SMPTE Public Committee Draft

Signal Sync Alternate Mode

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Foreword

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Intellectual Property

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Introduction

This clause is entirely informative and does not form an integral part of this Engineering Document.

The USB-C connector is increasingly being used to interconnect devices used in media production. There is a need to be able to interconnect and synchronize such devices with existing professional media equipment. Standards including but not limited to AES 11, SMPTE ST 274, and SMPTE ST 2110-10 define timing reference for analogue signals, digital audio streams, IP datagram networks, MAC bridges, serial data signals, and VLAN-aware bridges. Attempts to reconcile this broad span of timescales with newly standardized time labels include SMPTE ST 2120, SMPTE ST 2134, and SMPTE ST 12-4. These timing references cannot be directly transported over USB-C data connections without protocol overhead and other latency impacts. This is especially true in cases where highly accurate synchronization is required such as timing for camera shutter, display refresh, and lighting. To solve this problem, a USB-C Alternate Mode is used to enable transport of timing reference pulses between USB-C devices.

This document employs acronyms and terms that are defined in the standards listed in Clause 3, Normative References. As a quick guide, Annex A provides an informative Glossary listing of a number of these terms and their descriptions, as well as references to their source standards.

1 Scope

1.1 Compliance with USB Standards

Implementations of this USB-C Signal Sync Alternate Mode (SSAM) standard shall conform to the requirements specified in the USB 2.0, USB4, USB-C, and USB Power Delivery standards, as applicable. All components and functionalities related to data transfer, power delivery, cable, and connector configurations shall observe these standards to ensure compatibility, safety, and interoperability across compliant devices.

NOTE For brevity, “USB Power Delivery” is referred to as “USB PD” in this document.

1.2 Messaging

This USB-C Signal Sync Alternate Mode (SSAM) standard uses USB Power Delivery (USB PD) messages to discover and enter the Mode with an attached Port Partner. Within the Mode, the SSAM uses standard USB PD message structure and rules to pass information between the port partners to configure signal connections through the USB Type-C connector. This messaging includes:

- Reporting the sync signals and properties available to the port partner.
- Reporting available USB Type-C connector pins to the port partner.
- Requesting internal sync signal connections to reported connector pins.
- Reporting the port partner that will function as sync transmitter.
- Routing sync signals from a host/device through a USB Type-C connection target to an attached host/device.

1.3 Sync Signals

This USB-C Signal Sync Alternate Mode (SSAM) standard defines the signal electrical characteristics of sync signals.

NOTE USB PD messages are exchanged between directly connected USB port partners. USB PD messages are not relayed across USB hubs or USB multifunction devices.

2 Conformance Notation

Normative text is text that describes elements of the design that are indispensable or contains the conformance language keywords: "shall", "should", or "may". Informative text is text that is potentially helpful to the user, but not indispensable, and can be removed, changed, or added editorially without affecting interoperability. Informative text does not contain any conformance keywords.

All text in this document is, by default, normative, except: the Introduction, any clause explicitly labeled as "Informative" or individual paragraphs that start with "NOTE:"

The keywords "shall" and "shall not" indicate requirements strictly to be followed in order to conform to the document and from which no deviation is permitted.

The keywords "should" and "should not" indicate that, among several possibilities, one is recommended as particularly suitable, without mentioning or excluding others; or that a certain course of action is preferred but not necessarily required; or that (in the negative form) a certain possibility or course of action is deprecated but not prohibited.

The keywords "may" and "need not" indicate courses of action permissible within the limits of the document.

The keyword "reserved" indicates a provision that is not defined at this time, shall not be used, and may be defined in the future. The keyword "forbidden" indicates "reserved" and in addition indicates that the provision will never be defined in the future.

A conformant implementation according to this document is one that includes all mandatory provisions ("shall") and, if implemented, all recommended provisions ("should") as described. A conformant implementation need not implement optional provisions ("may") and need not implement them as described.

Unless otherwise specified, the order of precedence of the types of normative information in this document shall be as follows: Normative prose shall be the authoritative definition; tables shall be next; then formal languages; then figures; and then any other language forms.

3 Normative References

The following standard contains provisions that, through reference in this text, constitute provisions of this standard. Dated references require that the specific edition cited shall be used as the reference. Undated citations refer to the edition of the referenced document (including any amendments) current at the date of publication of this document. All standards are subject to revision, and users of this engineering document are encouraged to investigate the possibility of applying the most recent edition of any undated reference.

Universal Serial Bus Implementers Forum (USB-IF), *USB4® Specification v2.0*
NOTE 1 For brevity, referred to as "*USB4 Specification*" in this document.

Universal Serial Bus Implementers Forum (USB-IF), *USB Power Delivery Specification v2.0*
NOTE 2 For brevity, referred to as "*USB PD Specification*" in this document.

Universal Serial Bus Implementers Forum (USB-IF), *USB 2.0 Specification*
NOTE 3 For brevity, referred to as "*USB 2.0 Specification*" in this document.

Universal Serial Bus Implementers Forum (USB-IF), *USB Type-C® Cable and Connector Specification Release 2.4*
NOTE 4 For brevity, referred to "*USB Type-C® Cable and Connector Specification"* in this document.

4 Terms and Definitions

For the purposes of this document, the terms and definitions given in the *USB Power Delivery Specification v2.0*, *USB Type-C® Cable and Connector Specification Release 2.4*, and the following apply:

4.1 Alternate D+/D-

D+/D- pins on the opposite side of the USB-C receptacle from the connect/communications CC path

4.2 Primary D+/D-

D+/D- pins associated with the USB 2.0 logical data channel on the same side of the USB-C receptacle as the connect/communications CC path

5 SSAM VDM Header

5.1 Introduction

The USB-C Alt Mode Vendor Defined Message (VDM) is a structured sequence of communication exchanges defined within the *USB Power Delivery Specification*. It enables the negotiation, activation, and management of Alternate Modes.

See Annex C for informative examples of SSAM VDM entry and connection flows.

5.2 Overview

The SSAM VDM Message Structure shall implement the USB PD Structured VDM (SVDM) format as defined in the *USB Power Delivery Specification*. The SSAM VDM Header shall be as defined in Table 1.

Table 1 — SSAM VDM Header

Bit(s)	Description	Value
31:16	USB-IF SSAM SID	0xFF05
15	VDM Type	1b = Structured
14:13	SVDM Version (Major)	01b = USB PD SVDM Version 2.x
12:11	SVDM Version (Minor)	01b = USB PD SVDM minor version (2.1)
10:8	Object Position	000b if not Enter Mode, Exit Mode, or Attention Otherwise, numerical position (1…6) of SSAM in the mode list returned from the Discover Modes Command
7:6	Command Type	00b = REQ 01b = ACK 10b = NAK 11b = Busy
5	Reserved by USB PD	Shall be set to 0 and shall be ignored.
4:0	Command	0 = Reserved, shall not be used 1 = Discover Identity 2 = Discover SVIDs 3 = Discover Modes 4 = Enter Mode 5 = Exit Mode 6 = Attention 7 to15, Reserved, shall not be used 16 to 31 Reserved for future SSAM use.

5.3 USB-IF SSAM SID

The USB Implementers Forum (USB-IF) assigns a 16-bit Standard/Vendor Identification (SVID) value to either a Standards body or a Vendor where the SVID is either a Standards ID (SID) or Vendor ID (VID). The SID for SSAM is 0xFF05.

5.4 VDM Type

The value of VDM shall be set to 1b for Structured VDM.

5.5 SVDM Version (Major)

The Value of VDM Version (Major) shall be the USB PD SVDM major version.

5.6 SVDM Version (Minor)

The Value of VDM Version (Minor) shall be the USB PD SVDM minor version.

5.7 Object Position

When used for some standard USB PD commands, Object Position provides the location index for a received list of items.

5.8 Command Type

- REQ
    - Request from Initiator Port.
- ACK
    - Acknowledge Response from Responder Port.
- NACK
    - Negative Acknowledge Response from Responder Port.
- Busy
    - Busy Response from Responder Port.
- Reserved by USB PD
    - Shall be set to 0 and shall be ignored.

See the *USB Type-C® Cable and Connector Specification* for detailed VDM Header command type usage.

5.9 Command

The command that is being requested or responded to. USB PD specifies VDM Header Commands used to retrieve a list of SVIDs the device supports, to discover the Modes associated with each SVID, and to enter/exit the Modes. Clause 6 through Clause 11 provide details about the available VDM Header Commands.

6 Discover Identity

The SSAM utilizes information gathered by the DFP from the USB PD Discovery Identity responses for both the attached UFP and attached cable. Refer to the *USB Power Delivery Specification* for the full Discover Identity responses.

From the UFP Discover Identity the following pieces of information are used.

- Connector Type - used to determine if the device has a USB Type-C receptacle or a has a USB Type-C plug.
- Modal Operation Supported – used to determine if the DFP supports Modes and shall be true to support SSAM.
- USB Communications Capable – used to determine if the Primary D+/D- pair is not used for the USB 2.0 logical data channel.

From the Cable Discovery Identity, the following piece of information is used.

- USB Highest Speed – to determine if the Cable is USB 2.0 only or USB Full-featured.

7 Discover SVIDs

The USB PD Discover SVIDs command is sent by the DFP to the UFP to request the list of Standard and Vendor IDs (SVIDs) that are supported with alternate modes. To enter SSAM, a Discover SVIDs for the SSAM SVID shall be sent. A UFP that supports SSAM will return the SSAM SVID in this list of SVIDs.

8 Discover Modes

8.1 Introduction

The USB PD Discover Modes Request command is sent by the DFP to the UFP for any SVID that both the DFP and UFP support to determine what modes have been defined for that SVID. To enter SSAM, a Discover Modes Request for the SSAM SVID shall be sent.

For each mode supported, the UFP shall return the VDM header and a 32-bit Mode Vendor Defined Object (VDO). The Mode VDO content is not defined by the *USB Power Delivery Specification* but is left to the assignee of the SVID to determine the content. The following clauses show the Discover Modes Request and Response for the SSAM SID.

- Clause 8.2 describes SSAM Discover Modes Request.
- Clause 8.3 describes SSAM Discover Modes Response VDM Header.
- Clause 8.4 describes SSAM Discover Modes Response VDO.

See Annex C for informative examples of the Discover Modes flow.

8.2 SSAM Discover Modes Request

Table 2 shows the Discover Modes request from the DFP to the UFP for the SSAM SVID.

Table 2 — SSAM Discover Modes Request

Bit(s)	Description	Value
31:16	USB-IF SSAM SID	0xFF05
15	VDM Type	1b = Structured
14:13	SVDM Version (Major)	01b = USB PD SVDM Version 2.x
12:11	SVDM Version (Minor)	01b = USB PD SVDM minor version (2.1)
10:8	Object Position	000b
7:6	Command Type	00b = REQ
5	Reserved	0b
4:0	Command	3 = Discover Modes

8.3 SSAM Discover Modes Response VDM Header

The UFP Response to the DFP Discover Modes request shall include the VDM header shown in Table 3.

Table 3 — SSAM Discover Modes Response VDM Header

Bit(s)	Description	Value
31:16	USB-IF SSAM SID	0xFF05
15	VDM Type	1b = Structured
14:13	SVDM Version (Major)	01b = USB PD SVDM Version 2.x
12:11	SVDM Version (Minor)	01b = USB= PD SVDM minor version (2.1)
10:8	Object Position	000b
7:6	Command Type	01b = ACK
5	Reserved	0b
4:0	Command	3 = Discover Modes

8.4 SSAM Discover Modes Response VDO

8.4.1 Introduction

The UFP shall send a Mode VDO following the VDM Header. Table 4 shows the SSAM Discover Modes Response VDO.

See Annex C for informative examples of VDO in the SSAM entry and connection flows.

Table 4 — SSAM Discover Modes Response VDO

Bit(s)	Description	Value
31:30	Alt Mode	0 = SSAM 1 to 3 = Reserved for future definition
29:16	Reserved	Shall be set to 0 and shall be ignored.
15	USB 2.0 Signaling Not Used	0b = USB 2.0 might be needed on Primary D+/D- 1b = USB 2.0 is not needed on Primary D+/D- while in SSAM
14:9	Reserved	Shall be set to 0 and shall be ignored.
8:6	Max Sync Signaling Frequency Supported as Receiver	000b = Supports transmitter Only 001b = 10 Hz 010b = 60 Hz 011b = 240 Hz 100b = 10 kHz 101b = 60 kHz 110b = 240 kHz 111b = Reserved
5	Sync Signaling Pins	0b = Signaling on primary pin in pair only 1b = Signaling supported on both pins in pair
4:3	Sync Signaling as Transmitter or Receiver	00b = Reserved x1b = Can be receiver 1xb = Can be transmitter
2:0	Pairs Supported for Sync Signaling	000b = Reserved xx1b = Primary D+/D- supported x1xb = Alternate D+/D- supported 1xxb = SBU pair supported

8.4.2 Alt Mode

The Alt Mode field identifies the SSAM Alternate Mode to which the rest of the fields pertain. Only one Alternate Mode, SSAM, is defined and the other three options are reserved for future definition.

8.4.3 USB 2.0 Signaling Not Used

USB 2.0 Signaling Not Used shall be set to 0b when the connection might need USB 2.0 on the Primary D+/D- pair and 1b when USB 2.0 is not needed after entering SSAM.

8.4.4 Max Sync Signaling Frequency Supported as Receiver

The value of Max receiver Frequency Supported shall be set to the maximum support signaling frequency the UFP supports as a receiver of the signal from the DFP.

8.4.5 Sync Signaling Pins

- Signaling on primary pin in pair only
    - The value of Sync Signaling on Both Pins of Pair shall be set to No to connect only the Primary Pin. D+ shall be the primary pin for the Primary and Alternate D+/D- pairs. For SBU, the primary pin depends upon the connection type. SBU1 of the transmitter and SBU2 of the receiver shall be the primary pins for a receptacle device. SBU1 shall be the primary pin in both the DFP and UFP for a captive connection.
- Signaling supported on both pins in pair
    - The value of Sync Signaling on Both Pins of Pair shall be set to Yes to connect both pins in the pair to the Port Partner Pins.

8.4.6 Sync Signaling as Transmitter or Receiver

The value of this 2-bit mask field shall be set based on the UFP capability of being a transmitter or a receiver. The UFP can be capable of:

- Being a transmitter,
- Being a receiver, or
- Changing role from transmitter to receiver or vice versa.

Whether the UFP becomes the transmitter or the receiver in a connection will be set by the DFP.

See Annex C for informative examples of command flow to change UFP role.

8.4.7 Pairs Supported for Sync Signaling

The value of this 3-bit mask field shall be set based on which pairs the UFP supports signaling. This field will be used by the DFP to determine on which pair(s) a connection can be established. This field may be set to a single pair or any combination of the three pairs with the following restrictions specified in the *USB Type-C® Cable and Connector Specification* standard:

- Primary D+/D-
    - If supported for sync signaling over USB 2.0 Type-C cables or USB Full-featured Type-C Cables, the device shall expose a USB Billboard Device Class to provide information needed to identify the device.
    - Shall not be supported for sync signaling on downstream-facing USB-C ports of Alternate Mode expanders.
- Alternate D+/D-
    - Shall only be supported for sync signaling over Captive Cables.
    - Shall not be supported for sync signaling over USB 2.0 Type-C cables or USB Full-featured Type-C Cables.
- SBU1/SBU2
    - Shall only be supported for sync signaling over Captive Cables and USB Full-featured Type-C Cables.
    - Shall not be supported for sync signaling over USB 2.0 Type-C cables.

A single pair can function as either sync transmitter or sync receiver. A single pair cannot function as transmitter on one pin and receiver on the other pin.

See Annex B for information about USB-C pin usage.

9 Enter Mode

9.1 Introduction

Once the Discover Modes flow is complete, the DFP may choose to enter SSAM with the UFP. The USB PD Enter Mode command shall be used to accomplish this. The SSAM Enter Mode request shall be sent by the DFP and include the VDM Header and a single 32-bit VDO containing the expected configuration to be made when entering the mode.

Clause 9.2 describes the SSAM Enter Modes Request VDM Header. Clause 9.3 describes the SSAM Enter Mode Request VDO.

See Annex C for informative examples of the Discover Modes flow.

9.2 SSAM Enter Mode Request VDM Header

Table 5 shows the DFP Enter Mode request to the UFP for SSAM. The request shall include both the VDM header as well as a single Enter Mode VDO for SSAM.

Table 5 — SSAM Enter Mode Request VDM Header

Bit(s)	Description	Value
31:16	USB-IF SSAM SID	0xFF05
15	VDM Type	1b = Structured
14:13	SVDM Version (Major)	01b = USB PD SVDM Version 2.x
12:11	SVDM Version (Minor)	01b = USB PD SVDM minor version (2.1)
10:8	Object Position	Numerical position (1..6) of the SSAM in the Mode list returned from the Discover Modes Command
7:6	Command Type	00b = REQ
5	Reserved	0b
4:0	Command	4 = Enter Mode

9.3 SSAM Enter Mode Request VDO and Enter Mode Response

9.3.1 Introduction

Table 6 shows the SSAM Enter Mode VDO following the VDM Header in the request; the Clause 9.3.2 through Clause 9.3.6 provide further detail for each portion of the Enter Mode VDO.

Table 6 — Enter Mode Request VDO for SSAM

Bit(s)	Description	Value
31:16	Reserved	Shall be set to 0 and shall be ignored.
15	USB 2.0 Signaling Not Used	0b = USB 2.0 might be needed on Primary D+/D- 1b = USB 2.0 is not needed on Primary D+/D- while in SSAM
14:9	Reserved	Shall be set to 0 and shall be ignored.
8:6	Max DFP Sync Signaling Frequency Supported as Receiver	000b = Supports transmitter Only 001b = 10 Hz 010b = 60 Hz 011b = 240 Hz 100b = 10 kHz 101b = 60 kHz 110b = 240 kHz 111b = Reserved
5	Sync Signaling Pins	0b = Signaling on primary pin in pair only 1b = Signaling supported on both pins in pair
4	UFP is Sync Signaling Transmitter	0b = UFP is receiver (DFP is transmitter) 1b = UFP is transmitter (DFP is receiver)
3:2	Reserved	Shall be set to 0 and shall be ignored.
1:0	Pair to Reassign to Sync Signaling	00b = none (do not assign any pairs, maintain current connections) 01b = Primary D+/D- pair 10b = Alternate D+/D- pair 11b = SBU pair

9.3.2 USB 2.0 Signaling Not Used

USB 2.0 Signaling Not Used shall be set to 0b when the connection might need USB 2.0 on the Primary D+/D- pair and 1b when USB 2.0 is not needed after entering SSAM.

9.3.3 Max DFP Sync Signaling Frequency Supported as Receiver

The value of max DFP Sync Signaling Frequency Supported as receiver shall be set to the maximum support signaling frequency the DFP supports as a receiver (receiver of the signal from the UFP). If the DFP supports transmitter role only, this shall be set to 000b.

9.3.4 Sync Signaling Pins

- Signaling on primary pin in pair only
    - The value of Sync Signaling on Both Pins of Pair shall be set to No to connect only the Primary Pin. D+ shall be the primary pin for the Primary and Alternate D+/D- pairs. For SBU, the primary pin depends upon the connection type. SBU1 of the transmitter and SBU2 of the receiver shall be the primary pins for a receptacle device. SBU1 shall be the primary pin in both the DFP and UFP for a captive connection.
- Signaling supported on both pins in pair
    - The value of Sync Signaling on Both Pins of Pair shall be set to Yes to connect both pins in the pair to the Port Partner Pins.

9.3.5 UFP is Sync Signaling Transmitter

The value of UFP is Sync Signaling transmitter shall be set to Yes to configure the UFP as the transmitter and the DFP is the receiver of the sync signal.

See Annex C for informative examples of command flow to change UFP role.

9.3.6 Pair to Reassign to Sync Signaling

The value of Pair to Reassign to Sync Signaling shall be set to the pair over which signaling is to occur. The sync signaling pair shall be one of the following:

- Primary D+/D- pair
- Alternate D+/D- pair
- SBU pair

The remaining USB-C pins CC1/CC2, GND, RX+/RX-, TX+/TX-, and VBUS shall not be used for sync signaling.

If no pair is currently to be reassigned, this should be set to 00b.

NOTE USB 2.0 protocol will be disconnected if the Primary D+/D- pair is reassigned to Sync Signaling. See Annex B for overview of USB-C recommendations and requirements in cases where the Primary D+/D- pair is reassigned for use in an Alternate Mode.

9.3.7 Enter Mode Response

The DFP shall respond to the DFP SSAM Enter Mode request with one of two responses. The two options (acknowledge or not acknowledge) are shown in bits 7:6 in Table 7. If the DFP can connect with the configuration requested, then the request should be acknowledged. However, if the DFP is unable to connect with the configuration request, then it should not be acknowledged. This could be because the DFP requests pairs that are unavailable, dual signal when not supported, etc.

NOTE The response does not have a VDO.

Table 7 — Enter Mode Response VDM Header for SSAM

Bit(s)	Description	Value
31:16	USB-IF SSAM SID	0xFF05
15	VDM Type	1b = Structured
14:13	SVDM Version (Major)	01b = USB PD SVDM Version 2.x
12:11	SVDM Version (Minor)	01b = USB PD SVDM minor version (2.1)
10:8	Object Position	Numerical position (1..6) of the SSAM in the Mode list returned from the Discover Modes Command
7:6	Command Type	00b = ACK (if able to connect with configuration sent by DFP) 10b = NAK (if unable to connect with configuration sent by DFP)
5	Reserved	0b
4:0	Command	4 = Enter Mode

10 Exit Mode

The Exit Mode Command is used by a DFP to command a UFP to exit its Active Mode and return to normal USB operation. Only the DFP Shall initiate the Exit Mode Process. See the *USB Power Delivery Specification* for detailed description of the Exit Mode flow.

11 Attention

11.1 Introduction

The Attention message is a USB PD message that allows the UFP to initiate the sending of information to the DFP without the DFP requesting the information. For the SSAM, the UFP shall send an Attention message to the DFP whenever any of the information that was previously sent in the SSAM VDO changes. This allows the UFP to update the DFP on changed capabilities. The Attention message is nearly identical to the Discover Modes response with only the Command Type and Command fields of the SSAM VDM Header set differently.

11.2 Attention Message

Table 8 Shows the UFP Attention message VDM Header. The Attention message shall include both the VDM header as well as the Mode VDO for SSAM. The Mode VDO is the same information and structure that is sent with the Discover Modes response for SSAM.

Table 8 — Attention VDM Header for SSAM SID

Bit(s)	Description	Value
31:16	USB-IF SSAM SID	0xFF05
15	VDM Type	1b = Structured
14:13	SVDM Version (Major)	01b = USB PD SVDM Version 2.x
12:11	SVDM Version (Minor)	01b = USB PD SVDM minor version (2.1)
10:8	Object Position	000b
7:6	Command Type	01b = REQ
5	Reserved	0b
4:0	Command	6 = Discover Modes

11.3 Attention Response

The DFP shall re-evaluate the information contained in the SSAM VDO upon receipt of the Attention Message and determine if a change in connectivity is warranted. The DFP shall send a new Enter Mode command for SSAM with updated connectivity information if the DFP determines that a change to connectivity is warranted.

12 Signal Electrical Specifications

12.1 Sync Signals

SSAM sync signals sent from the transmitter are digital pulses.

12.2 Sync Pulses

The SSAM Sync pulses are intended for embedded applications which only require a positive digital pulse to indicate the sync time point.

12.3 Ground Differential

As described in the *USB Type-C® Cable and Connector Specification*, the maximum ground differential between the transmitter and receiver is ±250mV.

12.4 Sync Signal Transmitter

Table 9 shows the electrical requirements for the SSAM sync signal source.

Table 9 — Electrical Characteristics of the SSAM Sync Signal Transmitter

Parameter	Symbol	Min	Max	Unit
Output High	Vsync_VOH	2.25 [a, b]	3.47 [a, b]	V
Output Low	Vsync_VOL	0 [a, b]	0.55 [a, b]	V
Pulse Low Time	Sync_TL	2		µs
Pulse High Time	Sync_TH	2		µs
Pulse Rise Time	Sync_TR	3.5	65	ns
Pulse Fall Time	Sync_TF	3.5	65	ns

[a] Relative to ground at output
[b] Min-Max range accounts for ground differential between transmitter and receiver

12.5 Output High

SSAM sync pulse logical high transmitter voltage.

12.6 Output Low

SSAM sync pulse logical low transmitter voltage.

12.7 Pulse Low Time

SSAM sync pulse output minimum duration at the transmitter below Output Low maximum voltage.

12.8 Pulse High Time

SSAM sync pulse output minimum duration at the transmitter above Output High minimum voltage.

12.9 Pulse Rise Time

SSAM sync pulse output minimum and maximum rise time measured from 10% to 90% of output high voltage.

NOTE Minimum and maximum rise and fall time ranges match USB4 specification for SBU. Range is wider than USB 2.0 specification for full-speed drivers.

12.10 Pulse Fall Time

SSAM sync pulse output minimum and maximum fall time measured from 10% to 90% of output low voltage.

NOTE Minimum and maximum rise and fall time ranges match USB4 specification for SBU. Range is wider than USB 2.0 specification for full-speed drivers.

12.11 Sync Signal Receiver

Table 10 shows the electrical requirements for the SSAM sync signal receiver.

Table 10 — Electrical Characteristics of the SSAM Sync Signal Receiver

Parameter	Symbol	Min	Max	Unit
Input High	Vsync_VIH	2 [a, b]	3.72 [a, b]	V
Input Low	Vsync_VIL	-0.3 [a, b]	0.8 [a, b]	V
[a] Relative to ground at input [b] Min-Max range accounts for ground differential between transmitter and receiver				

12.12 Input High

SSAM sync pulse logical high receiver voltage. Sync pulse positive crossing of the minimum value shall represent the sync datum.

12.13 Input Low

SSAM sync pulse logical low receiver voltage.

Annex A
(Informative)

Glossary

A.1 Introduction

The following information is drawn from the *USB Power Delivery Specification* and the *USB Type-C® Cable and Connector Specification* cited in Clause 3, and is provided here for ease of reference.

A.2 Alternate Mode

Operation defined by a vendor or standards organization that is associated with a SVID assigned by the USB-IF, whose definition is outside the scope of USB-IF specifications. Entry and exit into and from an Alternate Mode is controlled by Structured VDM Enter and Exit Mode commands. Specified in the *USB Power Delivery Specification*.

A.3 Captive Cable

A cable that is terminated on one end with a USB Type-C plug and has a vendor-specific connection (hardwired or custom detachable) on the opposite end. See the *USB Type-C® Cable and Connector Specification*.

A.4 CC

Configuration Channel USB-C pins. Specified in the *USB Type-C® Cable and Connector Specification*.

A.5 D+/D-

Positive and negative differential data pin pair associated with USB 2.0 data transfer. Referenced in the *USB Type-C® Cable and Connector Specification*.

A.6 DFP

Downstream Facing Port. Referenced in the *USB Power Delivery Specification*.

A.7 Direct Connect Device

A device with either a captive cable or just a USB Type-C plug (e.g., thumb drive). Described in the *USB Type-C® Cable and Connector Specification*.

A.8 GND

Return current pin path. Specified in the *USB Type-C® Cable and Connector Specification*.

A.9 IOH

Input/Output High current.

A.10 Mode

See Clause A.2 Alternate Mode.

A.11 Port

An interface typically exposed through a receptacle, or via a plug on the end of a hard-wired captive cable. Described in the *USB Power Delivery Specification*.

A.12 Port Pair

Two attached USB PD capable ports. Described in the *USB Power Delivery Specification*.

A.13 Port Partner

Refers to the USB port (device or host) to which a port is attached. Described in the *USB Type-C® Cable and Connector Specification*.

A.14 RX+/RX-

Positive and negative RX differential pin pair for high-speed USB data. Specified in the *USB Type-C® Cable and Connector Specification*.

A.15 SBU

Sideband Use pins. Specified in the *USB Type-C® Cable and Connector Specification*.

A.16 SID

SMPTE Standard ID 0xFF05. 16-bit unsigned value assigned by the USB-IF to a given industry standard. Specified in the *USB Power Delivery Specification*.

A.17 SVDM

Structured VDM. Specified in the *USB Power Delivery Specification*.

A.18 SVID

Generic term referring to either a SID or VID. Used in place of the phrase "Standard or Vendor ID."

A.19 TX+/TX-

Positive and negative TX differential pin pair for high-speed USB. Specified in the *USB Type-C® Cable and Connector Specification*.

A.20 Type-C Plug

A USB plug conforming to the mechanical and electrical specifications in the *USB Type-C® Cable and Connector Specification*.

A.21 Type-C Port

The USB port associated with a USB Type-C receptacle. This includes the USB signaling, CC logic, multiplexers, and other associated logic. Specified in the *USB Type-C® Cable and Connector Specification*.

A.22 Type-C Receptacle

A USB receptacle conforming to the mechanical and electrical specifications in the *USB Type-C® Cable and Connector Specification*.

A.23 UFP

Upstream Facing Port. Referenced in the *USB Power Delivery Specification*.

A.24 USB

Universal Serial Bus physical interface, communication protocols, and performance specifications maintained by the USB Implementers Forum, as well as the hosts and devices that adhere to these standards.

A.25 USB 2.0

Universal Serial Bus Implementers Forum (USB-IF), *USB 2.0 Specification*.

A.26 USB 2.0 logical data channel

The abstraction for USB 2.0 data transfer, independent of the physical layer, as referenced in the *USB Type-C® Cable and Connector Specification*.

A.27 USB 2.0 Type-C Cable

A USB Type-C to USB Type-C cable that supports only USB 2.0 data operation. This cable does not include USB 3.2 or SBU wires. See the *USB Type-C® Cable and Connector Specification*.

A.28 USB 2.0 Type-C Plug

A USB Type-C plug specifically designed to implement the USB 2.0 Type-C cable. See the *USB Type-C® Cable and Connector Specification*.

A.29 USB4

Universal Serial Bus Implementers Forum (USB-IF), *USB4® Specification v2.0*.

A.30 USB-C

Universal Serial Bus Implementers Forum (USB-IF), *USB Type-C® Cable and Connector Specification Release 2.4*.

A.31 USB Billboard Device Class

USB Billboard Device Class specification. Referenced in the *USB Type-C® Cable and Connector Specification*.

A.32 USB Full-featured Type-C Cable

A USB Type-C to USB Type-C cable that supports USB 2.0, USB 3.2 and USB4 data operation. This cable includes SBU wires and is an Electronically Marked Cable. See the *USB Type-C® Cable and Connector Specification*.

A.33 USB Full-featured Type-C Plug

A USB Type-C plug specifically designed to implement the USB Full-featured Type-C cable. See the *USB Type-C® Cable and Connector Specification*.

A.34 USB Power Delivery (PD)

Universal Serial Bus Implementers Forum (USB-IF), *USB Power Delivery Specification v2.0*.

A.35 USB Type-C Receptacle

A USB receptacle conforming to the mechanical and electrical specifications in the *USB Type-C® Cable and Connector Specification*.

A.36 VBUS

USB Power delivery pin path. Specified in the USB Type-C® Cable and Connector Specification.

A.37 VDM

Vendor Defined Messages. Specified in the *USB Power Delivery Specification*.

A.38 VDO

Vendor Data Objects. Specified in the *USB Power Delivery Specification*.

A.39 VID

Vendor ID. 16-bit unsigned value assigned by the USB-IF to a given Vendor. Specified in the *USB Power Delivery Specification*.

Annex B
(Informative)

USB-C Pin Usage

B.1 Alternate Mode Pin Reassignment

Alternate Modes use USB PD messages that extend the functionality a device exposes, reassigning certain pins on the USB-C interconnect to enable functions outside the scope of USB. When pins are reassigned to an Alternate Mode, they are not available for USB protocol signaling until the Alternate Mode is exited. The *USB Type-C® Cable and Connector Specification* describes the USB-C pins available for Alternate Mode Pin Reassignment and Reconfiguration.

B.2 Functional

The *USB Type-C® Cable and Connector Specification* specifies functional requirements for signaling across USB Type-C cables and connectors. This includes distinct electrical characteristic requirements for each Signal Group available on USB Type-C connectors. The SSAM sync signal described in normative clauses of this Standard is not compatible with every Signal Group. Specifically, the USB-C TX and RX pins, which are available for Alternate Mode Pin Reassignment, have functional signal integrity requirements related to USB 3.2 and USB4 that are not suitable for SSAM sync signals.

B.3 SSAM Pin Usage

B.3.1 Overview

When combined, the functional and Alternate Mode requirements in the *USB Type-C® Cable and Connector Specification* constrain SSAM to using certain pins for connection of sync signals. Figure B.1 shows the pins on the USB Type-C connector pins that are not available for connecting SSAM sync signals and the pins that are available to be reassigned for connecting SSAM sync signals. USB-C pin usage is described in the *USB Power Delivery Specification* and *USB Type-C® Cable and Connector Specification*.

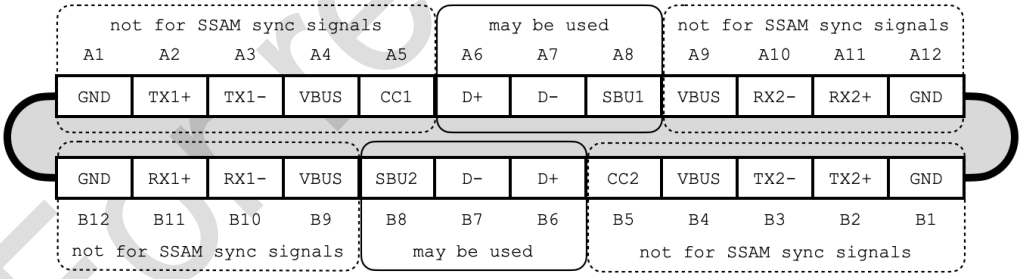

Figure B.1 — USB Type-C pins available for SSAM

B.3.2 Unavailable Pins

- GND
    - GND pins are not available for Alternate Mode Pin Reassignment.
- TX/RX
    - TX/RX pins have functional signal integrity requirements related to USB 3.2 and USB4 that are not suitable for SSAM sync signals.
- VBUS
    - VBUS pins are not available for Alternate Mode Pin Reassignment.
- CC
    - CC pins are not available for Alternate Mode Pin Reassignment.

B.3.3 Available Pins

- SBU
    - SBU pins are available for reassignment to carry sync pulses over Captive USB-C Cables and USB Full-featured Type-C Cables unless they are prioritized for use in some other Mode (e.g., USB4, Thunderbolt, DisplayPort).
- D+/D-
    - Both D+/D- pin pairs on USB-C Captive Cables are available for reconfiguration and reassignment to connect sync signals. The single D+/D- pin pair on USB 2.0 Type-C Cables and USB Full-featured Type-C Cables is available for reconfiguration and reassignment to connect sync signals.

NOTE Available pins can be referred to in pairs (D+/D- pair and SBU pair).

B.3.4 Sync Signaling Pairs

- Captive Cables
    - Figure B.2 shows the potential pair availability between the USB PD Downstream Facing Port (DFP) and the USB PD Upstream Facing Port (UFP) for Captive Cables.

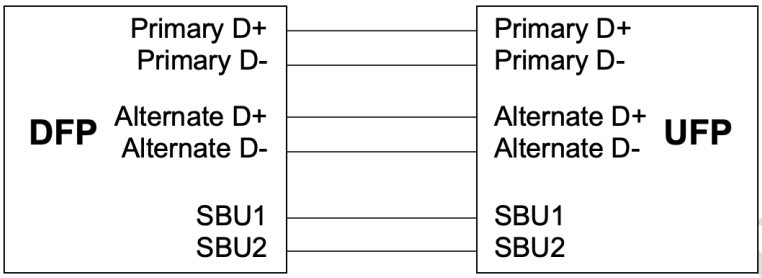

Figure B.2 — Captive Cable SSAM Pair Availability

- USB Full-featured Type-C Cable
    - Figure B.3 shows the potential pair availability between the USB PD Downstream Facing Port (DFP) and the USB PD Upstream Facing Port (UFP) for USB Full-featured Type-C cables. To support the reversible USB-C connection design, the SBU Pair crosses over.

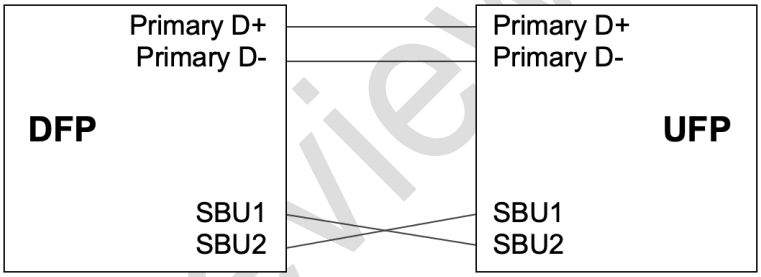

Figure B.3 — USB Full-featured Type-C Cable SSAM Pair Availability

- USB 2.0 Type-C Cable
    - Figure B.4 shows the potential pair availability between the USB PD Downstream Facing Port (DFP) and the USB PD Upstream Facing Port (UFP) for USB 2.0 Type-C cables.

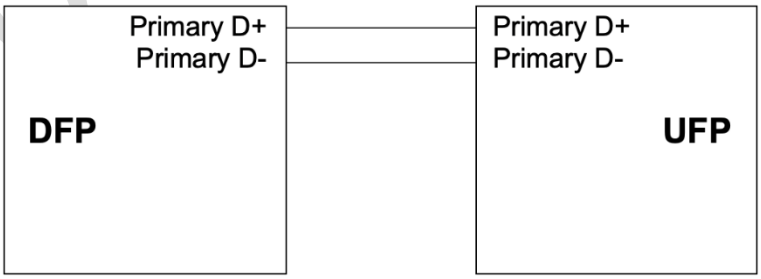

Figure B.4 — USB 2.0 Type-C Cable SSAM Pair Availability

B.4 Concurrent Alternate Modes

The *USB Power Delivery Specification* and *USB Type-C® Cable and Connector Specification* describe messaging that enables USB-C devices to support more than one concurrent Alternate Mode, with each Alternate Mode using distinct USB-C pins. For example, a Captive Cable device implementing DisplayPort Alternate Mode reassigns TX, RX, and SBU pins for DisplayPort Alt Mode. This leaves the D+/D- pins available for reassignment to another Alternate Mode such as SSAM.

B.5 USB Functionality

The *USB Power Delivery Specification* and *USB Type-C® Cable and Connector Specification* strongly recommends devices supporting Alternate Modes to also support USB functionality. This is an important consideration for SSAM devices when determining whether to support D+/D- pin pairs for sync signaling. Depending on the cable type and implementation, there are cases where reassigning D+/D- for sync signals disconnects USB 2.0 protocol on the USB-C connection. For these cases, USB-C requires the device to provide a USB Billboard Device Class. In the case of devices such as Alternate Mode expanders with downstream facing USB-C receptacles supporting Alternate Modes, USB-C requires the downstream facing ports to expose a USB 2.0 interface.

B.6 VDO

Vendor Data Objects. Specified in the *USB Power Delivery Specification*.

B.7 VID

Vendor ID. 16-bit unsigned value assigned by the USB-IF to a given Vendor. Specified in the *USB Power Delivery Specification*.

Annex C
(Informative)

Examples

C.1 Example 1

Figure C.1 shows SSAM connection between Host and Device using Alternate D+/D- pin pair over a Captive Cable. Both Host and Device support sync signaling on both pins and have both transmitter and receiver capabilities. The remaining USB-C pin pairs are available for USB or other Alternate Modes.

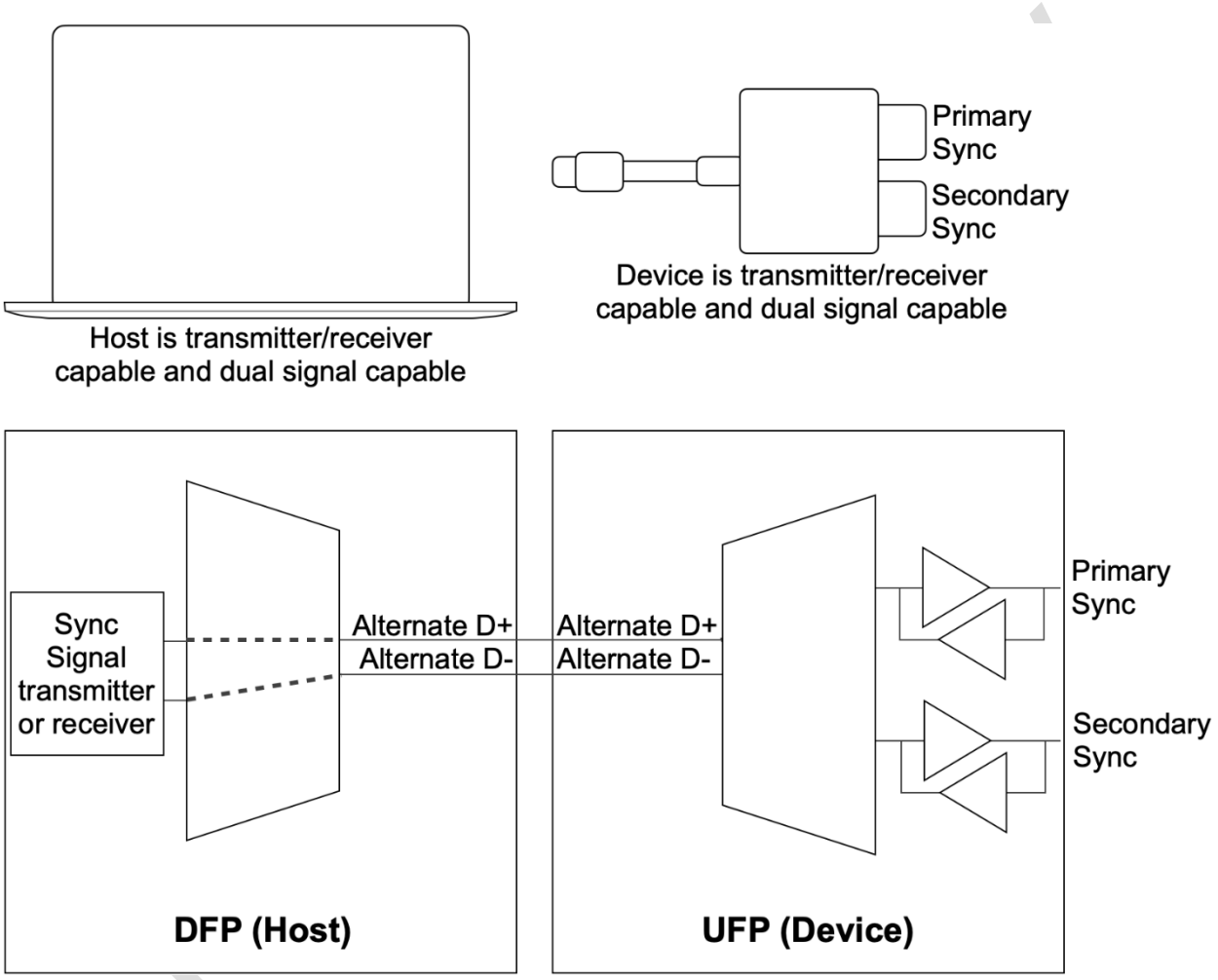

Figure C.1 — Host and Captive Cable SSAM Connection

C.2 Example 2

Figure C.2 shows VDM entry and connect flow commands and responses. In this case the UFP device is a Captive Cable. The Alternate D+/D- pin pair is selected for sync signals and the UFP device is configured as transmitter.

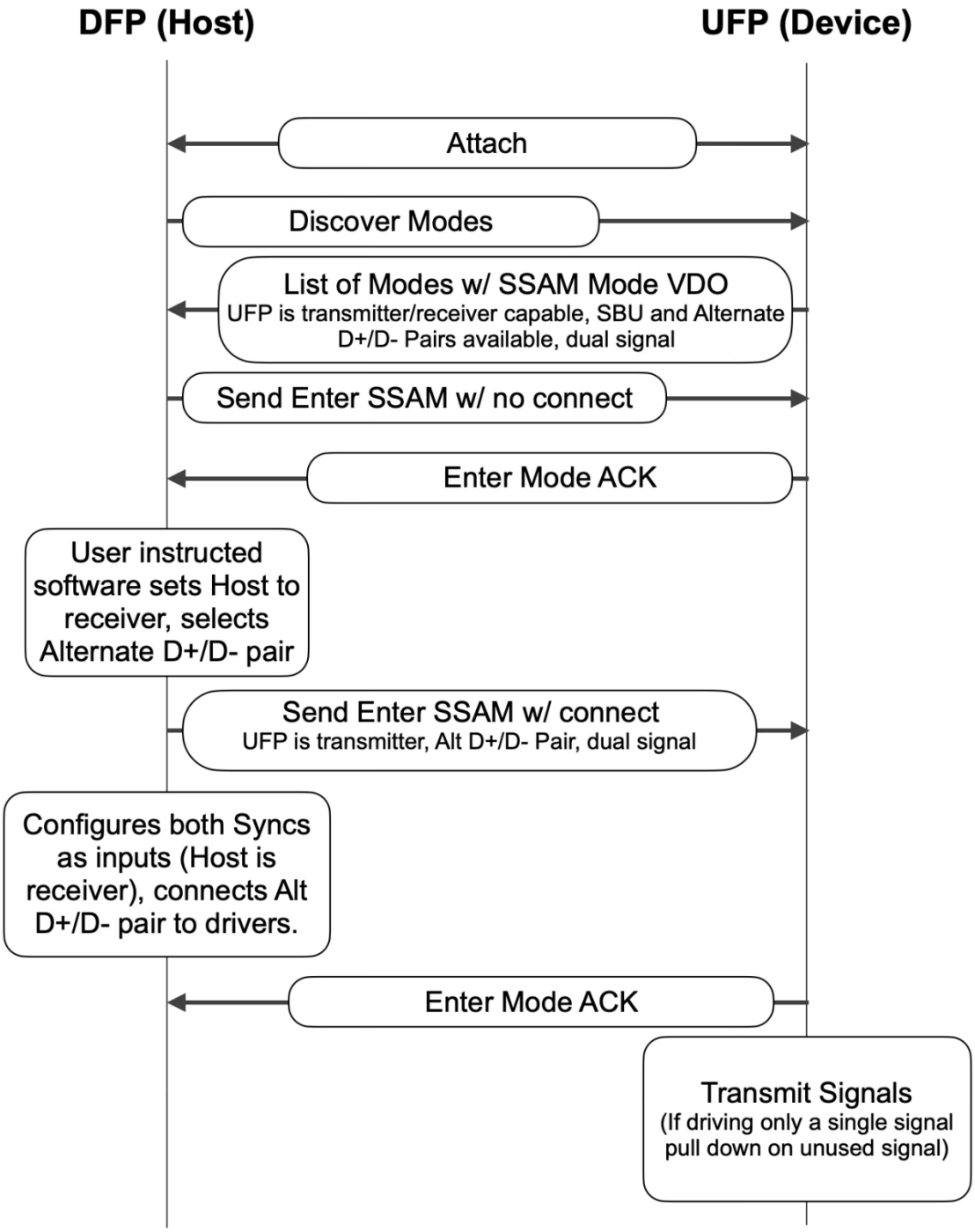

Figure C.2 — Host and Captive Cable VDM entry and connect flow

C.3 Example 3

Figure C.3 shows SSAM connection between two Hosts using SBU pin pair over a USB Full-featured Type-C Cable. Each Host supports sync signaling on both pins and has both transmitter and receiver capabilities.

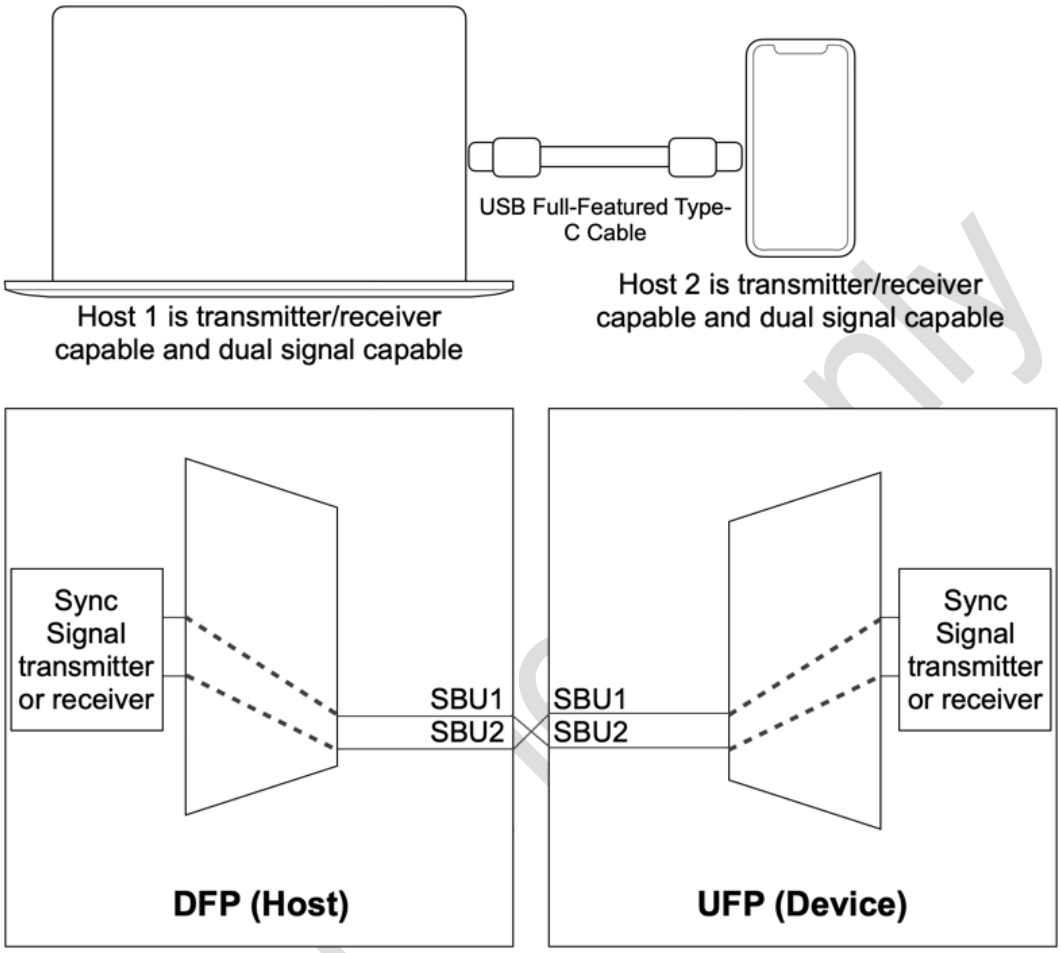

Figure C.3 — Host to Host SSAM Connection

C.4 Example 4

Figure C.4 shows VDM entry and connect flow commands and responses. In this case, the UFP device is also a Host, and the connection is over a USB Full-featured Type-C Cable. The SBU pin pair is selected for sync signals and the DFP Host device is configured as transmitter.

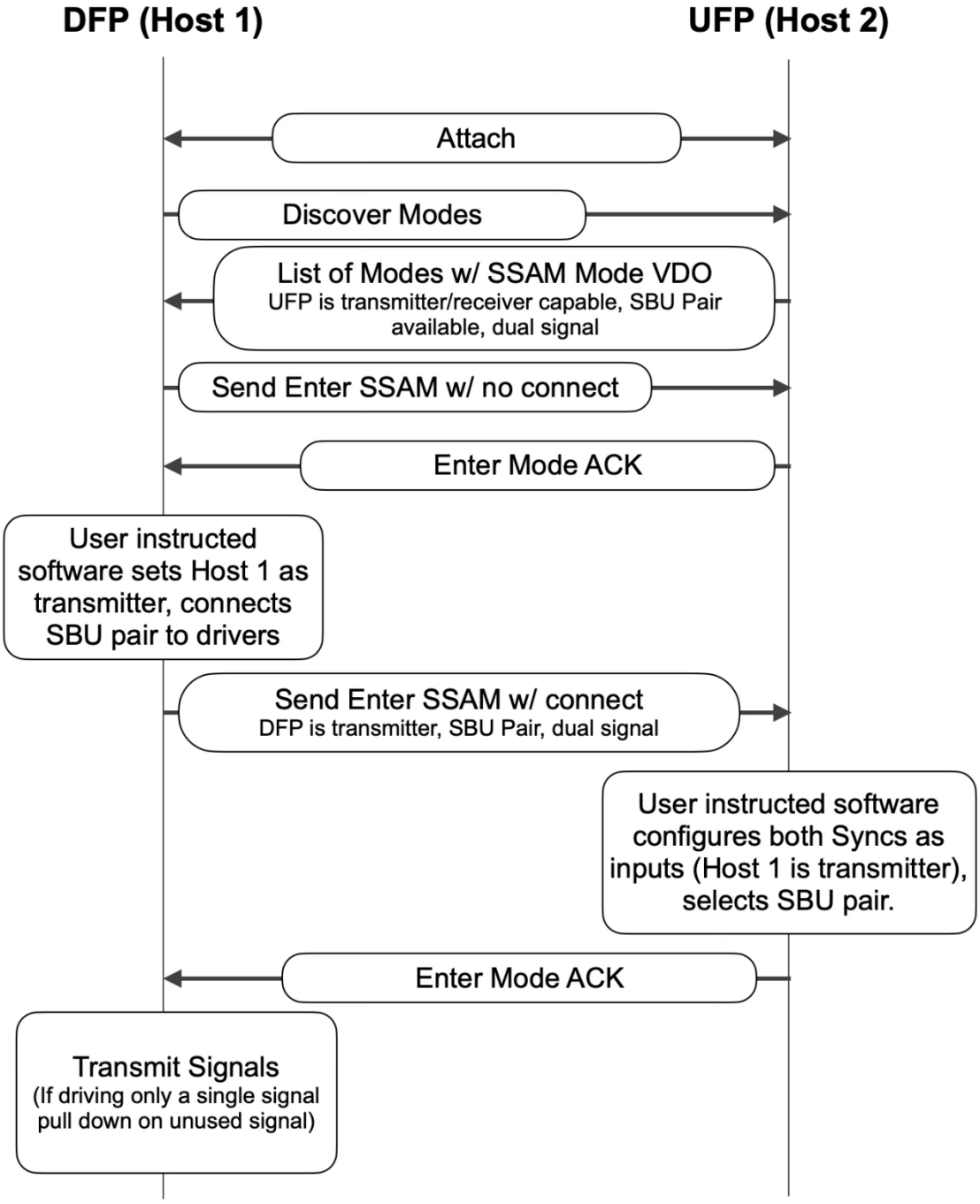

Figure C.4 — Host to Host VDM entry and connect flow

C.5 Example 5

Figure C.5 shows Host to Host command flow changing UFP from sync receiver to sync transmitter.

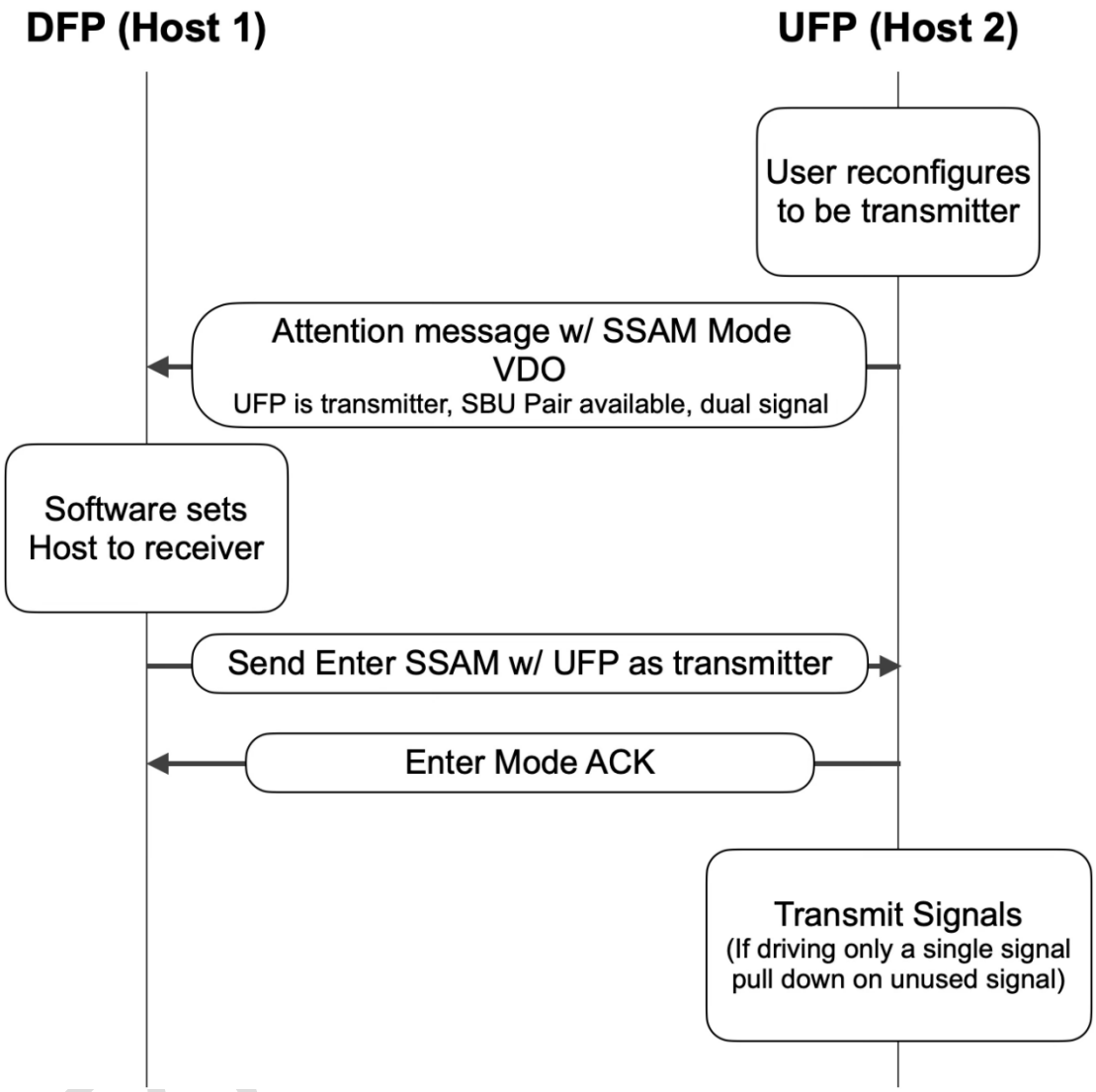

Figure C.5 — Change role to Transmitter on UFP