SMPTE STANDARD

Signal Sync Alternate Mode

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Foreword

SMPTE (the Society of Motion Picture and Television Engineers) is an internationally-recognized standards developing organization. Headquartered and incorporated in the United States of America, SMPTE has members in over 80 countries on six continents. SMPTE's Engineering Documents, including Standards, Recommended Practices, and Engineering Guidelines, are prepared by SMPTE's Technology Committees. Participation in these Committees is open to all with a bona fide interest in their work. SMPTE cooperates closely with other standards-developing organizations, including ISO, IEC and ITU.

SMPTE Engineering Documents are drafted in accordance with the rules given in its Standards Operations Manual. This SMPTE Engineering Document was prepared by Technology Committee 32NF Network/Facilities Infrastructure.

A previous version of this document contains an error in Subclause 13.3.5. The words "receiver" and "transmitter" were switched in the now-correct sentence, "The value of UFP is Sync Signaling Transmitter shall be set to 0b to configure the UFP as the **receiver** and the DFP is the **transmitter** of the sync signal." The error is fixed in this version.

Intellectual Property

At the time of publication, no notice had been received by SMPTE claiming patent rights essential to the implementation of this Engineering Document. However, attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. SMPTE shall not be held responsible for identifying any or all such patent rights.

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.

1 Scope

This standard defines a USB-C Alternate Mode, referred to as Signal Sync Alternate Mode (SSAM), for conveying synchronization signals over a USB Type-C Connection. It specifies the use of *USB Power Delivery Specification* messaging to negotiate entry into the Mode and to configure signal routing between directly connected USB Type-C ports. It also defines the electrical characteristics of the synchronization signals.

2 Conformance

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.

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 Numeric Notation

Conventions for representing numeric values are defined in Table 1:

Table 1 — Numeric Notation

Format	Example	Description
Binary	01b	Written in binary with a trailing b. Used for fields composed of one or more bits that encode configuration or state.
Decimal Integer	1	Base-10 value with no prefix or suffix. Used for enumerated commands or indices.
Hexadecimal	0xFF05	Base-16 unsigned integer with 0x prefix. Used for identifiers such as the SMPTE SID.

4 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*

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

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

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

5 Terms and Definitions

For the purposes of this document, the terms and definitions given in the Normative References (Clause 4) and the following apply. In addition, for convenience, informative Annex A provides a glossary of selected terms from the Normative References.

5.1 Alternate D+/D-

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

5.2 Primary D+/D-

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

5.3 USB 3.2

data transport protocol for SuperSpeed USB, operable over multiple USB connector types using one or two high-speed differential pairs

5.4 USB4

data transport protocol operating exclusively over the USB Type-C connector's high-speed differential lanes

6 Compliance with USB Standards

Implementations of this document shall conform to the requirements specified in the *USB 2.0 Specification*, *USB4 Specification*, *USB Type-C Specification*, and *USB Power Delivery Specification*, 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.

7 Forward Compatibility

Elements designated as reserved shall not be altered in implementations conforming to this version of this document. Such elements may be altered in future revisions. Implementations conforming to this document shall tolerate elements altered in a future revision that were reserved in this version, provided the message structure remains compliant with the USB Power Delivery Specification.

8 Messaging Overview

SSAM shall use *USB Power Delivery Specification* messages to discover and enter the Mode with an attached Port Partner. Once the Mode is entered, SSAM shall comply with the message structure and rules conforming to *USB Power Delivery Specification* for the exchange of information between port partners to configure signal connections through the USB Type-C connector. This messaging includes:

- Advertising available sync signals and their properties.
- Advertising USB Type-C connector pins available for sync signal assignment.
- Requesting mapping of sync signals to available connector pins.
- Indicating which Port Partner will function as the sync signal transmitter.
- Routing sync signals between attached devices.

9 VDM Header

9.1 Introduction

The 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.

9.2 Overview

The SSAM VDM Message Structure shall implement the Structured VDM (SVDM) format as defined in the *USB Power Delivery Specification*. The SSAM VDM Header shall be as defined in Table 2.

Table 2 — VDM Header

Bit(s)	Description	Value
31 to 16	USB-IF SMPTE SID	0xFF05
15	VDM Type	1b = Structured
14 to 13	SVDM Version (Major)	00b = Reserved by *USB Power Delivery Specification* 01b = SVDM Version 2.x 10b, 11b = Reserved by *USB Power Delivery Specification*
12 to 11	SVDM Version (Minor)	00b = Reserved by *USB Power Delivery Specification* 01b = SVDM Minor Version (2.1) 10b, 11b = Reserved by *USB Power Delivery Specification*
10 to 8	Object Position	For Enter Mode, Exit Mode, or Attention commands: Position 1 to 6 of SSAM in the Discover Modes response. For all other commands: 000b
7 to 6	Command Type	00b = REQ 01b = ACK 10b = NAK 11b = Busy
5	Reserved by *USB Power Delivery Specification*	Shall be set to 0 and shall be ignored.
4 to 0	Command	0 = Reserved by *USB Power Delivery Specification* 1 = Discover Identity 2 = Discover SVIDs 3 = Discover Modes 4 = Enter Mode 5 = Exit Mode 6 = Attention 7 to 15 Reserved by *USB Power Delivery Specification* 16 to 31 Reserved

9.3 USB-IF SMPTE 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 SMPTE is 0xFF05.

9.4 VDM Type

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

9.5 SVDM Version (Major)

The value of SVDM Version (Major) shall be 01b, corresponding to SVDM Version 2.x as defined in the *USB Power Delivery Specification*. Future revisions of this document that adopt an SVDM Version (Major) other than 01b shall not be assumed to be backward-compatible with this version.

9.6 SVDM Version (Minor)

The value of SVDM Version (Minor) shall be 01b, corresponding to SVDM Version 2.1 as defined in the *USB Power Delivery Specification*. Future revisions of this document that adopt an SVDM Version (Minor) other than 01b shall not be assumed to be backward-compatible with this version.

9.7 Object Position

When used for some commands, Object Position provides the location index for a received list of items. See the *USB Power Delivery Specification* for detailed Object Position command type usage.

9.8 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.

See the *USB Power Delivery Specification* for detailed VDM Header command type usage.

9.9 Command

The command that is being requested or responded to. *USB Power Delivery* Specification defines 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. Clauses 10 through 15 provide details about the available VDM Header Commands.

10 Discover Identity

10.1 Introduction

The Discover Identity command response includes one or more VDOs containing information about connector type, product type, and protocols supported between the Port Partners. For SSAM implementations, the Discover Identity command response is used:

- To determine the UFP connector type.
- To evaluate cable characteristics relevant to SSAM when a cable is present.

Refer to the *USB Power Delivery Specification* for the full Discover Identity responses and USB Type-C Cable and Connector Specification for cable construction requirements.

NOTE See Annex B for an informative description of USB-C pin usage.

10.2 DFP is a Captive Cable

To support SSAM, a DFP implemented as part of a captive cable assembly shall terminate with a USB Type-C plug. In this case, Discover Identity messaging is not required to determine connector type and the DFP shall determine SSAM sync signal pin pair availability using the UFP's Discover Modes VDO as described in Clause 12.

10.3 DFP is a Receptacle

10.3.1 Introduction

If the DFP is a receptacle, identity information is required from the UFP and, if present, attached cable. The DFP shall use SOP Communication to gather Discover Identity responses from the attached UFP. If a cable is present, the DFP shall use SOP' Communication to gather Discover Identity responses from the cable plug. This information is used to determine pin pairs available for connection of SSAM sync signals.

10.3.2 Evaluation of the UFP identity via SOP

The DFP shall evaluate the SOP Discover Identity command response to identify the UFP's Connector Type.

- If the UFP connector type is plug, the UFP is part of a Captive Cable assembly, and the DFP shall then determine SSAM sync signal pair availability using the UFP's Discover Modes VDO as described in Clause 12.
- If the UFP connector type is receptacle, a cable is present. In this case:
    - The Alternate D+/D- pin pair is not present in the cable and shall not be used for sync signaling.
    - The DFP shall proceed with SOP' messaging as described in Clause 10.3.3.

10.3.3 Evaluation of the cable identity via SOP'

When a cable is present, the DFP shall evaluate the SOP' Discover Identity command response to identify the cable Product Type. The DFP shall then evaluate signal pair availability for SSAM sync signaling.

- If Product Type is Passive Cable:
    - The Primary D+/D- pin pair is present.
    - The DFP shall evaluate the USB Highest Speed field in the Passive Cable VDO to determine availability of the SBU pin pair for sync signaling.
        - If USB Highest Speed is USB 2.0, the SBU pin pair is not present in the cable and shall not be used for sync signaling.
        - If USB Highest Speed is any value other than USB 2.0, the SBU pin pair may be used for sync signaling.
- If Product Type is Active Cable:
    - The DFP shall evaluate Active Cable VDO fields to determine physical presence of signal pairs:
        - If USB 2.0 is supported, the Primary D+/D- pin pair is present.
        - If SBU is supported, the SBU pin pair is present.
    - The DFP shall further evaluate the Active Cable VDO fields to determine pin pair compatibility with SSAM. Pin pairs routed through re-timers, re-drivers, or optical isolation shall not be used for SSAM sync signaling:
        - If Optically Isolated Active Cable is Yes, the DFP shall not use any pin pair in the cable for SSAM sync signaling.
        - If USB 2.0 Hub Hops Consumed is greater than 0, the Primary D+/D− pin pair shall not be used for SSAM sync signaling.
        - If SBU Type is Active, the SBU pin pair shall not be used for SSAM sync signaling.

10.3.4 SOP' Messaging in Captive Cables

Captive cables used in SSAM implementations shall respond to SOP' messages in accordance with the *USB Power Delivery Specification*. This enables the DFP to perform Discover Identity messaging with the Captive Cable to determine SSAM sync signal pair availability.

Use of an electronically marked cable assembly (eMarker) is not required. Captive cable implementations that include a programmable controller may implement SOP' response functionality directly, provided all applicable timing and electrical characteristics defined in the *USB Power Delivery Specification* are met.

11 Discover SVIDs

The 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 command for the SSAM SVID shall be sent. A UFP that supports SSAM will return the SSAM SVID in this list of SVIDs.

12 Discover Modes

12.1 Introduction

The 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 Alternate Mode Vendor Defined Object (VDO). The Alternate 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 describe the Discover Modes Request and Response for the SMPTE SID and the SSAM Alternate Mode VDO.

- Clause 12.2 describes SMPTE Discover Modes Request.
- Clause 12.3 describes SMPTE Discover Modes Response VDM Header.
- Clause 12.4 describes SSAM Discover Modes Response VDO.

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

12.2 Discover Modes Request

The Discover Modes request from the DFP to the UFP for the SSAM SVID shall be as specified in Table 3.

Table 3 — Discover Modes Request

Bit(s)	Description	Value
31 to 16	USB-IF SMPTE SID	0xFF05
15	VDM Type	1b = Structured
14 to 13	SVDM Version (Major)	01b (See Clause 9.5)
12 to 11	SVDM Version (Minor)	01b (See Clause 9.6)
10 to 8	Object Position	000b
7 to 6	Command Type	00b = REQ
5	Reserved by *USB Power Delivery Specification*	0b
4 to 0	Command	3 = Discover Modes

12.3 Discover Modes Response VDM Header

The UFP Response to the DFP Discover Modes request shall include the VDM header as specified in Table 4.

Table 4 — Discover Modes Response VDM Header

Bit(s)	Description	Value
31 to 16	USB-IF SMPTE SID	0xFF05
15	VDM Type	1b = Structured
14 to 13	SVDM Version (Major)	01b (See Clause 9.5)
12 to 11	SVDM Version (Minor)	01b (See Clause 9.6)
10 to 8	Object Position	000b
7 to 6	Command Type	01b = ACK
5	Reserved by *USB Power Delivery Specification*	0b
4 to 0	Command	3 = Discover Modes

12.4 Discover Modes Response VDO

12.4.1 Introduction

The UFP shall send a Mode VDO following the VDM Header. The Discover Modes Response VDO bit values shall be as specified in Table 5.

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

Table 5 — Discover Modes Response VDO

Bit(s)	Description	Value
31 to 30	Alt Mode	00b = SSAM 01b, 10b, 11b = Reserved for future SMPTE Alt Modes
29 to 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 need not be present on Primary D+/D- while in SSAM
14 to 9	Reserved	Shall be set to 0 and shall be ignored.
8 to 6	Max Sync Signaling Frequency Supported as Receiver	000b = Receiver function not supported 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 to 3	Sync Signaling as Transmitter or Receiver	00b = Reserved 01b = Can be Receiver 10b = Can be Transmitter 11b = Can be Transmitter or Receiver
2 to 0	Pairs Supported for Sync Signaling	000b = No Pair Available For Sync Signaling 001b = Primary D+/D- supported 010b = Alternate D+/D- supported 011b = Primary D+/D- and Alternate D+/D- supported 100b = SBU pair supported 101b = Primary D+/D- and SBU pair supported 110›b = Alternate D+/D- and SBU pair supported 111b = Primary D+/D-, Alternate D+/D-, and SBU pair supported

12.4.2 Alt Mode

The Alt Mode field identifies the Alternate Mode to which the remainder of the fields in the Discover Modes Response VDO apply. This document defines only SSAM, indicated by an Alt Mode field value of 00b. The values 01b, 10b, and 11b are reserved for future SMPTE Alternate Modes. SSAM devices shall ignore any Discover Modes Response VDO where the Alt Mode field is not equal to 00b, unless the device supports the corresponding Alternate Mode.

12.4.3 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 (depending on device configuration or operating mode) and 1b when USB 2.0 need not be present after entering SSAM.

12.4.4 Max Sync Signaling Frequency Supported as Receiver

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

12.4.5 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.

NOTE See Annex B for an informative description of USB-C pin usage.

12.4.6 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.

12.4.7 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 No pair available for Sync Signaling, 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 be supported only 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 be supported only 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 may function as either sync transmitter or sync receiver. A single pair shall not function as transmitter on one pin and receiver on the other pin.

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

13 Enter Mode

13.1 Introduction

Once the Discover Modes flow is complete, the DFP may choose to enter SSAM with the UFP. The 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 13.2 describes the SSAM Enter Modes Request VDM Header. Clause 13.3 describes the SSAM Enter Mode Request VDO.

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

13.2 Enter Mode Request VDM Header

The Enter Mode Request VDM Header bit values shall be as specified in Table 6. The request shall include both the VDM header as well as a single Enter Mode VDO for SSAM.

Table 6 — Enter Mode Request VDM Header

Bit(s)	Description	Value
31 to 16	USB-IF SMPTE SID	0xFF05
15	VDM Type	1b = Structured
14 to 13	SVDM Version (Major)	01b (See Clause 9.5)
12 to 11	SVDM Version (Minor)	01b (See Clause 9.6)
10 to 8	Object Position	Numeric position (1 to 6) of the SSAM in the Mode list returned from the Discover Modes Command
7 to 6	Command Type	00b = REQ
5	Reserved by *USB Power Delivery Specification*	0b
4 to 0	Command	4 = Enter Mode

13.3 Enter Mode Request VDO and Enter Mode Response

13.3.1 Introduction

The Enter Mode Request VDO for SSAM bit values shall be as specified in Table 7. Clause 13.3.2 through Clause 13.3.7 provide further detail for each portion of the Enter Mode VDO.

Table 7 — Enter Mode Request VDO for SSAM

Bit(s)	Description	Value
31 to 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 need not be present on Primary D+/D- while in SSAM
14 to 9	Reserved	Shall be set to 0 and shall be ignored.
8 to 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 to 2	Reserved	Shall be set to 0 and shall be ignored.
1 to 0	Pair to Assign to Sync Signaling	00b = Sync signaling is not assigned to any pair 01b = Primary D+/D- pair 10b = Alternate D+/D- pair 11b = SBU pair

13.3.2 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 need not be present after entering SSAM.

13.3.3 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.

13.3.4 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.

13.3.5 UFP is Sync Signaling Transmitter

The value of UFP is Sync Signaling Transmitter shall be set to 0b to configure the UFP as the receiver and the DFP is the transmitter of the sync signal.

However, when bits 1 and 0 of the request are set to 00b (indicating that no pairs are assigned for SSAM), the value of this field (bit 4) may be ignored. This reflects that no sync signaling configuration is being requested, and therefore the transmit/receive roles are not applicable.

NOTE See Annex C for informative examples of command flow to change UFP role from sync receiver to sync transmitter.

13.3.6 Pair to Assign 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.

13.3.7 Enter Mode Response

The Enter Mode Request VDM header for SSAM bit values shall be as specified in Table 8. 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 and 6 in Table 8. 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, requests signals on both pins in pair when UFP supports primary pin only, etc.

NOTE The response does not have a VDO.

Table 8 — Enter Mode Response VDM Header for SSAM

Bit(s)	Description	Value
31 to 16	USB-IF SMPTE SID	0xFF05
15	VDM Type	1b = Structured
14 to 13	SVDM Version (Major)	01b (See Clause 9.5)
12 to 11	SVDM Version (Minor)	01b (See Clause 9.6)
10 to 8	Object Position	Numeric position (1 to 6) of the SSAM in the Mode list returned from the Discover Modes Command
7 to 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 by *USB Power Delivery Specification*	0b
4 to 0	Command	4 = Enter Mode

14 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.

15 Attention

15.1 Introduction

The Attention message 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.

15.2 Attention Message

The UFP Attention message VDM Header bit values shall be as specified in Table 9. 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 9 — Attention VDM Header for SSAM SID

Bit(s)	Description	Value
31 to 16	USB-IF SMPTE SID	0xFF05
15	VDM Type	1b = Structured
14 to 13	SVDM Version (Major)	01b (See Clause 9.5)
12 to 11	SVDM Version (Minor)	01b (See Clause 9.6)
10 to 8	Object Position	000b
7 to 6	Command Type	01b = REQ
5	Reserved by *USB Power Delivery Specification*	0b
4 to 0	Command	6 = Attention

15.3 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.

16 Signal Electrical Specifications

16.1 Sync Signals

SSAM sync signals sent from the transmitter are digital pulses.

16.2 Sync Pulses

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

16.3 Ground Differential

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

16.4 Sync Signal Transmitter

The SSAM sync signal source shall comply with the electrical characteristics specified in Table 10.

Table 10 — 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

16.5 Output High

SSAM sync pulse logical high transmitter voltage.

16.6 Output Low

SSAM sync pulse logical low transmitter voltage.

16.7 Pulse Low Time

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

16.8 Pulse High Time

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

16.9 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.

16.10 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.

16.11 Sync Signal Receiver

The SSAM sync signal receiver shall comply with the electrical requirements specified in Table 11.

Table 11 — 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				

16.12 Input High

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

16.13 Input Low

SSAM sync pulse logical low receiver voltage.

Annex A
(Informative)

Glossary

A.1 Introduction

The information in this Annex is drawn from the *USB Power Delivery Specification* and the *USB Type-C Cable and Connector Specification* cited in Clause 4, and is provided here for ease of reference.

A.2 Alternate Mode

Operation defined by a Vendor or Standards organization that is associated with an SVID assigned by the USB Implementers Forum, whose definition is outside the scope of USB Implementers Forum specifications. Entry into and exit from an Alternate Mode is controlled by Structured VDM Enter and Exit Mode processes. Equivalent to Mode in the *USB Power Delivery Specification*. Specified in the *USB Type-C Cable and Connector 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 eMarker

Component in a cable that responds to SOP′ messages and reports cable characteristics. Described in the *USB Power Delivery* and *USB Type-C Cable and Connector* Specifications.

A.8 GND

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

A.9 Mode

See A.2 Alternate Mode.

A.10 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.11 Port Pair

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

A.12 Port Partner

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

A.13 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.14 SBU

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

A.15 SID

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

A.16 SOP

Start of Packet. Marker used to delineate the start of a packet for communication between Port Partners in USB Power Delivery. Described in the *USB Power Delivery Specification*.

A.17 SOP'

Start of Packet Prime. Marker used to delineate the start of a packet for communication between a DFP and a VCONN-powered cable identity device located in a cable plug. Described in the *USB Power Delivery Specification*.

A.18 SVDM

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

A.19 SVID

Generic term referring to either an SID or VID. Used in place of the phrase "Standard or Vendor ID." Described in the *USB Power Delivery Specification*.

A.20 TX+/TX-

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

A.21 Type-C Plug

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

A.22 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.23 Type-C Receptacle

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

A.24 UFP

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

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*.

A.30 USB-C

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

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*.

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 VCONN

A 5 V power supply provided by the DFP over the unused CC (Configuration Channel) pin in a USB Type-C connection. VCONN is used to power circuitry within a cable plug, such as a cable identity device that responds to SOP′ messaging. Defined in the *USB Type-C Cable and Connector Specification*.

A.37 VBUS

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

A.38 VDM

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

A.39 VDO

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

A.40 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 Power Delivery* Specification messages that extend the functionality that 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 document 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*.

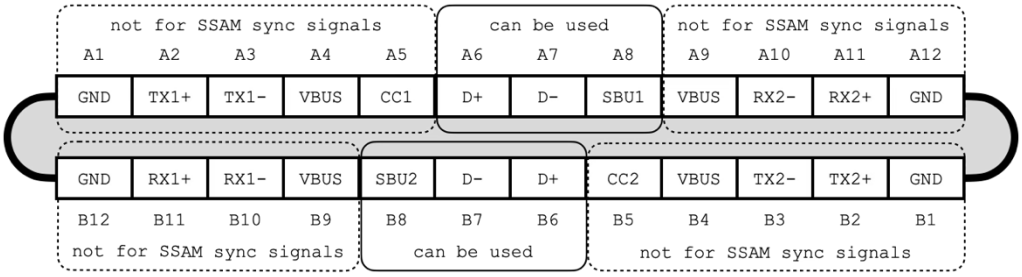

Figure B.1 — USB Type-C pins available for SSAM

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 Downstream Facing Port (DFP) and the Upstream Facing Port (UFP) for Captive Cables.

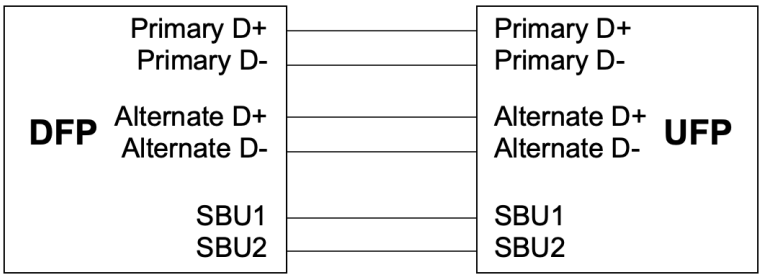

Figure B.2 — Captive Cable SSAM Pair Availability

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

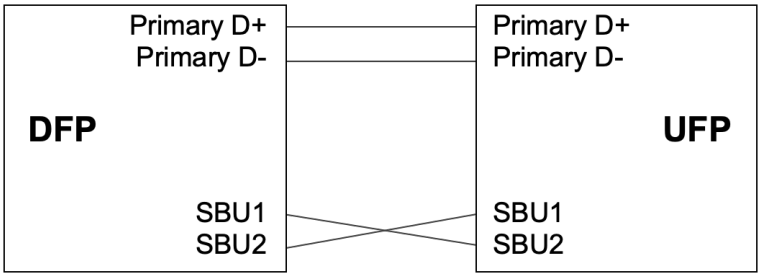

Figure B.3 — USB Full-featured Type-C Cable SSAM Pair Availability

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

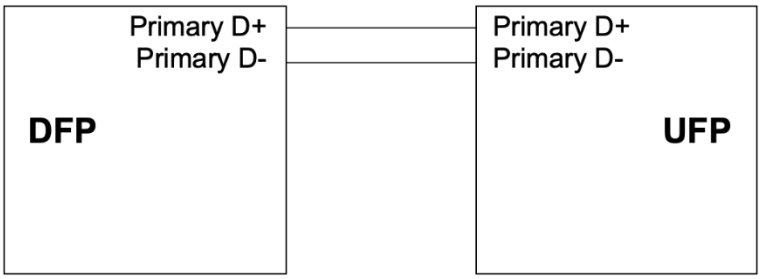

Figure B.4 — USB 2.0 Type-C Cable SSAM Pair Availability

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 Alternate 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 recommend 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 the 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.

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.

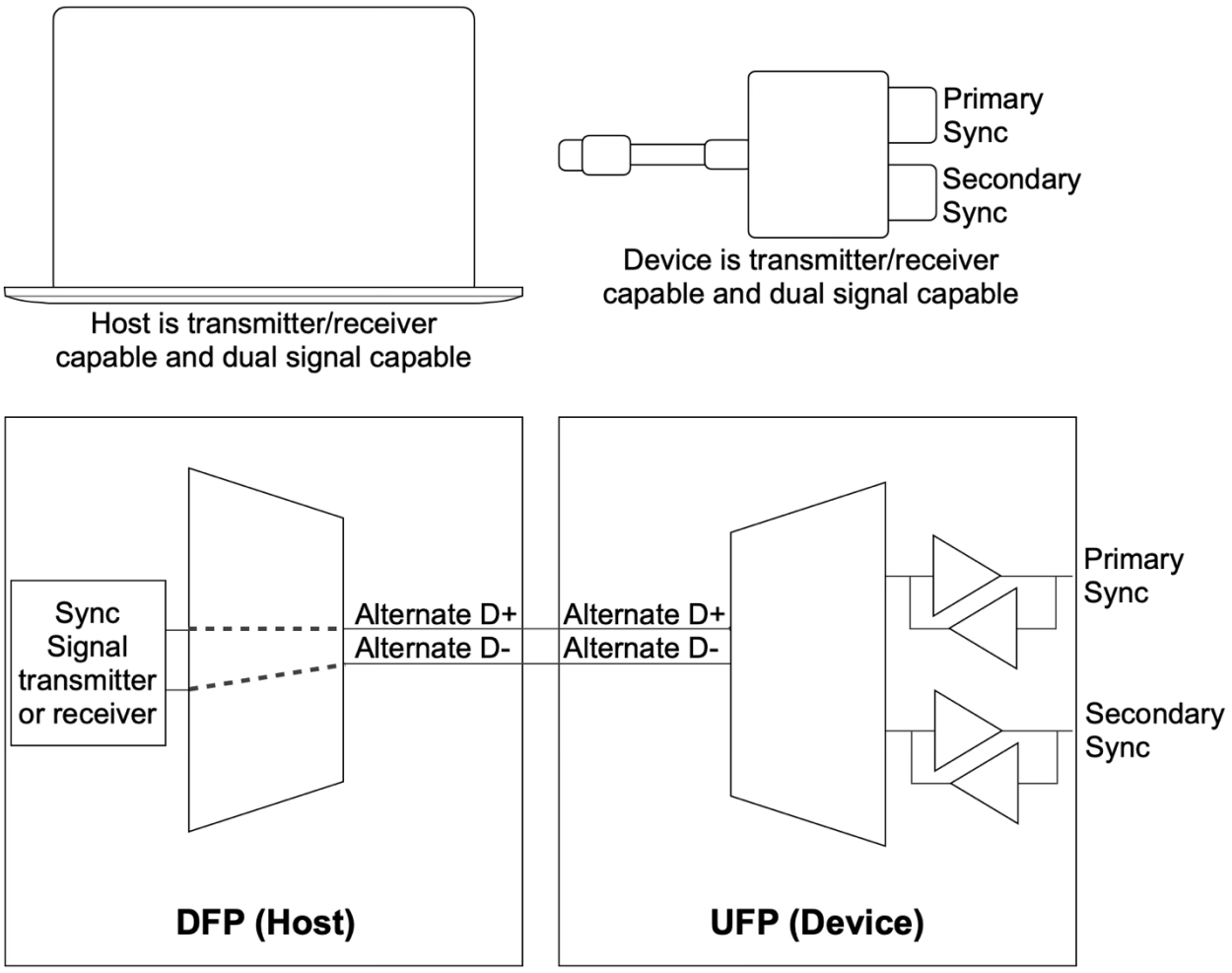

Figure C.1 — Host and Captive Cable SSAM Connection

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.

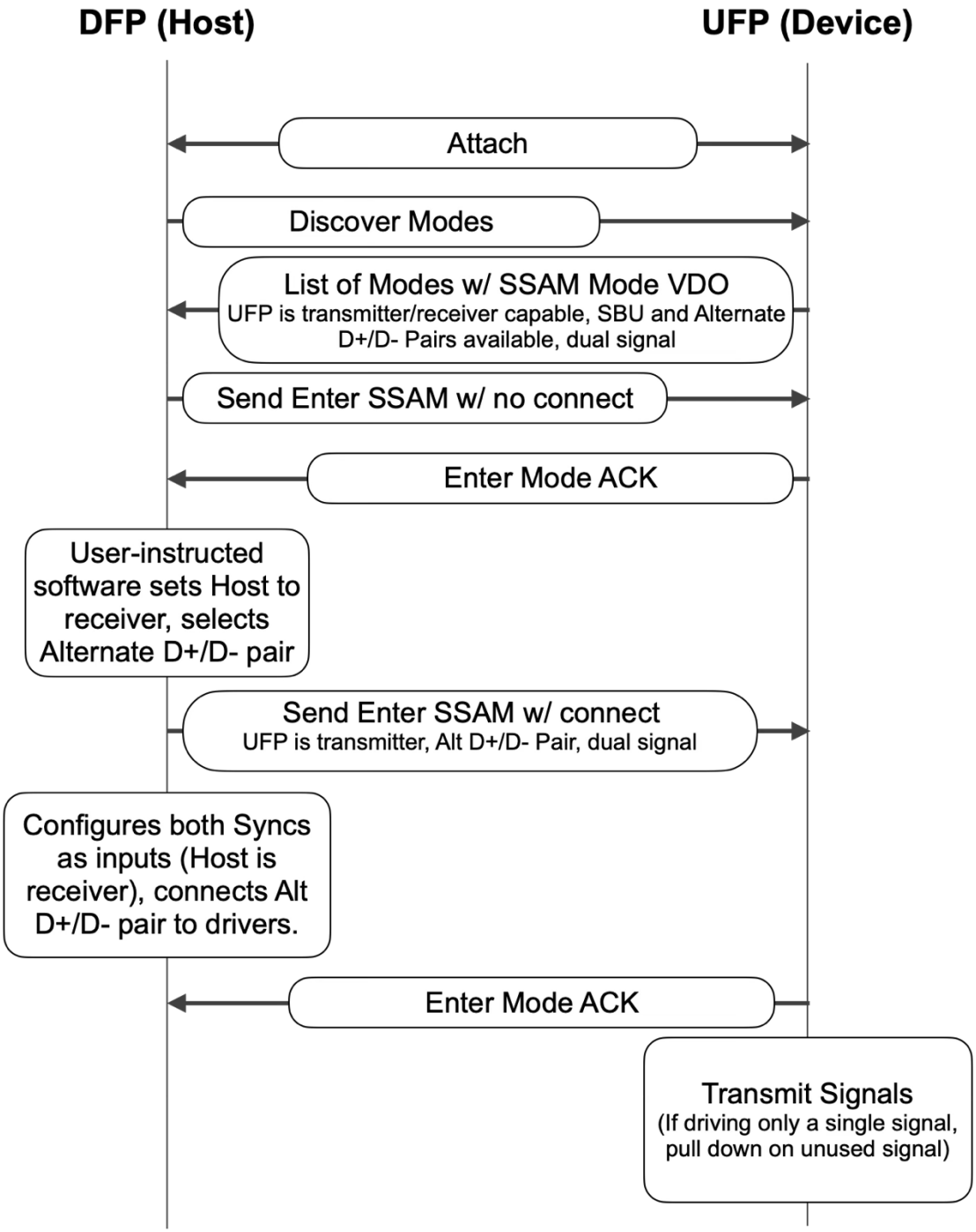

Figure C.2 — Host and Captive Cable VDM Entry and Connect Flow

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.

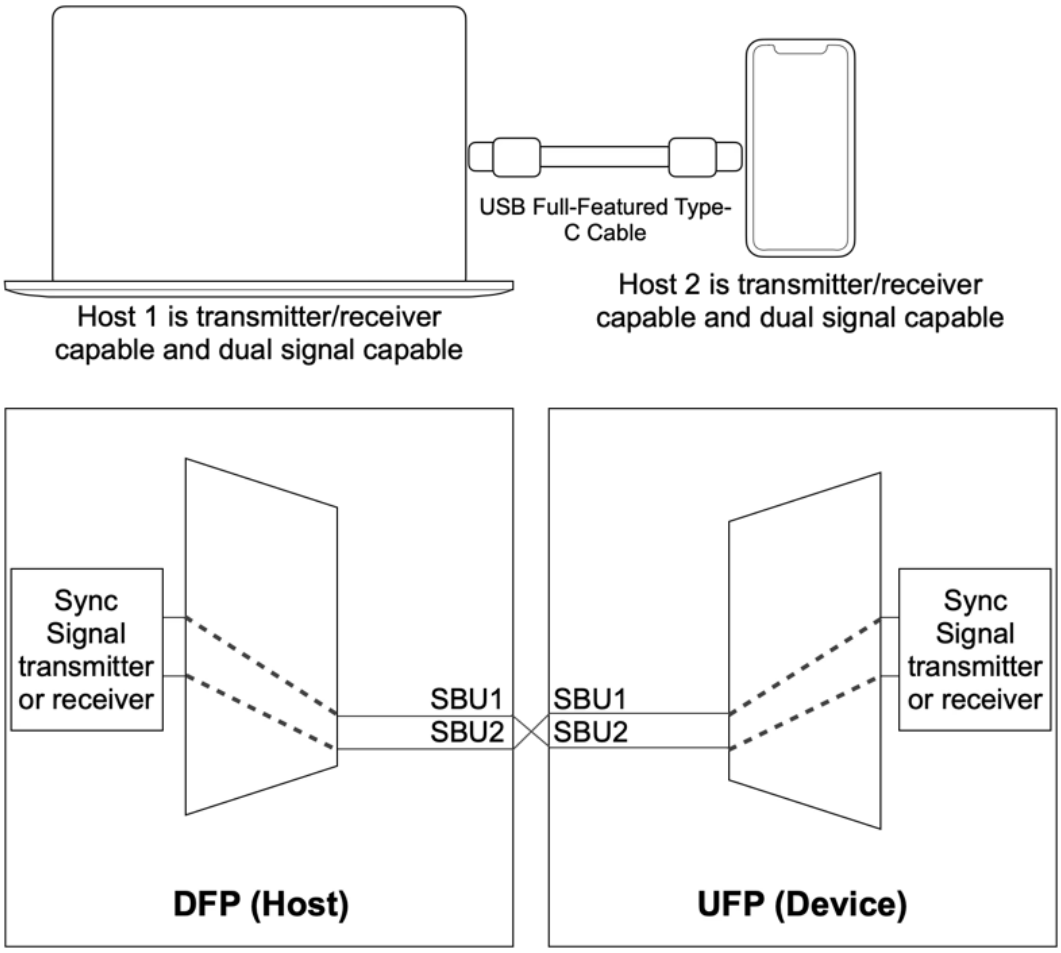

Figure C.3 — Host-to-Host SSAM Connection

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.

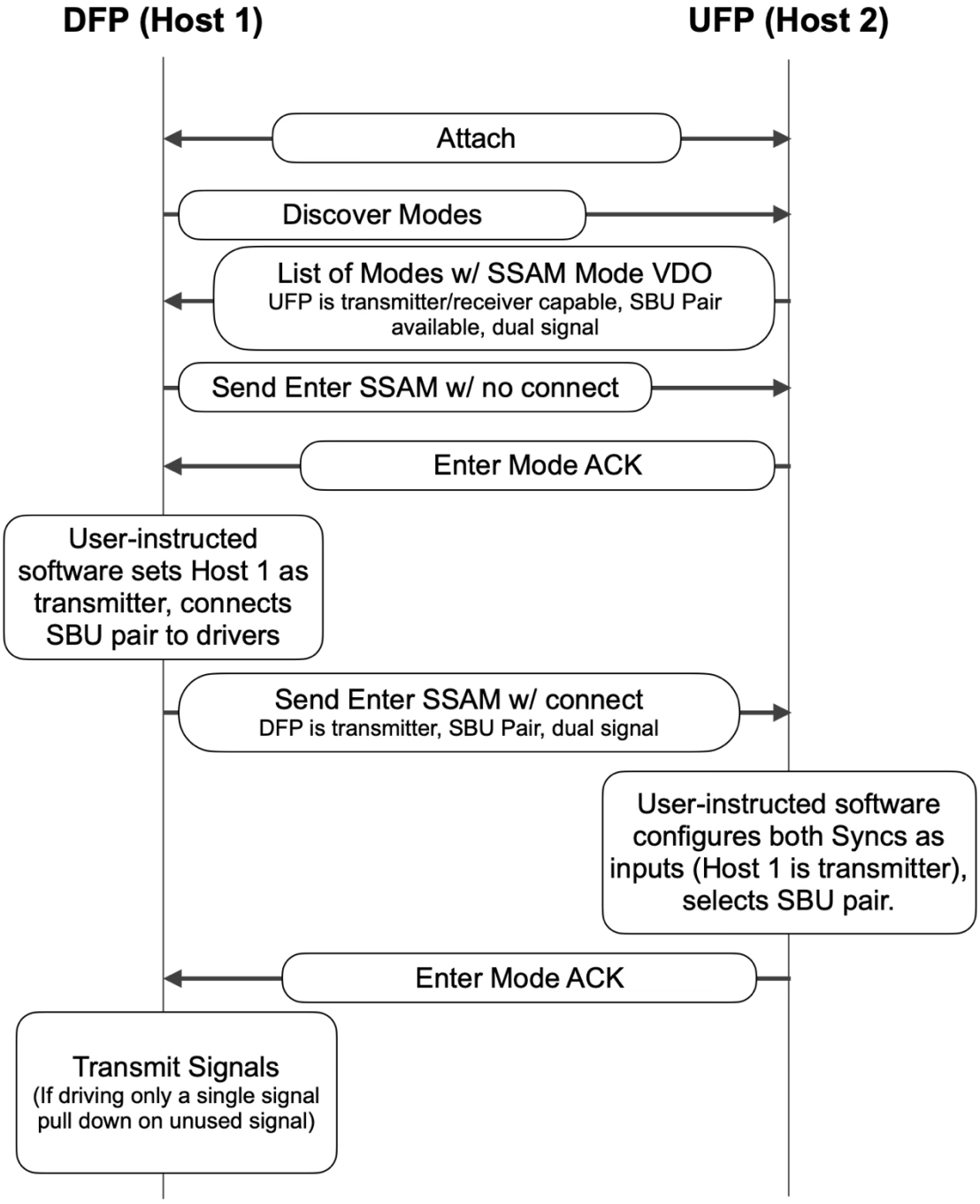

Figure C.4 — Host-to-Host VDM Entry and Connect Flow

C.5 Example 5

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

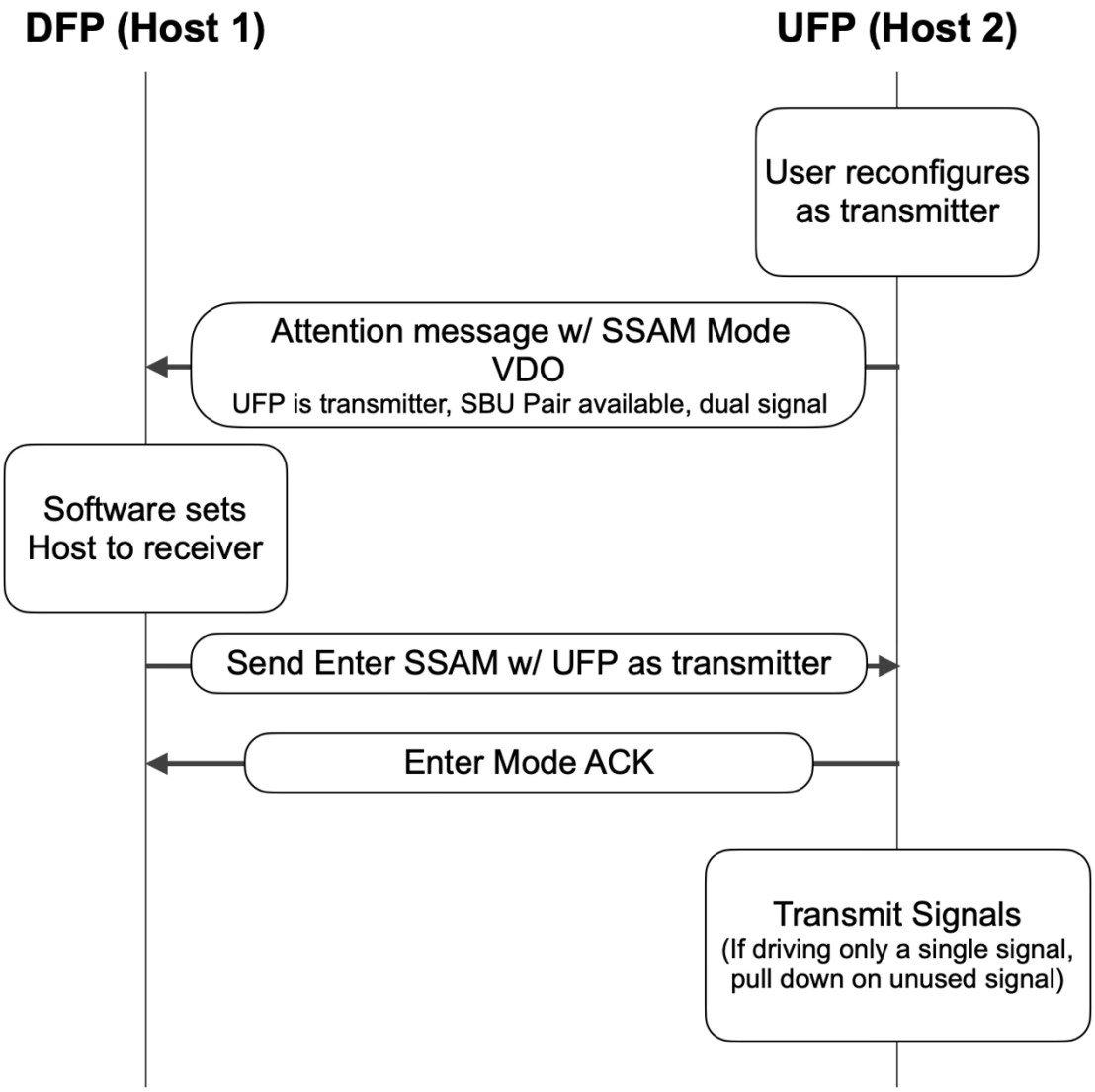

Figure C.5 — Change role to Transmitter on UFP