



USB Power Delivery Transport Interface Specification

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USB POWER DELIVERY TRANSPORT I/F

REV	CN	ORIGINATOR	DATE	DESCRIPTION OF CHANGE
0.22	Not Released	John Sisto	2013/08/08	Initial Release
0.24		Chris Murphy	2013/08/13	Updated "PD Request" Table 1.24 on page 23 with new bRequestType values
0.25		Chris Murphy	2013/08/21	<ul style="list-style-type: none"> Updated bit definitions in Table 1.32 on page 31 to include three bits for the Port Operation Mode and Last Command State fields. Shifted remaining bits to accommodate. Added note after Table 1.26 on page 25: "For system level PD feature selector commands (RECIPIENT = Device), the clear feature command must only be used to clear change statuses." Moved the AUTO_XXX_SWAP_YYY features into POLICY_MODE (Table 1.38 on page 38)
0.26		Chris Murphy	2013/08/30	<ul style="list-style-type: none"> Added new DEVICE_READY bit 3 to SMBus Status 0 definition in Table 1.9 on page 9. Updated PORT_POWER_ON definition and created new PORT_PD_CONFIGURED feature selector in Table 1.26 on page 25 and Section 1.8.16. Fixed "AUTO_NGT_PWR_RANGE_CONSUMER" to "AUTO_NEGOTIATION_POWER_CONSUMER" in Table 1.26 on page 25. Fixed "AUTO_NEGOTIATE_POWER_RANGE_CONSUMER" to "AUTO_NEGOTIATE_POWER_CONSUMER" in Section 1.8.21. Removed "POLICY_MODE" from step 11 description in Section 1.8.28.1.
0.27		Chris Murphy	2013/09/23	<ul style="list-style-type: none"> Minor typos and grammar Changed bit 0 in Table 1.33 on page 33 to Reserved. Changed bit 14 name and description in Table 1.33 on page 33 Added new section, "GetPortStatus PD Request Example" on page 45
Distribution Locations: Specification Location #58				

REV	CN	ORIGINATOR	DATE	DESCRIPTION OF CHANGE
0.30		Chris Murphy	2013/10/8	<ul style="list-style-type: none"> Fixed spelling and grammar in Section 1.1 and throughout document. Moved Section 1.8.27.1 to the top of Section 1.8.27 Updated definition of DATA_OUT_BUF_STATE in Table 1.7 Updated definition of DATA_IN_BUF_STATE in Table 1.8 Updated examples in Section 1.4.6 Corrected final WRITE_DATA entry from "S" to "P" (stop condition) in Figure 1.11 and Figure 1.5 Added ladder diagram Figure 1.12 to Section 1.8.28.1 Moved "GetPortStatus PD Request Example" on page 45 into Section 1.8.27
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Chapter 1 Transport Interface Definition

1.1 Overview

This document defines a transport framework to enable communication with a variety of PD devices.

1.2 PD Communication Stack

Figure 1.1 depicts the PD communication stack. Each of the elements shown below are implemented in the part. The Policy Engine and Device Policy Manager are implemented by FW.

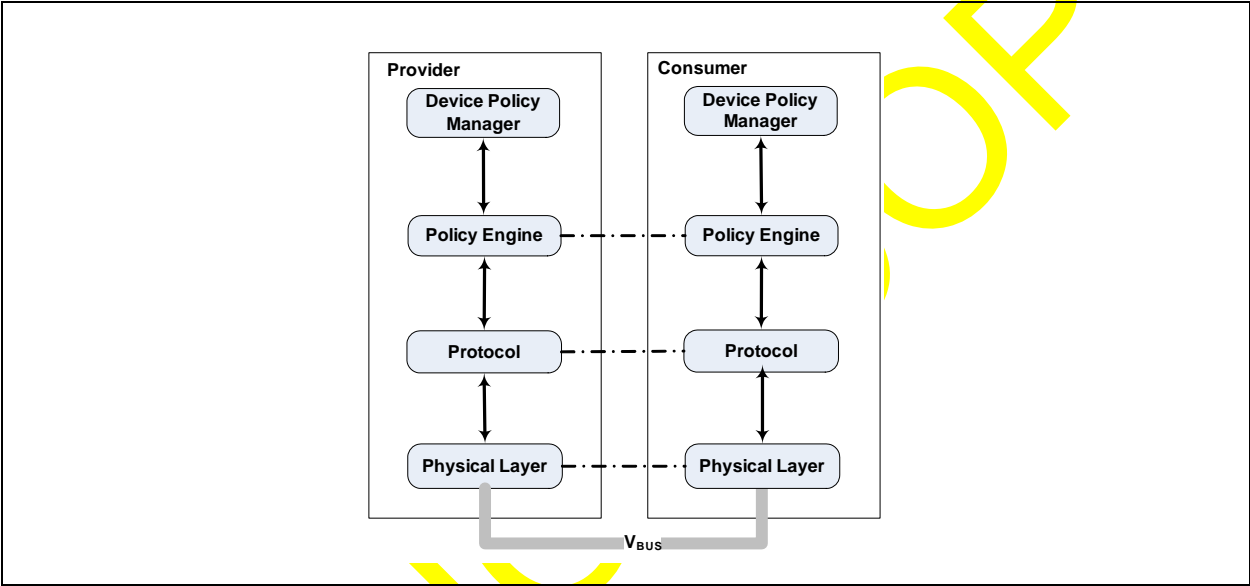


Figure 1.1 USB Power Delivery Communications Stack

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Figure 1.2 depicts the optional System Policy Manager. In this diagram SPM resides in a host controller in a future PD aware operating system.

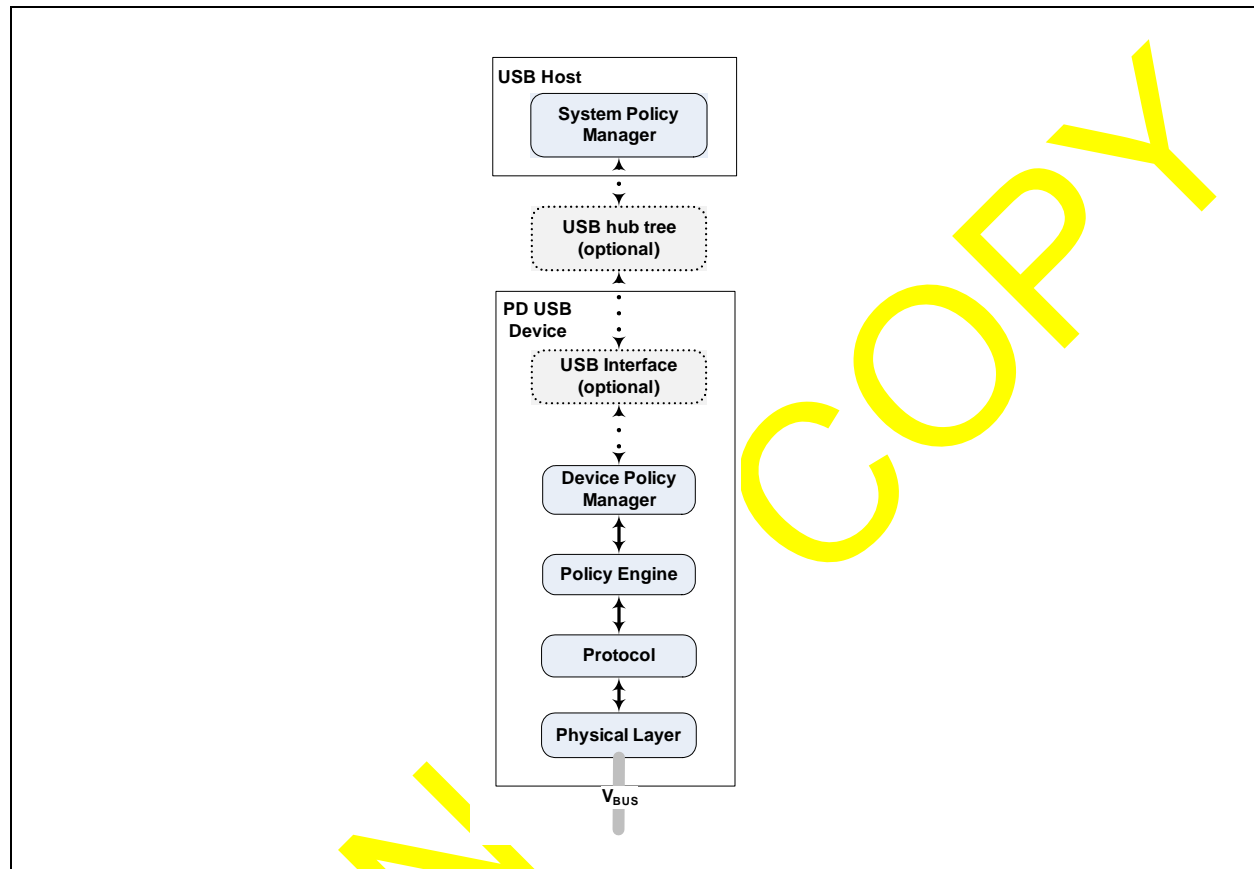


Figure 1.2 PD Communication Layers

1.2.1 Intrusive vs. Non-Intrusive Operation

The controller supports both Intrusive and Non-Intrusive operation as defined by the USB PD specification. Per specification Intrusive mode means that each and every request, which can be handled by the System Policy Manager, received by the Device Policy Manager is passed up to the USB Host for a response. In applications where it is partnered with a PD enabled hub the SPM function may reside in the hub.

Figure 1.3 illustrates a use case where multiple PD controllers are managed by PD enabled hub. Each controller's FW implements Policy Engine and Device Policy Manager and is controlled by the hub via SMBUS. The hub contains SPM module which allows it to orchestrate power allocation across each controller.

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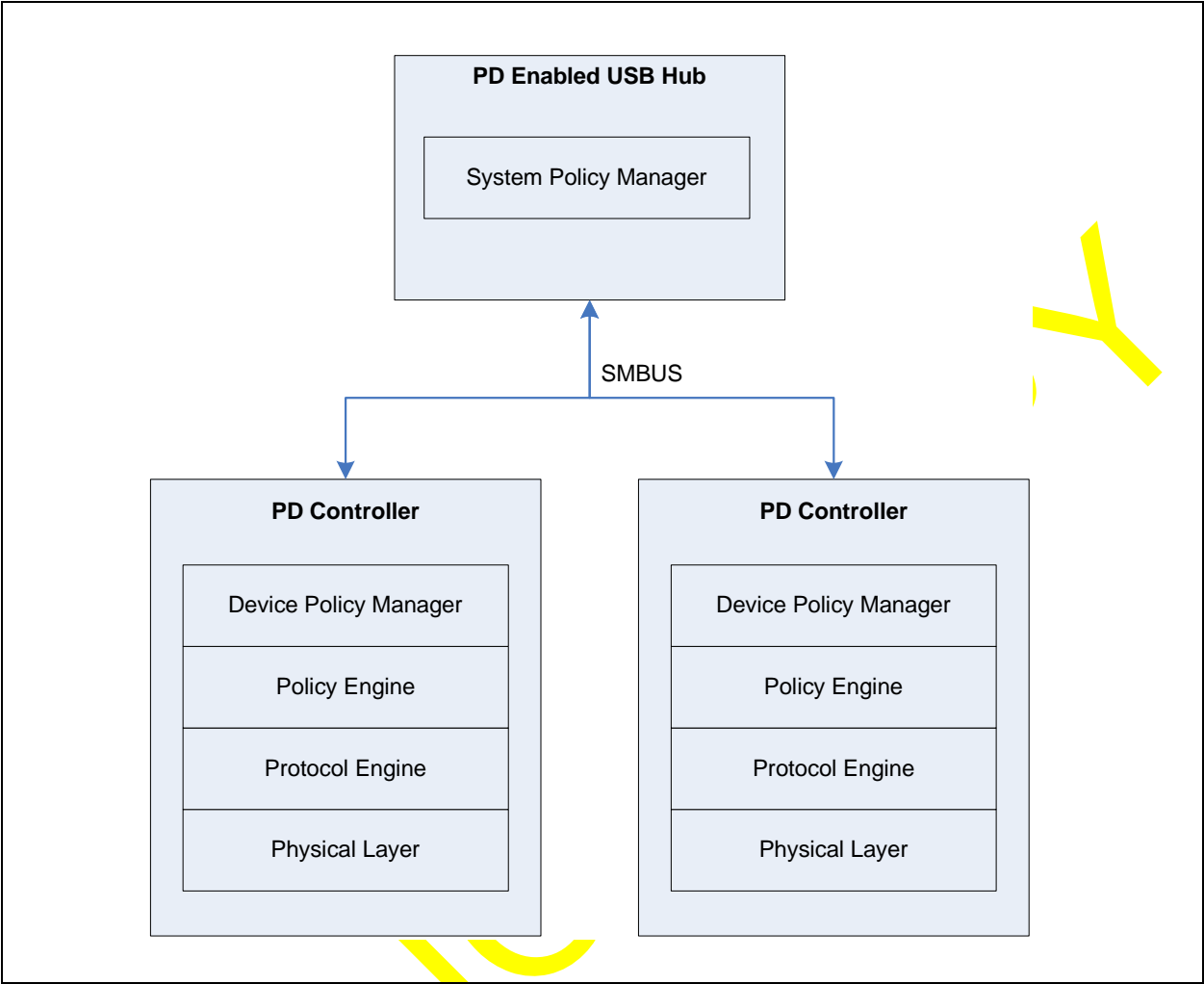


Figure 1.3 Operation with Intrusive PD USB Hub

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Figure 1.4 illustrates the controller operating in standalone mode. In this scenario SPM functions are implemented by the FW. This architecture is used in applications such as AC/DC adapters where the PD controller may be the only entity with processing capabilities.

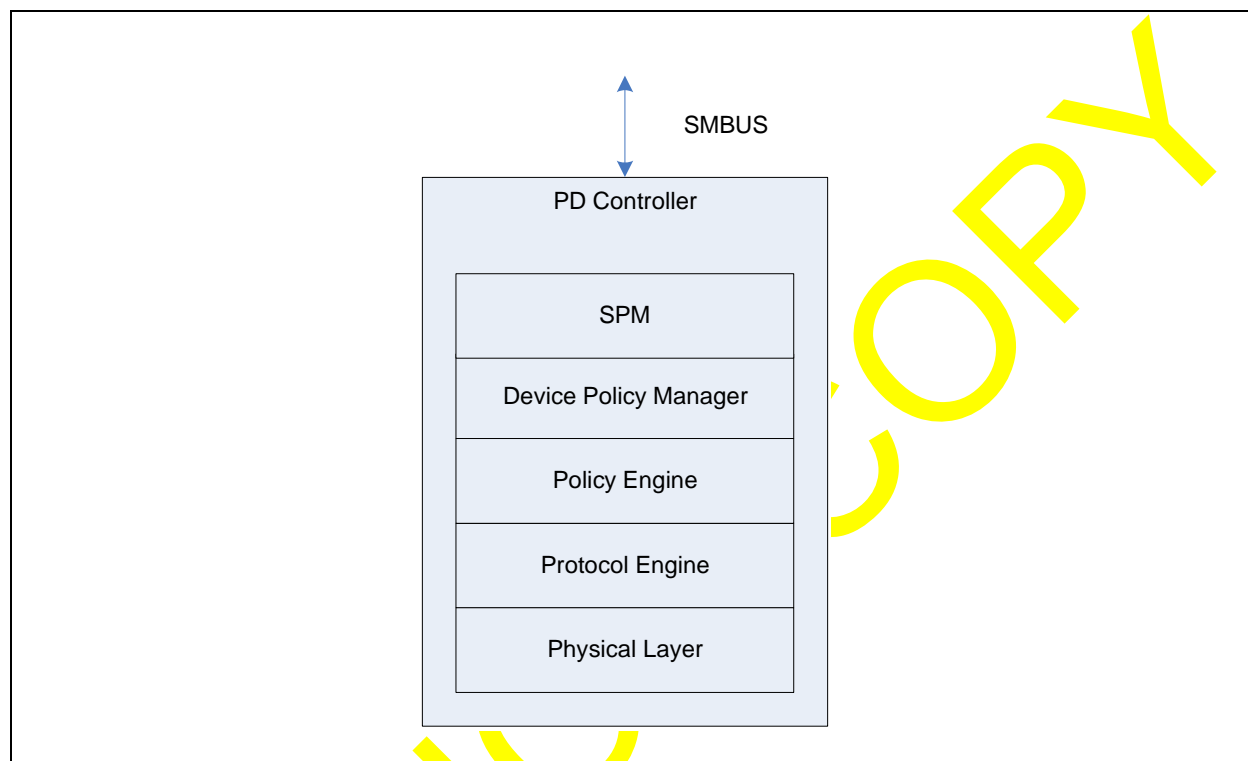


Figure 1.4 Standalone Operation

1.3 SMBUS Communication

SMBUS is the targeted interface. Nothing prevents the concepts of this specification to be expanded to other digital interfaces.

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1.4 SMBUS Transport Protocol

The below commands in [Table 1.1](#) are used for moving data across SMBus.

Table 1.1 SMBUS Transport Commands

CODE	COMMAND	DESCRIPTION
0x01	WRITE_DATA	Write block of data to the device
0x02	READ_DATA	Read block of data from the device
0x05	READ_STATUS	Reads four byte status of the device
0x06	CLEAR_STATUS	Clears status of the device via bit mask
0x07	GET_LAST_ERROR	Get the last error the occurred in the device.

1.4.1 Write Data Command

[Write Data Command](#) writes data contents to the data buffer in the device. This command uses SMBUS block write protocol. The block is terminated on a stop bit. The number of bytes written corresponds to the length field which follows the command code in the host to device frame.

[Write Data Command](#) shall not be issued unless the [DATA_IN_BUF_STATE](#) bit in the status is set to one. That indicates that the input buffer is ready for the master to write data.

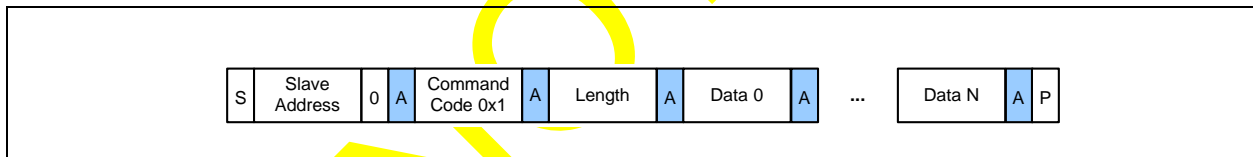


Figure 1.5 Write Data Command

Table 1.2 Write Data Command

OFFSET	FIELD	SIZE	VALUE	DESCRIPTION
0	Command	1	0x01	Write Data Command
1	Length	1	Number	Number of bytes written to the data input buffer
2	Data 0	1	Number	Data Byte 0 written to the data input buffer
N+2	Data N	1	Number	Data Byte N written to the data input buffer

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1.4.2 Read Data Command

[Read Data Command](#) reads data contents from the data out buffer in the device. This command uses the SMBUS block read protocol format. The number of bytes read corresponds to the value in the length byte that is sent as the first byte in the data sent from the slave device.

The read data command shall not be read unless the [DATA_OUT_BUF_STATE](#) bit in the status is set to one indicating the buffer is ready for the master to read it from the device.

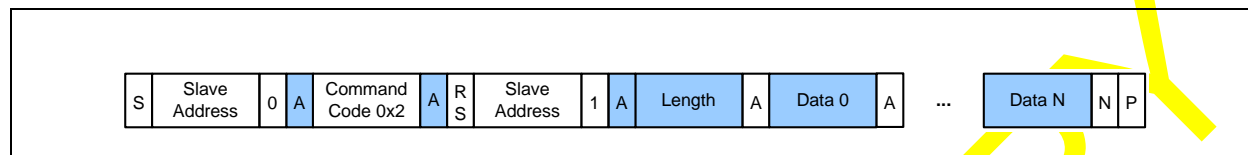


Figure 1.6 Read Data Command

Table 1.3 Read Data Command

OFFSET	FIELD	SIZE	VALUE	DESCRIPTION
0	Command	1	0x02	Read Data Command

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1.4.3 Read Status Command

Read Status Command obtains the status of the device. It is issued in response to assertion of ALERT_N or may be used to periodically determine the status if ALERT_N is not available.

DATA_OUT_BUF_STATE, when set, indicates there is data in the data buffer for the SMBus master to read using **Read Data Command**. The **DATA_OUT_BUF_LEN** reports the amount of data in the output buffer.

DATA_IN_BUF_STATE, when set, indicates the data buffer can accept data from the SMBus master using the **Write Data Command**.

PD_CHANGE indicates if there is a pending change in the device's status. The status change is obtained using the **Get Status** message to determine the port and then using **Get Port Status**.

DEV_CHANGE indicates if there is a pending change not associated with a PD port. The cause the status change is found by using the **Get Status** message. If the trigger is a PD System event then **Get System Status** is used.

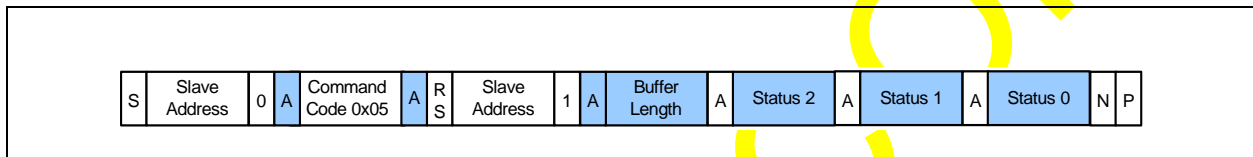


Figure 1.7 Read Status Command

Table 1.4 Read Status Command

OFFSET	FIELD	SIZE	VALUE	DESCRIPTION
0	Command	1	0x05	Read Status Command

Table 1.5 Status Register Format

OFFSET	FIELD	SIZE	VALUE	DESCRIPTION
0	Buffer Length	1	Number	See Table 1.6, "Buffer Length Definition"
1	Status 2	1	Bitmap	See Table 1.7, "Status 2 Definition"
2	Status 1	1	Bitmap	See Table 1.8, "Status 1 Definition"
3	Status 0	1	Bitmap	See Table 1.9, "Status 0 Definition"

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Table 1.6 Buffer Length Definition

BIT	FIELD	DESCRIPTION
7:0	DATA_OUT_BUF_LEN	Data Output Buffer Length Specifies the length of the data in the data buffer when the DATA_OUT_BUF_STATE is set.

Table 1.7 Status 2 Definition

BIT	FIELD	DESCRIPTION
7:2	Reserved	
1	ERROR	Error Notification 1: Error occurred processing SMBus commands 0: No error
0	DATA_OUT_BUF_STATE	Data Output Buffer State 1: Indicates that a previous command that results in the data output buffer being loaded with data has completed and the resulting data is ready to be read by the master. This bit is sticky and will not be cleared until a Clear Status Command with this bit set has been issued. 0: Indicates that no command that results in the data output buffer being loaded has completed since the last time this bit was cleared. This is the default reset value for this bit.

Table 1.8 Status 1 Definition

BIT	FIELD	DESCRIPTION
7:1	Reserved	
0	DATA_IN_BUF_STATE	Data Input Buffer State 1: Indicates that a previous command that the master wrote into the data input buffer has been processed. This bit is sticky and will not be cleared until a Clear Status Command with this bit set is issued. 0: Indicates that no command has been written into the data input buffer (or if there was, it has not been processed yet) since the last time this bit was cleared. This is the default reset value for this bit.

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Table 1.9 Status 0 Definition

BIT	FIELD	DESCRIPTION
7:4	Reserved	
3	DEVICE_READY	Device Ready Indicates when the device is ready to receive SMBus commands. The Host should not send any other command until it has successfully determined this bit is set. 1b: Device ready to start receiving SMBus commands 0b: Device not ready to receive SMBus commands
2	WAKE_SMBUS	Wake on SMBUS Alert when PD controller exits sleep from the first SMBus command. Host re-write/re-read last command. Note: This part may be configured to store the SMBUS packet which triggered the wake and obviate the need for the re-write/re-read.
1	DEV_CHANGE	Device Status Change 1b: Pending device status change 0b: No device status change pending This field only clears when all non-PD status event are cleared in Get Status .
0	PD_CHANGE	Power Deliver Port Status Changed 1b: Pending PD status change 0b: No PD status pending This field only clears after PD Port Event and PD System Event are cleared in Get Status .

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1.4.4 Clear Status Command

Clear Status Command acknowledges any pending status bit via a **Status Mask 2**. If a status bit in the mask is set, this command clears the pending status bit.

The ALERT_N remains asserted until all status bit have been acknowledge and cleared.

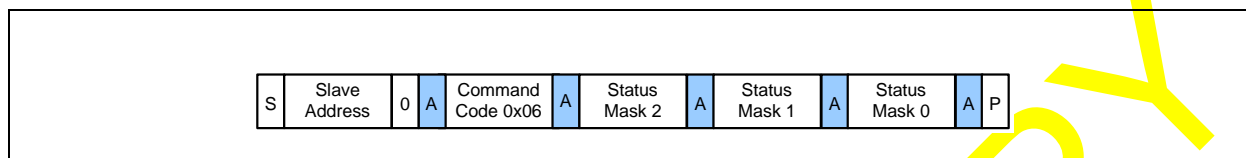


Figure 1.8 Clear Status Command

Table 1.10 Clear Status Command

OFFSET	FIELD	SIZE	VALUE	DESCRIPTION
0	Command	1	0x06	Clear Status Command
1	Status Mask 2	1	Bitmap	Status mask for acknowledging status 2 event.
2	Status Mask 1	1	Bitmap	Status mask for acknowledging status 1 event.
3	Status Mask 0	1	Bitmap	Status mask for acknowledging status 0 event.

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1.4.5 Get Last Error Command

After clearing the **ERROR** in **Read Data Command** the master may issue the **Get Last Error Command** to query the device for a specific error that occurs.

The device stores the error data structure data in the data out buffer and sets the **DATA_OUT_BUF_STATE** field in **Table 1.7, "Status 2 Definition"**. The device then asserts ALERT_N to notify the master the status has changed. The master then reads the status using the **Read Status Command** and will see that the **DATA_OUT_BUF_STATE** bit is set.

The master shall then acknowledge the status by issuing a **Clear Status Command** to clear **DATA_OUT_BUF_STATE** status bit. The master shall then acquire the data with the **Read Data Command**.

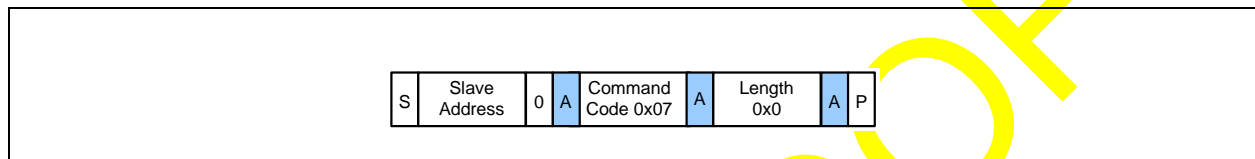


Figure 1.9 Get Last Error Command

Table 1.11 Data Response

OFFSET	FIELD	SIZE	VALUE	DESCRIPTION
0	ERROR_CODE	1	Number	Error Code
1	ADDITIONAL_ERROR_CODE	1	Number	Additional Error Code. Reserved for future use.

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1.4.6 Example Usage

1.4.6.1 SMBUS Block Write

1. Master issues [Write Data Command](#).
2. After device processes data buffer, ALERT_N asserts.
3. Master issues [Read Status Command](#) and verifies [DATA_IN_BUF_STATE](#) is set to 1.
4. Acknowledge [DATA_IN_BUF_STATE](#) with [Clear Status Command](#) which in turn de-asserts ALERT_N and clears [DATA_IN_BUF_STATE](#).

1.4.6.2 SMBUS Block Read

1. Master issues command which retrieves data such as .
2. After device processes command and moves data into the buffer, ALERT_N asserts.
3. Master issues [Read Status Command](#) and verifies [DATA_OUT_BUF_STATE](#) is set to 1.
4. Master issues [Read Data Command](#) and receives data from the buffer.
5. Acknowledge [DATA_OUT_BUF_STATE](#) with [Clear Status Command](#) which in turn de-asserts ALERT_N and clears [DATA_OUT_BUF_STATE](#).

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1.5 Application Protocol

The Application Protocol message format is depicted in [Figure 1.10](#).

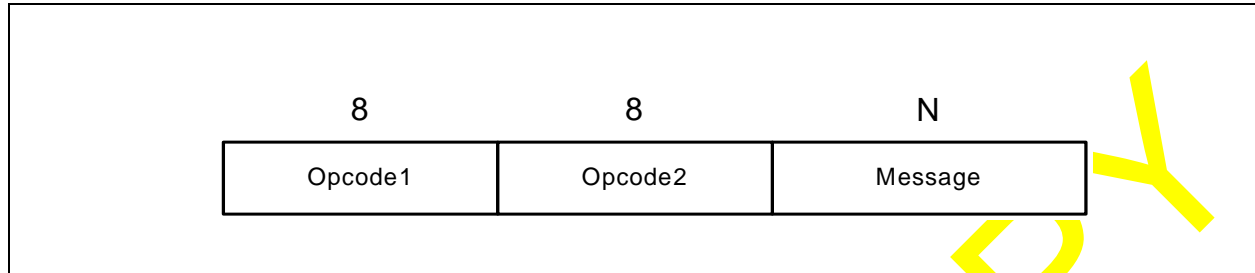


Figure 1.10 Application Message Format

Opcode1 indicates the command class. Opcode2 field decodes the message.

Note: Refer to [Section 1.8.27.1, "GetPortStatus PD Request Example"](#) for an example illustrating the usage of the Application Protocol over the SMBus transport.

1.6 Message Summary

Table 1.12 Opcode1 Decode

VALUE	MESSAGE TYPE
0x00	Power Delivery Control and Status
0x01	Status Change
0x02	General Configuration and Status
0x03 - 0xFF	Reserved

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Table 1.13 Opcode2 Decode

VALUE	MESSAGE
Power Delivery Control and Status	
0x00	Get Descriptor
0x01-0x0F	Reserved
0x10	PD Class Specific Requests and Events
0x11-0xFF	Reserved
General Configuration	
0x00	Get Information
0x01	System Configuration
0x02-0xFF	Reserved
Status Change	
0x00	Get Status
0x01-0xFF	Reserved

Note: Refer to [Section 1.8.27.1, "GetPortStatus PD Request Example"](#) for an example illustrating the usage of the Application Protocol over the SMBus transport.

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1.7 General Configuration

1.7.1 Get Information

Get Information requests the device to return an information data structure that describes the firmware version, product ID, and other parameters.

Table 1.14 Get Information Command

OFFSET	FIELD	SIZE	VALUE	DESCRIPTION
0	Device Revision	1	Number	Device Hardware Revision.
1	Device ID	1	Number	Device Hardware Identifier.
2	Reserved	1	Number	
3	Reserved	1	Number	
4	Reserved	1	Number	
5	Product ID	2	Number	16-bit product ID
7	Firmware Version Major	1	Number	Major field of the 2 byte firmware version.
8	Firmware Version Minor	1	Number	Minor field of the 2 byte firmware version.
9	Protocol Class	1	Number	The protocol class identifier.
10	Protocol Version Major	1	Number	Major field of the PD protocol version.
11	Protocol Version Minor	1	Number	Minor field of the PD protocol version.
12	Host interface Version Major	1	Number	Major field of the Host interface version.
13	Host interface Version Minor	1	Number	Minor field of the Host interface version.

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1.7.2 System Configuration

The System Configuration message is used to control non PD functions of the PD controller.

Table 1.15 System Configuration Command

BIT	FIELD
0	SMBUS Wakeup Enable When set the device shall exit sleep upon reception from an SMBUS command. The command shall be discarded and the Host must re-write/re-read last command.
31:1	Vendor Specific

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1.8 Power Delivery Control and Status

The transport interface retrieves information from and controls power delivery enabled devices utilizing descriptors and class requests.

1.8.1 Get Descriptor Message

Get Descriptor is utilized to retrieve descriptor information from the device. It uses USB standard device request as a format.

Table 1.16 Get Descriptor

REQUEST	BMREQUESTTYPE	BREQUEST	WVALUE	WINDEX	WLENGTH	DATA
Get Descriptor	10000000B	GET_DESCRIPTOR	Descriptor Type or Descriptor Index	Zero or Language ID	Descriptor Length	Descriptor

Table 1.17 illustrates the decode for descriptor types supported by this device.

Table 1.17 Descriptor Types

FIELD	VALUE
STRING	0
POWER_DELIVERY_CAPABILITY	1
BATTERY_INFO_CAPABILITY	2
PD_CONSUMER_PORT_CAPABILITY	3
PD_PROVIDER_PORT_CAPABILITY	4

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1.8.2 USB Power Delivery Capability Descriptor

The following data structure is returned in response to a Get USB Power Delivery Capability Descriptor message.

Table 1.18 USB Power Delivery 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: POWER_DELIVERY_CAPABILITY
3	Reserved	1	Reserved	Shall be set to zero.
4	bmAttributes	4	Bitmap	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:
				BIT DESCRIPTION
				0 Reserved. Shall be set to zero.
				1 Battery Charging. This bit shall be set to one to indicate this device supports the Battery Charging Specification as per the value reported in the bcdBCVersion field.
				2 USB Power Delivery. This bit shall be set to one to indicate this device supports the USB Power Delivery Specification as per the value reported in the bcdPDVersion field.
				3 Provider. This bit shall be set to one to indicate this device is capable of providing power. This field is only valid if Bit 2 is set to one.
				4 Consumer. This bit shall be set to one to indicate that this device is a consumer of power. This field is only valid if Bit 2 is set to one.
				7:5 Reserved. Shall be set to zero.
				15:8 bmPowerSource. See Table 1.19 for decode. At least one of the bits 8, 9 and 14 shall be set to indicate which power sources are supported.
				31:16 Reserved. Shall be set to zero.
8	bmProviderPorts	2	Bitmap	The bit corresponding to the port shall be set to one to indicate that this device is capable of providing power on that port. (Either BC 1.2 or PD) Bit zero refers to the upstream port of the device. Bits one through fifteen are only valid for hubs and refers to the downstream ports of the hub.

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Table 1.18 USB Power Delivery Capability Descriptor

OFFSET	FIELD	SIZE	VALUE	DESCRIPTION
10	bmConsumerPorts	2	Bitmap	The bit corresponding to the port shall be set to one to indicate that this device is capable of consuming power on that port. (Either BC 1.2 or PD). Bit zero refers to the upstream port of the device. Bits one through fifteen are only valid for hubs and refers to the downstream ports of the hub.
12	bcdBCVersion	2	BCD	Battery Charging Specification Release Number in Binary-Coded Decimal (i.e., 2.10 is 210H). This field shall only be valid if the device indicates that it supports BC in the bmAttributes field.
14	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.

Table 1.19 bmPowerSource

BIT	DESCRIPTION
8	AC or other Bulk Supply
9	Battery
10	Other
13:11	NumBatteries. This field shall only be valid when the Battery field is set to one and shall be used to report the number of batteries in the device.
14	Uses VBUS
15	Reserved and shall be set to zero.

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1.8.3 Battery Information Capability Descriptor

This message returns a descriptor for each battery it supports.

Table 1.20 Battery Information 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 Battery Charging 1.2).
16	dwBatteryDesignCapacity	4	mWh	Shall contain the design capacity of the battery.
20	dwBatteryLastFullcharge Capacity	4	mWh	Shall contain the maximum capacity of the battery when fully charged.

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1.8.4 PD Consumer Port Capability Descriptor

Table 1.21 PD Consumer Port 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: PD_CONSUMER_PORT_CAPABILITY	
3	bReserved	1	Number	Reserved and shall be set to zero.	
4	bmCapabilities	2	Bitmap	Capability: This field shall indicate the specification the Consumer port will operate under.	
				BIT	DESCRIPTION
				0	Battery Charging (BC)
				1	USB Power Delivery (PD)
				15:2	Reserved and shall be set to zero.
6	wMinVoltage	2	Number	Shall contain the minimum voltage that this Consumer is capable of operating at.	
8	wMaxVoltage	2	Number	Shall contain the maximum voltage that this Consumer is capable of operating at.	
10	bReserved	2	Number	Reserved and shall be set to zero.	
12	dwMaxOperatingPower	4	Number	Shall contain the maximum power in 10mW units this Consumer can draw when it is in a steady state operating mode.	
16	dwMaxPeakPower	4	Number	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.	
20	dwMaxPeakPowerTime	4	Number	Shall contain the time in 100ms units that this Consumer can draw peak power. A device shall set this field to 0xFFFF if this value is unknown.	

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1.8.5 PD Provider Port Capability Descriptor

Table 1.22 PD Provider Port 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: PD_PROVIDER_PORT_CAPABILITY	
3	bReserved	1	Number	Reserved and shall be set to zero.	
4	bmCapabilities	2	Bitmap	Capability: This field shall indicate the specification the Provider port will operate under.	
				BIT	DESCRIPTION
				0	Battery Charging (BC)
				1	USB Power Delivery (PD)
				15:2	Reserved and shall be set to zero.
6	bNumOfPDObjects	1	Number	Shall indicate the number of Power Data Objects.	
7	bReserved	1	Number	Reserved and shall be set to zero.	
8	wPowerDataObject1	4	Bitmap	Shall contain the first Power Data Object supported by this Provider port.	
...	
N+4	wPowerDataObjectN	4	Bitmap	Shall contain the 2nd and subsequent Power Data Objects supported by this Provider port.	

1.8.6 String Descriptor

Table 1.23 String Descriptor

OFFSET	FIELD	SIZE	VALUE	DESCRIPTION
0	bLength	1	Number	Size of descriptor
1	bDescriptorType	1	Constant	STRING Descriptor Type
2	Unicode String	2*N	Constant	String data. Two bytes per unicode character, no trailing NULL.

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1.8.7 PD Requests

PD requests utilizes the USB device request format.

Table 1.24 PD Requests

REQUEST	BMREQUESTTYPE	BREQUEST	WVALUE	WINDEX	WLENGTH	DATA
ClearSysFeature	00100000b	CLEAR_FEATURE	Feature Selector	Zero	Four	Clear Change Mask
ClearPortFeature	00100011b	CLEAR_FEATURE	Feature Selector	Port Number	Four	Clear Change Mask
GetBatteryStatus	10100000b	GET_BATTERY_STATUS	Zero	Battery ID	Eight	Battery Status
GetSysStatus	10100000b	GET_STATUS	Zero	Zero	Eight	System Status
GetPortStatus	10100011b	GET_STATUS	Zero	Port Number	Sixteen	Port Status
SetSysStatusMask	00100000b	STATUS_MASK	Zero	Zero	Four	Mask
SetPortStatusMask	00100011b	STATUS_MASK	Zero	Port Number	Four	Mask
SetSysFeature	00100000b	SET_FEATURE	Feature Selector	Feature Specific	Zero	None
SetPortFeature	00100011b	SET_FEATURE	Feature Selector	Port Number	Variable	None
SetSysPIO	00100000b	SET_PIO	Zero	Zero	Four	Bitmap
SetPortPIO	00100011b	SET_PIO	Zero	Port Number	Four	Bitmap
SetPDO	00100011b	SET_PDO	Zero or One	Port Number	Variable	Power Data Objects
SetRDO	00100011b	SET_RDO	Zero	Port Number	Four	Request Data Object
SetPDOPref	00100011b	SET_PDO_PREFERENCE	Zero	Port Number	Seven	Array
GetPartnerPDO	10100011b	GET_PARTNER_PDO	Zero or One	Port Number	Zero	Power Data Objects
GetPDO	10100011b	GET_PDO	Zero or One	Port Number	Zero	Power Data Objects
GetRcvPDO	10100011b	GET_RCV_PDO	Zero	Port Number	Four	Power Data Objects
GetNgtPDO	10100011b	GET_NGT_PDO	Zero	Port Number	Four	Power Data Objects
SetAutoNgtPwrRngCon	00100011b	AUTO_NGT_PWR_RNG	Zero	Port Number	Four	Bitmap

Note: For a single port device the port number set by wIndex shall always be set to one. For a PD capable upstream hub port wIndex shall always be set to zero

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Table 1.25 PD Class Request Codes

BREQUEST	VALUE
GET_PARTNER_PDO	20
GET_BATTERY_STATUS	21
SET_PDO	24
GET_PARTNER_RDO	25
SET_RDO	26
SET_PDO_PREFERENCE	27
GET_NGT_PDO	28
GET_RCV_PDO	29
STATUS_MASK	30
SET_PIO	31
GET_PDO	32
AUTO_NGT_PWR_RNG	33

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Table 1.26 PD Feature Selectors

FEATURE SELECTOR	RECIPIENT	VALUE
BATTERY_WAKE_MASK	Device	40
OS_IS_PD_AWARE	Device	41
CLEAR_STATUS_CHANGE	Device	42
POLICY_MODE	Port	128
SWAP	Port	129
GOTO_MIN	Port	130
RETURN_POWER	Port	131
ACCEPT_PD_REQUEST	Port	132
REJECT_PD_REQUEST	Port	133
PORT_PD_RESET	Port	134
PORT_POWER_ON	Port	135
SLEEP	Port	136
PORT_PD_CONFIGURED	Port	137
AUTO_NEGOTIATION_POWER_CONSUMER	Port	141
CLEAR_STATUS_CHANGE	Port	142
GATE_SINK_CONSUMER	Port	143
ENABLE_SINK_CONSUMER	Port	144

Note: For system level PD feature selector commands (RECIPIENT = Device), the clear feature command must only be used to clear change statuses.

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1.8.8 Clear System Feature

This request is used to reset a system power delivery feature.

The wIndex field shall be set to zero.

The wLength field shall be set to four.

The wValue field shall be set to the feature selector, see [Table 1.26](#). This request uses feature selectors that target the device.

If feature selector is associated with a status change, CLEAR_STATUS_CHANGE, [Table 1.27](#) defines the status changes that are acknowledged by the request.

Only after all the status changes in [Clear System Change Mask](#) are acknowledged shall [PD System Event](#) be cleared.

Table 1.27 Clear System Change Mask

BIT	CHANGE ACKNOWLEDGED WHEN BIT IS SET
15:0	System PD Monitors
16	System Error
31:17	Reserved

This request shall be a [System Error](#) if wValue is not a feature selector listed in [Table 1.26](#), or if wIndex is not zero, or if wLength is not as specified above.

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1.8.9 Clear Port Feature

This request resets a feature that was set for the respective power delivery enabled port.

The wLength field shall be set to four.

The wValue field shall be set to the feature selector. Refer to [Table 1.26](#) for feature selector definitions that shall apply when the port is the recipient.

If the feature selector is associated with status change, CLEAR_STATUS_CHANGE, [Table 1.28](#) defines the status changes that are acknowledged by the request.

Only after all the status changes in [Clear Port Change Mask](#) are acknowledged shall [PD Port Event](#) be cleared.

Table 1.28 Clear Port Change Mask

BIT	CHANGE ACKNOWLEDGED WHEN BIT IS SET
0	Change Port Power Source
1	External supply
2	Port operation mode
3	Supported provider capabilities
4	Negotiated power level
5	Received RDO
6	New power direction
7	Swap Complete
8	PD Reset Complete
9	Insertion detect
10	PD capable cable
11	Request rejected
12	IR Drop
13	BIST Status
14	Power Source Change
15	Received New Source PDOs
16	Last Command Status
17	Port Error
31:18	Port PD Monitors

This request shall be a [Port Error](#) if wValue is not a feature selector listed in [Table 1.26](#), or if wIndex specifies a port that does not exist, or if wLength is not as specified above.

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1.8.10 Get Battery Status

Every PDUSB Device that has a battery shall return its Battery Status when queried with this request. For Providers or Consumers with multiple batteries, the status of each battery shall be reported per battery.

The wIndex field shall be set to the battery ID.

The wLength field shall be set to eight.

The wValue field shall be set to zero.

Table 1.29 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				

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Table 1.29 Battery Status Structure

OFFSET	FIELD	SIZE	VALUE	DESCRIPTION	
3	bRemoteWakeCapStatus	1	Bitmap	If the device supports remote wake, then the device shall support Battery Remote wake events. The default value for the Remote wake events shall be turned off (set to zero) and can be enable/disabled by the host as required.	
				BIT	DESCRIPTION
				0	Battery present event
				1	Charging flow
				2	Battery error
				7:3	Reserved and shall not be used
4	wRemainingOperating Time	2	Number	Shall 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. Note: this value shall exclude any additional power received from charging. A battery that is not capable of returning this information shall return a value of 0xFFFF.	
6	wRemainingChargeTime	2	Number	Shall 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 shall only be valid if the Charging Flow is Charging. A battery that is not capable of returning this information shall return a value of 0xFFFF.	

This request causes a [System Error](#) if wIndex is not a valid battery ID, if wValue is not set to zero, or if wLength are not as specified above.

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1.8.11 Get System Status

This request returns the power delivery system status as defined in [Table 1.30](#). Assertion of any bit in [System Status Change](#) results in communicating the status change to the host unless the corresponding mask bit is set in [Set System Status Change Mask](#) request.

The wIndex field shall be set to zero.

The wLength field shall be set to eight.

The wValue field shall be set to zero.

Table 1.30 System Status

BIT	FIELD
31:0	System Status Change A one in the bit position shall indicate the types of status changes that occurred. See System Status Change for a decode of this field.
47:32	System Monitor Value This field contains the state of 16 monitors I/O which may be used to observe a variety of system functions. These monitors are used for functions that are not specific to a PD port. The assignment of the monitors is application specific.
63:48	Reserved

Table 1.31 System Status Change

BIT	CHANGE INDICATED
15:0	System Monitor Change Status This field indicates a change on one of the 16 monitors.
30:16	Reserved
31	System Error When set, this field shall indicate that an unknown error has occurred.

It shall be a Request [System Error](#) if wValue is not set to zero, or if wIndex is not set to eight, or if wLength is not as specified above.

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1.8.12 Get Port Status

This request returns the power delivery port status as defined in [Table 1.32](#). Assertion of any bit in [Port Status Change](#) results in communicating the status change to the host unless the corresponding mask bit is set in [Set Port Status Change Mask](#) request.

The wValue field shall be set to zero.

The wIndex field shall be set to the port number.

The wLength field shall be set to sixteen.

Table 1.32 Port Status

BIT	FIELD
31:0	Port Status Change A one in the bit position shall indicate the types of status changes that have occurred on the port. See Table 1.33 for a decode of this field.
32	Supply This field shall indicate the type of supply that is attached to this port. 0b: No Supply 1b: Supply Present
35:33	Port Operation Mode The field shall indicate the current mode of operation of the port. 000b: No Consumer 001b: Legacy Charger 010b: Battery Charging 011b: Power Delivery 1xxb: Reserved
36	Insertion Detect The field shall indicate the current status of whether a cable is plugged into this port. 0b: No cable detected. 1b: Cable detected.
37	BIST Status 0b: No BIST in progress 1b: BIST in progress
40:38	Last Command State Valid only if Command State is cleared (no command in progress). 000b: Last received command accepted and completed or command never received 001b: Timeout waiting for event on PD (e.g. PS_RDY) 010b: Invalid last received Command or Error 011b: Far-end device rejects or SenderResponseTime expires last received Command (Swap or GetSourceCap) 100b: Wait message received 101b - 111b: Reserved
41	Command State 0b: No PD command in progress. 1b: PD command in progress

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Table 1.32 Port Status

BIT	FIELD
45:42	Cable Type 0000b: Non-PD Type-A 0001b: Non-PD Type-B 0010b: PD Type-A 0011b: PD Type-B 0100b: Non-PD Micro-A 0101b: Non-PD Micro-B 0110b: PD Micro-A 0111b: PD Micro-B All other values are reserved; shall be ignored by receiver
49:46	Receptacle Type 0000b: Vendor specific 0001b: Standard A 0010b: Standard A without INSRT 0011b: Micro AB 0100b: Standard B 0101b: Micro B 0110b: Vendor specific 0111b-1111b: Reserved; shall be ignored by receiver
63:50	Port PIO Monitor State. Indicates state of the respective PD Port PIO monitor.
64	IR Drop When set, this field shall indicate that the IR drop over ground connection exceeds the allowable drop.
65	PD Direction This field shall indicate whether the port is operating as consumer or provider. 0b: Port is operating as a consumer. 1b: Port is operating as a provider.
95:66	Vendor Specific
127:96	Request Data Object This field shall return the currently negotiated power level if operating in Non-Intrusive mode. If operating in intrusive mode then this field shall indicate the power level that the port partner wants to operate at.

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Table 1.33 Port Status Change

BIT	CHANGE INDICATED
0	Reserved
1	External supply When set, the Supply field shall indicate the current status of the supply.
2	Port operation mode When set, the Port Operation Mode field shall indicate the current operational mode of the port.
3	Supported Provider Capabilities When set, the SPM shall use Get PD Descriptor to obtain further details on this notification.
4	Negotiated power level When set, shall indicate the negotiation for a new power level has completed. See Request Data Object field for contract that has been negotiated.
5	Received RDO When set, this field shall indicate new Request Data Object has been received. See Request Data Object field to obtain newly received RDO.
6	New power direction When set, this field shall indicate that the power direction has changed if operation is in Non-Intrusive mode. If operation is in intrusive mode then, when set, this field shall indicate the port partner wants to perform a power swap.
7	Swap Complete When set, the swap has completed.
8	PD Reset Complete When set, this field shall indicate that a PD Hard Reset has completed. When this bit is set, then the other bits in the PD Status Change field shall report their change status as if operation is in Non-Intrusive mode,
9	Insertion Detect When set, the Insertion Detect field shall indicate the current status of whether a cable is plugged into this port.
10	PD Capable Cable When set, the PD Capable Cable field shall indicate the current status of whether a PD Capable Cable is plugged into this port.
11	Request Rejected This bit shall be only valid if operating is in Non-Intrusive mode. When set, this field shall indicate one of two conditions: <ul style="list-style-type: none"> the device received a request to change the power level (Negotiated power level bit shall be set) that was rejected the device received a request to role swap (New power direction bit shall be set) that was rejected.
12	IR Drop When set, this field shall indicate that the IR drop over the ground connection exceeds the allowable drop.
13	BIST Alert when PD controller enters BIST mode.

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Table 1.33 Port Status Change

BIT	CHANGE INDICATED
14	Power Ready When set, this bit indicates the power supply has reached the desired operating conditions that were previously negotiated. For a sink, this event corresponds to reception of the PS_RDY message. For a source, it corresponds to having sent the PS_RDY message.
15	Received New Source PDOs New set of PDOs received.
16	Last Command Status When set, this field shall indicate a new Last Command State .
17	Port Error When set, this field shall indicate that an unknown error has occurred on the port.
31:18	Port PIO Monitor Change Note: This can be used to generate SMBUS ALERT_N from port events including status changes of the PD port monitors.

It shall be a Request [Port Error](#) if wValue is not zero, or if wIndex specifies a port that does not exist, or if wLength is not as specified above.

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1.8.13 Set System Status Change Mask

This request is used to prevent the corresponding bit in [System Status Change](#) from issuing an alert to the host.

The wValue field shall be set to zero.

The wIndex field shall be set to zero.

The wLength field shall be set to four.

Table 1.34 PD System Status Mask

BITS	FIELD
31:0	System Status Change Mask 0b: Associated System Status Change bit is not masked. 1b: Associated System Status Change bit is masked (default)

An unmasked [System Status Change](#) shall trigger a wakeup when the device is a sleep.

It shall be a Request [System Error](#) if wValue is not zero, or if wIndex is not zero, or if wLength is not as specified above.

1.8.14 Set Port Status Change Mask

This request is used to prevent the corresponding bit in [Port Status Change](#) from communicating the change event with the host.

The wValue field shall be set to zero.

The wIndex field shall be set to the port.

The wLength field shall be set to four.

Table 1.35 PD Port Status Change Mask

BITS	FIELD
31:0	PD Port Status Change Mask 0b: Associated Port Status Change bit is not masked. 1b: Associated Port Status Change bit is masked (default)

An unmasked [Port Status Change](#) shall trigger a wakeup when the device is a sleep.

It shall be a Request [Port Error](#) if wValue is not zero, or if wIndex is not a valid port, or if wLength is not as specified above.

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1.8.15 Set System Feature

Setting a feature enables that feature or starts a process associated with that feature; see [Table 1.26](#) for the feature selector definitions. Features that may be set with this request are:

- BATTERY_WAKE_MASK
- OS_IS_PD_AWARE

When the feature selector is set to BATTERY_WAKE_MASK, then the wIndex field is structured as shown in [Table 1.36](#).

The wValue field shall be set to the feature selector.

The wIndex field is feature specific.

The wLength field shall be set to zero.

When the feature selector is set to BATTERY_WAKE_MASK, then the wIndex field is structured as shown in [Table 1.36](#).

Table 1.36 Battery Wake Mask

BIT	DEFINITION
0	Battery Present When this bit is set then the PD USB Device shall generate a wake event if it detects that a battery has been attached.
1	Charging Flow When this bit is set then the PD USB 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 PD USB Device shall generate a wake event if the battery has detected an error condition.
15:3	Reserved

The SPM may Enable or Disable the wake events associated with one or more of the above events by using this feature.

When the feature selector is set to OS_IS_PD_AWARE, then if the wIndex field is set to one it informs the device that the SPM is active on the host. If the wIndex field is set to zero then it informs the device that the SPM is not active on the host. The default state for this feature shall be zero.

[System Error](#) bit in the [Get System Status](#) shall be set if wValue is not a device feature selector listed in [Table 1.26](#), or if wIndex is not set appropriately, or if wLength is not zero.

1.8.16 Set Port Feature

This request sets the feature for a USB PD enabled port.

The wValue field shall be set to the feature selector.

The wIndex field is feature specific.

The wLength field is variable.

The wIndex field shall indicate the PD capable port that is being queried. The port number shall be a valid port number.

Setting a feature enables that feature or starts a process associated with that feature; see [Table 1.26](#) for the feature selector definitions. Features that may be set with this request are:

- SWAP
- GOTO_MIN
- RETURN_POWER
- ACCEPT_PD_REQUEST
- REJECT_PD_REQUEST
- PORT_PD_RESET
- PORT_POWER_ON
- SLEEP
- PORT_PD_CONFIGURED
- AUTO_NEGOTIATE_POWER_CONSUMER
- POLICY_MODE
- GATE_SINK_CONSUMER
- ENABLE_SINK_CONSUMER

When operating in intrusive mode the SPM implemented by the partner device shall respond with a Wait message when it receives any Request message.

When the feature selector is set to SWAP then the controller shall initiate a Role Swap with the partner.

When the feature selector is set to GOTO_MIN, and the port is operating as a Provider, it shall send the GotoMin request to the port partner.

When the feature selector is set to PORT_POWER_ON, and the port is operating as a Provider, it shall indicate to the port that it and may provide power on VBUS. When this feature is cleared the port shall immediately remove power from VBUS.

When the feature selector is set to PORT_PD_CONFIGURE, the host indicates to the port that it has been provided all the configuration information it needs and should start the PD state machine. Clearing this feature has no effect.

When the feature selector is set to RETURN_POWER, and the port is operating as a Provider, then the power borrowed from the PD Device on that port shall be returned.

When the feature selector is set to ACCEPT_PD_REQUEST then the port shall accept the request that was previously made by the port partner on this downstream port.

When the feature selector is set to REJECT_PD_REQUEST the port shall reject the request that was previously made by the port partner on this downstream port.

When the feature selector is set to PORT_PD_RESET, the port shall send a Hard Reset. Once the Hard Reset is complete [PD Reset Complete](#) bit is set in [Port Status Change](#).

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if AUTO_NEGOTIATE_POWER_CONSUMER is set the controller utilizes the voltage and current ranges defined to negotiate the power contract via [Set Auto Negotiate Power Range Consumer](#) request.

APPLICATION NOTE: The feature AUTO_NEGOTIATE_POWER_CONSUMER only applies to local mode. It has no meaning when operating in intrusive mode as defined by [POLICY_MODE Encoding](#).

The features GATE_SINK_CONSUMER and ENABLE_SINK_CONSUMER provide a mechanism to delay the port from sinking power from VBUS until explicitly directed by the host. These features shall only apply to a port operating as a Consumer.

Under default operation the consumer starts sinking power after receiving PS_RDY. If GATE_SINK_CONSUMER is set the consumer will not draw power until PS_RDY is received and the feature ENABLE_SINK_CONSUMER is also set. There shall be no requirement for the order in which PS_RDY and ENABLE_SINK_CONSUMER is received.

When the feature selector is set to SLEEP the corresponding port shall abide by the behavior in [Table 1.37](#). The wValue shall be set to two and the data structure depicted in [Table 1.37](#) is provided.

Table 1.37 SLEEP Encoding

BIT	DEFINITION
0	Sleep Mode 0b: Clear enter sleep mode request (default), 1b: Whenever possible, the port enters lowest possible power consumption level.
2:1	Sleep Timer Timeout value after expiry of which the PD controller will automatically enter sleep mode. 00b: Always active (default) 01b: 100ms 10b: Vendor specific 11b: Vendor specific
15:3	Reserved

When the feature selector is set to POLICY_MODE, the corresponding port shall abide by the behavior in [Table 1.38](#). The wValue shall be set to two and the data structure depicted in [Table 1.38](#) is provided.

Table 1.38 POLICY_MODE Encoding

BIT	DEFINITION
0	Provider Negotiation Mode Determines whether contract negotiations when the port is operating as a provider as handled locally or intrusively. 0b: Local 1b: Intrusive
1	Consumer Negotiation Mode Determines whether contract negotiations when the port is operating as a consumer are handled locally or intrusively. 0b: Local 1b: Intrusive

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Table 1.38 POLICY_MODE Encoding

BIT	DEFINITION
2	Provider Swap Determines whether swaps when the port is operating as a provider are handled locally or intrusively. 0b: Local 1b: Intrusive
3	Consumer Swap Determines whether swaps when the port is operating as a consumer are handled locally or intrusively. 0b: Local 1b: Intrusive
4	Auto Accept Provider Swap Determines whether the device accepts swap requests to be a provider. (Note 1.1) 0b: Do Not Accept Provider Swap Requests 1b: Accept Provider Swap Requests
5	Auto Accept Consumer Swap Determines whether the device accepts swap requests to be a consumer. (Note 1.1) 0b: Do Not Accept Consumer Swap Requests 1b: Accept Consumer Swap Requests
6	Auto Request Provider Swap Determines whether the device shall send a swap request to be a provider. (Note 1.2) 0b: Do Not Send Provider Swap Request 1b: Send Provider Swap Request
7	Auto Request Consumer Swap Determines whether the device shall send a swap request to be a consumer. (Note 1.2) 0b: Do Not Send Consumer Swap Request 1b: Send Consumer Swap Request
15:8	Reserved and shall not be used.

Note 1.1 **Auto Accept Provider Swap** and **Auto Accept Consumer Swap** only apply to local mode. If neither **Auto Accept Provider Swap** or **Auto Accept Consumer Swap** are set, the controller shall reject all swap requests. These bits have no meaning when operating in intrusive mode.

Note 1.2 **Auto Request Provider Swap** and **Auto Request Consumer Swap** only apply to local mode. If neither **Auto Request Provider Swap** or **Auto Request Consumer Swap** the controller shall not send any requests. These bits have no meaning when operating in intrusive mode.

If the Policy Mode is set to Intrusive, the SPM built into the controller must be deactivated and the function SPM in a partner PD enabled USB Hub or other shall be used.

If the Policy Mode is set to Local, the device shall operate in Non-Intrusive mode for the assigned function.

When the Policy Mode is set to Intrusive, the device shall pass any requests that need policy decisions to be made to the SPM and use PD mechanisms to delay the completion of PD Requests (e.g. using the Wait Message) over PD.

Some requests are only valid when the device is operating in Intrusive mode. The requests that are valid in Intrusive mode are indicated as such in the description for those requests. In addition notifications that operate differently in Intrusive mode are also called out in the description of those notifications.

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Port Error bit in **Port Status Change** shall be set if wValue is not a port assigned feature selector as listed in [Table 1.26](#), or if wIndex specifies a port that does not exist, or if wLength is not as specified above.

1.8.17 Set System Programmable I/O

This request is used to control PD related programmable I/Os that are not associated with a specific PD port.

The wValue field shall be set to zero.

The wIndex field shall be set to zero.

The wLength field shall be set to four.

Table 1.39 Set System Programmable IO

BIT	FIELD
31:0	System PIO Each corresponds to a System PIO. The value written here provides instruction to FW on how to drive the PIO. The value here may not directly corresponds to the state driven by the PIO. That is system and application dependent.

System Error bit in **System Status Change** shall be set if wValue is not a valid port, or if wIndex specifies a port that is not supported, or if wLength is not as specified above.

1.8.18 Set Port Programmable I/O

This request is used to control up to 32 programmable I/O associated with the respective PD port.

The wValue field shall be set to zero.

The wIndex field shall be set to the respective port.

The wLength field shall be set to four.

Table 1.40 Set Port Programmable IO

BIT	FIELD
31:0	Port PIO Each bit corresponds to a port PIO. The value written here provides instruction to FW on how to drive the PIO. The value here may not directly corresponds to the state driven by the PIO. That is system and application dependent.

Port Error bit in **Port Status Change** shall be set if wValue is not a valid port, or if wIndex specifies a port that is not supported, or if wLength is not as specified above.

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1.8.19 Set RDO

This request sets the RDO that shall be used during negotiations with Port Partner when the port operates as a Consumer. This feature is used during Intrusive operation.

The wValue field shall be set to zero.

The wIndex field shall indicate the PD capable port that is being queried. The port number shall be a valid port number.

The wLength field shall be set to four.

It is the responsibility of controller to verify that the contents of the RDO set by the SPM is valid for this port. **Port Error** bit in **Get Port Status** shall be set if the RDO set by the SPM is not valid for the port specified.

When any RDO set exceeds the capabilities of the port this request shall be rejected.

Port Error bit shall also be set if wValue is not set to zero or if wIndex specifies a port that does not exist, or if wLength is not as specified above.

1.8.20 Set PDO

Use wValue for consumer/provider.

This request sets the PDOs that shall be used by the port and sent to the Port Partner when operating as a provider. Setting the PDO shall cause the controller to send an updated Capabilities message.

When operating as a consumer the PDOs are used for determining the power contract when operating in non-intrusive mode and the feature is AUTO_NEGOTIATE_POWER_RANGE_CONSUMER not set.

When any PDO set exceeds the capabilities of the device this request shall be rejected.

The wIndex field shall indicate the PD capable port that is being queried. The port number shall be a valid port number.

The wLength field shall be a multiple of 4 and shall include all the PDOs that the port may send to its port partner when sending its PD capabilities.

It is the responsibility of the controller to verify that the contents of the PDOs sent by the SPM are valid for this port. **Port Error** bit in **Get Port Status** shall be set if the PDOs sent by the SPM are not valid for the port specified.

Port Error bit shall also be set if wIndex specifies a port that does not exist or if wLength is not as specified above.

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1.8.21 Set Auto Negotiate Power Range Consumer

This request provides a minimum/maximum range of voltage levels as well as a maximum operating current to be used when the AUTO_NEGOTIATE_POWER_CONSUMER feature is set with [Set Port Feature](#).

The wValue field shall be set to zero.

The wIndex field shall indicate the PD capable port that is being queried. The port number shall be a valid port number.

The wLength field shall be set to four.

It is the responsibility of the controller to verify that the contents of this request are valid for this port. [Port Error](#) bit in [Get Port Status](#) shall be set if the ranges sent by SPM are not valid for the port specified.

[Port Error](#) bit shall also be set if wValue is not zero, or if wIndex specifies a port that does not exist or if wLength is not as specified above.

Table 1.41 Set Auto Negotiate Power Range Consumer

OFFSET	DEFINITION
31:24	Minimum Voltage Minimum voltage in 200mv units. 00011001b: 5V 00111100b: 12V 01100100b: 20V
23:22	Minimum Voltage LSBs The LSBs are vendor specific
21:20	Peak Current (IMAX) Peak operating current. 00b: IMAX equals Maximum Operating Current (IOC) (default) 01b: IMAX equals 130% Maximum Operating Current (IOC) for 1ms @ 50% duty cycle 10b: IMAX equals 150% Maximum Operating Current (IOC) for 1ms @ 25% duty cycle 11b: IMAX equals 200% Maximum Operating Current (IOC) for 1ms @ 5% duty cycle
19:12	Maximum Voltage Maximum voltage in 200mv units. 00011001b: 5V 00111100b: 12V 01100100b: 20V
11:10	Maximum Voltage LSBs LSBs are vendor specific
9:0	Maximum Operating Current (IOC) Maximum operating current in 10 mA units.

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1.8.22 Set PDO Preference

This command lists the preference of the device's consumer PDOs when negotiating a PD contract.

Offset zero is given highest priority and offset six the lowest. The indexes are assigned in the order the PDO are written via [Set PDO](#) request.

The wValue field shall be set to zero.

The wIndex field shall indicate the PD capable port that is being queried. The port number shall be a valid port number.

The wLength field shall be set to seven.

Table 1.42 Set PDO Preference

OFFSET	DEFINITION
0	PDO Index 0 The field has a value between 0 and 6.
1	PDO Index 1 The field has a value between 0 and 6.
2	PDO Index 2 The field has a value between 0 and 6.
3	PDO Index 3 The field has a value between 0 and 6.
4	PDO Index 4 The field has a value between 0 and 6.
5	PDO Index 5 The field has a value between 0 and 6.
6	PDO Index 6 The field has a value between 0 and 6.

Port Error shall be set if wValue is not zero, or if wIndex specifies a port that does not exist, or if wLength is not as specified above.

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1.8.23 Get PDO

This request retrieves all PDOs for the controllers respective PD enabled port.

Use wValue to indicate consumer when set zero or provider when set to one.

The wIndex field shall indicate the PD capable port that is being queried.

The wLength field shall be set to zero as the request returns all PDOs set for the port.

Port Error shall be set if wIndex specifies a port that does not exist or if wLength is not as specified above.

1.8.24 Get Negotiated PDO

This request retrieves the PDO that was negotiated for the current power contract by the respective provider configured port.

The wValue shall be set zero. The wIndex field shall indicate the PD capable port that is being queried.

The wIndex field shall be set to the respective port.

The wLength field shall be set to four.

Port Error shall be set if wValue is not zero, or if wIndex specifies a port that does not exist, or if wLength is not as specified above.

1.8.25 Get Partner PDO

This request returns the Provider/Consumer PD Objects from the partner PD device attached via VBUS. When this request is received the partner shall return the Consumer PDOs (if wValue is set to zero) or Provider PDOs (if wValue is set to one).

The wIndex field shall be set to the respective port.

The wLength field shall specify the number of bytes to return. The maximum length of this field is a function of the maximum number of PDOs a PDUSB device can return as defined in Section 6.2.1.2 of the PD specification.

Port Error bit in **Port Status Change** shall be set if wIndex specifies a port that is not supported.

1.8.26 Get Received Partner PDO

This request retrieves all PDOs that have been received from the PD partner for the respective port. This differs from **Get Partner PDO** which initiates a request to receive the PDOs directly from the partner.

When this request is received the partner shall return the Consumer PDOs (if wValue is set to zero) or Provider PDOs (if wValue is set to one).

The wIndex field shall indicate the PD capable port that is being queried.

The wLength field shall specify the number of bytes to return. The maximum length of this field is a function of the maximum number of PDOs a PDUSB device can return as defined in Section 6.2.1.2 of the PD specification.

Port Error shall be set if wIndex specifies a port that does not exist.

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1.8.27 PD Request Example Usages

1.8.27.1 GetPortStatus PD Request Example

Figure 1.11 details an example GetPortStatus PD request at the SMBus level. This example is provided to show the interaction between the application protocol message format and the low level SMBus format. As seen in Figure 1.11, Get Port Status request first requires an SMBus WRITE_DATA command to send the GetPortStatus PD request. This is followed by an SMBus READ_DATA command to read the returned GetPortStatus data.

Note: For the WRITE_DATA command, the SMBus Length field must include the number of bytes included in the application protocol message as well as the OPCODE1 and OPCODE2 bytes. Refer to Table 1.24 for details on the contents of the GetPortStatus PD request message format.

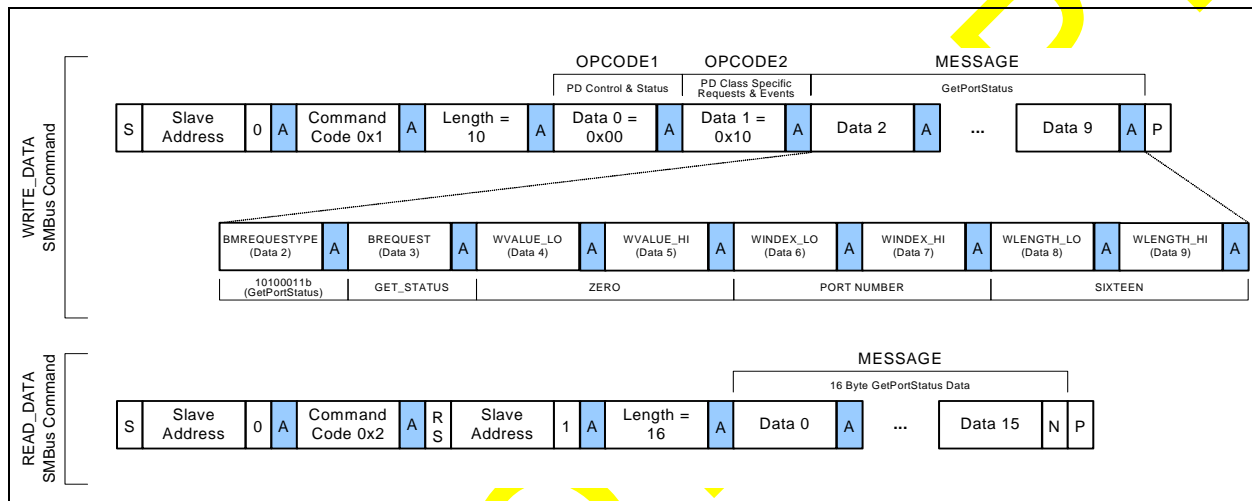


Figure 1.11 SMBus Get Port Status Example

1.8.27.2 Set four PDOs to a single port PD controller (16 bytes)

1. Issue **Set PDO** with windex set to one since there is a single port and wLength set to indicate 16 bytes of PDO data is appended to the message.
2. Wait for ALERT_N assertion.
3. Issue **Read Status Command** and verify **DATA_IN_BUF_STATE** is set to one.
4. Acknowledge **DATA_IN_BUF_STATE** with **Clear Status Command** which in turn de-asserts ALERT_N.

1.8.27.3 Get four provider PDOs from a single port PD controller (16 bytes)

1. Issue **Get PDO** command with wValue set to one to indicate provider and windex set to one since there is a single port in the controller.
2. Wait for ALERT_N assertion.
3. Issue **Read Status Command** and verify **DATA_OUT_BUF_STATE** is set to one.
4. Acknowledge **DATA_OUT_BUF_STATE** with **Clear Status Command** which in turn de-asserts ALERT_N.
5. Issue **Read Data Command** to get the PDO data from the output data buffer.

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1.8.28 PD Use Cases

1.8.28.1 Automatic Negotiation Of Consumer Power Contract using Power Ranges

This use case illustrates how a power contract is automatically negotiated by the sink utilizing the [Set Auto Negotiate Power Range Consumer](#) request. In this example the controller is also configured to automatically accept and request swaps requests to operates as a consumer.

This example assumes controller communicates with the host via SMBUS on port one. A ladder diagram representation can be seen in [Figure 1.12](#).

1. USB PD plug is inserted and detect by the controller.
2. Controller alerts host of status change with ALERT_N pin.
3. Host issues [Read Status Command](#) which indicates pending PD event.
4. Host issues [Get Status](#) Command. The command indicates a PD Port Event occurred.
5. Host issues [Get Port Status](#) request for the respective port.
6. The request indicates that cable insertion detected and PD capable cable present.
7. Host issues [Set Port Status Change Mask](#) to clear status change vector.
8. Host issues [Set Auto Negotiate Power Range Consumer](#) to define consumer's operational capabilities.
9. Host issues [Set Port Feature.POLICY_MODE.AUTO_REQ_SWAP_CONSUMER](#).
10. Host issues [Set Port Feature.POLICY_MODE.AUTO_ACCEPT_SWAP_CONSUMER](#).
11. Host issues [Set Port Feature.AUTO_NEGOTIATE_POWER_CONSUMER](#).
12. Controller alerts host of status change with ALERT_N pin.
13. Host issues [Read Status Command](#) which indicates pending PD event.
14. Host issues [Get Status](#) Command. The command indicates a PD Port Event occurred.
15. Host issues [Get Port Status](#) request for the respective port.
16. The request indicates that a Swap has completed and port received an RDO. The RDO is returned with the [Get Port Status](#) request.
17. Host may issue [Get Received Partner PDO](#) request to retrieve all PDOs received from the partner PD consumer.

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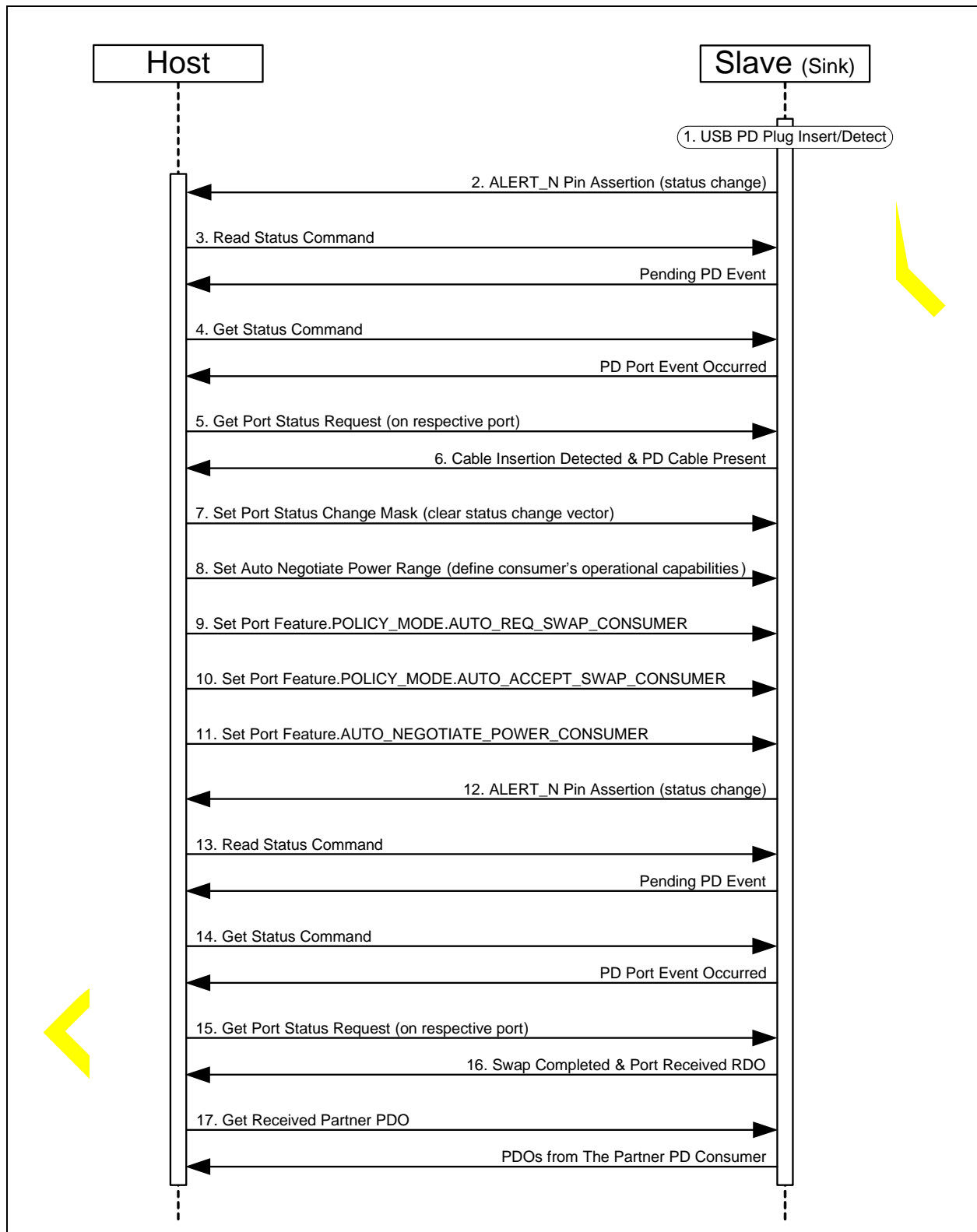


Figure 1.12 Auto-Negotiation of Consumer Power - Ladder Diagram

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1.9 Get Status

The Get Status message is used to obtain determine the source of the controller's status change.

As with other commands its contents are read from the data buffer by the master using [Read Data Command](#).

Table 1.43 Get Status

BIT	DESCRIPTION
31:0	Status Change Status Change Vector. See Table 1.44 .
63:32	Reserved

Table 1.44 Status Change

BIT	CHANGE INDICATED
0	Command Buffer Ready Ready to accept the next command.
1	Over-current Event Detection of an over-current event.
15:2	Reserved
16	PD System Event Indicates a PD system event occurred. Consult Get System Status to determine PD system event.
31:17	PD Port Event Indicates which port the PD event occurred on. Consult Get Port Status to determine PD port event. Note: A single port PD controller always sets bit 18. All other bits are unused in this device.

1.10 Status and Event Reporting

SMBUS ALERT_N pin communicates the occurrence of a status change event. The [Read Status Command](#) is used to determine whether the status change is due to a change in the state of the data buffer or [PD_CHANGE](#) status.

In the event of a [PD_CHANGE](#) the [Get Status](#) command is used to determine the status change event. If a PD port event caused the status change then the [Get Port Status](#) command must be used. If a PD system event caused the status change then the [Get System Status](#) command must be used.

In some system implementations multiple controllers may be utilized in which the respective ALERT_N pins are ORed together into a single pin on the master.

APPLICATION NOTE: If the ALERT_N pin is not implemented then the part must be polled for status.

Chapter 2 Reference Documentation (REF)

This document was created using the following parent documents:

1. Universal Serial Bus Power Delivery Specification Rev 1.0
2. Universal Serial Bus Specification Rev 2.0
3. Universal Serial Bus 3.0 Specification Rev 1.0
4. Universal Serial Bus Battery Charging Specification Rev 1.1

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System Management Bus Specification

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