_Get_Country_Info	*Section 8.3.3.14.3.1*
Give Country Information	
PE_Give_Country_Info	*Section 8.3.3.14.4.1*
Revision	
Get Revision	
PE_Get_Revision	*Section 8.3.3.15.1.1*
Give Revision	
PE_Give_Revision	*Section 8.3.3.15.2.1*
Enter USB	
DFP Enter USB	
PE_DEU_Send_Enter_USB	*Section 8.3.3.16.1.1*
UFP Enter USB	
PE_UEU_Enter_USB_Received	*Section 8.3.3.16.2.1*
Security Request/Response	
Send Security Request	
PE_Send_Security_Request	*Section 8.3.3.17.1.1*
Send Security Response	
PE_Send_Security_Response	*Section 8.3.3.17.2.1*
Security Response Received	
PE_Security_Response_Received	*Section 8.3.3.17.3.1*
Firmware Update Request/Response	
Send Firmware Update Request	
PE_Send_Firmware_Update_Request	*Section 8.3.3.18.1.1*
Send Firmware Update Response	
PE_Send_Firmware_Update_Response	*Section 8.3.3.18.2.1*
Firmware Update Response Received	
PE_Firmware_Update_Response_Received	*Section 8.3.3.18.3.1*
Dual-Role Port	
DFP to UFP Data Role Swap	
PE_DRS_DFP_UFP_Evaluate_Swap	*Section 8.3.3.19.1.2*
PE_DRS_DFP_UFP_Accept_Swap	*Section 8.3.3.19.1.3*
PE_DRS_DFP_UFP_Change_to_UFP	*Section 8.3.3.19.1.4*
PE_DRS_DFP_UFP_Send_Swap	*Section 8.3.3.19.1.5*
PE_DRS_DFP_UFP_Reject_Swap	*Section 8.3.3.19.1.6*

Table 8.154 Policy Engine States

State name	Reference
UFP to DFP Data Role Swap	
PE_DRS_UFP_DFP_Evaluate_Swap	*Section 8.3.3.19.2.2*
PE_DRS_UFP_DFP_Accept_Swap	*Section 8.3.3.19.2.3*
PE_DRS_UFP_DFP_Change_to_DFP	*Section 8.3.3.19.2.4*
PE_DRS_UFP_DFP_Send_Swap	*Section 8.3.3.19.2.5*
PE_DRS_UFP_DFP_Reject_Swap	*Section 8.3.3.19.2.6*
Source to Sink Power Role Swap	
PE_PRS_SRC_SNK_Evaluate_Swap	*Section 8.3.3.19.3.2*
PE_PRS_SRC_SNK_Accept_Swap	*Section 8.3.3.19.3.3*
PE_PRS_SRC_SNK_Transition_to_off	*Section 8.3.3.19.3.4*
PE_PRS_SRC_SNK_Assert_Rd	*Section 8.3.3.19.3.5*
PE_PRS_SRC_SNK_Wait_Source_on	*Section 8.3.3.19.3.6*
PE_PRS_SRC_SNK_Send_Swap	*Section 8.3.3.19.3.7*
PE_PRS_SRC_SNK_Reject_Swap	*Section 8.3.3.19.3.8*
Sink to Source Power Role Swap	
PE_PRS_SNK_SRC_Evaluate_Swap	*Section 8.3.3.19.4.2*
PE_PRS_SNK_SRC_Accept_Swap	*Section 8.3.3.19.4.3*
PE_PRS_SNK_SRC_Transition_to_off	*Section 8.3.3.19.4.4*
PE_PRS_SNK_SRC_Assert_Rp	*Section 8.3.3.19.4.5*
PE_PRS_SNK_SRC_Source_on	*Section 8.3.3.19.4.6*
PE_PRS_SNK_SRC_Send_Swap	*Section 8.3.3.19.4.7*
PE_PRS_SNK_SRC_Reject_Swap	*Section 8.3.3.19.4.8*
Source to Sink Fast Role Swap	
PE_FRS_SRC_SNK_Evaluate_Swap	*Section 8.3.3.19.5.2*
PE_FRS_SRC_SNK_Accept_Swap	*Section 8.3.3.19.5.3*
PE_FRS_SRC_SNK_Transition_to_off	*Section 8.3.3.19.5.4*
PE_FRS_SRC_SNK_Assert_Rd	*Section 8.3.3.19.5.5*
PE_FRS_SRC_SNK_Wait_Source_on	*Section 8.3.3.19.5.6*
Sink to Source Fast Role Swap	
PE_FRS_SNK_SRC_Start_AMS	*Section 8.3.3.19.6.1*
PE_FRS_SNK_SRC_Send_Swap	*Section 8.3.3.19.6.2*
PE_FRS_SNK_SRC_Transition_to_off	*Section 8.3.3.19.6.3*
PE_FRS_SNK_SRC_VBUS_Applied	*Section 8.3.3.19.6.4*
PE_FRS_SNK_SRC_Assert_Rp	*Section 8.3.3.19.6.5*
PE_FRS_SNK_SRC_Source_on	*Section 8.3.3.19.6.6*
Dual-Role Source Port Get Source Capabilities	
PE_DR_SRC_Get_Source_Cap	*Section 8.3.3.19.7.1*
Dual-Role Source Port Give Sink Capabilities	
PE_DR_SRC_Give_Sink_Cap	*Section 8.3.3.19.8.1*

Table 8.154 Policy Engine States

State name	Reference
Dual-Role Sink Port Get Sink Capabilities	
PE_DR_SNK_Get_Sink_Cap	Section 8.3.3.19.9.1
Dual-Role Sink Port Give Source Capabilities	
PE_DR_SNK_Give_Source_Cap	Section 8.3.3.19.10.1
Dual-Role Source Port Get Source Capabilities Extended	
PE_DR_SRC_Get_Source_Cap_Ext	Section 8.3.3.19.11.1
Dual-Role Sink Port Give Source Capabilities Extended	
PE_DR_SNK_Give_Source_Cap_Ext	Section 8.3.3.19.12.1
Dual-Role Sink Port Get Sink Capabilities Extended	
PE_DR_SNK_Get_Sink_Cap_Ext	Section 8.3.3.19.13.1
Dual-Role Source Port Give Sink Capabilities Extended	
PE_DR_SRC_Give_Sink_Cap_Ext	Section 8.3.3.19.14.1
Dual-Role Source Port Get Source Information	
PE_DR_SRC_Get_Source_Info	Section 8.3.3.19.15.1
Dual-Role Sink Port Give Source Information	
PE_DR_SNK_Give_Source_Info	Section 8.3.3.19.16.1
USB Type-C VCONN Swap	
PE_VCS_Send_Swap	Section 8.3.3.20.1
PE_VCS_Evaluate_Swap	Section 8.3.3.20.2
PE_VCS_Accept_Swap	Section 8.3.3.20.3
PE_VCS_Reject_Swap	Section 8.3.3.20.4
PE_VCS_Wait_For_VCONN	Section 8.3.3.20.5
PE_VCS_Turn_Off_VCONN	Section 8.3.3.20.6
PE_VCS_Turn_On_VCONN	Section 8.3.3.20.7
PE_VCS_Send_Ps_Rdy	Section 8.3.3.20.8
PE_VCS_Force_VCONN	Section 8.3.3.20.9
Initiator Structured VDM	
Initiator to Port Structured VDM Discover Identity	
PE_INIT_PORT_VDM_Identity_Request	Section 8.3.3.21.1.1
PE_INIT_PORT_VDM_Identity_ACKed	Section 8.3.3.21.1.2
PE_INIT_PORT_VDM_Identity_NAKed	Section 8.3.3.21.1.3
Initiator Structured VDM Discover SVIDs	
PE_INIT_VDM_SVIDs_Request	Section 8.3.3.21.2.1
PE_INIT_VDM_SVIDs_ACKed	Section 8.3.3.21.2.2
PE_INIT_VDM_SVIDs_NAKed	Section 8.3.3.21.2.3
Initiator Structured VDM Discover Modes	
PE_INIT_VDM_Modes_Request	Section 8.3.3.21.3.1
PE_INIT_VDM_Modes_ACKed	Section 8.3.3.21.3.2
PE_INIT_VDM_Modes_NAKed	Section 8.3.3.21.3.3

Table 8.154 Policy Engine States

State name	Reference
Initiator Structured VDM Attention	
PE_INIT_VDM_Attention_Request	*Section 8.3.3.21.4.1*
Responder Structured VDM	
Responder Structured VDM Discovery Identity	
PE_RESP_VDM_Get_Identity	*Section 8.3.3.22.1.1*
PE_RESP_VDM_Send_Identity	*Section 8.3.3.22.1.2*
PE_RESP_VDM_Get_Identity_NAK	*Section 8.3.3.22.1.3*
Responder Structured VDM Discovery SVIDs	
PE_RESP_VDM_Get_SVIDs	*Section 8.3.3.22.2.1*
PE_RESP_VDM_Send_SVIDs	*Section 8.3.3.22.2.2*
PE_RESP_VDM_Get_SVIDs_NAK	*Section 8.3.3.22.2.3*
Responder Structured VDM Discovery Modes	
PE_RESP_VDM_Get_Modes	*Section 8.3.3.22.3.1*
PE_RESP_VDM_Send_Modes	*Section 8.3.3.22.3.2*
PE_RESP_VDM_Get_Modes_NAK	*Section 8.3.3.22.3.3*
Receiving a Structured VDM Attention	
PE_RCV_VDM_Attention_Request	*Section 8.3.3.22.4.1*
DFP Structured VDM	
DFP Structured VDM Mode Entry	
PE_DFP_VDM_Mode_Entry_Request	*Section 8.3.3.23.1.1*
PE_DFP_VDM_Mode_Entry_ACKed	*Section 8.3.3.23.1.2*
PE_DFP_VDM_Mode_Entry_NAKed	*Section 8.3.3.23.1.3*
DFP Structured VDM Mode Exit	
PE_DFP_VDM_Mode_Exit_Request	*Section 8.3.3.23.2.1*
PE_DFP_VDM_Mode_Exit_ACKed	*Section 8.3.3.23.2.2*
UFP Structure VDM	
UFP Structured VDM Enter Mode	
PE_UFP_VDM_Evaluate_Mode_Entry	*Section 8.3.3.24.1.1*
PE_UFP_VDM_Mode_Entry_ACK	*Section 8.3.3.24.1.2*
PE_UFP_VDM_Mode_Entry_NAK	*Section 8.3.3.24.1.3*
UFP Structured VDM Exit Mode	
PE_UFP_VDM_Mode_Exit	*Section 8.3.3.24.2.1*
PE_UFP_VDM_Mode_Exit_ACK	*Section 8.3.3.24.2.2*
PE_UFP_VDM_Mode_Exit_NAK	*Section 8.3.3.24.2.3*

Table 8.154 Policy Engine States

State name	Reference
Cable Plug Specific	
Cable Ready	
PE_CBL_Ready	*Section 8.3.3.25.1.1*
Mode Entry	
PE_CBL_Evaluate_Mode_Entry	*Section 8.3.3.25.4.1.1*
PE_CBL_Mode_Entry_ACK	*Section 8.3.3.25.4.1.2*
PE_CBL_Mode_Entry_NAK	*Section 8.3.3.25.4.1.3*
Mode Exit	
PE_CBL_Mode_Exit	*Section 8.3.3.25.4.2.1*
PE_CBL_Mode_Exit_ACK	*Section 8.3.3.25.4.2.2*
PE_CBL_Mode_Exit_NAK	*Section 8.3.3.25.4.1.3*
Cable Soft Reset	
PE_CBL_Soft_Reset	*Section 8.3.3.25.2.1.1*
Cable Hard Reset	
PE_CBL_Hard_Reset	*Section 8.3.3.25.2.2.1*
DFP/VCONN Source Soft Reset or Cable Reset	
PE_DFP_VCS_CBL_Send_Soft_Reset	*Section 8.3.3.25.2.3.1*
PE_DFP_VCS_CBL_Send_Cable_Reset	*Section 8.3.3.25.2.3.2*
UFP/VCONN Source Soft Reset or Cable Reset	
PE_UFP_VCS_CBL_Send_Soft_Reset	*Section 8.3.3.25.2.4.1*
Source Startup Structured VDM Discover Identity	
PE_SRC_VDM_Identity_Request	*Section 8.3.3.25.3.1*
PE_SRC_VDM_Identity_ACKed	*Section 8.3.3.25.3.2*
PE_SRC_VDM_Identity_NAKed	*Section 8.3.3.25.3.3*
EPR Mode	
Source EPR Mode Entry	
PE_SRC_Evaluate_EPR_Mode_Entry	*Section 8.3.3.26.1.1*
PE_SRC_EPR_Mode_Entry_Ack	*Section 8.3.3.26.1.2*
PE_SRC_EPR_Mode_Discover_Cable	*Section 8.3.3.26.1.3*
PE_SRC_EPR_Mode_Evaluate_Cable_EPR	*Section 8.3.3.26.1.4*
PE_SRC_EPR_Mode_Entry_Succeeded	*Section 8.3.3.26.1.5*
PE_SRC_EPR_Mode_Entry_Failed	*Section 8.3.3.26.1.6*
Sink EPR Mode Entry	
PE_SNK_Send_EPR_Mode_Entry	*Section 8.3.3.26.2.1*
PE_SNK_EPR_Mode_Wait_For_Response	*Section 8.3.3.26.2.2*
Source EPR Mode Exit	
PE_SRC_Send_EPR_Mode_Exit	*Section 8.3.3.26.3.1*
PE_SRC_EPR_Mode_Exit_Received	*Section 8.3.3.26.3.2*

Table 8.154 Policy Engine States

State name	Reference
Sink EPR Mode Exit	
PE_SNK_Send_EPR_Mode_Exit	*Section 8.3.3.26.4.1*
PE_SNK_EPR_Mode_Exit_Received	*Section 8.3.3.26.4.2*
BIST	
BIST Carrier Mode	
PE_BIST_Carrier_Mode	*Section 8.3.3.27.1.1*
BIST Carrier Mode	
PE_BIST_Test_Mode	*Section 8.3.3.27.2.1*
BIST Shared Capacity Test Mode	
PE_BIST_Shared_Capacity_Test_Mode	*Section 8.3.3.27.3.1*
USB Type-C referenced states	
ErrorRecovery	*Section 8.3.3.28.1*

9 States and Status Reporting

9.1 Overview

This chapter describes the Status reporting mechanisms for devices with data connections (e.g., D+/D- and or SSTx+/- and SSRx+/-). It also describes the corresponding USB state a device that supports USB PD ***Shall*** transition to as a result of changes to the USB PD state that the device is in.

This chapter does not define the *System Policy* or the *System Policy Manager*. That is defined in ***[UCSI]***. In addition, the Policies themselves are not described here; these are left to the implementers of the relevant products and systems to define.

All PD Capable USB (PDUSB) *Device*s ***Shall*** report themselves as self-powered devices (over USB) when plugged into a PD capable *Port* even if they are entirely powered from *VBUS*. However, there are some differences between PD and ***[USB 2.0]*** / ***[USB 3.2]***; for example, the presence of *VBUS* alone does not mean that the device (*Consumer*) moves from the *USB Attached State* to the *USB Powered State*. Similarly, the removal of *VBUS* alone does not move the device (*Consumer*) from any of the USB states to the *USB Attached State*. See *Section 9.1.2, "Mapping to USB Device States"* for details.

*PDUSB Device*s ***Shall*** follow the PD requirements when it comes to suspend (see *Section 6.4.1.2.1.2, "USB Suspend Supported"*), configured, and operational power. The PD requirements when the device is configured or operational are defined in this section (see *Table 9.4, "PD Consumer Port Descriptor"*).

Note: The power requirements reported in the PD *Consumer Port* descriptor of the device ***Shall*** override the power draw reported in the bMaxPower field in the configuration descriptor. A *PDUSB Device* ***Shall*** report zero in the bMaxPower field after successfully negotiating a mutually agreeable *Explicit Contract* and ***Shall*** disconnect and re-enumerate when it switches operation back to operating in standard ***[USB 2.0]***, ***[USB 3.2]***, ***[USB4]***, ***[USB Type-C 2.4]*** or ***[USBBC 1.2]***. When operating in ***[USB 2.0]***, ***[USB 3.2]***, ***[USB Type-C 2.4]*** or ***[USBBC 1.2]*** mode it ***Shall*** report its power draw via the bMaxPower field.

Each *Provider* and *Consumer* will have their own Local Policies which operate between *Port Partner*s. An example of a typical PD system is shown in *Figure 9.1, "Example PD Topology"*. This example consists of a *Provider*, *Consumer/Provider*s and *Consumer*s connected together in a tree topology. Between directly connected devices there is both a flow of Power and also Communication consisting of both Status and Control information.

Figure 9.1 Example PD Topology

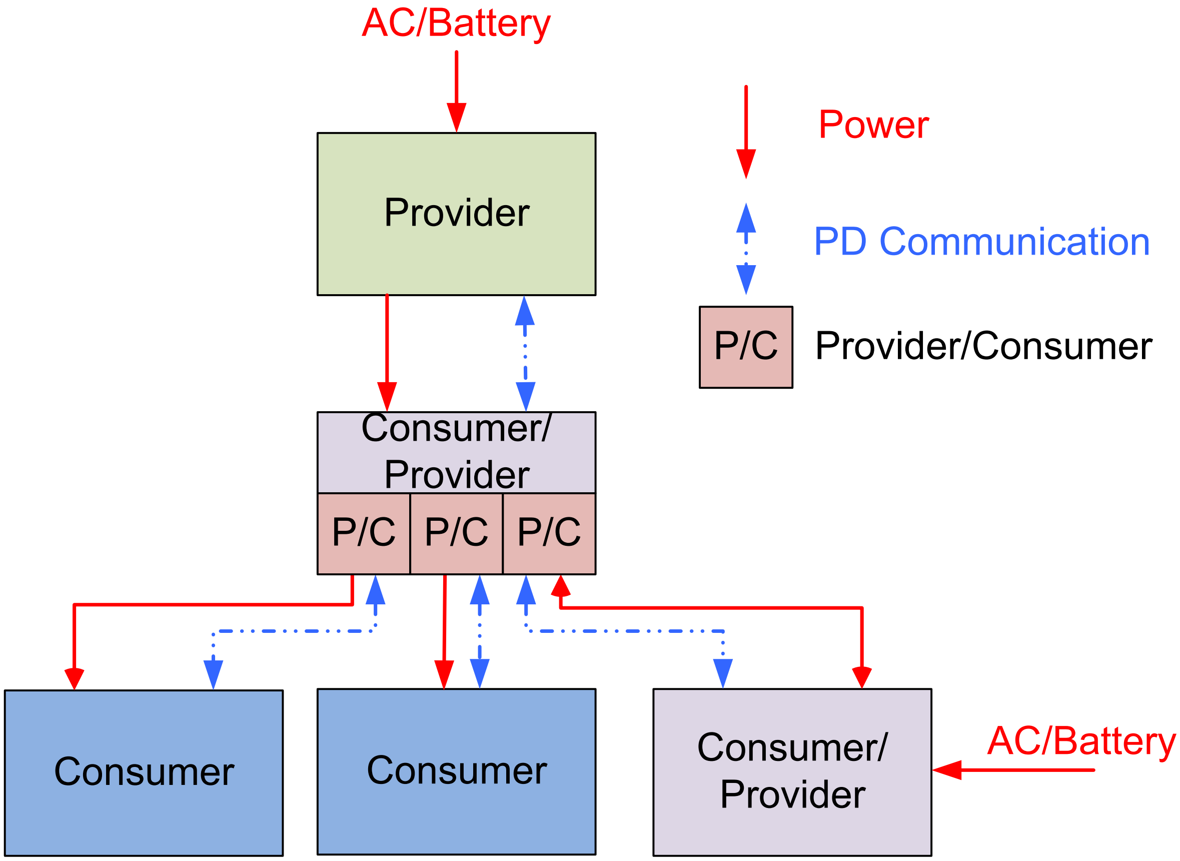
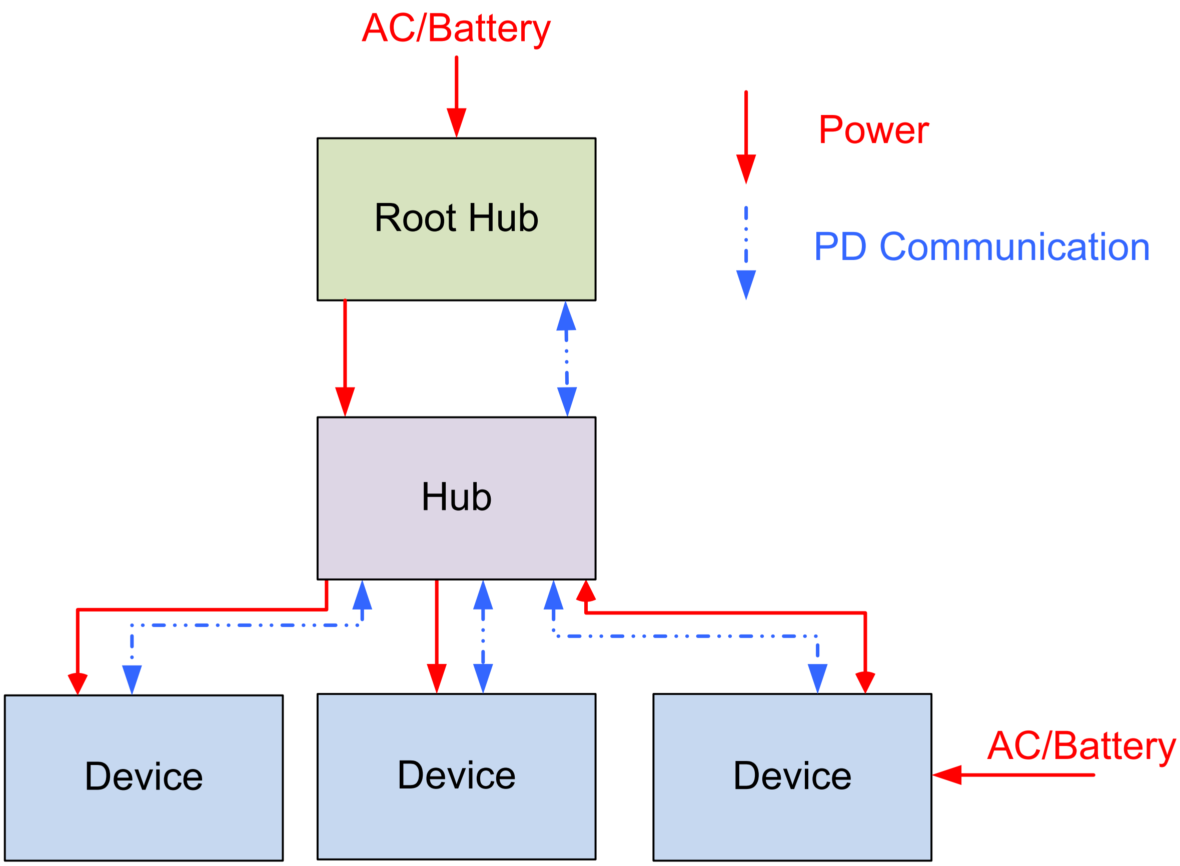


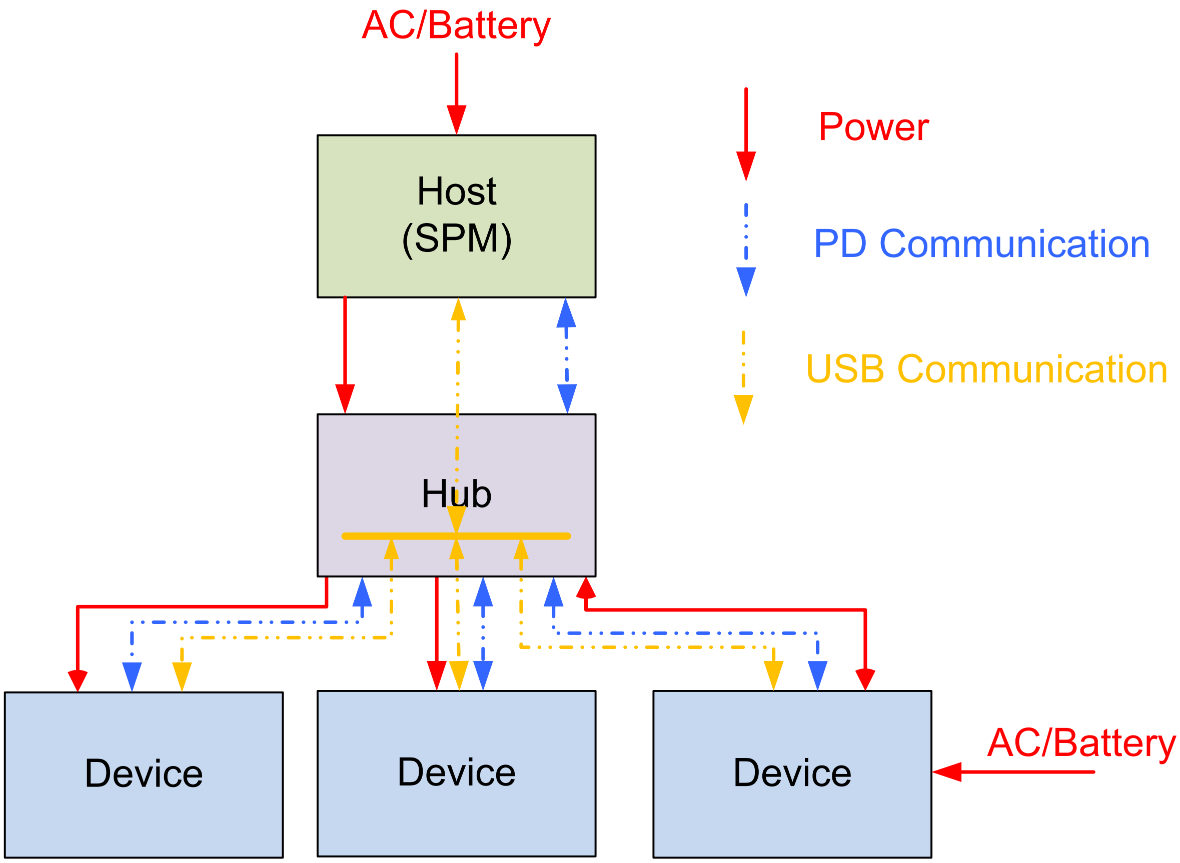
Figure 9.2, "Mapping of PD Topology to USB" shows how this same topology can be mapped to USB.

Figure 9.2 Mapping of PD Topology to USB



In a USB based system, policy is managed by the host and communication of system level policy information is via standard USB data line communication. This is a separate mechanism to the USB Power Delivery *VBUS* protocol which is used to manage *Local Policy*. When *USB Communication* is used, status information and control requests are passed directly between the *System Policy Manager* (*SPM*) on the host and the *Provider* or *Consumer*. See *Figure 9.3, "Use of SPM in the PD System"*.

Figure 9.3 Use of SPM in the PD System



Status information comes from a *Provider* or *Consumer* to the *SPM* so it can better manage the resources on the host and provide feedback to the end user.

Real systems will be a mixture of devices which in terms of power management support might have implemented PD, ***[USB 2.0]***, ***[USB 3.2]***, ***[USB4]***, ***[USB Type-C 2.4]*** or ***[USBBC 1.2]*** or they might even just be non-compliant "power sucking devices". The level of communication of system status to the *SPM* will therefore not necessarily be comprehensive. The aim of the status mechanisms described here is to provide a mechanism whereby each connected entity in the system provides as much information as possible on the status of itself.

Information described in this section that is communicated to the *SPM* is as follows:

- Versions of *USB Type-C*®, PD and BC supported.
- Capabilities as a *Provider/Consumer*.
- Current operational state of each *Port* e.g. Standard, *USB Type-C* Current, BC, PD and *Negotiated* power level.
- Status of AC or *Battery* Power for each *PDUSB Device* in the system.

The *SPM* can *Negotiate* with *Provider*s or *Consumer*s in the system in order to request a different *Local Policy*, or to request the amount of power to be delivered by the *Provider* to the *Consumer*. Any change in *Local Policy* could trigger a *Re-negotiation* of the *Explicit Contract*, using USB Power Delivery protocols, between a directly connected *Provider* and *Consumer*. A change in how much power is available can, for example, cause a *Re-negotiation*.

9.1.1 PDUSB Device and Hub Requirements

All *PDUSB Device*s ***Shall*** return all relevant descriptors mentioned in this chapter. *PDUSB Hub*s ***Shall*** also support a PD bridge as defined in ***[UCSI]***.

9.1.2 Mapping to USB Device States

As mentioned in *Section 9.1, "Overview"* a *PDUSB Device* reports itself as a self-powered device. However, the device ***Shall*** determine whether or not it is in the *USB Attached State* or *USB Powered States* as described in *Figure 9.4, "USB Attached to USB Powered State Transition"*, *Figure 9.5, "Any USB State to USB Attached State Transition (When operating as a Consumer)"* and *Figure 9.6, "Any USB State to USB Attached State Transition (When operating as a Provider)"* All other USB states of the *PDUSB Device* ***Shall*** be as described in Chapter 9 of ***[USB 2.0]*** and ***[USB 3.2]***.

Figure 9.4, "USB Attached to USB Powered State Transition" shows how a *PDUSB Device* determines when to transition from the *USB Attached State* to the *USB Powered State*. *USB Type-C Dead Battery* operation does not require special handling since the default state at *Attach* or after a *Hard Reset* is that the *USB Device* is a *Sink*.

Figure 9.4 USB Attached to USB Powered State Transition

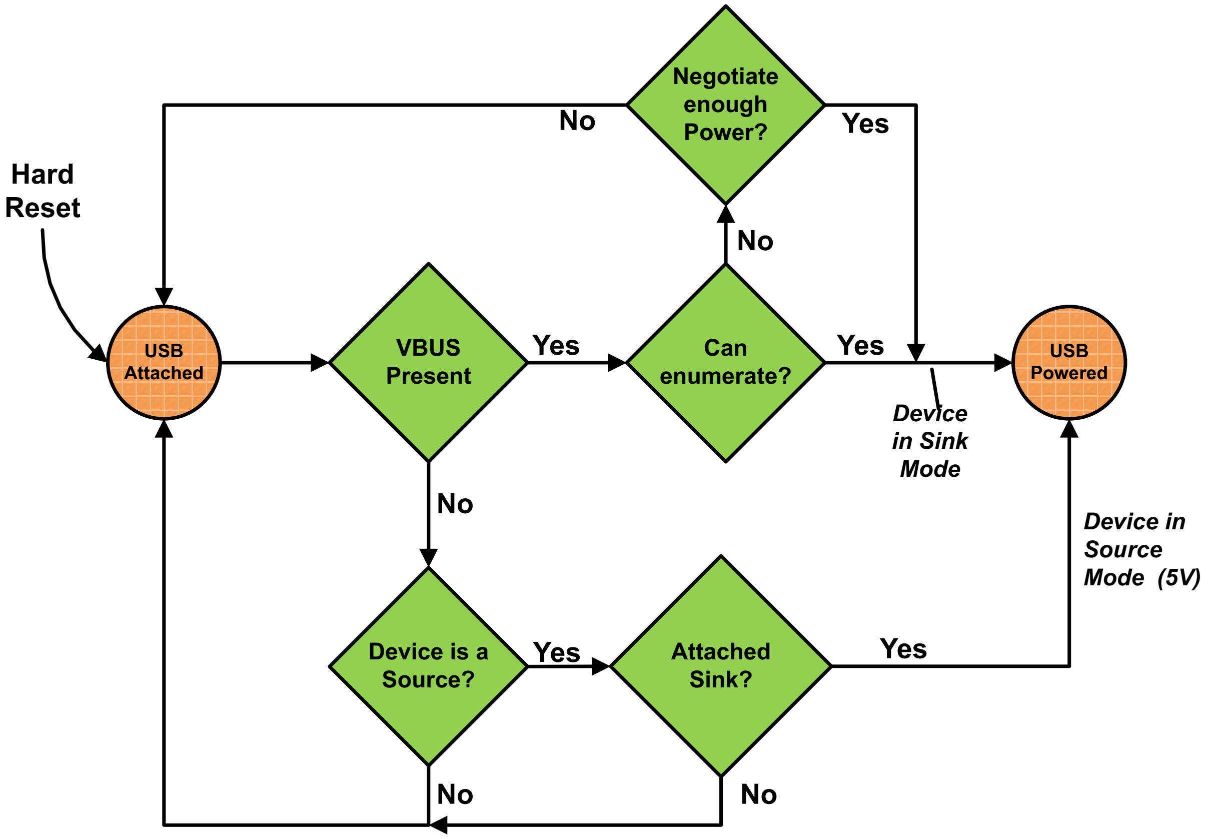


Figure 9.5, "Any USB State to USB Attached State Transition (When operating as a Consumer)" shows how a *PDUSB Device* determines when to transition from the *USB Powered State* to the *USB Attached State* when the device is a *Consumer*. A *PDUSB Device* determines that it is performing a *Power Role Swap* as described in *Section 8.3.3.19.3, "Policy Engine in Source to Sink Power Role Swap State Diagram"* and *Section 8.3.3.19.4, "Policy Engine in Sink to Source Power Role Swap State Diagram"*. See *Section 7.1.5, "Response to Hard Resets"* for additional information on device behavior during *Hard Resets*.

Figure 9.5 Any USB State to USB Attached State Transition (When operating as a Consumer)

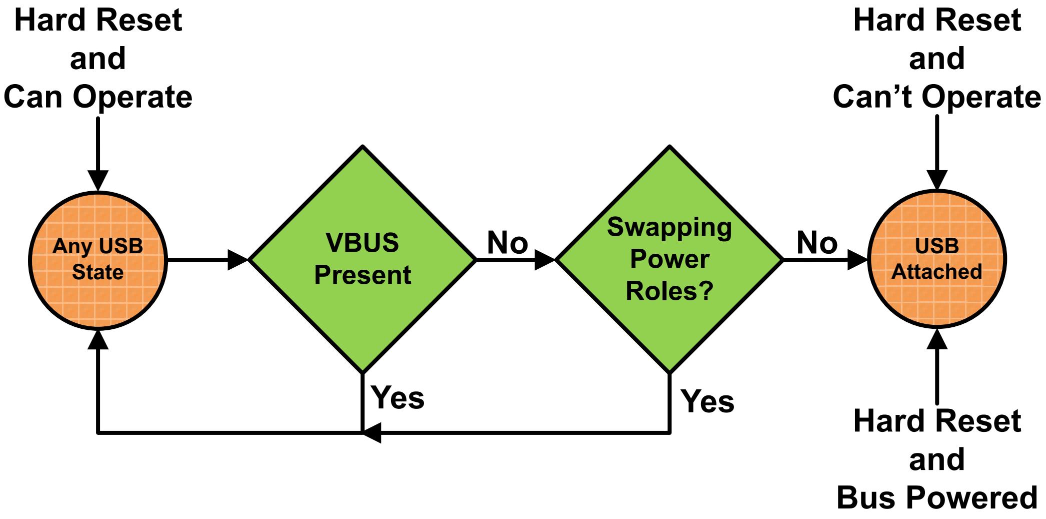


Figure 9.6, "Any USB State to USB Attached State Transition (When operating as a Provider)" shows how a *PDUSB Device* determines when to transition from the *USB Powered State* to the *USB Attached State* when the device is a *Provider*.

Figure 9.6 Any USB State to USB Attached State Transition (When operating as a Provider)

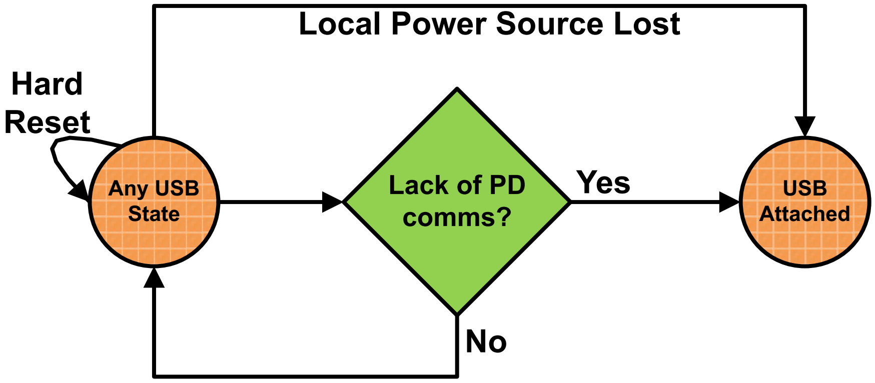
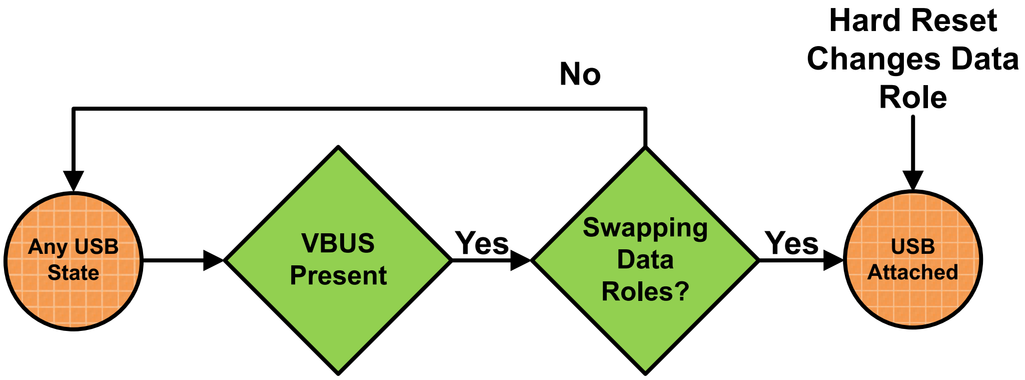


Figure 9.7, "Any USB State to USB Attached State Transition (After a USB Type-C Data Role Swap)" shows how a *PDUSB Device* using the *USB Type-C* connector determines when to transition from the *USB Powered State* to the *USB Attached State* after a *Data Role Swap* has been performed i.e., it has just changed from operation as a *PDUSB Host* to operation as a *PDUSB Device*. The *Data Role Swap* is described in *Section 6.3.9, "DR_Swap Message"*. A *Hard Reset* will also return a *Sink* acting as a *PDUSB Host* to *PDUSB Device* operation as described in *Section 6.8.3, "Hard Reset"*. See *Section 7.1.5, "Response to Hard Resets"* for additional information on device behavior during *Hard Resets*.

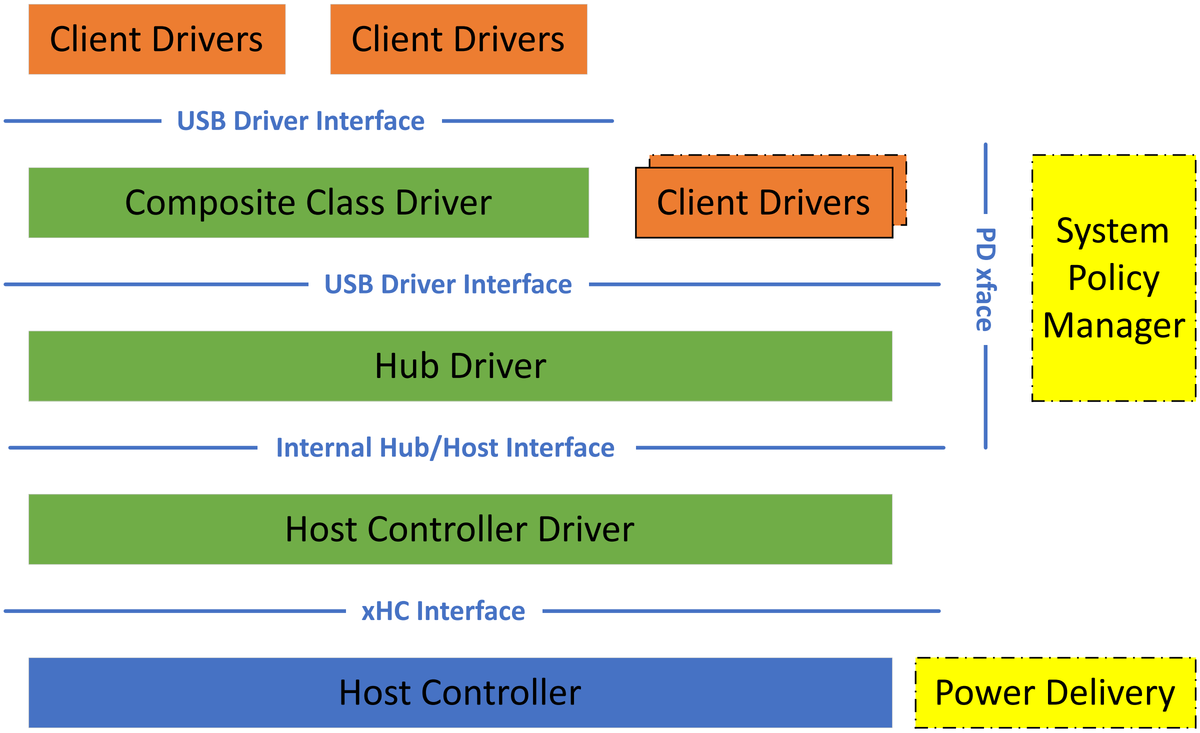
Figure 9.7 Any USB State to USB Attached State Transition (After a USB Type-C Data Role Swap)



9.1.3 PD Software Stack

Figure 9.8, "Software stack on a PD aware OS" gives an example of the software stack on a PD aware OS. In this stack we are using the example of a system with an xHCI based controller. The USB Power Delivery hardware ***May*** or ***May Not*** be a part of the xHC.

Figure 9.8 Software stack on a PD aware OS

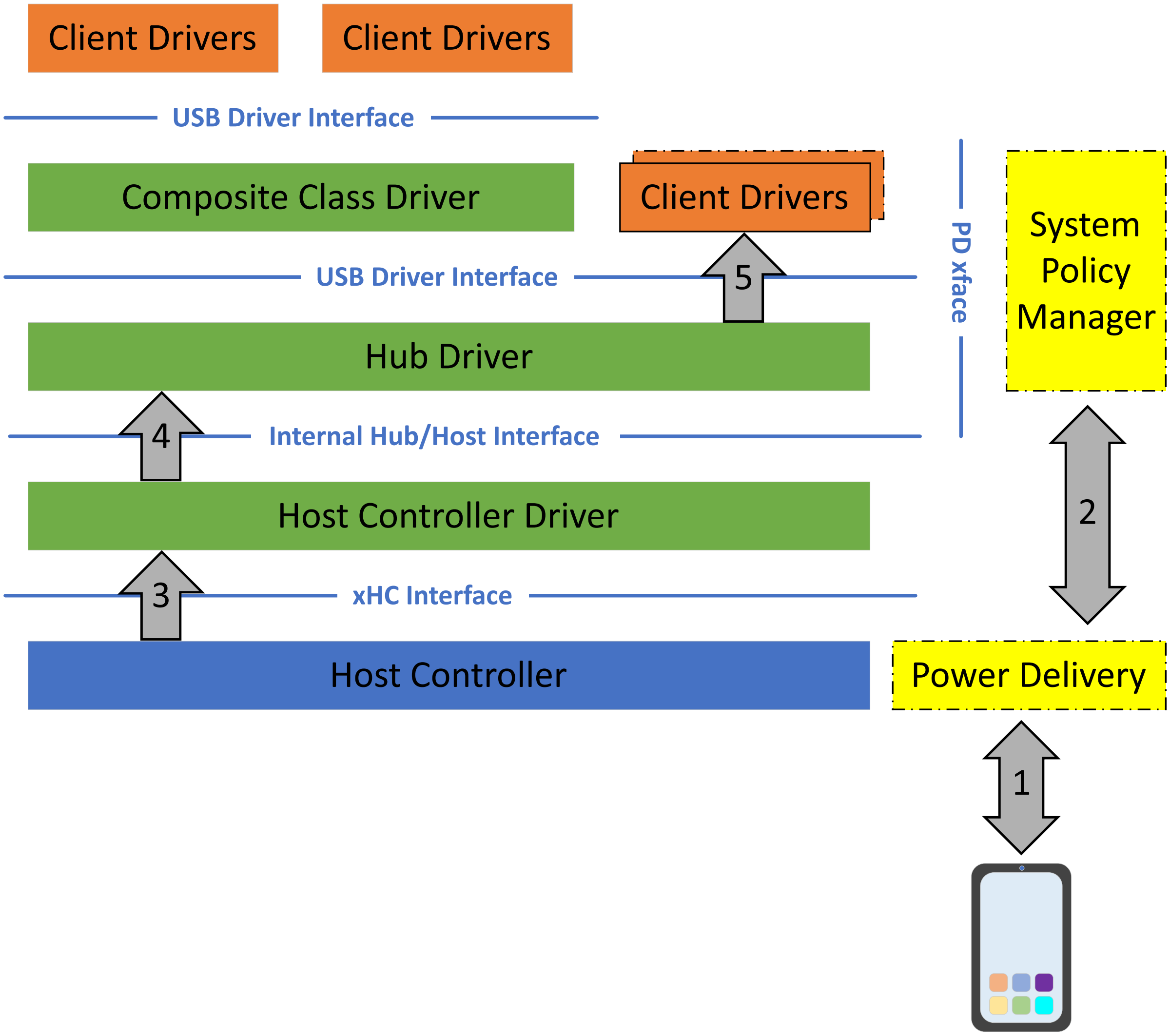


9.1.4 PDUSB Device Enumeration

As described earlier, a *PDUSB Device* acts as a self-powered device with some caveats with respect to how it transitions from the *USB Attached State* to *USB Powered State*. *Figure 9.9, "Enumeration of a PDUSB Device"* gives a high-level overview of the enumeration steps involved due to this change. A *PDUSB Device* will first (Step1) interact with the Power Delivery hardware and the *Local Policy* manager to determine whether or not it can get sufficient power to enumerate/operate.

PD is likely to have established a *Explicit Contract* prior to enumeration. The *SPM* will be notified (Step 2) of the result of this *Negotiation* between the Power Delivery hardware and the *PDUSB Device*. After successfully negotiating a mutually agreeable *Explicit Contract* the device will signal a connect to the xHC. The standard USB enumeration process (Steps 3, 4 and 5) is then followed to load the appropriate driver for the function(s) that the *PDUSB Device* exposes.

Figure 9.9 Enumeration of a PDUSB Device



If a *PDUSB Device* cannot perform its intended function with the amount of power that it can get from the *Port* it is connected to, then the host system ***Should*** display a notification (on a PD aware OS) about the failure to provide sufficient power to the device. In addition, the device ***Shall*** follow the requirements listed in *Section 8.2.5.2.1, "Local device handling of mismatch"*.

9.2 PD Specific Descriptors

A *PDUSB Device* ***Shall*** return all relevant descriptors mentioned in this section.

The device ***Shall*** return its capability descriptors as part of the device's Binary Object Store (BOS) descriptor set. *Table 9.1, "USB Power Delivery Type Codes"* lists the type of PD device capabilities.

Table 9.1 USB Power Delivery Type Codes

Capability Code	Value	Description
POWER_DELIVERY_CAPABILITY	06H	Defines the various PD Capabilities of this device
BATTERY_INFO_CAPABILITY	07H	Provides information on each *Battery* supported by the device
PD_CONSUMER_PORT_CAPABILITY	08H	The *Consumer* characteristics of a *Port* on the device
PD_PROVIDER_PORT_CAPABILITY	09H	The *Provider* characteristics of a *Port* on the device

9.2.1 USB Power Delivery Capability Descriptor

Table 9.2, "USB Power Delivery Capability Descriptor" details the fields in the USB ***POWER_DELIVERY_CAPABILITY*** Descriptor.

Table 9.2 USB Power Delivery Capability Descriptor

<table>
<tr><th>Offset</th><th>Field</th><th>Size</th><th>Value</th><th>Description</th></tr>
<tr><td>0</td><td>bLength</td><td>1</td><td>Number</td><td>Size of descriptor</td></tr>
<tr><td>1</td><td>bDescriptorType</td><td>1</td><td>Constant</td><td>DEVICE CAPABILITY Descriptor type</td></tr>
<tr><td>2</td><td>bDevCapabilityType</td><td>1</td><td>Constant</td><td>Capability type: <b><i>POWER_DELIVERY_CAPABILITY</i></b></td></tr>
<tr><td>3</td><td>bReserved</td><td>1</td><td><b><i>Reserved</i></b></td><td><b><i>Shall</i></b> be set to zero.</td></tr>
<tr><td>4</td><td>bmAttributes</td><td>4</td><td>Bitmap</td><td>Bitmap encoding of supported device level features. A value of one in a bit location indicates a feature is supported; a value of zero indicates it is not supported. Encodings are:
<table>
<tr><th>Bit</th><th>Description</th></tr>
<tr><td>0</td><td><b><i>Reserved</i></b>. <b><i>Shall</i></b> be set to zero.</td></tr>
<tr><td>1</td><td>Battery Charging. This bit <b><i>Shall</i></b> be set to one to indicate this device supports <b><i>[USBBC 1.2]</i></b> as per the value reported in the bcdBCVersion field.</td></tr>
<tr><td>2</td><td>USB Power Delivery. This bit <b><i>Shall</i></b> be set to one to indicate this device supports the USB Power Delivery Specification as per the value reported in the bcdPDVersion field.</td></tr>
<tr><td>3</td><td><i>Provider</i>. This bit <b><i>Shall</i></b> be set to one to indicate this device is capable of providing power. This field is only <b><i>Valid</i></b> if Bit 2 is set to one.</td></tr>
<tr><td>4</td><td><i>Consumer</i>. This bit <b><i>Shall</i></b> be set to one to indicate that this device is a consumer of power. This field is only <b><i>Valid</i></b> if Bit 2 is set to one.</td></tr>
<tr><td>5</td><td>This bit <b><i>Shall</i></b> be set to 1 to indicate that this device supports the feature CHARGING_POLICY.
<b>Note:</b> Supporting the CHARGING_POLICY feature does not require a BC or PD mechanism to be implemented.</td></tr>
<tr><td>6</td><td><i>USB Type-C</i> Current. This bit <b><i>Shall</i></b> be set to one to indicate this device supports power capabilities defined in<b><i>[USB Type-C 2.4]</i></b> as per the value reported in the bcdUSBTypeCVersion field</td></tr>
<tr><td>7</td><td><b><i>Reserved</i></b>. <b><i>Shall</i></b> be set to zero.</td></tr>
<tr><td>15:8</td><td>bmPowerSource. At least one of the following bits 8, 9 and 14 <b><i>Shall</i></b> be set to indicate which power sources are supported.
<table>
<tr><th>Bit</th><th>Description</th></tr>
<tr><td>8</td><td><i>AC Supply</i></td></tr>
<tr><td>9</td><td><i>Battery</i></td></tr>
<tr><td>10</td><td>Other</td></tr>
<tr><td>13:11</td><td>NumBatteries. This field <b><i>Shall</i></b> only be <b><i>Valid</i></b> when the Battery field is set to one and <b><i>Shall</i></b> be used to report the number of batteries in the device.</td></tr>
<tr><td>14</td><td>Uses <i>VBUS</i></td></tr>
<tr><td>15</td><td><b><i>Reserved</i></b> and <b><i>Shall</i></b> be set to zero.</td></tr>
</table></td></tr>
<tr><td>13:16</td><td><b><i>Reserved</i></b>. <b><i>Shall</i></b> be set to zero.</td></tr>
</table></td></tr>
</table>

Table 9.2 USB Power Delivery Capability Descriptor

Offset	Field	Size	Value	Description
8	bcdBCVersion	2	BCD	Battery Charging Specification Release Number in Binary-Coded Decimal (e.g., V1.20 is 120H). This field ***Shall*** only be ***Valid*** if the device indicates that it supports ***[USBBC 1.2]*** in the bmAttributes field.
10	bcdPDVersion	2	BCD	USB Power Delivery Specification Release Number in Binary-Coded Decimal. This field ***Shall*** only be ***Valid*** if the device indicates that it supports PD in the bmAttributes field.
12	bcdUSBTypeCVersion	2	BCD	*USB Type-C* Specification Release Number in Binary-Coded Decimal. This field ***Shall*** only be ***Valid*** if the device indicates that it supports *USB Type-C* in the bmAttributes field.

9.2.2 Battery Info Capability Descriptor

A *PDUSB Device* ***Shall*** support the capability descriptor shown in *Table 9.3, "Battery Info Capability Descriptor"* if it reported that one of its power sources was a *Battery* in the bmPowerSource field in its Power Deliver Capability Descriptor. It ***Shall*** return one ***BATTERY_INFO_CAPABILITY*** Descriptor per *Battery* it supports.

Table 9.3 Battery Info Capability Descriptor

Offset	Field	Size	Value	Description
0	bLength	1	Number	Size of descriptor
1	bDescriptorType	1	Constant	DEVICE CAPABILITY Descriptor type
2	bDevCapabilityType	1	Constant	Capability type: ***BATTERY_INFO_CAPABILITY***
3	iBattery	1	Index	Index of string descriptor ***Shall*** contain the user-friendly name for this *Battery*.
4	iSerial	1	Index	Index of string descriptor ***Shall*** contain the Serial Number String for this *Battery*.
5	iManufacturer	1	Index	Index of string descriptor ***Shall*** contain the name of the Manufacturer for this *Battery*.
6	bBatteryId	1	Number	Value ***Shall*** be used to uniquely identify this *Battery* in status Messages.
7	bReserved	1	Number	***Reserved*** and ***Shall*** be set to zero.
8	dwChargedThreshold	4	mWh	***Shall*** contain the *Battery* charge value above which this *Battery* is considered to be fully charged but not necessarily "topped off."
12	dwWeakThreshold	4	mWh	***Shall*** contain the minimum charge level of this *Battery* such that above this threshold, a device can be assured of being able to power up successfully (see ***[USBBC 1.2]***).
16	dwBatteryDesignCapacity	4	mWh	***Shall*** contain the design capacity of the *Battery*.
20	dwBatteryLastFullchargeCapacity	4	mWh	***Shall*** contain the maximum capacity of the *Battery* when fully charged.

9.2.3 PD Consumer Port Capability Descriptor

A *PDUSB Device* ***Shall*** support the ***PD_CONSUMER_PORT_CAPABILITY*** descriptor shown in *Table 9.4, "PD Consumer Port Descriptor"* if it is a *Consumer*.

Table 9.4 PD Consumer Port Descriptor

<table>
<tr><th>Offset</th><th>Field</th><th>Size</th><th>Value</th><th>Description</th></tr>
<tr><td>0</td><td>bLength</td><td>1</td><td>Number</td><td>Size of descriptor</td></tr>
<tr><td>1</td><td>bDescriptorType</td><td>1</td><td>Constant</td><td>DEVICE CAPABILITY Descriptor type</td></tr>
<tr><td>2</td><td>bDevCapabilityType</td><td>1</td><td>Constant</td><td>Capability type: ***PD_CONSUMER_PORT_CAPABILITY***</td></tr>
<tr><td>3</td><td>bReserved</td><td>1</td><td>Number</td><td>***Reserved*** and ***Shall*** be set to zero.</td></tr>
<tr><td>4</td><td>bmCapabilities</td><td>2</td><td>Bitmap</td><td>Capability: This field ***Shall*** indicate the specification the *Consumer Port* will operate under.
<table>
<tr><th>Bit</th><th>Description</th></tr>
<tr><td>0</td><td>Battery Charging (BC)</td></tr>
<tr><td>1</td><td>USB Power Delivery (PD)</td></tr>
<tr><td>2</td><td>*USB Type-C* Current</td></tr>
<tr><td>15:3</td><td>***Reserved*** and ***Shall*** be set to zero.</td></tr>
</table></td></tr>
<tr><td>6</td><td>wMinVoltage</td><td>2</td><td>Number</td><td>***Shall*** contain the minimum voltage in 50mV units that this *Consumer* is capable of operating at.</td></tr>
<tr><td>8</td><td>wMaxVoltage</td><td>2</td><td>Number</td><td>***Shall*** contain the maximum voltage in 50mV units that this *Consumer* is capable of operating at.</td></tr>
<tr><td>10</td><td>wReserved</td><td>2</td><td>Number</td><td>***Reserved*** and ***Shall*** be set to zero.</td></tr>
<tr><td>12</td><td>dwMaxOperatingPower</td><td>4</td><td>Number</td><td>***Shall*** contain the maximum power in 10mW units this *Consumer* can draw when it is in a steady state operating mode.</td></tr>
<tr><td>16</td><td>dwMaxPeakPower</td><td>4</td><td>Number</td><td>***Shall*** contain the maximum power in 10mW units this *Consumer* can draw for a short duration of time (*dwMaxPeakPowerTime*) before it falls back into a steady state.</td></tr>
<tr><td>20</td><td>dwMaxPeakPowerTime</td><td>4</td><td>Number</td><td>***Shall*** contain the time in 100ms units that this *Consumer* can draw peak current.
A device ***Shall*** set this field to 0xFFFF if this value is unknown.</td></tr>
</table>

9.2.4 PD Provider Port Capability Descriptor

A *PDUSB Device* ***Shall*** support the ***PD_PROVIDER_PORT_CAPABILITY*** descriptor shown in *Table 9.5, "PD Provider Port Descriptor"* if it is a *Provider*.

Table 9.5 PD Provider Port Descriptor

<table>
<tr><th>Offset</th><th>Field</th><th>Size</th><th>Value</th><th colspan="2">Description</th></tr>
<tr><td>0</td><td>bLength</td><td>1</td><td>Number</td><td colspan="2">Size of descriptor</td></tr>
<tr><td>1</td><td>bDescriptorType</td><td>1</td><td>Constant</td><td colspan="2">DEVICE CAPABILITY Descriptor type</td></tr>
<tr><td>2</td><td>bDevCapabilityType</td><td>1</td><td>Constant</td><td colspan="2">Capability type: <b><i>PD_PROVIDER_PORT_CAPABILITY</i></b></td></tr>
<tr><td>3</td><td>b<b><i>Reserved</i></b></td><td>1</td><td>Number</td><td colspan="2"><b><i>Reserved</i></b> and <b><i>Shall</i></b> be set to zero.</td></tr>
<tr><td rowspan="6">4</td><td rowspan="6">bmCapabilities</td><td rowspan="6">2</td><td rowspan="6">Bitmap</td><td colspan="2">Capability: This field <b><i>Shall</i></b> indicate the specification the <i>Provider Port</i> will operate under.</td></tr>
<tr><th>Bit</th><th>Description</th></tr>
<tr><td>0</td><td>Battery Charging (BC)</td></tr>
<tr><td>1</td><td>USB Power Delivery (PD)</td></tr>
<tr><td>2</td><td><i>USB Type-C</i> Current</td></tr>
<tr><td>15:3</td><td><b><i>Reserved</i></b> and <b><i>Shall</i></b> be set to zero.</td></tr>
<tr><td>6</td><td>bNumOfPDObjects</td><td>1</td><td>Number</td><td colspan="2"><b><i>Shall</i></b> indicate the number of <i>Power Data Objects</i>.</td></tr>
<tr><td>7</td><td>bReserved</td><td>1</td><td>Number</td><td colspan="2"><b><i>Reserved</i></b> and <b><i>Shall</i></b> be set to zero.</td></tr>
<tr><td>8</td><td>wPowerDataObject1</td><td>4</td><td>Bitmap</td><td colspan="2"><b><i>Shall</i></b> contain the first <i>Power Data Object</i> supported by this <i>Provider Port</i>. See <i>Section 6.4.1, "Capabilities Message"</i> for details of the <i>Power Data Objects</i>.</td></tr>
<tr><td>...</td><td>...</td><td>...</td><td>...</td><td colspan="2">...</td></tr>
<tr><td>4*(N+1)</td><td>wPowerDataObjectN</td><td>4</td><td>Bitmap</td><td colspan="2"><b><i>Shall</i></b> contain the 2nd and subsequent <i>Power Data Objects</i> supported by this <i>Provider Port</i>. See <i>Section 6.4.1, "Capabilities Message"</i> for details of the <i>Power Data Objects</i>.</td></tr>
</table>

9.3 PD Specific Requests and Events

A *PDUSB Device* that is compliant to this specification ***Shall*** support the *Battery* related requests if it has a *Battery*.

A *PDUSB Hub* that is compliant to this specification ***Shall*** support a USB PD Bridge as described in ***[UCSI]*** irrespective of whether the *PDUSB Hub* is a *Provider*, a *Consumer*, or both.

9.3.1 PD Specific Requests

PD defines requests to which *PDUSB Devices* ***Shall*** respond as outlined in *Table 9.6, "PD Requests"*. All ***Valid*** requests in *Table 9.6, "PD Requests"* ***Shall*** be implemented by *PDUSB Device*s.

Table 9.6 PD Requests

Request	bmRequestType	bRequest	wValue	wIndex	wLength	Data
GetBatteryStatus	10000000B	***GET_BATTERY_STATUS***	Zero	Battery ID	Eight	Battery Status
SetPDFeature	00000000B	set_feature	Feature Selector	Feature Specific	Zero	None

Table 9.7, "PD Request Codes" gives the bRequest values for *Command*s that are not listed in the hub/device framework chapters of ***[USB 2.0]***, ***[USB 3.2]***.

Table 9.7 PD Request Codes

bRequest	Value
GET_BATTERY_STATUS	21

Table 9.8, "PD Feature Selectors" gives the ***Valid*** feature selectors for the PD class. Refer to *Section 9.4.2.1, "BATTERY_WAKE_MASK Feature Selector"*, and *Section 9.4.2.2, "CHARGING_POLICY Feature Selector"* for a description of the features.

Table 9.8 PD Feature Selectors

Feature Selector	Recipient	Value
BATTERY_WAKE_MASK	*Device*	40
CHARGING_POLICY	*Device*	54

9.4 PDUSB Hub and PDUSB Peripheral Device Requests

9.4.1 GetBatteryStatus

The request shown in *Table 9.9, "Get Battery Status Request"* returns the current status of the *Battery* in a *PDUSB Hub*/Peripheral, with *Battery* Status information as shown in *Table 9.10, "Battery Status Structure"*.

Table 9.9 Get Battery Status Request

bmRequestType	bRequest	wValue	wIndex	wLength	Data
10000000B	*GET_BATTERY_STATUS*	Zero	Battery ID	Eight	Battery Status

Table 9.10 Battery Status Structure

Offset	Field	Size	Value	Description	
0	bBatteryAttributes	1	Number	***Shall*** indicate whether a *Battery* is installed and whether this is charging or discharging.	
				Value	**Description**
				0	There is no *Battery*
				1	The *Battery* is charging
				2	The *Battery* is discharging
				3	The *Battery* is neither discharging nor charging
				255...4	***Reserved*** and ***Shall Not*** be used
1	bBatterySOC	1	Number	***Shall*** indicate the Battery State of Charge given as percentage value from Battery Remaining Capacity.	
2	bBatteryStatus	1	Number	If a *Battery* is present ***Shall*** indicate the present status of the *Battery*.	
				Value	**Description**
				0	No error
				1	*Battery* required and not present
				2	*Battery* non-chargeable/wrong chemistry
				3	Over-temp shutdown
				4	Over-voltage shutdown
				5	Over-current shutdown
				6	Fatigued *Battery*
				7	Unspecified error
				255...8	***Reserved*** and ***Shall Not*** be used

Table 9.10 Battery Status Structure

<table>
<tr><th>Offset</th><th>Field</th><th>Size</th><th>Value</th><th>Description</th></tr>
<tr><td>3</td><td>bRemoteWakeCapStatus</td><td>1</td><td>Bitmap</td><td>If the device supports remote wake, then the device <b><i>Shall</i></b> support Battery Remote wake events. The default value for the Remote wake events <b><i>Shall</i></b> be turned off (set to zero) and can be enable/disabled by the host as required. If set to one the device <b><i>Shall</i></b> generate a wake event when a change of status occurs. See <i>Section 9.4.2, "SetPDFeature"</i> for more details.
<table>
<tr><th>Value</th><th>Description</th></tr>
<tr><td>0</td><td>Battery present event</td></tr>
<tr><td>1</td><td>Charging flow</td></tr>
<tr><td>2</td><td>Battery error</td></tr>
<tr><td>7:3</td><td><b><i>Reserved</i></b> and <b><i>Shall</i></b> be set to zero</td></tr>
</table></td></tr>
<tr><td>4</td><td>wRemainingOperatingTime</td><td>2</td><td>Number</td><td><b><i>Shall</i></b> contain the operating time (in minutes) until the Weak Battery threshold is reached, based on Present Battery Strength and the device's present operational power needs.
<b>Note:</b> This value <b><i>Shall</i></b> exclude any additional power received from charging.
A Battery that is not capable of returning this information <b><i>Shall</i></b> return a value of 0xFFFF.</td></tr>
<tr><td>6</td><td>wRemainingChargeTime</td><td>2</td><td>Number</td><td><b><i>Shall</i></b> contain the remaining time (in minutes) until the Charged Battery threshold is reached based on Present Battery Strength, charging power and the device's present operational power needs. Value <b><i>Shall</i></b> only be <b><i>Valid</i></b> if the Charging Flow is "Charging".
A Battery that is not capable of returning this information <b><i>Shall</i></b> return a value of 0xFFFF.</td></tr>
</table>

If wValue or wLength are not as specified above, then the behavior of the *PDUSB Device* is not specified.

If wIndex refers to a Battery that does not exist, then the *PDUSB Device* ***Shall*** respond with a Request Error.

If the *PDUSB Device* is not configured, the *PDUSB Hub*'s response to this request is undefined.

If the *PDUSB Hub* is not configured, the *PDUSB Hub*'s response to this request is undefined.

9.4.2 SetPDFeature

The request shown in *Table 9.11, "Set PD Feature"* sets the value requested in the *PDUSB Hub*/Peripheral.

Table 9.11 Set PD Feature

bmRequestType	bRequest	wValue	wIndex	wLength	Data
00000000B	set_ feature	Feature Selector	Feature Specific	Zero	None

Setting a feature enables that feature or starts a process associated with that feature; see *Table 9.8, "PD Feature Selectors"* for the feature selector definitions. Features that ***May*** be set with this request are:

- BATTERY_WAKE_MASK.
- CHARGING_POLICY.

9.4.2.1 BATTERY_WAKE_MASK Feature Selector

When the feature selector is set to BATTERY_WAKE_MASK, then the wIndex field is structured as shown in *Table 9.12, "Battery Wake Mask"*.

Table 9.12 Battery Wake Mask

Bit	Description
0	**Battery Present**: When this bit is set then the *PDUSB Device* ***Shall*** generate a wake event if it detects that a Battery has been inserted.
1	**Charging Flow**: When this bit is set then the *PDUSB Device* ***Shall*** generate a wake event if it detects that a Battery switched from charging to discharging or vice versa.
2	**Battery Error**: When this bit is set then the *PDUSB Device* ***Shall*** generate a wake event if the Battery has detected an error condition.
15:3	***Reserved*** and ***Shall Not*** be used

The *SPM* ***May*** Enable or Disable the wake events associated with one or more of the above events by using this feature.

If the *PDUSB Hub* is not configured, the *PDUSB Hub*'s response to this request is undefined.

9.4.2.2 CHARGING_POLICY Feature Selector

When the feature selector is set to CHARGING_POLICY, the wIndex field ***Shall*** be set to one of the values defined in *Table 9.13, "Charging Policy Encoding"*. If the device is using *USB Type-C* Current above the default value or is using PD then this feature setting has no effect and the rules for power levels specified in the ***[USB Type-C 2.4]*** or USB PD specifications ***Shall*** apply.

Table 9.13 Charging Policy Encoding

Value	Description
00H	The device ***Shall*** follow the default current limits as defined in the USB 2.0 or USB 3.1 specification, or as negotiated through other USB mechanisms such as BC. This is the default value.
01H	The *Device* ***May*** draw additional power during the unconfigured and suspend states for the purposes of charging. For charging the device itself, the device ***Shall*** limit its current draw to the higher of these two values: ICCHPF as defined in the USB 2.0 or USB 3.1 specification, regardless of its USB state. Current limit as negotiated through other USB mechanisms such as BC.
02H	The *Device* ***May*** draw additional power during the unconfigured and suspend states for the purposes of charging. For charging the device itself, the device ***Shall*** limit its current draw to the higher of these two values: ICCLPF as defined in the USB 2.0 or USB 3.1 specification, regardless of its USB state. Current limit as negotiated through other USB mechanisms such as BC.
03H	The device ***Shall Not*** consume any current for charging the device itself regardless of its USB state.
04H-FFFFH	***Reserved*** and ***Shall Not*** be used

This is a ***Valid*** *Command* for the *PDUSB Hub*/Peripheral in the Address or Configured USB states. Further, it is only ***Valid*** if the device reports a USB PD capability descriptor in its BOS descriptor and Bit 5 of the bmAttributes in that descriptor is set to 1. The device will go back to the wIndex default value of 0 whenever it is reset.

10 Power Rules

10.1 Introduction

The flexibility of power provision on *USB Type-C®* is expected to lead to power adapter re-use and the increasingly widespread provision of USB power outlets in domestic and public places and in transport of all kinds. Environmental considerations could result in unbundled power adapters. Rules are needed to avoid incompatibility between the *Source*s and the *Sink*s they are used to power, in order to avoid user confusion and to meet user expectations. This section specifies a set of rules that *Source*s and *Sink*s ***Shall*** follow. These rules provide a simple and consistent user experience.

The *PDP Rating* is a manufacturer declared value placed on packaging to help the user understand the capabilities of a *Charger* or the size of *Charger* required to power their device. For *PDP* values of 10W and above the *PDP* ***Shall*** be declared as an integer number of Watts. For *PDP* values less than 10W, the *PDP* ***Shall*** be declared in increments of 0.5W.

The *Source Power Rules* define a *PDP* to provide a simple way to tell the user about the capabilities of their power adapter or device. *PDP Rating* is akin to the wattage rating of a light bulb - bigger numbers mean more capability.

The *Sink Power Rules* define a *PDP* to provide a simple way to tell the user which *Source*s will provide adequate power for their *Sink*.

10.2 Source Power Rules

The *Source Power Rules* defined in this section include both ***Normative*** and ***Optional*** rules. For all of the defined rules, the capabilities a *Source* exposes are based on the ***Port Maximum PDP***, or if power constrained, the ***Port Present PDP*** of the *Port*.

For a *Guaranteed Capability Port*, the *Source* ***Shall*** always include in every ***Source_Capabilities*** or ***EPR_Source_Capabilities*** *Message* sent to a *Sink* all the *(A)PDO*s that are defined by the ***Normative*** (and ***Optional*** when implemented) rules based on the *Port*'s ***Port Maximum PDP*** and *Mode* of operation (i.e., *SPR Mode* or *EPR Mode*).

For a *Managed Capability Port*, except before the *First Explicit Contract* or before the *Explicit Contract* after the ***Port Present PDP*** changes on a *Shared Capacity Charger Port*, the *Source* ***Shall*** always include in every ***Source_Capabilities*** or ***EPR_Source_Capabilities*** *Message* sent to a *Sink* all the *(A)PDO*s that are defined by the ***Normative*** (and ***Optional*** when implemented) rules based on the *Port*'s ***Port Present PDP*** and *Mode* of operation (i.e., *SPR Mode* or *EPR Mode*). After the *First Explicit Contract*, this requirement assures that the attached *Sink* will always know what voltages (or voltage modes) are presently available from the *Source*.

In order to meet the expectations of the user, the Maximum Current/Power in the *Source Capabilities* PDO or *APDO* for *Source*s with a *PDP Rating* of x Watts ***Shall*** be as follows:

- Maximum current for ***Normative*** and ***Optional*** *Fixed Supply*/*Variable Supply* PDOs ***Shall*** be either RoundUp(x/voltage) or RoundDown(x/voltage) to the nearest 10mA.
- Maximum current for SPR Programmable Power Supply *APDO*s ***Shall*** be as defined in *Table 10.10, "SPR Programmable Power Supply PDOs and APDOs based on the Port Maximum PDP"*.

Note: When the Constant Power bit is set in the *APDO*, the programmable power supply's output current is as defined in *Table 10.10, "SPR Programmable Power Supply PDOs and APDOs based on the Port Maximum PDP"* however the programmable power supply will limit its output current so that the product of its actual output voltage times the output current does not exceed the *PDP*.

- If a 9V Prog, 15V Prog or 20V Prog Programmable Power Supply *APDO* is *Advertise*d when not required by *Table 10.10, "SPR Programmable Power Supply PDOs and APDOs based on the Port Maximum PDP"*, then the maximum current ***Shall*** be RoundDown (x/Prog Voltage) to the nearest 50mA. When the PPS Power Limited bit is clear the *Source* ***Shall*** provide this current at ***Maximum Voltage***.
- Maximum power for ***Optional*** *Battery Supply* PDOs ***Shall*** be ≤ x.

10.2.1 Source Power Rule Considerations

The *Source Power Rules* are designed to:

- Ensure the *PDP Rating* (*PDP*) of an adapter specified in watts explicitly defines the voltages and currents at each voltage the adapter supports.
- Ensure that adapters with a large *PDP Rating*s are always capable of providing the power to devices designed for use with adapters with a smaller *PDP Rating*.
- Enable an ecosystem of adapters that are inter-operable with the devices in the ecosystem.

The considerations that lead to the *Source Power Rules* are based are summarized in *Table 10.1, "Considerations for Sources"*.

Table 10.1 Considerations for Sources

Considerations	Rationale	Consequence
Simple to identify capability	A user going into an electronics retailer knows what they need	Cannot have a complex identification scheme
Higher power *Sources* are a superset of smaller ones	Bigger is always better in user's eyes – don't want a degradation in performance	Higher power *Sources* do everything smaller ones do
Unambiguous *Source* definitions	*Sources* with the same power rating but different VI combinations might not inter-operate	To avoid user confusion, any given power rating has a single definition
A range of power ratings	Users and companies will want freedom to pick appropriate *Source* ratings	Fixed profiles at specific power levels don't provide adequate flexibility, e.g., profiles as defined in previous versions of PD.
5V@3A *USB Type-C Source* is defined by ***[USB Type-C 2.4]***	5V@3A *USB Type-C Source* is considered	All > 15W adapters must support 5V@3A or superset consideration is violated
Maximize 3A cable utilization	3A cables will be ubiquitous	Increase to maximum voltage (20V) before increasing current beyond 3A
Optimize voltage rail count	More rails are a higher burden for *Sources*, particularly in terms of testing	5V is a basic USB requirement. 48V provides the maximum capability.
Some *Sources* are not able to provide significant power	Some small *Battery*-operated *Sources* e.g., mobile devices, are able to provide more power directly from their *Battery* than from a regulated 5V supply	In addition to the minimal 5V *Advertise*ments are able to *Advertise* more power from their *Battery*
Some *Sources* share power between multiple Ports (*Hubs* and multi-*Port* ***Chargers***)	*Hubs* and multi-port ***Charger***s have to be supported	See *Section 10.3, "Sink Power Rules"*

10.2.2 Normative Voltages and Currents

The voltages and currents an *SPR Source* with a *PDP Rating* of x Watts ***Shall*** support are as defined in *Table 10.2, "SPR Normative Voltages and Minimum Currents"*.

Table 10.2 SPR Normative Voltages and Minimum Currents

Port Maximum PDP Rating (W)	5V Fixed	9V Fixed	15V Fixed	20V Fixed	SPR AVS
0.5 ≤ x ≤ 15	(*PDP*/5)A[3]	-	-	-	-
15 < x ≤ 27	3A[2]	(*PDP*/9)A[3]	-	-	-
27 < x ≤ 45	3A[2]	3A[2]	(*PDP*/15)A[3]	-	(9V – 15V): • (15V *Fixed Supply* Max Current) A

45 < x ≤ 60	3A[2]	3A[2]	3A[2]	(*PDP*/20)A[3]	(9V – 15V):
					• (15V *Fixed Supply* Max Current) A[4]
					(15V – 20V):
					• (20V *Fixed Supply* Max Current) A

60 < x ≤ 100	3A[2]	3A[2]	3A[2]	(*PDP*/20)A[1, 3]	(9V – 15V):
					• (15V *Fixed Supply* Max Current) A[4, 5]
					(15V – 20V):
					• (20V *Fixed Supply* Max Current) A[1, 5]

1) Requires a 5A cable.

2) The *Fixed Supply* PDOs Maximum Current field ***Shall*** *Advertise* at least 3A, but ***May*** *Advertise* up to RoundUp (*PDP*/voltage) to the nearest 10mA. Requires a 5A cable if over 3A is *Advertise*d.

3) The *Fixed Supply* PDOs Maximum Current field ***Shall*** *Advertise* either RoundDown (*PDP*/voltage) or RoundUp (*PDP*/voltage) to the nearest 10mA.

4) *SPR AVS* current for this voltage range is the maximum current as *Advertise*d by the 15V *Fixed Supply* PDO. This current can be higher than 3A (refer to *Note 2*). Requires a 5A cable if over 3A is *Advertise*d.

5) The *Sink* is allowed to request up to the 20V *Fixed Supply* Max Current when the requested voltage is 15.0V.

SPR *Managed Capability Ports* when power constrained are defined to offer ***Valid*** *(A)PDOs* based on the port's ***Port Maximum PDP*** (as per *Table 10.2, "SPR Normative Voltages and Minimum Currents"*) at lower ***Port Present PDP*** (as per *Table 10.3, "SPR Source Capabilities When Port Present PDP is less than Port Maximum PDP"*) because these voltages would otherwise be available if the *Managed Capability Port* power hadn't been constrained.

Table 10.3 SPR Source Capabilities When Port Present PDP is less than Port Maximum PDP

Port Present PDP (W)	5V Fixed	9V Fixed	15V Fixed	20V Fixed	SPR AVS with Max Voltage of 15V or 20V per Table 10.2^{6}

5 < x ≤ 15	(*PDP*/5)A^{3}	(*PDP*/9)A$^{3,7, 8}$	(*PDP*/15)A^{3,7,8}	(*PDP*/20)A^{3,7,8}	(9V – 15V):
					• (15V *Fixed Supply* Max Current) A$^{4, 6, 8}$
					(15V – 20V):
					• (20V *Fixed Supply* Max Current) A^{6,8}

15 < x ≤ 27	3A^{2}	(*PDP*/9)A^{3}	(*PDP*/15)A^{3,7}	(*PDP*/20)A^{3,7}	(9V – 15V):
					• (15V *Fixed Supply* Max Current) A^{4}
					(15V – 20V):
					• (20V *Fixed Supply* Max Current) A^{6}

27 < x ≤ 45	3A^{2}	3A^{2}	(*PDP*/15)A^{3}		

45 < x ≤ 60	3A^{2}	3A^{2}	3A^{2}	(*PDP*/20)A^{3}	(9V – 15V):
					• (15V *Fixed Supply* Max Current) A^{4}
					(15V – 20V):
					• (20V *Fixed Supply* Max Current) A

60 < x ≤ 100	3A^{2}	3A^{2}	3A^{2}	(*PDP*/20)A$^{1, 3}$	(9V – 15V):
					• (15V *Fixed Supply* Max Current) A$^{4, 5}$
					(15V – 20V):
					• (20V *Fixed Supply* Max Current) A$^{1, 5}$

1) Requires a 5A cable.

2) The *Fixed Supply* PDOs Maximum Current field ***Shall*** *Advertise* at least 3A, but ***May*** *Advertise* up to RoundUp (*PDP*/voltage) to the nearest 10mA. Requires a 5A cable if over 3A is *Advertised*.

3) The *Fixed Supply* PDOs Maximum Current field ***Shall*** *Advertise* either RoundDown (*PDP*/voltage) or RoundUp (*PDP*/voltage) to the nearest 10mA.

4) *SPR AVS* current for this voltage range is the maximum current as *Advertised* by the 15V *Fixed Supply* PDO. This current can be higher than 3A (refer to *Note 2*). Requires a 5A cable if over 3A is *Advertised*.

5) The *Sink* is allowed to request up to the 20V *Fixed Supply* Max Current when the requested voltage is 15.0V.

6) The Max Voltage for *SPR AVS* is what is allowed by *Table 10.2, "SPR Normative Voltages and Minimum Currents"* based on the port's ***Port Maximum PDP***.

7) This SPR *Fixed Supply* voltage is only available if allowed by *Table 10.2, "SPR Normative Voltages and Minimum Currents"* based on the port's ***Port Maximum PDP***.

8) *SPR Sources* ***May*** offer *(A)PDOs* at this ***Port Present PDP***

In reference to *Table 10.3, "SPR Source Capabilities When Port Present PDP is less than Port Maximum PDP"*, *Table 10.4, "SPR Source Port Present PDP less than Port Maximum PDP Examples"* gives examples of which SPR capabilities are *Advertise*d based on ***Port Present PDP*** on a *Managed Capability Port* and the port's ***Port Maximum PDP*** and cable's current rating.

Table 10.4 SPR Source Port Present PDP less than Port Maximum PDP Examples

Port Maximum PDP and Cable Rating	Port Present PDP	Offers				
		5V Fixed	**9V Fixed**	**15V Fixed**	**20V Fixed**	**SPR AVS**
80W / 5A	65W	3A[1]	3A[1]	3A[1]	3.25A	9V – 15V: 3A 15V – 20V: 3.25A
80W / 5A	40W	3A[1]	3A[1]	2.67A	2A	9V – 15V: 2.67A 15V – 20V: 2A
80W / 3A	40W	3A[1]	3A	2.67A	2A	9V – 15V: 2.67A 15V – 20V: 2A
40W / 5A	40W	3A[1]	3A[1]	2.67A	Not Offered	9V – 15V: 2.67A
40W / 3A	40W	3A[1]	3A	2.67A	Not Offered	9V – 15V: 2.67A
80W / 5A	20W	3A[1]	2.22A	1.33A	1A	9V – 15V: 1.33A 15V – 20V: 1A
80W / 3A	20W	3A[1]	2.22A	1.33A	1A	9V – 15V: 1.33A 15V – 20V: 1A
40W / 5A	20W	3A[1]	2.22A	1.33A	Not Offered	9V – 15V: 1.33A
40W / 3A	20W	3A[1]	2.22A	1.33A	Not Offered	9V – 15V: 1.33A
80W/3A	15W	3A	1.67A[2]	1A[2]	0.75A[2]	9V - 15V: 1A[2] 15V - 20V: 0.75A[2]
40W/3A	15W	3A	1.67A[2]	1A[2]	Not offered	9V - 15V: 1A[2]

1) The *Fixed Supply* PDO Maximum Current field will *Advertise* at least 3A but ***May*** *Advertise* up to RoundUp (*PDP*/voltage) to the nearest 10mA.

2) These *Capabilities* are not required but may be offered at this ***Port Present PDP***.

10.2.2.1 Fixed Supply PDOs

Figure 10.1, "SPR Source Power Rule Illustration for Fixed Supply PDOs" illustrates the minimum current that an *SPR Source* ***Shall*** support at each voltage for a given *PDP Rating* for *Fixed Supply* PDOs.

Note: Not illustrated are that currents higher than 3A are allowed to be offered up to a limit of 5A given that a 5A cable is detected by the *Source* and the voltage times current remains within the *Source PDP Rating*.

Figure 10.1 SPR Source Power Rule Illustration for Fixed Supply PDOs

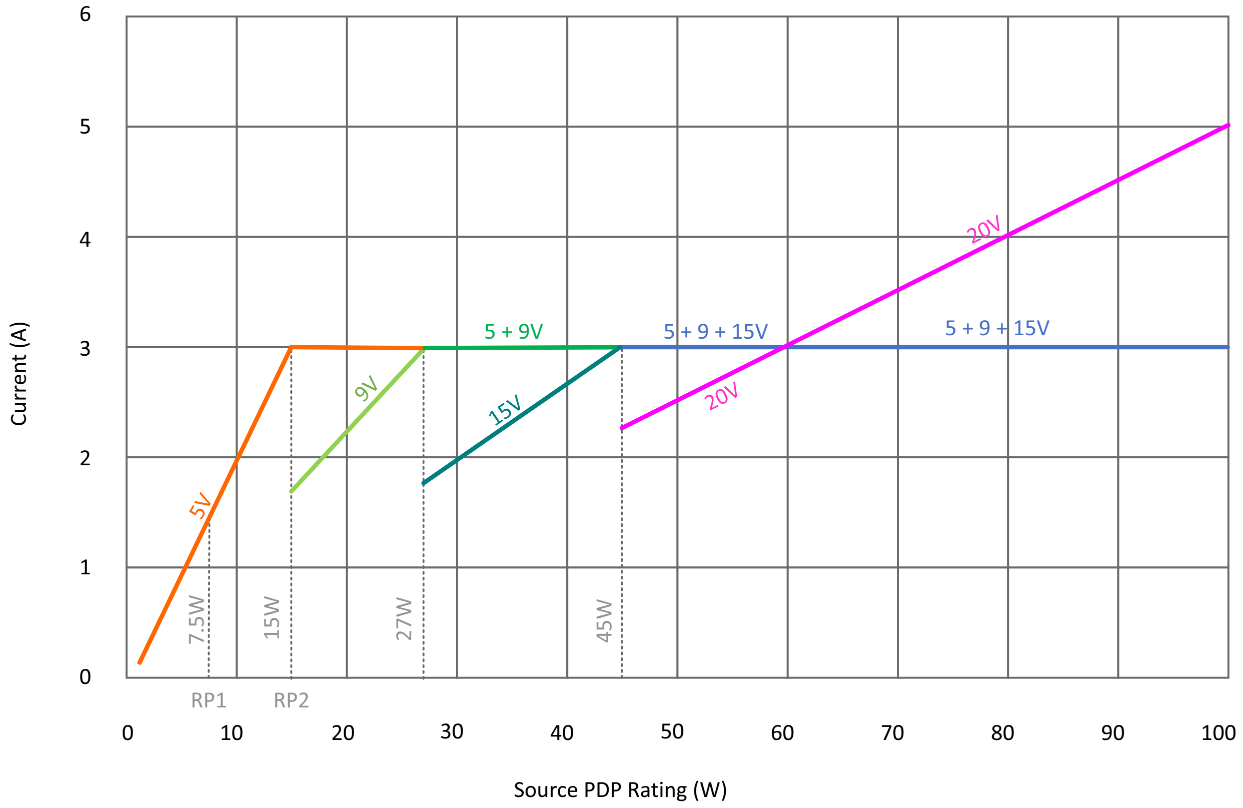


Figure 10.2, "SPR Source Power Rule Example For Fixed Supply PDOs" shows an example of an adapter with a rating at 50W. The adapter is required to support 20V at 2.5A, 15V at 3A, 9V at 3A and 5V at 3A.

Figure 10.2 SPR Source Power Rule Example For Fixed Supply PDOs

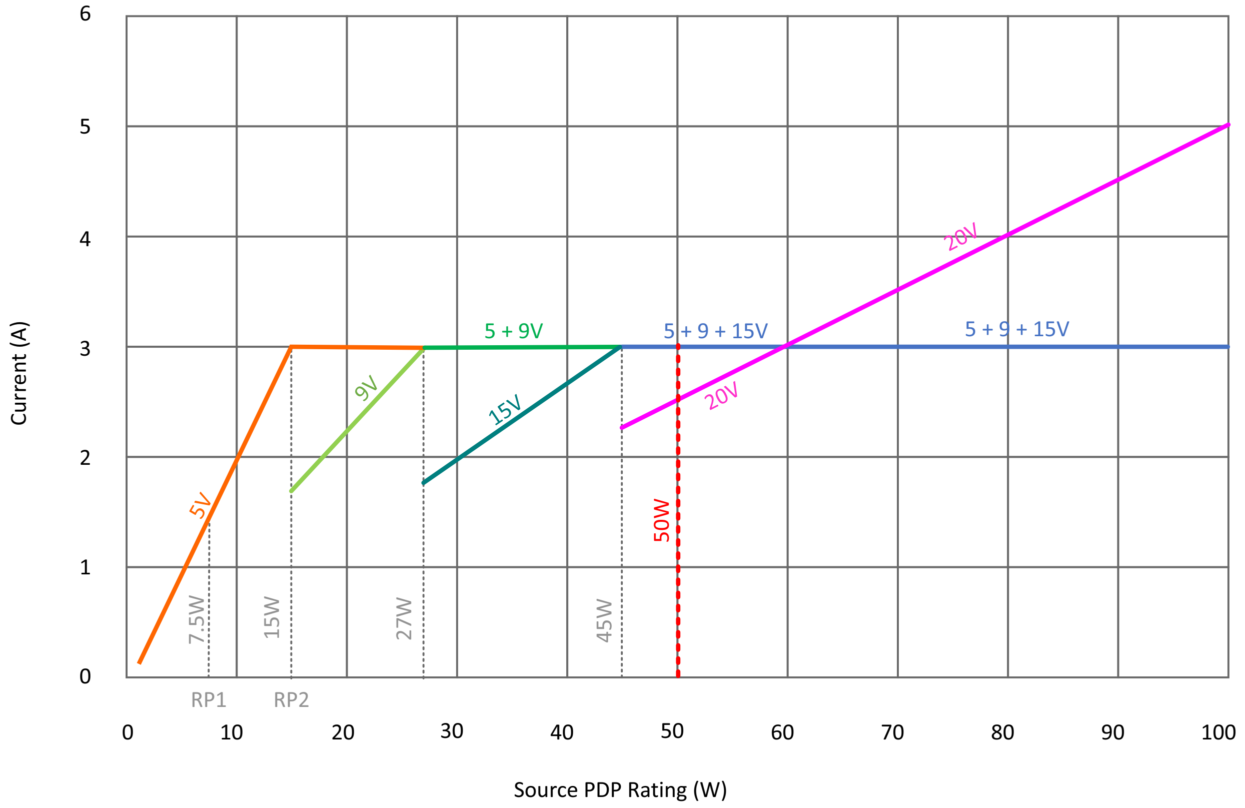


Table 10.5, "Fixed Supply PDO - Source 5V", *Table 10.6, "Fixed Supply PDO - Source 9V"*, *Table 10.7, "Fixed Supply PDO - Source 15V"* and *Table 10.8, "Fixed Supply PDO - Source 20V"* show the *Fixed Supply* PDOs that ***Shall*** be supported for each of the ***Normative*** voltages defined in *Table 10.2, "SPR Normative Voltages and Minimum Currents"*.

Table 10.5 Fixed Supply PDO - Source 5V

<table>
<tr><th>Bit(s)</th><th colspan="2">Description</th></tr>
<tr><td>B31…30</td><td colspan="2"><i>Fixed Supply</i></td></tr>
<tr><td>B29</td><td colspan="2"><b><i>Dual-Role Power</i></b></td></tr>
<tr><td>B28</td><td colspan="2"><b><i>USB Suspend Supported</i></b></td></tr>
<tr><td>B27</td><td colspan="2"><b><i>Unconstrained Power</i></b></td></tr>
<tr><td>B26</td><td colspan="2"><b><i>USB Communications Capable</i></b></td></tr>
<tr><td>B25</td><td colspan="2"><b><i>Dual-Role Data</i></b></td></tr>
<tr><td>B24</td><td colspan="2"><b><i>Unchunked Extended Messages Supported</i></b></td></tr>
<tr><td>B23</td><td colspan="2"><b><i>EPR Capable</i></b></td></tr>
<tr><td>B22</td><td colspan="2"><b><i>Reserved</i></b> – <b><i>Shall</i></b> be set to zero.</td></tr>
<tr><td>B21…20</td><td colspan="2"><b><i>Peak Current</i></b></td></tr>
<tr><td>B19…10</td><td colspan="2">5V</td></tr>
<tr><td rowspan="5">B9…0</td><td colspan="2">Current based on <i>PDP</i></td></tr>
<tr><th>PDP Rating (x)</th><th>Current (A)</th></tr>
<tr><td>0.5 ≤ x ≤ 15</td><td>x ÷ 5</td></tr>
<tr><td>15 &lt; x ≤ 25</td><td>3 ≤ A ≤ x ÷ 5</td></tr>
<tr><td>25 &lt; x ≤ 100</td><td>3 ≤ A ≤ 5</td></tr>
</table>

Table 10.6 Fixed Supply PDO - Source 9V

<table>
<tr><th>Bit(s)</th><th colspan="2">Description</th></tr>
<tr><td>B31…30</td><td colspan="2"><i>Fixed Supply</i></td></tr>
<tr><td>B29…22</td><td colspan="2"><b><i>Reserved</i></b> – <b><i>Shall</i></b> be set to zero.</td></tr>
<tr><td>B21…20</td><td colspan="2"><b><i>Peak Current</i></b></td></tr>
<tr><td>B19…10</td><td colspan="2">9V</td></tr>
<tr><td rowspan="6">B9…0</td><td colspan="2">Current based on <i>PDP</i></td></tr>
<tr><th>PDP Rating (x)</th><th>Current (A)</th></tr>
<tr><td>0.5 ≤ x ≤ 15</td><td>PDO not required</td></tr>
<tr><td>15 < x ≤ 27</td><td>x ÷ 9</td></tr>
<tr><td>27 < x ≤ 45</td><td>3 ≤ A ≤ x ÷ 9</td></tr>
<tr><td>45 < x ≤ 100</td><td>3 ≤ A ≤ 5</td></tr>
</table>

Table 10.7 Fixed Supply PDO - Source 15V

<table>
<tr><th>Bit(s)</th><th colspan="2">Description</th></tr>
<tr><td>B31…30</td><td colspan="2"><i>Fixed Supply</i></td></tr>
<tr><td>B29…22</td><td colspan="2"><b><i>Reserved</i></b> – <b><i>Shall</i></b> be set to zero.</td></tr>
<tr><td>B21…20</td><td colspan="2"><b><i>Peak Current</i></b></td></tr>
<tr><td>B19…10</td><td colspan="2">15V</td></tr>
<tr><td rowspan="6">B9…0</td><td colspan="2">Current based on <i>PDP</i></td></tr>
<tr><th>PDP Rating (x)</th><th>Current (A)</th></tr>
<tr><td>0.5 ≤ x ≤ 27</td><td>PDO not required</td></tr>
<tr><td>27 < x ≤ 45</td><td>x ÷ 15</td></tr>
<tr><td>45 < x ≤ 75</td><td>3 ≤ A ≤ x ÷ 15</td></tr>
<tr><td>75 < x ≤ 100</td><td>3 ≤ A ≤ 5</td></tr>
</table>

Table 10.8 Fixed Supply PDO - Source 20V

<table>
<tr><th>Bit(s)</th><th colspan="2">Description</th></tr>
<tr><td>B31…30</td><td colspan="2"><i>Fixed Supply</i></td></tr>
<tr><td>B29…22</td><td colspan="2"><b><i>Reserved</i></b> – <b><i>Shall</i></b> be set to zero.</td></tr>
<tr><td>B21…20</td><td colspan="2"><b><i>Peak Current</i></b></td></tr>
<tr><td>B19…10</td><td colspan="2">20V</td></tr>
<tr><td rowspan="4">B9…0</td><td colspan="2">Current based on <i>PDP</i></td></tr>
<tr><th>PDP Rating (x)</th><th>Current (A)</th></tr>
<tr><td>0.5 ≤ x ≤ 45</td><td>PDO not required</td></tr>
<tr><td>45 < x ≤ 100</td><td>x ÷ 20</td></tr>
</table>

More current ***May*** be offered in the PDOs when ***Optional*** voltages/currents are supported and a 5A cable is being used (see *Section 10.2.3, "Optional Voltages/Currents"*).

10.2.2.2 SPR Adjustable Voltage Supply (AVS)

For *SPR AVS*, *Figure 10.3, "Valid SPR AVS Operating Region for a Source advertising in the range of 27W < PDP ≤ 45W"*, *Figure 10.4, "Valid SPR AVS Operating Region for a Source advertising in the range of 45W < PDP ≤ 60W"* and *Figure 10.5, "Valid SPR AVS Operating Region for a Source advertising in the range of 60W < PDP ≤ 100W"* illustrate the valid operating region for *SPR AVS RDO* requests in the ranges of 27W < *PDP* ≤ 45W, 45W < *PDP* ≤ 60W and 60W < *PDP* ≤ 100W, respectively.

Figure 10.3 Valid SPR AVS Operating Region for a Source advertising in the range of 27W < PDP ≤ 45W

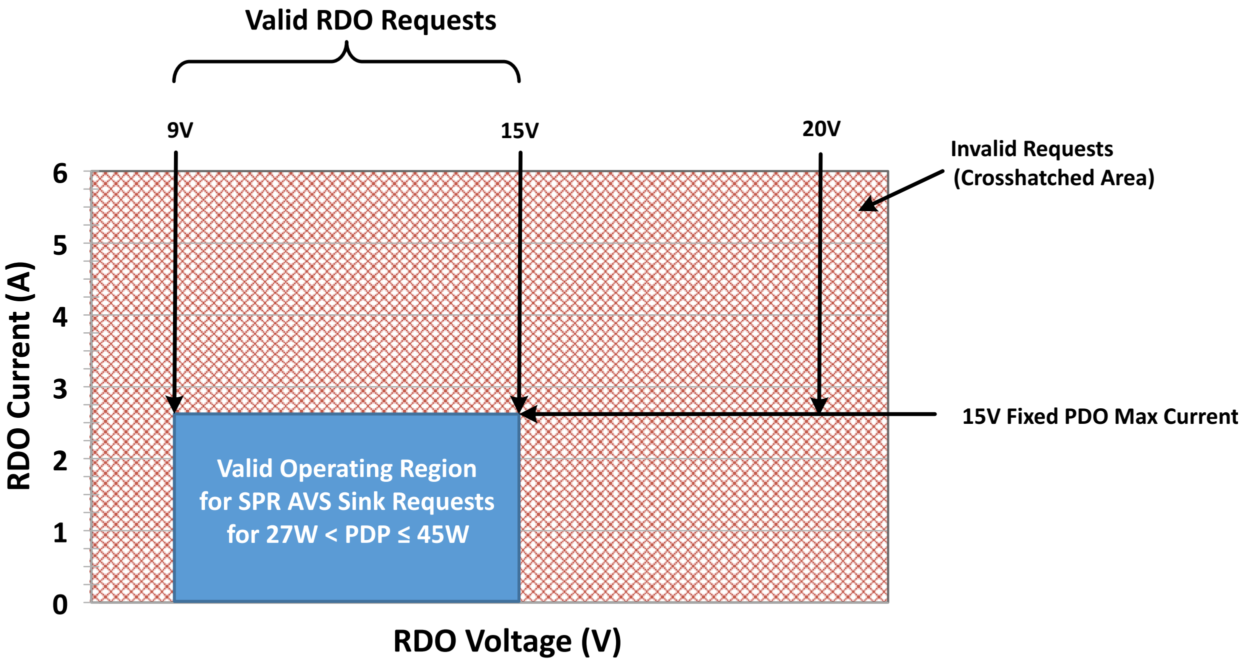


Figure 10.4 Valid SPR AVS Operating Region for a Source advertising in the range of 45W < PDP ≤ 60W

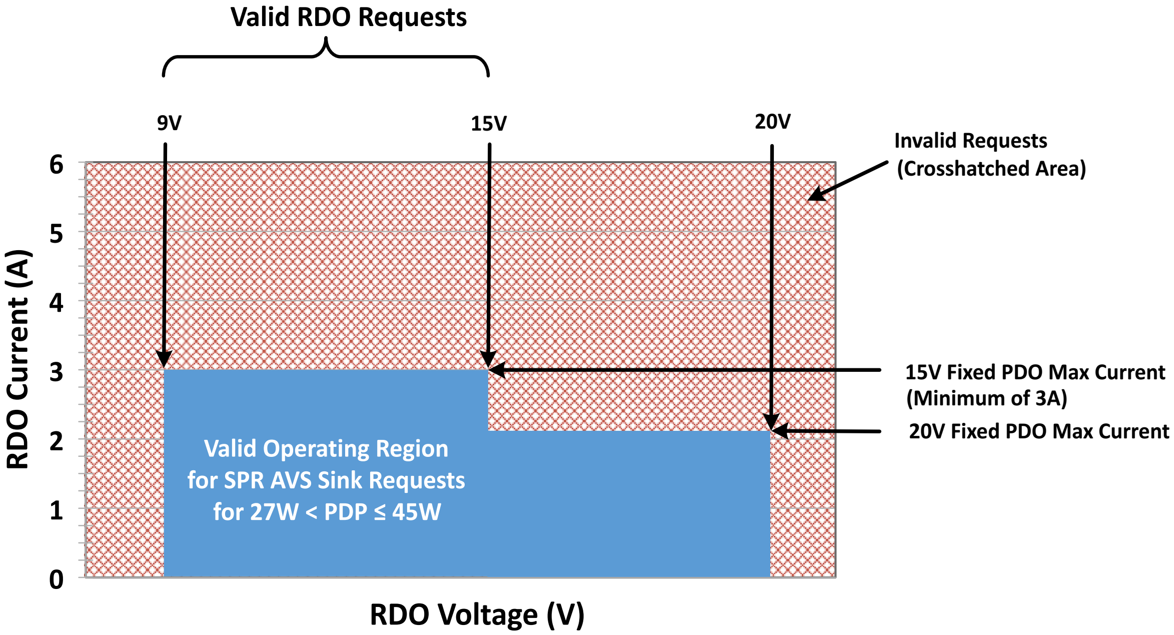
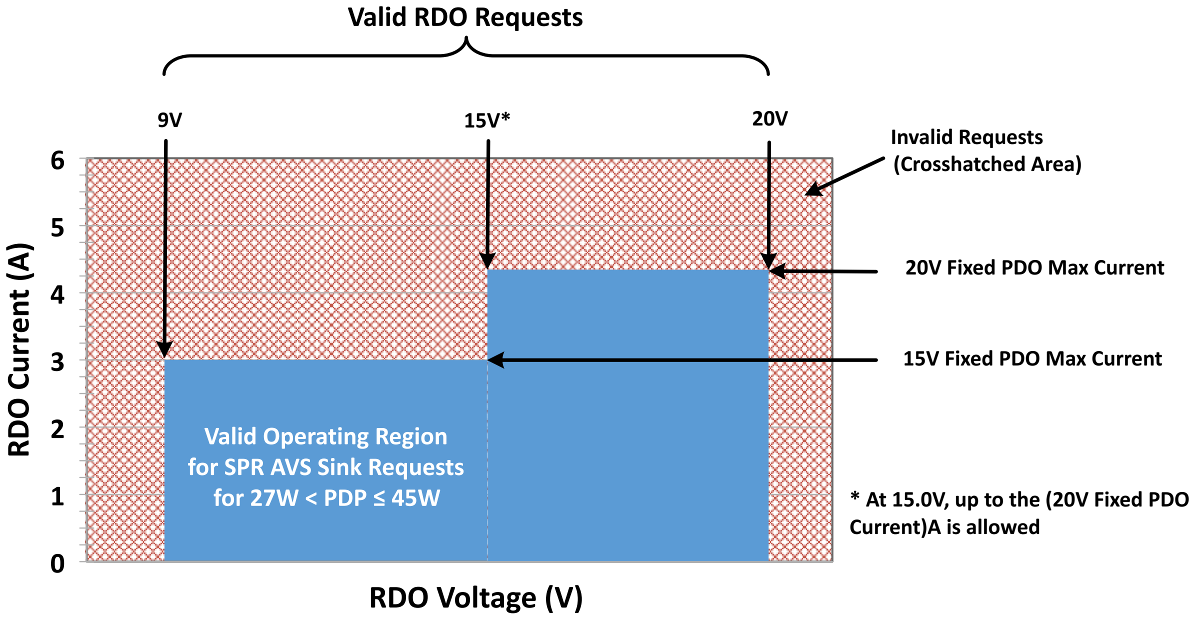


Figure 10.5 Valid SPR AVS Operating Region for a Source advertising in the range of 60W < PDP ≤ 100W



10.2.2.2.1 SPR Adjustable Voltage Supply (AVS) Voltage Ranges

Table 10.12, "EPR Source Capabilities based on the Port Maximum PDP and using an EPR Capable Cable" shows the Minimum and Maximum Voltage for the *SPR AVS* ranges.

Table 10.9 SPR Adjustable Voltage Supply (AVS) Voltage Ranges

	AVS Voltage Range	
	15V AVS	20V AVS
Maximum Voltage	15V	20V
Minimum Voltage	9V	9V

The voltage output at the *Source*'s connector ***Shall*** be +/-5% for both the Maximum Voltage and the Minimum Voltage.

10.2.3 Optional Voltages/Currents

10.2.3.1 Optional Normative Fixed, Variable and Battery Supply

In addition to the voltages and currents specified in Section 10.2.2, "Normative Voltages and Currents", an *SPR Source* that is optimized for use with a specific *Sink* or a specific class of *Sink*s ***May Optionally*** supply additional voltages and increased currents. However, the ***Optional*** voltages ***Shall Not*** exceed 9V.

Optional voltages ***Shall Not*** be implemented on *EPR Source* including for both *SPR Mode* and *EPR Mode*s of operation. *EPR* versions of *Variable Supply* and *Battery Supply PDO*s are not defined and ***Shall Not*** be implemented, however *SPR Variable Supply* and *Battery Supply PDO*s are allowed in *EPR Mode*.

While allowed, the use of ***Optional*** voltages and currents is not recommended as two *Source*s with the same *PDP Rating* but not supporting the same ***Optional*** voltages and currents can behave differently thus confusing the user.

See Section 10.2, "Source Power Rules" for the rules that ***Shall*** apply to ***Optional*** PDOs in order to be consistent with the declared *PDP Rating* and the ***Normative*** voltages and currents.

10.2.3.2 Optional Normative SPR Programmable Power Supply

The voltages and currents a Programmable Power Supply with a *PDP Rating* of x Watts ***Shall*** support are as defined Table 10.10, "SPR Programmable Power Supply PDOs and APDOs based on the Port Maximum PDP".

When ***Optional*** Programmable Power Supply *APDO*s are offered, the following requirements ***Shall*** apply:

- A *Source* that *Advertises* ***Optional*** Programmable Power Supply *APDOs* ***Shall*** *Advertise* the PDOs and *APDO*s shown in Table 10.10, "SPR Programmable Power Supply PDOs and APDOs based on the Port Maximum PDP".
- A *Source* ***Shall*** *Advertise* ***Optional*** Programmable Power Supply *APDO*s with Maximum Voltage and Minimum Voltages for nominal voltage as defined in Table 10.11, "SPR Programmable Power Supply Voltage Ranges".
- A *Source* ***Shall Not*** *Advertise* a Programmable Power Supply *APDO* that does not follow the Minimum Voltage and Maximum Voltage defined in Table 10.11, "SPR Programmable Power Supply Voltage Ranges".
- In no case ***Shall*** a *Source Advertise* a current that exceeds the *Attached* cable's current rating.
- The Max Voltage ***Shall Not*** exceed 21V while in *SPR Mode*.

Table 10.10 SPR Programmable Power Supply PDOs and APDOs based on the Port Maximum PDP

PDP Maximum PDP (W)	SPR Fixed and AVS	9V Prog[3]	15V Prog[3]	20V Prog[3]
x < 15W	Required per Table 10.2, "SPR Normative Voltages and Minimum Currents" (or Table 10.3, "SPR Source Capabilities When Port Present PDP is less than Port Maximum PDP" when applicable)	-	-	-
15W		-	-	-
15 < x < 27W		(*PDP*/9)A[1]	-	-
27W		3A	-	-
27 < x < 45W		3A[2]	(*PDP*/15)A[1]	-
45W		-	3A	-
45 < x < 60W		-	3A[2]	(*PDP*/20)A[1]
60W		-	-	3A
60 < x < 100W		-	-	(*PDP*/20)A[1]
100W		-	-	5A

1) The *SPR PPS APDO*s Maximum Current field ***Shall*** *Advertise* RoundDown (*PDP*/Prog Voltage) to the nearest 50mA.

2) The *SPR PPS APDO*s Maximum Current field ***Shall*** *Advertise* at least 3A, but ***May*** *Advertise* up to RoundDown(*PDP*/Prog Voltage) to the nearest 50mA.

3) Applies to *APDO*s regardless of value of the PPS Power Limited bit.

10.2.3.2.1 SPR Programmable Power Supply Voltage Ranges

The *SPR PPS* Voltage ranges map to the *Fixed Supply* Voltages. For each fixed voltage there is a defined voltage range for the matching *SPR PPS APDO*. *Table 10.11, "SPR Programmable Power Supply Voltage Ranges"* shows the Minimum and Maximum Voltage for the Programmable Power Supply that corresponds to the Fixed nominal voltage.

Table 10.11 SPR Programmable Power Supply Voltage Ranges

	Fixed Nominal Voltage		
	9V Prog	15V Prog	20V Prog
Maximum Voltage	11V	16V	21V
Minimum Voltage	5V	5V	5V

The voltage output at the *Source*'s connector ***Shall*** be +/-5% for both the Maximum Voltage and the Minimum Voltage.

10.2.3.2.2 Examples of the use of SPR Programmable Power Supplies

The following examples illustrate what a power adapter that *Advertise*s a particular *PDP Rating* ***May*** offer:

1) *PDP* 27W implementation includes:
   - 5V @ 3A,
   - 9V @ 3A, and
   - 9V Prog @ 3A.
2) *PDP* 36W implementation includes:
   - 5V @ 3A,
   - 9V @ 3A,
   - 15 @ 2.4A,
   - *SPR AVS* with 9V - 15V @ 2.4A,
   - 9V Prog @ 3 A, and
   - 15V Prog @ 2.4A.
3) *PDP* 36W implementation that ***Optionally*** includes higher current in the 9V Prog PPS:
   - 5V @ 3A,
   - 9V @ 3A,
   - 15 @ 2.4A,
   - *SPR AVS* with 9V - 15V @ 2.4A,
   - 9V Prog @ >3A up to 4A (with a 5A cable) and 15V
   - Prog @ 2.4A.
4) *PDP* 50W implementation includes:
   - 5V @ 3A,
   - 9V @ 3A,
   - 15 @ 3A,
   - 20V @ 2.5A,

- *SPR AVS* with 9V - 15V @ 3A & 15V - 20V @ 2.5A,
- 15V Prog @ 3A, and
- 20V Prog @ 2.5A.

5) *PDP* 80W implementation includes:

- 5V @ 3A,
- 9V @ 3A,
- 15 @ 3A,
- 20V @ 4A,
- *SPR AVS* with 9V - 15V @ 3A & 15V - 20V @ 4A,
- 15V Prog @ 3A, and
- 20V Prog @ 4A.

The first example illustrates a basic example of a supply that can only support 5V and 9V.

The second and third examples illustrates as the *PDP Rating* goes higher there are more possible combinations that meet the *Power Rules*. These examples also add *SPR AVS*. Although there are multiple ways to meet the *Power Rules*, while operating in *SPR Mode* no more than a combination of seven *SPR (A)PDO*s and *APDO*s can be offered.

The fourth and fifth example show that the 15V Prog @ 3A fully covers the 9V Prog @3A range so it is not necessary to *Advertise* both. These examples also illustrate *SPR AVS* being extended up to 20V with separate current limits for the 9V - 15V and 15V - 20V ranges - a single *SPR AVS APDO* covers advertising both ranges.

10.2.3.3 Optional Normative Extended Power Range (EPR)

Support of *EPR Mode* is ***Optional***. An *EPR Capable* port has a *PDP Rating* that is >100W and ≤ 240W. An *EPR Capable Source Port* (*EPR Source Port*) ***May*** operate in either *SPR Mode* or *EPR Mode* when operating at 100W or less.

An *EPR Source Port* operating in *SPR Mode* ***May*** offer less than 100W to avoid violating safety regulations. When operating in *EPR Mode*, an *EPR Source Port* ***Shall*** offer 100W in Fixed 20V when not constrained by multi- port sharing limits.

An *EPR Source* ***May*** include multiple ports and these ports can be functionally implemented as *Shared Capacity Charger* or *Assured Capacity Charger* ports as defined in ***[USB Type-C 2.4]***.

Any port on an *EPR Source* that has a ***Port Present PDP*** of 100W or less ***Shall*** follow the ***Normative*** requirements for *SPR Source Port*s and ***Shall*** operate only in *SPR Mode*. Any port on an *EPR Source* that is operating with a cable that is not *EPR Capable* ***Shall*** operate only in *SPR Mode*. An *EPR Source*, when operating in *SPR Mode* with a 5A cable, ***May*** offer less than 5A due to design tolerances in order to meet applicable safety standards. For best user experience it ***Should*** be as close to 100W as possible.

Table 10.12, "EPR Source Capabilities based on the Port Maximum PDP and using an EPR Capable Cable" and *Table 10.13, "EPR Source Capabilities when Port Present PDP is less than Port Maximum PDP and using an EPR-capable cable"* define the ***Normative*** requirements *EPR Source Port*s. While not included in these tables, any *EPR Source Port* that also supports *SPR PPS* ***Shall*** offer the SPR Fixed 20V PDO and PPS 20V Prog *APDO* at 100W (or the maximum available *PDP* when the port is operating at an Equivalent *PDP* <100W) when in *EPR Mode*:

- When an *EPR Source Port* is capable of supplying its *PDP Rating*, it ***Shall*** adhere to the requirements defined in *Table 10.12, "EPR Source Capabilities based on the Port Maximum PDP and using an EPR Capable Cable"* based on its *PDP Rating* of x Watts.
- When a *Source Port* on an *EPR Charger* is unable to provide its ***Port Maximum PDP***, it ***Shall*** adhere to the requirements defined in *Table 10.13, "EPR Source Capabilities when Port Present PDP is less than Port Maximum PDP and using an EPR-capable cable"* based on a ***Port Present PDP*** of x Watts. Some examples:
  - An *EPR Source Port* ***May*** be unable to provide its *PDP Rating* because it is thermally constrained at the time of power *Negotiation*.
  - A Shared port on a multi-port *EPR Charger* that is limited by the remaining available power.
- When an *EPR Charger* is in an *Adjustable Voltage Supply* (*AVS*) *Explicit Contract*:
  - It ***Shall*** Reject all Requests outside of the defined voltage range (see *Table 10.15, "EPR Adjustable Voltage Supply (AVS) Voltage Ranges"*) or for a requested voltage and Current that results in a power level that is more than the Port's *Advertised PDP*.
  - In no case ***Shall*** a *Source Advertise* a Current or accept a Current requested by a *Sink* that exceeds the *Attached* cable's current rating.

- The Max Voltage offered by an *EPR Source* ***Shall Not*** exceed 48V.

Table 10.12 EPR Source Capabilities based on the Port Maximum PDP and using an EPR Capable Cable

Port Maximum PDP (W)	SPR Fixed and AVS	28V Fixed	36V Fixed[3]	48V Fixed	EPR AVS[3, 4]

100 < x ≤ 140	Required per *Table 10.2, "SPR Normative Voltages and Minimum Currents"* (or *Table 10.3, "SPR Source Capabilities When Port Present PDP is less than Port Maximum PDP"* when applicable)	(*PDP*/28)A[2]	***N/A***[1]	***N/A***[1]	(15V – *PDP*/5A):
					• 5A
					(>*PDP*/5A – 28V):
					• (*PDP*/*AVS* voltage) A

140 < x ≤ 180		5A	(*PDP*/ 36)A[2]	***N/A***[1]	(15V – *PDP*/5A):
					• 5A
					(>*PDP*/5A – 36V):
					• (*PDP*/*AVS* voltage) A

180 < x ≤ 240		5A	5A	(*PDP*/48)A[2]	(15V – *PDP*/5A):
					• 5A
					(>*PDP*/5A – 48V):
					• (*PDP*/*AVS* voltage) A

1) *EPR Source*s are disallowed from offering *Fixed Supply* voltages that are above the defined voltages for a given *PDP*, e.g., 36V is disallowed for any *PDP* of 140W or lower.

2) The Fixed PDOs Maximum Current field ***Shall*** *Advertise* either RoundDown (*PDP*/voltage) or RoundUp (*PDP*/voltage) to the nearest 10mA.

3) *EPR Source*s ***Shall*** reject any request for more than the *Advertise*d *PDP*, i.e., when output voltage and operating current requested in the *Sink RDO* is outside of the defined *AVS* voltage and current range represented by the *Advertise*d *PDP*, the *RDO* will be rejected.

4) The current available for a given *AVS* voltage is as indicated in this column. The current defined here is describing the top edge of the ***Valid*** Operating Region as illustrated in *Figure 10.6, "Valid EPR AVS Operating Region"*. The *AVS APDO* does not have a Maximum Current field, so the maximum current has to be calculated from the *PDP*.

Table 10.13 EPR Source Capabilities when Port Present PDP is less than Port Maximum PDP and using an EPR-capable cable

Port Present PDP (W)	SPR Fixed and AVS	28V Fixed	36V Fixed[4]	48V Fixed[4]	EPR AVS with Max Voltage of 28V, 36V or 48V per Table 10.12[2, 5, 6]		
					28V	36V	48V
7.5 ≤ x ≤ 15	Required per *Table 10.2, "SPR Normative Voltages and Minimum Currents"* (or *Table 10.3, "SPR Source Capabilities When Port Present PDP is less than Port Maximum PDP"* when applicable)	(*PDP*/28) A[3]	(*PDP*/36) A[3]	(*PDP*/48) A[3]	• (15V – max voltage): ○ (*PDP*/AVS Voltage) A[3]		
15 < x ≤ 27							
27 < x ≤ 45		(*PDP*/28) A[1]					
45 < x ≤ 60			(*PDP*/36) A[1]				
60 < x ≤ 100				(*PDP*/48) A[1]	**Up to 75W:** • (15V – max voltage): ○ (*PDP*/AVS voltage) A **Above 75W:** • (15V – *PDP*/5A): ○ 5A • (>*PDP*/5A – max voltage): ○ (*PDP*/AVS voltage) A		
100 < x ≤ 140	*Table 10.3, "SPR Source Capabilities When Port Present PDP is less than Port Maximum PDP"* with a ***Port Present PDP*** of 100W.						
140 < x ≤ 180		5A					
180 < x ≤ 240		5A	5A				

1) The *Fixed Supply* PDOs Maximum Current field ***Shall*** *Advertise* either RoundDown (*PDP*/voltage) or RoundUp (*PDP*/voltage) to the nearest 10mA.

2) *EPR Source*s ***Shall*** reject any Request for more than the *Advertise*d *PDP*, i.e., when output voltage and operating current requested in the *Sink RDO* is outside of the defined *AVS* voltage and current range represented by the *Advertise*d *PDP*, the *RDO* will be rejected.

3) *EPR Source*s ***May*** offer an *(A)PDO*s at this ***Port Present PDP***. When offered, the *Fixed Supply PDO*s ***Maximum Current*** field ***Shall*** *Advertise* either RoundDown (*PDP*/Voltage) or RoundUp (*PDP*/Voltage) to the nearest 10mA.

4) This *EPR Fixed Supply* voltage is only available if allowed by *Table 10.12, "EPR Source Capabilities based on the Port Maximum PDP and using an EPR Capable Cable"* based on the port's *PDP Rating*.

5) The Max Voltage for *AVS* is what is allowed by T*Table 10.12, "EPR Source Capabilities based on the Port Maximum PDP and using an EPR Capable Cable"* based on the port's ***Port Maximum PDP***.

6) The current available based on *AVS* voltage is as indicated in this column. The current defined here is describing the top edge of the ***Valid*** Operating Region as illustrated in *Figure 10.6, "Valid EPR AVS Operating Region"*. *AVS APDO* does not have a Maximum Current field so the maximum current has to be calculated from the *PDP*.

Note: *EPR Managed Capability Ports* when power constrained are defined to offer higher voltages at lower ***Port Present PDP*** (as per *Table 10.13, "EPR Source Capabilities when Port Present PDP is less than Port Maximum PDP and using an EPR-capable cable"*) than the port's ***Port Maximum PDP*** (as per *Table 10.12, "EPR Source Capabilities based on the Port Maximum PDP and using an EPR Capable Cable"*) because these voltages would otherwise be available if the *Managed Capability Port* power hadn't been constrained. *Managed Capability Ports* are required to be properly identified to the user based on the port's ***Port Maximum PDP***.

In reference to *Table 10.13, "EPR Source Capabilities when Port Present PDP is less than Port Maximum PDP and using an EPR-capable cable"*, *Table 10.14, "EPR Source Examples when Port Present PDP is less than Port Maximum PDP"* gives examples of which *EPR Capabilities*, in addition to the required *SPR Fixed Supply* PDOs and *SPR AVS APDO*, are *Advertise*d based on ***Port Present PDP*** and the port's ***Port Maximum PDP***.

Table 10.14 EPR Source Examples when Port Present PDP is less than Port Maximum PDP

Port Maximum PDP	Port Present PDP	Offers			
		28V Fixed	36V Fixed	48V Fixed	AVS
200W	108W	3.86A	3A	2.25A	48V@108W
160W	108W	3.86A	3A	Not offered	36V@108W
120W	108W	3.86A	Not offered	Not offered	28V@108W
200W	72W	2.57A	2A	1.5A	48V@72W
160W	72W	2.57A	2A	Not offered	36V@72W
120W	72W	2.57A	Not offered	Not offered	28V@72W
200W	36W	1.29A	1A[1]	0.75A[1]	48V@36W[1]

1) These *Capabilities* are not required but may be offered at this ***Port Present PDP***.

Table 10.14 EPR Source Examples when Port Present PDP is less than Port Maximum PDP

Port Maximum PDP	Port Present PDP	Offers			
		28V Fixed	36V Fixed	48V Fixed	AVS
160W	36W	1.29A	1A[1]	Not offered	36V@36W[1]
120W	36W	1.29A	Not offered	Not offered	28V@36W
1) These *Capabilities* are not required but may be offered at this ***Port Present PDP***.					

*EPR Source*s when operating in an *AVS Explicit Contract* are required to stay within their *PDP* as such they ***Shall*** respond to any request (VA) for more than the *PDP* with a ***Reject*** *Message*. *Figure 10.6, "Valid EPR AVS Operating Region"* illustrates the definition of the ***Valid*** operating range for an *EPR Source* operating in an *AVS Explicit Contract* based on its *Advertised PDP*.

Figure 10.6 Valid EPR AVS Operating Region

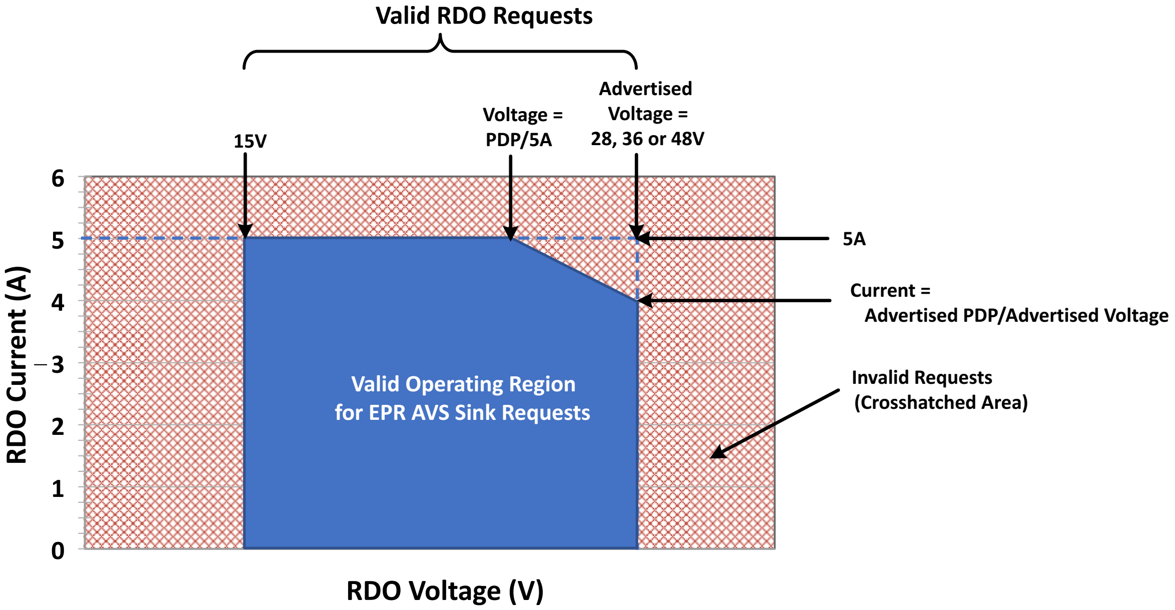
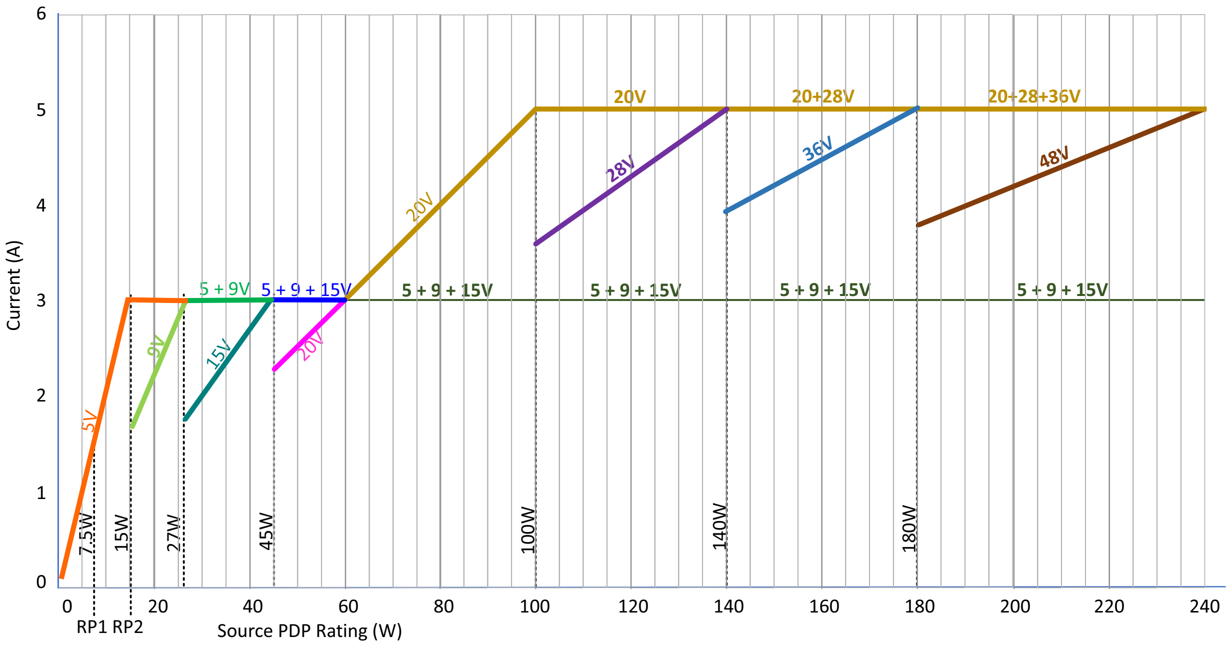


Figure 10.7, "EPR Source Power Rule Illustration for Fixed PDOs" illustrates the minimum current that an *EPR Source* ***Shall*** support at each voltage for a given *PDP Rating*.

Note: Not illustrated are that currents higher than 3A are allowed to be offered up to a limit of 5A given that a 5A cable is detected by the *Source* and the voltage times current remains within the *Source PDP Rating*.

Figure 10.7 EPR Source Power Rule Illustration for Fixed PDOs



10.2.3.3.1 EPR Adjustable Voltage Supply (AVS) Voltage Ranges

Table 10.15, "EPR Adjustable Voltage Supply (AVS) Voltage Ranges" shows the Minimum and Maximum Voltage for the *EPR AVS* ranges.

Table 10.15 EPR Adjustable Voltage Supply (AVS) Voltage Ranges

	AVS Voltage Ranges		
	28V AVS	36V AVS	48V AVS
Maximum Voltage	28V	36V	48V
Minimum Voltage	15V	15V	15V

The voltage output at the *Source*'s connector ***Shall*** be +/-5% for both the Maximum Voltage and the Minimum Voltage.

10.3 Sink Power Rules

10.3.1 Sink Power Rule Considerations

The *Sink Power Rules* are designed to ensure the best possible user experience when a given *Sink* used with a compliant *Source* of arbitrary Output Power Rating that only supplies the ***Normative*** voltages and currents.

The *Sink Power Rules* are based on the following considerations:

- Low power *Sources* (e.g., 5V) are expected to be very common and will be used with *Sink*s designed for a higher *PDP*.
- Optimizing the user experience when *Source*s with a higher *PDP Rating* are used with low power *Sink*s.
- Preventing *Sink*s that only function well (or at all) when using ***Optional*** voltages and currents.

10.3.2 Normative Sink Rules

*Sink*s designed to use *Source*s with a *PDP Rating* of x W ***Shall***:

- Either operate or charge from *Source*s that have a *PDP Rating* ≥ x W.
- Either operate, charge or indicate a *Capabilities Mismatch* (see *Section 6.4.2.3, "Capability Mismatch"*) from *Source*s that have a *PDP Rating* < x W and ≥ 0.5W.

A *Sink* optimized for a *Source* with ***Optional*** voltages and currents or power as described in *Section 10.2.3, "Optional Voltages/Currents"* with a *PDP Rating* of x W ***Shall*** provide a similar user experience when powered from a *Source* with a *PDP Rating* of ≥ x W that supplies only the ***Normative*** voltages and currents as specified in *Section 10.2.2, "Normative Voltages and Currents"*. For example, a 60W *Source* might not offer 9V Prog or 15V Prog since 20V Prog is a suitable substitute for both (as shown in *Table 10.10, "SPR Programmable Power Supply PDOs and APDOs based on the Port Maximum PDP"*).

The Operational Current/Power in the *Sink Capabilities* PDO for *Sink*s with an Operational *PDP* of x Watts ***Shall*** be as follows:

- Operational current for *Fixed Supply*/*Variable Supply* PDOs: RoundDown(x/voltage) to the nearest 10mA.
- Operational power for *Battery Supply* PDOs: ≤ x.
- Operational current for Programmable Power Supply *APDO*s as defined in *Table 10.10, "SPR Programmable Power Supply PDOs and APDOs based on the Port Maximum PDP"*: RoundDown (x/Prog Voltage) to the nearest 50mA.

The Maximum Current/Power in the *Sink RDO* for *Sink*s with an Operational *PDP* of x Watts and Maximum *PDP* of y Watts ***Shall*** be as follows:

- Maximum current for *Fixed Supply*/*Variable Supply RDO*s from *Sink*s without a *Battery*: RoundDown(x/voltage) to the nearest 10mA.
- Maximum current for *Fixed Supply*/*Variable Supply RDO*s from *Sink*s with a *Battery*: RoundDown(y/Voltage) to the nearest 10mA.
- Maximum power for *Battery Supply RDO*s from *Sink*s without a *Battery*: ≤ x.
- Maximum power for *Battery Supply RDO*s from *Sink*s with a *Battery*: ≤ y.
- Maximum current for PPS Supply *RDO*s from *Source* PDOs as defined in *Table 10.10, "SPR Programmable Power Supply PDOs and APDOs based on the Port Maximum PDP"* or *Table 10.14, "EPR Source Examples when Port Present PDP is less than Port Maximum PDP"*: RoundDown (y/Prog Voltage) to the nearest 50mA.

The following requirements ***Shall*** apply to the *Advertised Sink Capabilities*:

- A *Sink* ***Shall Not*** *Advertise Fixed Supply* PDO maximum voltages and currents that exceed the *PDP Rating* they were designed to use.
- A *Sink* ***Shall Not*** *Advertise Variable Supply* PDO maximum voltages and currents that exceed the *PDP Rating* they were designed to use.
- A *Sink* ***Shall Not*** *Advertise* a *Battery Supply* PDO maximum allowable power that exceeds the *PDP Rating* they were designed to use.
- A *Sink* ***Shall Not*** *Advertise* a PPS *APDO* maximum allowable power that exceeds the *PDP Rating* they were designed to use.
- A *Sink* ***Shall Not*** *Advertise* an *AVS APDO* maximum allowable power that exceeds the *PDP Rating* they were designed to use.

A CRC calculation

A.1 C code example

```
//
// USB PD CRC Demo Code.
//
#include <stdio.h>
int crc;
//-----------------------------------------------------------------------------
void crcBits(int x, int len) {
      const int poly = 0x04C11DB6; //spec 04C1 1DB7h
      int newbit, newword, rl_crc;
      for(int i=0; i<len; i++) {
            newbit = ((crc>>31) ^ ((x>>i)&1)) & 1;
            if(newbit) newword=poly; else newword=0;
            rl_crc = (crc<<1) | newbit;
            crc = rl_crc ^ newword;
            printf("%2d newbit=%d, x>>i=0x%x, crc=0x%x\n", i, newbit,(x>>i),crc);
      }
}
int crcWrap(int c){
      int ret = 0;
      int j, bit;
      c = ~c;
      printf("~crc=0x%x\n", c);
      for(int i=0;i<32;i++) {
            j = 31-i;
            bit = (c>>i) & 1;
            ret |= bit<<j;
      }
      return ret;
}
//-----------------------------------------------------------------------------
int main(){
      int txCrc=0,rxCrc=0,residue=0,data;
      printf("using packet data 0x%x\n", data=0x0101);
      crc = 0xffffffff;
      crcBits(data,16);
      txCrc = crcWrap(crc);
      printf("crc=0x%x, txCrc=0x%x\n", crc, txCrc);
      printf("received packet after decode= 0x%x, 0x%x\n", data, txCrc);
      crc = 0xffffffff;
      crcBits(data,16);
      rxCrc = crcWrap(crc);
      printf("Crc of the received packet data is (of course) =0x%x\n", rxCrc);
      printf("continue by running the transmit crc through the crc\n");
      crcBits(rxCrc,32);
      printf("Now the crc residue is 0x%x\n", crc);
      printf("should be 0xc704dd7b\n");
}
```

B Message Sequence Examples (Deprecated)

This appendix has been ***Deprecated***.

C VDM Command Examples

C.1 Discover Identity Example

C.1.1 Discover Identity Command request

Table C.1, "Discover Identity Command request from Initiator Example" below shows the contents of the key fields in the *Message Header* and *VDM Header* for an *Initiator* sending a ***Discover Identity*** *Command* request.

Table C.1 Discover Identity Command request from Initiator Example

Bit(s)	Field	Value
	Message Header	
15	***Reserved***	0
14…12	***Number of Data Objects***	1 (*VDM Header*)
11…9	***MessageID***	0…7
8	***Port Power Role***	0 or 1
7…6	***Specification Revision***	10b (*Revision 3.x*)
5…4	***Reserved***	0
3…0	***Message Type***	1111b (*Vendor Defined Message*)
	VDM Header	
B31…16	***Standard or Vendor ID (SVID)***	0xFF00 (***PD SID***)
B15	***VDM Type***	1 (*Structured VDM*)
B14…13	***Structured VDM Version (Major)***	01b (Version 2.0)
B12…11	***Structured VDM Version (Minor)***	01b (Version 2.1)
B10…8	***Object Position***	000b
B7…6	***Command Type***	00b (*Initiator*)
B5	***Reserved***	0
B4…0	***Command***	1 (***Discover Identity***)

C.1.2 Discover Identity Command response - Active Cable.

Table C.2, "Discover Identity Command response from Active Cable Responder Example" shows the contents of the key fields in the *Message Header* and *VDM Header* for a *Responder* returning *VDOs* in response to a ***Discover Identity*** *Command* request. In this illustration, the *Responder* is an active Gen2 cable which supports *Modal Operation*.

Table C.2 Discover Identity Command response from Active Cable Responder Example

Bit(s)	Field	Value
	Message Header	
15	***Reserved***	0
14…12	***Number of Data Objects***	5 (*VDM Header* + *ID Header VDO* + *Cert Stat VDO* + *Product VDO* + *Cable VDO*)
11…9	***MessageID***	0…7
8	***Cable Plug***	1
7…6	***Specification Revision***	10b (*Revision 3.x*)
5…4	***Reserved***	0
3…0	***Message Type***	1111b (*Vendor Defined Message*)
	VDM Header	
B31…16	***Standard or Vendor ID (SVID)***	0xFF00 (***PD SID***)
B15	***VDM Type***	1 (*Structured VDM*)
B14…13	***Structured VDM Version (Major)***	01b (Version 2.0)
B12…11	***Structured VDM Version (Minor)***	01b (Version 2.1)
B10…8	***Object Position***	000b
B7…6	***Command Type***	01b (*Responder* ***ACK***)
B5	***Reserved***	0
B4…0	***Command***	2 (***Discover Identity***)
	ID Header VDO	
B31	***USB Communications Capable as USB Host***	0 (not *USB Communications* capable as a *USB Host*)
B30	***USB Communications Capable as a*** *USB Device*	0 (not data capable as a Device)
B29…27	***SOP' Product Type (Cable Plug/VPD)***	100b (*Active Cable*)
B26	***Modal Operation Supported***	1 (supports Modes)
B25…16	***Reserved***. ***Shall*** be set to zero.	0
B15…0	16-bit unsigned integer. ***USB Vendor ID***	USB-IF assigned *VID* for this cable vendor
	Cert Stat VDO	
B31…0	32-bit unsigned integer	USB-IF assigned XID for this cable
	Product VDO	
B31…16	16-bit unsigned integer. USB Product ID	Product ID assigned by the cable vendor
B15…0	16-bit unsigned integer. bcdDevice	Device version assigned by the cable vendor
	Cable VDO1 (returned for Product Type "Active Cable")	
B31…28	***HW Version***	Cable HW version number (vendor defined)
B27…24	***Firmware Version***	Cable FW version number (vendor defined)
B23…21	***VDO Version***	010b (Version 1.2)

Table C.2 Discover Identity Command response from Active Cable Responder Example

Bit(s)	Field	Value
B20	***Reserved***	0
B19…18	***USB Type-C plug to USB Type-C/Captive***	10b (*USB Type-C*®)
B17	***EPR Capable (Active Cable)***	0 (not *EPR Capable*)
B16…13	***Cable Latency***	0001b (<10ns (~1m))
B12…11	***Cable Termination Type (Active Cable)***	11b (Both ends Active, *VCONN* required)
B10…9	***Maximum VBUS Voltage (Active Cable)***	00b (20V)
B8	***SBU Supported***	0 (SBUs connections supported)
B7	***SBU Type***	0 (SBU is passive)
B6…5	***VBUS Current Handling Capability (Active Cable)***	01b (3A)
B4	***VBUS Through Cable***	1 (Yes)
B3	***SOP'' Controller Present***	1 (*SOP''* controller present)
B2…0	***Reserved***	0
Cable VDO2 (returned for Product Type "Active Cable")		
B31…24	***Maximum Operating Temperature***	70
B23…16	***Shutdown Temperature***	80
B15	***Reserved***	0
B14…12	***U3/CLd Power***	010b (1-5mW)
B11	***U3 to U0 transition mode***	00b (U3 to U0 direct)
B10	***Physical connection***	0 (Copper)
B9	***Active element***	0 (Active Re-driver)
B8	***USB4 Supported***	0 (USB4 Supported)
B7…6	***USB 2.0 Hub Hops Consumed***	2
B5	***USB 2.0 Supported***	0 (*[USB 2.0]* supported)
B4	***USB 3.2 Supported***	0 (*[USB 3.2]* SuperSpeed supported)
B3	***USB Lanes Supported***	1b (Two lanes)
B2	***Optically Isolated Active Cable***	0 (Not supported)
B1	***USB4 Asymmetric Mode Supported***	0 (Not Supported)
B0	***USB Gen***	1b (Gen 2 or higher)

C.1.3 Discover Identity Command response - Hub.

Table C.3, "Discover Identity Command response from Hub Responder Example" shows the contents of the key fields in the *Message Header* and *VDM Header* for a *Responder* returning VDOs in response to a ***Discover SVIDs*** *Command* request. In this illustration, the *Responder* is a *Hub*.

Table C.3 Discover Identity Command response from Hub Responder Example

Bit(s)	Field	Value
Message Header		
15	***Reserved***	0
14…12	***Number of Data Objects***	4 (*VDM Header* + *ID Header VDO* + *Cert Stat VDO* + *Product VDO*)
11…9	***MessageID***	0…7
8	***Port Power Role***	0 or 1
7…6	***Specification Revision***	10b (*Revision 3.x*)
5…4	***Reserved***	0
3…0	***Message Type***	1111b (*Vendor Defined Message*)
VDM Header		
B31…16	***Standard or Vendor ID (SVID)***	0xFF00 (***PD SID***)
B15	***VDM Type***	1 (*Structured VDM*)
B14…13	***Structured VDM Version (Major)***	01b (Version 2.0)
B12…11	***Structured VDM Version (Minor)***	01b (Version 2.1)
B10…8	***Object Position***	000b
B7…6	***Command Type***	01b (*Responder* ***ACK***)
B5	***Reserved***	0
B4…0	***Command***	2 (***Discover Identity***)
ID Header VDO		
B31	***USB Communications Capable as USB Host***	0 (not *USB Communications* capable as a *USB Host*)
B30	***USB Communications Capable as a*** *USB Device*	1 (data capable as a Device)
B29…27	***SOP' Product Type (Cable Plug/VPD)***	001b (*Hub*)
B26	***Modal Operation Supported***	0 (doesn't support Modes)
B25…16	***Reserved***. ***Shall*** be set to zero.	0
B15…0	16-bit unsigned integer. ***USB Vendor ID***	USB-IF assigned *VID* for this *Hub* vendor
Cert Stat VDO		
B31…0	32-bit unsigned integer	USB-IF assigned XID for this *Hub*
Product VDO		
B31…16	16-bit unsigned integer. USB Product ID	Product ID assigned by the *Hub* vendor
B15…0	16-bit unsigned integer. bcdDevice	Device version assigned by the *Hub* vendor

C.2 Discover SVIDs Example

C.2.1 Discover SVIDs Command request

Table C.4, "Discover SVIDs Command request from Initiator Example" below shows the contents of the key fields in the *Message Header* and *VDM Header* for an *Initiator* sending a ***Discover SVIDs*** *Command* request.

Table C.4 Discover SVIDs Command request from Initiator Example

Bit(s)	Field	Value
	Message Header	
15	***Reserved***	0
14…12	***Number of Data Objects***	1 (*VDM Header*)
11…9	***MessageID***	0…7
8	***Port Power Role***	0 or 1
7…6	***Specification Revision***	10b (*Revision 3.x*)
5…4	***Reserved***	0
3…0	***Message Type***	1111b (*Vendor Defined Message*)
	VDM Header	
B31…16	***Standard or Vendor ID (SVID)***	0xFF00 (***PD SID***)
B15	***VDM Type***	1 (*Structured VDM*)
B14…13	***Structured VDM Version (Major)***	01b (Version 2.0)
B12…11	***Structured VDM Version (Minor)***	01b (Version 2.1)
B10…8	***Object Position***	000b
B7…6	***Command Type***	00b (*Initiator*)
B5	***Reserved***	0
B4…0	***Command***	2 (***Discover SVIDs***)

C.2.2 Discover SVIDs Command response

Table C.5, "Discover SVIDs Command response from Responder Example" shows the contents of the key fields in the *Message Header* and *VDM Header* for a *Responder* returning VDOs in response to a ***Discover SVIDs*** *Command* request. In this illustration, the value 3 in the Message Header ***Number of Data Objects*** field indicates that one VDO containing the supported SVIDs would be returned followed by a terminating VDO.

Note: The last VDO returned (the terminator of the transmission) contains zero value SVIDs. If a SVID value is zero, it is not used.

Table C.5 Discover SVIDs Command response from Responder Example

Bit(s)	Field	Value
	Message Header	
15	***Reserved***	0
14…12	***Number of Data Objects***	3 (*VDM Header* + 2*VDO)
11…9	***MessageID***	0…7
8	***Port Power Role***	0 or 1
7…6	***Specification Revision***	10b (*Revision 3.x*)
5…4	***Reserved***	0
3…0	***Message Type***	1111b (*Vendor Defined Message*)
	VDM Header	
B31…16	***Standard or Vendor ID (SVID)***	0xFF00 (***PD SID***)
B15	***VDM Type***	1 (*Structured VDM*)
B14…13	***Structured VDM Version (Major)***	01b (Version 2.0)
B12…11	***Structured VDM Version (Minor)***	01b (Version 2.1)
B10…8	***Object Position***	000b
B7…6	***Command Type***	01b (*Responder* ***ACK***)
B5	***Reserved***	0
B4…0	***Command***	2 (***Discover SVIDs***)
	VDO 1	
B31…16	SVID 0	SVID value
B15…0	SVID 1	SVID value
	VDO 2	
B31…16	SVID 2	0x0000
B15…0	SVID 3	0x0000

C.3 Discover Modes Example

C.3.1 Discover Modes Command request

Table C.6, "Discover Modes Command request from Initiator Example" shows the contents of the key fields in the *Message Header* and *VDM Header* for an *Initiator* sending a ***Discover Modes*** *Command* request. The *Initiator* of the ***Discover Modes*** *Command AMS* sends a Message Header with the ***Number of Data Objects*** field set to 1 followed by a *VDM Header* with the ***Command Type*** (B7…6) set to zero indicating the *Command* is from an *Initiator* and the ***Command*** (B4…0) is set to 3 indicating Mode discovery.

Table C.6 Discover Modes Command request from Initiator Example

Bit(s)	Field	Value
Message Header		
15	***Reserved***	0
14…12	***Number of Data Objects***	1 (*VDM Header*)
11…9	***MessageID***	0…7
8	***Port Power Role***	0 or 1
7…6	***Specification Revision***	10b (*Revision 3.x*)
5…4	***Reserved***	0
3…0	***Message Type***	1111b (*Vendor Defined Message*)
VDM Header		
B31…16	***Standard or Vendor ID (SVID)***	SVID for which Modes are being requested
B15	***VDM Type***	1 (*Structured VDM*)
B14…13	***Structured VDM Version (Major)***	01b (Version 2.0)
B12…11	***Structured VDM Version (Minor)***	01b (Version 2.1)
B10…8	***Object Position***	000b
B7…6	***Command Type***	00b (*Initiator*)
B5	***Reserved***	0
B4…0	***Command***	3 (***Discover Modes***)

C.3.2 Discover Modes Command response

The *Responder* to the ***Discover Modes*** *Command* request returns a Message Header with the ***Number of Data Objects*** field set to a value of 1 to 7 (the actual value is the number of Mode objects plus one) followed by a *VDM Header* with the ***Command Type*** (B7…6) set to 1 indicating the *Command* is from a *Responder* and the ***Command*** (B4…0) set to 3 indicating the following objects describe the Modes the device supports. If the ID is a *VID*, the structure and content of the VDO is left to the vendor. If the ID is a SID, the structure and content of the VDO is defined by the Standard.

Table C.7, "Discover Modes Command response from Responder Example" shows the contents of the key fields in the *Message Header* and *VDM Header* for a *Responder* returning VDOs in response to a ***Discover Modes*** *Command* request. In this illustration, the value 2 in the Message Header ***Number of Data Objects*** field indicates that the device is returning one VDO describing the Mode it supports. It is possible for a *Responder* to report up to six different Modes.

Table C.7 Discover Modes Command response from Responder Example

Bit(s)	Field	Value
Message Header		
15	***Reserved***	0
14…12	***Number of Data Objects***	2 (*VDM Header* + 1 Mode VDO)
11…9	***MessageID***	0…7
8	***Port Power Role***	0 or 1
7…6	***Specification Revision***	10b (*Revision 3.x*)
5…4	***Reserved***	0
3…0	***Message Type***	1111b (*Vendor Defined Message*)
VDM Header		
B31…16	***Standard or Vendor ID (SVID)***	SVID for which Modes were requested
B15	***VDM Type***	1 (*Structured VDM*)
B14…13	***Structured VDM Version (Major)***	01b (Version 2.0)
B12…11	***Structured VDM Version (Minor)***	01b (Version 2.1)
B10…8	***Object Position***	000b
B7…6	***Command Type***	01b (*Responder* ***ACK***)
B5	***Reserved***	0
B4…0	***Command***	3 (***Discover Modes***)
Mode VDO		
B31…0	Mode 1	Standard or Vendor defined Mode value

C.4 Enter Mode Example

C.4.1 Enter Mode Command request

The *Initiator* of the ***Enter Mode*** *Command* request sends a Message Header with the ***Number of Data Objects*** field set to 1 followed by a *VDM Header* with the ***Command Type*** (B7…6) set to 0 indicating the *Command* is from an *Initiator* and the ***Command*** (B4…0) set to 4 to request the *Responder* to enter its mode of operation and sets the Object Position field to the desired functional VDO based on its offset as received during Discovery.

Table C.8, "Enter Mode Command request from Initiator Example" shows the contents of the key fields in the *Message Header* and *VDM Header* for an *Initiator* sending an ***Enter Mode*** *Command* request.

Table C.8 Enter Mode Command request from Initiator Example

Bit(s)	Field	Value
Message Header		
15	***Reserved***	0
14…12	***Number of Data Objects***	1 (*VDM Header*)
11…9	***MessageID***	0…7
8	***Port Power Role***	0 or 1
7…6	***Specification Revision***	10b (*Revision 3.x*)
5…4	***Reserved***	0
3…0	***Message Type***	1111b (*Vendor Defined Message*)
VDM Header		
B31…16	***Standard or Vendor ID (SVID)***	SVID for the Mode being entered
B15	***VDM Type***	1 (*Structured VDM*)
B14…13	***Structured VDM Version (Major)***	01b (Version 2.0)
B12…11	***Structured VDM Version (Minor)***	01b (Version 2.1)
B10…8	***Object Position***	001b (a one in this field indicates a request to enter the first Mode in list returned by ***Discover Modes***)
B7…6	***Command Type***	00b (*Initiator*)
B5	***Reserved***	0
B4…0	***Command***	4 (***Enter Mode***)

C.4.2 Enter Mode Command response

The *Responder* that is the target of the ***Enter Mode*** *Command* request sends a Message Header with the ***Number of Data Objects*** field set to a value of 1 followed by a *VDM Header* with the ***Command Type*** (B7…6) set to 1 indicating the *Command* is from a *Responder* and the ***Command*** (B4…0) set to 4 indicating the *Responder* has entered the Mode and is ready to operate.

Table C.9, "Enter Mode Command response from Responder Example" shows the contents of the key fields in the *Message Header* and *VDM Header* for a *Responder* sending an ***Enter Mode*** *Command* response with an ***ACK***.

Table C.9 Enter Mode Command response from Responder Example

Bit(s)	Field	Value
Message Header		
15	***Reserved***	0
14…12	***Number of Data Objects***	1 (*VDM Header*)
11…9	***MessageID***	0…7
8	***Port Power Role***	0 or 1
7…6	***Specification Revision***	10b (*Revision 3.x*)
5…4	***Reserved***	0
3…0	***Message Type***	1111b (*Vendor Defined Message*)
VDM Header		
B31…16	***Standard or Vendor ID (SVID)***	SVID for the Mode entered
B15	***VDM Type***	1 (*Structured VDM*)
B14…13	***Structured VDM Version (Major)***	01b (Version 2.0)
B12…11	***Structured VDM Version (Minor)***	01b (Version 2.1)
B10…8	***Object Position***	001b (offset of the Mode entered)
B7…6	***Command Type***	01b (*Responder* ***ACK***)
B5	***Reserved***	0
B4…0	***Command***	4 (***Enter Mode***)

C.4.3 Enter Mode Command request with additional VDO.

The *Initiator* of the ***Enter Mode*** *Command* request sends a Message Header with the ***Number of Data Objects*** field set to 2 indicating an additional VDO followed by a *VDM Header* with the ***Command Type*** (B7…6) set to zero indicating the *Command* is from an *Initiator* and the ***Command*** (B4…0) set to 4 to request the *Responder* to enter its mode of operation and sets the Object Position field to the desired functional VDO based on its offset as received during Discovery.

Table C.10, "Enter Mode Command request with additional VDO Example" shows the contents of the key fields in the *Message Header* and *VDM Header* for an *Initiator* sending an ***Enter Mode*** *Command* request with an additional VDO.

Table C.10 Enter Mode Command request with additional VDO Example

Bit(s)	Field	Value
Message Header		
15	***Reserved***	0
14…12	***Number of Data Objects***	1 (*VDM Header*)
11…9	***MessageID***	0…7
8	***Port Power Role***	0 or 1
7…6	***Specification Revision***	10b (*Revision 3.x*)
5…4	***Reserved***	0
3…0	***Message Type***	1111b (*Vendor Defined Message*)
VDM Header		
B31…16	***Standard or Vendor ID (SVID)***	SVID for the Mode being entered
B15	***VDM Type***	1 (*Structured VDM*)
B14…13	***Structured VDM Version (Major)***	01b (Version 2.0)
B12…11	***Structured VDM Version (Minor)***	01b (Version 2.1)
B10…8	***Object Position***	001b (a one in this field indicates a request to enter the first Mode in list returned by ***Discover Modes***)
B7…6	***Command Type***	00b (*Initiator*)
B5	***Reserved***	0
B4…0	***Command***	4 (***Enter Mode***)
Including ***Optional*** Mode specific VDO		
B31…0	Mode specific	

C.5 Exit Mode Example

C.5.1 Exit Mode Command request

The *Initiator* of the ***Exit Mode*** *Command* request sends a Message Header with the ***Number of Data Objects*** field set to 1 followed by a *VDM Header* with the ***Command Type*** (B7…6) set to zero indicating the *Command* is from an *Initiator* and the ***Command*** (B4…0) set to 5 to request the *Responder* to exit its Mode of operation.

Table C.11, "Exit Mode Command request from Initiator Example" shows the contents of the key fields in the *Message Header* and *VDM Header* for an *Initiator* sending an ***Exit Mode*** *Command* request.

Table C.11 Exit Mode Command request from Initiator Example

Bit(s)	Field	Value
Message Header		
15	***Reserved***	0
14…12	***Number of Data Objects***	1 (*VDM Header*)
11…9	***MessageID***	0…7
8	***Port Power Role***	0 or 1
7…6	***Specification Revision***	10b (*Revision 3.x*)
5…4	***Reserved***	0
3…0	***Message Type***	1111b (*Vendor Defined Message*)
VDM Header		
B31…16	***Standard or Vendor ID (SVID)***	SVID for the Mode being exited
B15	***VDM Type***	1 (*Structured VDM*)
B14…13	***Structured VDM Version (Major)***	01b (Version 2.0)
B12…11	***Structured VDM Version (Minor)***	01b (Version 2.1)
B10…8	***Object Position***	001b (identifies the previously entered Mode by its Object Position that is to be exited)
B7…6	***Command Type***	00b (*Initiator*)
B5	***Reserved***	0
B4…0	***Command***	5 (***Exit Mode***)

C.5.2 Exit Mode Command response

The *Responder* that receives the ***Exit Mode*** *Command* request sends a Message Header with the ***Number of Data Objects*** field set to a value of 1 followed by a *VDM Header* with the ***Command Type*** (B7…6) set to 1 indicating the *Command* is from a *Responder* and the ***Command*** (B4…0) set to 5 indicating the *Responder* has exited the Mode and has returned to normal USB operation.

Table C.12, "Exit Mode Command response from Responder Example" shows the contents of the key fields in the *Message Header* and *VDM Header* for a *Responder* sending an ***Exit Mode*** *Command* ***ACK*** response.

Table C.12 Exit Mode Command response from Responder Example

Bit(s)	Field	Value
Message Header		
15	***Reserved***	0
14…12	***Number of Data Objects***	1 (*VDM Header*)
11…9	***MessageID***	0…7
8	***Port Power Role***	0 or 1
7…6	***Specification Revision***	10b (*Revision 3.x*)
5…4	***Reserved***	0
3…0	***Message Type***	1111b (*Vendor Defined Message*)
VDM Header		
B31…16	***Standard or Vendor ID (SVID)***	SVID for the Mode exited
B15	***VDM Type***	1 (*Structured VDM*)
B14…13	***Structured VDM Version (Major)***	01b (Version 2.0)
B12…11	***Structured VDM Version (Minor)***	01b (Version 2.1)
B10…8	***Object Position***	001b (offset of the Mode to be exited)
B7…6	***Command Type***	01b (*Responder* ***ACK***)
B5	***Reserved***	0
B4…0	***Command***	5 (***Exit Mode***)

C.6 Attention Example

C.6.1 Attention Command request

The *Initiator* of the ***Attention*** *Command* request sends a Message Header with the ***Number of Data Objects*** field set to 1 followed by a *VDM Header* with the ***Command Type*** (B7…6) set to zero indicating the *Command* is from an *Initiator* and the ***Command*** (B4…0) set to 6 to request attention from the *Responder*.

Table C.13, "Attention Command request from Initiator Example" shows the contents of the key fields in the *Message Header* and *VDM Header* for an *Initiator* sending an ***Attention*** *Command* request.

Table C.13 Attention Command request from Initiator Example

Bit(s)	Field	Value
Message Header		
15	***Reserved***	0
14…12	***Number of Data Objects***	1 (*VDM Header*)
11…9	***MessageID***	0…7
8	***Port Power Role***	0 or 1
7…6	***Specification Revision***	10b (*Revision 3.x*)
5…4	***Reserved***	0
3…0	***Message Type***	1111b (*Vendor Defined Message*)
VDM Header		
B31…16	***Standard or Vendor ID (SVID)***	SVID for which attention is being requested
B15	***VDM Type***	1 (*Structured VDM*)
B14…13	***Structured VDM Version (Major)***	01b (Version 2.0)
B12…11	***Structured VDM Version (Minor)***	01b (Version 2.1)
B10…8	***Object Position***	001b (offset of the Mode requesting attention)
B7…6	***Command Type***	00b (*Initiator*)
B5	***Reserved***	0
B4…0	***Command***	6 (***Attention***)

C.6.2 Attention Command request with additional VDO.

The *Initiator* of the ***Attention*** *Command* request sends a Message Header with the ***Number of Data Objects*** field set to 2 indicating an additional VDO followed by a *VDM Header* with the ***Command Type*** (B7…6) set to zero indicating the *Command* is from a *Responder* and the ***Command*** (B4…0) set to 6 to request attention from the *Responder*.

Table C.14, "Attention Command request from Initiator with additional VDO Example" shows the contents of the key fields in the *Message Header* and *VDM Header* for an *Initiator* sending an ***Attention*** *Command* request with an additional VDO.

Table C.14 Attention Command request from Initiator with additional VDO Example

Bit(s)	Field	Value
	Message Header	
15	***Reserved***	0
14…12	***Number of Data Objects***	2 (*VDM Header* + VDO)
11…9	***MessageID***	0…7
8	***Port Power Role***	0 or 1
7…6	***Specification Revision***	10b (*Revision 3.x*)
5…4	***Reserved***	0
3…0	***Message Type***	1111b (*Vendor Defined Message*)
	VDM Header	
B31…16	***Standard or Vendor ID (SVID)***	SVID for which attention is being requested
B15	***VDM Type***	1 (*Structured VDM*)
B14…13	***Structured VDM Version (Major)***	01b (Version 2.0)
B12…11	***Structured VDM Version (Minor)***	01b (Version 2.1)
B10…8	***Object Position***	001b (offset of the Mode requesting attention)
B7…6	***Command Type***	000b (*Initiator*)
B5	***Reserved***	0
B4…0	***Command***	6 (***Attention***)
	Including *Optional* Mode specific VDO	
B31…0	Mode specific	

D BMC Receiver Design Examples

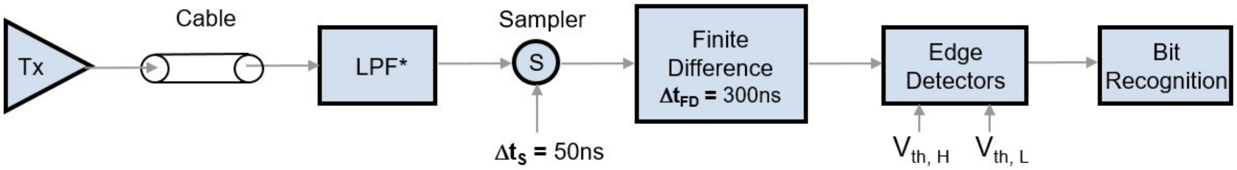
The *BMC* signal is DC-coupled so that the voltage level is affected by the ground *IR Drop*. The DC offset of the *BMC* signal at Power Source and Power *Sink* are in the opposite directions. When the *VBUS* current is increased from 0A, the *BMC* signal waveform shifts downward at Power *Sink* and shifts upward at Power Source. This section introduces two sample *BMC* receiver circuit implementations, which are immune from DC offset and high current load step. They can be used in Power Source, Power *Sink* and inside cables.

D.1 Finite Difference Scheme

D.1.1 Sample Circuitry

The sample Finite Difference *BMC* receiver shown in *Figure D.1, "Circuit Block of BMC Finite Difference Receiver"*consists of the Rx bandwidth limiting filter with the time constant ***tRxFilter***, a sampler with the sampling step Δt_S, 50ns, a Finite Difference Calculator which calculates the voltage difference between the time interval of Δt_{FD}, 300ns, an edge detector controlled by two voltage thresholds, $V_{th,\ H}$ and $V_{th,\ L}$ and a logic block for bit recognition.

Figure D.1 Circuit Block of BMC Finite Difference Receiver



D.1.2 Theory

This section describes the fundamental theory of Finite Difference Scheme to recover the received *BMC* signal with the input and output signal waveforms of the circuit blocks shown in *Figure D.1, "Circuit Block of BMC Finite Difference Receiver"*. To illustrate the robustness of the implementation, the *VBUS* current load step rate is intentionally increased to 2A/µs at the *Sink* load. In *Figure D.2, "BMC AC and DC noise from VBUS at Power Sink"* (a), the red curve represents the *VBUS* current measured at the Power *Sink* when the current is increased at 9 µs from 0A to 5A and the blue dash curve represents the *VBUS* current measured at the *USB Type-C*®connector of the power *Sink*. In this example, the peak current overshoot with larger load step rate is increased to 518 mA which exceeds ***iOvershoot***. *Figure D.2, "BMC AC and DC noise from VBUS at Power Sink"* (b) shows the total *BMC* noise at Power *Sink*, coupled from *VBUS* and D+/D- through the worst ***[USB Type-C 2.4]*** compliant cable, after the Rx bandwidth limiting filter with the time constant ***tRxFilter*** is applied. The noise can be decomposed into 3 components. The first is the DC offset, I_{VBUS}(t)*RGND, while I_{VBUS} is the *VBUS* current and R_{GND} is the ground DC resistance of the cable. The offset is negative in Power *Sink* and positive at Power Source. The second noise component is the inductive *VBUS* noise, M*d I_{VBUS}(t)/dt, while M is the mutual inductance between the *VBUS* and *CC* wires in the cable and d I_{VBUS}(t)/dt is the load step rate. The third component is ***[USB 2.0]*** Full Speed SE0 coupling noise which would normally occur randomly but was assumed to occur periodically in the simulation to account for the crosstalk in any phase between the *BMC* and ***[USB 2.0]*** signals. In *Figure D.3, "Sample BMC Signals (a) without USB 2.0 SE0 Noise (b) with USB 2.0 SE0 Noise"*, the blue dash curve represents the *BMC* signal when there is no *VBUS* current, and the red solid curve represents the *BMC* signal affected by the *VBUS* coupling noise shown in *Figure D.2, "BMC AC and DC noise from VBUS at Power Sink"*(b). The green solid curve is the sample ***[USB 2.0]*** noise, after the Rx bandwidth limiting filter with the time constant ***tRxFilter*** is applied.

Figure D.2 BMC AC and DC noise from VBUS at Power Sink

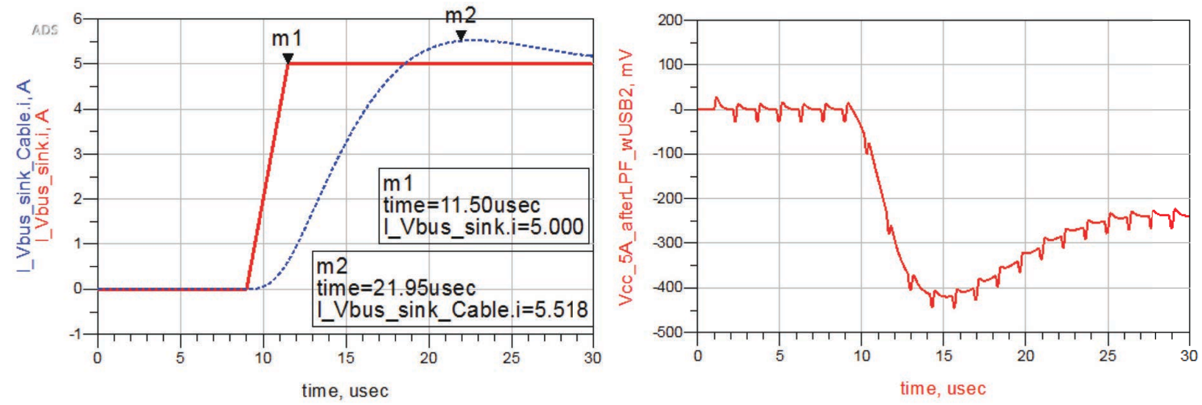
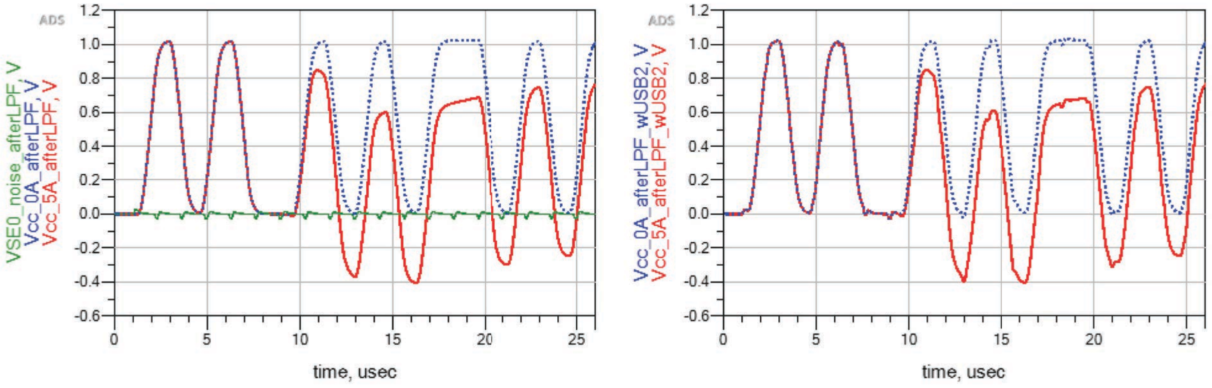


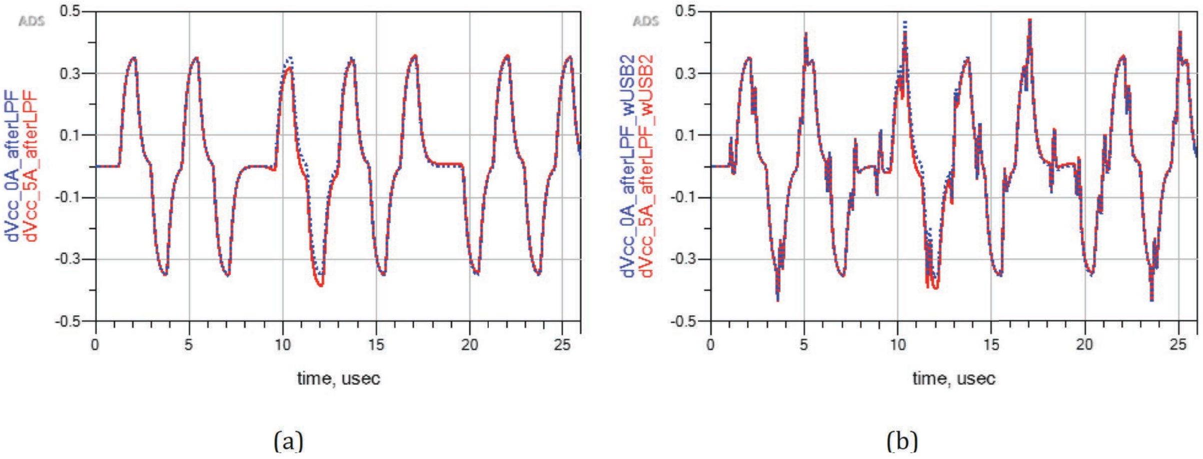
Figure D.3 Sample BMC Signals (a) without USB 2.0 SE0 Noise (b) with USB 2.0 SE0 Noise



(a) (b)

The *BMC* signals shown in *Figure D.3, "Sample BMC Signals (a) without USB 2.0 SE0 Noise (b) with USB 2.0 SE0 Noise"* are sampled every 50ns and the scaled derivative waveforms, Vcc(t) - Vcc (t - 50ns), without and with ***[USB 2.0]*** noise are shown in *Figure D.4, "Scaled BMC Signal Derivative with 50ns Sampling Rate (a) without USB 2.0 Noise (b) with USB 2.0 Noise"* (a) and (b), respectively. In *Figure D.4, "Scaled BMC Signal Derivative with 50ns Sampling Rate (a) without USB 2.0 Noise (b) with USB 2.0 Noise"* (a), if there is no ***[USB 2.0]*** noise, the derivative waveform just changes slightly before and after the *VBUS* current transition. That means, the slope of the *BMC* waveform is not sensitive to the DC offset and is very useful to be used to design a robust receiver against a large DC offset. However, the derivative waveforms with ***[USB 2.0]*** noise have large perturbation as shown in *Figure D.4, "Scaled BMC Signal Derivative with 50ns Sampling Rate (a) without USB 2.0 Noise (b) with USB 2.0 Noise"* (b).

Figure D.4 Scaled BMC Signal Derivative with 50ns Sampling Rate (a) without USB 2.0 Noise (b) with USB 2.0 Noise

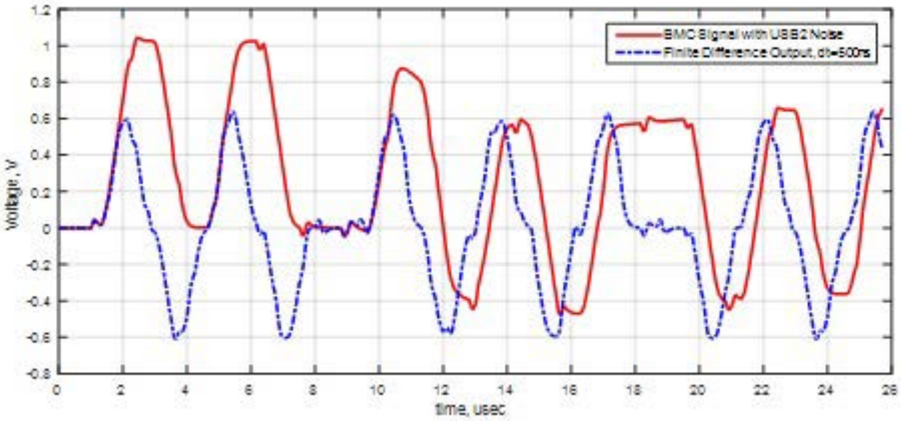


(a)

(b)

To remove the high frequency content of the *[USB 2.0]* noise, Finite Difference technique with the proper time interval is applied to the *BMC* waveform with *[USB 2.0]* noise in *Figure D.3, "Sample BMC Signals (a) without USB 2.0 SE0 Noise (b) with USB 2.0 SE0 Noise"*. Using Backward Finite Difference Calculator, ΔVcc = Vcc (t) - Vcc(t- Δt), *Figure D.5, "BMC Signal and Finite Difference Output with Various Time Steps"* shows the Finite Difference Output while Δt = 500ns. The larger the time interval Δt is, the larger the peak-to-peak magnitude of the Finite Difference Output will be. However, the time interval is bounded by the rise time of the *BMC* signal so that 300ns to 500ns is a good range of the time interval.

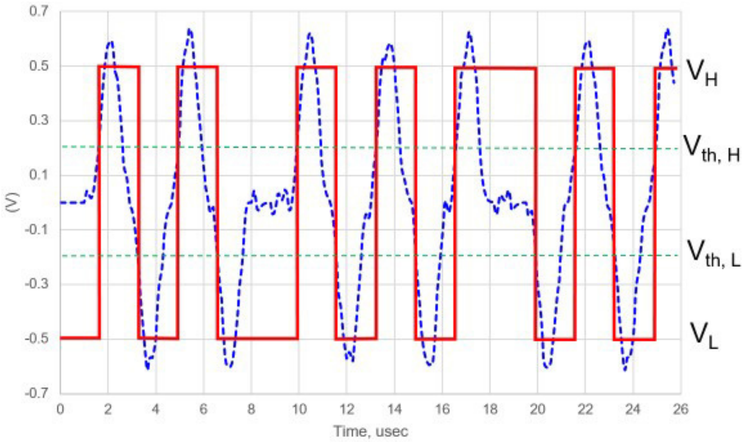
Figure D.5 BMC Signal and Finite Difference Output with Various Time Steps



D.1.3 Data Recovery

The edge detection is followed by the Finite Difference Calculation. At the input of the edge detector, if the voltage is larger than $V_{th, H}$ at the rising edge, the output will become high voltage level, V_H, if the voltage is smaller than $V_{th, L}$ at the falling edge, the output will become low voltage level, V_L. In this example, $V_{th, H}$ and $V_{th, L}$ are 0.2V and -0.2V, respectively. The solid curve in *Figure D.6, "Output of Finite Difference in dash line and Edge Detector in solid line"* represents the output of the edge detector, where V_H is 0.5V and V_L is -0.5V.

Figure D.6 Output of Finite Difference in dash line and Edge Detector in solid line



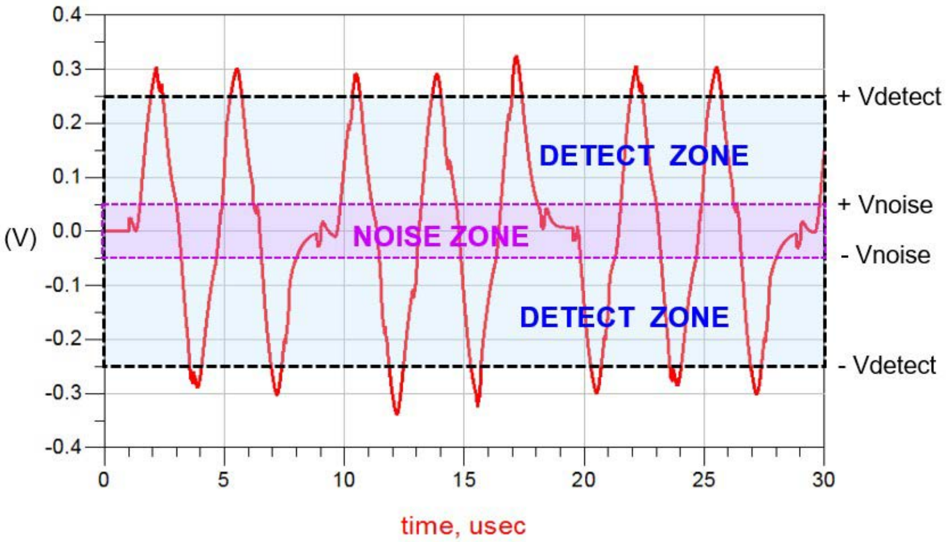
The duty cycle of the output signal from the edge detector varies depending on the thresholds, $V_{th, H}$ and $V_{th, L}$, as well as jitter and noise from silicon and channel. The techniques such as integrating receiver can be used to recover the *BMC* signal.

D.1.4 Noise Zone and Detection Zone

Figure D.7, "Noise Zone and Detect Zone of BMC Receiver" shows the output of Finite Difference when the time interval of Finite Difference is set to 300ns. The noise Zone is defined in between +Vnoise and -Vnoise, in which the noise glitches occur. The detect zone is defined in between +Vdetect and -Vdetect, excluding the noise zone. The thresholds of the edge detectors, $V_{th, H}$ and $V_{th, L}$, must be properly set within the detect zone so that the data can be recovered successfully.

In this example, Vdetect is 250mV and Vnoise is 50mV. It is highly recommended that the product implemented with the similar techniques indicates the performance with the range of Vnoise and Vdetect in the electrical specification.

Figure D.7 Noise Zone and Detect Zone of BMC Receiver

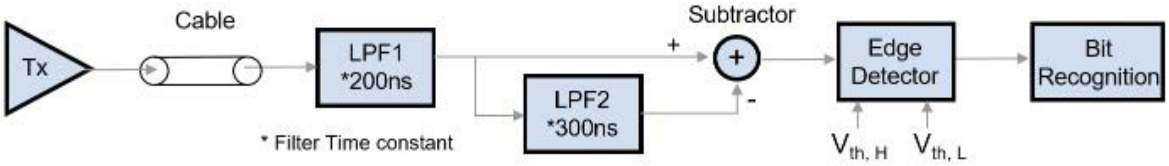


D.2 Subtraction Scheme

D.2.1 Sample Circuitry

The sample Subtraction *BMC* receiver shown in *Figure D.8, "Circuit Block of BMC Subtraction Receiver"* consists of the two Low Pass Filters (LPF1 and LPF2), a Subtractor, an Edge Detector and a logic block for bit recognition. The time constant of the first and second LPF are 200ns and 300ns, respectively. The Subtractor subtracts the LPF1 output from the LPF2 output. The Edge Detector controlled by two voltage thresholds, $V_{th, H}$ and $V_{th, L}$ to recover the data.

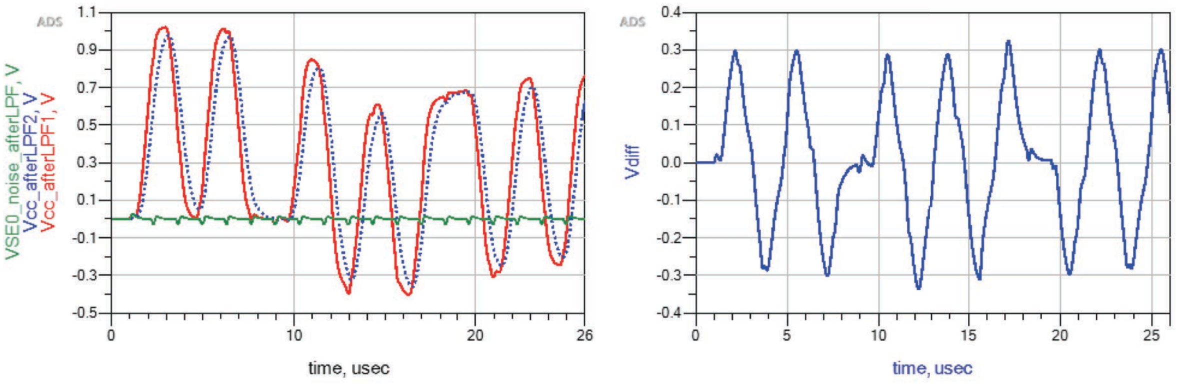
Figure D.8 Circuit Block of BMC Subtraction Receiver



D.2.2 Output of Each Circuit Block

Figure D.9, "(a) Output of LPF1 and LPF2 (b) Subtraction of LPF1 and LPF2 Output" (a) shows the output of LPF1 as the red solid line and LPF2 as the blue dash line as well as the ***[USB 2.0]*** noise in green solid line. *Figure D.9, "(a) Output of LPF1 and LPF2 (b) Subtraction of LPF1 and LPF2 Output"* (b) shows the voltage difference between the two output filters, Vdiff = Vcc_afterLPF1 - Vcc_afterLPF2. The Vdiff waveform looks very similar to the Finite Difference output waveform shown in *Figure D.6, "Output of Finite Difference in dash line and Edge Detector in solid line"* so that the data recovery method through the edge detector is the same as described in *Section D.1.3, "Data Recovery"*.

Figure D.9 (a) Output of LPF1 and LPF2 (b) Subtraction of LPF1 and LPF2 Output

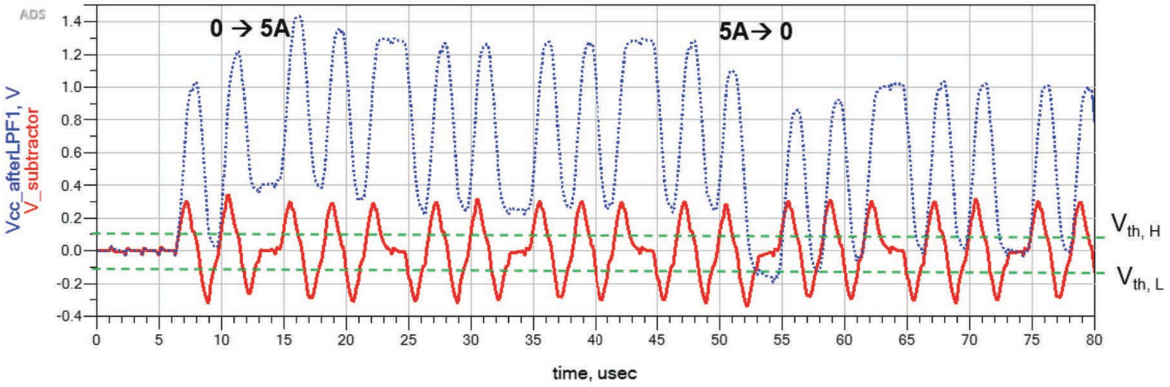


(a) **(b)**

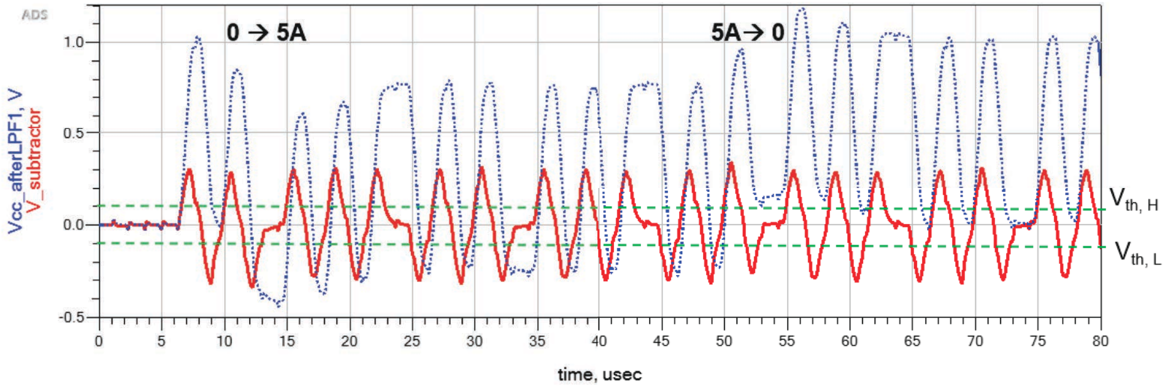
D.2.3 Subtractor Output at Power Source and Power Sink

The following figures shows the example when the *VBUS* current increases from 0A to 5A and then decreases to 0A with high load step rate. The output of the LPF1 and the Subtractor at Power Source and Power *Sink* are shown in *Figure D.10, "Output of the BMC LPF1 in blue dash curve and the Subtractor in red solid curve (a) at Power Source (b) at Power Sink"* (a) and (b), respectively. Although the *BMC* signals at Power Source and Power *Sink* shift toward the opposite direction, the Subtractor outputs at Power Source and Power *Sink* are almost identical disregard of the opposite direction of the DC offset.

Figure D.10 Output of the BMC LPF1 in blue dash curve and the Subtractor in red solid curve (a) at Power Source (b) at Power Sink



(a)



(b)

D.2.4 Noise Zone and Detection Zone

The zone definition is the same as defined in *Section D.1.4, "Noise Zone and Detection Zone"*. The sizes of the noise zone and detection zone of the Subtraction Scheme are dependent on the filter time constant. When the time constant of the first and second LPF are 200ns and 300ns, respectively, Vdetect is 250mV and Vnoise is 50mV. It is highly recommended that the product implemented with the similar techniques indicates the performance with the range of Vnoise and Vdetect in the electrical specification.

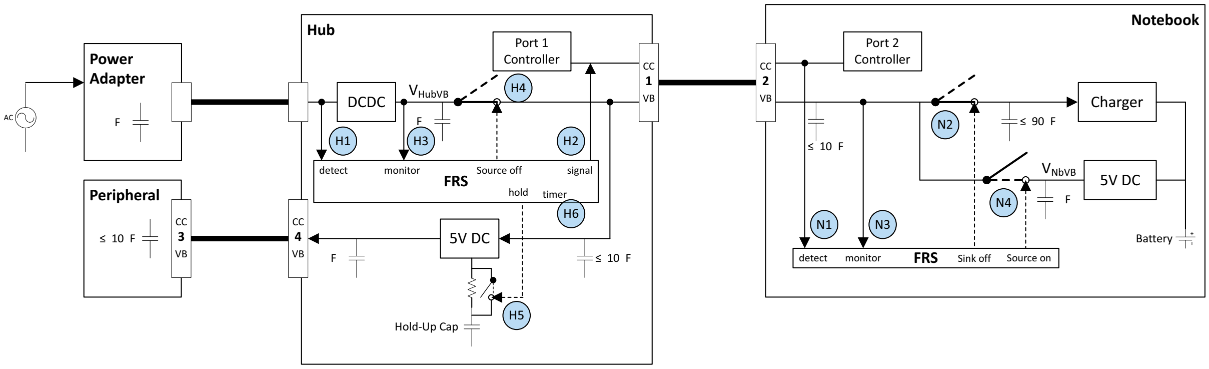
E FRS System Level Example

E.1 Overview

Appendix E, "FRS System Level Example" is intended to clarify *Fast Role Swap* (*FRS*) functionality at the system level through the use of an example implementation.

Figure E.1, "Example FRS Capable System" is an example of a *Hub* and laptop implementation that supports *Fast Role Swap* (see *Figure 7.16, "VBUS Power during Fast Role Swap"*). It is not the only possible *Hub* or laptop architecture. However, it is intended to provide an example system whose functionality is used here to illustrate how *Fast Role Swap* works.

Figure E.1 Example FRS Capable System



This appendix describes two cases that cover a variety of behaviors that might be seen in practice.

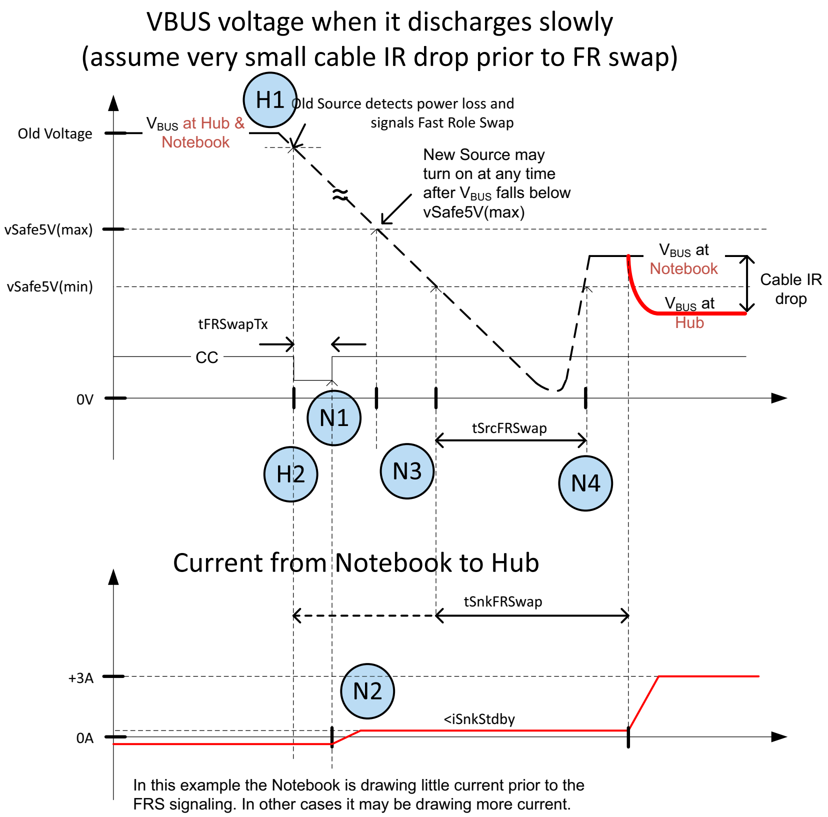
- Slow *VBUS* Discharge where *VBUS* between the *Hub* and the laptop takes more than 15ms (***tFRSwapInit***) to discharge below 5.5 V (***vSafe5V*** (max)). In this case the ***FR_Swap*** *Message* is sent by the laptop while *VBUS* is still greater than ***vSafe5V*** (max). See *Figure E.2, "Slow VBUS Discharge"*.
- Fast *VBUS* Discharge where *VBUS* between the *Hub* and the laptop discharges very quickly, perhaps before the *Fast Role Swap Request* is even complete. See *Figure E.3, "Fast VBUS Discharge"*.

However, neither the *Hub* nor the laptop can anticipate how quickly *VBUS* will discharge until the power adapter is disconnected from an *AC Supply* or it is unplugged from the *Hub*.

The *Fast Role Swap Request* is the momentary low driven by the *Hub* on the *CC* wire which is detected by the laptop.

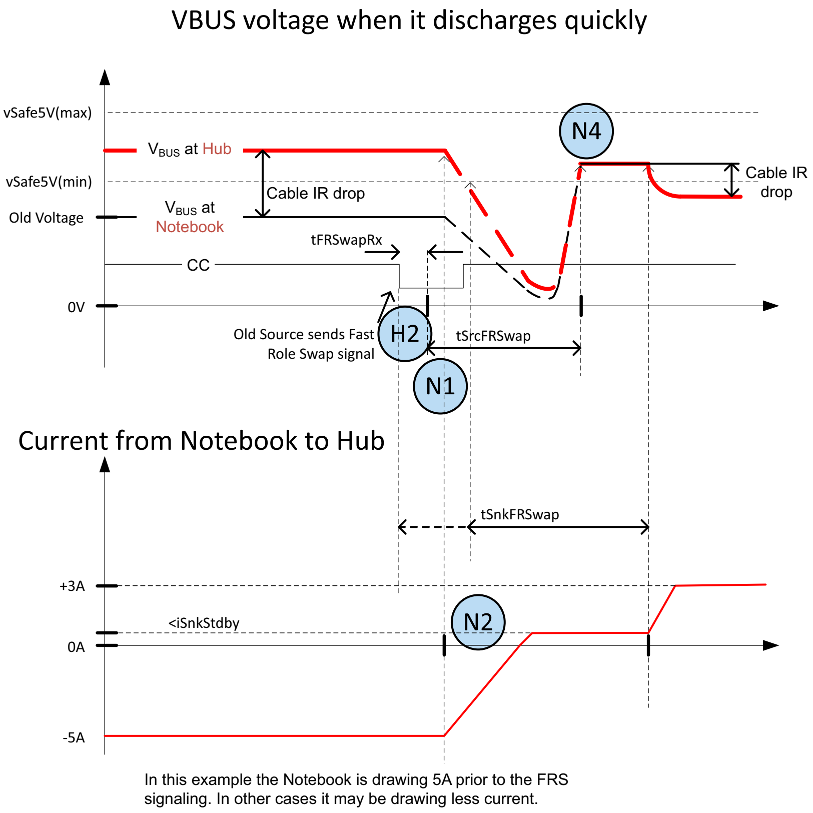
Figure E.2, "Slow VBUS Discharge" and *Figure E.3, "Fast VBUS Discharge"* show the voltage seen on *VBUS* in relationship to the *Fast Role Swap Request* They also show the transition between when the *Hub* stops supplying *VBUS* and when the laptop starts supplying *VBUS*.

Figure E.2 Slow VBUS Discharge


VBUS voltage when it discharges slowly
(assume very small cable IR drop prior to FR swap)
H1
Old Source detects power loss and signals Fast Role Swap
Old Voltage
V_{BUS} at Hub & Notebook
New Source may turn on at any time after V_{BUS} falls below vSafe5V(max)
vSafe5V(max)
vSafe5V(min)
V_{BUS} at Notebook
Cable IR drop
V_{BUS} at Hub
tFRSwapTx
CC
0V
N1
tSrcFRSwap
H2
N3
N4
Current from Notebook to Hub
tSnkFRSwap
+3A
N2
<iSnkStdby
0A

In this example the Notebook is drawing little current prior to the FRS signaling. In other cases it may be drawing more current.

Figure E.3 Fast VBUS Discharge



E.2 FRS Initial Setup

Before a *Fast Role Swap* can occur, some initial setup steps are required. They require the laptop to discover whether *Fast Role Swap* is supported by the *Hub*, the amount of current the *Hub* requires after a *Fast Role Swap*, and whether the laptop is able and willing to provide that amount. They also ensure that the laptop supplies *VCONN* before, during and after an *FRS*. *Table E.1, "Sequence for setup of a Fast Role Swap (Hub connected to Power Adapter first)"* and *Table E.2, "Sequence for setup of a Fast Role Swap (Hub connected to laptop before Power Adapter)"* below show two typical sequences that might be used to prepare a laptop to support *Fast Role Swap*.

Table E.1 Sequence for setup of a Fast Role Swap (Hub connected to Power Adapter first)

Step #	Hub	Laptop
1	*Hub* connected to power adapter	
2	*Hub* is connected to laptop.	
3		Laptop sources 5 V to *VBUS* (***vSafe5V***). Laptop sources 5 V to *VCONN*
4		Laptop reads the cable to check its current carrying capability and/or if it is an *Active Cable* requiring *VCONN*.
5		Laptop sends a *Capabilities Message*
6	*Hub* sends a ***Request*** *Message*	
7	*Hub* and laptop establish an *Explicit Contract* with *Hub* as *Sink*.	
8		Laptop sends a ***Get_Source_Cap*** *Message* to determine how much power the *Hub* can provide.
9	*Hub* sends a ***Source_Capabilities*** *Message* with the ***Dual-Role Power*** bit set, and ***Unconstrained Power*** bit set, and ***Maximum Current*** > 0.	
10		Since the *Hub* can supply power the laptop sends a ***PR_Swap*** *Message*
11	*Hub* sends an ***Accept*** *Message* and starts supplying *VBUS*	
12		Laptop sends a ***Get_Sink_Cap*** *Message* to determine the current required by the *Hub* to support an *FRS*. If the *Hub* does not support *FRS* or the laptop cannot supply the required current, the laptop ***Ignores*** any *Fast Role Swap Requests* it might see.
13	If the *Hub* can supply more than 3A, it initiates a *VCONN Swap* to make to make itself the *VCONN Source* and reads the cable to check its current carrying capability.	
14	*Hub* sends a ***Sink_Capabilities*** *Message*	
15		Laptop sends a ***Request*** *Message*
16	*Hub* and laptop establish an *Explicit Contract* with *Hub* as source.	

Table E.1 Sequence for setup of a Fast Role Swap (Hub connected to Power Adapter first)

Step #	Hub	Laptop
17		If the laptop has detected that it is connected via an *Active Cable* (or one that supports *Alternate Modes*) and/or that it can support an *FRS*, it initiates a *VCONN Swap* to make itself the *VCONN Source*. This removes a requirement that the *Hub* to hold up *VCONN* during the *FRS*.
18	Normal PD Power traffic flow	
19	The *Hub* and laptop are now ready to do a *Fast Role Swap* in case the power adapter gets removed.	

Table E.2 Sequence for setup of a Fast Role Swap (Hub connected to laptop before Power Adapter)

Step #	Hub	Laptop
0	*Hub* is connected to laptop.	
1		Laptop sources 5 V to *VBUS* (***vSafe5V***). Laptop sources 5 V to *VCONN*
2		Laptop reads the cable to check its current carrying capability and/or if it is an *Active Cable* requiring *VCONN*.
3		Laptop sends ***Source_Capabilities*** *Message*
4	*Hub* sends ***Request*** *Message*	
5	*Hub* and laptop establish an *Explicit Contract* with *Hub* as *Sink*.	
6		Laptop sends a ***Get_Source_Cap*** *Message* to determine how much power the *Hub* can provide
7	*Hub* sends a ***Source_Capabilities*** *Message* with the ***Dual-Role Power*** bit set, and ***Unconstrained Power*** bit cleared, and ***Maximum Current*** = 0.	
8		Since the *Hub* cannot supply power, the laptop does not send a ***PR_Swap*** *Message*
9	The power adapter is connected to the *Hub*	
10	If the *Hub* can source more than 3A, it initiates a *VCONN Swap* to become the *VCONN Source*.	
11	*Hub* reads the e-marker to determine the cable's current carrying capability.	
12	*Hub* initiates a *Power Role Swap* to become the *Source*	
13	*Hub* sends a ***Source_Capabilities*** *Message* with the Unconstrained Power bit set and Maximum Current > 0.	
14	*Hub* and laptop establish an *Explicit Contract* with *Hub* as source.	
15		Laptop sends a ***Get_Sink_Cap*** *Message* to determine the current required by the *Hub* to support an *FRS*. If the *Hub* does not support *FRS* or the laptop cannot supply the required current, the laptop ***Ignores*** any *Fast Role Swap Requests* it might see.

Table E.2 Sequence for setup of a Fast Role Swap (Hub connected to laptop before Power Adapter)

Step #	Hub	Laptop
16		If the laptop has detected that it is connected via an *Active Cable* (or one that supports *Alternate Modes*) and/or that it can support an *FRS*, it initiates a *VCONN Swap* to make itself the *VCONN Source*. This removes a requirement that the *Hub* also hold up *VCONN* during the *FRS*.
17	The *Hub* and laptop are now ready to do a *Fast Role Swap* in case the power adapter gets removed.	

E.3 FRS Process

After the initial setup is completed and the laptop has determined both that the *Hub* can request *FRS* and that the laptop is able and willing to supply the requested current, the system is ready to support *FRS*. This section describes the sequence of events that take place during a *Fast Role Swap*. The following figures and tables do not cover the actions of the *Device Policy Manager* or the Policy Engine. Those actions occur orthogonally to the electrical events shown in this appendix. However, the diagrams do indicate the inputs/outputs where the DPM and Policy Engine interact with the electrical events:

- The laptop sends the ***FR_Swap*** *Message* to initiate the *FRS AMS* (see *Figure 7.43, "Transition Diagram for Fast Role Swap"*) within 15ms after the laptop detects the *Fast Role Swap Request* on *CC*.
- The laptop sends the final ***PS_RDY*** *Message* in the *FRS AMS* only after it is sourcing *VBUS*.

Figure E.4 Slow VBUS discharge after FR_Swap message is sent

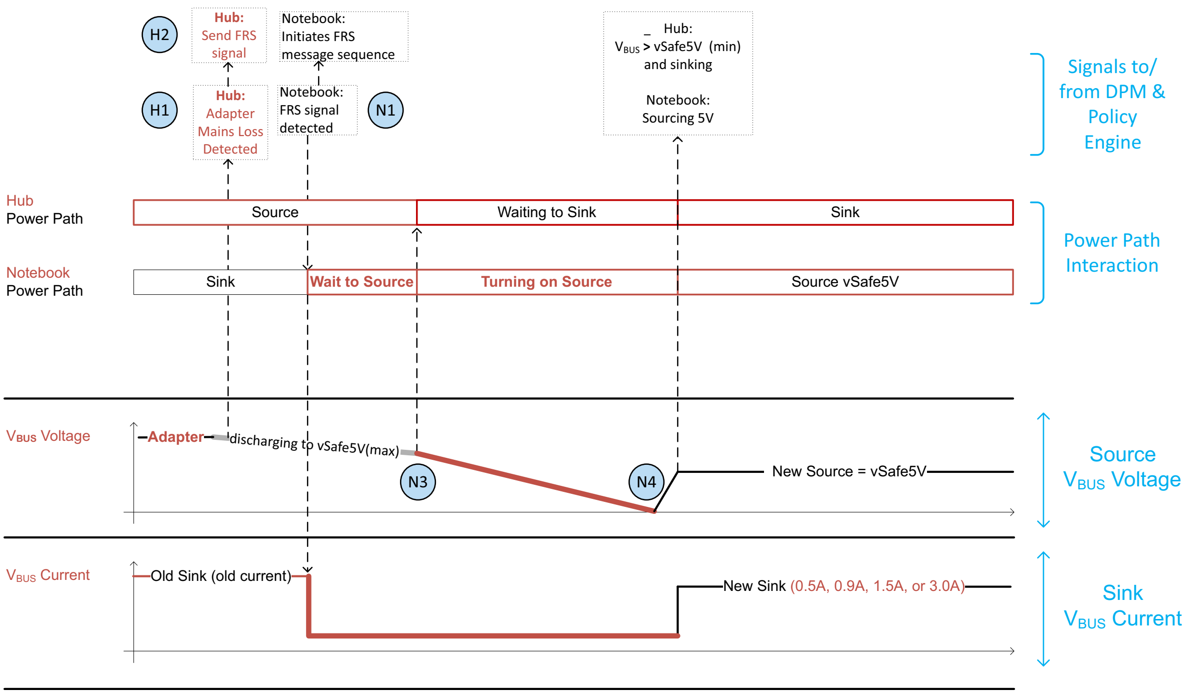


Table E.3 Sequence for slow VBUS discharge (it discharges after FR_Swap message is sent)

Step #	Hub	Laptop
1	The power adapter’s *AC Supply* power is lost.	
2	*Hub* detects the power adapter disconnect (H1) as quickly as possible.	
3	*Hub* sends *Fast Role Swap Request* on *CC* (H2) and starts monitoring V_{HubVB} (H3). *Hub* also starts a ***tSnkFRSwap*** timer after the FRS signal begins and *VBUS* has fallen below ***vSafe5V*** (min).	
4		Laptop detects *Fast Role Swap Request* on *CC* (N1) that triggers sending of the ***FR_Swap*** *Message*. This can happen at any point in the following steps so long as it is within 15 ms (***tFRSwapInit***).
5		Laptop opens the sinking switch (N2), as quickly as possible to minimize power drained from *Hub* after the *Fast Role Swap Request*.
6		Laptop begins monitoring *VBUS* (N3) to know when to turn the laptop into a *Source* .
7	*Hub* opens the sourcing switch (H4) while V_{HubVB} > 5.5V (after the *Fast Role Swap Request* is sent). However, the sourcing switch (H4) must be kept closed until V_{HubVB} is as close to 5.5V as possible. It is important for the *Hub* to open its sourcing switch (H4) before the laptop’s sourcing switch (N4) gets closed to minimize inrush current.	
8	*Hub* closes the switch (H5) to use the hold-up capacitor to supply *VBUS* to the peripheral(s). Systems with a holding cap permanently in place do not need the switch (H5). *Hub* does not draw more than ***iSnkStdby*** from *VBUS*, until the ***tSnkFRSwap*** timer expires.	
9		Laptop detects *VBUS* < V_{NbVB} (N1) before closing the sourcing switch (N4) when V_{NbVB} is as close as possible to 5.5V. This minimizes the time when *VBUS* is not sourced.
10		Laptop closes sourcing switch (N4). When this occurs the *Hub*’s input capacitance on *VBUS* will be less than 10μF (***cSnkBulk***).
11	*Hub*’s ***tSnkFRSwap*** timer expires (H6).	
12	*Hub* draws up to the current it *Advertise*d in the ***Fast Role Swap required USB Type-C Current*** field of its ***Sink_Capabilities*** *Message*.	
13	*Hub*s with (H5) will open (H5) and remove the Hold-Up capacitor.	

Figure E.5 VBUS discharges quickly before FR_Swap message is sent after adapter disconnected

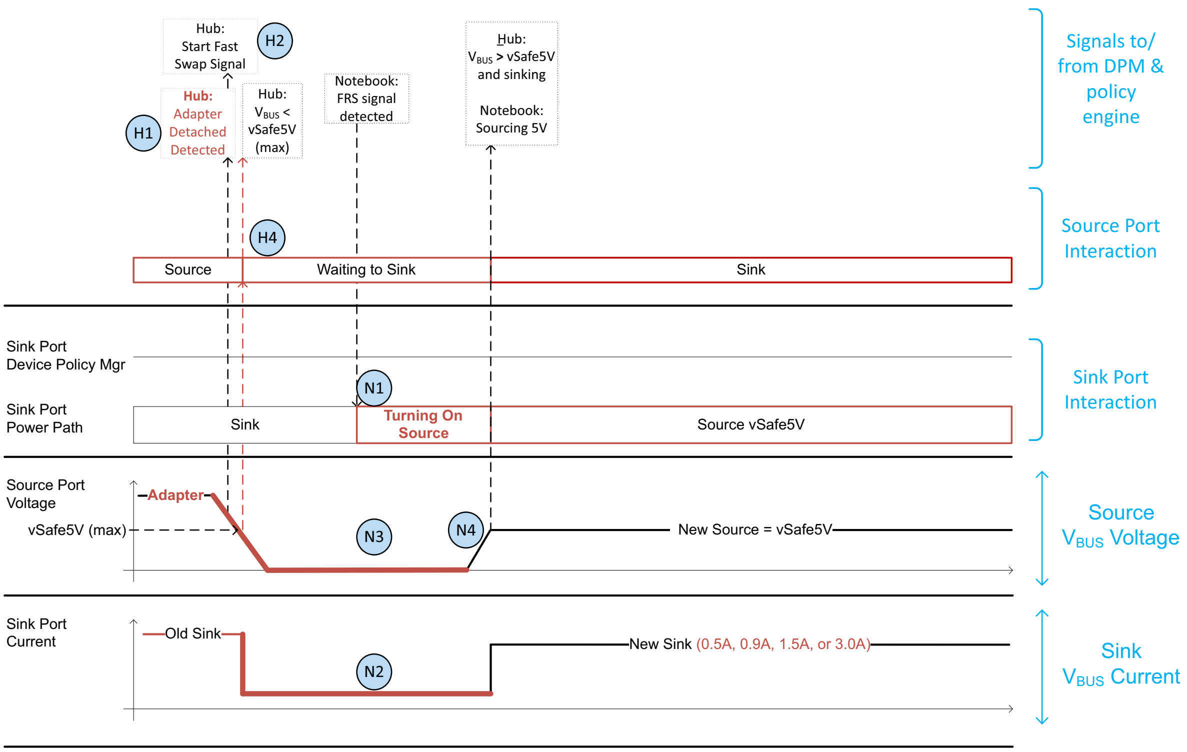


Table E.4 VBUS discharges quickly after adapter disconnected

Step #	Hub	Laptop
1	The power adapter is *Detached* from the *Hub*.	
2	*Hub* detects power adapter disconnect (H1)-causing V_{HubVB} to drop below 5.5V very rapidly.	
3	*Hub* sends *Fast Role Swap Request* on *CC* (H2) and starts monitoring V_{HubVB} (H3). *Hub* opens sourcing switch (H4). *Hub* also starts a ***tSnkFRSwap*** timer.	
4	*Hub* closes the switch (H5) to use the hold-up capacitor to supply *VBUS* to the peripheral(s). Systems with a holding cap permanently in place do not need the switch (H5). *Hub* does not draw more than ***iSnkStdby*** from *VBUS*, until the ***tSnkFRSwap*** timer expires.	
5		Laptop detects *Fast Role Swap Request* on *CC* (N1) that triggers sending of the ***FR_Swap*** *Message*. This can happen at any point in the following steps so long as it is within 15 ms (***tFRSwapInit***).
6		Laptop opens the sinking switch (N2), as quickly as possible to minimize power drained from *Hub* after the *Fast Role Swap Request*.
7		Laptop begin monitoring *VBUS* (N3) to know when to turn the laptop into a *Source* .

Table E.4 VBUS discharges quickly after adapter disconnected

Step #	Hub	Laptop
8		Laptop detects *VBUS* < V_{NbVB} (N3).
9		Laptop closes sourcing switch (N4). When this occurs the *Hub*'s input capacitance on *VBUS* will be less than 10 µF (***cSnkBulk***).
10	*Hub*'s ***tSnkFRSwap*** timer expires (H6).	
11	*Hub* draws up to the current it *Advertise*d in the ***Fast Role Swap required USB Type-C Current*** field of its ***Sink_Capabilities*** *Message*.	
12	*Hub*s with (H5) will open (H5) and remove the Hold-Up capacitor.	