

Essentials of USB-C DP Alt Mode Protocols

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Agenda – USB-C DP Alt Mode

- USB-C DP Alt Mode – What Is It?
- USB-C DP Alt Mode Operation
- Power Delivery Protocol Negotiation into DP Alt Mode
- Review DisplayPort Protocols & Testing
- USB Protocol Testing
- DisplayPort Physical Layer Testing

- ◆ Please Check out our DisplayPort “Essentials of” Webinars:
 - ◆ [Essentials of DisplayPort Protocols](#)
 - ◆ [Essentials of HDCP 2.2 Protocols](#)
 - ◆ [Essentials of DisplayPort Display Stream \(DSC\) Protocols](#)
 - ◆ [Essentials of DisplayPort Link Layer Compliance Testing](#)
 - ◆ [Essentials of DisplayPort Forward Error Correction \(FEC\)](#)
 - ◆ [Essentials of DisplayPort USB-C DP Alt Mode Protocols](#)
- ◆ Go To:
https://www.quantumdata.com/980_dp_14_usb.html

980 Source and Sink Testing

USB-C DP Alt Mode Capable Laptop DFP (Source)



980 DP USB-C/eDP Video Generator Protocol Analyzer



980 DP USB-C/eDP Video Generator/Protocol Analyzer

DisplayPort Sink (Monitor/TV)



- ◆ Protocol Analysis - Source Testing
 - ◆ Sink emulation EDID, DPCD.
 - ◆ Protocol Analysis – Main Link, Aux Channel. Supports HBR3 link rates and Display Stream Compression and Forward Error Correction.
 - ◆ Compliance Testing - Link Layer, (including FEC), DSC, HDCP.
- ◆ Video Generation - Sink Testing
 - ◆ Source emulation and Link Training control.
 - ◆ Video Pattern Testing – HBR3 link rates. Supports generation of Display Stream Compression and Forward Error Correction DSC.
 - ◆ Compliance Testing (Link Layer, FEC, HDCP).
- ◆ Power Delivery DP Alt Mode Testing.
 - ◆ Run all source and sink testing through the USB-C DP Alt Mode ports.

DP 1.4 USB-C DP Alt Mode – What Is It?

December – 2018



USB-C DP Alt Mode – What Is It?

- ◆ Standard by VESA – “DisplayPort Alt Mode on USB Type C Standard,” Version 1.0b, November 3, 2017.
- ◆ A method of transporting DisplayPort video/audio through USB-C connectors/cables:
 - USB-C Host (DP source) to DP Sink using an active cable “adapter.”
 - USB-C Host (DP source) to USB-C Device (DP sink) using a passive cable.
- ◆ Uses the USB-C Power Delivery messaging protocol over a Configuration Channel (CC) to negotiate into and exit out of DisplayPort Alt Mode signaling.
- ◆ Supports 1, 2, or 4 lane modes up to HBR3 bit rates (8.1Gb/s).
- ◆ Supports simultaneous transport of USB Super Speed and DisplayPort over 2 lanes—**Multi-Function**.

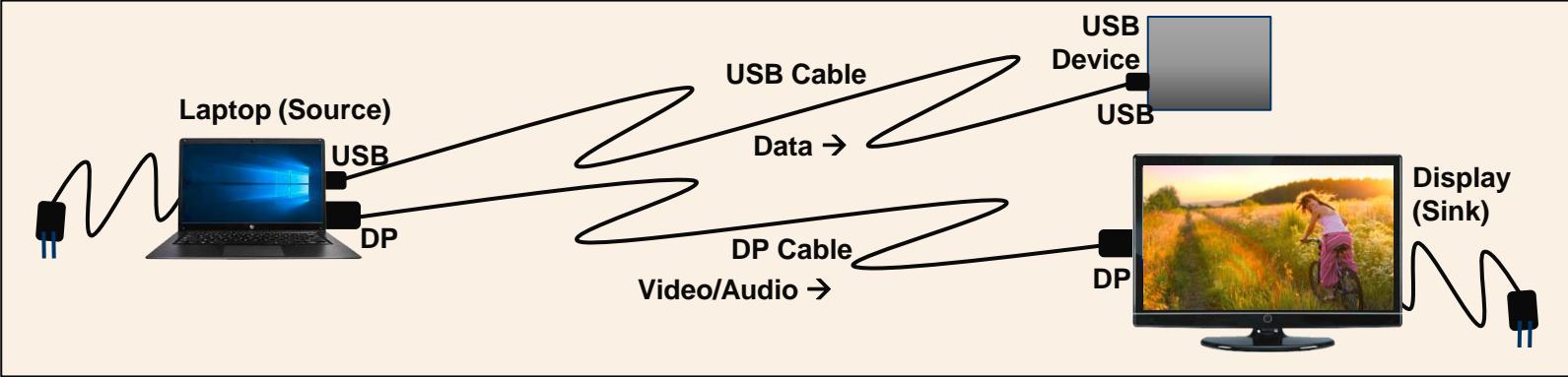
◆ Terminology

- **Port Partners** – A USB-C Host and a USB-C Device connection relationship.
- **DFP-U** – Downward Facing Port defined in the USB specification (a Host).
- **DFP-D** – Downward Facing Port defined in the DisplayPort Alt Mode specification (a DP Source).
- **UFP-U** – Upward Facing Port defined in the USB specification (a Device).
- **UFP-D** – Upward Facing Port defined in the DisplayPort Alt Mode specification (a DP Sink).
- **Configuration Channel (CC)** – A singled ended bus running at 300kHz. Used for the Power Delivery Protocol messages.
- **USB-C Receptacle** – Host or Device connector.
- **USB-C Plug** – Mating cable connector.
- **DP/USB-C Adapter** – Active device that conducts the Power Delivery (PD) negotiations into and out of DP Alt Mode. Has a notification service (“Billboard”) for error notification. Powered by VCONN.
- **Cable Plug** – A passive or active USB-C cable with logic that supports PD protocol commands.
- **PD_SID (Power Delivery Standard Identifier)** – 16-bit Identifier assigned by the USB-IF for the Power Delivery mode (FF00h).
- **DP_SID (DisplayPort Standard Identifier)** - 16-bit Identifier assigned by the USB-IF for the DisplayPort alt mode (FF01h) specification (standard).

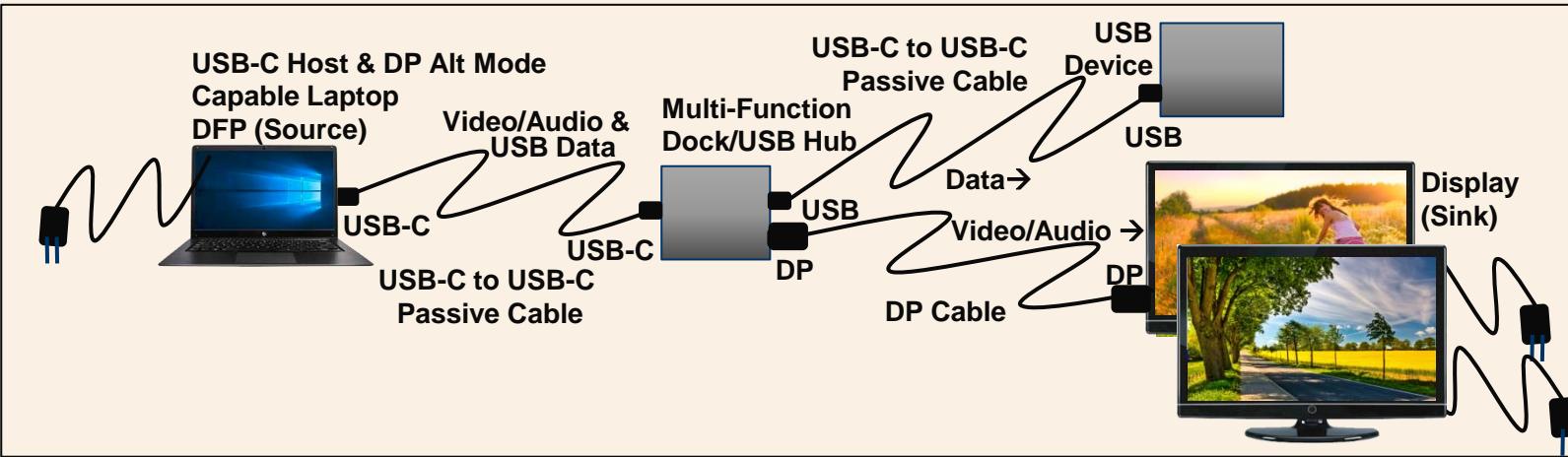
USB-C DP Alt Mode – What Is It?

- ◆ Consolidation of functions:
 - SuperSpeed USB Data Traffic.
 - Power Delivery.
 - Video/Audio Transmission.

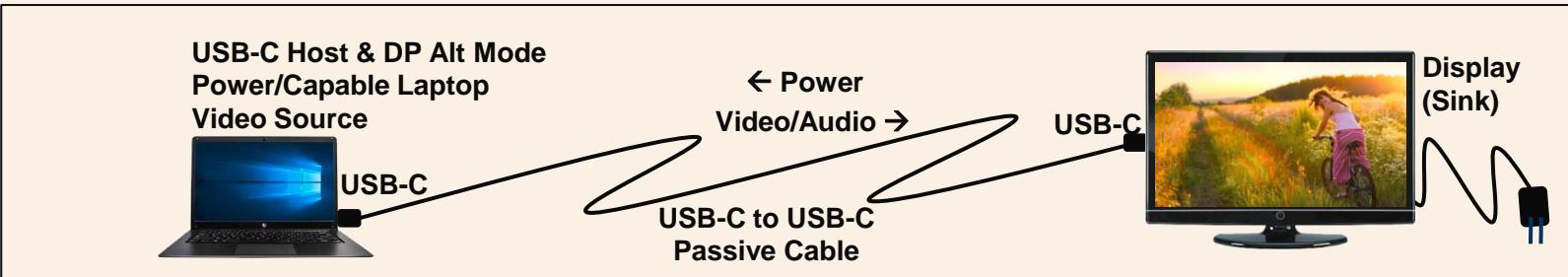
Traditional
Mode of
Operation



New USB-C
Mode of
Operation
(Video/Data)

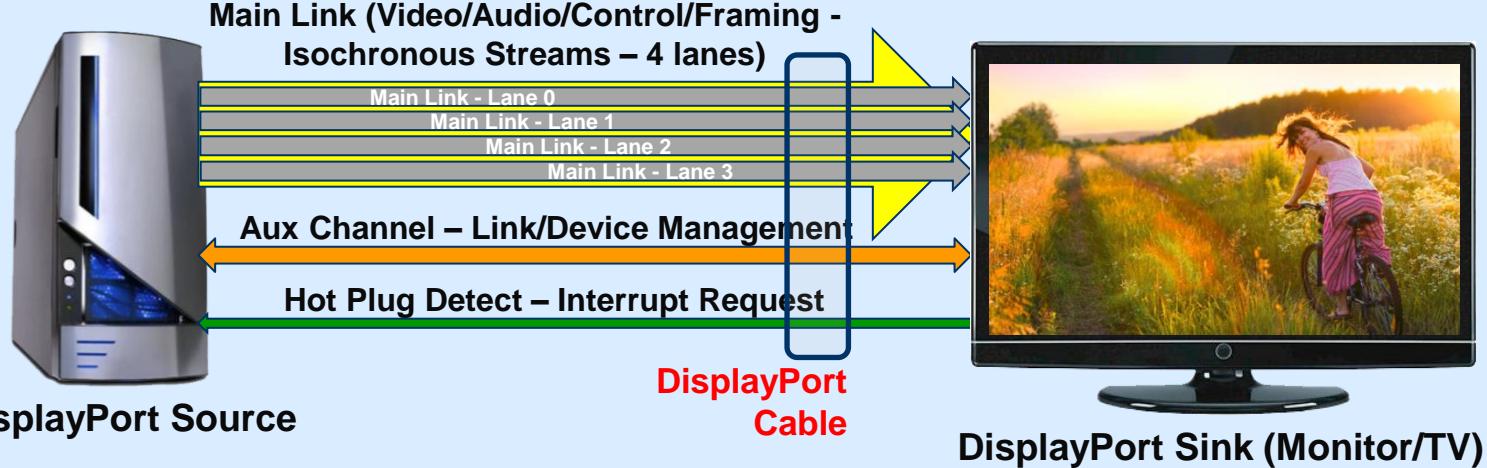


New USB-C
Mode of
Operation
(Video/Power)



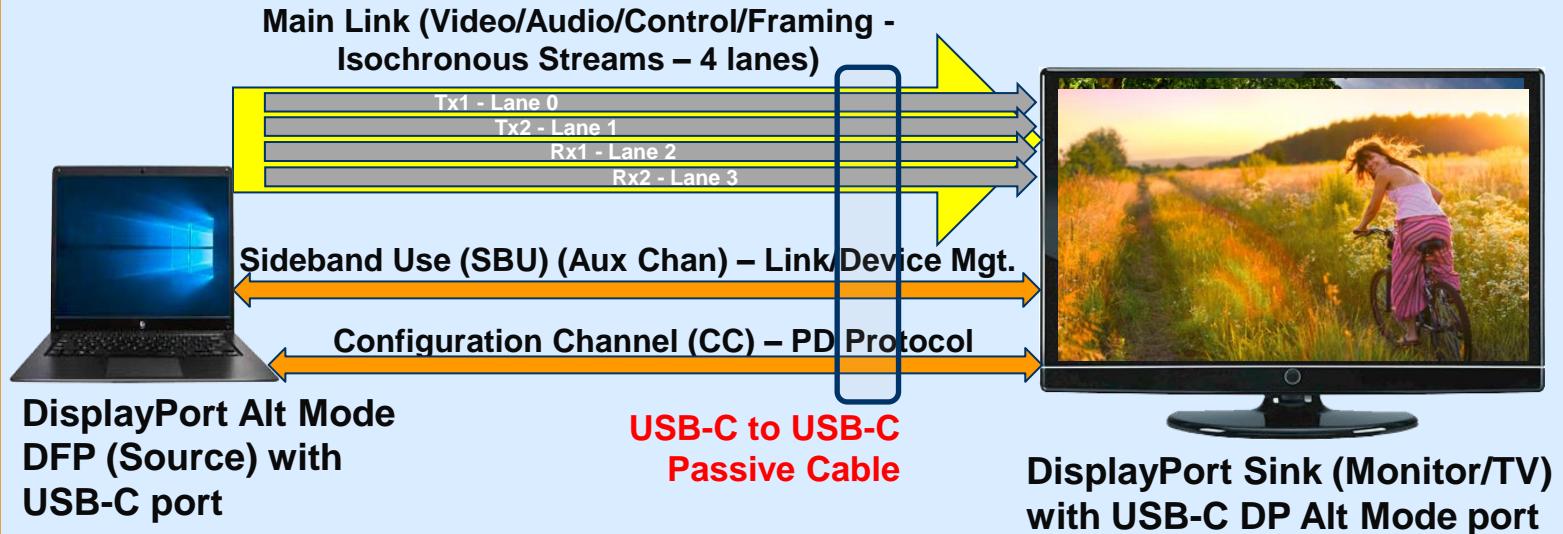
USB-C DP Alt Mode – What Is It?

DisplayPort



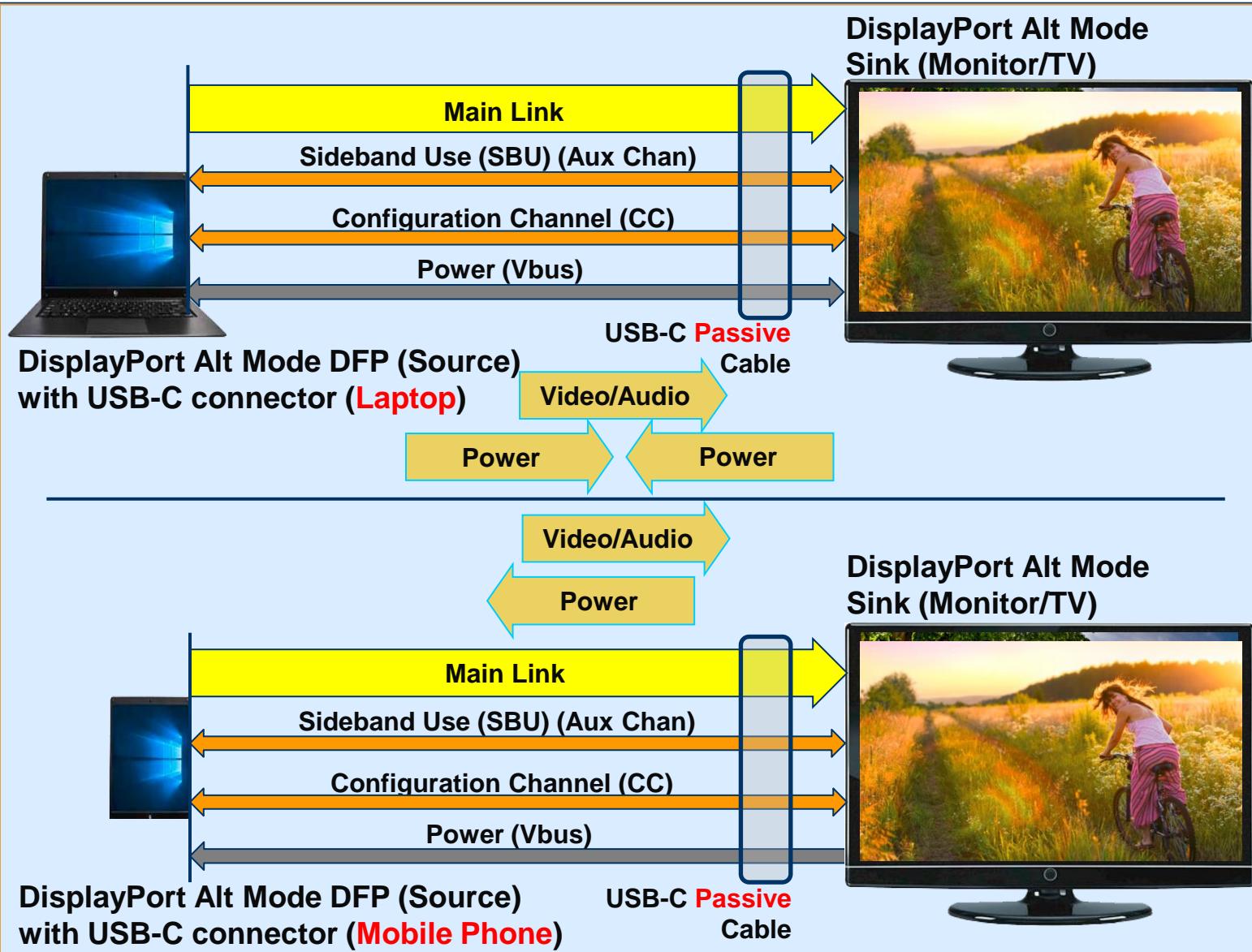
- **Main Link:** Unidirectional, high-bandwidth channel used to transport video/audio.
- Main Link 1, 2 or 4 Lane Configurations.
- Main Link 4 link rates: 1.62Gbps - 8.1Gbps.
- Aux Channel: Bidirectional, half duplex channel with a data rate of 1Mbps. Link Training, DPCD Register configuration and status, HDCP authentication & EDID exchange.
- Hot plug lead:
 - Connection Detection.
 - Interrupt mechanism.

USB-C DP Alt Mode



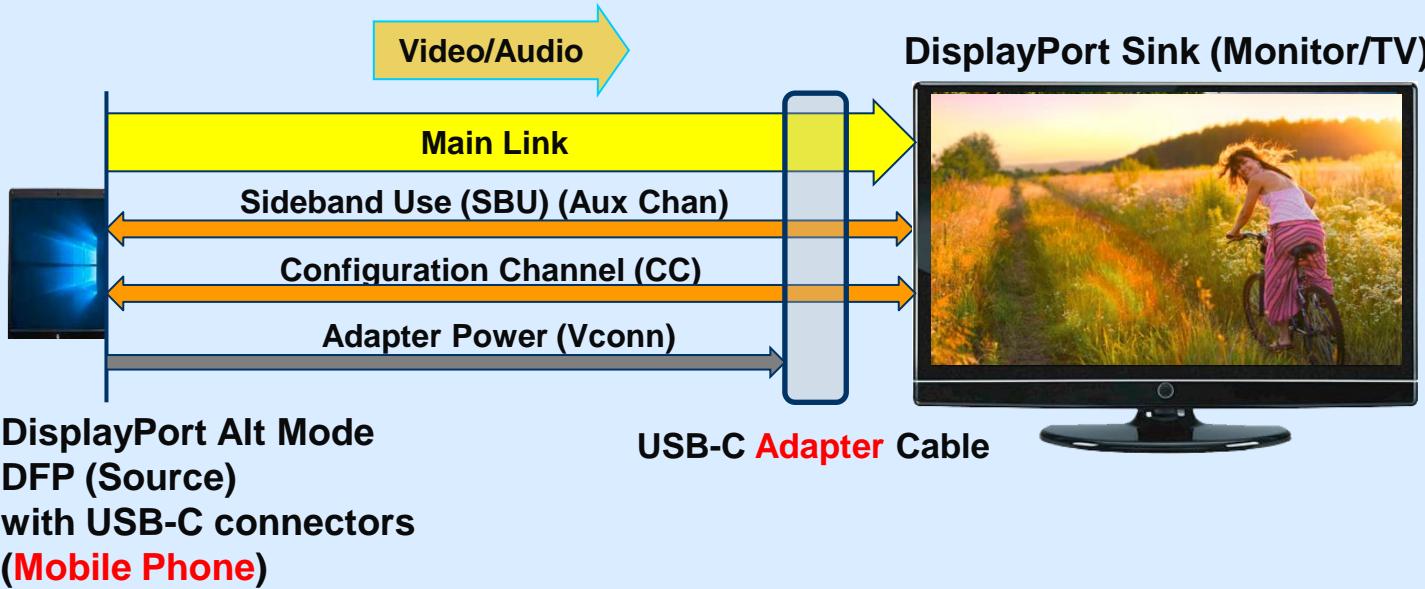
- DisplayPort Alt Mode repurposes USB-C leads for DisplayPort transmission.
- **USB-C Tx1/2 & Rx1/2 differential pairs (DP Main Link Lanes).** Unidirectional, high-bandwidth channel used to transport video/audio.
- **USB-C Sideband Use (DP Aux Channel).** Bidirectional, half duplex channel runs at Aux Chan rate of 1Mbps. Used for Link Training, DPCD read/write, HDCP & EDID exchange.
- **USB-C Configuration Channel (CC).** Bidirectional, half duplex (single ended) channel for Power Delivery (PD) protocol negotiations into DP Alt Mode. Runs at 300kHz. Also enables connection detection.

USB-C DP Alt Mode – Video/Audio and Power Roles



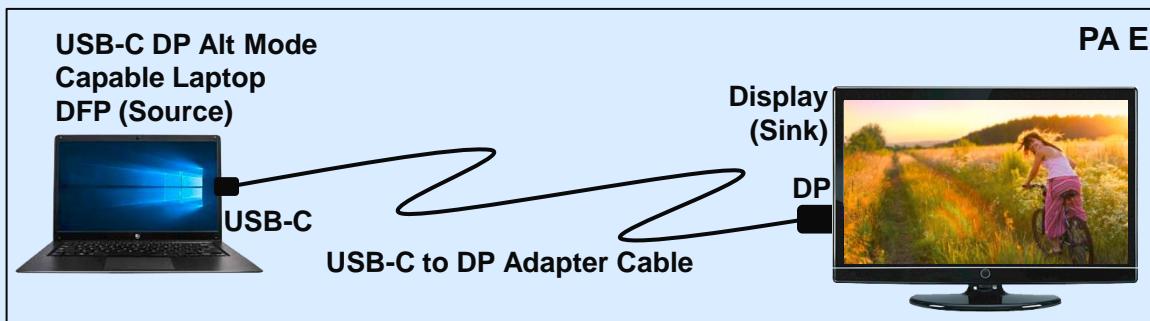
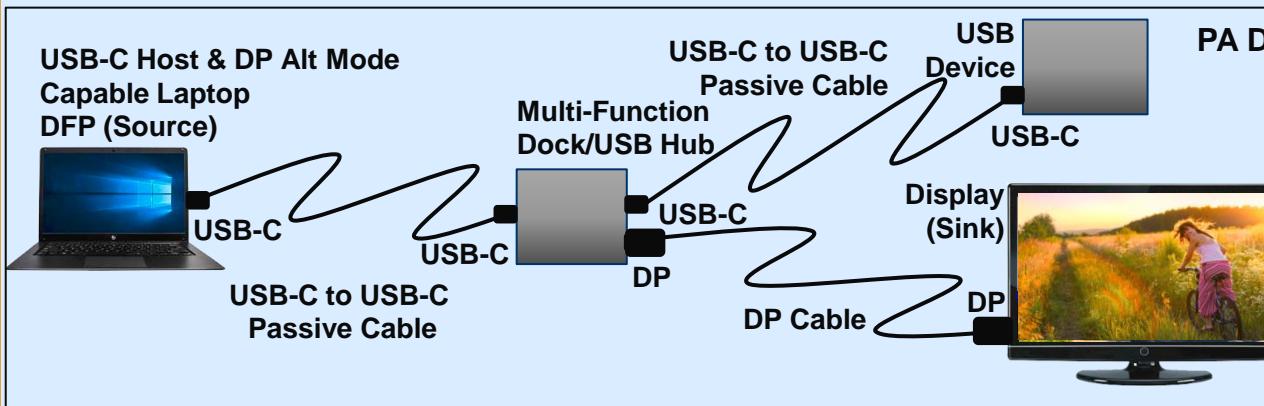
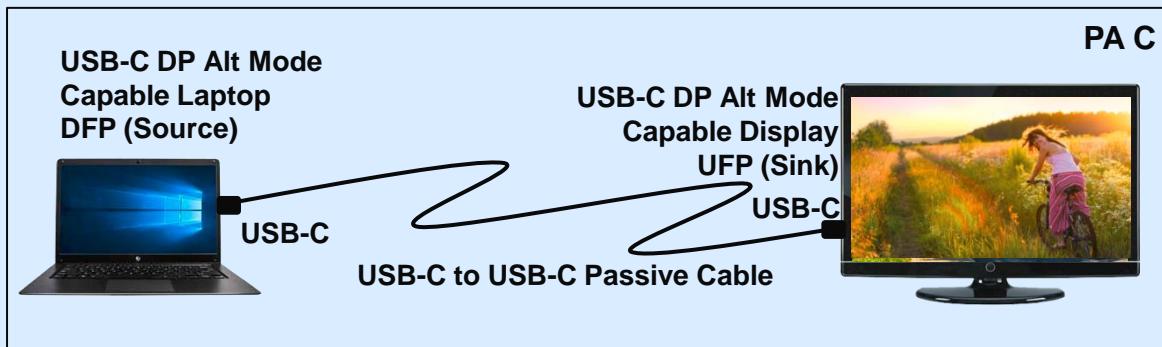
- ◆ **Video/Audio & Power Roles (Laptop)**
 - Laptop is streaming video/audio data to monitor. Data flows from the Laptop (DFP/Source) to the Monitor (DFP Sink).
 - Power can be supplied either from the Laptop or the Monitor via VBus.
 - A Laptop with a dead battery is required to operate as a Power Consumer (a power consumer UFP).
 - **DFP_D could act as a UFP_U.**
- ◆ **Video/Audio & Power Roles (Mobile Phone)**
 - Mobile Phone is streaming video/audio data to monitor. Data flows from the Mobile Phone (DFP/Source) to the Monitor (DFP Sink).
 - Power is supplied from Monitor to the Mobile Phone via VBus.
 - **Phone: DFP_D (source) is a UFP_U.**
 - **Monitor: UFP_D (sink) is a DFP_U.**

USB-C DP Alt Mode – Video/Audio and Power Roles (Adapter Cable)



- ◆ **Video/Audio with Adapter Cable**
 - Connection from Mobile Phone with a USB-C DP Alt Mode connector.
 - Monitor is a DisplayPort device without DP Alt Mode capabilities.
 - Video/Audio flows from the Mobile Phone (DFP/Source) to the Monitor (UFP/Sink) through the USB-to-DP Adapter.
 - Power to the USB-to-DP Adapter cable is supplied from the Mobile Phone through USB-C Vconn.

USB-C DP Alt Mode – Connections, Applications & Pin Assignments



◆ What are “Pin Assignments”?

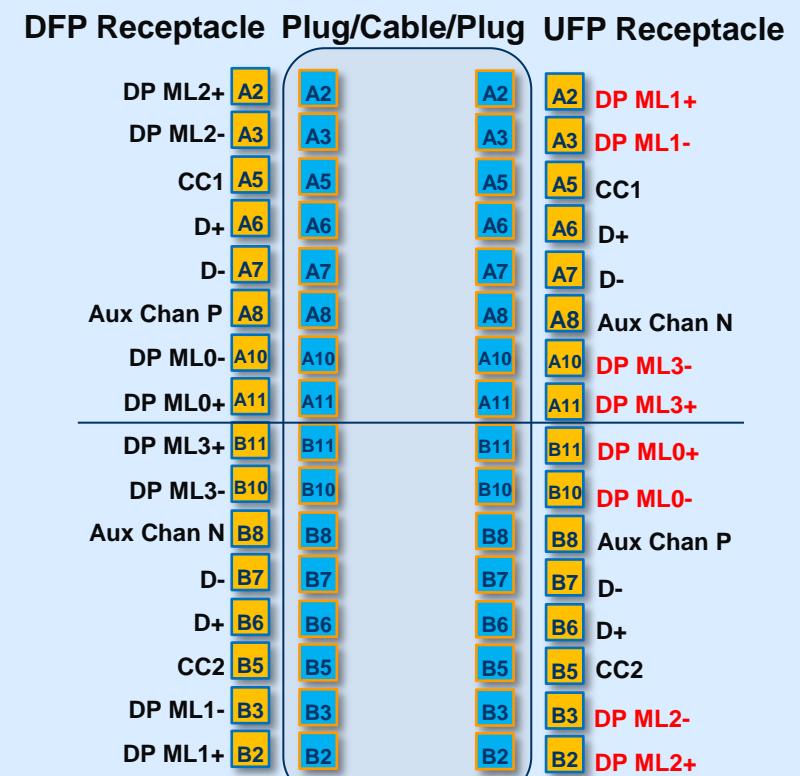
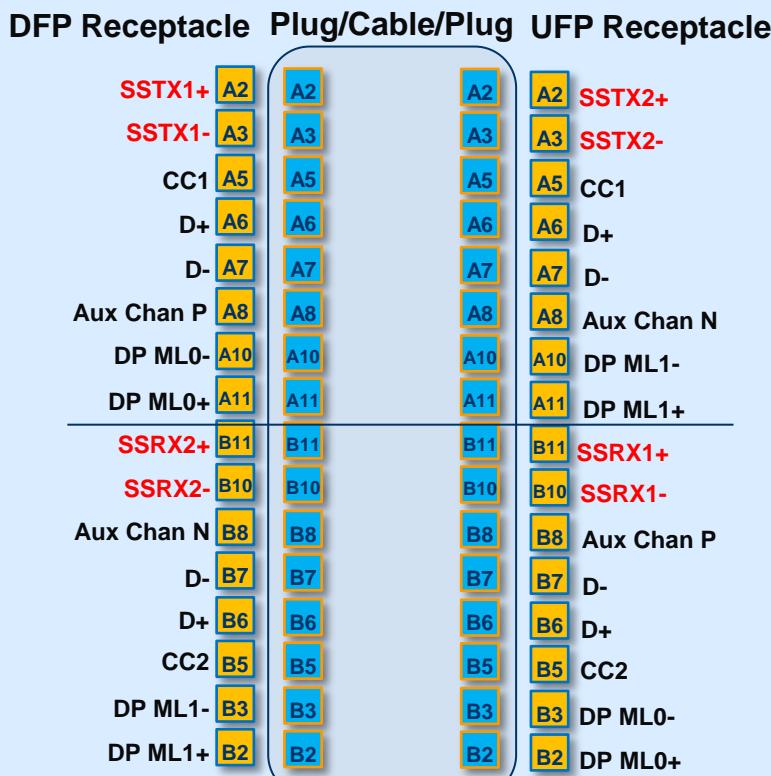
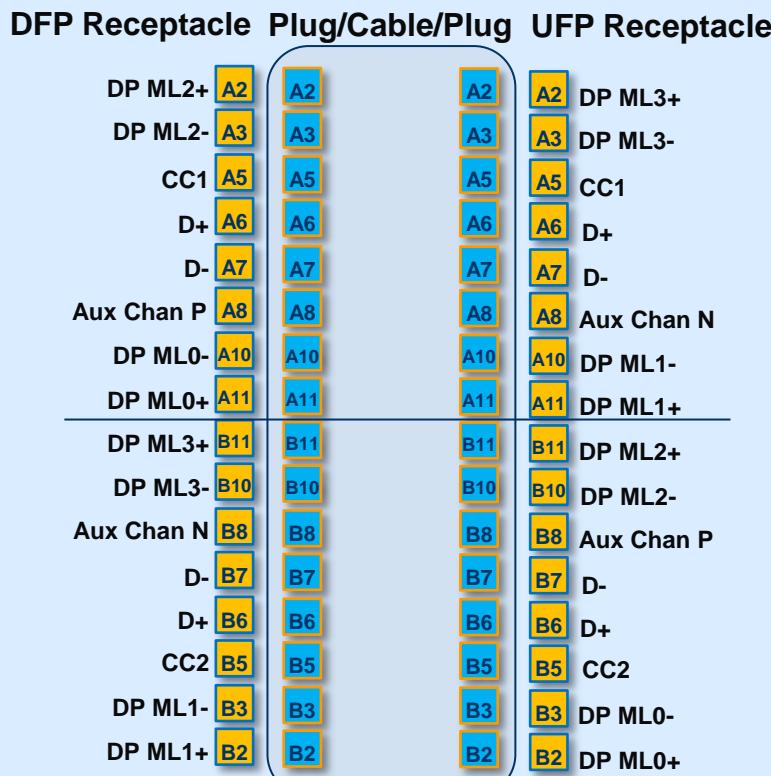
- ◆ USB Type-C pin assignments define the pin function on the USB Type-C receptacle for DP Alt Mode.
- ◆ A mapping of DisplayPort functions from a USB-C receptacle to a USB-C plug.

◆ Pin Assignments for DFP_D & UFP_D:

- ◆ C – Used w/ USB-C DFP (Source) to USB-C UFP connection thru a passive cable when four (4) lanes of DP transmission are needed.
- ◆ D – Used w/ USB-C DFP (Source) to USB-C UFP connection thru a passive cable to a docking station for Multi-Function applications where two (2) lanes of USB Super Speed are needed and two (2) lanes of DP are used.
- ◆ E – Used w/ USB-C DFP (Source) connection to an UFP (Sink) w/ a standard DP connector using an USB-C/DP adapter cable.

USB-C DP Alt Mode – Pin Assignments

- ◆ Pin Assignment C:
 - ◆ Used w/ USB-C DFP (Source) to USB-C UFP connection thru a passive cable when four (4) lanes of DP transmission are needed.
- ◆ Pin Assignment D:
 - ◆ Used w/ USB-C DFP (Source) to USB-C UFP connection thru a passive cable in **Multi-Function** applications where two (2) lanes of DP transmission and two (2) lanes of USB Super Speed are needed.
- ◆ Pin Assignment E:
 - ◆ Used w/ USB-C DFP (Source) connection to an UFP (Sink) w/ a standard DP connector using an USB-C/DP adapter cable.



980 Aux Channel Analyzer (ACA)



Transaction Log Panel

The screenshot shows the ACA Data Viewer software interface with three main panels:

- Transaction Log Panel (Left):** Displays a list of transactions with columns for Address, Device, Value, Time, and Description. A yellow arrow points to the "Time" column.
- Transactions Message (Top Center):** A yellow box highlights the transaction at index 19: "SNK:2 ACK Discover Identity". A red box surrounds the detailed message information.
- Transaction Details Panel (Right):** Shows detailed information for the selected transaction, including Start Time, Start of Packet, Message Type, Port Power Role, Port Data Role, Spec Revision, and Data Objects. It also lists individual message details and provides options for Raw Hex and Decoded Message views.

Decoded Message:

```
Start Time: +69:49:58.431054
Start of Packet: SOP
Message Type: Vendor_Defined
MessageID: 2
Port Power Role: Sink
Port Data Role: UFP
Spec Revision: Revision 2.0
Data Objects: 4

1) VDM Header
   SVID or VID      : 0xFF00 (65280)
   VDM Type        : Structured
   VDM Version     : 1.0
   Object Position: 0
   Command Type   : ACK
   Command        : Discover Identity

2) ID Header VDO
   Data Capable as USB Host    : Yes
   Data Capable as a USB Device: Yes
   Product Type          : Undefined
   Modal Operation Supported : Yes
   USB Vendor ID         : 0x043E

3) Cert Stat VDO
   TID: 0x00000

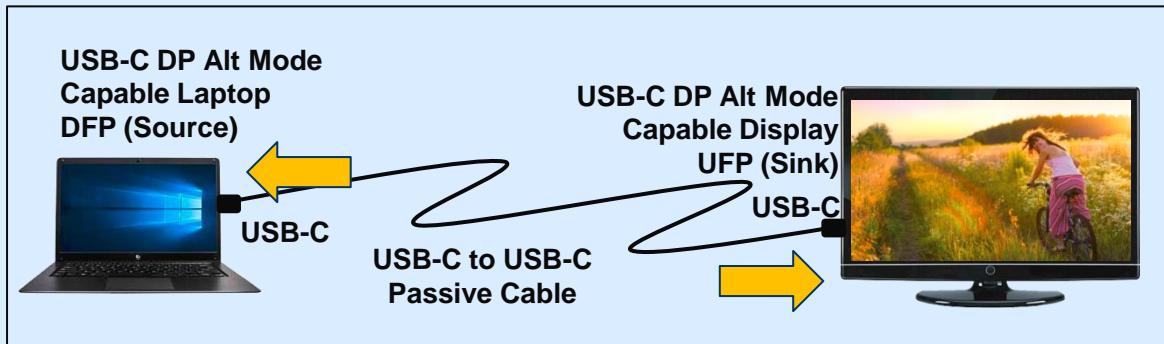
4) Product VDO
   USB Product ID: 0x9A30
   bcdDevice       : 0x0010

- Preamble: CC-1, 63, [Sync-1, Sync-1, Sync-1, Sync-2]
- Header: 444Fh
- Object 1: FF008041h
- Object 2: C400043Eh
- Object 3: 00000000h
- Object 4: 9A300010h
- CRC: C1B79DE2h
- EOP
```

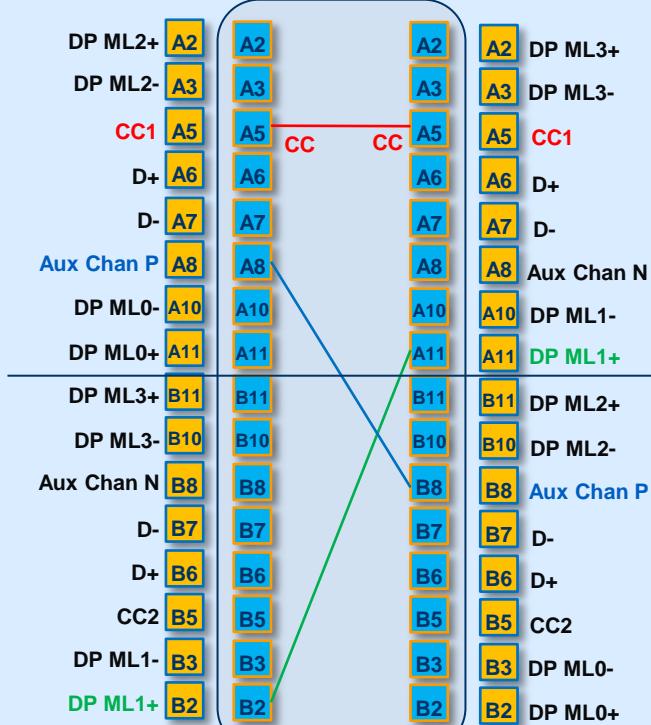
Raw Hex:

```
19: SNK:2 ACK Discover Identity
```

USB-C DP Alt Mode – Connection Orientation (Pin Assignment C)



DFP Receptacle for PA C & D Plug / Cable / Plug UFP Receptacle – for PA C



- ◆ DFP Normal; UFP Normal
- ◆ Generator Side.



ACA Data Viewer

[AA_980_FlipTest] Events: 1040 (2760)

Start Time: +01:32:14.483183
Start of Packet: SOP
Message Type: Vendor_Defined
MessageID: 2
Port Power Role: Source
Port Data Role: DFP
Spec Revision: Revision 2.0
Data Objects: 2

1) VDM Header
SVID or VID : 0xFF01 (65281)
VDM Type : Structured
VDM Version : 1.0
Object Position: 1
Command Type : Initiator
Command : DP_Configure

DisplayPort Configuration
Select Configuration : UFP_U as UFP_D
Signaling for Transport: DP v1.3
UFP_U/DP_D Pin Assign : C
UFP_U/UFP_D Pin Assign : De-select DFP_D pin assignment

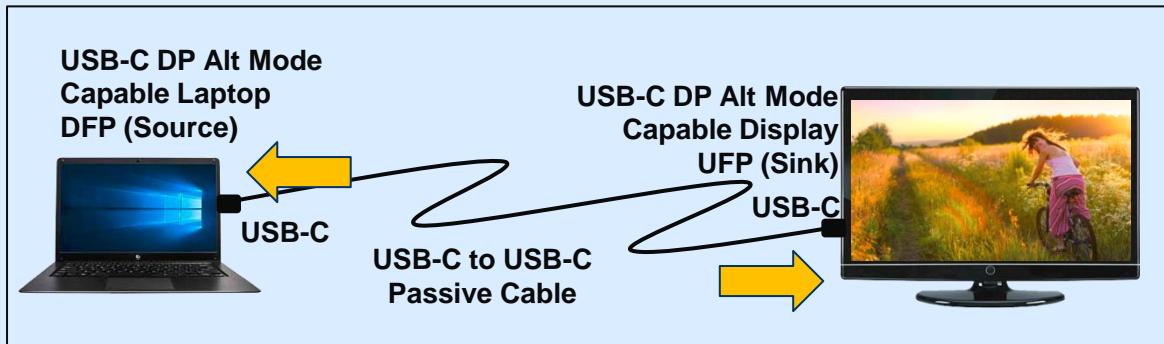
- Preamble: CC-1, Sync-1, Sync-2]

752 PDVDM 61 +01:32:14.483183 SRC:2 DP_Configure
SNK:1 GoodCRC
SNK:1 GoodCRC
SRC:2 DP_Configure
SNK:2 GoodCRC
SNK:2 GoodCRC
SRC:2 DP_Configure
SNK:0 ACK DP_Configure
SNK:0 ACK DP_Configure
SRC:0 GoodCRC
SRC:0 GoodCRC
SNK:1 Attention 1
SNK:1 Attention 1
SRC:1 GoodCRC
SRC:1 GoodCRC
SRC:3 Enter Mode 1
SRC:3 Enter Mode 1
SNK:3 GoodCRC

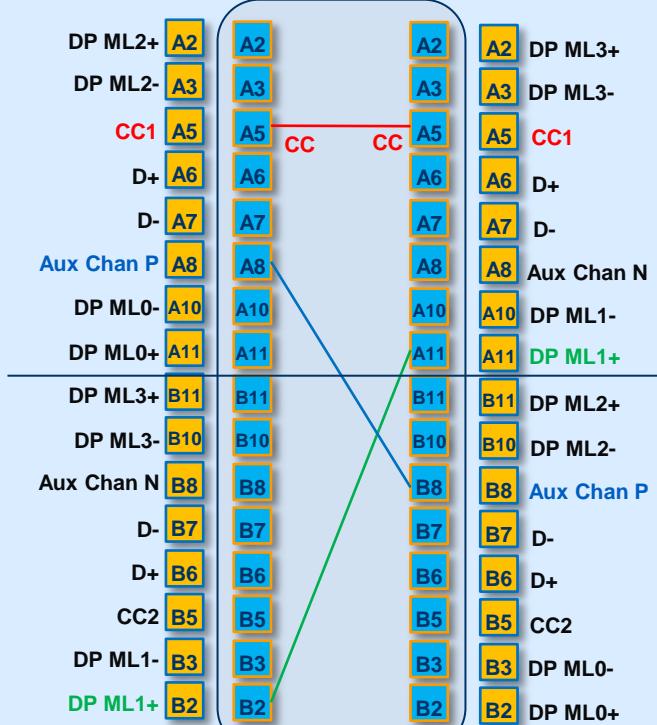
753 PDVDM 63 +01:32:14.483183
754 PDCTL 61 +01:32:14.483984
755 PDCTL 63 +01:32:14.483984
756 PDVDM 61 +01:32:14.485498
757 PDVDM 63 +01:32:14.485498
758 PDCTL 61 +01:32:14.486175
759 PDCTL 63 +01:32:14.486175
760 PDVDM 61 +01:32:14.487531
761 PDVDM 63 +01:32:14.487531
762 PDCTL 61 +01:32:14.488348
763 PDCTL 63 +01:32:14.488348
764 PDVDM 61 +01:32:14.513325
765 PDVDM 63 +01:32:14.513325
766 PDCTL 61 +01:32:14.514133

752: SRC:2 DP_Configure

USB-C DP Alt Mode – Connection Orientation (Pin Assignment C)



DFP Receptacle for PA C & D Plug / Cable / Plug UFP Receptacle – for PA C

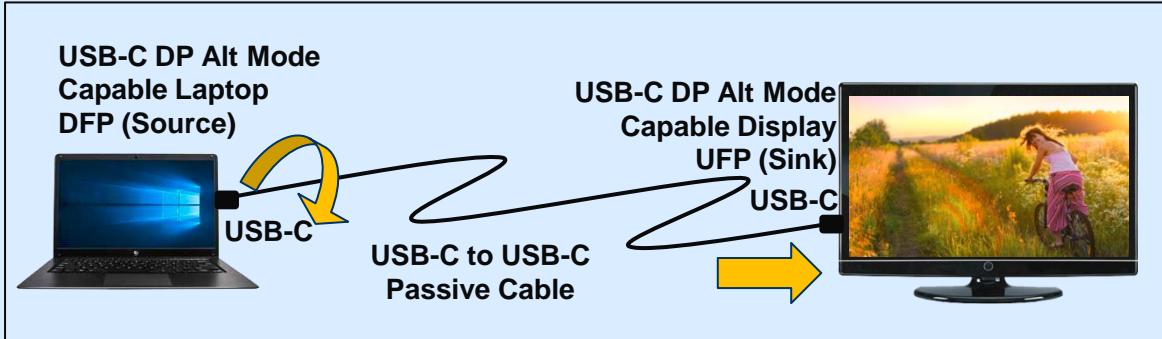


- ◆ DFP Normal; UFP Normal
- ◆ Analyzer Side

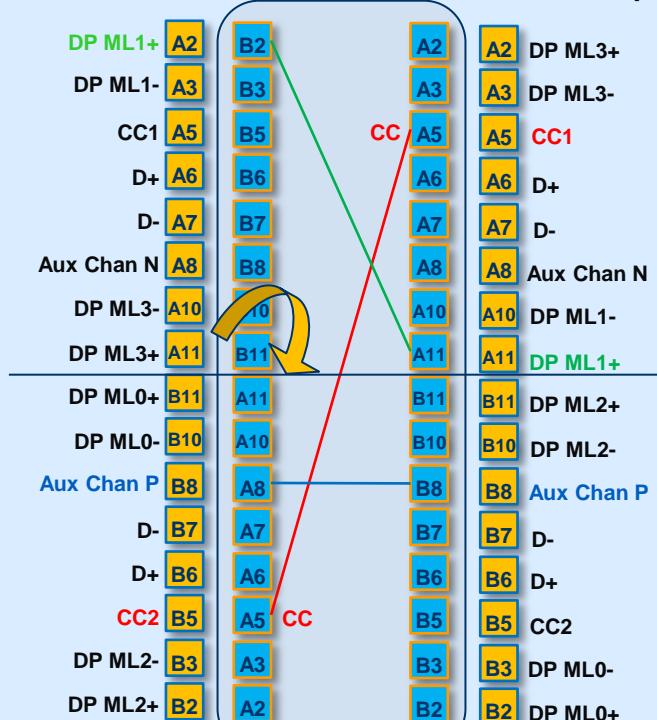


ACA Data Viewer					
[AA_980_FlipTest] Events: 1040 (2760)					
730	PDVDM	61	+01:32:14.468822	'PRT:0 Discover Identity	
731	PDVDM	63	+01:32:14.468822	'PRT:0 Discover Identity	
732	PDVDM	61	+01:32:14.470534	'PRT:0 Discover Identity	
733	PDVDM	63	+01:32:14.470534	'PRT:0 Discover Identity	
734	PDVDM	61	+01:32:14.472247	'PRT:0 Discover Identity	
735	PDVDM	63	+01:32:14.472247	'PRT:0 Discover Identity	
736	PDVDM	61	+01:32:14.474201	'SRC:0 Enter Mode 1	
737	PDVDM	63	+01:32:14.474201	'SRC:0 Enter Mode 1	
738	PDCTL	61	+01:32:14.474872	SNK:0 GoodCRC	
739	PDCTL	63	+01:32:14.474872	SNK:0 GoodCRC	
740	PDVDM	61	+01:32:14.476379	SNK:6 ACK Enter Mode 1	
741	PDVDM	63	+01:32:14.476379	SNK:6 ACK Enter Mode 1	
742	PDCTL	61	+01:32:14.477061	SRC:6 GoodCRC	
743	PDCTL	63	+01:32:14.477061	SRC:6 GoodCRC	
744	PDVDM	61	+01:32:14.478554	SRC:1 DP_Status_Update	
745	PDVDM	63	+01:32:14.478554	SRC:1 DP_Status_Update	
746	PDCTL	61	+01:32:14.479362	SNK:1 GoodCRC	
747	PDCTL	63	+01:32:14.479362	SNK:1 GoodCRC	
748	PDVDM	61	+01:32:14.480869	SNK:7 ACK DP_Status_Update	
749	PDVDM	63	+01:32:14.480869	SNK:7 ACK DP_Status_Update	
750	PDCTL	61	+01:32:14.481684	SRC:7 GoodCRC	
751	PDCTL	63	+01:32:14.481684	SRC:7 GoodCRC	
752	PDVDM	61	+01:32:14.493183	SRC:2 DP_Configure	
753	PDVDM	63	+01:32:	SRC:2 DP_Configure	
754	PDCTL	61	+01:32:14.493984	SNK:2 GoodCRC	
755	PDCTL	63	+01:32:14.493984	SNK:2 GoodCRC	
756	PDVDM	61	+01:32:14.495498	SNK:0 ACK DP_Configure	
757	PDVDM	63	+01:32:14.495498	SNK:0 ACK DP_Configure	
758	PDCTL	61	+01:32:14.496175	SRC:0 GoodCRC	
759	PDCTL	63	+01:32:14.496175	SRC:0 GoodCRC	
760	PDVDM	61	+01:32:14.497531	SNK:1 Attention 1	
761	PDVDM	63	+01:32:14.497531	SNK:1 Attention 1	
762	PDCTL	61	+01:32:14.498348	SRC:1 GoodCRC	
763	PDCTL	63	+01:32:14.498348	SRC:1 GoodCRC	
764	PDVDM	61	+01:32:14.513325	SRC:3 Enter Mode 1	
765	PDVDM	63	+01:32:14.514133	SRC:3 Enter Mode 1	
766	PDCTL	61	+01:32:14.514133	SNK:3 GoodCRC	

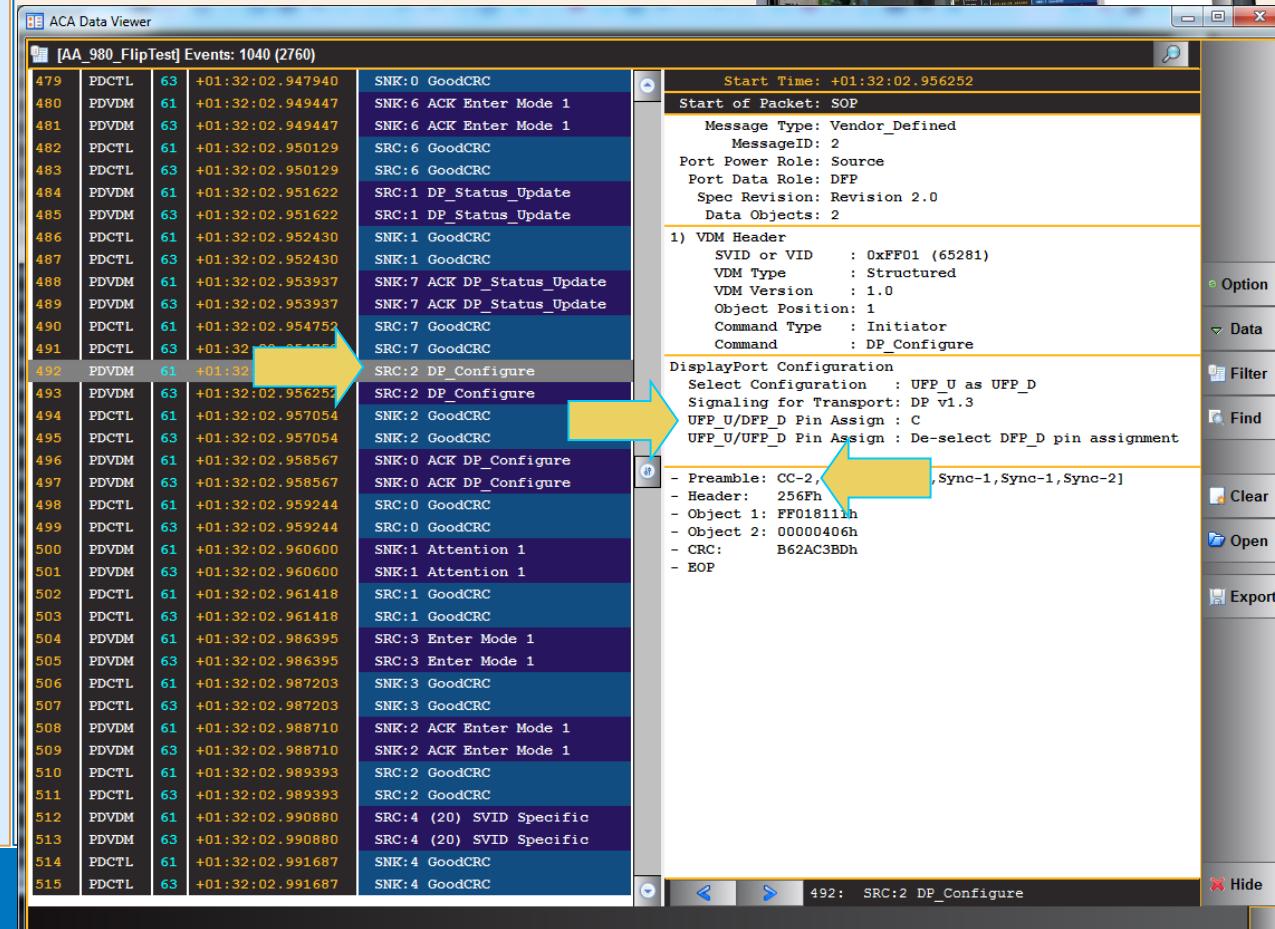
USB-C DP Alt Mode – Connection Orientation (Pin Assignment C)



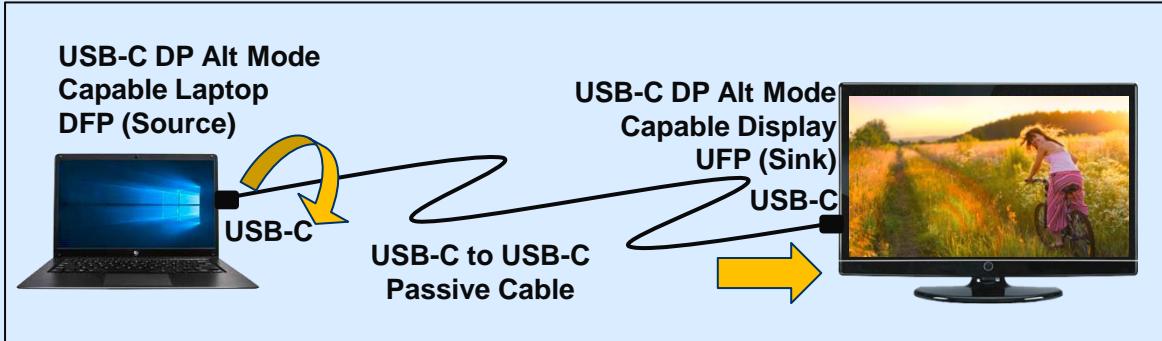
DFP Receptacle PA C Plug / Cable / Plug UFP Receptacle PA C



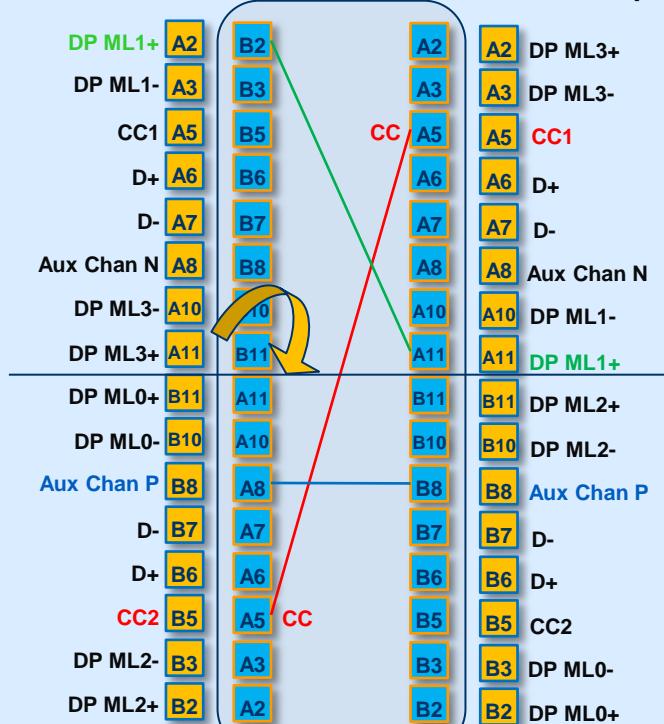
- ◆ DFP Flipped; UFP Normal
- ◆ Generator Side



USB-C DP Alt Mode – Connection Orientation (Pin Assignment C)



DFP Receptacle PA C Plug / Cable / Plug UFP Receptacle PA C



- ◆ DFP Flipped; UFP Normal
- ◆ Analyzer Side

ACA Data Viewer

[AA_980_FlipTest] Events: 1040 (2760)

Event ID	Type	Timestamp	Source	Destination	Details
479	PDCTL	+01:32:02.947940	SNK:0	GoodCRC	
480	PDVDM	+01:32:02.949447	SNK:6	ACK Enter Mode 1	
481	PDVDM	+01:32:02.949447	SNK:6	ACK Enter Mode 1	
482	PDCTL	+01:32:02.950129	SRC:6	GoodCRC	
483	PDCTL	+01:32:02.950129	SRC:6	GoodCRC	
484	PDVDM	+01:32:02.951622	SRC:1	DP_Status_Update	
485	PDVDM	+01:32:02.951622	SRC:1	DP_Status_Update	
486	PDCTL	+01:32:02.952430	SNK:1	GoodCRC	
487	PDCTL	+01:32:02.952430	SNK:1	GoodCRC	
488	PDVDM	+01:32:02.953937	SNK:7	ACK DP_Status_Update	
489	PDVDM	+01:32:02.953937	SNK:7	ACK DP_Status_Update	
490	PDCTL	+01:32:02.954752	SRC:7	GoodCRC	
491	PDCTL	+01:32:02.954752	SRC:7	GoodCRC	
492	PDVDM	+01:32:02.956258	SRC:2	DP_Configure	
493	PDVDM	+01:32:02.957005	SRC:2	DP_Configure	
494	PDCTL	+01:32:02.957054	SNK:2	GoodCRC	
495	PDCTL	+01:32:02.957054	SNK:2	GoodCRC	
496	PDVDM	+01:32:02.958567	SNK:0	ACK DP_Configure	
497	PDVDM	+01:32:02.958567	SNK:0	ACK DP_Configure	
498	PDCTL	+01:32:02.959244	SRC:0	GoodCRC	
499	PDCTL	+01:32:02.959244	SRC:0	GoodCRC	
500	PDVDM	+01:32:02.960600	SNK:1	Attention 1	
501	PDVDM	+01:32:02.960600	SNK:1	Attention 1	
502	PDCTL	+01:32:02.961418	SRC:1	GoodCRC	
503	PDCTL	+01:32:02.961418	SRC:1	GoodCRC	
504	PDVDM	+01:32:02.986395	SRC:3	Enter Mode 1	
505	PDVDM	+01:32:02.986395	SRC:3	Enter Mode 1	
506	PDCTL	+01:32:02.987203	SNK:3	GoodCRC	
507	PDCTL	+01:32:02.987203	SNK:3	GoodCRC	
508	PDVDM	+01:32:02.988710	SNK:2	ACK Enter Mode 1	
509	PDVDM	+01:32:02.988710	SNK:2	ACK Enter Mode 1	
510	PDCTL	+01:32:02.989393	SRC:2	GoodCRC	
511	PDCTL	+01:32:02.989393	SRC:2	GoodCRC	
512	PDVDM	+01:32:02.990880	SRC:4 (20)	SVID_Specific	
513	PDVDM	+01:32:02.990880	SRC:4 (20)	SVID_Specific	
514	PDCTL	+01:32:02.991687	SNK:4	GoodCRC	
515	PDCTL	+01:32:02.991687	SNK:4	GoodCRC	

Start of Packet: SOP

Message Type: Vendor Defined

MessageID: 2

Port Power Role: Source

Port Data Role: DFP

Spec Revision: Revision 2.0

Data Objects: 2

1) VDM Header

SVID or VID : 0xFF01 (65281)

VDM Type : Structured

VDM Version : 1.0

Object Position: 1

Command Type : Initiator

Command : DP_Configure

DisplayPort Configuration

Select Configuration : UFP_U as UFP_D

Signaling for Transport: DP v1.3

UFP_U/DFP_D Pin Assign : C

UFP_U/UFP_D Pin Assign : De-select DFP_D pin assignment

Preamble: CC-1, Sync-1, Sync-2

Header: 256Fh

Object 1: FF01811h

Object 2: 00000406h

CRC: B62AC3BDh

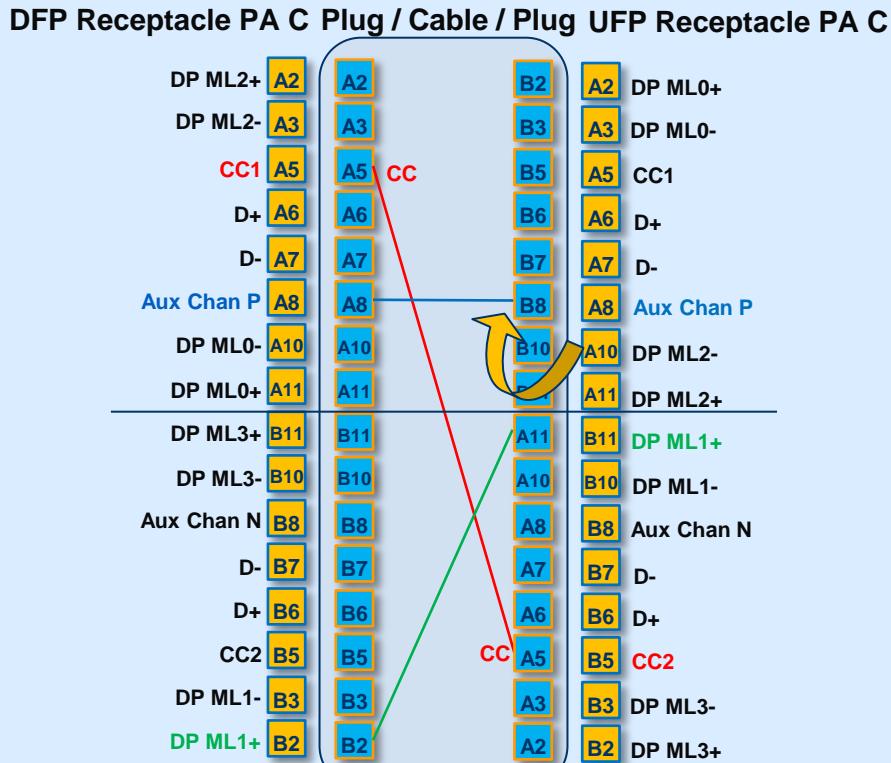
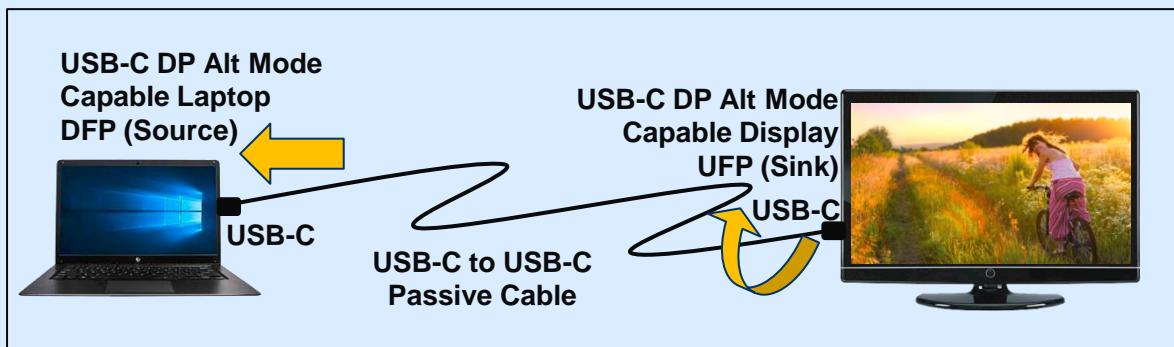
EOP

Sync-1, Sync-2

493: SRC:2 DP_Configure



USB-C DP Alt Mode – Connection Orientation (Pin Assignment C)



- ◆ DFP Normal; UFP Flipped
 - ◆ Generator Side



ACA Data Viewer

[AA_980_FlipTest] Events: 1040 (2760)

996	PDVDM	61	+01:32:22.938520	SRC:0 Enter Mode 1
997	PDVDM	63	+01:32:22.938520	SRC:0 Enter Mode 1
998	PDCTL	61	+01:32:22.939190	SNK:0 GoodCRC
999	PDCTL	63	+01:32:22.939190	SNK:0 GoodCRC
1000	PDVDM	61	+01:32:22.940697	SNK:6 ACK Enter Mode 1
1001	PDVDM	63	+01:32:22.940697	SNK:6 ACK Enter Mode 1
1002	PDCTL	61	+01:32:22.941379	SRC:6 GoodCRC
1003	PDCTL	63	+01:32:22.941379	SRC:6 GoodCRC
1004	PDVDM	61	+01:32:22.942873	SRC:1 DP_Status_Update
1005	PDVDM	63	+01:32:22.942873	SRC:1 DP_Status_Update
1006	PDCTL	61	+01:32:22.943681	SNK:1 GoodCRC
1007	PDCTL	63	+01:32:22.943681	SNK:1 GoodCRC
1008	PDVDM	61	+01:32:22.945188	SNK:7 ACK DP_Status_Update
1009	PDVDM	63	+01:32:22.945188	SNK:7 ACK DP_Status_Update
1010	PDCTL	61	+01:32:22.946000	SRC:7 GoodCRC
1011	PDCTL	63	+01:32:	SRC:7 GoodCRC
1012	PDVDM	61	+01:32:	SRC:2 DP_Configure
1013	PDVDM	63	+01:32:22.94750	SRC:2 DP_Configure
1014	PDCTL	61	+01:32:22.948303	SNK:2 GoodCRC
1015	PDCTL	63	+01:32:22.948303	SNK:2 GoodCRC
1016	PDVDM	61	+01:32:22.949817	SNK:0 ACK DP_Configure
1017	PDVDM	63	+01:32:22.949817	SNK:0 ACK DP_Configure
1018	PDCTL	61	+01:32:22.950493	SRC:0 GoodCRC
1019	PDCTL	63	+01:32:22.950493	SRC:0 GoodCRC
1020	PDVDM	61	+01:32:22.951850	SNK:1 Attention 1
1021	PDVDM	63	+01:32:22.951850	SNK:1 Attention 1
1022	PDCTL	61	+01:32:22.952667	SRC:1 GoodCRC
1023	PDCTL	63	+01:32:22.952667	SRC:1 GoodCRC
1024	PDVDM	61	+01:32:22.977644	SRC:3 Enter Mode 1
1025	PDVDM	63	+01:32:22.977644	SRC:3 Enter Mode 1
1026	PDCTL	61	+01:32:22.978452	SNK:3 GoodCRC
1027	PDCTL	63	+01:32:22.978452	SNK:3 GoodCRC
1028	PDVDM	61	+01:32:22.979959	SNK:2 ACK Enter Mode 1
1029	PDVDM	63	+01:32:22.979959	SNK:2 ACK Enter Mode 1
1030	PDCTL	61	+01:32:22.980642	SRC:2 GoodCRC
1031	PDCTL	63	+01:32:22.980642	SRC:2 GoodCRC
1032	PDVDM	61	+01:32:22.982129	SRC:4 (20) SVID Specific

Start Time: +01:32:22.947502
Start of Packet: SOP
Message Type: Vendor_Defined
MessageID: 2
Port Power Role: Source
Port Data Role: DFP
Spec Revision: Revision 2.0
Data Objects: 2

1) VDM Header

- SVID or VID : 0xFF01 (65281)
- VDM Type : Structured
- VDM Version : 1.0
- Object Position: 1
- Command Type : Initiator
- Command : DP_Configure

DisplayPort Configuration

- Select Configuration : UFP_U as UFP_D
- Signaling for Transport: DP v1.3
- UFP_U/DFP_D Pin Assign : C
- UFP_U/UFP_D Pin Assign : De-select DFP_D pin assignment

- Preamble: CC-1, Sync-1, Sync-1, Sync-2

- Header: 256Ph

- Object 1: FF018111h

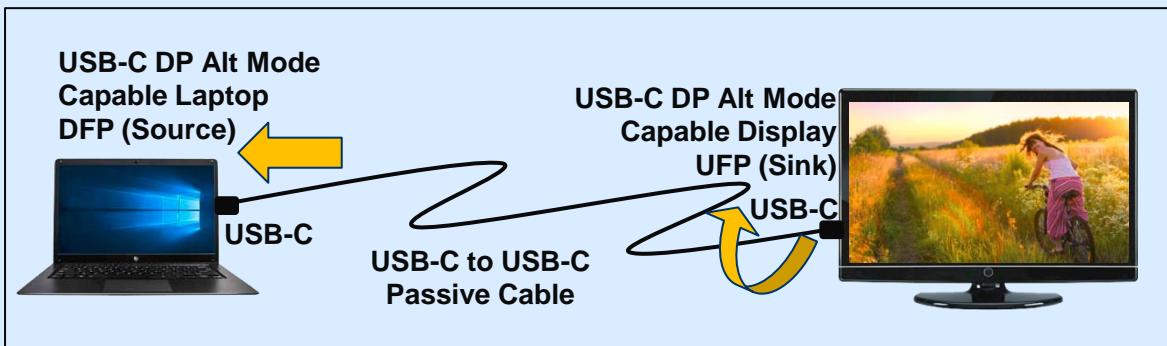
- Object 2: 00000406h

- CRC: B62AC3Bdh

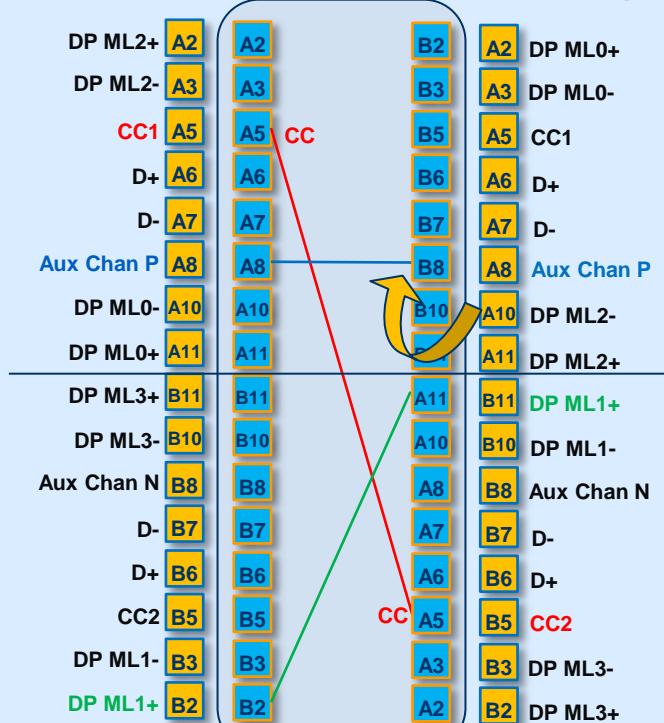
- EOP

1012: SRC:2 DP_Configure

USB-C DP Alt Mode – Connection Orientation (Pin Assignment C)



DFP Receptacle PA C Plug / Cable / Plug UFP Receptacle PA C

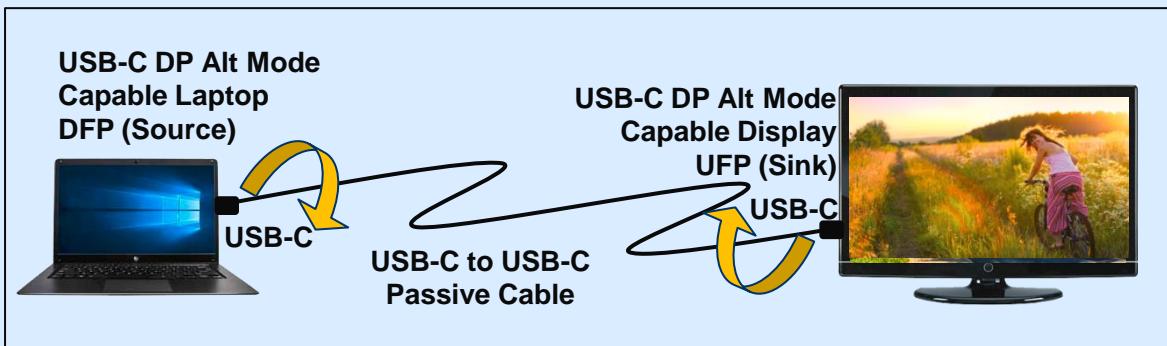


- ◆ DFP Normal; UFP Flipped
- ◆ Analyzer Side

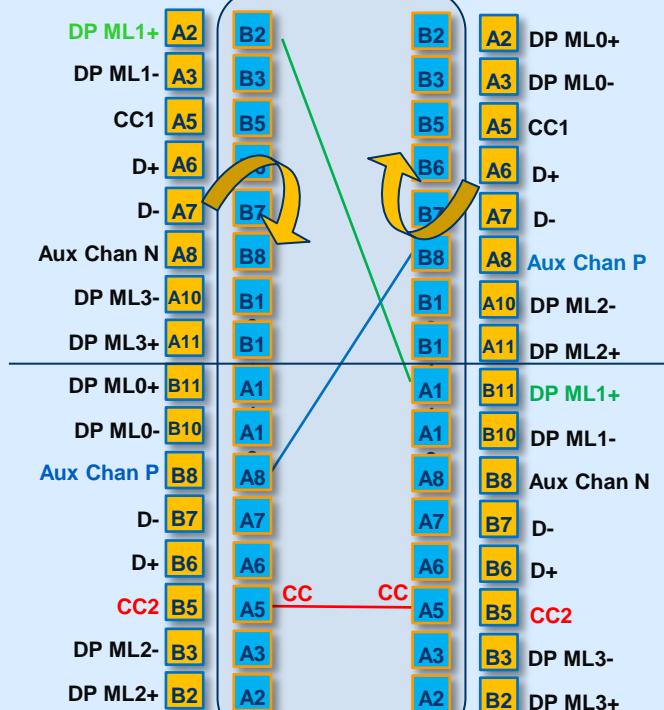


ACA Data Viewer					
[AA_980_FlipTest] Events: 1040 (2760)					
996	PDVDM	61	+01:32:22.938520	SRC:0	Enter Mode 1
997	PDVDM	63	+01:32:22.938520	SRC:0	Enter Mode 1
998	PDCTL	61	+01:32:22.939190	SNK:0	GoodCRC
999	PDCTL	63	+01:32:22.939190	SNK:0	GoodCRC
1000	PDVDM	61	+01:32:22.940697	SNK:6	ACK Enter Mode 1
1001	PDVDM	63	+01:32:22.940697	SNK:6	ACK Enter Mode 1
1002	PDCTL	61	+01:32:22.941379	SRC:6	GoodCRC
1003	PDCTL	63	+01:32:22.941379	SRC:6	GoodCRC
1004	PDVDM	61	+01:32:22.942873	SRC:1	DP_Status_Update
1005	PDVDM	63	+01:32:22.942873	SRC:1	DP_Status_Update
1006	PDCTL	61	+01:32:22.943681	SNK:1	GoodCRC
1007	PDCTL	63	+01:32:22.943681	SNK:1	GoodCRC
1008	PDVDM	61	+01:32:22.945188	SNK:7	ACK DP_Status_Update
1009	PDVDM	63	+01:32:22.945188	SNK:7	ACK DP_Status_Update
1010	PDCTL	61	+01:32:22.946002	SRC:7	GoodCRC
1011	PDCTL	63	+01:32:22.946002	SRC:7	GoodCRC
1012	PDVDM	61	+01:32:22.947447	SRC:2	DP_Configure
1013	PDVDM	63	+01:32:22.947447	SRC:2	DP_Configure
1014	PDCTL	61	+01:32:22.94830	SNK:2	GoodCRC
1015	PDCTL	63	+01:32:22.948303	SNK:2	GoodCRC
1016	PDVDM	61	+01:32:22.949817	SNK:0	ACK DP_Configure
1017	PDVDM	63	+01:32:22.949817	SNK:0	ACK DP_Configure
1018	PDCTL	61	+01:32:22.950493	SRC:0	GoodCRC
1019	PDCTL	63	+01:32:22.950493	SRC:0	GoodCRC
1020	PDVDM	61	+01:32:22.951850	SNK:1	Attention 1
1021	PDVDM	63	+01:32:22.951850	SNK:1	Attention 1
1022	PDCTL	61	+01:32:22.952667	SRC:1	GoodCRC
1023	PDCTL	63	+01:32:22.952667	SRC:1	GoodCRC
1024	PDVDM	61	+01:32:22.977644	SRC:3	Enter Mode 1
1025	PDVDM	63	+01:32:22.977644	SRC:3	Enter Mode 1
1026	PDCTL	61	+01:32:22.978452	SNR:3	GoodCRC
1027	PDCTL	63	+01:32:22.978452	SNR:3	GoodCRC
1028	PDVDM	61	+01:32:22.979959	SNK:2	ACK Enter Mode 1
1029	PDVDM	63	+01:32:22.979959	SNK:2	ACK Enter Mode 1
1030	PDCTL	61	+01:32:22.980642	SRC:2	GoodCRC
1031	PDCTL	63	+01:32:22.980642	SRC:2	GoodCRC
1032	PDVDM	61	+01:32:22.982129	SRC:4	(20) SVID Specific

USB-C DP Alt Mode – Connection Orientation (Pin Assignment C)



DFP Receptacle PA C Plug / Cable / Plug UFP Receptacle PA C



- ◆ DFP Flipped; UFP Flipped
- ◆ Generator Side



ACA Data Viewer

[AA_980_FlipTest] Events: 1040 (2760)

Start Time: +01:31:52.666865

Start of Packet: SOP

Message Type: Vendor_Defined
MessageID: 2
Port Power Role: Source
Port Data Role: DFP
Spec Revision: Revision 2.0
Data Objects: 2

1) VDM Header
SVID or VID : 0xFF01 (65281)
VDM Type : Structured
VDM Version : 1.0
Object Position: 1
Command Type : Initiator
Command : DP_Configure

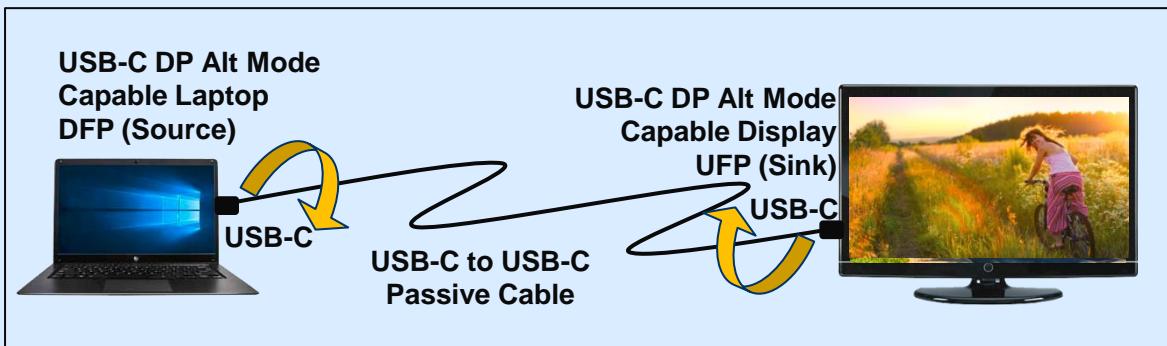
DisplayPort Configuration
Select Configuration : UFP_U as UFP_D
Signaling for Transport: DP v1.3
UFP_U/DFP_D Pin Assign : C
UFP_U/UFP_D Pin Assign : De-select DFP_D pin assignment

- Preamble: CC-2, Sync-1, Sync-1, Sync-2]
- Header: 256Fh
- Object 1: FF018111h
- Object 2: 00000406h
- CRC: B62AC3BDh
- EOP

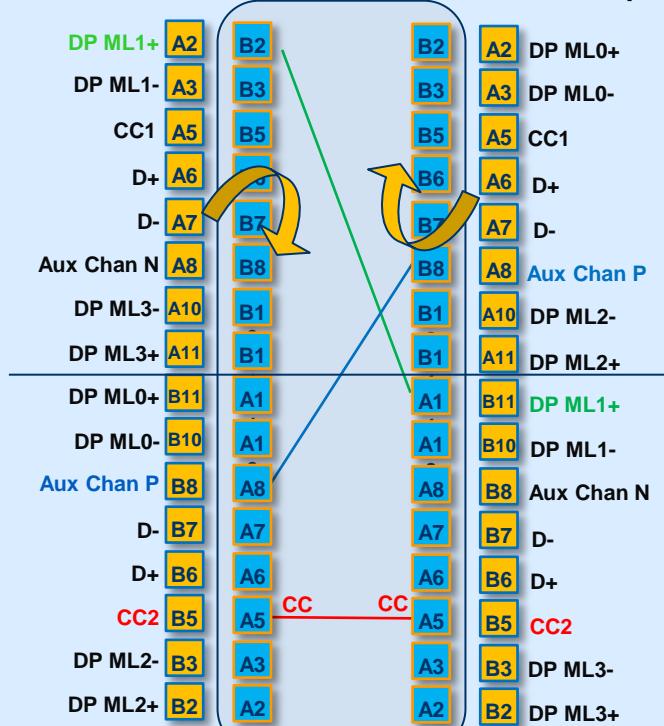
232: SRC:2 DP_Configure

216 PDVDM 61 +01:31:52.657880 SRC:0 Enter Mode 1
217 PDVDM 63 +01:31:52.657880 SRC:0 Enter Mode 1
218 PDCTL 61 +01:31:52.658550 SNR:0 GoodCRC
219 PDCTL 63 +01:31:52.658550 SNR:0 GoodCRC
220 PDVDM 61 +01:31:52.660057 SNR:6 ACK Enter Mode 1
221 PDVDM 63 +01:31:52.660057 SNR:6 ACK Enter Mode 1
222 PDCTL 61 +01:31:52.660740 SRC:6 GoodCRC
223 PDCTL 63 +01:31:52.660740 SRC:6 GoodCRC
224 PDVDM 61 +01:31:52.662234 SRC:1 DP_Status_Update
225 PDVDM 63 +01:31:52.662234 SRC:1 DP_Status_Update
226 PDCTL 61 +01:31:52.663042 SNR:1 GoodCRC
227 PDCTL 63 +01:31:52.663042 SNR:1 GoodCRC
228 PDVDM 61 +01:31:52.664551 SNR:7 ACK DP_Status_Update
229 PDVDM 63 +01:31:52.664551 SNR:7 ACK DP_Status_Update
230 PDCTL 61 +01:31:52.665365 SRC:7 GoodCRC
231 PDCTL 63 +01:31:52.665365 SRC:7 GoodCRC
232 PDVDM 61 +01:31:52.666865 SRC:2 DP_Configure
233 PDVDM 63 +01:31:52.666865 SRC:2 DP_Configure
234 PDCTL 61 +01:31:52.667666 SNR:2 GoodCRC
235 PDCTL 63 +01:31:52.667666 SNR:2 GoodCRC
236 PDVDM 61 +01:31:52.669183 SNR:0 ACK DP_Configure
237 PDVDM 63 +01:31:52.669183 SNR:0 ACK DP_Configure
238 PDCTL 61 +01:31:52.669859 SRC:0 GoodCRC
239 PDCTL 63 +01:31:52.669859 SRC:0 GoodCRC
240 PDVDM 61 +01:31:52.671275 SNR:1 Attention 1
241 PDVDM 63 +01:31:52.671275 SNR:1 Attention 1
242 PDCTL 61 +01:31:52.672093 SRC:1 GoodCRC
243 PDCTL 63 +01:31:52.672093 SRC:1 GoodCRC
244 PDVDM 61 +01:31:52.697070 SRC:3 Enter Mode 1
245 PDVDM 63 +01:31:52.697070 SRC:3 Enter Mode 1
246 PDCTL 61 +01:31:52.697878 SNR:3 GoodCRC
247 PDCTL 63 +01:31:52.697878 SNR:3 GoodCRC
248 PDVDM 61 +01:31:52.699385 SNR:2 ACK Enter Mode 1
249 PDVDM 63 +01:31:52.699385 SNR:2 ACK Enter Mode 1
250 PDCTL 61 +01:31:52.700068 SRC:2 GoodCRC
251 PDCTL 63 +01:31:52.700068 SRC:2 GoodCRC
252 PDVDM 61 +01:31:52.701555 SRC:4 (20) SVID Specific

USB-C DP Alt Mode – Connection Orientation (Pin Assignment C)



DFP Receptacle PA C Plug / Cable / Plug UFP Receptacle PA C



- ◆ DFP Flipped; UFP Flipped
- ◆ Analyzer Side



ACA Data Viewer					
[AA_980_FlipTest] Events: 1040 (2760)					
216	PDVDM	61	+01:31:52.657880	SRC:0 Enter Mode 1	
217	PDVDM	63	+01:31:52.657880	SRC:0 Enter Mode 1	
218	PDCTL	61	+01:31:52.658550	SNK:0 GoodCRC	
219	PDCTL	63	+01:31:52.658550	SNK:0 GoodCRC	
220	PDVDM	61	+01:31:52.660057	SNK:6 ACK Enter Mode 1	
221	PDVDM	63	+01:31:52.660057	SNK:6 ACK Enter Mode 1	
222	PDCTL	61	+01:31:52.660740	SRC:6 GoodCRC	
223	PDCTL	63	+01:31:52.660740	SRC:6 GoodCRC	
224	PDVDM	61	+01:31:52.662234	SRC:1 DP_Status_Update	
225	PDVDM	63	+01:31:52.662234	SRC:1 DP_Status_Update	
226	PDCTL	61	+01:31:52.663042	SNK:1 GoodCRC	
227	PDCTL	63	+01:31:52.663042	SNK:1 GoodCRC	
228	PDVDM	61	+01:31:52.664551	SNK:7 ACK DP_Status_Update	
229	PDVDM	63	+01:31:52.664551	SNK:7 ACK DP_Status_Update	
230	PDCTL	61	+01:31:52.665365	SRC:7 GoodCRC	
231	PDCTL	63	+01:31:52.665365	SRC:7 GoodCRC	
232	PDVDM	61	+01:31:52.66625	SRC:2 DP_Configure	
233	PDVDM	63	+01:31:	SRC:2 DP_Configure	
234	PDCTL	61	+01:31:52.667766	SNK:2 GoodCRC	
235	PDCTL	63	+01:31:52.667766	SNK:2 GoodCRC	
236	PDVDM	61	+01:31:52.669183	SNK:0 ACK DP_Configure	
237	PDVDM	63	+01:31:52.669183	SNK:0 ACK DP_Configure	
238	PDCTL	61	+01:31:52.669859	SRC:0 GoodCRC	
239	PDCTL	63	+01:31:52.669859	SRC:0 GoodCRC	
240	PDVDM	61	+01:31:52.671275	SNK:1 Attention 1	
241	PDVDM	63	+01:31:52.671275	SNK:1 Attention 1	
242	PDCTL	61	+01:31:52.672093	SRC:1 GoodCRC	
243	PDCTL	63	+01:31:52.672093	SRC:1 GoodCRC	
244	PDVDM	61	+01:31:52.697070	SRC:3 Enter Mode 1	
245	PDVDM	63	+01:31:52.697070	SRC:3 Enter Mode 1	
246	PDCTL	61	+01:31:52.697878	SNK:3 GoodCRC	
247	PDCTL	63	+01:31:52.697878	SNK:3 GoodCRC	
248	PDVDM	61	+01:31:52.699385	SNK:2 ACK Enter Mode 1	
249	PDVDM	63	+01:31:52.699385	SNK:2 ACK Enter Mode 1	
250	PDCTL	61	+01:31:52.700068	SRC:2 GoodCRC	
251	PDCTL	63	+01:31:52.700068	SRC:2 GoodCRC	
252	PDVDM	61	+01:31:52.701555	SRC:4 (20) SVID Specific	

DP 1.4 USB-C DP Alt Mode - Operation

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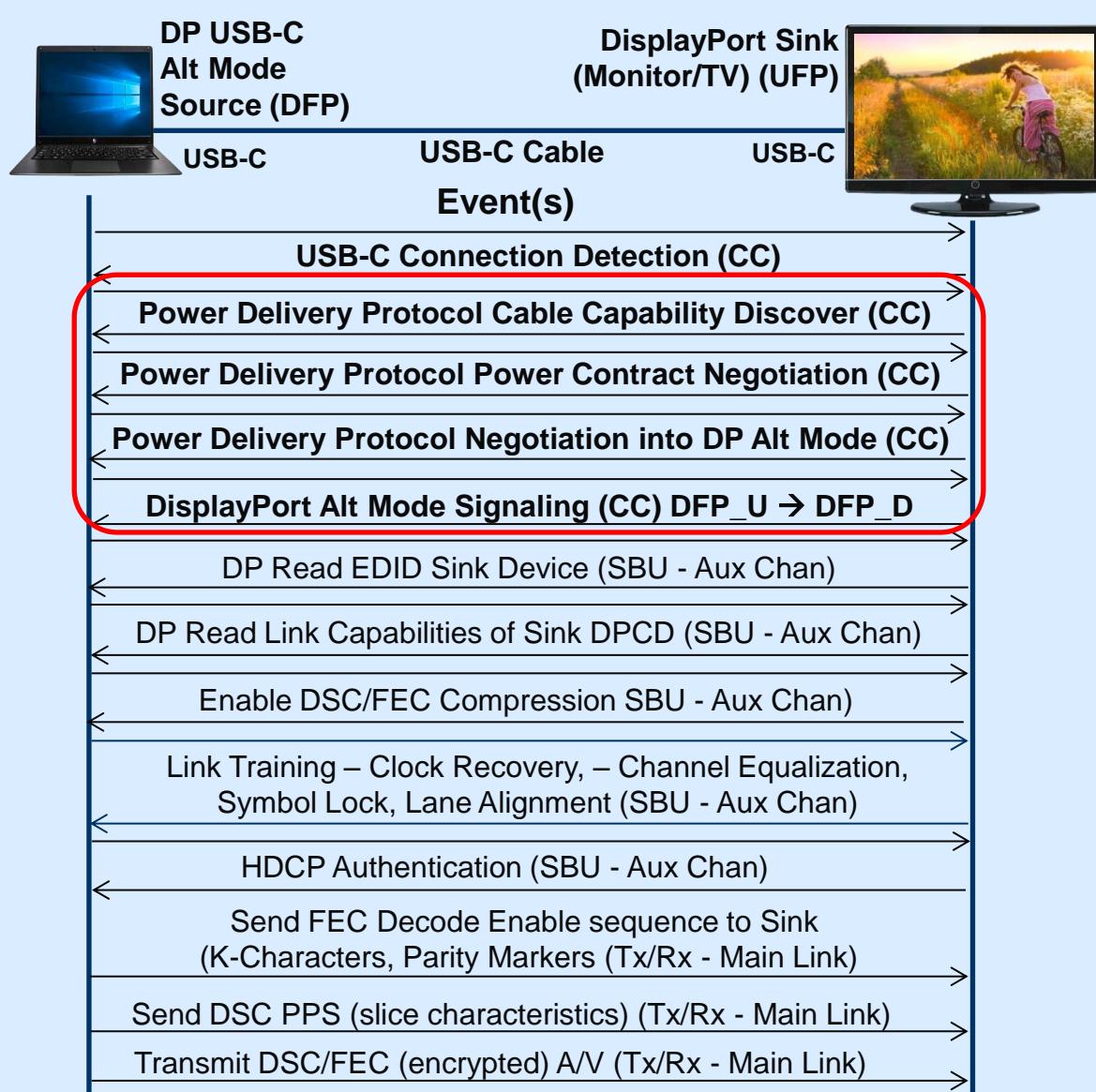
USB-C DP Alt Mode – Messages and Commands (Phy Layer)

- ◆ Phy Layer – Configuration Channel (CC):
 - ◆ Single-ended (not a differential pair) communication channel running at 300kHz.
 - ◆ Messages are superimposed on a DC bias from the connection detection voltage.
 - ◆ Line Coding
 - ◆ 4b/5b & Bi-Phase Mark Encoding.
 - ◆ Bi-Phase Mark aids in clock recovery.
 - ◆ 4b/5b is for disparity control.
 - ◆ Preamble
 - ◆ 64 bit alternating 0s and 1s (not 4b/5b encoding).
 - ◆ Used to achieve receiver lock (achieve sync.)

- ◆ Device addressing - Start of Packet (SOP)
 - ◆ K-character sequence to identify start of a packet.
 - ◆ SOP (for devices) – sync-1, sync-1, sync-1, sync-2.
 - ◆ SOP' (cable plugs – near end) – sync-1, sync-1, sync-3, sync-3.
 - ◆ SOP'' (cable plugs – far end) – sync-1, sync-3, sync-1, sync-3.
- ◆ Message Header and Message Data Bytes.
- ◆ CRC
 - ◆ 32 bit CRC to check for errors.
 - ◆ Messages require “GoodCRC” message to continue.
- ◆ End of Packet
 - ◆ Terminates a packet.
 - ◆ Single K-character.

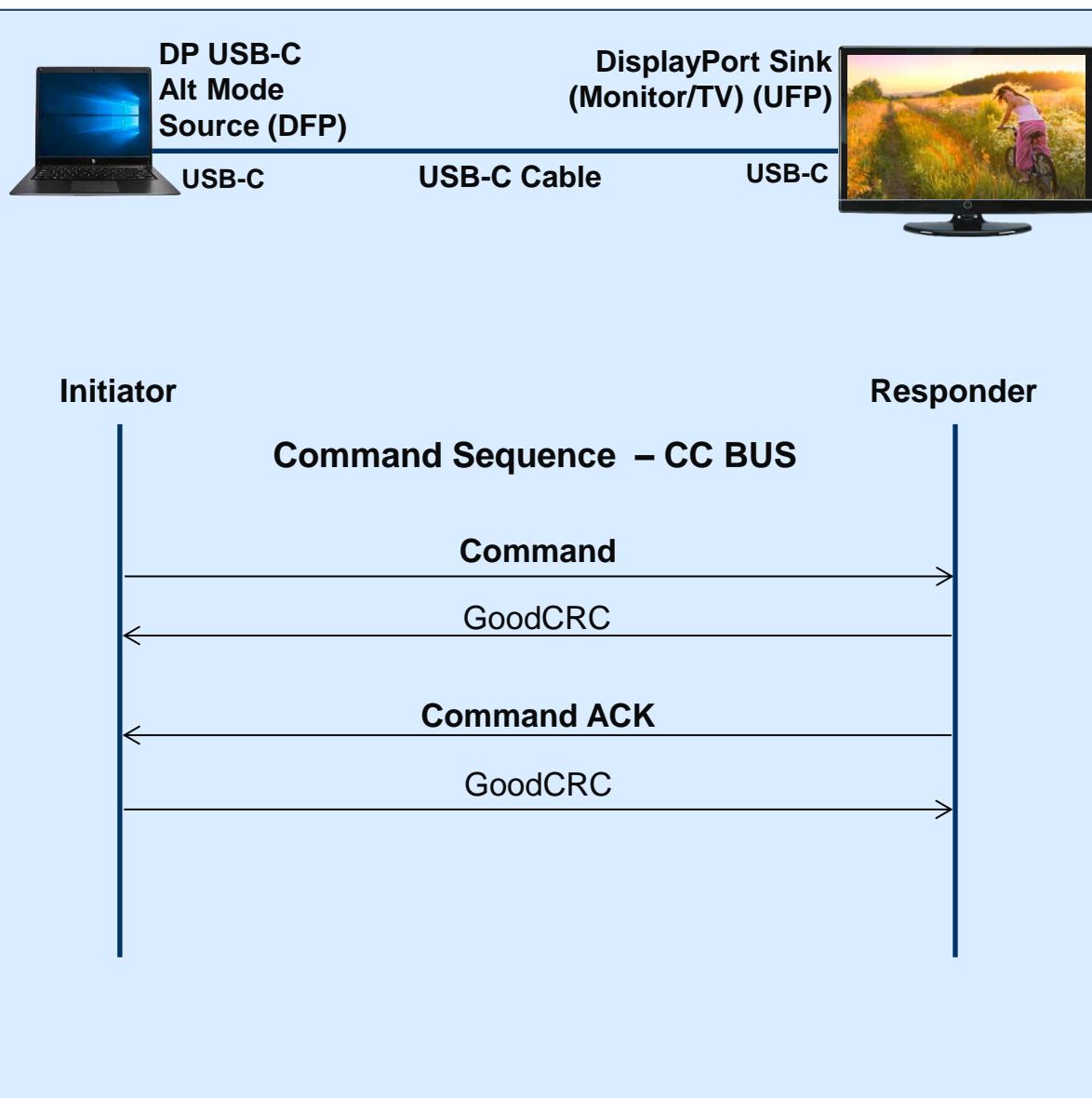


USB-C DP Alt Mode Connection Sequence USB-C to USB-C - Overview



- **Connection Detection.** Indication to the Source that there is a Display device connect to it.
- **USB-C Power Negotiation (CC).** Establishes power contract between DFP and UFP.
- **USB-C PD Negotiation into DP Alt Mode (CC).** Establishes DP Alt Mode and initiates DP signaling.
- **EDID read (Aux Chan).** EDID is a data structure provided by a DisplayPort display that describe its video and audio capabilities.
- **DPCD read (Aux Chan).** DPCD is a data structure provided by a DisplayPort device that describe its link capabilities and its DSC and FEC capabilities to a DisplayPort source.
- **Enable DSC/ FEC.** Source writes to sink DPCD to enable DSC Decompression and FEC Ready bit.
- **Link Training (Aux Chan):** 1) Clock Recovery, 2) Channel Equalization, Symbol Lock and Inter-Lane alignment. Establishes physical link parameters (number of lanes, link rate, voltage swing, pre-emphasis, equalization) used for transmission of video and audio over the Main Link.
- **HDCP Authentication (Aux Chan).** HDCP authentication for A/V content flagged for High-bandwidth Digital Content Protection.
- **FEC Enable (Main Link).** Transmit FEC Decode Enable sequence (K-Character sequence).
- **DSC/FEC AV Transmission.** Compressed, encrypted video transmission with FEC is initiated. Picture Parameter (PPS) metadata is transmitted, VB-ID compressed flag is set.

USB-C DP Alt Mode – Commands and Messages (Protocol Layer)



- ◆ Two Types of Messages:
 - ◆ **Control Messages** – Manage the Message Flow.
 - ◆ **Data Messages** – Exchange Information.
- ◆ Initiator – Typically the DFP (except Attention command which is like an interrupt).
- ◆ Responder – Typically the UFP or Cable Plug.
- ◆ Message ID – Each message has a sequence identifier. This is verified by the receiver of the message.
- ◆ Command Sequence.
 - ◆ Initiator Command
 - ◆ GoodCRC (timeout enforcement)
 - ◆ Responder Command ACK
 - ◆ GoodCRC (timeout enforcement)

Power Delivery DP Alt Mode Protocol – Control Messages

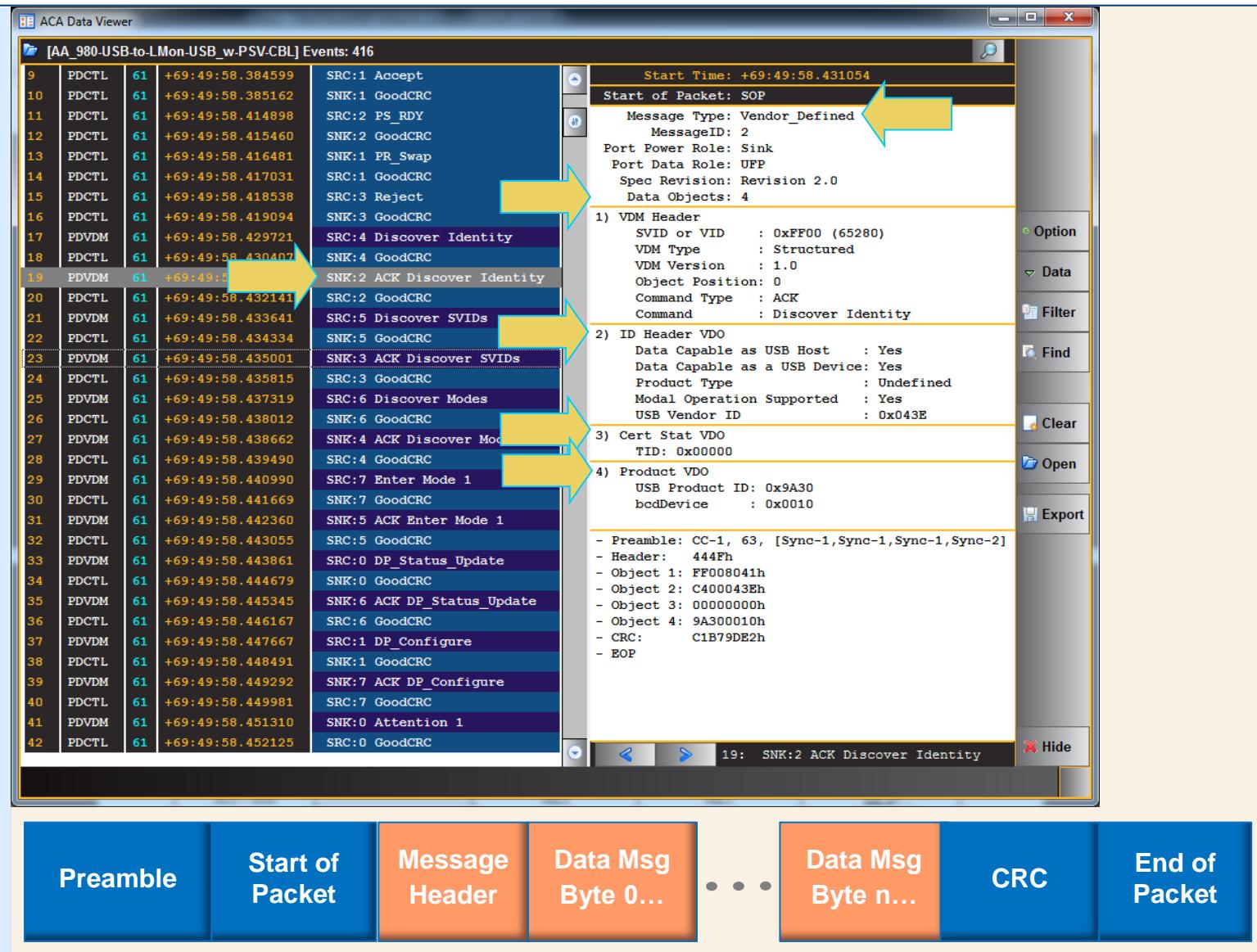
- ◆ Control Messages manage the message flow.
- ◆ Message Construction:
 - ◆ Phy Layer elements.
 - ◆ Message Header.
 - ◆ No Message Objects.
- ◆ Control Messages, Examples:
 - ◆ GoodCRC
 - ◆ Send by the receiver to acknowledge that the previous message's CRC check was good. Must occur between 0.9 and 1.1 msec.
 - ◆ Request
 - ◆ Message sent by the sink to request power.
 - ◆ Sent in response to a Source Capabilities message.
 - ◆ Part of the power contract, used with Accept.
 - ◆ Accept
 - ◆ Message sent by the source to inform the sink that it will deliver the requested power level.
 - ◆ PS_RDY
 - ◆ Sent by source during power contract to indicate it is ready to deliver the agreed upon power level.
 - ◆ Others...

The screenshot shows the ACA Data Viewer interface with two main panes. The left pane displays a list of events from a trace named 'IAA_980_USB_to_Doc_MST_PSV_CBL' with 533 events. The right pane provides detailed information for the selected event at index 10, which is 'SRC:3 Discover Identity'. The details pane includes fields for Start Time, Message Type, Port Power Role, Port Data Role, Spec Revision, and Data Objects. It also lists the VDM Header, Preamble, Header, Object 1, CRC, and EOP. Below the details pane, a legend defines the message components: Preamble (blue), Start of Packet (light blue), Message Header (orange), CRC (blue), and End of Packet (blue).

Preamble	Start of Packet	Message Header	CRC	End of Packet

Power Delivery DP Alt Mode Protocol – Data Messages (Vendor Defined)

- ◆ PD Data Message Construction:
 - ◆ Phy Layer elements.
 - ◆ Message Header.
 - ◆ Data Objects.
- ◆ DP Alt Mode – Vendor Defined Messages (VDMs).
 - ◆ Enables Vendor devices to communicate functions outside of the USB feature set, e.g. DP Alt Mode.
 - ◆ Vendor Defined Messages - Used for Power Delivery (PD) DP Alt Mode negotiations).
 - ◆ VDMs have Vendor Defined Objects (VDOs) - Can contain up to six (6) VDOs).
 - ◆ DFP is the bus master for the Vendor Defined Messages (VDMs).
- ◆ Example shows Discover Capabilities Message.

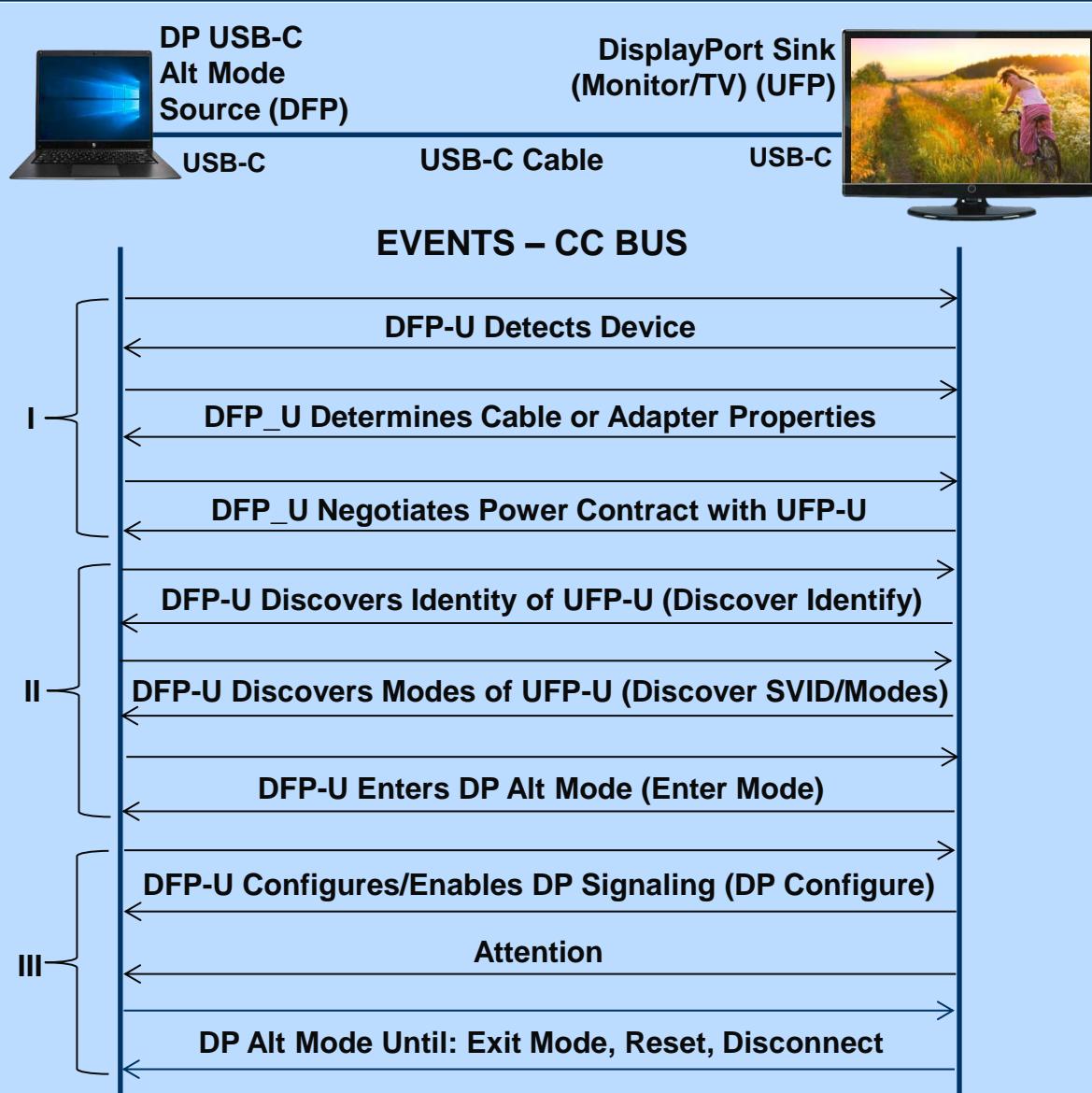


DP 1.4 USB-C DP Alt Mode Negotiation into DP Alt Mode

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USB-C DP Alt Mode Connection Sequence - PD Negotiation Into DP Alt Mode



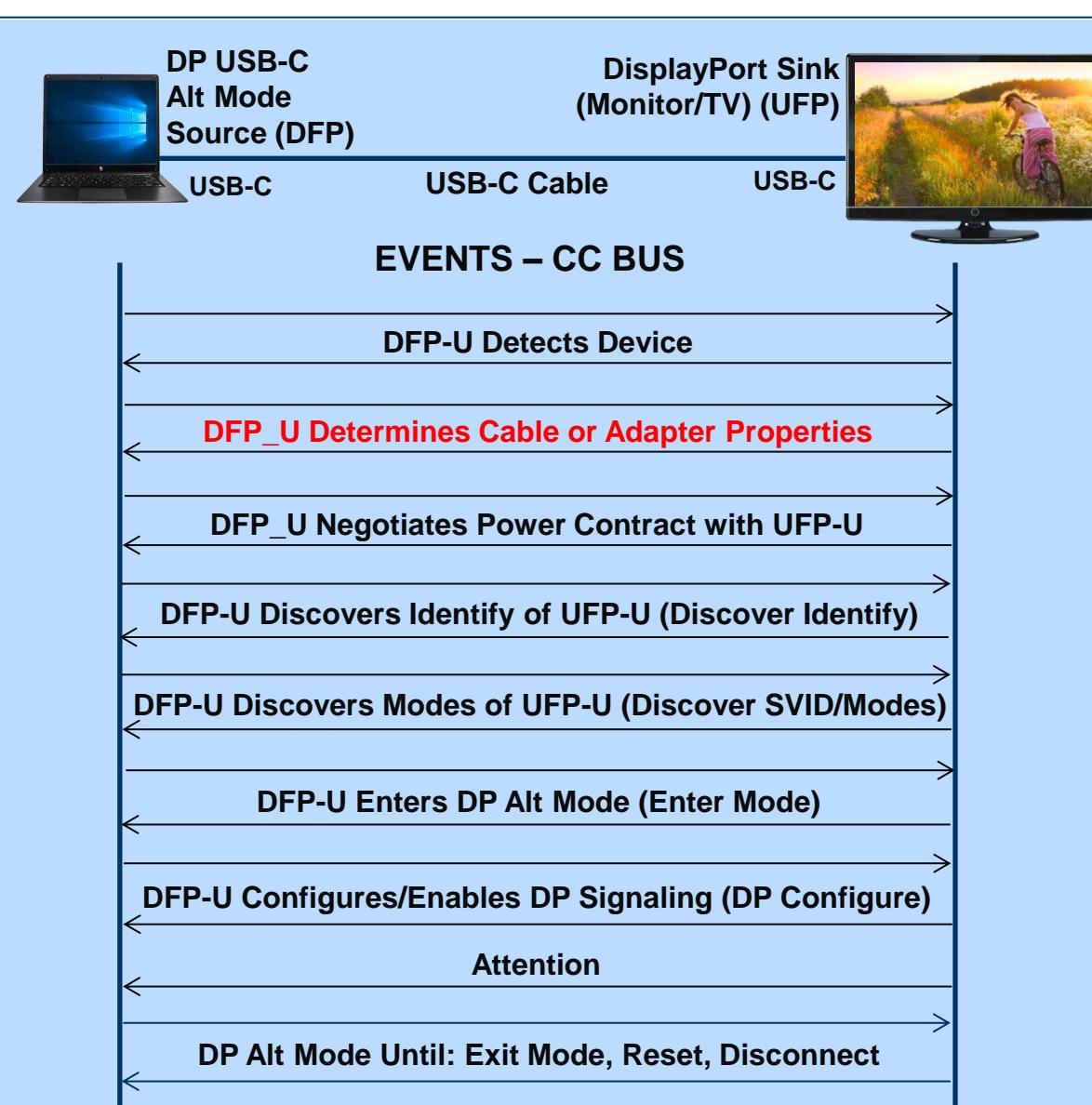
- Phase I – Connection Detection/Power Contract
 - Detect Connected Device** – DFP_U detects presence of device connected on CC pins.
 - Determine Cable or Adapter Properties** – DFP_U issues commands to acquire information about its soon to be Port Partner (UFP_U) and the Cable Plug.
 - Negotiate Power Contract** - DFP_U (Source) negotiates power contract with UFP_U.
- Phase II – Negotiate into DP Alt Mode (Uses VDMs)
 - Discover Identity** – DFP_U discovers the identity and capabilities of the UFP_U, its Port Partner.
 - Discover SVIDs** – DFP_U discovers the Vendor IDs of the connected device(s). Used with Discover modes to determine the modes that a Port Partner supports.
 - Discover Modes** – DFP discovers the Modes supported by the UFP. Used in conjunction with Discover SVIDs.
 - Enter into DP Alt Mode** – DFP and UFP enter into the Mode (example DP Alt Mode) determined by the DFP.
- Phase III – DisplayPort Alt Mode
 - Configure DisplayPort Signaling** - DFP and UFP are configured for DisplayPort signaling on their USB-C leads.
 - Attention** – Serves as an Interrupt mechanism for the UFP-D to notify the DFP_D that there has been a change in status.

Power Delivery DP Alt Mode Protocol – Data Messages (Discover Identity)

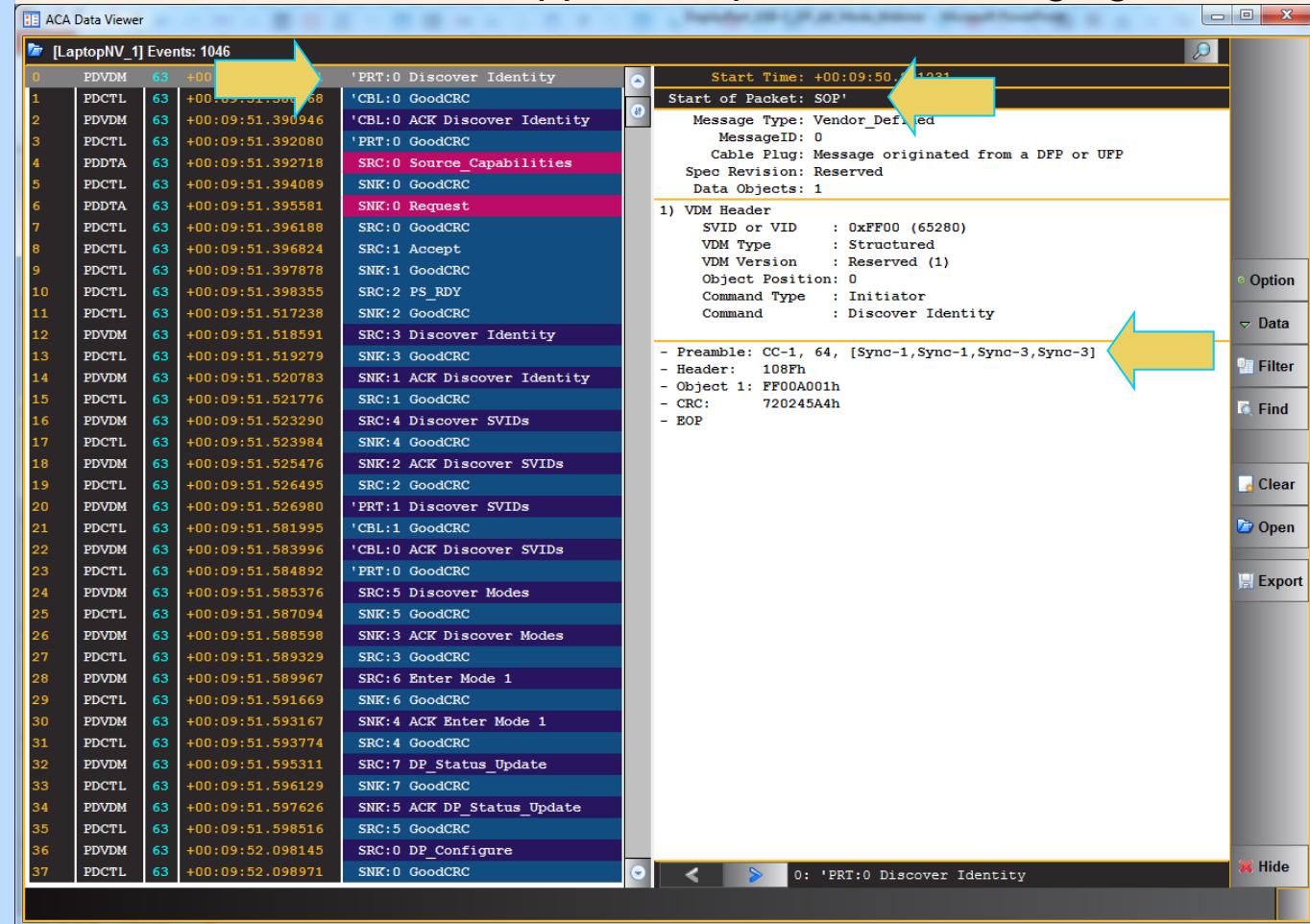


- ◆ Discover Identity – Cable Plug (SOP'):
 - ◆ Used by DFP (Initiator) to identify:
 - ◆ Cables that support PD protocol messaging are “Electronically Marked.”
 - ◆ A Cable Plug is an Electronic Marked cable even if it is a “passive cable.”
 - ◆ Example shows connection to an “Electronically Marked” USB-C to USB-C passive cable.

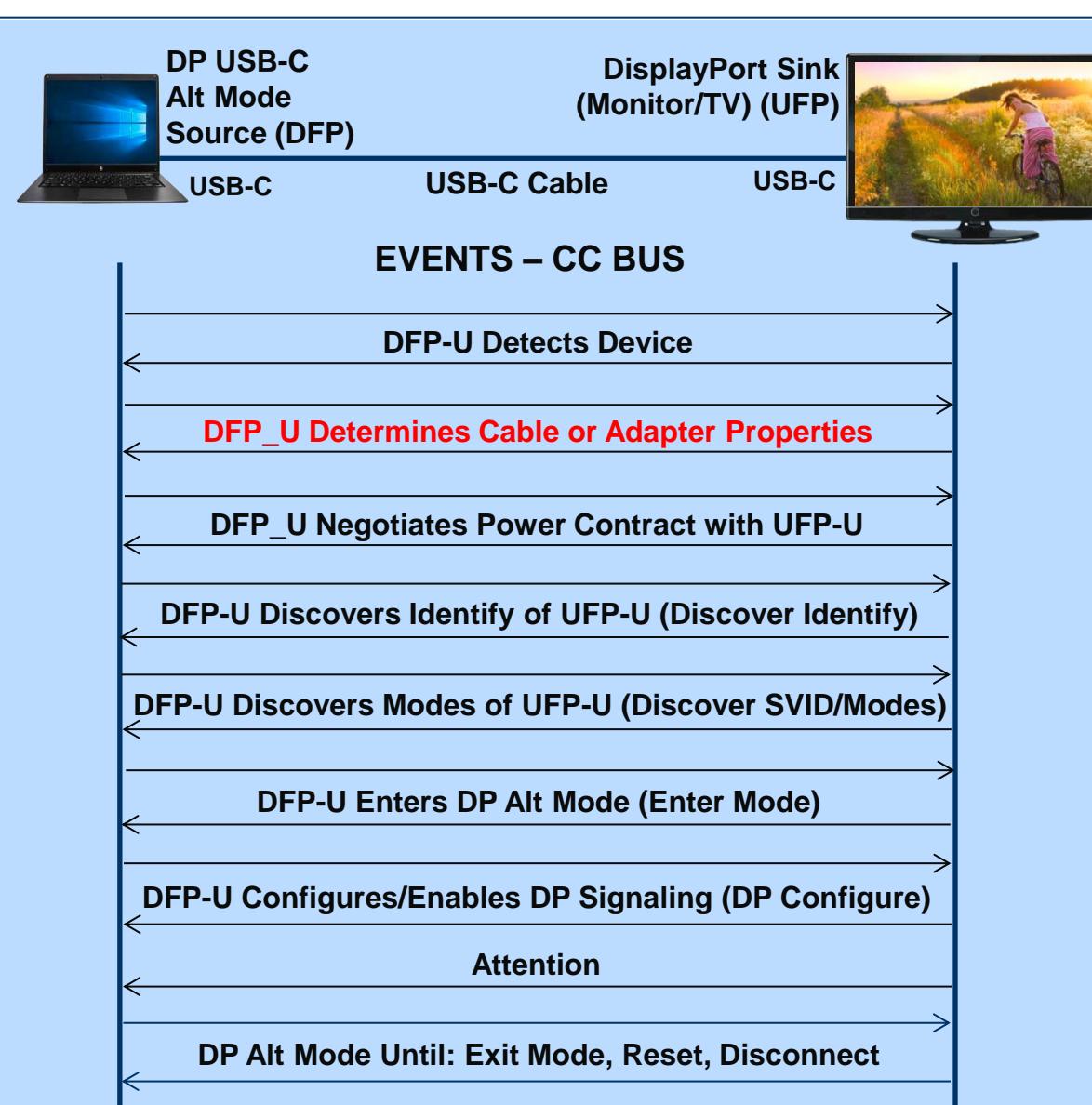
Power Delivery DP Alt Mode Protocol – Data Messages (Discover Identity)



- ◆ Discover Identity – Cable Plug (SOP'):
- ◆ Used by DFP (Initiator) to identify:
- ◆ Cables that support PD protocol messaging are



Power Delivery DP Alt Mode Protocol – Data Messages (Discover Identity)



- ◆ Discover Identity – Cable Plug (SOP'):
 - ◆ Used by DFP (Initiator) to identify:
 - ◆ Cables that support PD protocol messaging are “Electronically Marked”

The screenshot shows the ACA Data Viewer interface with the following details:

- File:** [LaptopNV_1] Events: 1046
- Start Time:** +00:00:00.000000
- Start of Packet:** SOP
- Message Type:** Vendor Defined
- MessageID:** 0
- Cable Plug:** Message originated from a Cable Plug
- Spec Revision:** Revision 2.0
- Data Objects:** 5

Message List: (Messages 0 to 37 shown)

Index	Type	Address	Time	Content
0	PDVDM	63	+00:09:50.881231	'PRT:0 Discover Identity
1	PDCTL	63	+00:09:51.392100	'CBL:0 GoodCRC
2	PDVDM	63	+00:09:51.392100	'CBL:0 ACK Discover Identity
3	PDCTL	63	+00:09:51.392100	'PRT:0 GoodCRC
4	PDDTA	63	+00:09:51.392718	SRC:0 Source_Capabilities
5	PDCTL	63	+00:09:51.394089	SNK:0 GoodCRC
6	PDDTA	63	+00:09:51.395581	SNK:0 Request
7	PDCTL	63	+00:09:51.396188	SRC:0 GoodCRC
8	PDCTL	63	+00:09:51.396824	SRC:1 Accept
9	PDCTL	63	+00:09:51.397878	SNK:1 GoodCRC
10	PDCTL	63	+00:09:51.398355	SRC:2 PS_RDY
11	PDCTL	63	+00:09:51.517238	SNK:2 GoodCRC
12	PDVDM	63	+00:09:51.518591	'SRC:3 Discover Identity
13	PDCTL	63	+00:09:51.519279	SNK:3 GoodCRC
14	PDVDM	63	+00:09:51.520783	SNK:1 ACK Discover Identity
15	PDCTL	63	+00:09:51.521776	SRC:1 GoodCRC
16	PDVDM	63	+00:09:51.523290	'SRC:4 Discover SVIDs
17	PDCTL	63	+00:09:51.523984	SNK:4 GoodCRC
18	PDVDM	63	+00:09:51.525476	SNK:2 ACK Discover SVIDs
19	PDCTL	63	+00:09:51.526495	SRC:2 GoodCRC
20	PDVDM	63	+00:09:51.526980	'PRT:1 Discover SVIDs
21	PDCTL	63	+00:09:51.526995	'CBL:1 GoodCRC
22	PDVDM	63	+00:09:51.583996	'CBL:0 ACK Discover SVIDs
23	PDCTL	63	+00:09:51.584892	'PRT:0 GoodCRC
24	PDVDM	63	+00:09:51.585376	SRC:3 Discover Modes
25	PDCTL	63	+00:09:51.587094	SNK:5 GoodCRC
26	PDVDM	63	+00:09:51.588598	SNK:3 ACK Discover Modes
27	PDCTL	63	+00:09:51.589329	SRC:3 GoodCRC
28	PDVDM	63	+00:09:51.589967	SRC:6 Enter Mode 1
29	PDCTL	63	+00:09:51.591669	SNK:6 GoodCRC
30	PDVDM	63	+00:09:51.593167	SNK:4 ACK Enter Mode 1
31	PDCTL	63	+00:09:51.593774	SRC:4 GoodCRC
32	PDVDM	63	+00:09:51.595311	SRC:7 DP_Status_Update
33	PDCTL	63	+00:09:51.596129	SNK:7 GoodCRC
34	PDVDM	63	+00:09:51.597626	SNK:5 ACK DP_Status_Update
35	PDCTL	63	+00:09:51.598516	SRC:5 GoodCRC
36	PDVDM	63	+00:09:52.098145	SRC:0 DP_Configure
37	PDCTL	63	+00:09:52.098971	SNK:0 GoodCRC

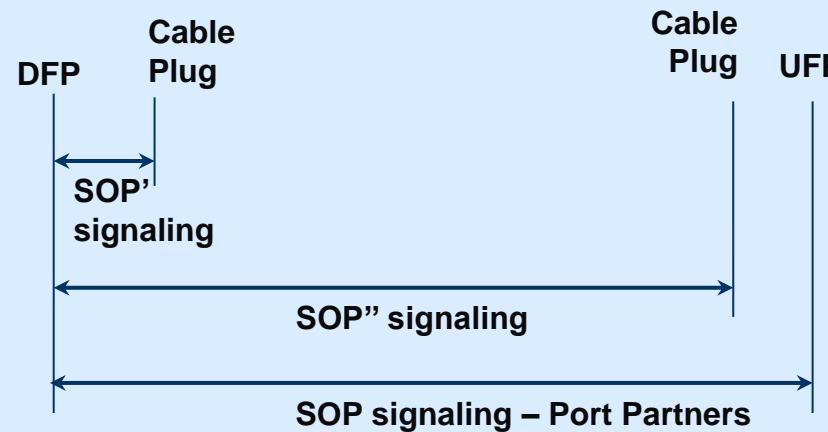
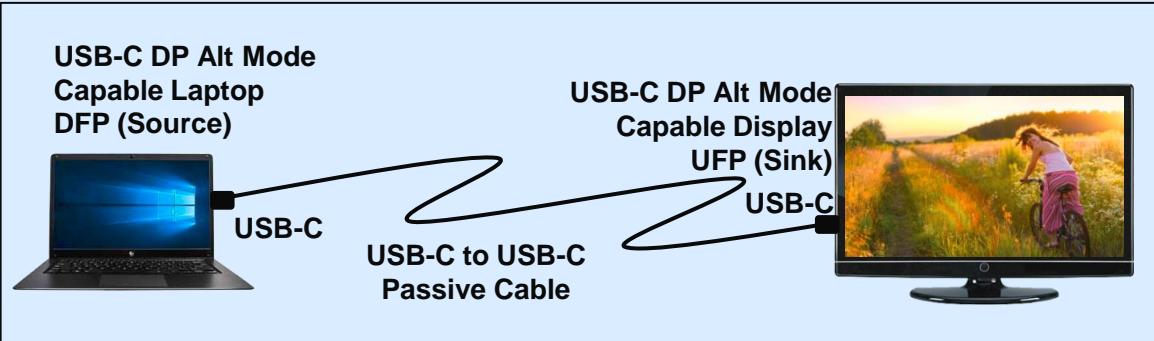
Details:

- HW Version : 1
- Firmware Version : 1
- Type-C plug to : Type-C
- Plug : Plug
- Cable Latency : 10ns to 20ns (~2m)
- Cable Termination : Both ends Passive, VCONN not required
- SSTX1 Dir Support : Fixed
- SSTX2 Dir Support : Fixed
- SSRX1 Dir Support : Fixed
- SSRX2 Dir Support : Fixed
- Vbus Current Cap : 3A
- Vbus through Cable: Yes
- SOP" controller : Not Present
- USB Superspeed : [USB 3.1] Gen1 and Gen2

- Preamble: CC-1, 63, [Sync-1, Sync-1, Sync-3, Sync-3]
 - Header: 514Fh
 - Object 1: FF008041h

2: 'CBL:0 ACK Discover Identity'

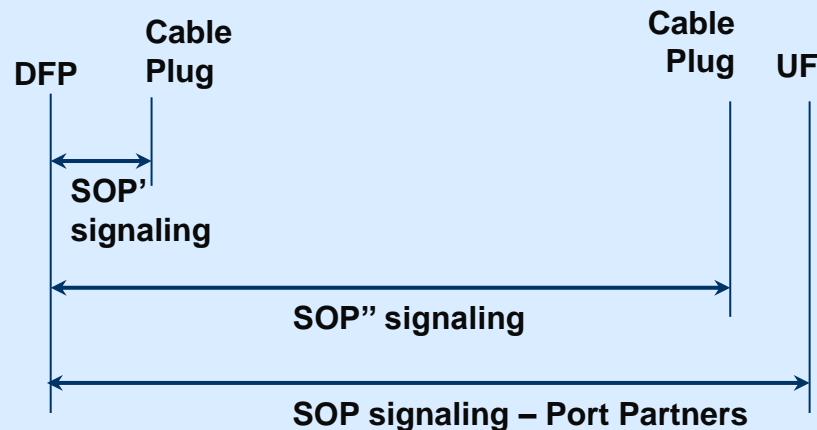
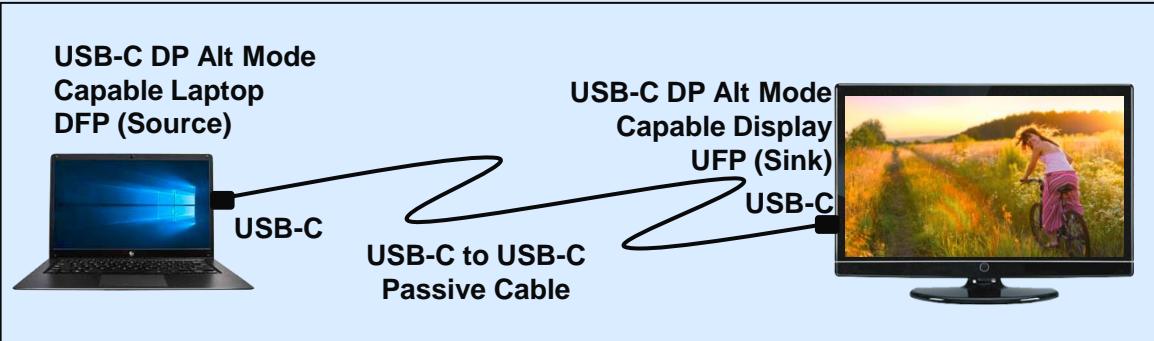
Power Delivery DP Alt Mode Protocol – Addressing SOP, SOP' & SOP”



- ◆ An SOP addressed message is intended for an UFP, i.e. the Port Partner (typically the sink).
- ◆ An SOP' addressed message is intended for the PD Controller in the Cable Plug associated with the DFP.
- ◆ An SOP” addressed message is intended for the PD Controller in the Cable Plug associated with the UFP.



Power Delivery DP Alt Mode Protocol – Addressing SOP, SOP' & SOP"



- ◆ An SOP addressed message is intended for an UFP, i.e. the Port Partner (typically the sink).
- ◆ An SOP' addressed message is intended for

ACA Data Viewer

[AA_980-USB-to-LMon-USB_w-PSV.CBL] Events: 416

Index	Event Type	Description
0	DPH	HPD Falling Edge
1	PDVDM	'PRT:0 Discover Identity
2	PDCTL	'CBL:0 GoodCRC
3	PDVDM	'CBL:0 ACK Discover Identity
4	PDCTL	'PRT:0 GoodCRC
5	PDDTA	'SRC:0 Source Capabilities
6	PDCTL	SNK:0 GoodCRC
7	PDDTA	'SNK:0 Request
8	PDCTL	SRC:0 GoodCRC
9	PDCTL	SRC:1 Accept
10	PDCTL	SNK:1 GoodCRC
11	PDCTL	SRC:2 PS_RDY
12	PDCTL	SNK:2 GoodCRC
13	PDCTL	SNK:1 PR_Swap
14	PDCTL	SRC:1 GoodCRC
15	PDCTL	SRC:3 Reject
16	PDCTL	SNK:3 GoodCRC
17	PDVDM	'SRC:4 Discover Identity
18	PDCTL	SNK:4 GoodCRC
19	PDVDM	SNK:2 ACK Discover Identity
20	PDCTL	SRC:2 GoodCRC
21	PDVDM	'SRC:5 Discover SVIDs
22	PDCTL	SNK:5 GoodCRC
23	PDVDM	SNK:3 ACK Discover SVIDs
24	PDCTL	SRC:3 GoodCRC
25	PDVDM	'SRC:6 Discover Modes
26	PDCTL	SNK:6 GoodCRC
27	PDVDM	SNK:4 ACK Discover Modes
28	PDCTL	SRC:4 GoodCRC
29	PDVDM	SNK:7 Enter Mode 1
30	PDCTL	SNK:7 GoodCRC
31	PDVDM	'SNK:5 ACK Enter Mode 1
32	PDCTL	SRC:5 GoodCRC
33	PDVDM	'SRC:0 DP_Status_Update
34	PDCTL	SNK:0 GoodCRC
35	PDVDM	SNK:6 ACK DP_Status_Update
36	PDCTL	SRC:6 GoodCRC
37	PDVDM	'SRC:1 DP_Configure

Start Time: +69:49:00.000000000

Start of Packet: SOP'

Message Type: Vendor_Signed

MessageID: 0

Cable Plug: Message originated from a DFP or UFP

Spec Revision: Revision 2.0

Data Objects: 1

1) VDM Header

- SVID or VID : 0xFF00 (65280)
- VDM Type : Structured
- VDM Version : Reserved (1)
- Object Position: 0
- Command Type : Initiator
- Command : Discover Identity

- Preamble: CC-1, 64, [Sync-1,Sync-1,Sync-3,Sync-3]

- Header: 104Fh

- Object 1: FF008001h

- CRC: 5BA71DF0h

- EOP

Clear

Option

Data

Filter

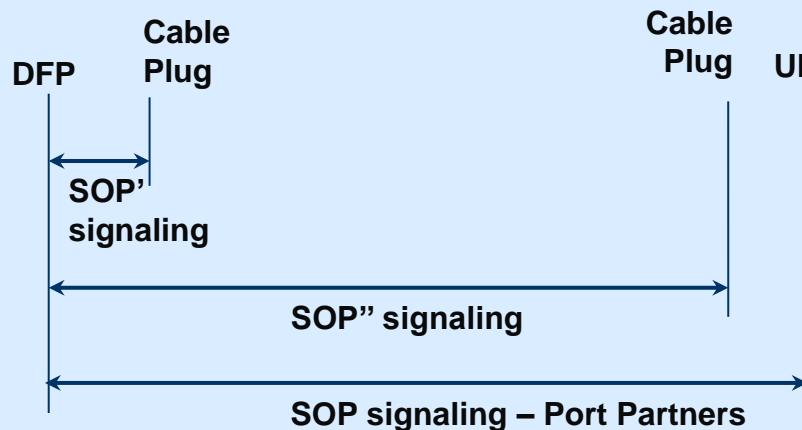
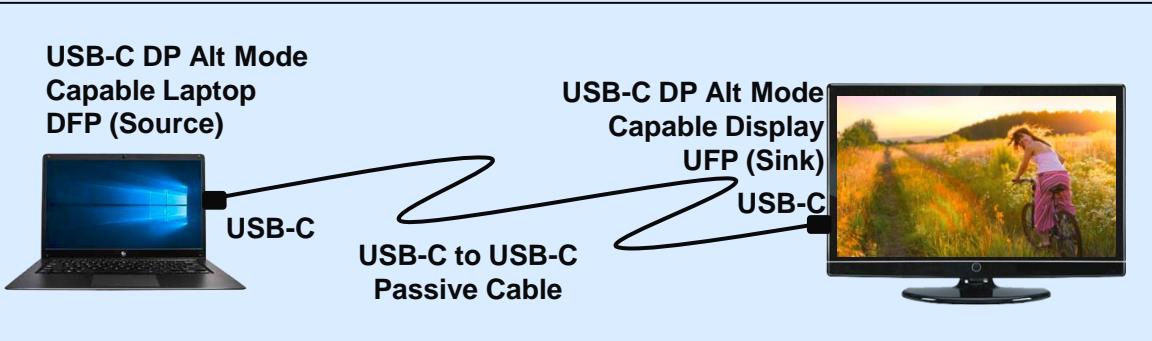
Find

Open

Export

Hide

Power Delivery DP Alt Mode Protocol – Addressing SOP, SOP' & SOP”



- ◆ An SOP addressed message is intended for an UFP, i.e. the Port Partner (typically the sink).
 - ◆ An SOP' addressed message is intended for the PD Controller in the Cable Plug associated with the DFP.

The screenshot shows the ACAP Data Viewer interface with a list of events on the left and a detailed analysis on the right.

Events List:

Index	Event Type	Value
0	DPHM	61 HPD Falling Edge
1	PDVDM	61 'PRT:0 Discover Identity
2	PDCTL	61 'CBL:0 GoodCRC
3	PDVDM	61 'CBL:0 ACK Discover Identity
4	PDCTL	61 'PRT:0 GoodCRC
5	PDDTA	61 SRC:0 Source_Capabilities
6	PDCTL	61 SNK:0 GoodCRC
7	PDDTA	61 SNK:0 Request
8	PDCTL	61 SRC:0 GoodCRC
9	PDCTL	61 SRC:1 Accept
10	PDCTL	61 SNK:1 GoodCRC
11	PDCTL	61 SRC:2 PS_RDY
12	PDCTL	61 SNK:2 GoodCRC
13	PDCTL	61 SNK:1 PR_Swap
14	PDCTL	61 SRC:1 GoodCRC
15	PDCTL	61 SRC:3 Reject
16	PDCTL	61 SNK:3 GoodCRC
17	PDVDM	61 SRC:4 Discover Identity
18	PDCTL	61 SNK:4 GoodCRC
19	PDVDM	61 SNK:2 ACK Discover Identity
20	PDCTL	61 SRC:2 GoodCRC
21	PDVDM	61 SRC:5 Discover SVIDs
22	PDCTL	61 SNK:5 GoodCRC
23	PDVDM	61 SNK:3 ACK Discover SVIDs
24	PDCTL	61 SRC:3 GoodCRC
25	PDVDM	61 SRC:6 Discover Modes
26	PDCTL	61 SNK:6 GoodCRC
27	PDVDM	61 SNK:4 ACK Discover Modes
28	PDCTL	61 SRC:4 GoodCRC
29	PDVDM	61 SRC:7 Enter Mode 1
30	PDCTL	61 SNK:7 GoodCRC
31	PDVDM	61 SNK:5 ACK Enter Mode 1
32	PDCTL	61 SRC:5 GoodCRC
33	PDVDM	61 SRC:0 DP_Status_Update
34	PDCTL	61 SNK:0 GoodCRC
35	PDVDM	61 SNK:6 ACK DP_Status_Update
36	PDCTL	61 SRC:6 GoodCRC
37	PDVDM	61 SRC:1 DP_Configure

Detailed Analysis (Event 61):

Start Time: +69:49
Start of Packet: SOP

Message Type: Vendor Defined
MessageID: 0
Cable Plug: Message originated from a Cable Plug
Spec Revision: Revision 2.0
Data Objects: 5

1) VDM Header

SVID or VID	: 0xFF00 (65280)
VDM Type	: Structured
VDM Version	: 1.0
Object Position	: 0
Command Type	: ACK
Command	: Discover Identity

2) ID Header VDO

Data Capable as USB Host	: No
Data Capable as a USB Device	: No
Product Type	: Passive Cable
Modal Operation Supported	: Yes
USB Vendor ID	: 0x050D

3) Cert Stat VDO

TID	: 0x00448
-----	-----------

4) Product VDO

USB Product ID	: 0x030A
bcdDevice	: 0x0000

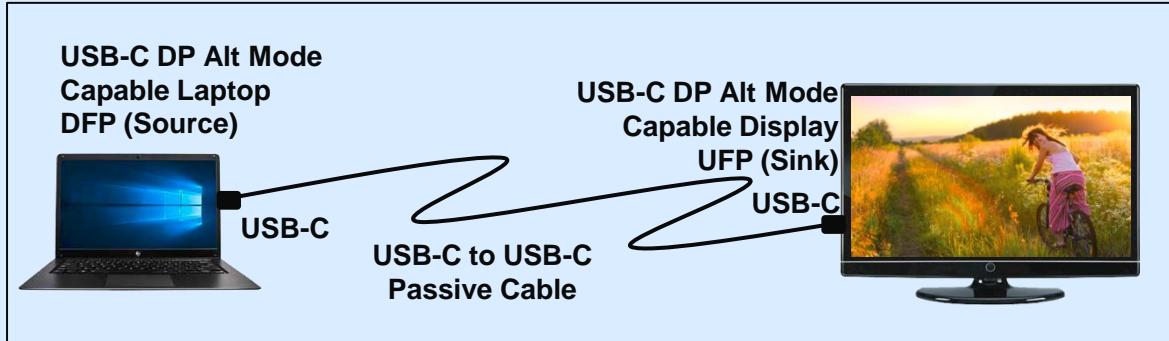
5) Cable VDO

HW Version	: 1
Firmware Version	: 1
Type-C plug to	: Type-C
	: Plug
Cable Latency	: 10ns to 20ns (~2m)
Cable Termination	: Both ends Passive, VCONN not required
SSTX1 Dir Support	: Fixed
SSTX2 Dir Support	: Fixed
SSRX1 Dir Support	: Fixed
SSRX2 Dir Support	: Fixed
Vbus Current Cap	: 3A
Vbus through Cable	: Yes
SOP" controller	: Not Present
USB Superspeed	: [USB 3.1] Gen1 and Gen2

- Preamble: CC-1, 64, [Sync-1, Sync-1, Sync-3, Sync-3]
- Header: 514Fh
- Object 1: FF008041h

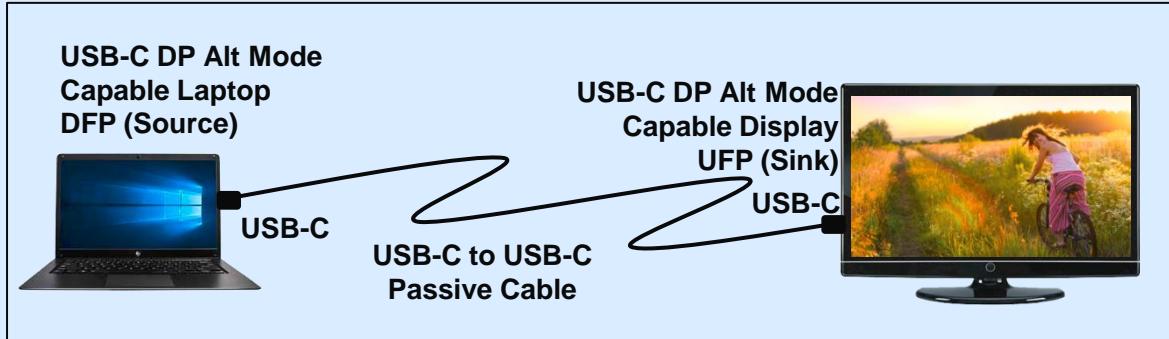
3: 'CBL:0 ACK Discover Identity

Power Delivery DP Alt Mode Protocol – Billboard Notification



- ◆ UFP must present a “Billboard” notification to the DFP in the event that the UFP does not receive an Enter Mode request after a specified timeout period (1000 msec).
- ◆ Notification reports that an unsupported device has been connected.

Power Delivery DP Alt Mode Protocol – Billboard Notification

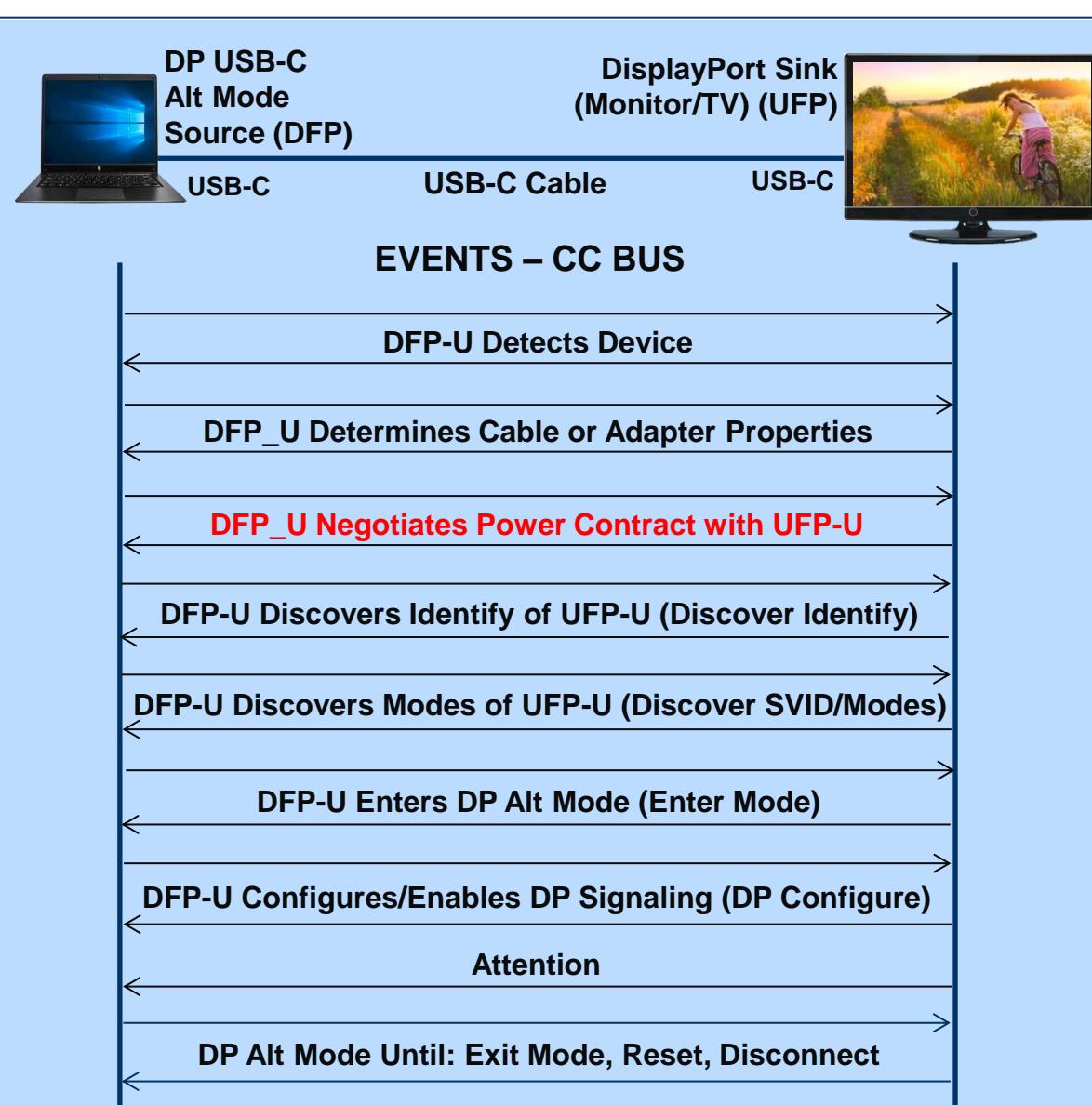


- ◆ UFP must present a “Billboard” notification to the DFP in the event that the UFP does not receive an Enter Mode request after a specified timeout period (1000 msec).

ACA Data Viewer					
[AA_980-USB-to-LMon-USB_w-PSV-CBL] Events: 416					
0	DPHP	61	-00:00:01.334657	HPD Falling Edge	
1	PDVDM	61	+00:00:00.000000	'PRT:0 Discover Identity	Start Time: +00:00:00.000000
2	PDCTL	61	+00:00:00.000756	'CBL:0 GoodCRC	Start of Packet: SOP
3	PDVDM	61	+00:00:00.002890	'CBL:0 ACK Discover Identity	Message Type: Vendor_Defined
4	PDCTL	61	+00:00:00.004105	'PRT:0 GoodCRC	MessageID: 0
5	PDDTA	61	+00:00:00.005362	SRC:0 Source_Capabilities	Cable Plug: Message originated from a DFP or UFP
6	PDCTL	61	+00:00:00.006055	SNK:0 GoodCRC	Spec Revision: Revision 2.0
7	PDDTA	61	+00:00:00.006804	SNK:0 Request	Data Objects: 1
8	PDCTL	61	+00:00:00.007505	SRC:0 GoodCRC	1) VDM Header
9	PDCTL	61	+00:00:00.008992	SRC:1 Accept	SVID or VID : 0xFF00 (65280)
10	PDCTL	61	+00:00:00.009555	SRC:1 GoodCRC	VDM Type : Structured
11	PDCTL	61	+00:00:00.039291	SRC:2 PS_RDY	VDM Version : 1.0
12	PDCTL	61	+00:00:00.039853	SNK:2 GoodCRC	Object Position: 0
13	PDCTL	61	+00:00:00.040874	SNK:2 PR_Swap	Command Type : Initiator
14	PDCTL	61	+00:00:00.041424	SRC:1 GoodCRC	Command : Discover Identity
15	PDCTL	61	+00:00:00.042931	SRC:3 Reject	
16	PDCTL	61	+00:00:00.043487	SNK:3 GoodCRC	
17	PDVDM	61	+00:00:00.054114	SRC:4 Discover Identity	
18	PDCTL	61	+00:00:00.054800	SNK:4 GoodCRC	
19	PDVDM	61	+00:00:00.055447	'SNK:2 ACK Discover Identity	
20	PDCTL	61	+00:00:00.056534	SRC:2 GoodCRC	
21	PDVDM	61	+00:00:00.058034	SRC:5 Discover SVIDs	
22	PDCTL	61	+00:00:00.058727	SNK:5 GoodCRC	
23	PDVDM	61	+00:00:00.059394	SNK:3 ACK Discover SVIDs	
24	PDCTL	61	+00:00:00.060208	SRC:3 GoodCRC	
25	PDVDM	61	+00:00:00.061712	SRC:6 Discover Modes	
26	PDCTL	61	+00:00:00.062405	SNK:6 GoodCRC	
27	PDVDM	61	+00:00:00.063055	SNK:4 ACK Discover Modes	
28	PDCTL	61	+00:00:00.063883	SRC:4 GoodCRC	
29	PDVDM	61	+00:00:00.065383	SRC:7 Enter Mode 1	
30	PDCTL	61	+00:00:00.066062	SNK:7 GoodCRC	
31	PDVDM	61	+00:00:00.066753	SNK:5 ACK Enter Mode 1	
32	PDCTL	61	+00:00:00.067448	SRC:5 GoodCRC	
33	PDVDM	61	+00:00:00.068254	SRC:0 DP_Status_Update	
34	PDCTL	61	+00:00:00.069072	SNK:0 GoodCRC	
35	PDVDM	61	+00:00:00.069738	SNK:6 ACK DP_Status_Update	
36	PDCTL	61	+00:00:00.070560	SRC:6 GoodCRC	
37	PDVDM	61	+00:00:00.072060	SRC:1 DP_Configure	

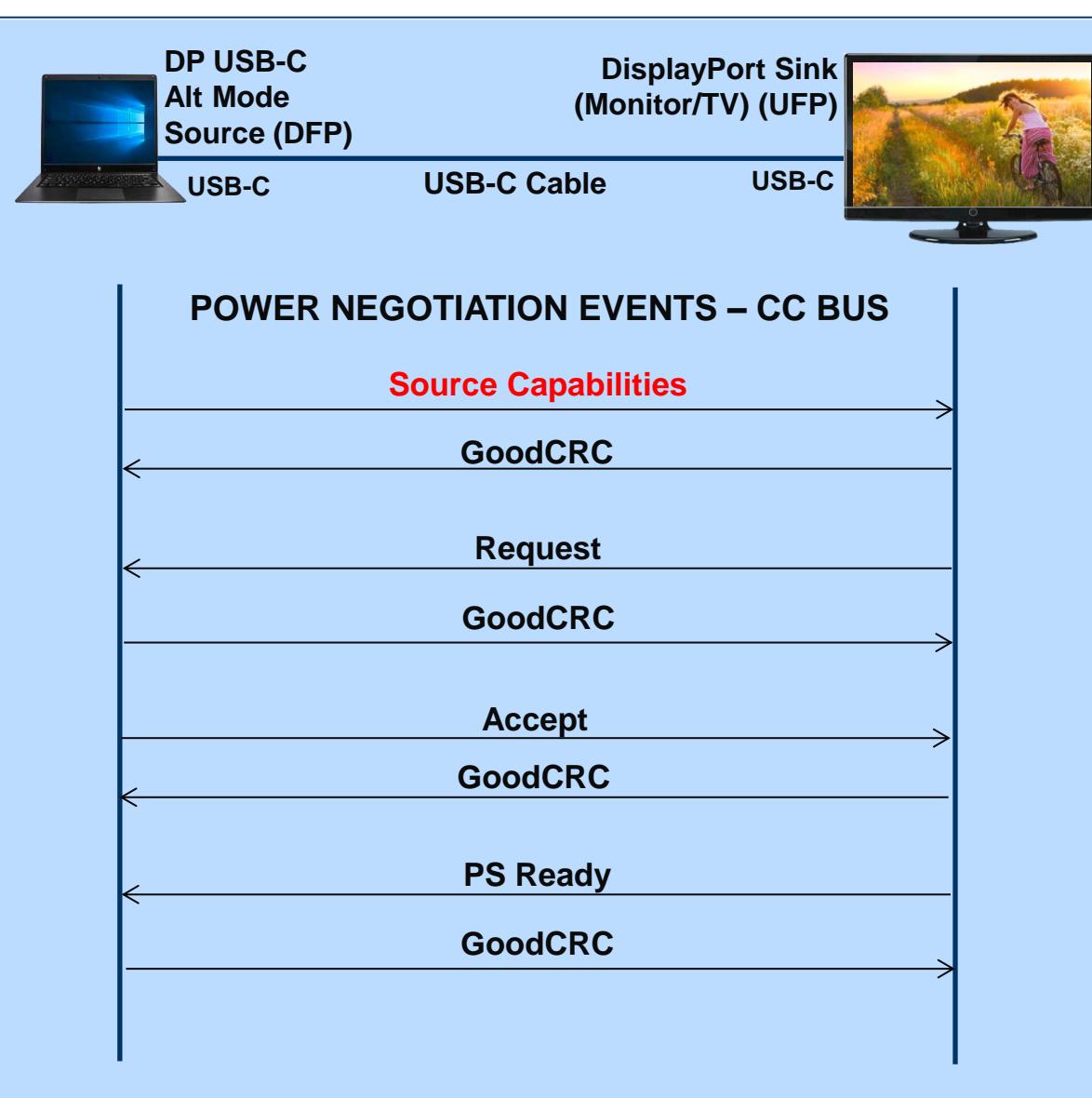
USB-C Power Delivery Protocol Power Contract Negotiation

Power Delivery DP Alt Mode Protocol – Data Messages (Power Negotiation)



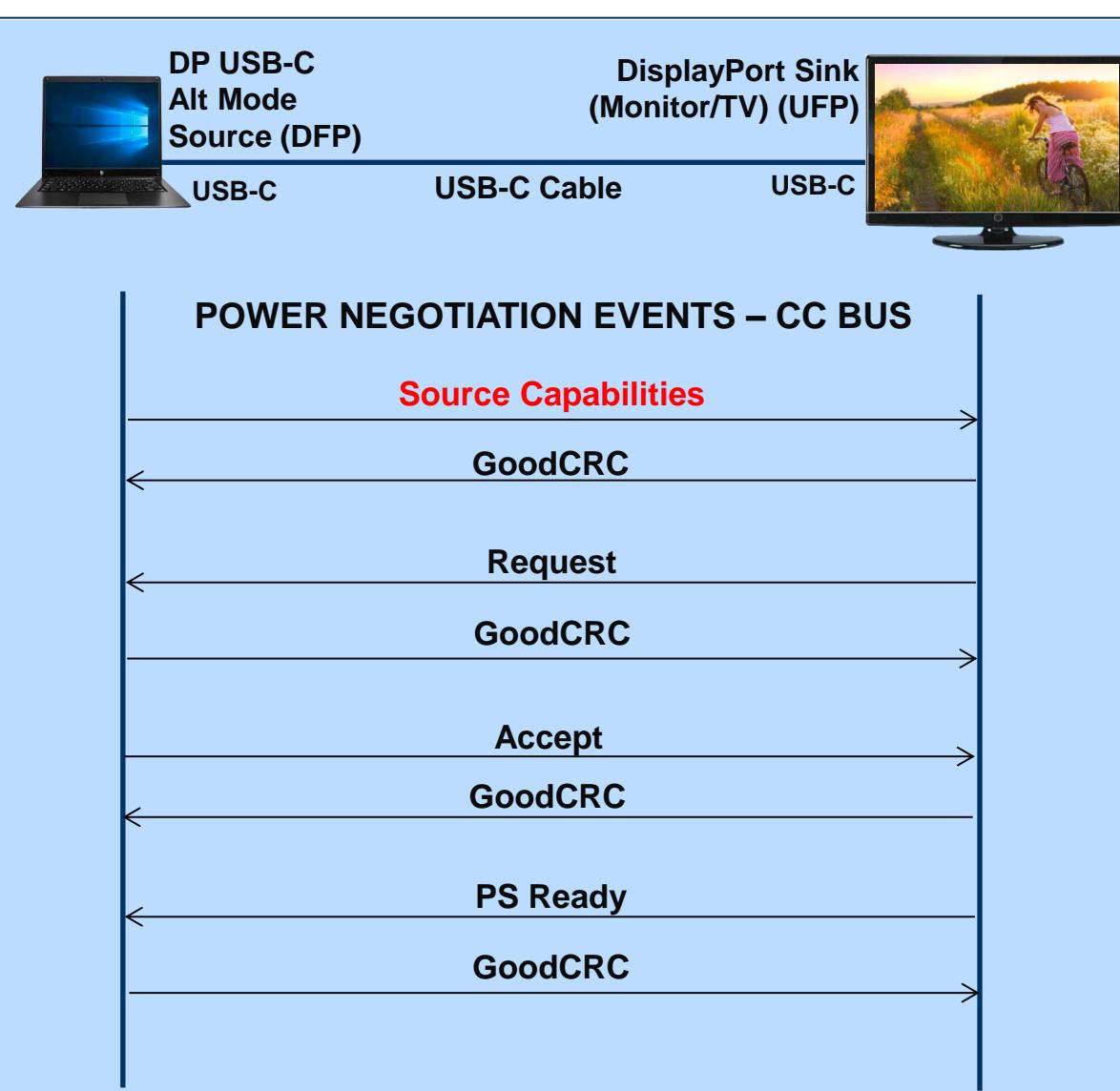
- ◆ PD Data Messages – Power Negotiation:
 - ◆ Source Capabilities
 - ◆ DFP (Source) advertises its port capabilities to connected UFP (Sink).
 - ◆ Request
 - ◆ UFP (Sink) requests power.
 - ◆ Accept
 - ◆ DFP (Source) Accepts request for power.
 - ◆ PS-RDY
 - ◆ DFP (Source) indicates that it is ready to supply power.

Power Delivery DP Alt Mode Protocol – Power Negotiation (Source Capabilities)



- ◆ PD Data Messages – Power Negotiation:
 - ◆ Source Capabilities (e.g. Multiple Fixed Supply profiles).

Power Delivery DP Alt Mode Protocol – Power Negotiation (Source Capabilities)



◆ PD Data Messages – Power Negotiation:

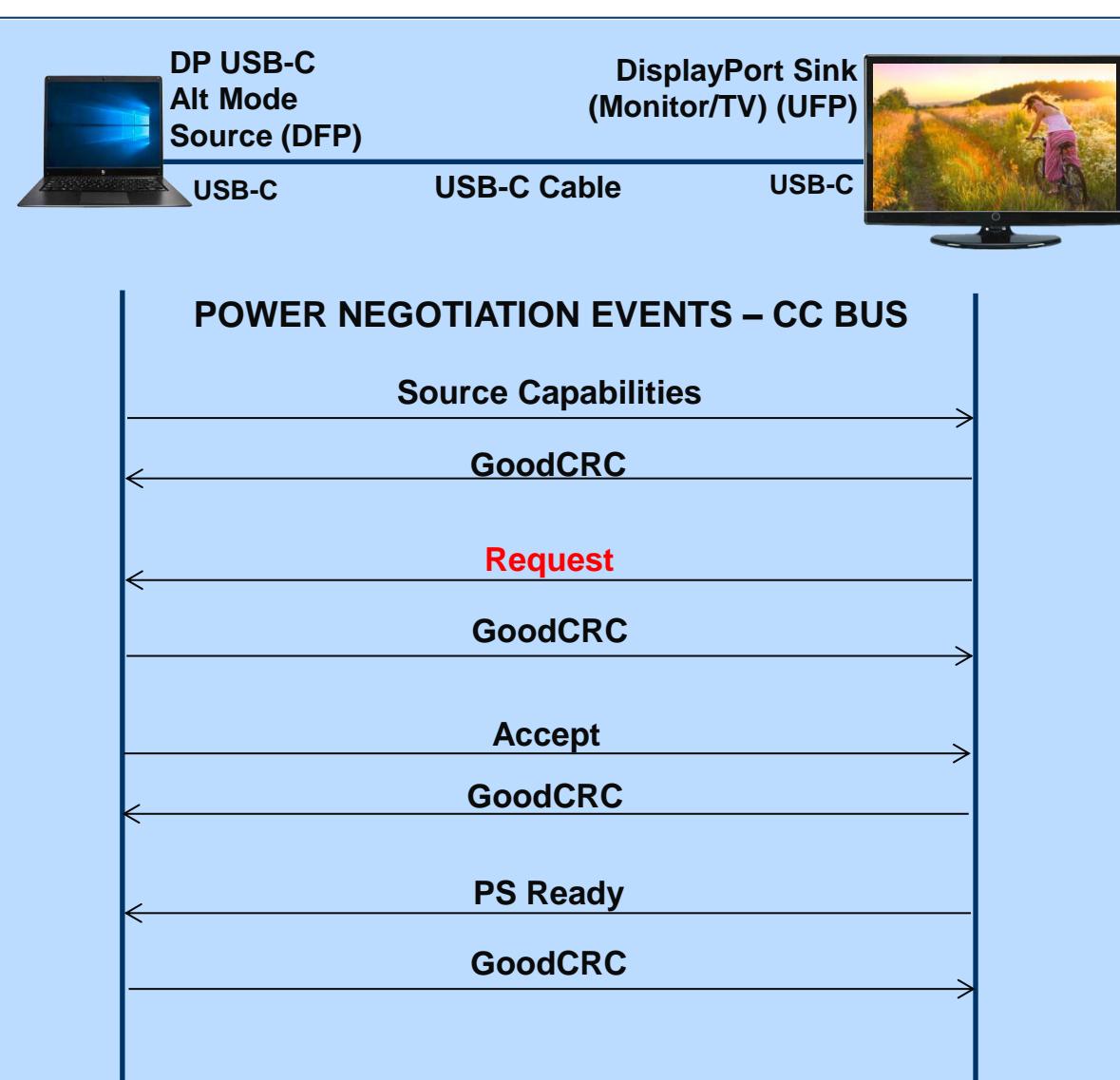
ACA Data Viewer					
[AA_LaptopNV_USB_to_980_USB] Events: 1046					
0	PDVDM	63	+00:09:50.881231	'PRT:0 Discover Identity	
1	PDCTL	63	+00:09:51.388668	'CBL:0 GoodCRC	
2	PDVDM	63	+00:09:51.390946	'CBL:0 ACK Discover Identity	
3	PDCTL	63	+00:09:51.392080	'PRT:0 GoodCRC	
4	PDDTA	63	+00:09:51.394005	'SRC:0 Source_Capabilities	
5	PDCTL	63	+00:09:51.394005	SNK:0 GoodCRC	
6	PDDTA	63	+00:09:51.395581	SNK:0 Request	
7	PDCTL	63	+00:09:51.396188	SRC:0 GoodCRC	
8	PDCTL	63	+00:09:51.396824	SRC:1 Accept	
9	PDCTL	63	+00:09:51.397878	SNK:1 GoodCRC	
10	PDCTL	63	+00:09:51.398355	SRC:2 PS_RDY	
11	PDCTL	63	+00:09:51.517238	SNK:2 GoodCRC	
12	PDVDM	63	+00:09:51.518591	'SRC:3 Discover Identity	
13	PDCTL	63	+00:09:51.519279	SNK:3 GoodCRC	
14	PDVDM	63	+00:09:51.520783	SNK:1 ACK Discover Identity	
15	PDCTL	63	+00:09:51.521776	SRC:1 GoodCRC	
16	PDVDM	63	+00:09:51.523290	'SRC:4 Discover SVIDs	
17	PDCTL	63	+00:09:51.523984	SNK:4 GoodCRC	
18	PDVDM	63	+00:09:51.525476	SNK:2 ACK Discover SVIDs	
19	PDCTL	63	+00:09:51.526495	SRC:2 GoodCRC	
20	PDVDM	63	+00:09:51.526980	'PRT:1 Discover SVIDs	
21	PDCTL	63	+00:09:51.581995	'CBL:1 GoodCRC	
22	PDVDM	63	+00:09:51.583996	'CBL:0 ACK Discover SVIDs	
23	PDCTL	63	+00:09:51.584892	'PRT:0 GoodCRC	
24	PDVDM	63	+00:09:51.585376	'SRC:5 Discover Modes	
25	PDCTL	63	+00:09:51.587094	SNK:5 GoodCRC	
26	PDVDM	63	+00:09:51.588598	SNK:3 ACK Discover Modes	
27	PDCTL	63	+00:09:51.589329	SRC:3 GoodCRC	
28	PDVDM	63	+00:09:51.589967	SRC:6 Enter Mode 1	
29	PDCTL	63	+00:09:51.591669	SNK:6 GoodCRC	
30	PDVDM	63	+00:09:51.593167	SNK:4 ACK Enter Mode 1	
31	PDCTL	63	+00:09:51.593774	SRC:4 GoodCRC	
32	PDVDM	63	+00:09:51.595311	'SRC:7 DP_Status_Update	
33	PDCTL	63	+00:09:51.596129	SNK:7 GoodCRC	
34	PDVDM	63	+00:09:51.597626	SNK:5 ACK DP_Status_Update	
35	PDCTL	63	+00:09:51.598516	SRC:5 GoodCRC	
36	PDVDM	63	+00:09:52.098145	'SRC:0 DP_Configure	
37	PDCTL	63	+00:09:52.098971	SNK:0 GoodCRC	
38	PDVDM	63	+00:09:52.100463	SNK:6 ACK DP_Configure	
39	PDCTL	63	+00:09:52.101071	SRC:6 GoodCRC	

Power Delivery DP Alt Mode Protocol – Power Negotiation (Request)



- ◆ PD Data Messages – Power Negotiation:
 - ◆ Source Capabilities.
 - ◆ Request.
 - ◆ UFP (Sink) requests power.
 - ◆ Accept
 - ◆ DFP (Source) Accepts request for power.
 - ◆ PS-RDY
 - ◆ DFP (Source) indicates that it is ready to supply power.

Power Delivery DP Alt Mode Protocol – Power Negotiation (Request)



◆ PD Data Messages – Power Negotiation:

ACA Data Viewer

[AA_LaptopNV_USB_to_980_USB] Events: 1046

Index	Type	Time	Message
0	PDVDM	+00:09:50.881231	'PRT:0 Discover Identity
1	PDCTL	+00:09:51.388668	'CBL:0 GoodCRC
2	PDVDM	+00:09:51.390946	'CBL:0 ACK Discover Identity
3	PDCTL	+00:09:51.392080	'PRT:0 GoodCRC
4	PDDTA	+00:09:51.392718	SRC:0 Source_Capabilities
5	PDCTL	+00:09:51.394089	SNK:0 GoodCRC
6	PDDTA	+00:09:51.394089	SNK:0 Request
7	PDCTL	+00:09:51.396188	SRC:0 GoodCRC
8	PDCTL	+00:09:51.396824	SRC:1 Accept
9	PDCTL	+00:09:51.397878	SNK:1 GoodCRC
10	PDCTL	+00:09:51.398355	SRC:2 PS_RDY
11	PDCTL	+00:09:51.517238	SNK:2 GoodCRC
12	PDVDM	+00:09:51.518591	SRC:3 Discover Identity
13	PDCTL	+00:09:51.519279	SNK:3 GoodCRC
14	PDVDM	+00:09:51.520783	SNK:1 ACK Discover Identity
15	PDCTL	+00:09:51.521776	SRC:1 GoodCRC
16	PDVDM	+00:09:51.523290	SRC:4 Discover SVIDs
17	PDCTL	+00:09:51.523984	SNK:4 GoodCRC
18	PDVDM	+00:09:51.525476	SNK:2 ACK Discover SVIDs
19	PDCTL	+00:09:51.526495	SRC:2 GoodCRC
20	PDVDM	+00:09:51.526980	'PRT:1 Discover SVIDs
21	PDCTL	+00:09:51.581995	'CBL:1 GoodCRC
22	PDVDM	+00:09:51.583996	'CBL:0 ACK Discover SVIDs
23	PDCTL	+00:09:51.584892	'PRT:0 GoodCRC
24	PDVDM	+00:09:51.585376	SRC:5 Discover Modes
25	PDCTL	+00:09:51.587094	SNK:5 GoodCRC
26	PDVDM	+00:09:51.588598	SNK:3 ACK Discover Modes
27	PDCTL	+00:09:51.589329	SRC:3 GoodCRC
28	PDVDM	+00:09:51.589967	SRC:6 Enter Mode 1
29	PDCTL	+00:09:51.591669	SNK:6 GoodCRC
30	PDVDM	+00:09:51.593167	SNK:4 ACK Enter Mode 1
31	PDCTL	+00:09:51.593774	SRC:4 GoodCRC
32	PDVDM	+00:09:51.595311	SRC:7 DP_Status_Update
33	PDCTL	+00:09:51.596129	SNK:7 GoodCRC
34	PDVDM	+00:09:51.597626	SNK:5 ACK DP_Status_Update
35	PDCTL	+00:09:51.598516	SRC:5 GoodCRC
36	PDVDM	+00:09:52.098145	SRC:0 DP_Configure
37	PDCTL	+00:09:52.098971	SNK:0 GoodCRC
38	PDVDM	+00:09:52.100463	SNK:6 ACK DP_Configure
39	PDCTL	+00:09:52.101071	SRC:6 GoodCRC

Start Time: +00:09:51.395581
 Start of Packet: SOP
 Message Type: Request
 MessageID: 0
 Port Power Role: Sink
 Port Data Role: UFP
 Spec Revision: Revision 2.0
 Data Objects: 1

Request Data Objects

- 0: Fixed Supply
 - Object Position: 1
 - GiveBack Flag: No
 - Capability Mismatch: Yes
 - USB Comms Capable: Yes
 - No USB Suspend: Yes
 - Operating Current: 3000 mA
 - Max Operating Current: 0 mA

- Preamble: CC-1, 63, [Sync-1, Sync-1, Sync-1, Sync-2]
 - Header: 1042h
 - Object 1: 1704B000h
 - CRC: B1532395h
 - EOP

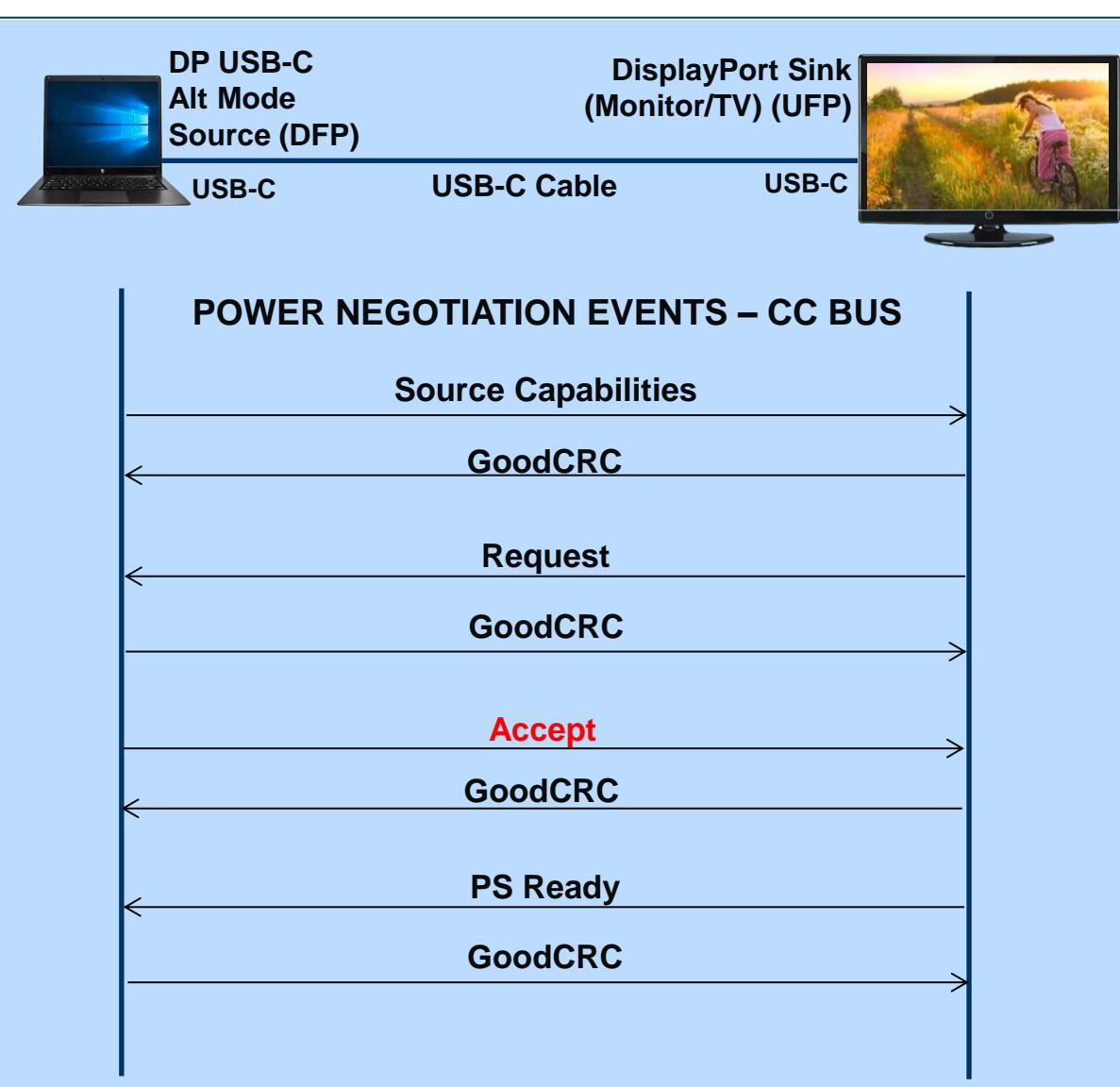
6: SNK:0 Request

Power Delivery DP Alt Mode Protocol – Power Negotiation (Accept)



- ◆ PD Data Messages – Power Negotiation:
 - ◆ Source Capabilities
 - ◆ Request
 - ◆ Accept
 - ◆ DFP (Source) Accepts request for power.
 - ◆ PS-RDY
 - ◆ DFP (Source) indicates that it is ready to supply power.

Power Delivery DP Alt Mode Protocol – Power Negotiation (Accept)



◆ PD Data Messages – Power Negotiation:

ACA Data Viewer

[AA_980-USB-to-LMon-USB_w-PSV.CBL] Events: 416

0	DPHP	61	+69:49:57.040950	HPD Falling Edge
1	PDVDM	61	+69:49:58.375607	'PRT:0 Discover Identity
2	PDCTL	61	+69:49:58.376363	'CBL:0 GoodCRC
3	PDVDM	61	+69:49:58.378497	'CBL:0 ACK Discover Identity
4	PDCTL	61	+69:49:58.379712	'PRT:0 GoodCRC
5	PDDTA	61	+69:49:58.380969	SRC:0 Source_Capabilities
6	PDCTL	61	+69:49:58.381662	SNK:0 GoodCRC
7	PDDTA	61	+69:49:58.382411	SNK:0 Request
8	PDCTL	61	+69:49:58.383112	SRC:0 GoodCRC
9	PDCTL	61	+69:49:58.385162	SRC:1 Accept
10	PDCTL	61	+69:49:58.414898	SNK:1 GoodCRC
11	PDCTL	61	+69:49:58.415460	SRC:2 PS_RDY
12	PDCTL	61	+69:49:58.416481	SNK:2 GoodCRC
13	PDCTL	61	+69:49:58.417031	SNK:1 PR_Swap
14	PDCTL	61	+69:49:58.418538	SRC:1 GoodCRC
15	PDCTL	61	+69:49:58.419094	SRC:3 Reject
16	PDVDM	61	+69:49:58.429721	SNK:3 GoodCRC
17	PDVDM	61	+69:49:58.430407	SRC:4 Discover Identity
18	PDVDM	61	+69:49:58.431054	SNK:2 ACK Discover Identity
19	PDVDM	61	+69:49:58.432141	SRC:2 GoodCRC
20	PDVDM	61	+69:49:58.433641	SRC:5 Discover SVIDs
21	PDVDM	61	+69:49:58.434334	SNK:5 GoodCRC
22	PDVDM	61	+69:49:58.435001	SNK:3 ACK Discover SVIDs
23	PDVDM	61	+69:49:58.435815	SRC:3 GoodCRC
24	PDVDM	61	+69:49:58.437319	SRC:6 Discover Modes
25	PDVDM	61	+69:49:58.438012	SNK:6 GoodCRC
26	PDVDM	61	+69:49:58.438662	SNK:4 ACK Discover Modes
27	PDVDM	61	+69:49:58.439490	SRC:4 GoodCRC
28	PDVDM	61	+69:49:58.440990	SRC:7 Enter Mode 1
29	PDVDM	61	+69:49:58.441669	SNK:7 GoodCRC
30	PDVDM	61	+69:49:58.442360	SNK:5 ACK Enter Mode 1
31	PDVDM	61	+69:49:58.443055	SRC:5 GoodCRC
32	PDVDM	61	+69:49:58.443861	SRC:0 DP_Status_Update
33	PDVDM	61	+69:49:58.444679	SNK:0 GoodCRC
34	PDVDM	61	+69:49:58.445345	SNK:6 ACK DP_Status_Update
35	PDVDM	61	+69:49:58.446167	SRC:6 GoodCRC
36	PDVDM	61	+69:49:58.447667	SRC:1 DP_Configure
37	PDVDM	61	+69:49:58.448491	SNK:1 GoodCRC
38	PDVDM	61	+69:49:58.449292	SNK:7 ACK DP_Configure
39	PDVDM	61	+69:49:58.449981	SRC:7 GoodCRC
40	PDVDM	61	+69:49:58.450672	

Start Time: +69:49:58.384599
 Start of Packet: SOP
 Message Type: Accept
 MessageID: 1
 Port Power Role: Source
 Port Data Role: DFP
 Spec Revision: Revision 2.0
 Data Objects: 0

- Preamble: CC-1, 64, [Sync-1, Sync-1, Sync-1, Sync-2]
 - Header: 0363h
 - CRC: 96007B21h
 - EOP

Option
 Data
 Filter
 Find
 Clear
 Open
 Export
 Hide

Power Delivery DP Alt Mode Protocol – Power Negotiation (PS Ready)



- ◆ PD Data Messages – Power Negotiation:
 - ◆ Source Capabilities
 - ◆ Request
 - ◆ Accept
 - ◆ PS-RDY
 - ◆ DFP (Source) indicates that it is ready to supply power.

Power Delivery DP Alt Mode Protocol – Power Negotiation (PS Ready)



◆ PD Data Messages – Power Negotiation:

ACA Data Viewer

[AA_980-USB-to-LMon-USB_w-PSV.CBL] Events: 416

0	DPHP	61	+69:49:57.040950	HPD Falling Edge
1	PDVDM	61	+69:49:58.375607	'PRT:0 Discover Identity
2	PDCTL	61	+69:49:58.376363	'CBL:0 GoodCRC
3	PDVDM	61	+69:49:58.378497	'CBL:0 ACK Discover Identity
4	PDCTL	61	+69:49:58.379712	'PRT:0 GoodCRC
5	PDDTA	61	+69:49:58.380969	SRC:0 Source_Capabilities
6	PDCTL	61	+69:49:58.381662	SNK:0 GoodCRC
7	PDDTA	61	+69:49:58.382411	SNK:0 Request
8	PDCTL	61	+69:49:58.383112	SRC:0 GoodCRC
9	PDCTL	61	+69:49:58.384599	SRC:1 Accept
10	PDCTL	61	+69:49:58.385162	SNK:1 GoodCRC
11	PDCTL	61	+69:49:58.415460	SRC:2 PS_RDY
12	PDCTL	61	+69:49:58.415460	SNK:2 GoodCRC
13	PDCTL	61	+69:49:58.416481	SNK:1 PR_Swap
14	PDCTL	61	+69:49:58.417031	SRC:1 GoodCRC
15	PDCTL	61	+69:49:58.418538	SRC:3 Reject
16	PDCTL	61	+69:49:58.419094	SNK:3 GoodCRC
17	PDVDM	61	+69:49:58.429721	SRC:4 Discover Identity
18	PDCTL	61	+69:49:58.430407	SNK:4 GoodCRC
19	PDVDM	61	+69:49:58.431054	SNK:2 ACK Discover Identity
20	PDCTL	61	+69:49:58.432141	SRC:2 GoodCRC
21	PDVDM	61	+69:49:58.433641	SRC:5 Discover SVIDs
22	PDCTL	61	+69:49:58.434334	SNK:5 GoodCRC
23	PDVDM	61	+69:49:58.435001	SNK:3 ACK Discover SVIDs
24	PDCTL	61	+69:49:58.435815	SRC:3 GoodCRC
25	PDVDM	61	+69:49:58.437319	SRC:6 Discover Modes
26	PDCTL	61	+69:49:58.438012	SNK:6 GoodCRC
27	PDVDM	61	+69:49:58.438662	SNK:4 ACK Discover Modes
28	PDCTL	61	+69:49:58.439490	SRC:4 GoodCRC
29	PDVDM	61	+69:49:58.440990	SRC:7 Enter Mode 1
30	PDCTL	61	+69:49:58.441669	SNK:7 GoodCRC
31	PDVDM	61	+69:49:58.442360	SNK:5 ACK Enter Mode 1
32	PDCTL	61	+69:49:58.443055	SRC:5 GoodCRC
33	PDVDM	61	+69:49:58.443861	SRC:0 DP_Status_Update
34	PDCTL	61	+69:49:58.444679	SNK:0 GoodCRC
35	PDVDM	61	+69:49:58.445345	SNK:6 ACK DP_Status_Update
36	PDCTL	61	+69:49:58.446167	SRC:6 GoodCRC
37	PDVDM	61	+69:49:58.447667	SRC:1 DP_Configure
38	PDCTL	61	+69:49:58.448491	SNK:1 GoodCRC
39	PDVDM	61	+69:49:58.449292	SNK:7 ACK DP_Configure
40	PDCTL	61	+69:49:58.449981	SRC:7 GoodCRC

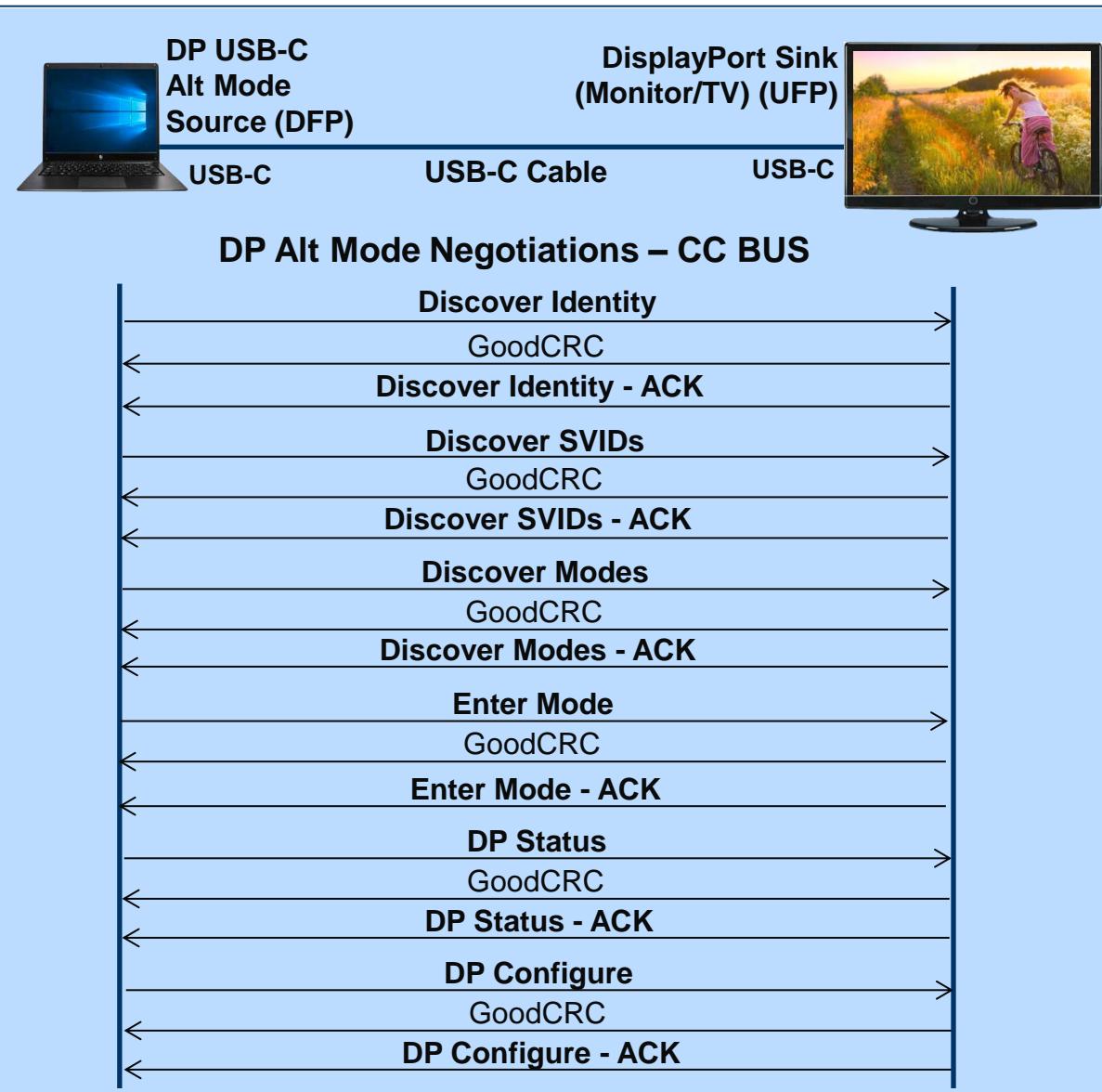
Start Time: +69:49:58.414898
 Start of Packet: SOP
 Message Type: PS_RDY
 MessageID: 2
 Port Power Role: Source
 Port Data Role: DFP
 Spec Revision: Revision 2.0
 Data Objects: 0

- Preamble: CC-1, 64, [Sync-1, Sync-1, Sync-1, Sync-2]
 - Header: 0566h
 - CRC: 02142A51h
 - EOP

Option
 Data
 Filter
 Find
 Clear
 Open
 Export
 Hide

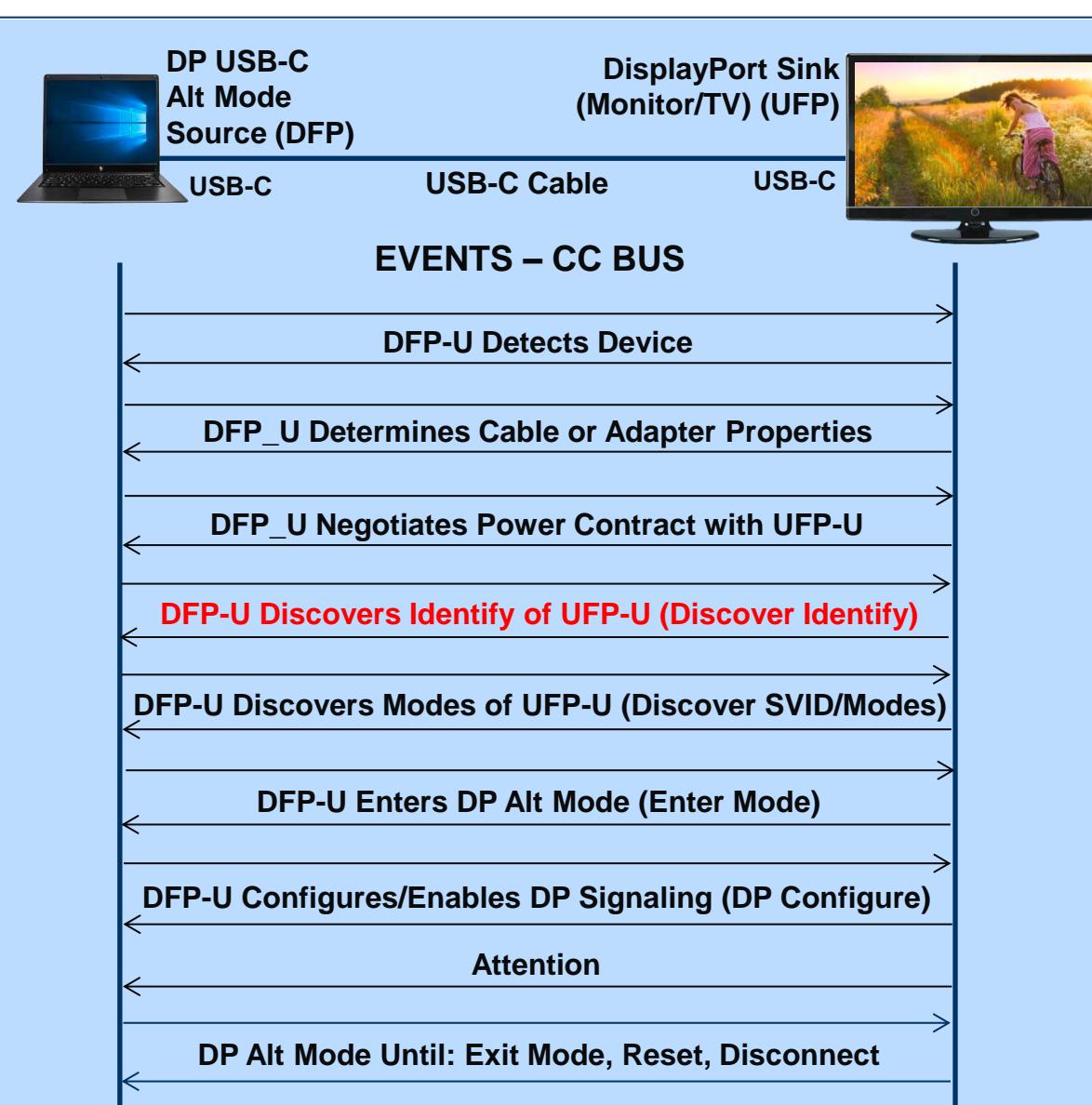
USB-C Power Delivery Protocol DisplayPort Alt Mode Negotiation

Power Delivery DP Alt Mode Protocol – Overview



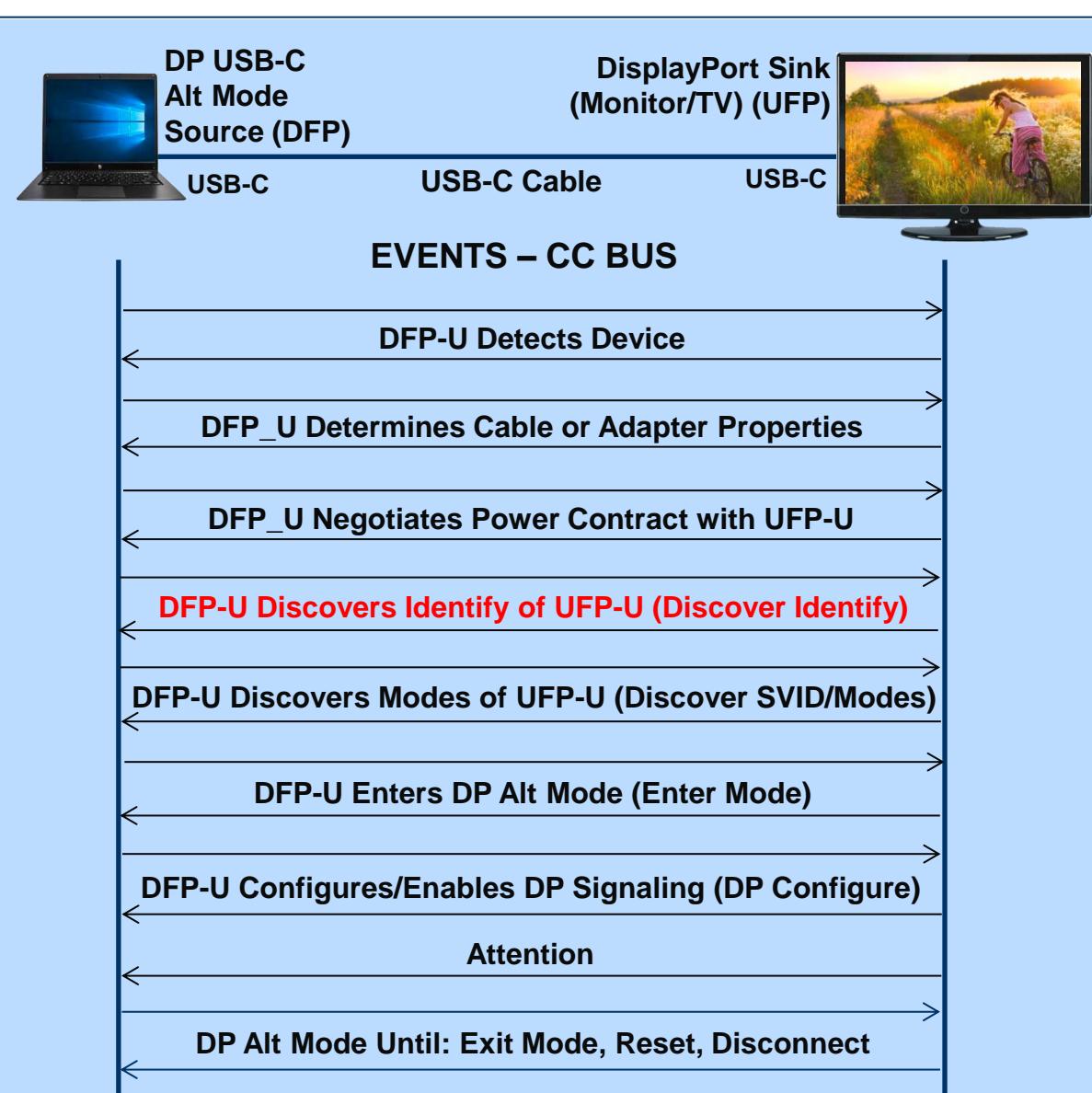
- ◆ PD Data Messages – DP Alt Mode Negotiation.
Note: Power contract must be completed.
- ◆ Commands below use Structured Vendor Defined Messages (VDMs).
 - ◆ Timeout enforcement, e.g. response to a Discover ID, SVID, Modes is 24 to 30 msec.
 - ◆ Discover Identify
 - ◆ Discovers the identify of the connected UFP device or cable.
 - ◆ Discover SVIDs
 - ◆ Discovers supported alternate modes of the UFP.
 - ◆ Discover Modes
 - ◆ Discovers alternate modes for a specific SVID of the UFP.
 - ◆ Enter Mode
 - ◆ Commands the UFP to enter a specified alternative mode. DFP and UFP are officially DFP_D & UFP_D.
 - ◆ DP Status/Configure
 - ◆ VESA Alt Mode commands are used to configure DisplayPort transmission.

Power Delivery DP Alt Mode Protocol – Data Messages (Discover Identity)



- ◆ Discover Identity Sink/Data:
 - ◆ Vendor Defined Message (VDM)
 - ◆ Used by DFP (Initiator) to identify attributes of the connected device (e.g. UFP):
 - ◆ Product type, Vendor ID, etc.
 - ◆ Port power role.
 - ◆ Port data role and capabilities.

Power Delivery DP Alt Mode Protocol – Data Messages (Discover Identity)



◆ Discover Identity Sink/Data:

ACA Data Viewer

[AA_980-USB-to-LMon-USB_w-PSV-CBL] Events: 416

HPD Falling Edge

'PRT:0 Discover Identity

'CBL:0 GoodCRC

'CBL:0 ACK Discover Identity

'PRT:0 GoodCRC

SRC:0 Source_Capabilities

SNK:0 GoodCRC

SNK:0 Request

SRC:1 GoodCRC

SRC:1 Accept

SNK:1 GoodCRC

SNK:2 PS_RDY

SNK:2 GoodCRC

SNK:1 PR_Swap

SRC:1 GoodCRC

SRC:3 Reject

SNK:3 GoodCRC

SRC:4 Discover Identity

SNK:4 GoodCRC

SNK:2 ACK Discover Identity

PDVDM 61 +69:49:58.432141

PDVDM 61 +69:49:58.433641

PDVDM 61 +69:49:58.434334

PDVDM 61 +69:49:58.435001

PDVDM 61 +69:49:58.435815

PDVDM 61 +69:49:58.437319

PDVDM 61 +69:49:58.438012

PDVDM 61 +69:49:58.438662

PDVDM 61 +69:49:58.439490

PDVDM 61 +69:49:58.440990

PDVDM 61 +69:49:58.441669

PDVDM 61 +69:49:58.442360

PDVDM 61 +69:49:58.443055

PDVDM 61 +69:49:58.443861

PDVDM 61 +69:49:58.444679

PDVDM 61 +69:49:58.445345

PDVDM 61 +69:49:58.446167

PDVDM 61 +69:49:58.447667

PDVDM 61 +69:49:58.448491

PDVDM 61 +69:49:58.449292

PDVDM 61 +69:49:58.449981

Start Time: +69:49:58.431054

Start of Packet: SOP

Message Type: Vendor_Defined

MessageID: 2

Port Power Role: Sink

Port Data Role: UFP

Spec Revision: Revision 2.0

Data Objects: 4

1 VDM Header

SVID or VID : 0xFF00 (65280)

VDM Type : Structured

VDM Version : 1.0

Object Position: 0

Command Type : ACK

Command : Discover Identity

2 ID Header VDO

Data Capable as USB Host : Yes

Data Capable as a USB Device: Yes

Product Type : Undefined

Modal Operation Supported : Yes

USB Vendor ID :

3) Cert Stat VDO

TID: 0x00000

4) Product VDO

USB Product ID: 0x9A30

bcdDevice : 0x0010

- Preamble: CC-1, 63, [Sync-1,Sync-1,Sync-1,Sync-2]

- Header: 444Fh

- Object 1: FF008041h

- Object 2: C400043Eh

- Object 3: 0000000h

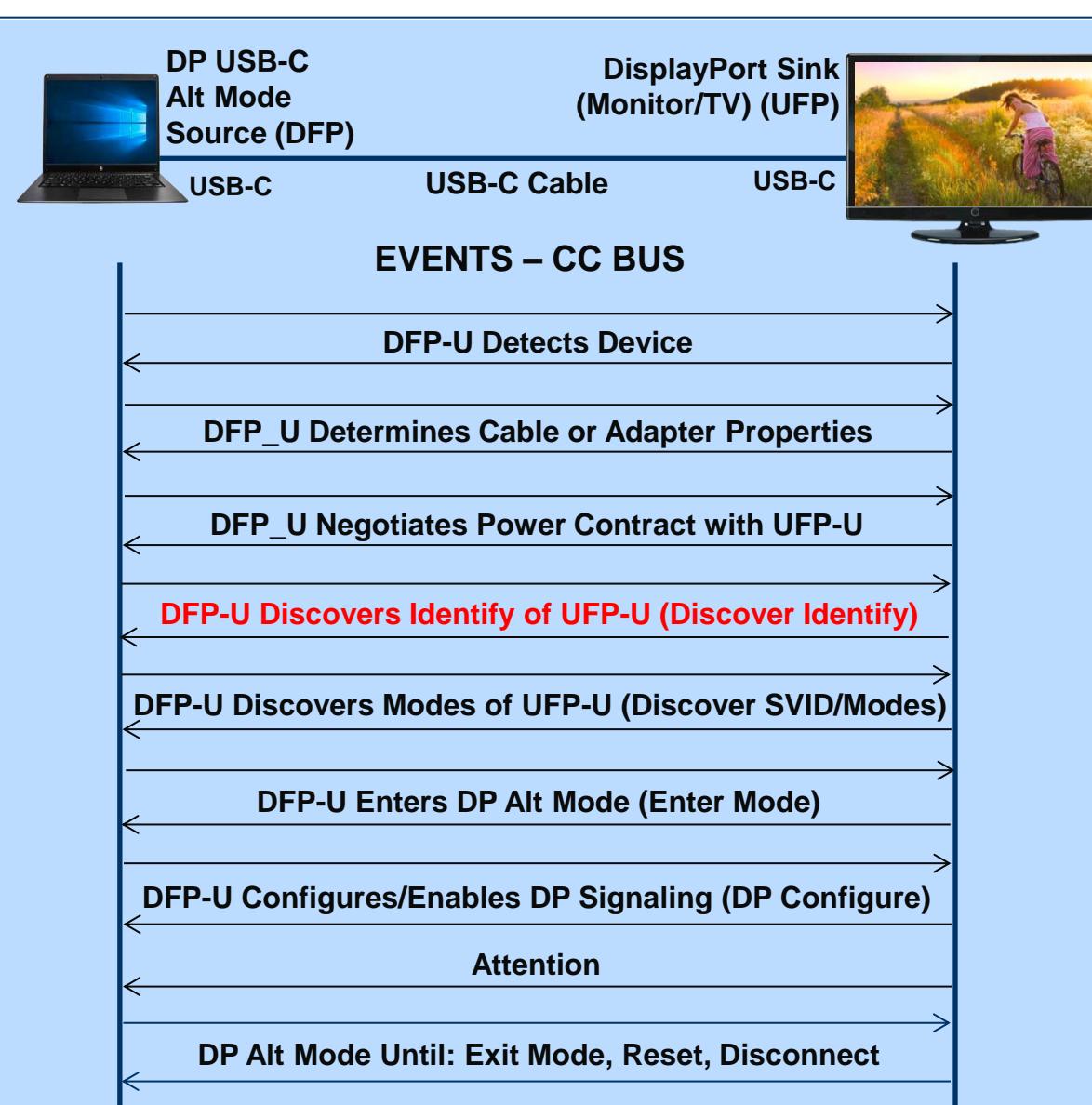
- Object 4: 9A300010h

- CRC: C1B79DE2h

- EOP

19: SNK:2 ACK Discover Identity

Power Delivery DP Alt Mode Protocol – Data Messages (Discover Identity)



◆ Discover Identity Sink/Data:

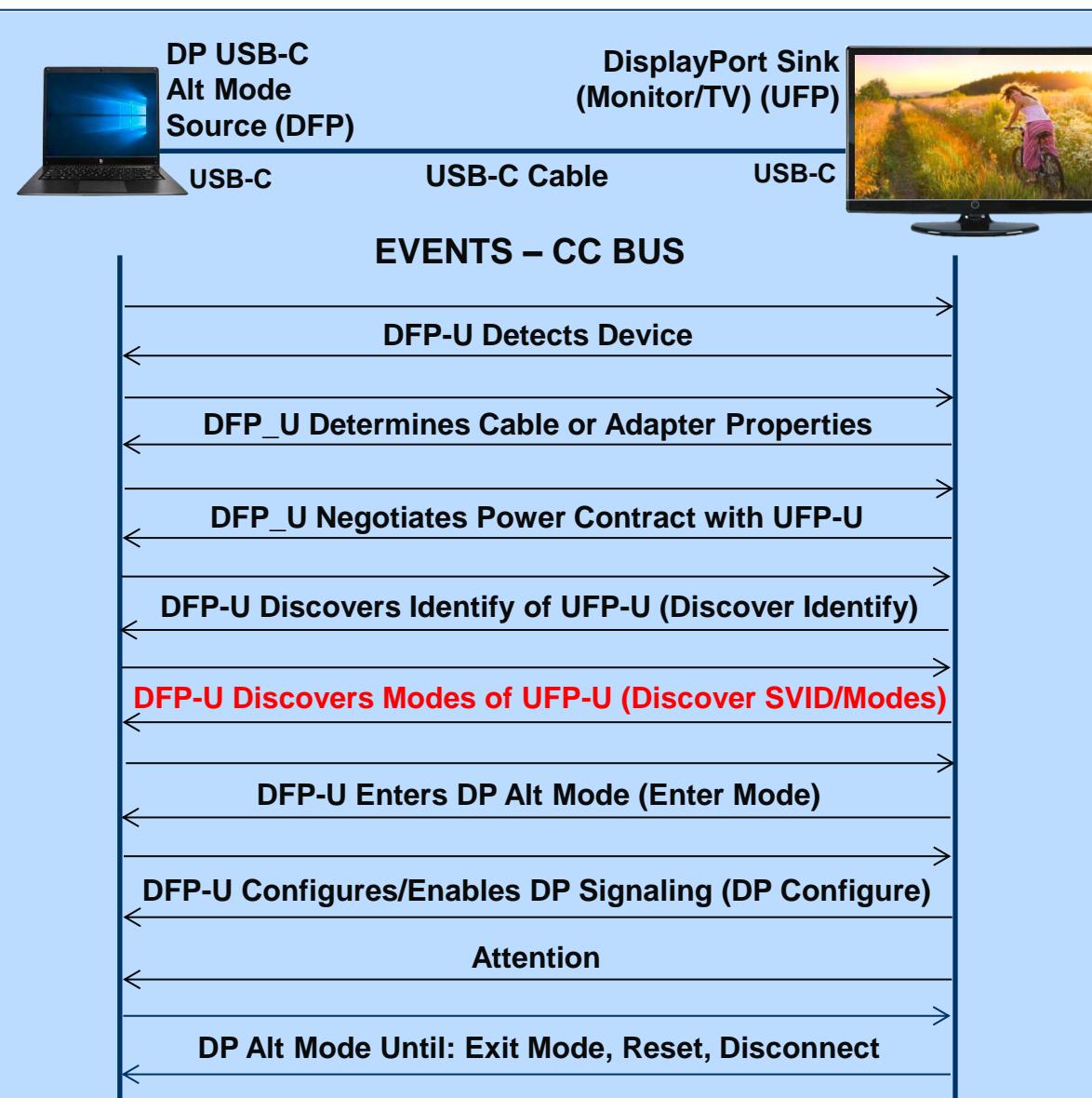
ACA Data Viewer

[AA_980-USB-to-LMon-USB_w-PSV-CBL] Events: 416

0	DPHP	61	+69:49:58.040950	HPD Falling Edge	Start Time: +69:49:58.429721
1	PDVDM	61	+69:49:58.375607	'PRT:0 Discover Identity	Start of Packet: SOP
2	PDCTL	61	+69:49:58.376363	'CBL:0 GoodCRC	Message Type: Vendor Defined
3	PDVDM	61	+69:49:58.378497	'CBL:0 ACK Discover Identity	MessageID: 4
4	PDCTL	61	+69:49:58.379712	'PRT:0 GoodCRC	Port Power Role: Source
5	PDDTA	61	+69:49:58.380969	SRC:0 Source_Capabilities	Port Data Role: DFP
6	PDCTL	61	+69:49:58.381662	SNK:0 GoodCRC	Spec Revision: Revision 2.0
7	PDDTA	61	+69:49:58.382411	SNK:0 Request	Data Objects: 1
8	PDCTL	61	+69:49:58.383112	SRC:0 GoodCRC	1) VDM Header
9	PDCTL	61	+69:49:58.384599	SRC:1 Accept	SVID or VID : 0xFF00 (65280)
10	PDCTL	61	+69:49:58.385162	SNK:1 GoodCRC	VDM Type : Structured
11	PDCTL	61	+69:49:58.414898	SRC:2 PS_RDY	VDM Version : 1.0
12	PDCTL	61	+69:49:58.415460	SNK:2 GoodCRC	Object Position: 0
13	PDCTL	61	+69:49:58.416481	SNK:1 PR_Swap	Command Type : Initiator
14	PDCTL	61	+69:49:58.417031	SRC:1 GoodCRC	Command : Discover Identity
15	PDCTL	61	+69:49:58.418538	SRC:3 Reject	
16	PDCTL	61	+69:49:58.419000	SNK:3 GoodCRC	
17	PDVDM	61	+69:49:58.430407	SRC:4 Discover Identity	
18	PDCTL	61	+69:49:58.431054	SNK:4 GoodCRC	
19	PDVDM	61	+69:49:58.432141	SNK:2 ACK Discover Identity	
20	PDCTL	61	+69:49:58.433641	SRC:2 GoodCRC	
21	PDVDM	61	+69:49:58.434334	SRC:5 Discover SVIDs	
22	PDCTL	61	+69:49:58.435001	SNK:5 GoodCRC	
23	PDVDM	61	+69:49:58.435815	SNK:3 ACK Discover SVIDs	
24	PDCTL	61	+69:49:58.437319	SRC:3 GoodCRC	
25	PDVDM	61	+69:49:58.438012	SRC:6 Discover Modes	
26	PDCTL	61	+69:49:58.438662	SNK:6 GoodCRC	
27	PDVDM	61	+69:49:58.439490	SNK:4 ACK Discover Modes	
28	PDCTL	61	+69:49:58.440990	SRC:4 GoodCRC	
29	PDVDM	61	+69:49:58.441669	SRC:7 Enter Mode 1	
30	PDCTL	61	+69:49:58.442360	SNK:7 GoodCRC	
31	PDVDM	61	+69:49:58.443055	SNK:5 ACK Enter Mode 1	
32	PDCTL	61	+69:49:58.443861	SRC:5 GoodCRC	
33	PDVDM	61	+69:49:58.444679	SRC:0 DP_Status_Update	
34	PDCTL	61	+69:49:58.445345	SNK:0 GoodCRC	
35	PDVDM	61	+69:49:58.446167	SNK:6 ACK DP_Status_Update	
36	PDCTL	61	+69:49:58.447667	SRC:6 GoodCRC	
37	PDVDM	61	+69:49:58.448491	SRC:1 DP_Configure	
38	PDCTL	61	+69:49:58.449292	SNK:1 GoodCRC	
39	PDVDM	61	+69:49:58.449981	SNK:7 ACK DP_Configure	
40	PDCTL	61	+69:49:58.450000	SRC:7 GoodCRC	

17: SRC:4 Discover Identity

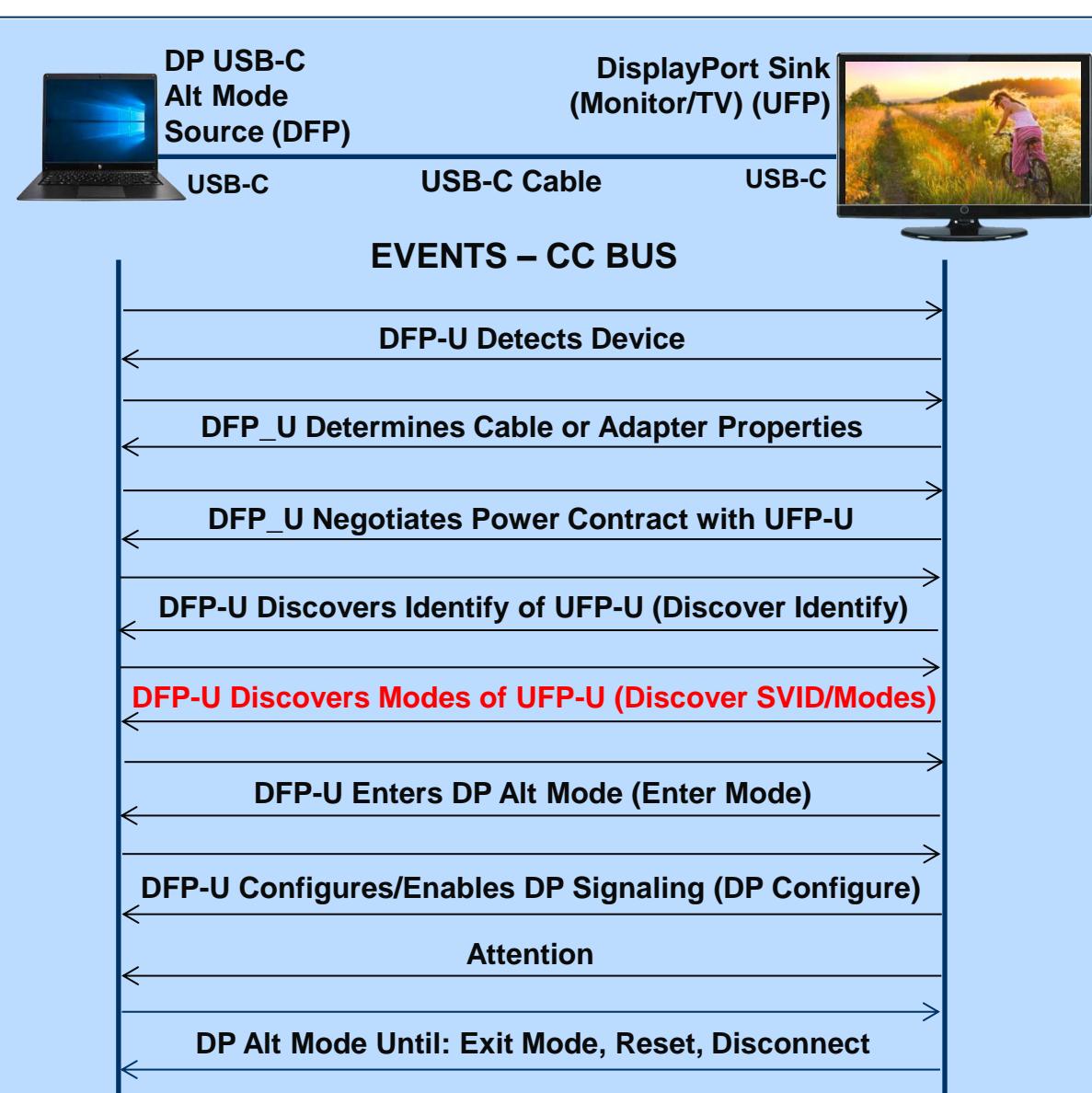
Power Delivery DP Alt Mode Protocol – Data Messages (Discover SVIDs)



◆ Discover SVIDs:

- ◆ Used by DFP (Initiator) to identify SVIDs of connected device (UFP):
 - ◆ Used to determine the SVID supported modes of the UFP connected device.
 - ◆ Uses in conjunction with Discover Mode command and Enter Mode command to transition into DP Alt Mode.

Power Delivery DP Alt Mode Protocol – Data Messages (Discover SVIDs)



◆ Discover SVIDs:

ACA Data Viewer

[AA_980-USB-to-LMon-USB_w-PSV.CBL] Events: 416

Index	Event Type	Timestamp	Description	
0	DPHP	61	+69:49:57.040950	HPD Falling Edge
1	PDVDM	61	+69:49:58.375607	'PRT:0 Discover Identity
2	PDCTL	61	+69:49:58.376363	'CBL:0 GoodCRC
3	PDVDM	61	+69:49:58.378497	'CBL:0 ACK Discover Identity
4	PDCTL	61	+69:49:58.379712	'PRT:0 GoodCRC
5	PDDTA	61	+69:49:58.380969	SRC:0 Source_Capabilities
6	PDCTL	61	+69:49:58.381662	SNK:0 GoodCRC
7	PDDTA	61	+69:49:58.382411	SNK:0 Request
8	PDCTL	61	+69:49:58.383112	SRC:0 GoodCRC
9	PDCTL	61	+69:49:58.384599	SRC:1 Accept
10	PDCTL	61	+69:49:58.385162	SNK:1 GoodCRC
11	PDCTL	61	+69:49:58.414898	SNK:2 PS_RDY
12	PDCTL	61	+69:49:58.415460	SNK:2 GoodCRC
13	PDCTL	61	+69:49:58.416481	SNK:1 PR_Swap
14	PDCTL	61	+69:49:58.417031	SRC:1 GoodCRC
15	PDCTL	61	+69:49:58.418538	SRC:3 Reject
16	PDCTL	61	+69:49:58.419094	SNK:3 GoodCRC
17	PDVDM	61	+69:49:58.429721	SRC:4 Discover Identity
18	PDCTL	61	+69:49:58.430407	SNK:4 GoodCRC
19	PDVDM	61	+69:49:58.431054	SNK:2 ACK Discover Identity
20	PDCTL	61	+69:49:58.432141	SRC:2 GoodCRC
21	PDVDM	61	+69:49:58.434334	SRC:5 Discover SVIDs
22	PDCTL	61	+69:49:58.435001	SNK:5 GoodCRC
23	PDVDM	61	+69:49:58.435815	SNK:3 ACK Discover SVIDs
24	PDCTL	61	+69:49:58.437319	SRC:3 GoodCRC
25	PDVDM	61	+69:49:58.438012	SRC:6 Discover Modes
26	PDCTL	61	+69:49:58.438662	SNK:6 GoodCRC
27	PDVDM	61	+69:49:58.439490	SNK:4 ACK Discover Modes
28	PDCTL	61	+69:49:58.440990	SRC:4 GoodCRC
29	PDVDM	61	+69:49:58.441669	SNK:7 Enter Mode 1
30	PDCTL	61	+69:49:58.442360	SNK:5 ACK Enter Mode 1
31	PDVDM	61	+69:49:58.443055	SRC:5 GoodCRC
32	PDCTL	61	+69:49:58.443861	SRC:0 DP_Status_Update
33	PDVDM	61	+69:49:58.444679	SNK:0 GoodCRC
34	PDCTL	61	+69:49:58.445345	SNK:6 ACK DP_Status_Update
35	PDVDM	61	+69:49:58.446167	SRC:6 GoodCRC
36	PDCTL	61	+69:49:58.447667	SRC:1 DP_Configure
37	PDVDM	61	+69:49:58.448491	SNK:1 GoodCRC
38	PDCTL	61	+69:49:58.449292	SNK:7 ACK DP_Configure
39	PDVDM	61	+69:49:58.449981	SRC:7 GoodCRC
40	PDCTL	61	+69:49:58.450641	

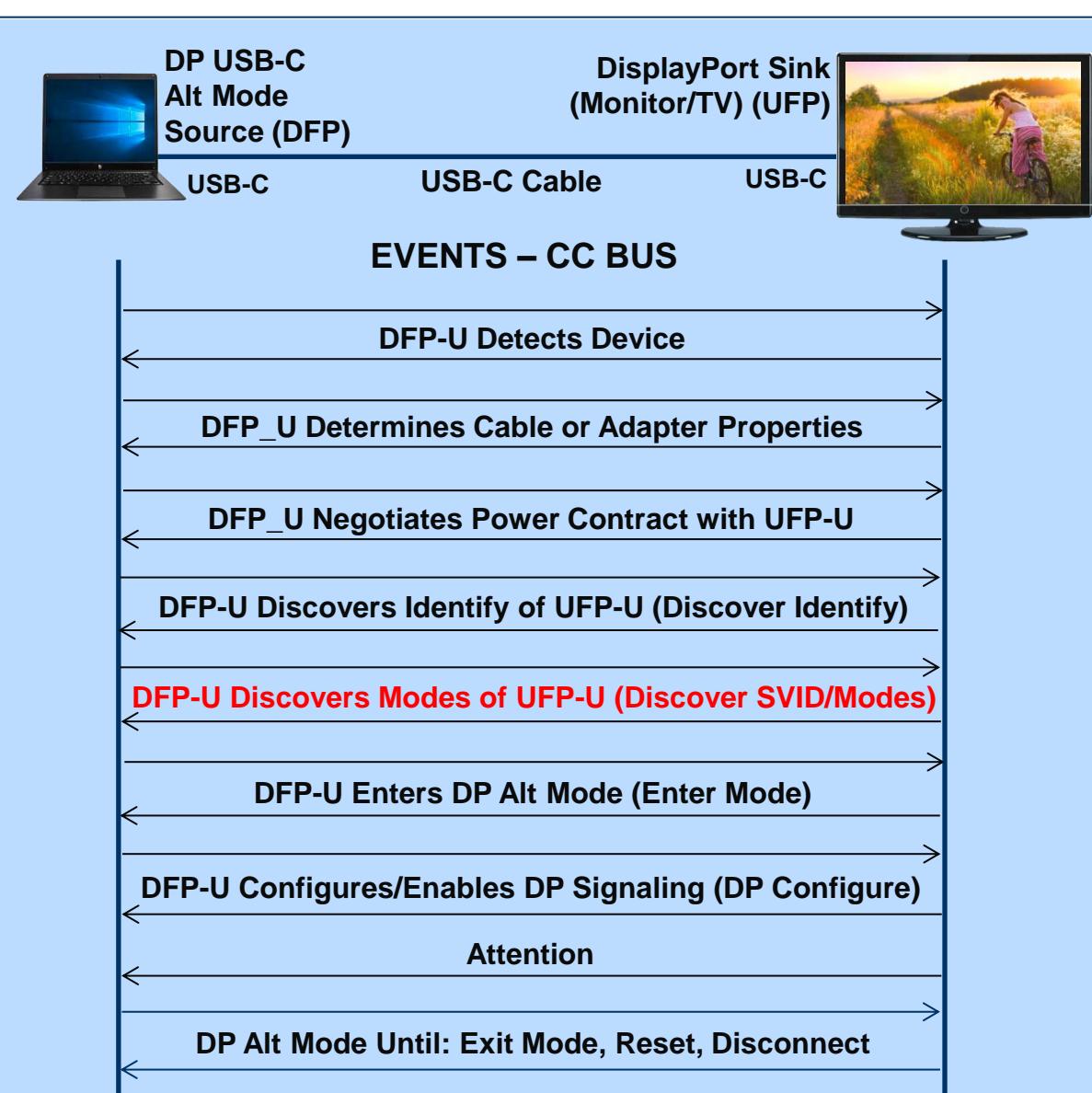
Start Time: +69:49:58.433641
Start of Packet: SOP
Message Type: Vendor Defined
MessageID: 5
Port Power Role: Source
Port Data Role: DFP
Spec Revision: Revision 2.0
Data Objects: 1

1) VDM Header
SVID or VID : 0xFF00 (65280)
VDM Type : Structured
VDM Version : 1.0
Object Position: 0
Command Type : Initiator
Command : Discover SVIDs

- Preamble: CC-1, 63, [Sync-1, Sync-1, Sync-1, Sync-2]
- Header: 1B6Fh
- Object 1: FF008002h
- CRC: 396E8639h
- EOP

21: SRC:5 Discover SVIDs

Power Delivery DP Alt Mode Protocol – Data Messages (Discover SVIDs)



◆ Discover SVIDs:

ACA Data Viewer

[AA_980-USB-to-LMon-USB_w-PSV-CBL] Events: 416

Index	Object	Time	Message
0	DPHP	61	+69:49:57.040950
1	PDVDM	61	+69:49:58.375607
2	PDCTL	61	+69:49:58.376363
3	PDVDM	61	+69:49:58.378497
4	PDCTL	61	+69:49:58.379712
5	PDDTA	61	+69:49:58.380969
6	PDCTL	61	+69:49:58.381662
7	PDDTA	61	+69:49:58.382411
8	PDCTL	61	+69:49:58.383112
9	PDCTL	61	+69:49:58.384599
10	PDCTL	61	+69:49:58.385162
11	PDCTL	61	+69:49:58.414898
12	PDCTL	61	+69:49:58.415460
13	PDCTL	61	+69:49:58.416481
14	PDCTL	61	+69:49:58.417031
15	PDCTL	61	+69:49:58.418538
16	PDVDM	61	+69:49:58.419094
17	PDVDM	61	+69:49:58.429721
18	PDCTL	61	+69:49:58.430407
19	PDVDM	61	+69:49:58.431054
20	PDCTL	61	+69:49:58.432141
21	PDVDM	61	+69:49:58.433641
22	PDCTL	61	+69:49:58.434334
23	PDVDM	61	+69:49:58.435815
24	PDCTL	61	+69:49:58.435815
25	PDVDM	61	+69:49:58.437319
26	PDCTL	61	+69:49:58.438012
27	PDVDM	61	+69:49:58.438662
28	PDCTL	61	+69:49:58.439490
29	PDVDM	61	+69:49:58.440990
30	PDCTL	61	+69:49:58.441669
31	PDVDM	61	+69:49:58.442360
32	PDCTL	61	+69:49:58.443055
33	PDVDM	61	+69:49:58.443861
34	PDCTL	61	+69:49:58.444679
35	PDVDM	61	+69:49:58.445345
36	PDCTL	61	+69:49:58.446167
37	PDVDM	61	+69:49:58.447667
38	PDCTL	61	+69:49:58.448491
39	PDVDM	61	+69:49:58.449292
40	PDCTL	61	+69:49:58.449981

Start Time: +69:49:58.435001
Start of Packet: SOP
Message Type: Vendor Defined
MessageID: 3
Port Power Role: Sink
Port Data Role: UFP
Spec Revision: Revision 2.0
Data Objects: 2

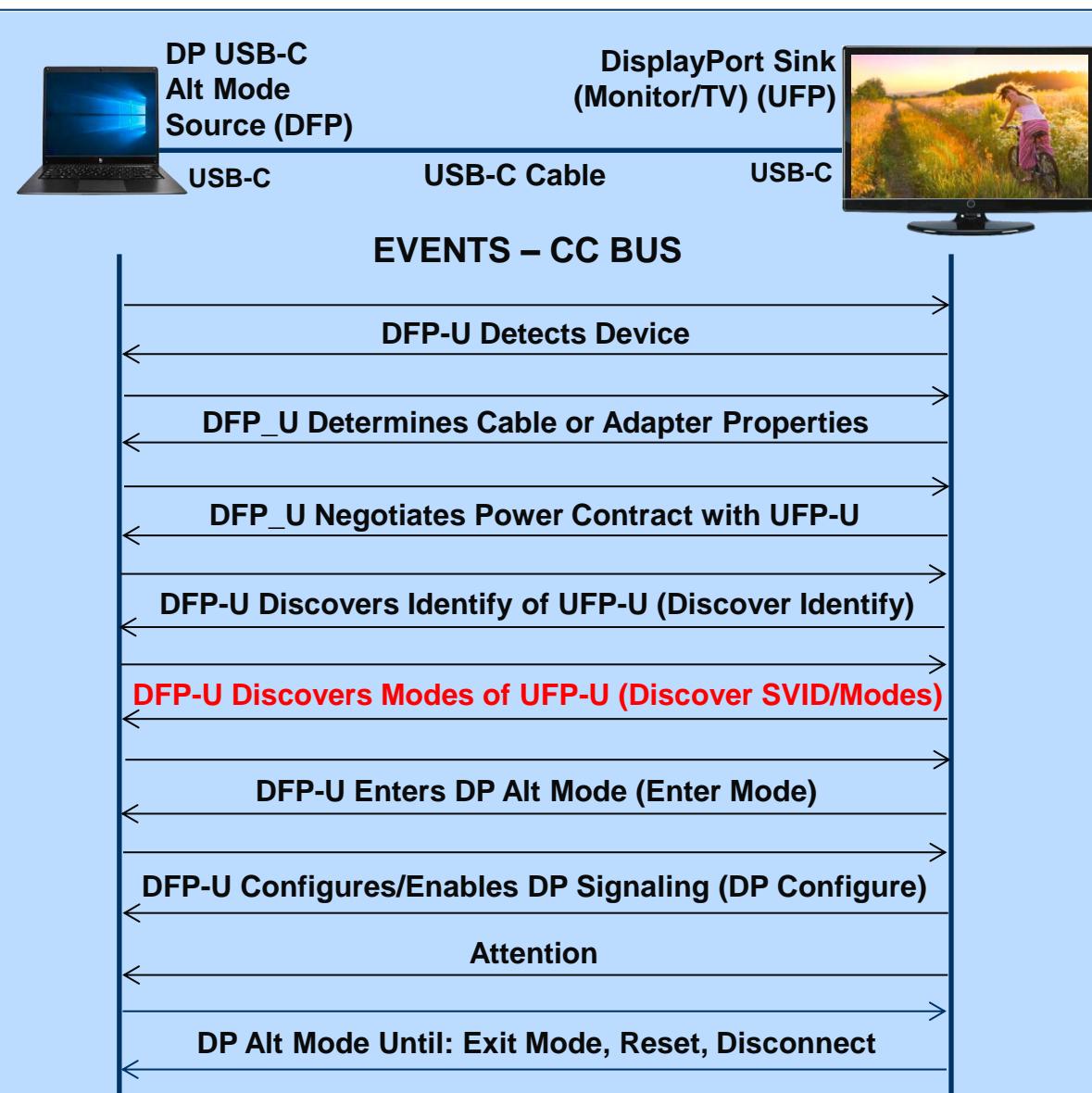
1) VDM Header
SVID or VID : 0xFF00 (65280)
VDM Type : Structured
VDM Version : 1.0
Object Position: 0
Command Type : ACK
Command : Discover SVIDs

SVID List
0xFF01 (DP_SID)
**** End-Of-List *****

- Preamble: CC-1, 62, [Sync-1, Sync-1, Sync-1, Sync-2]
- Header: 264Fh
- Object 1: FF008042h
- Object 2: FF010000h
- CRC: 6003F950h
- EOP

23: SNK:3 ACK Discover SVIDs

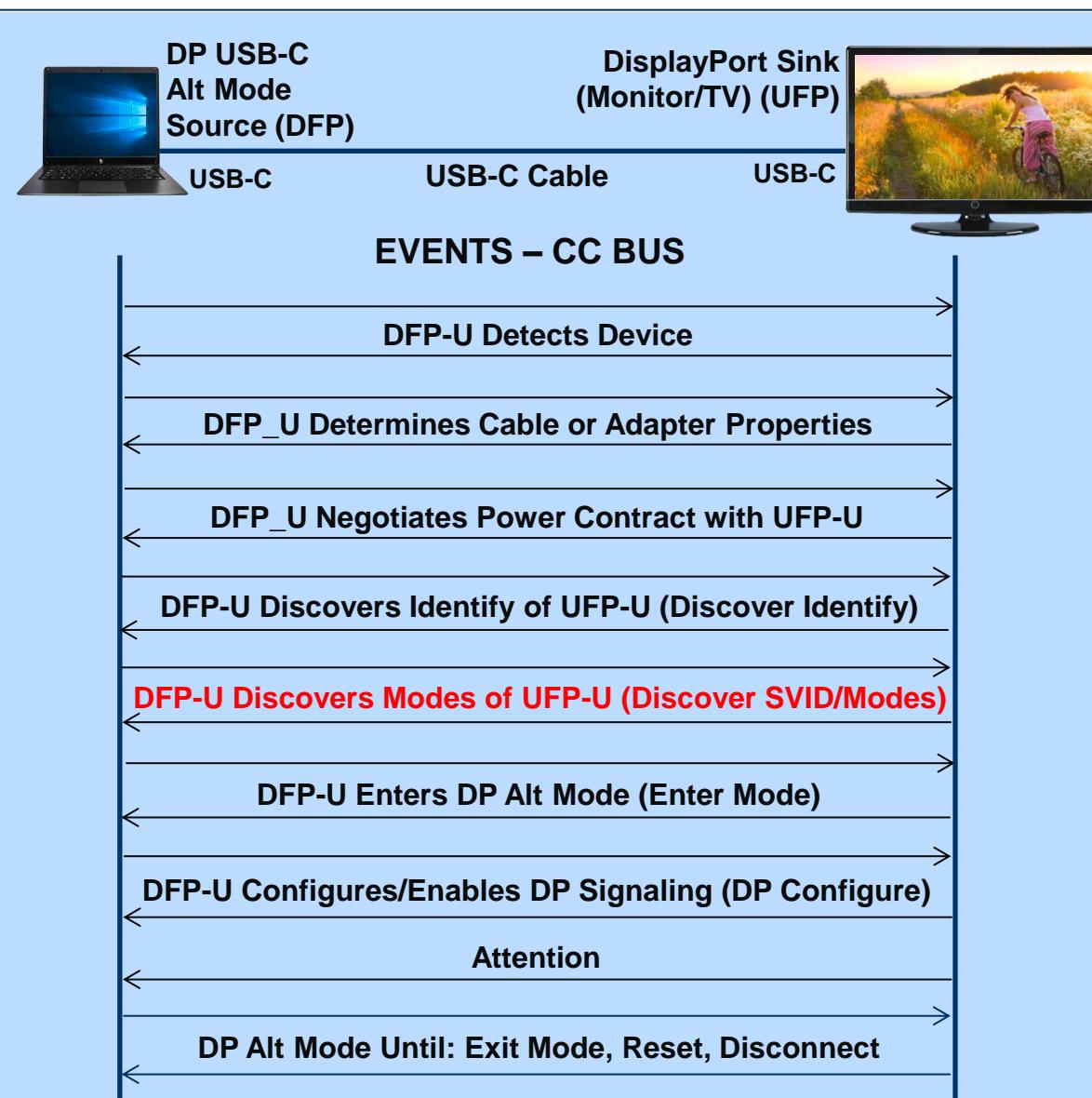
Power Delivery DP Alt Mode Protocol – Data Messages (Discover Modes)



◆ Discover Modes:

- ◆ Used by DFP (Initiator) to identify supported modes of connected device (UFP):
 - ◆ Used to determine the supported alternate modes of an SVID of the UFP connected device.
 - ◆ Uses in conjunction with Discover SVID command and Enter Mode command to transition into DP Alt Mode.

Power Delivery DP Alt Mode Protocol – Data Messages (Discover Modes)



◆ Discover Modes:

ACA Data Viewer

[AA_980-USB-to-LMon-USB_w-PSV-CBL] Events: 416

Index	Event Type	Timestamp	Description	
0	DPHP	61	+69:49:57.040950	HPD Falling Edge
1	PDVDM	61	+69:49:58.375607	'PRT:0 Discover Identity
2	PDCTL	61	+69:49:58.376363	'CBL:0 GoodCRC
3	PDVDM	61	+69:49:58.378497	'CBL:0 ACK Discover Identity
4	PDCTL	61	+69:49:58.379712	'PRT:0 GoodCRC
5	PDDTA	61	+69:49:58.380969	SRC:0 Source_Capabilit
6	PDCTL	61	+69:49:58.381662	SNK:0 GoodCRC
7	PDDTA	61	+69:49:58.382411	SNK:0 Request
8	PDCTL	61	+69:49:58.383112	SRC:0 GoodCRC
9	PDCTL	61	+69:49:58.384599	SRC:1 Accept
10	PDCTL	61	+69:49:58.385162	SNK:1 GoodCRC
11	PDCTL	61	+69:49:58.414898	SRC:2 PS_RDY
12	PDCTL	61	+69:49:58.415460	SNK:2 GoodCRC
13	PDCTL	61	+69:49:58.416481	SNK:1 PR_Swap
14	PDCTL	61	+69:49:58.417031	SRC:1 GoodCRC
15	PDCTL	61	+69:49:58.418538	SRC:3 Reject
16	PDCTL	61	+69:49:58.419094	SNK:3 GoodCRC
17	PDVDM	61	+69:49:58.429721	SRC:4 Discover Identity
18	PDCTL	61	+69:49:58.430407	SNK:4 GoodCRC
19	PDVDM	61	+69:49:58.431054	SNK:2 ACK Discover Identity
20	PDCTL	61	+69:49:58.432141	SRC:2 GoodCRC
21	PDVDM	61	+69:49:58.433641	SRC:5 Discover SVIDs
22	PDCTL	61	+69:49:58.434334	SNK:5 GoodCRC
23	PDVDM	61	+69:49:58.435001	SNK:3 ACK Discover SVIDs
24	PDCTL	61	+69:49:58.435815	SRC:3 GoodCRC
25	PDVDM	61	+69:49:58.438012	SRC:6 Discover Modes
26	PDCTL	61	+69:49:58.438662	SNK:6 GoodCRC
27	PDVDM	61	+69:49:58.439490	SNK:4 ACK Discover Modes
28	PDCTL	61	+69:49:58.440990	SRC:4 GoodCRC
29	PDVDM	61	+69:49:58.441669	SRC:7 Enter Mode 1
30	PDCTL	61	+69:49:58.442360	SNK:7 GoodCRC
31	PDVDM	61	+69:49:58.443055	SNK:5 ACK Enter Mode 1
32	PDCTL	61	+69:49:58.443861	SRC:5 GoodCRC
33	PDVDM	61	+69:49:58.444679	SRC:0 DP_Status_Update
34	PDCTL	61	+69:49:58.445345	SNK:0 GoodCRC
35	PDVDM	61	+69:49:58.446167	SNK:6 ACK DP_Status_Update
36	PDCTL	61	+69:49:58.447667	SRC:6 GoodCRC
37	PDVDM	61	+69:49:58.448491	SRC:1 DP_Configure
38	PDCTL	61	+69:49:58.449292	SNK:1 GoodCRC
39	PDVDM	61	+69:49:58.449981	SNK:7 ACK DP_Configure
40	PDCTL	61	+69:49:58.450635	SRC:7 GoodCRC

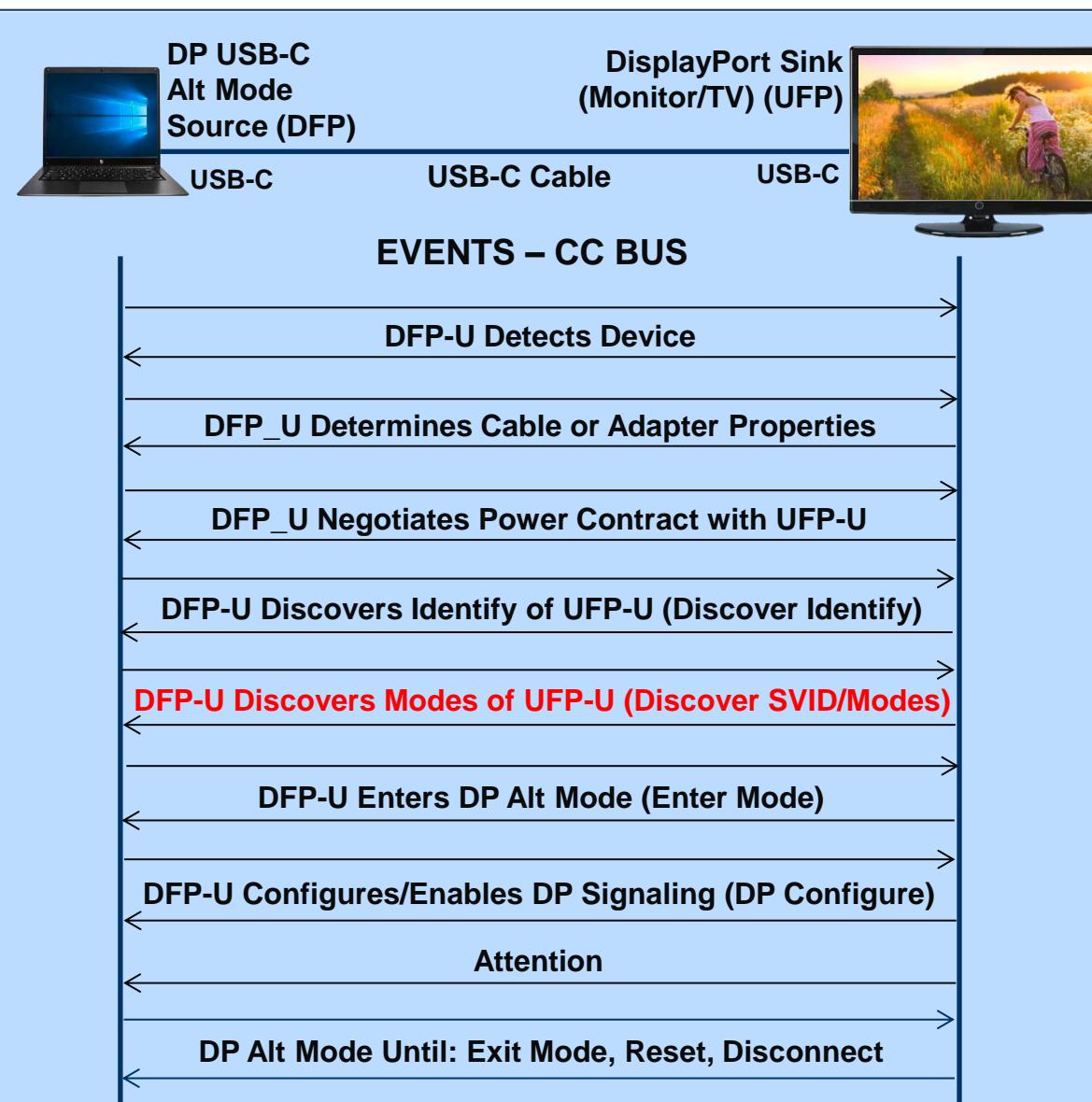
Start Time: +69:49:58.437319
 Start of Packet: SOP
 Message Type: Vendor_Defined
 MessageID: 6
 Port Power Role: Source
 Port Data Role: DFP
 Spec Revision: Revision 2.0
 Data Objects: 1

VDM Header
 SVID or VID : 0xFF01 (65281)
 VDM Type : Structured
 VDM Version : 1.0
 Object Position: 0
 Command Type : Initiator
 Command : Discover Modes

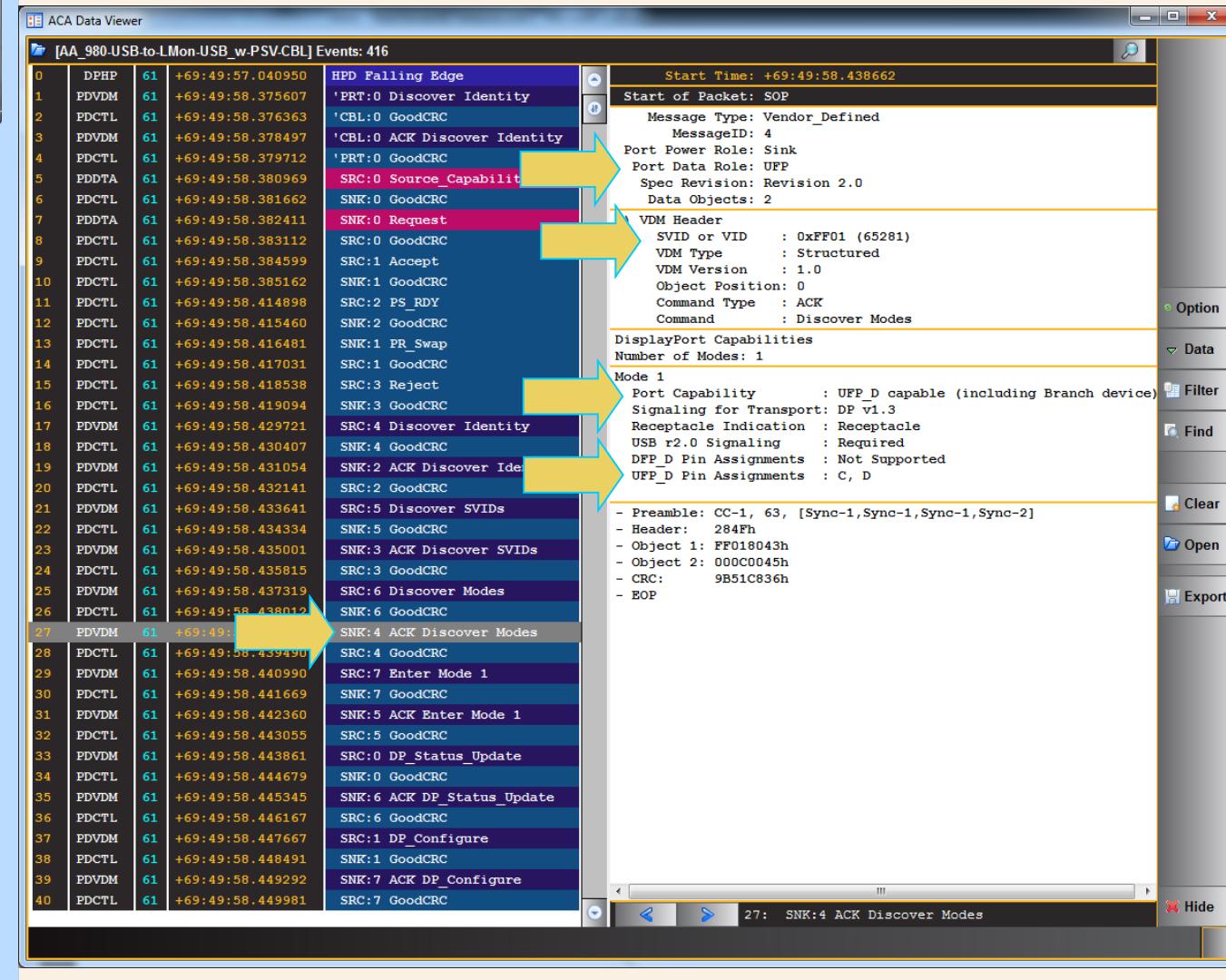
- Preamble: CC-1, 63, [Sync-1,Sync-1,Sync-1,Sync-2]
 - Header: 1D6Fh
 - Object 1: FF018003h
 - CRC: 178925BDh
 - EOP

25: SRC:6 Discover Modes

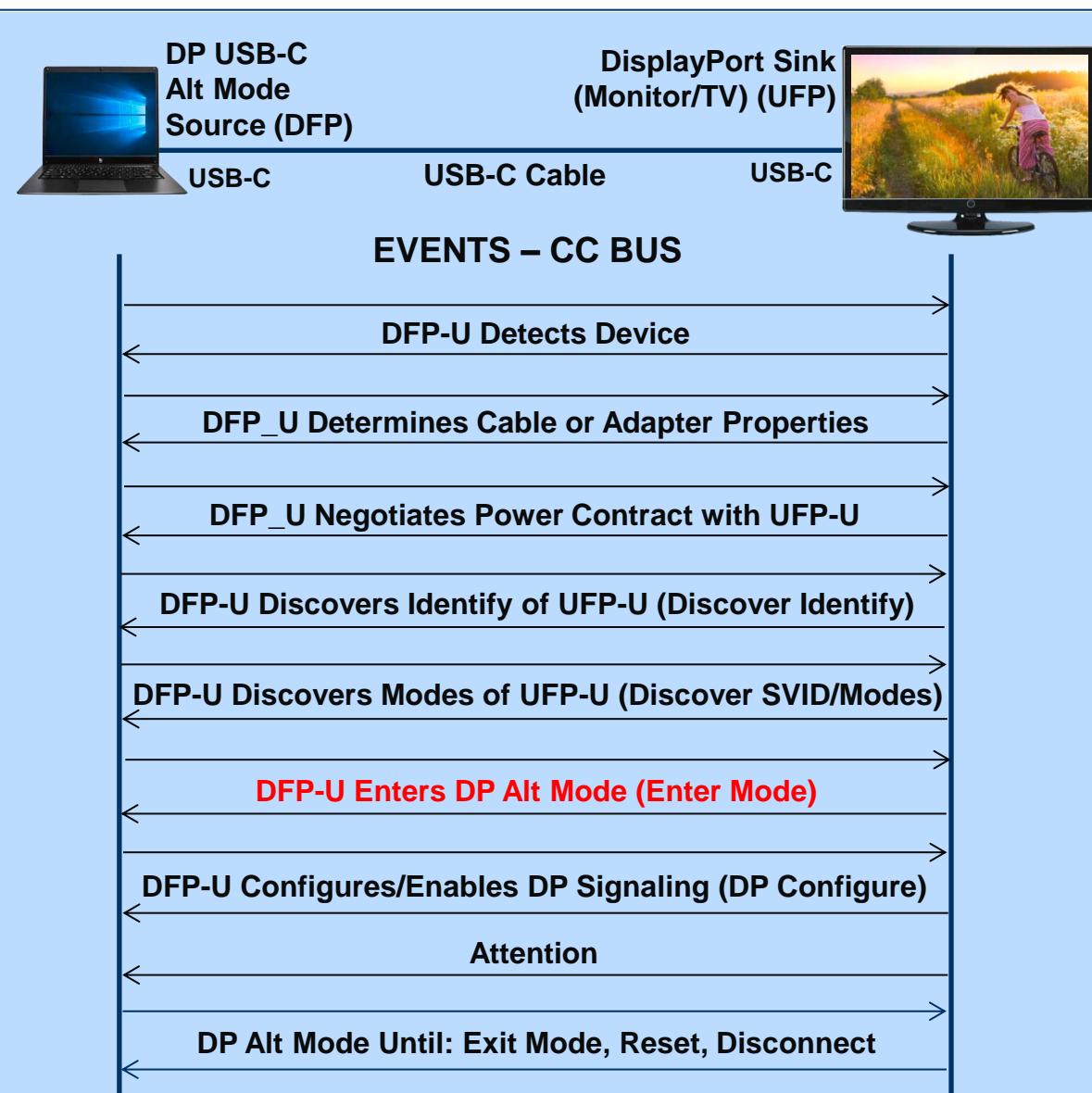
Power Delivery DP Alt Mode Protocol – Data Messages (Discover Modes)



◆ Discover Modes:



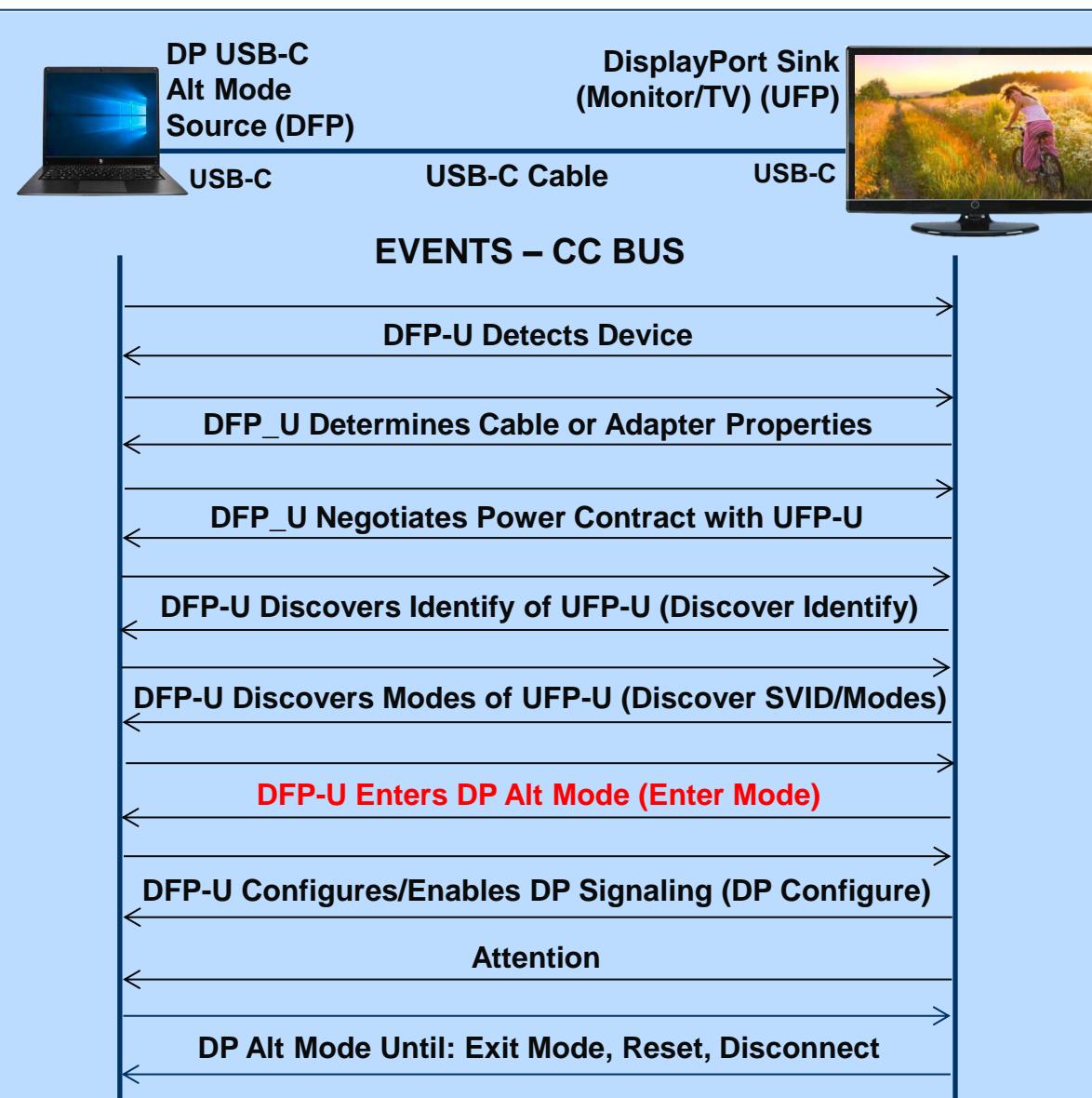
Power Delivery DP Alt Mode Protocol – Enter Messages (Enter Mode)



◆ Enter Mode:

- Used by DFP to cause the UFP to go into the proper alternate mode that was identified during the Discover Modes command, i.e. the UFP_D mode.
- Starts the communication for the specific set of commands for a particular alternate mode (e.g. DP Alt Mode).
- Timeout is 25 msec.

Power Delivery DP Alt Mode Protocol – Enter Messages (Enter Mode)



◆ Enter Mode:

ACA Data Viewer

[AA_980-USB-to-LMon-USB_w-PSV.CBL] Events: 416

Index	Event Type	Timestamp	Description
0	DPHP	+69:49:57.040950	HPD Falling Edge
1	PDVDM	+69:49:58.375607	'PRT:0 Discover Identity
2	PDCTL	+69:49:58.376363	'CBL:0 GoodCRC
3	PDVDM	+69:49:58.378497	'CBL:0 ACK Discover Identity
4	PDCTL	+69:49:58.379712	'PRT:0 GoodCRC
5	PDDTA	+69:49:58.380969	SRC:0 Source_Capabilities
6	PDCTL	+69:49:58.381662	SNK:0 GoodCRC
7	PDDTA	+69:49:58.382411	SNK:0 Request
8	PDCTL	+69:49:58.383112	SRC:0 GoodCRC
9	PDCTL	+69:49:58.384599	SRC:1 Accept
10	PDCTL	+69:49:58.385162	SNK:1 GoodCRC
11	PDCTL	+69:49:58.414898	SRC:2 PS_RDY
12	PDCTL	+69:49:58.415460	SNK:2 GoodCRC
13	PDCTL	+69:49:58.416481	SNK:1 PR_Swap
14	PDCTL	+69:49:58.417031	SRC:1 GoodCRC
15	PDCTL	+69:49:58.418538	SRC:3 Reject
16	PDCTL	+69:49:58.419094	SNK:3 GoodCRC
17	PDVDM	+69:49:58.429721	SRC:4 Discover Identity
18	PDCTL	+69:49:58.430407	SNK:4 GoodCRC
19	PDVDM	+69:49:58.431054	SNK:2 ACK Discover Identity
20	PDCTL	+69:49:58.432141	SRC:2 GoodCRC
21	PDVDM	+69:49:58.433641	SRC:5 Discover SVIDs
22	PDCTL	+69:49:58.434334	SNK:5 GoodCRC
23	PDVDM	+69:49:58.435001	SNK:3 ACK Discover SVIDs
24	PDCTL	+69:49:58.435815	SRC:3 GoodCRC
25	PDVDM	+69:49:58.437319	SRC:6 Discover Modes
26	PDCTL	+69:49:58.438012	SNK:6 GoodCRC
27	PDVDM	+69:49:58.438662	SNK:4 ACK Discover Modes
28	PDCTL	+69:49:58.439490	SRC:4 GoodCRC
29	PDVDM	+69:49:58.440166	SRC:7 Enter Mode 1
30	PDCTL	+69:49:58.441669	SNK:7 GoodCRC
31	PDVDM	+69:49:58.442360	SNK:5 ACK Enter Mode 1
32	PDCTL	+69:49:58.443055	SRC:5 GoodCRC
33	PDVDM	+69:49:58.443861	SRC:0 DP_Status_Update
34	PDCTL	+69:49:58.444679	SNK:0 GoodCRC
35	PDVDM	+69:49:58.445345	SNK:6 ACK DP_Status_Update
36	PDCTL	+69:49:58.446167	SRC:6 GoodCRC
37	PDVDM	+69:49:58.447667	SNK:1 DP_Configure
38	PDCTL	+69:49:58.448491	SRC:1 DP_Configure
39	PDVDM	+69:49:58.449292	SNK:7 ACK DP_Configure
40	PDCTL	+69:49:58.449981	SRC:7 GoodCRC

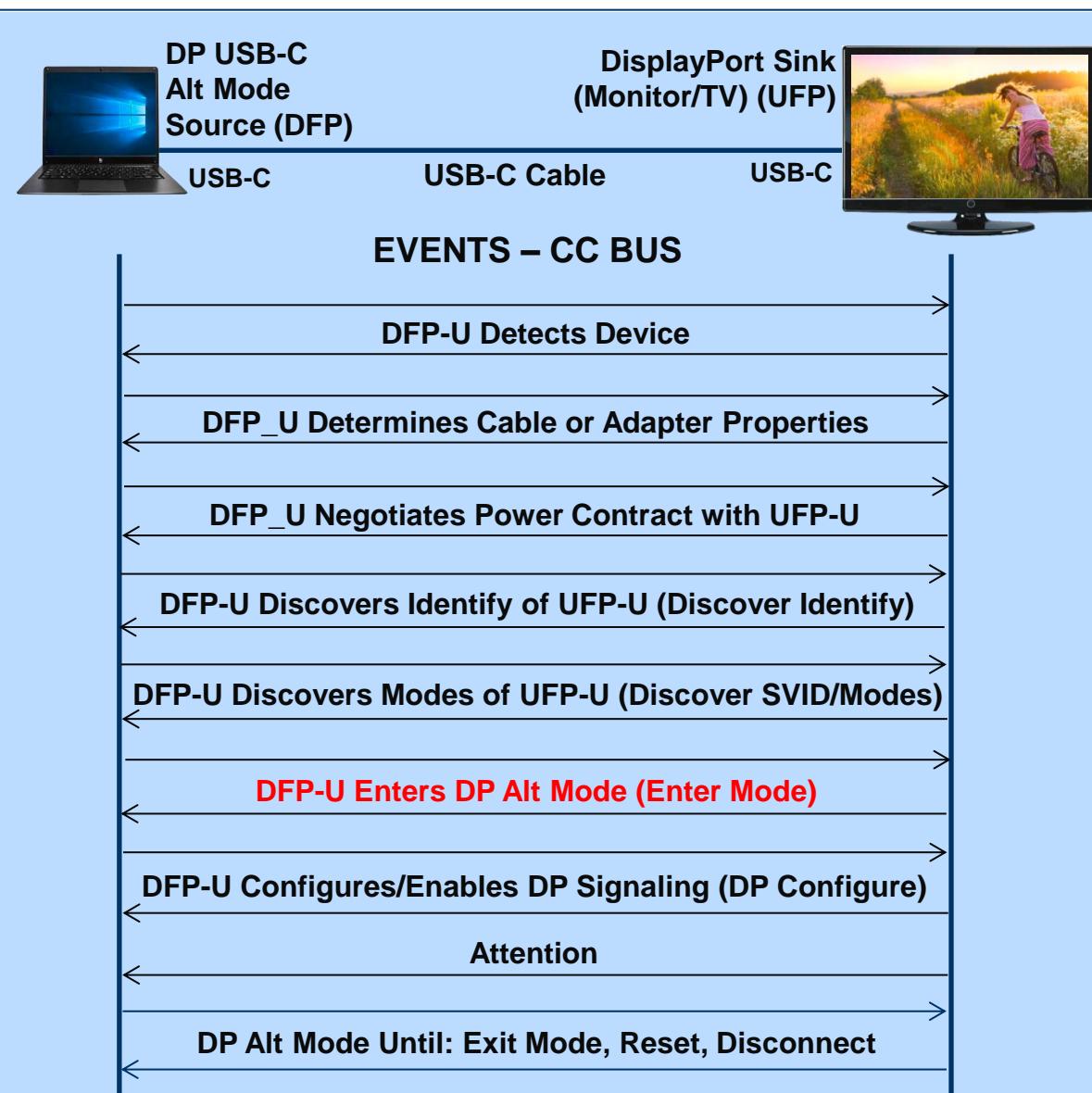
Start Time: +69:49:58.440990
 Start of Packet: SOP
 Message Type: Vendor_Defined
 MessageID: 7
 Port Power Role: Source
 Port Data Role: DFP
 Spec Revision: Revision 2.0
 Data Objects: 1

1) VDM Header
 SVID or VID : 0xFF01 (65281)
 VDM Type : Structured
 VDM Version : 1.0
 Object Position: 1
 Command Type : Initiator
 Command : Enter Mode

- Preamble: CC-1, 62, [Sync-1, Sync-1, Sync-1, Sync-2]
- Header: 1F6Fh
- Object 1: FF018104h
- CRC: F15C2453h
- EOP

29: SRC:7 Enter Mode 1

Power Delivery DP Alt Mode Protocol – Enter Messages (Enter Mode)



◆ Enter Mode:

ACA Data Viewer

[AA_980-USB-to-LMon-USB_w-PSV.CBL] Events: 416

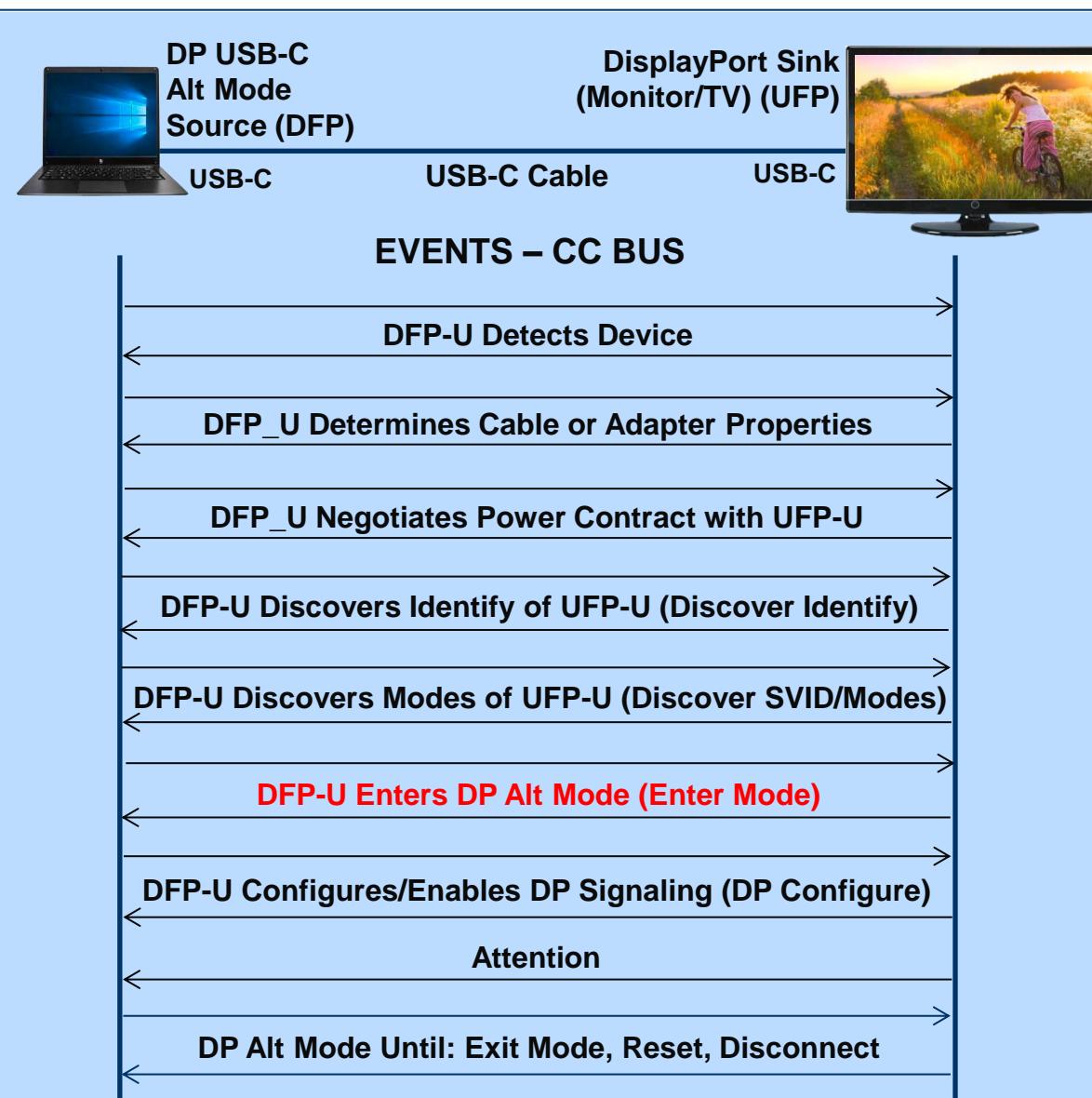
Index	Event Type	Timestamp	Description	
0	DPHP	61	+69:49:57.040950	HPD Falling Edge
1	PDVDM	61	+69:49:58.375607	'PRT:0 Discover Identity
2	PDCTL	61	+69:49:58.376363	'CBL:0 GoodCRC
3	PDVDM	61	+69:49:58.378497	'CBL:0 ACK Discover Identity
4	PDCTL	61	+69:49:58.379712	'PRT:0 GoodCRC
5	PDDTA	61	+69:49:58.380969	SRC:0 Source_Capabilities
6	PDCTL	61	+69:49:58.381662	SNK:0 GoodCRC
7	PDDTA	61	+69:49:58.382411	SNK:0 Request
8	PDCTL	61	+69:49:58.383112	SRC:0 GoodCRC
9	PDCTL	61	+69:49:58.384599	SRC:1 Accept
10	PDCTL	61	+69:49:58.385162	SNK:1 GoodCRC
11	PDCTL	61	+69:49:58.414898	SRC:2 PS_RDY
12	PDCTL	61	+69:49:58.415460	SNK:2 GoodCRC
13	PDCTL	61	+69:49:58.416481	SNK:1 PR_Swap
14	PDCTL	61	+69:49:58.417031	SRC:1 GoodCRC
15	PDCTL	61	+69:49:58.418538	SRC:3 Reject
16	PDCTL	61	+69:49:58.419094	SNK:3 GoodCRC
17	PDVDM	61	+69:49:58.429721	SRC:4 Discover Identity
18	PDCTL	61	+69:49:58.430407	SNK:4 GoodCRC
19	PDVDM	61	+69:49:58.431054	SNK:2 ACK Discover Identity
20	PDCTL	61	+69:49:58.432141	SRC:2 GoodCRC
21	PDVDM	61	+69:49:58.433641	SRC:5 Discover SVIDs
22	PDCTL	61	+69:49:58.434334	SNK:5 GoodCRC
23	PDVDM	61	+69:49:58.435001	SNK:3 ACK Discover SVIDs
24	PDCTL	61	+69:49:58.435815	SRC:3 GoodCRC
25	PDVDM	61	+69:49:58.437319	SRC:6 Discover Modes
26	PDCTL	61	+69:49:58.438012	SNK:6 GoodCRC
27	PDVDM	61	+69:49:58.438662	SNK:4 ACK Discover Modes
28	PDCTL	61	+69:49:58.439490	SRC:4 GoodCRC
29	PDVDM	61	+69:49:58.440990	SRC:7 Enter Mode 1
30	PDCTL	61	+69:49:58.441620	SNK:7 GoodCRC
31	PDVDM	61	+69:49:58.442000	SNK:5 ACK Enter Mode 1
32	PDCTL	61	+69:49:58.443054	SRC:5 GoodCRC
33	PDVDM	61	+69:49:58.443861	SRC:0 DP_Status_Update
34	PDCTL	61	+69:49:58.444679	SNK:0 GoodCRC
35	PDVDM	61	+69:49:58.445345	SNK:6 ACK DP_Status_Update
36	PDCTL	61	+69:49:58.446167	SRC:6 GoodCRC
37	PDVDM	61	+69:49:58.447667	SRC:1 DP_Configure
38	PDCTL	61	+69:49:58.448491	SNK:1 GoodCRC
39	PDVDM	61	+69:49:58.449292	SNK:7 ACK DP_Configure
40	PDCTL	61	+69:49:58.449981	SRC:7 GoodCRC

Start Time: +69:49:58.442360
 Start of Packet: SOP
 Message Type: Vendor_Defined
 MessageID: 5
 Port Power Role: Sink
 Port Data Role: UFP
 Spec Revision: Revision 2.0
 Data Objects: 1

1) VDM Header
 SVID or VID : 0xFF01 (65281)
 VDM Type : Structured
 VDM Version : 1.0
 Object Position: 1
 Command Type : ACK
 Command : Enter Mode

- Preamble: CC-1, 63, [Sync-1, Sync-1, Sync-1, Sync-2]
- Header: 1A4Fh
- Object 1: FF018144h
- CRC: A504F628h
- EOP

Power Delivery DP Alt Mode Protocol – Enter Messages (Enter Mode)



◆ Enter Mode:

ACA Data Viewer

[AA_980-USB-to-LMon-USB_w-PSV-CBL] Events: 416

Start Time: +00:00:00.000000
Start of Packet: SOP
Message Type: Vendor_Defined
MessageID: 7
Port Power Role: Source
Port Data Role: DFP
Spec Revision: Revision 2.0
Data Objects: 1

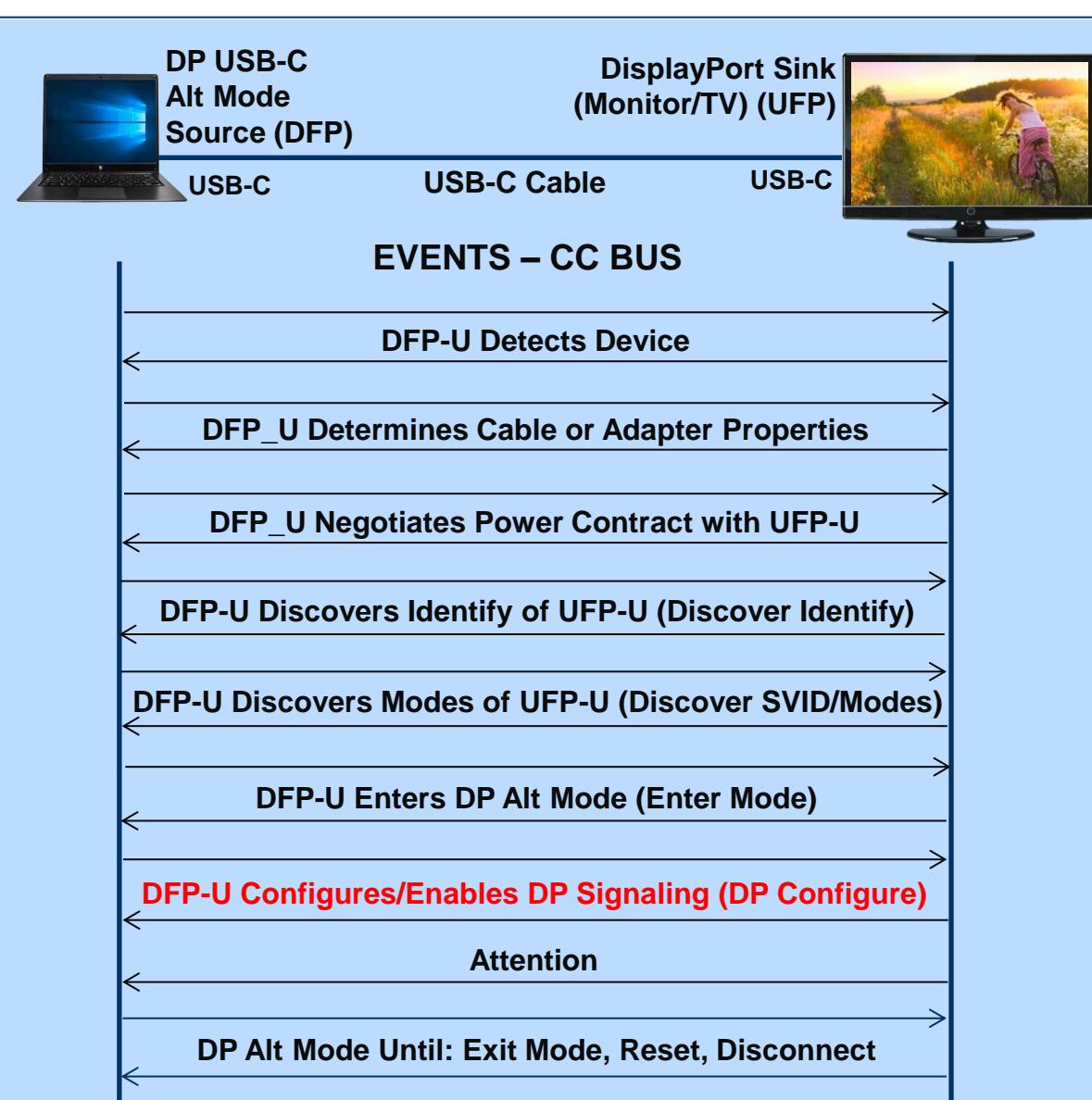
1) VDM Header
SVID or VID : 0xFF01 (65281)
VDM Type : Structured
VDM Version : 1.0
Object Position: 1
Command Type : Initiator
Command : Enter Mode

- Preamble: CC-1, 62, [Sync-1,Sync-1,Sync-1,Sync-2]
- Header: 1F6Fh
- Object 1: FF018104h
- CRC: F15C2453h
- EOP

Index	Type	Value	Description
10	PDCTL	61	+00:00:00.055828 SNK:1 GoodCRC
11	PDCTL	61	+00:00:00.026092 SRC:2 PS_RDY
12	PDCTL	61	+00:00:00.025530 SNK:2 GoodCRC
13	PDCTL	61	+00:00:00.024509 SNK:1 PR_Swap
14	PDCTL	61	+00:00:00.023959 SRC:1 GoodCRC
15	PDCTL	61	+00:00:00.022452 SRC:3 Reject
16	PDCTL	61	+00:00:00.021896 SNK:3 GoodCRC
17	PDVDM	61	+00:00:00.011269 SRC:4 Discover Identity
18	PDCTL	61	+00:00:00.010583 SNK:4 GoodCRC
19	PDVDM	61	+00:00:00.009936 SNK:2 ACK Discover Identity
20	PDCTL	61	+00:00:00.008849 SRC:2 GoodCRC
21	PDVDM	61	+00:00:00.007349 SRC:5 Discover SVIDs
22	PDCTL	61	+00:00:00.006656 SNK:5 GoodCRC
23	PDVDM	61	+00:00:00.005989 SNK:3 ACK Discover SVIDs
24	PDCTL	61	+00:00:00.005175 SRC:3 GoodCRC
25	PDVDM	61	+00:00:00.003671 SRC:6 Discover Modes
26	PDCTL	61	+00:00:00.002978 SNK:6 GoodCRC
27	PDVDM	61	+00:00:00.002328 SNK:4 ACK Discover Modes
28	PDCTL	61	+00:00:00.001500 SRC:4 GoodCRC
29	I	61	+00:00:00.000000 SRC:7 Enter Mode 1
30	PDCTL	61	+00:00:00.000679 SNK:7 GoodCRC
31	PDVDM	61	+00:00:00.001370 SNK:5 ACK Enter Mode 1
32	PDCTL	61	+00:00:00.002065 SRC:5 GoodCRC
33	PDVDM	61	+00:00:00.002871 SRC:0 DP_Status_Update
34	PDCTL	61	+00:00:00.003689 SNK:0 GoodCRC
35	PDVDM	61	+00:00:00.004355 SNK:6 ACK DP_Status_Update
36	PDCTL	61	+00:00:00.005177 SRC:6 GoodCRC
37	PDVDM	61	+00:00:00.006677 SRC:1 DP_Configure
38	PDCTL	61	+00:00:00.007501 SNK:1 GoodCRC
39	PDVDM	61	+00:00:00.008302 SNK:7 ACK DP_Configure
40	PDCTL	61	+00:00:00.008991 SRC:7 GoodCRC
41	PDVDM	61	+00:00:00.010320 SNK:0 Attention 1
42	PDCTL	61	+00:00:00.011135 SRC:0 GoodCRC
43	DPHP	61	+00:00:00.014996 HPD Rising Edge
44	DNAT	61	+00:00:00.015790 > R:200 SINK_COUNT L=6

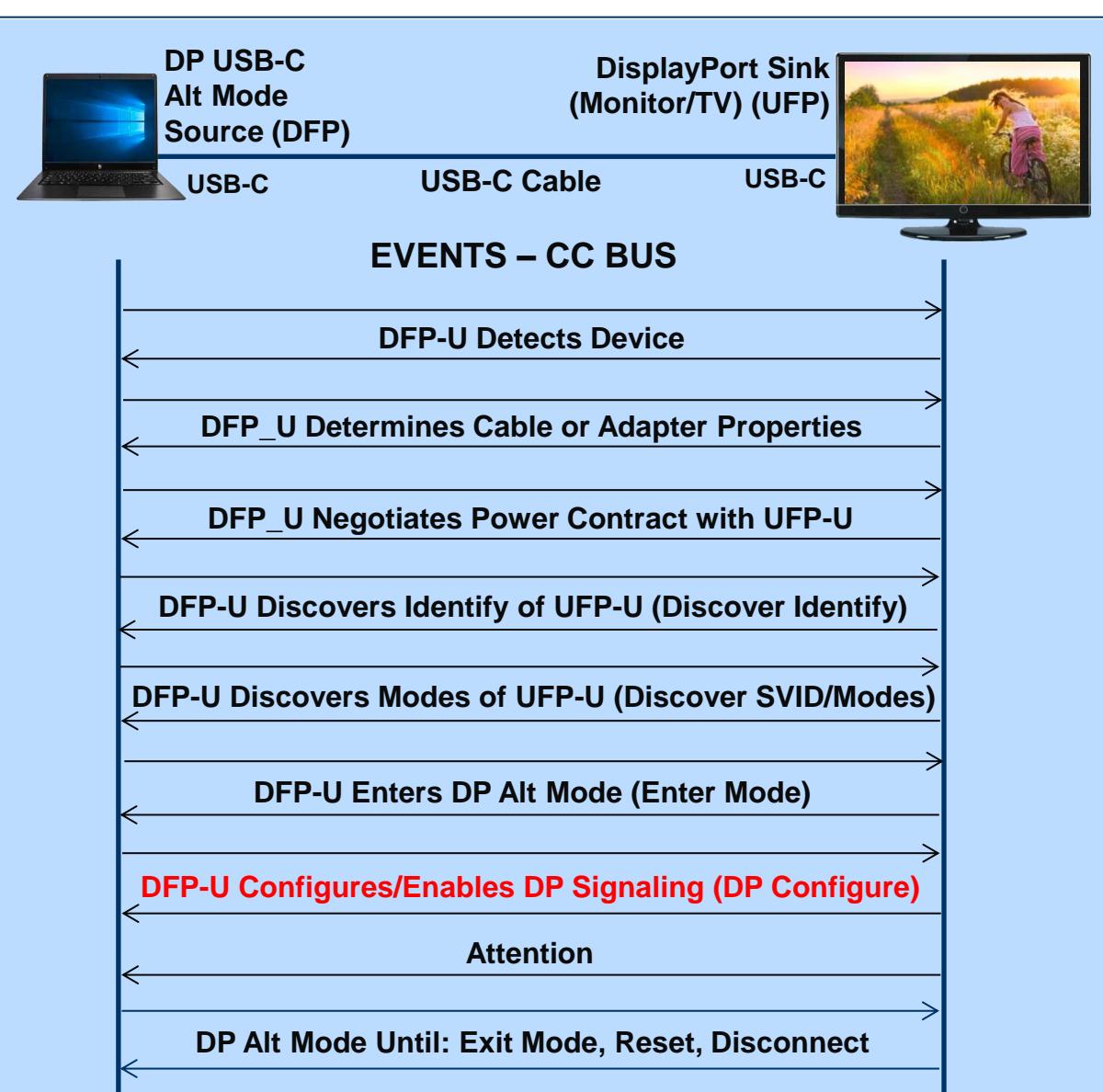
29: SRC:7 Enter Mode 1

Power Delivery DP Alt Mode Protocol – DisplayPort Alt Mode Messages



- ◆ DisplayPort Status Update Message:
 - ◆ Send by Initiator (DFP) to inform connected device what its status is and request status from the connected device (UFP).
 - ◆ Example shows Source is in the DFP_D mode Sink is in UFP_D mode.

Power Delivery DP Alt Mode Protocol – DisplayPort Alt Mode Messages



◆ DisplayPort Status Update Message:

ACA Data Viewer

[AA_980-USB-to-LMon-USB_w-PSV.CBL] Events: 416

Index	Event Type	Value	Description
0	DPHP	61	+69:49:57.040950
1	PDVDM	61	+69:49:58.375607
2	PDCTL	61	+69:49:58.376363
3	PDVDM	61	+69:49:58.378497
4	PDCTL	61	+69:49:58.379712
5	PDDTA	61	+69:49:58.380969
6	PDCTL	61	+69:49:58.381662
7	PDDTA	61	+69:49:58.382411
8	PDCTL	61	+69:49:58.383112
9	PDCTL	61	+69:49:58.384599
10	PDCTL	61	+69:49:58.385162
11	PDCTL	61	+69:49:58.414898
12	PDCTL	61	+69:49:58.415460
13	PDCTL	61	+69:49:58.416481
14	PDCTL	61	+69:49:58.417031
15	PDCTL	61	+69:49:58.418538
16	PDCTL	61	+69:49:58.419094
17	PDVDM	61	+69:49:58.429721
18	PDCTL	61	+69:49:58.430407
19	PDVDM	61	+69:49:58.431054
20	PDCTL	61	+69:49:58.432141
21	PDVDM	61	+69:49:58.433641
22	PDCTL	61	+69:49:58.434334
23	PDVDM	61	+69:49:58.435001
24	PDCTL	61	+69:49:58.435815
25	PDVDM	61	+69:49:58.437319
26	PDCTL	61	+69:49:58.438012
27	PDVDM	61	+69:49:58.438662
28	PDCTL	61	+69:49:58.439490
29	PDVDM	61	+69:49:58.440990
30	PDCTL	61	+69:49:58.441669
31	PDVDM	61	+69:49:58.442360
32	PDCTL	61	+69:49:58.443055
33	PDVDM	61	+69:49:58.444679
34	PDCTL	61	+69:49:58.444679
35	PDVDM	61	+69:49:58.445345
36	PDCTL	61	+69:49:58.446167
37	PDVDM	61	+69:49:58.447667
38	PDCTL	61	+69:49:58.448491
39	PDVDM	61	+69:49:58.449292
40	PDCTL	61	+69:49:58.449981

Start Time: +69:49:58.443861
Start of Packet: SOP
Message Type: Vendor_Defined
MessageID: 0
Port Power Role: Source
Port Data Role: DFP
Spec Revision: Revision 2.0
Data Objects: 2

1) VDM Header
SVID or VID : 0xFF01 (65281)
VDM Type : Structured
VDM Version : 1.0
Object Position: 1
Command Type : Initiator
Command : DP_Status_Update

DisplayPort Status Update
DFP_D/UFP_D Connected : DFP_D
Power Low : No
Enabled : No
Multi-function Preferred: No
USB Config Request : No
Exit DP Mode Request : No
HDP State : Low
IRQ_HPD : No

- Preamble: CC-1, 62, [Sync-1, Sync-1, Sync-1, Sync-2]
- Header: 216Fh
- Object 1: FF018110h
- Object 2: 00000001h
- CRC: BDB2024Ah
- EOP

33: SRC:0 DP_Status_Update

Power Delivery DP Alt Mode Protocol – DisplayPort Alt Mode Messages



◆ DisplayPort Status Update Message:

ACA Data Viewer

[AA_980-USB-to-LMon-USB_w-PSV.CBL] Events: 416

Index	Object	Value	Timestamp	Message
0	DPHP	61	+69:49:57.040950	'HPD Falling Edge
1	PDVDM	61	+69:49:58.375607	'PRT:0 Discover Identity
2	PDCTL	61	+69:49:58.376363	'CBL:0 GoodCRC
3	PDVDM	61	+69:49:58.378497	'CBL:0 ACK Discover Identity
4	PDCTL	61	+69:49:58.379712	'PRT:0 GoodCRC
5	PDDTA	61	+69:49:58.380969	SRC:0 Source_Capabilities
6	PDCTL	61	+69:49:58.381662	SNK:0 GoodCRC
7	PDDTA	61	+69:49:58.382411	SNK:0 Request
8	PDCTL	61	+69:49:58.383112	SRC:0 GoodCRC
9	PDCTL	61	+69:49:58.384599	SRC:1 Accept
10	PDCTL	61	+69:49:58.385162	SNK:1 GoodCRC
11	PDCTL	61	+69:49:58.414898	SRC:2 PS_RDY
12	PDCTL	61	+69:49:58.415460	SNK:2 GoodCRC
13	PDCTL	61	+69:49:58.416481	SNK:1 PR_Swap
14	PDCTL	61	+69:49:58.417031	SRC:1 GoodCRC
15	PDCTL	61	+69:49:58.418538	SRC:3 Reject
16	PDVDM	61	+69:49:58.419094	SNK:3 GoodCRC
17	PDVDM	61	+69:49:58.429721	SRC:4 Discover Identity
18	PDCTL	61	+69:49:58.430407	SNK:4 GoodCRC
19	PDVDM	61	+69:49:58.431054	SNK:2 ACK Discover Identity
20	PDCTL	61	+69:49:58.432141	SRC:2 GoodCRC
21	PDVDM	61	+69:49:58.433641	SRC:5 Discover SVIDs
22	PDCTL	61	+69:49:58.434334	SNK:5 GoodCRC
23	PDVDM	61	+69:49:58.435001	SNK:3 ACK Discover SVIDs
24	PDCTL	61	+69:49:58.435815	SRC:3 GoodCRC
25	PDVDM	61	+69:49:58.437319	SRC:6 Discover Modes
26	PDCTL	61	+69:49:58.438012	SNK:6 GoodCRC
27	PDVDM	61	+69:49:58.438662	SNK:4 ACK Discover Modes
28	PDCTL	61	+69:49:58.439490	SRC:4 GoodCRC
29	PDVDM	61	+69:49:58.440990	SRC:7 Enter Mode 1
30	PDCTL	61	+69:49:58.441669	SNK:7 GoodCRC
31	PDVDM	61	+69:49:58.442360	SNK:5 ACK Enter Mode 1
32	PDCTL	61	+69:49:58.443055	SRC:5 GoodCRC
33	PDVDM	61	+69:49:58.443861	SRC:0 DP_Status_Update
34	PDCTL	61	+69:49:58.444679	SNK:0 GoodCRC
35	PDVDM	61	+69:49:58.445151	SNK:6 ACK DP_Status_Update
36	PDCTL	61	+69:49:58.446167	SRC:6 GoodCRC
37	PDVDM	61	+69:49:58.447667	SRC:1 DP_Configure
38	PDCTL	61	+69:49:58.448491	SNK:1 GoodCRC
39	PDVDM	61	+69:49:58.449292	SNK:7 ACK DP_Configure
40	PDCTL	61	+69:49:58.449981	SRC:7 GoodCRC

Start Time: +69:49:58.445345

Start of Packet: SOP

Message Type: Vendor_Defined

MessageID: 6

Port Power Role: Sink

Port Data Role: UFP

Spec Revision: Revision 2.0

Data Objects: 2

1) VDM Header

SVID or VID : 0xFF01 (65281)
VDM Type : Structured
VDM Version : 1.0
Object Position: 1
Command Type : ACK
Command : DP_Status_Update

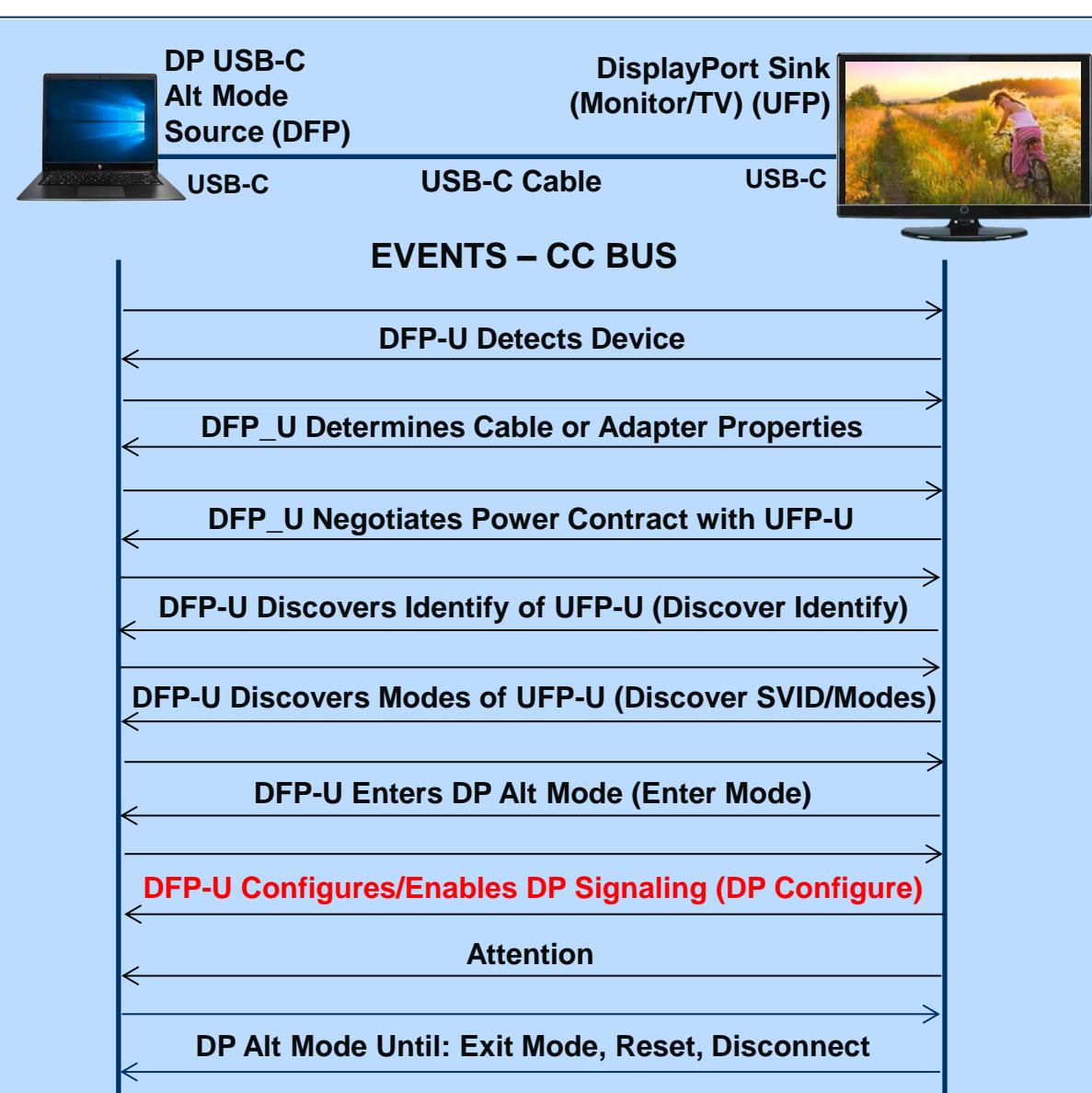
DisplayPort Status Update

DFP_D/UFP_D Connected : UFP_D
Power Low : No
Enabled : Yes
Multi-function Preferred: No
USB Config Request : No
Exit DP Mode Request : No
HDP State : Low
IRQ_HPD : No

- Preamble: CC-1, 63, [Sync-1, Sync-1, Sync-1, Sync-2]
- Header: 2C4Fh
- Object 1: FF018150h
- Object 2: 000000Ah
- CRC: FD3CA321h
- EOP

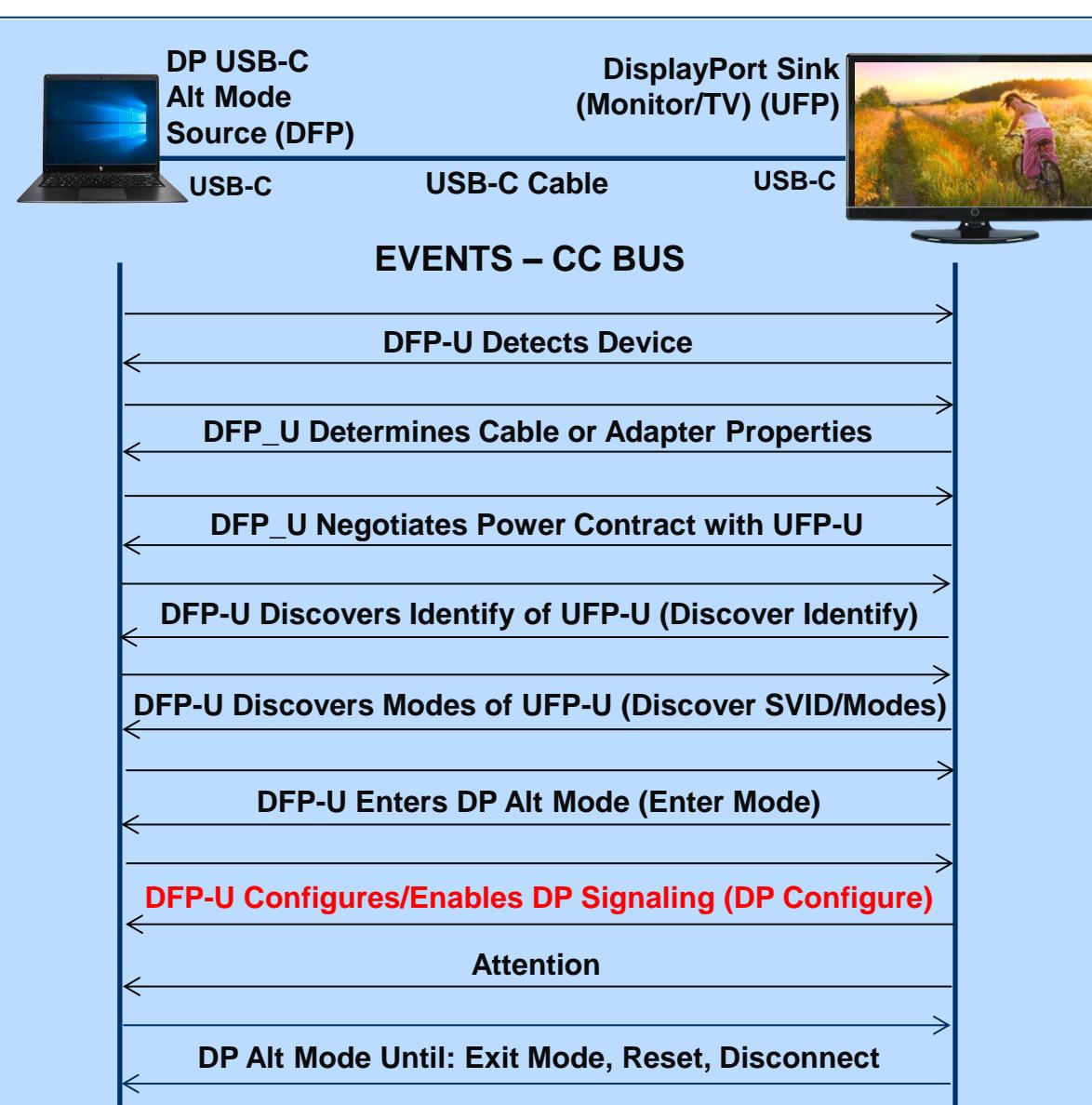
35: SNK:6 ACK DP_Status_Update

Power Delivery DP Alt Mode Protocol – DisplayPort Alt Mode Messages



- ◆ **DisplayPort Configuration Message:**
 - ◆ Sets DFP and UFP in DisplayPort Alt Mode using DisplayPort signaling on its USB-C leads.
 - ◆ Example uses Pin Assignment D.
 - ◆ Commands UFP-U to go into UFP_D.
 - ◆ Connects Sideband Use for Aux Channel.
 - ◆ Optionally, places DFP and UFP in Multi-Function mode with USB Super Speed mode.

Power Delivery DP Alt Mode Protocol – DisplayPort Alt Mode Messages



◆ DisplayPort Configuration Message:

DisplayPort Configuration Message:

The screenshot shows the ACD Data Viewer interface displaying a list of events for the message. The message details are as follows:

- Start Time: +69:49:58.447667
- Start of Packet: SOP
- Message Type: Vendor_Defined
- MessageID: 1
- Port Power Role: Source
- Port Data Role: DFP
- Spec Revision: Revision 2.0
- Data Objects: 2

VDM Header

- SVID or VID : 0xFF01 (65281)
- VDM Type : Structured
- VDM Version : 1.0
- Object Position: 1
- Command Type : Initiator
- Command : DP_Configure

DisplayPort Configuration

- Select Configuration : UFP_U as UFP_D
- Signaling for Transport: DP v1.3
- UFP_U/DP_D Pin Assign : C
- UFP_U/UFP_D Pin Assign : De-select DFP_D pin assignment

Preamble: CC-1, 63, [Sync-1, Sync-1, Sync-1, Sync-2]

Header: 236Fh

Object 1: FF01811h

Object 2: 00000406h

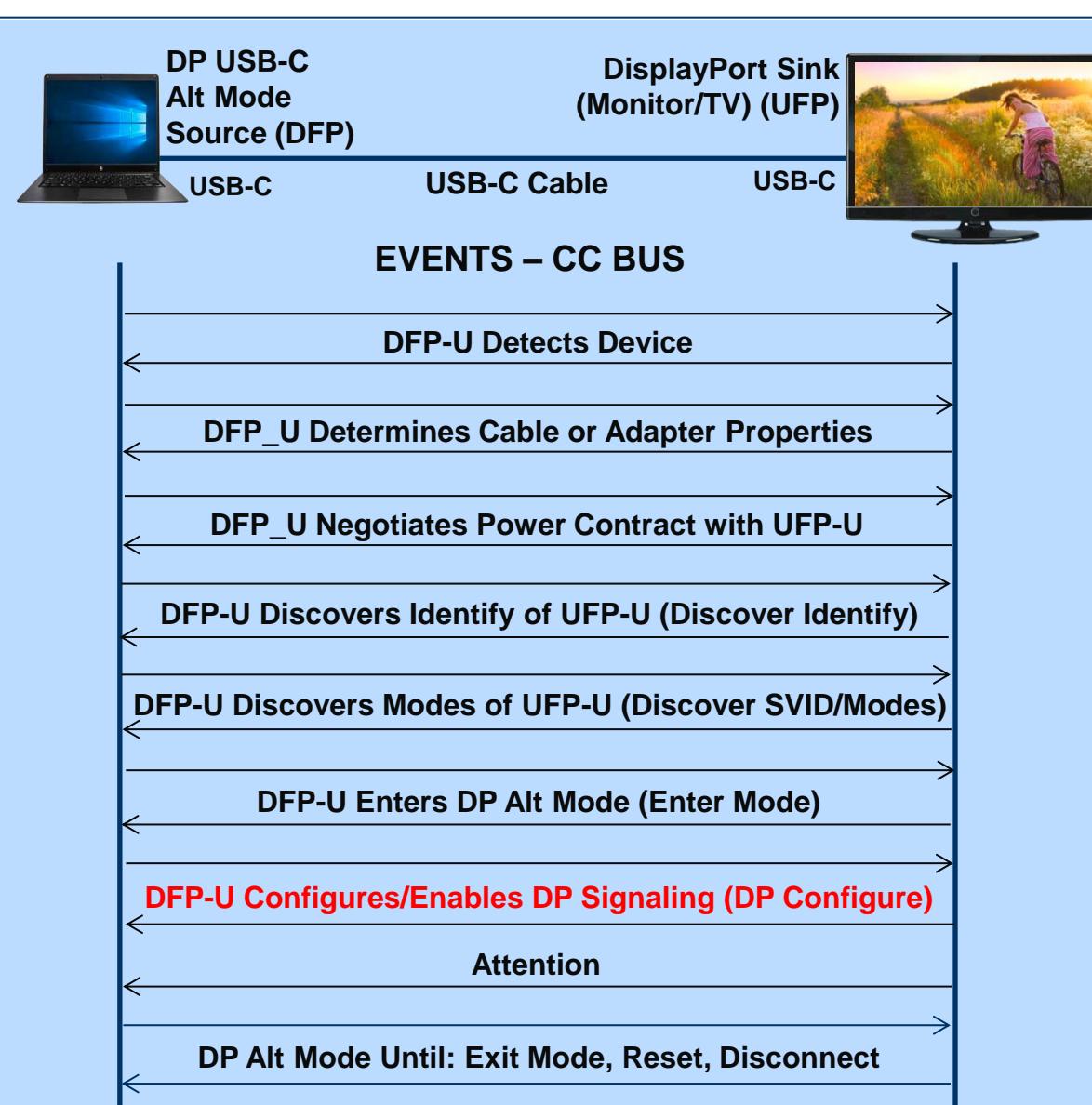
CRC: C530BA37h

EOP:

Event Log (Events: 416):

- 0: DPHP 61 +69:49:57.040950
- 1: PDVDM 61 +69:49:58.375607
- 2: PDCTL 61 +69:49:58.376363
- 3: PDVDM 61 +69:49:58.378497
- 4: PDCTL 61 +69:49:58.379712
- 5: PDDTA 61 +69:49:58.380969
- 6: PDCTL 61 +69:49:58.381662
- 7: PDDTA 61 +69:49:58.382411
- 8: PDCTL 61 +69:49:58.383112
- 9: PDCTL 61 +69:49:58.384599
- 10: PDCTL 61 +69:49:58.385162
- 11: PDCTL 61 +69:49:58.414898
- 12: PDCTL 61 +69:49:58.415460
- 13: PDCTL 61 +69:49:58.416481
- 14: PDCTL 61 +69:49:58.417031
- 15: PDCTL 61 +69:49:58.418538
- 16: PDCTL 61 +69:49:58.419094
- 17: PDVDM 61 +69:49:58.429721
- 18: PDCTL 61 +69:49:58.430407
- 19: PDVDM 61 +69:49:58.431054
- 20: PDCTL 61 +69:49:58.432141
- 21: PDVDM 61 +69:49:58.433641
- 22: PDCTL 61 +69:49:58.434334
- 23: PDVDM 61 +69:49:58.435001
- 24: PDCTL 61 +69:49:58.435815
- 25: PDVDM 61 +69:49:58.437319
- 26: PDCTL 61 +69:49:58.438012
- 27: PDVDM 61 +69:49:58.438662
- 28: PDCTL 61 +69:49:58.439490
- 29: PDVDM 61 +69:49:58.440990
- 30: PDCTL 61 +69:49:58.441669
- 31: PDVDM 61 +69:49:58.442360
- 32: PDCTL 61 +69:49:58.443055
- 33: PDVDM 61 +69:49:58.443861
- 34: PDCTL 61 +69:49:58.444679
- 35: PDVDM 61 +69:49:58.445345
- 36: PDCTL 61 +69:49:58.446167
- 37: PDVDM 61 +69:49:58.448493
- 38: PDCTL 61 +69:49:58.449292
- 39: PDVDM 61 +69:49:58.449981
- 40: PDCTL 61 +69:49:58.449981

Power Delivery DP Alt Mode Protocol – DisplayPort Alt Mode Messages



◆ DisplayPort Configuration Message:

ACA Data Viewer [AA_980-USB-to-LMon-USB_w-PSV-CBL] Events: 416

Index	Role	Object ID	Time	Message
0	DPHP	61	+69:49:57.040950	HPD Falling Edge
1	PDVDM	61	+69:49:58.375607	'PRT:0 Discover Identity
2	PDCTL	61	+69:49:58.376363	'CBL:0 GoodCRC
3	PDVDM	61	+69:49:58.378497	'CBL:0 ACK Discover Identity
4	PDCTL	61	+69:49:58.379712	'PRT:0 GoodCRC
5	PDDTA	61	+69:49:58.380969	SRC:0 Source_Capabilities
6	PDCTL	61	+69:49:58.381662	SNK:0 GoodCRC
7	PDDTA	61	+69:49:58.382411	SNK:0 Request
8	PDCTL	61	+69:49:58.383112	SRC:0 GoodCRC
9	PDCTL	61	+69:49:58.384599	SRC:1 Accept
10	PDCTL	61	+69:49:58.385162	SNK:1 GoodCRC
11	PDCTL	61	+69:49:58.414898	SRC:2 PS_RDY
12	PDCTL	61	+69:49:58.415460	SNK:2 GoodCRC
13	PDCTL	61	+69:49:58.416481	SNK:1 PR_Swap
14	PDCTL	61	+69:49:58.417031	SRC:1 GoodCRC
15	PDCTL	61	+69:49:58.418538	SRC:3 Reject
16	PDCTL	61	+69:49:58.419094	SNK:3 GoodCRC
17	PDVDM	61	+69:49:58.429721	SRC:4 Discover Identity
18	PDCTL	61	+69:49:58.430407	SNK:4 GoodCRC
19	PDVDM	61	+69:49:58.431054	SNK:2 ACK Discover Identity
20	PDCTL	61	+69:49:58.432141	SRC:2 GoodCRC
21	PDVDM	61	+69:49:58.433641	SRC:5 Discover SVIDs
22	PDCTL	61	+69:49:58.434334	SNK:5 GoodCRC
23	PDVDM	61	+69:49:58.435001	SNK:3 ACK Discover SVIDs
24	PDCTL	61	+69:49:58.435815	SRC:3 GoodCRC
25	PDVDM	61	+69:49:58.437319	SRC:6 Discover Modes
26	PDCTL	61	+69:49:58.438012	SNK:6 GoodCRC
27	PDVDM	61	+69:49:58.438662	SNK:4 ACK Discover Modes
28	PDCTL	61	+69:49:58.439490	SRC:4 GoodCRC
29	PDVDM	61	+69:49:58.440990	SRC:7 Enter Mode 1
30	PDCTL	61	+69:49:58.441669	SNK:7 GoodCRC
31	PDVDM	61	+69:49:58.442360	SNK:5 ACK Enter Mode 1
32	PDCTL	61	+69:49:58.443055	SRC:5 GoodCRC
33	PDVDM	61	+69:49:58.443861	SRC:0 DP_Status_Update
34	PDCTL	61	+69:49:58.444679	SNK:0 GoodCRC
35	PDVDM	61	+69:49:58.445345	SNK:6 ACK DP_Status_Update
36	PDCTL	61	+69:49:58.446167	SRC:6 GoodCRC
37	PDVDM	61	+69:49:58.447667	SRC:1 DP_Configure
38	PDCTL	61	+69:49:58.448401	SNK:1 GoodCRC
39	PDVDM	61	+69:49:58.449981	SNK:7 ACK DP_Configure
40	PDCTL	61	+69:49:58.449981	SRC:7 GoodCRC

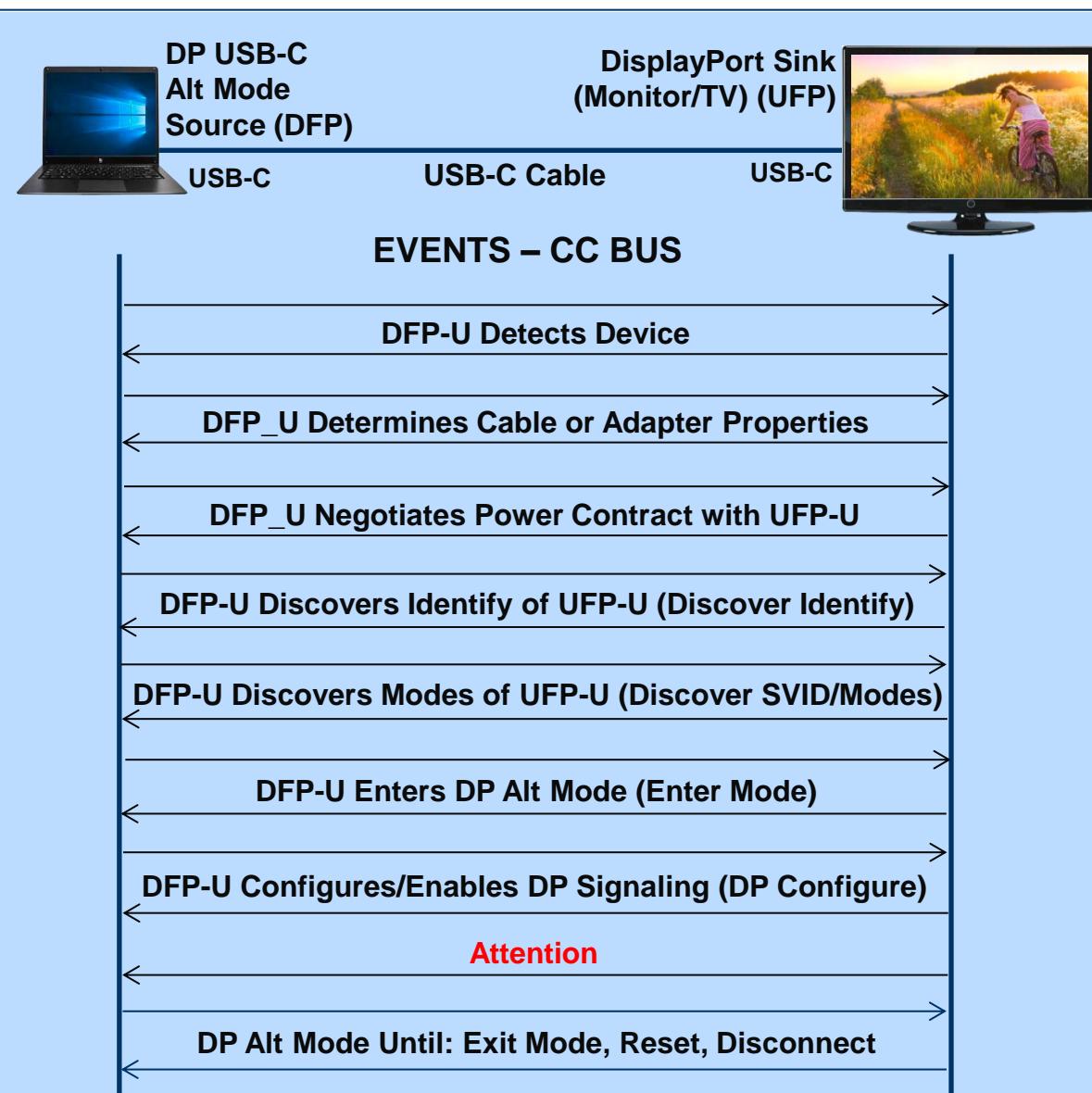
Start Time: +69:49:58.449292
Start of Packet: SOP
Message Type: Vendor_Defined
MessageID: 7
Port Power Role: Sink
Port Data Role: UFP
Spec Revision: Revision 2.0
Data Objects: 1

1) VDM Header
SVID or VID : 0xFF01 (65281)
VDM Type : Structured
VDM Version : 1.0
Object Position: 1
Command Type : ACK
Command : DP_Configure

- Preamble: CC-1, 63, [Sync-1,Sync-1,Sync-1,Sync-2]
- Header: 1E4Fh
- Object 1: FF018151h
- CRC: 3743F745h
- EOP

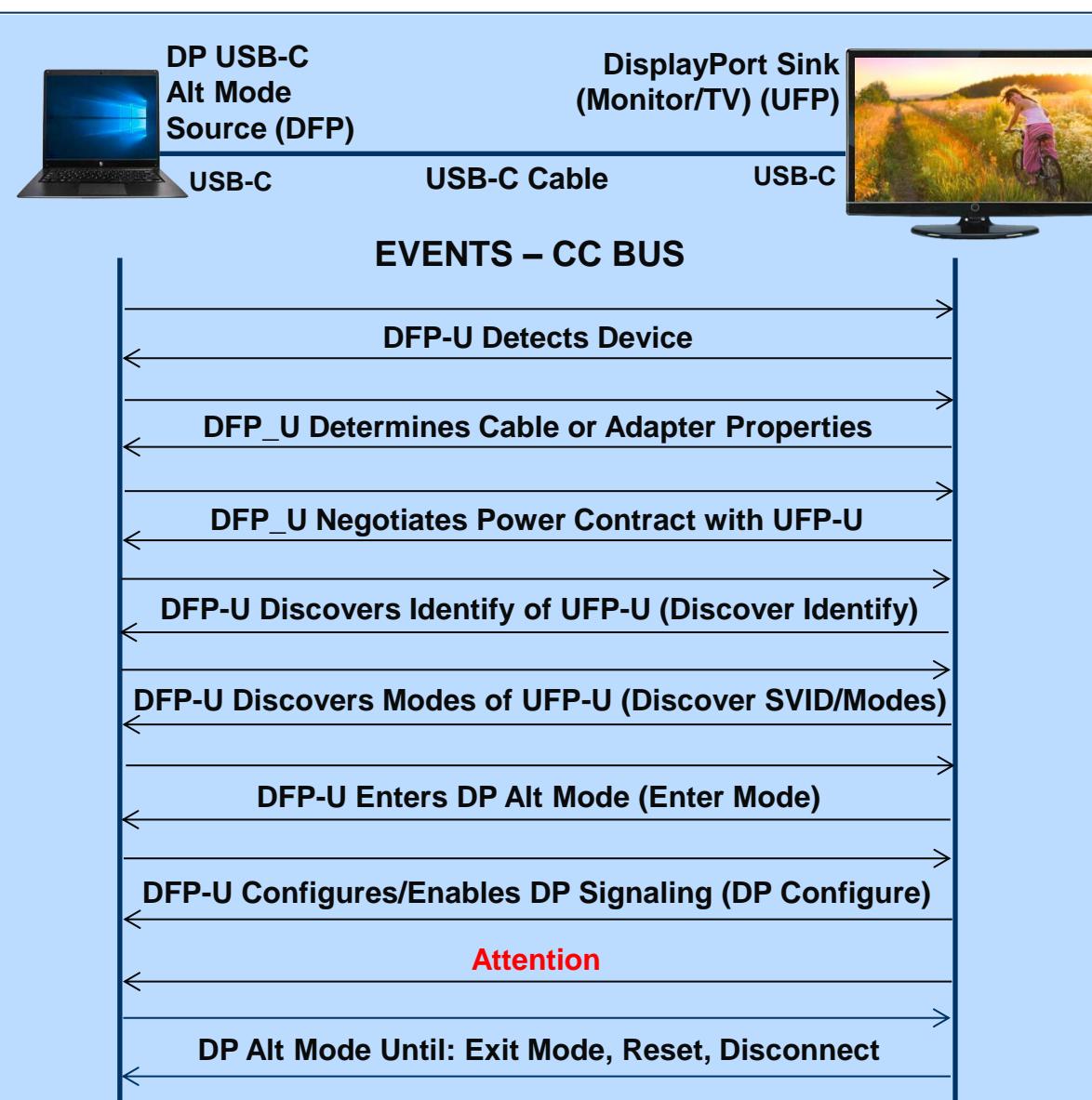
Option
Data
Filter
Find
Clear
Open
Export
Hide

Power Delivery DP Alt Mode Protocol – Attention Message



- ◆ DisplayPort Attention Message:
 - ◆ Sideband Use (SBU) is connected to support the DP Aux Chan.
 - ◆ Initiates the DisplayPort Link Training with HPD High. (Must receive a GoodCRC message.)
 - ◆ Enables an UFP to notify a DFP that there has been a status change downstream.
 - ◆ Exit DP Alt Mode request.

Power Delivery DP Alt Mode Protocol – Attention Message



◆ DisplayPort Attention Message:

ACA Data Viewer

[AA_980-USB-to-LMon-USB_w-PSV-CBL] Events: 416

Event ID	Event Type	Timestamp	Source	Message
15	PDCTL	61	+69:49:58.418538	SRC:3 Reject
16	PDCTL	61	+69:49:58.419094	SNK:3 GoodCRC
17	PDVDM	61	+69:49:58.429721	SRC:4 Discover Identity
18	PDCTL	61	+69:49:58.430407	SNK:4 GoodCRC
19	PDVDM	61	+69:49:58.431054	SNK:2 ACK Discover Identity
20	PDCTL	61	+69:49:58.432141	SRC:2 GoodCRC
21	PDVDM	61	+69:49:58.433641	SRC:5 Discover SVIDs
22	PDCTL	61	+69:49:58.434334	SNK:5 GoodCRC
23	PDVDM	61	+69:49:58.435001	SNK:3 ACK Discover SVIDs
24	PDCTL	61	+69:49:58.435815	SRC:3 GoodCRC
25	PDVDM	61	+69:49:58.437319	SRC:6 Discover Modes
26	PDCTL	61	+69:49:58.438012	SNK:6 GoodCRC
27	PDVDM	61	+69:49:58.438662	SNK:4 ACK Discover Modes
28	PDCTL	61	+69:49:58.439490	SRC:4 GoodCRC
29	PDVDM	61	+69:49:58.440990	SRC:7 Enter Mode 1
30	PDCTL	61	+69:49:58.441669	SNK:7 GoodCRC
31	PDVDM	61	+69:49:58.442360	SNK:5 ACK Enter Mode 1
32	PDCTL	61	+69:49:58.443055	SRC:5 GoodCRC
33	PDVDM	61	+69:49:58.443861	SRC:0 DP_Status_Update
34	PDCTL	61	+69:49:58.44467	SNK:0 GoodCRC
35	PDVDM	61	+69:49:58.44501	SNK:6 ACK DP_Status_Update
36	PDCTL	61	+69:49:58.44561	SRC:6 GoodCRC
37	PDVDM	61	+69:49:58.447667	SRC:1 DP_Configure
38	PDCTL	61	+69:49:58.448491	SNK:1 GoodCRC
39	PDVDM	61	+69:49:58.449292	SNK:7 ACK DP_Configure
40	PDCTL	61	+69:49:58.449981	SRC:7 GoodCRC
41	PDVDM	61	+69:49:58.451310	SNK:0 Attention 1
42	PDCTL	61	+69:49:58.452125	SRC:0 GoodCRC
43	DHDP	61	+69:49:58.455986	HPD Rising Edge
44	DNAT	61	+69:49:58.456780	> R:200 SINK_COUNT L=6
45	DNAT	61	+69:49:58.456849	< ACK 41 00 00 00 80 00
46	DNAT	61	+69:49:58.456984	> R:E TRAINING_AUX_RD_INTE...
47	DNAT	61	+69:49:58.457052	< ACK 00
48	DNAT	61	+69:49:58.457120	> R:0 DPCD_REV L=1
49	DNAT	61	+69:49:58.457188	< ACK 12
50	DNAT	61	+69:49:58.457257	> R:0 DPCD_REV L=16
51	DNAT	61	+69:49:58.457326	< ACK 12 14 C2 01 01 00 01...
52	DNAT	61	+69:49:58.457533	> R:0 FEC_CAPABILITY L=1
53	DNAT	61	+69:49:58.457601	< ACK 00
54	DNAT	61	+69:49:58.457670	> R:60 DSC_SUPPORT L=15
55	DNAT	61	+69:49:58.457740	< ACK 00 00 00 00 00 00 00...

Start Time: +69:49:58.445345
 Start of Packet: SOP
 Message Type: Vendor_Defined
 MessageID: 6
 Port Power Role: Sink
 Port Data Role: UFP
 Spec Revision: Revision 2.0
 Data Objects: 2

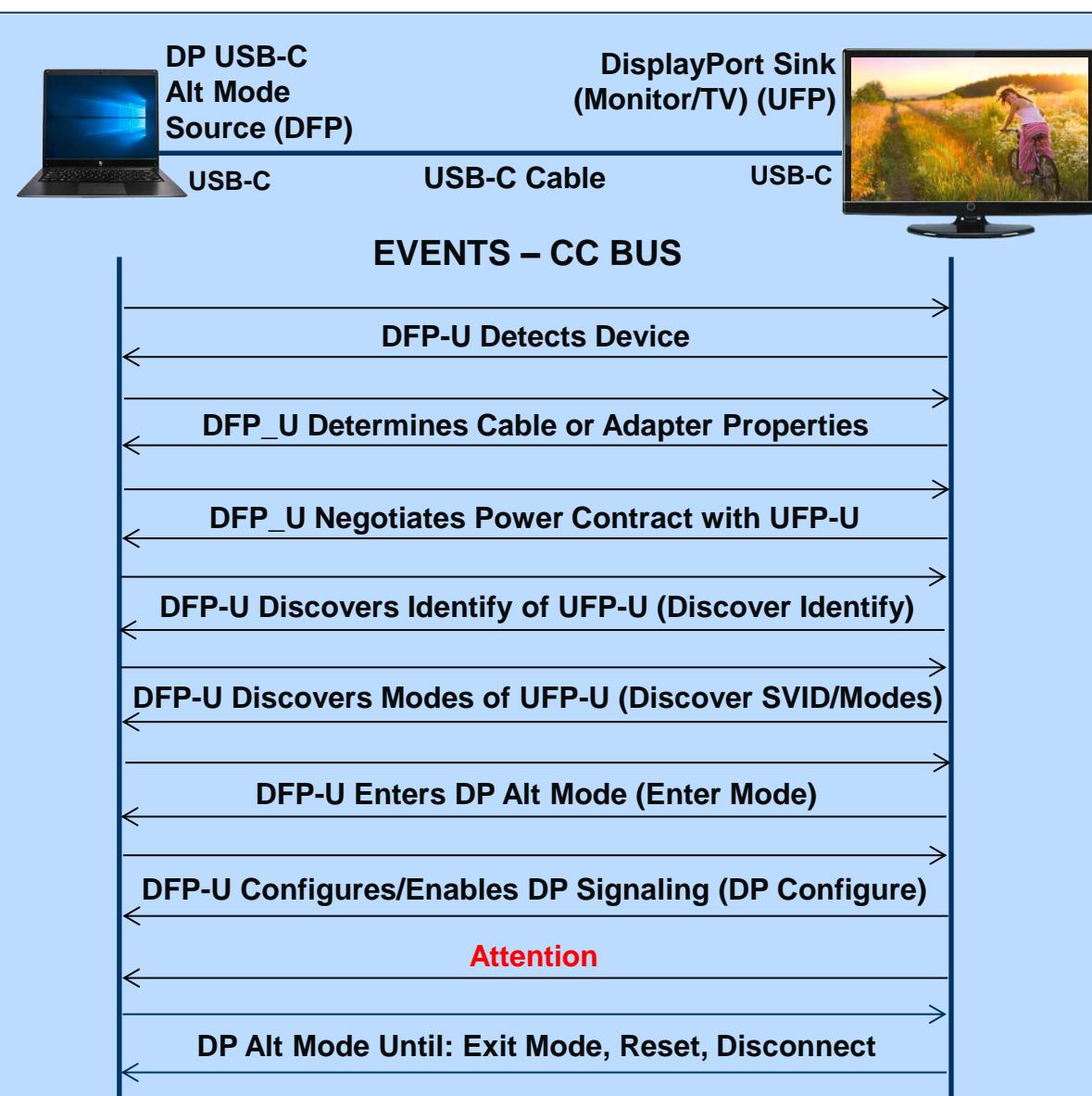
1) VDM Header
 SVID or VID : 0xFF01 (65281)
 VDM Type : Structured
 VDM Version : 1.0
 Object Position: 1
 Command Type : ACK
 Command : DP_Status_Update

DisplayPort Status Update
 DFP_D/UFP_D Connected : UFP_D
 Power Low : No
 Enabled : Yes
 Multi-function Preferred: No
 USB Config Request : No
 Exit DP Mode Request : No
 HPD State : Low
 IRQ_HPD : No

- Preamble: CC-1, 63, [Sync-1, Sync-1, Sync-1, Sync-2]
- Header: 2C4Fh
- Object 1: FF018150h
- Object 2: 0000000Ah
- CRC: FD3CA321h
- EOP

35: SNK:6 ACK DP_Status_Update

Power Delivery DP Alt Mode Protocol – Attention Message



◆ DisplayPort Attention Message:

ACA Data Viewer [AA_980-USB-to-LMon-USB_w-PSV-CBL] Events: 416

Start Time: +69:49:58.451310
 Start of Packet: SOP
 Message Type: Vendor_Defined
 MessageID: 0
 Port Power Role: Sink
 Port Data Role: UFP
 Spec Revision: Revision 2.0
 Data Objects: 2

1) VDM Header
 SVID or VID : 0xFF01 (65281)
 VDM Type : Structured
 VDM Version : 1.0
 Object Position: 1
 Command Type : Initiator
 Command : Attention

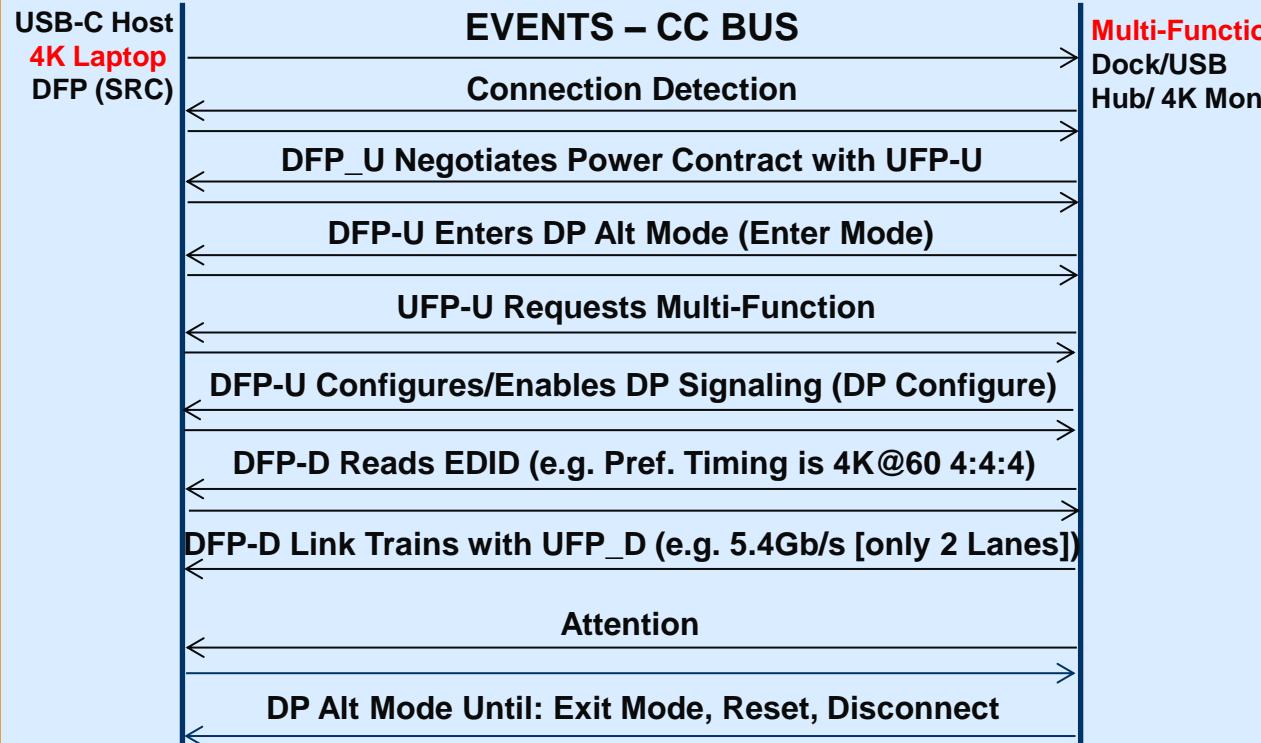
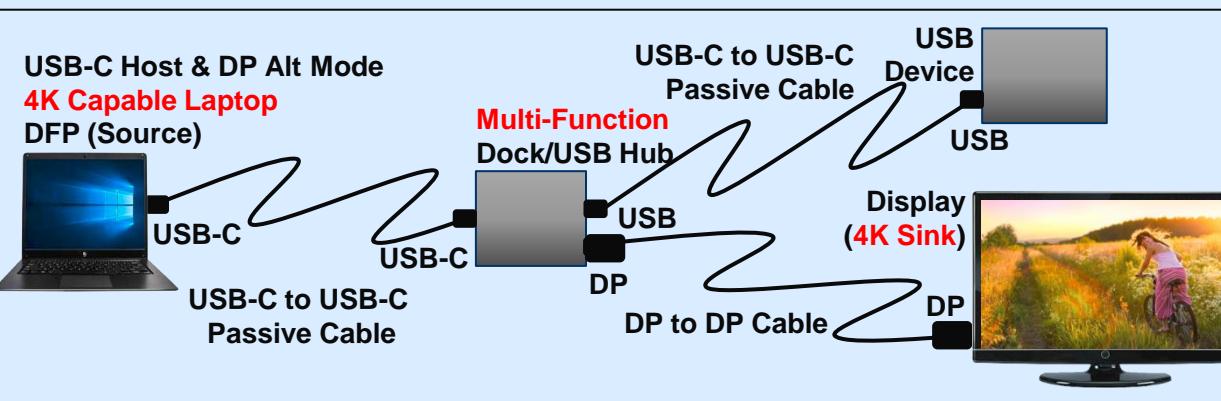
DisplayPort Status Update
 DFP_D/UFP_D Connected : UFP_D
 Power Low : No
 Enabled : Yes
 Multi-function Preferred: No
 USB Config Request : No
 Exit DP Mode Request : No
 HPD State : High
 IRQ_HPD : No

Preamble: CC-1, 62, [Sync-1, Sync-1, Sync-1, Sync-2]
 Header: 204Fh
 Object 1: FF018106h
 Object 2: 0000008Ah
 CRC: 65181C4Fh
 - EOP

Event Number	Event Type	Timestamp	Source	Message
15	PDCTL	+69:49:58.418538	SRC:3	Reject
16	PDCTL	+69:49:58.419094	SNK:3	GoodCRC
17	PDVDM	+69:49:58.429721	SRC:4	Discover Identity
18	PDCTL	+69:49:58.430407	SNK:4	GoodCRC
19	PDVDM	+69:49:58.431054	SNK:2	ACK Discover Identity
20	PDCTL	+69:49:58.432141	SRC:2	GoodCRC
21	PDVDM	+69:49:58.433641	SRC:5	Discover SVIDs
22	PDCTL	+69:49:58.434334	SNK:5	GoodCRC
23	PDVDM	+69:49:58.435001	SNK:3	ACK Discover SVIDs
24	PDCTL	+69:49:58.435815	SRC:3	GoodCRC
25	PDVDM	+69:49:58.437319	SRC:6	Discover Modes
26	PDCTL	+69:49:58.438012	SNK:6	GoodCRC
27	PDVDM	+69:49:58.438662	SNK:4	ACK Discover Modes
28	PDCTL	+69:49:58.439490	SRC:4	GoodCRC
29	PDVDM	+69:49:58.440990	SRC:7	Enter Mode 1
30	PDCTL	+69:49:58.441669	SNK:7	GoodCRC
31	PDVDM	+69:49:58.442360	SNK:5	ACK Enter Mode 1
32	PDCTL	+69:49:58.443055	SRC:5	GoodCRC
33	PDVDM	+69:49:58.443861	SRC:0	DP_Status_Update
34	PDCTL	+69:49:58.444679	SNK:0	GoodCRC
35	PDVDM	+69:49:58.445345	SNK:6	ACK DP_Status_Update
36	PDCTL	+69:49:58.446167	SRC:6	GoodCRC
37	PDVDM	+69:49:58.447667	SRC:1	DP_Configure
38	PDCTL	+69:49:58.448491	SNK:1	GoodCRC
39	PDVDM	+69:49:58.449292	SNK:7	ACK DP_Configure
40	PDCTL	+69:49:58.449985	SNK:7	GoodCRC
41	PDVDM	+69:49:58.450085	SNK:0	Attention 1
42	PDCTL	+69:49:58.452121	SRC:0	GoodCRC
43	DHPH	+69:49:58.455986		HPD Rising Edge
44	DNAT	+69:49:58.456780		> R:200 SINK_COUNT L=6
45	DNAT	+69:49:58.456849		< ACK 41 00 00 00 80 00
46	DNAT	+69:49:58.456984		> R:E TRAINING_AUX_RD_INTE...
47	DNAT	+69:49:58.457052		< ACK 00
48	DNAT	+69:49:58.457120		> R:0 DPCD_REV L=1
49	DNAT	+69:49:58.457188		< ACK 12
50	DNAT	+69:49:58.457257		> R:0 DPCD_REV L=16
51	DNAT	+69:49:58.457326		< ACK 12 14 C2 01 01 00 01...
52	DNAT	+69:49:58.457533		> R:90 FEC_CAPABILITY L=1
53	DNAT	+69:49:58.457601		< ACK 00
54	DNAT	+69:49:58.457670		> R:60 DSC_SUPPORT L=15
55	DNAT	+69:49:58.457740		< ACK 00 00 00 00 00 00 00 ...

41: SNK:0 Attention 1

Power Delivery DP Alt Mode Protocol – Multi-Function (Docking Station)



◆ Multi-Function with 4K@60Hz video

ACA Data Viewer

[IAA_980_USB_to_Doc_MST_PSV_CBL] Events: 533 (1157)

0	PDVDM	61	+00:02:51.271649	'PRT:0 Discover Identity
1	PDCTL	61	+00:02:51.272454	'CBL:0 GoodCRC
2	PDDTA	61	+00:02:51.302265	SRC:0 Source_Capabilities
3	PDCTL	61	+00:02:51.302967	SNK:0 GoodCRC
4	PDDTA	61	+00:02:51.306934	SRC:0 Request
5	PDCTL	61	+00:02:51.307624	SNK:0 GoodCRC
6	PDCTL	61	+00:02:51.309130	SRC:1 Accept
7	PDCTL	61	+00:02:51.309706	SNK:1 GoodCRC
8	PDCTL	61	+00:02:51.339684	SRC:2 PS_RDY
9	PDCTL	61	+00:02:51.340261	SNK:2 GoodCRC
10	PDVDM	61	+00:02:51.351098	SRC:3 Discover Identity
11	PDCTL	61	+00:02:51.35179	SNK:3 GoodCRC
12	PDVDM	61	+00:02:51.358364	SNK:1 ACK Discover Identity
13	PDVDM	61	+00:02:51.358364	SRC:1 GoodCRC
14	PDVDM	61	+00:02:51.358364	SRC:4 Discover SVIDs
15	PDCTL	61	+00:02:51.359066	SNK:4 GoodCRC
16	PDVDM	61	+00:02:51.363032	SNK:2 ACK Discover SVIDs
17	PDCTL	61	+00:02:51.363984	SRC:2 GoodCRC
18	PDVDM	61	+00:02:51.365490	SRC:5 Discover Modes
19	PDCTL	61	+00:02:51.366192	SNK:5 GoodCRC
20	PDVDM	61	+00:02:51.370172	SNK:3 ACK Discover Modes
21	PDCTL	61	+00:02:51.370980	SRC:3 GoodCRC
22	PDVDM	61	+00:02:51.372492	'PRT:1 Discover Identity
23	PDCTL	61	+00:02:51.373293	'CBL:1 GoodCRC
24	PDVDM	61	+00:02:51.375529	'CBL:0 ACK Discover Identity
25	PDCTL	61	+00:02:51.376737	'PRT:0 GoodCRC
26	PDVDM	61	+00:02:51.378005	SRC:6 Enter Mode 1
27	PDCTL	61	+00:02:51.378706	SNK:6 GoodCRC
28	PDVDM	61	+00:02:51.382680	SNK:4 ACK Enter Mode 1
29	PDCTL	61	+00:02:51.383363	SRC:4 GoodCRC
30	PDVDM	61	+00:02:51.384883	SRC:7 DP_Status_Update
31	PDCTL	61	+00:02:51.385709	SNK:7 GoodCRC
32	PDVDM	61	+00:02:51.389682	SNK:5 ACK DP_Status_Update
33	PDCTL	61	+00:02:51.390504	SRC:5 GoodCRC
34	PDVDM	61	+00:02:51.392017	SRC:0 DP_Configure
35	PDCTL	61	+00:02:51.392850	SNK:0 GoodCRC
36	PDVDM	61	+00:02:51.396817	SNK:6 ACK DP_Configure
37	PDCTL	61	+00:02:51.397500	SRC:6 GoodCRC
38	PDVDM	61	+00:02:51.398829	SNK:7 Attention 1
39	PDCTL	61	+00:02:51.399644	SRC:7 GoodCRC
40	DPHP	61	+00:02:51.403535	HPD Rising Edge

Start Time: +00:02:51.355774

Start of Packet: SOP

Message Type: Vendor Defined

MessageID: 1

Port Power Role: Sink

Port Data Role: UFP

Spec Revision: Revision 2.0

Data Objects: 4

1) VDM Header

2) ID Header VDO

3) Cert Stat VDO

4) Product VDO

Preamble: CC-2, 62, [Sync-1, Sync-1, Sync-1, Sync-2]

Header: 424Fh

Object 1: FF008041h

Object 2: 4400413Ch

Object 3: 0000413Ch

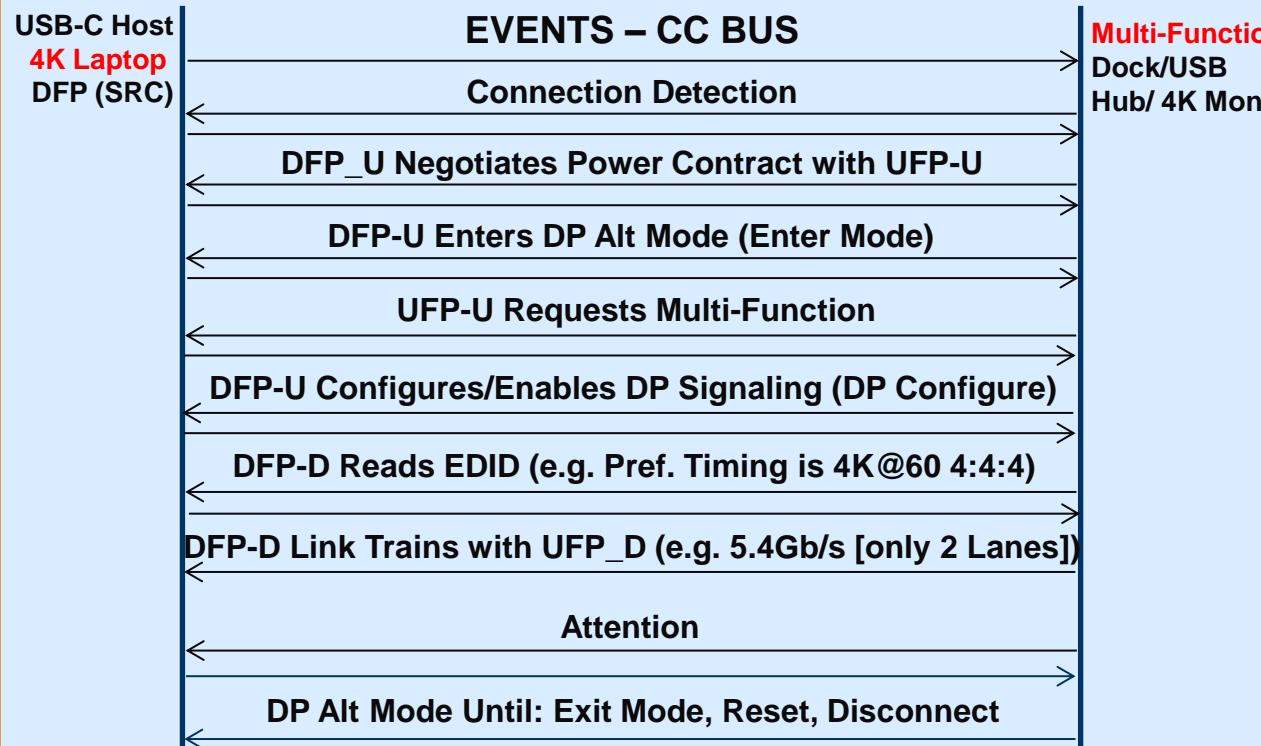
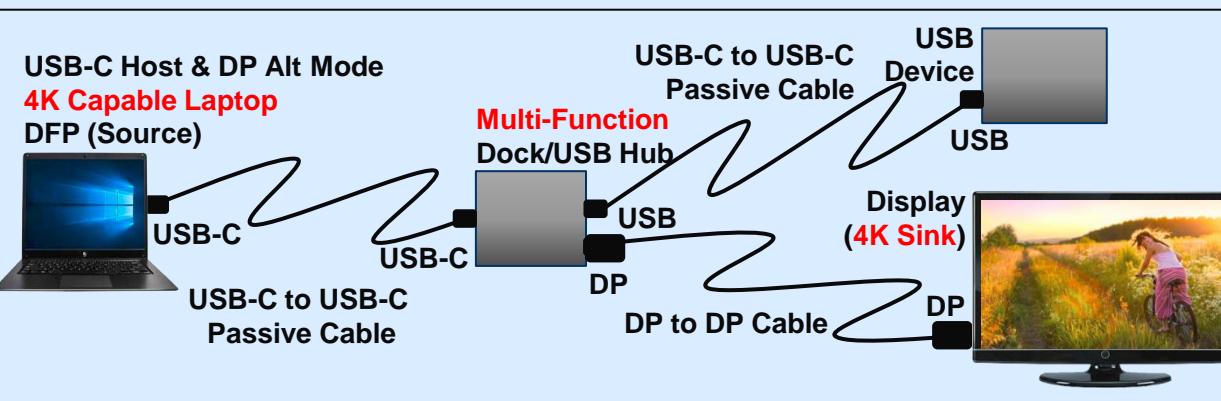
Object 4: B0530001h

CRC: 0622F620h

EOB

12: SNK:1 ACK Discover Identity

Power Delivery DP Alt Mode Protocol – Multi-Function (Docking Station)



◆ Multi-Function with 4K@60Hz video

ACA Data Viewer		
[AA_980_USB_to_Doc_MST_PSV_CBL] Events: 533 (1157)		
0	PDVDM	61
1	PDCTL	61
2	PDDTA	61
3	PDCTL	61
4	PDDTA	61
5	PDCTL	61
6	PDCTL	61
7	PDCTL	61
8	PDCTL	61
9	PDCTL	61
10	PDVDM	61
11	PDCTL	61
12	PDVDM	61
13	PDCTL	61
14	PDVDM	61
15	PDCTL	61
16	PDVDM	61
17	PDCTL	61
18	PDVDM	61
19	PDCTL	61
20	PDVDM	61
21	PDCTL	61
22	PDVDM	61
23	PDCTL	61
24	PDVDM	61
25	PDCTL	61
26	PDVDM	61
27	PDCTL	61
28	PDVDM	61
29	PDCTL	61
30	PDVDM	61
31	PDCTL	61
32	PDVDM	61
33	PDCTL	61
34	PDVDM	61
35	PDCTL	61
36	PDVDM	61
37	PDCTL	61
38	PDVDM	61
39	PDCTL	61
40	DHPH	61

Start Time: +00:02:51.389682
 Start of Packet: SOP
 Message Type: Vendor Defined
 MessageID: 5
 Port Power Role: Sink
 Port Data Role: UFP
 Spec Revision: Revision 2.0
 Data Objects: 2

1) VDM Header
 VID or VID : 0xFF01 (65281)
 VDM Type : Structured
 VDM Version : 1.0
 Object Position: 1
 Command Type : ACK
 Command : DP_Status_Update

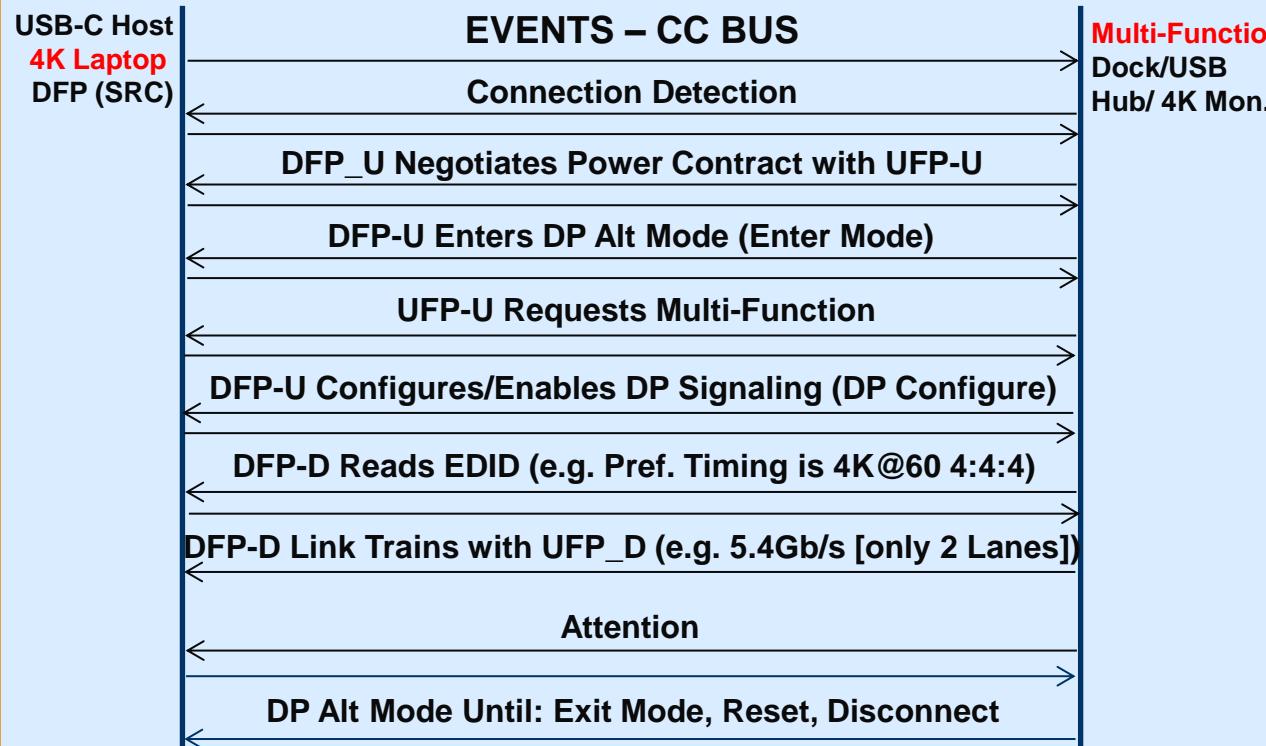
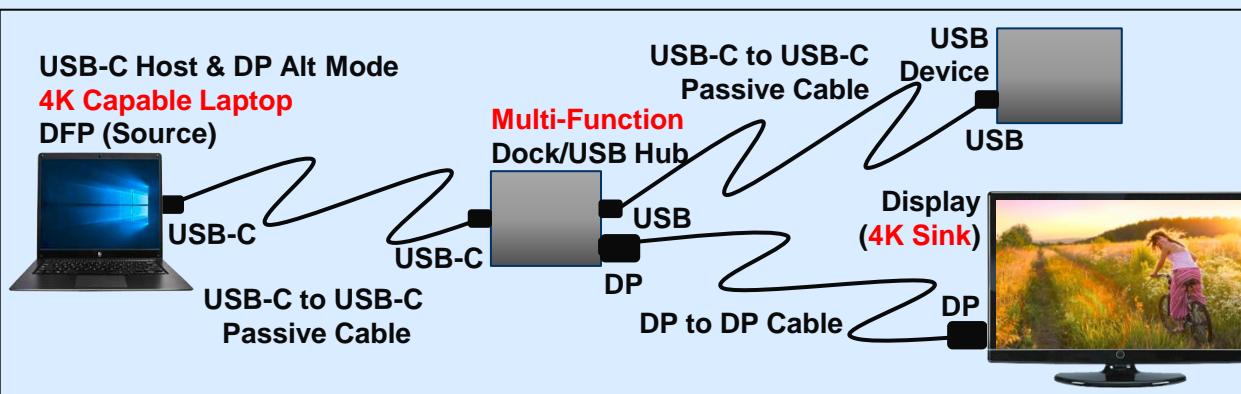
DisplayPort Status Update
 DFP_D/UFP_D Connected : UFP_D
 Power Low : No
 Enabled : Yes
 Multi-function Preferred: Yes
 USB Config Request : No
 Exit DP Mode Request : No
 HPD State : Low
 IRQ_HPD : No

- Preamble: CC-2, 63, [Sync-1, Sync-1, Sync-1, Sync-2]
 - Header: 2A4Fh
 - Object 1: FF018150h
 - Object 2: 0000001Ah
 - CRC: DE3F8D34h
 - EOP

32: SNK:5 ACK DP_Status_Update

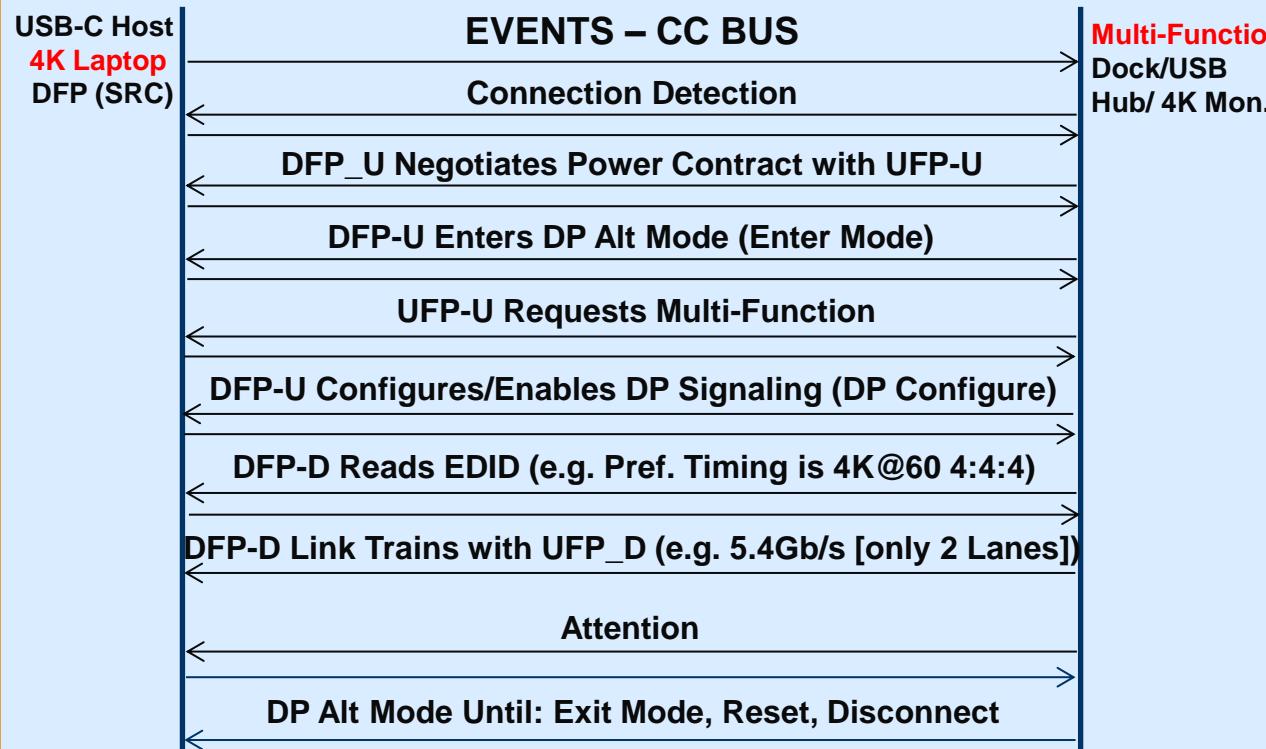
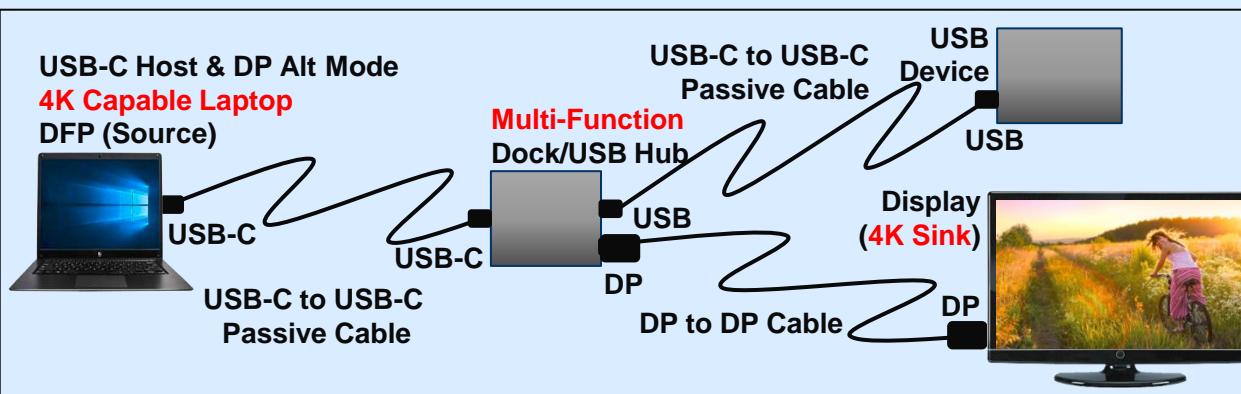
TELEDYNE LECROY
Everywhereyoulook™

Power Delivery DP Alt Mode Protocol – Multi-Function (Docking Station)



- ◆ Multi-Function with 4K@60Hz video

Power Delivery DP Alt Mode Protocol – Multi-Function (Docking Station)



- ◆ Multi-Function with 4K@60Hz video

The screenshot shows the ACA Data Viewer interface with the following details:

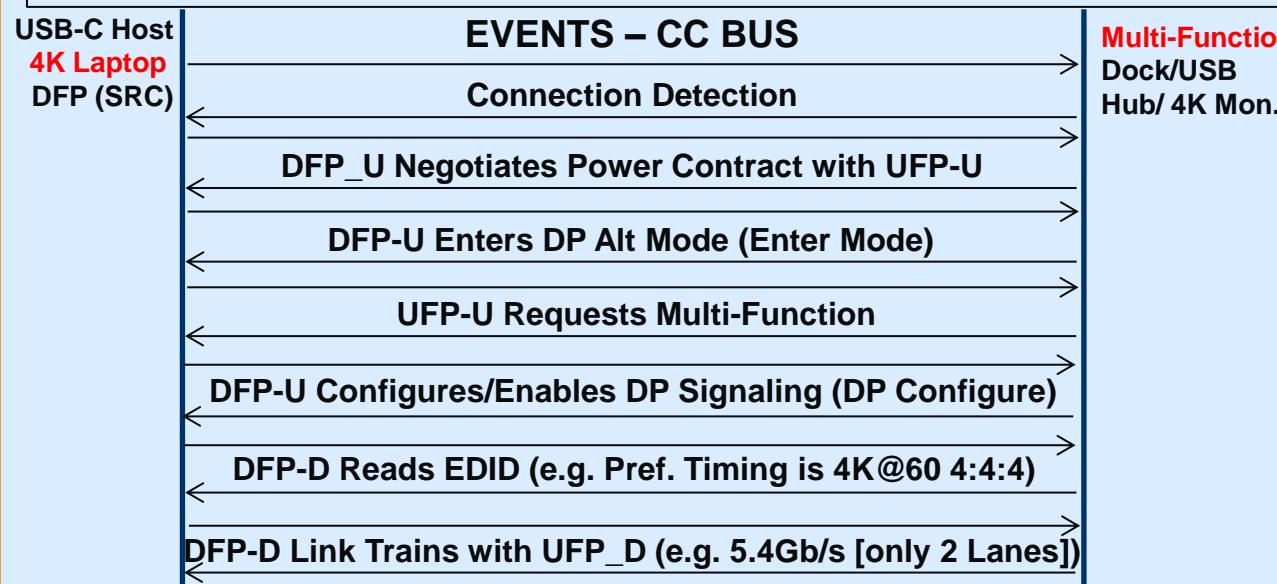
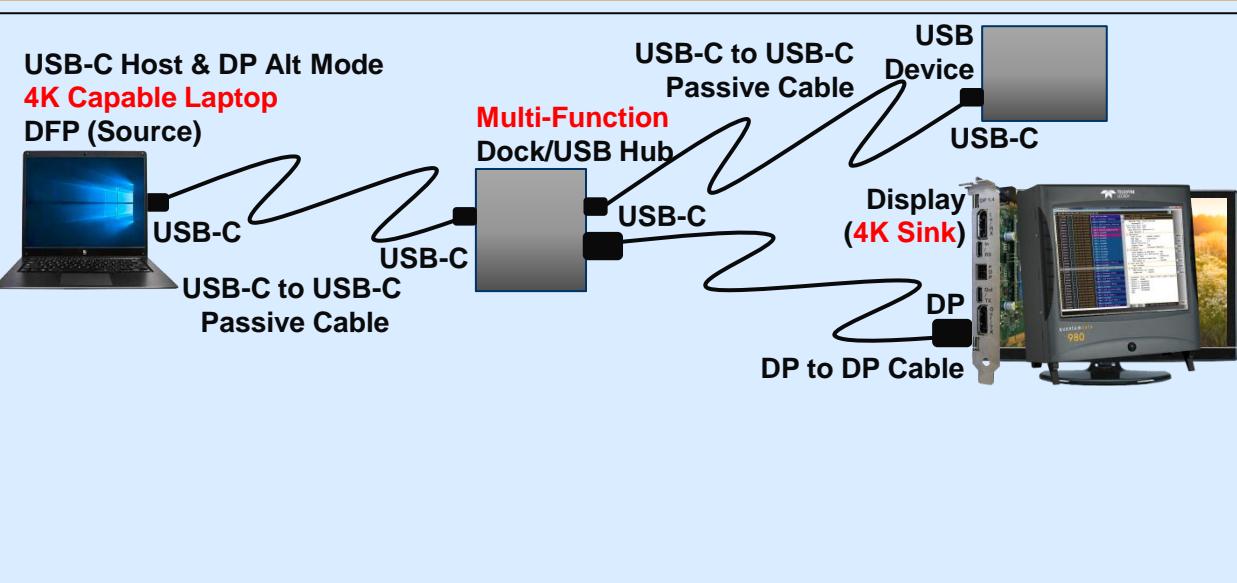
- Left Panel (Events):** Shows a list of 533 events from AA_980_USB_to_Doc_MST_PSV_CBL. The events are color-coded by source (e.g., DNAT, DEPLT) and destination (e.g., ACK, R:xx). A yellow arrow points to event 124: < ACK 77 00 81.
- Right Panel (Status and Configuration):**
 - Start Time:** +00:02:51.816243
 - Type:** Native
 - Direction:** Reply
 - Command:** ACK
 - Reply to Read Request.**
 - Lane 0 Status (Event 00202):**

Bit	Name	Value	Description
0	LANE0_CR_DONE	Y(1)	
1	LANE0_CHANNEL_EQ_DONE	Y(1)	
2	LANE0_SYMBOL_LOCKED	Y(1)	
3		0	Reserved
4	LANE1_CR_DONE	Y(1)	
5	LANE1_CHANNEL_EQ_DONE	Y(1)	
6	LANE1_SYMBOL_LOCKED	Y(1)	
7		0	Reserved
 - Lane 1 Status (Event 00203):**

Bit	Name	Value	Description
0	LANE2_CR_DONE	N(0)	
1	LANE2_CHANNEL_EQ_DONE	N(0)	
2	LANE2_SYMBOL_LOCKED	N(0)	
3		0	Reserved
4	LANE3_CR_DONE	N(0)	
5	LANE3_CHANNEL_EQ_DONE	N(0)	
6	LANE3_SYMBOL_LOCKED	N(0)	
7		0	Reserved
 - Lane 2 Status (Event 00204):**

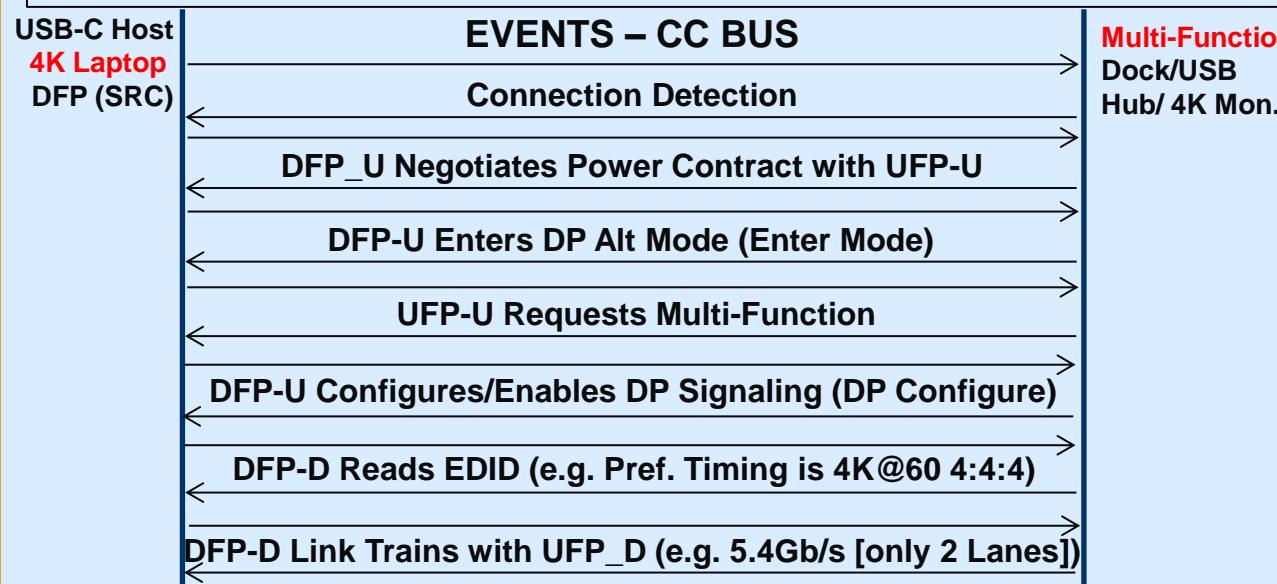
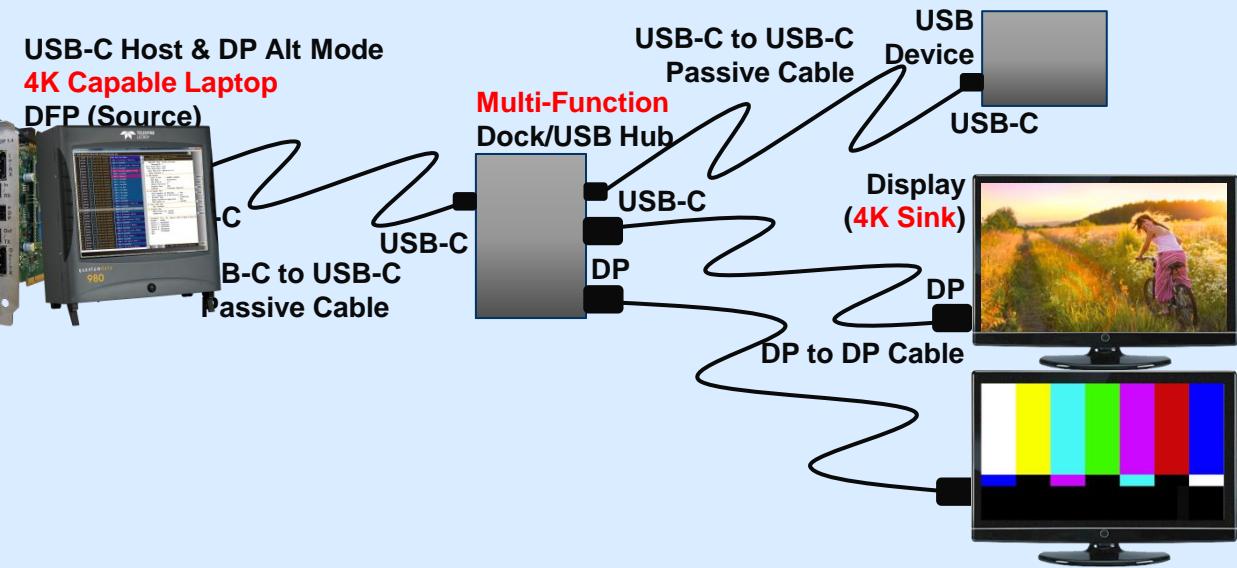
Bit	Name	Value	Description
0	INTERLANE_ALIGN_DONE	Y(1)	
1	POST_LT_ADJ_REQ_IN_PROGRESS	N(0)	
2		0	Reserved
3		0	Reserved
4		0	Reserved
5		0	Reserved
6	DOWNTREAM_PORT_STATUS_CHANGED	N(0)	
7	LINK_STATUS_UPDATED	Y(1)	

Power Delivery DP Alt Mode Protocol – Multi-Function

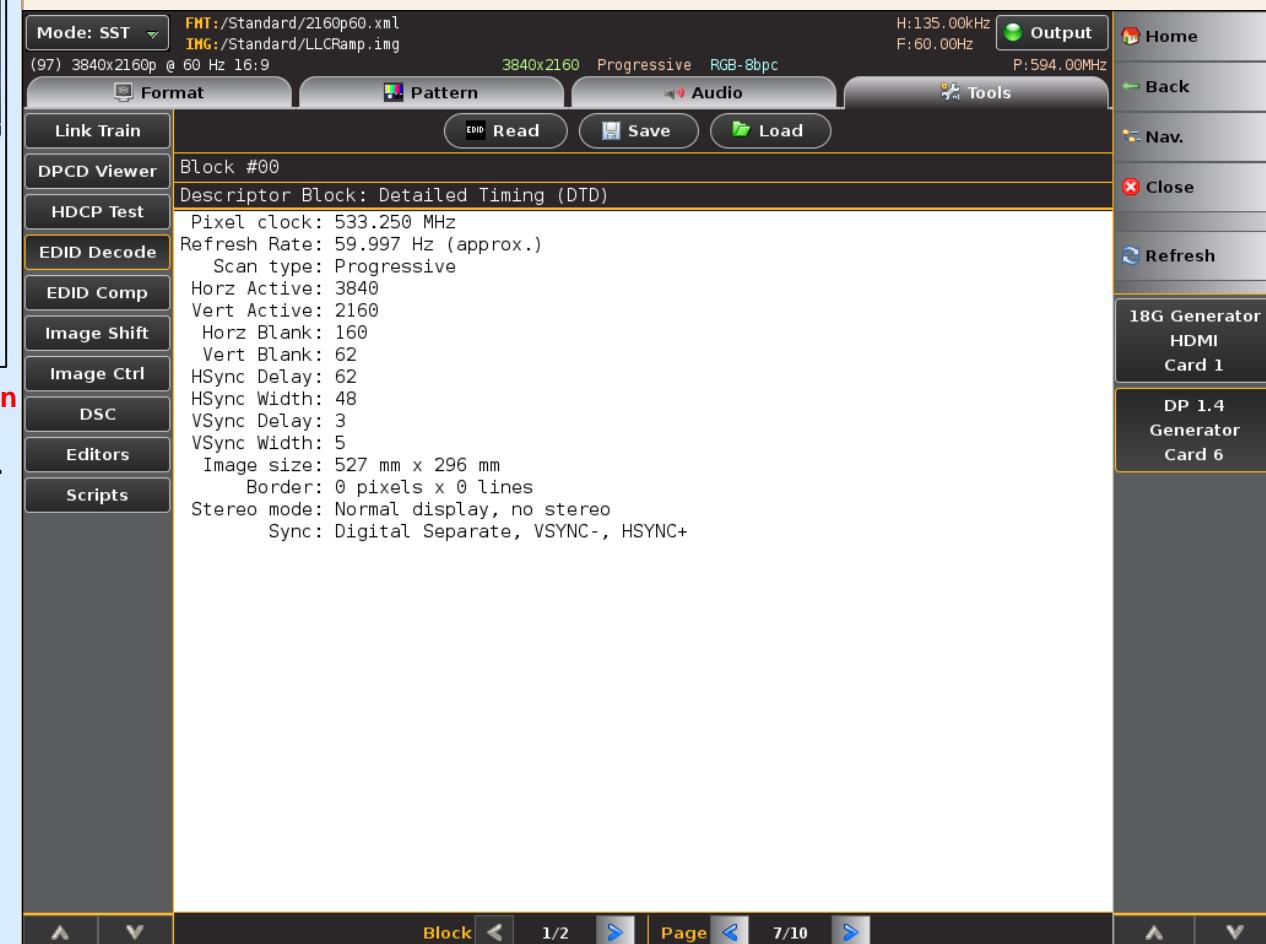


- ◆ Multi-Function with 4K video. Complications related to bandwidth limitations:
 - ◆ Two (2) Lanes for DisplayPort in Multi-Function applications.
 - ◆ Example Scenario:
 - ◆ Source capable of 4K@60Hz.
 - ◆ Sink EDID Preferred Timing indicates 4K@60Hz.
 - ◆ Other Considerations:
 - ◆ Chroma subsampling, e.g. 4:4:4 (or 4:2:0).
 - ◆ Reduce frame rate.
 - ◆ High Dynamic Range (HDR) with 10bit deep color.
 - ◆ Application: Lean in or Lean back.
 - ◆ Multi-Stream Transport (MST).
 - ◆ Display Stream Compression (DSC).

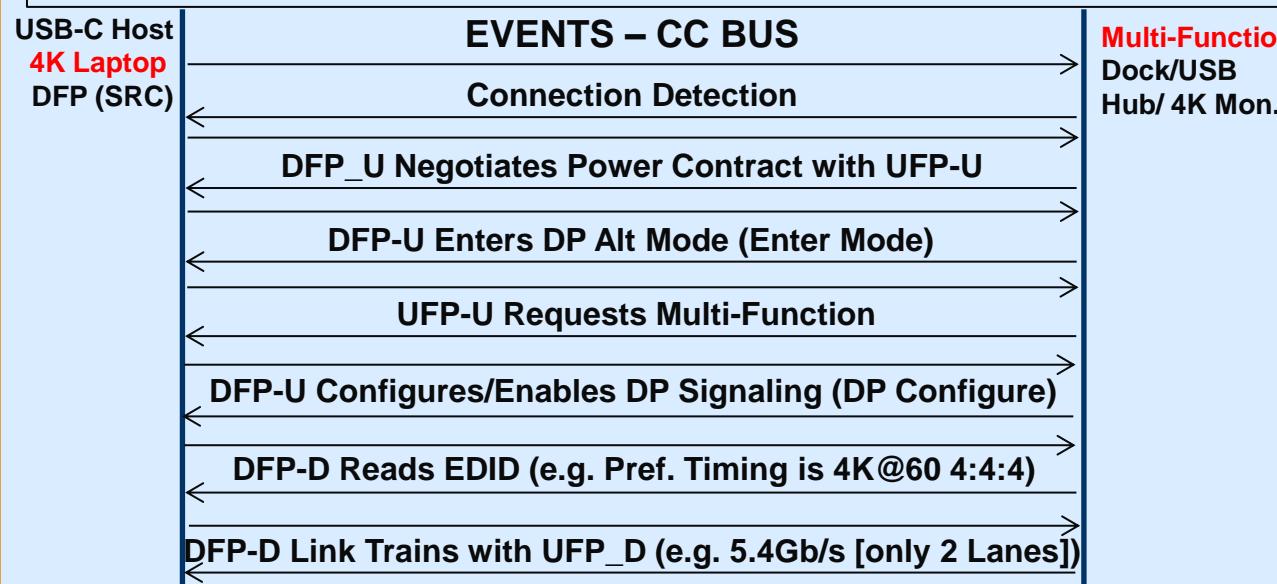
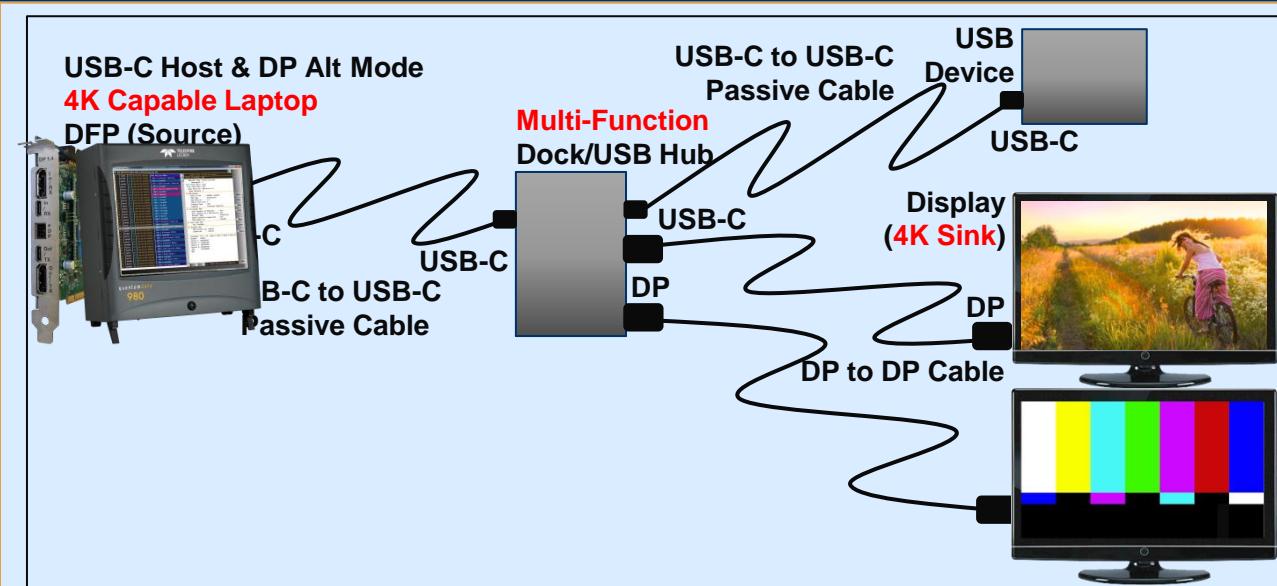
Power Delivery DP Alt Mode Protocol – Multi-Function



- ◆ Multi-Function with 4K video.
- ◆ Read EDID.



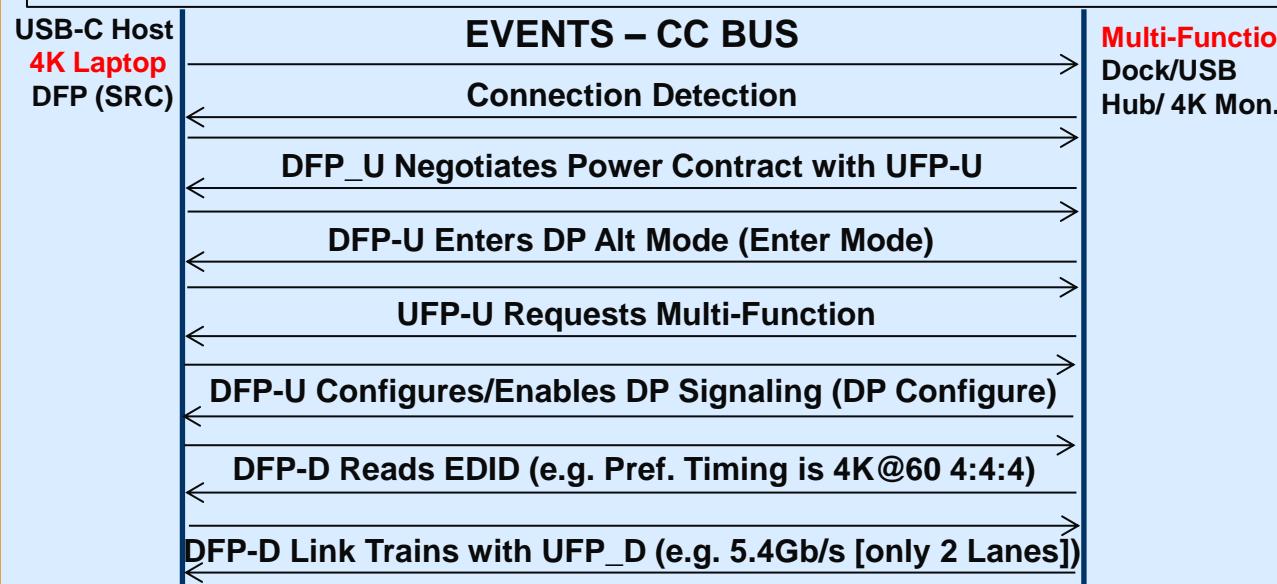
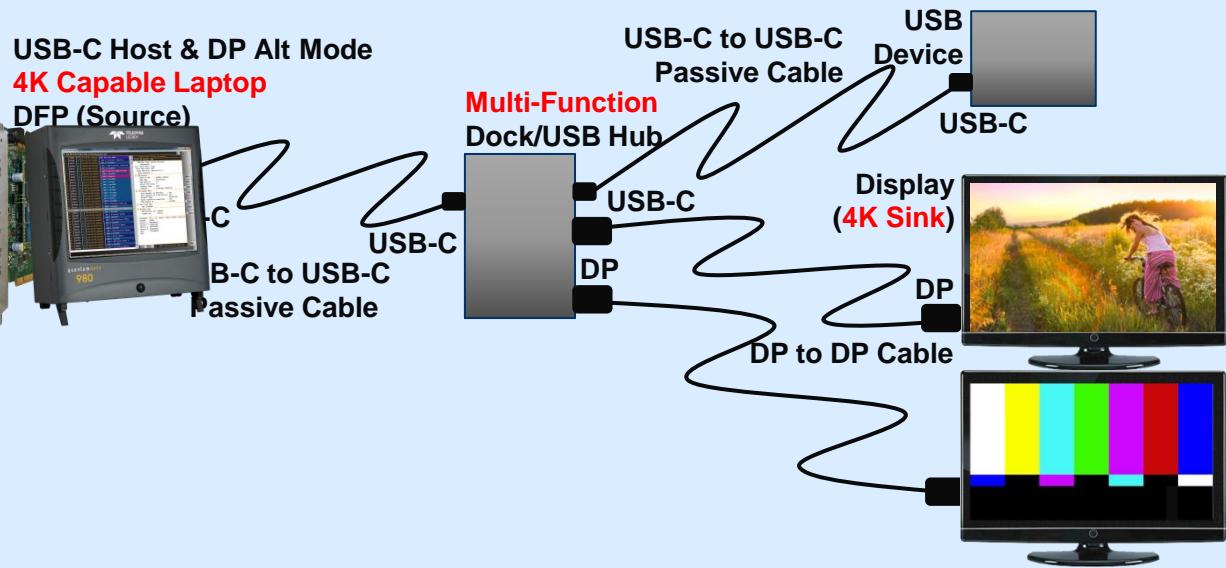
Power Delivery DP Alt Mode Protocol – Multi-Function



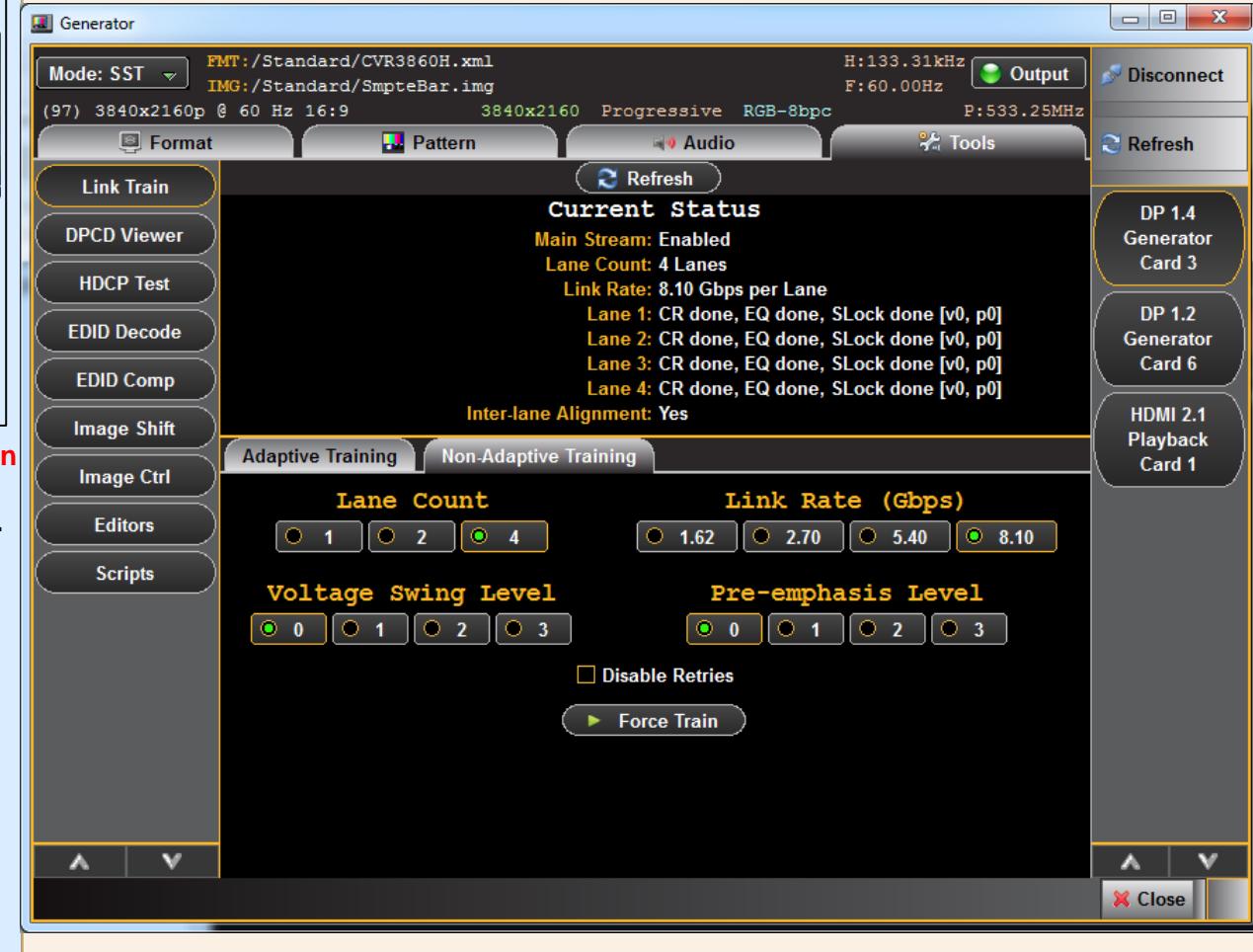
- ◆ Multi-Function with 4K video.
- ◆ Generate 4K Video Resolutions.
- ◆ Set video parameters.



Power Delivery DP Alt Mode Protocol – Multi-Function



- ◆ Multi-Function with 4K video.
- ◆ Control Link Training with Sink.

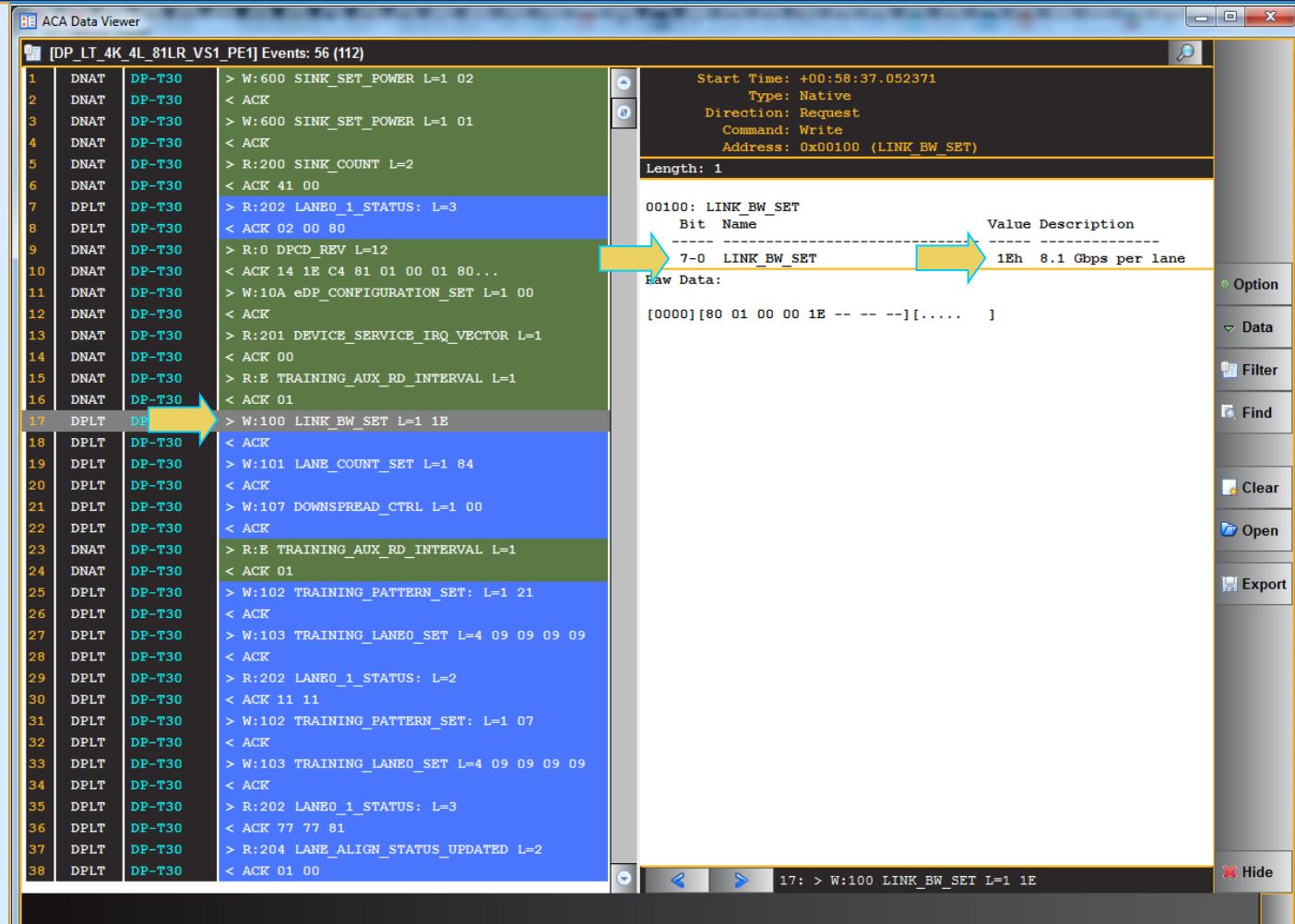
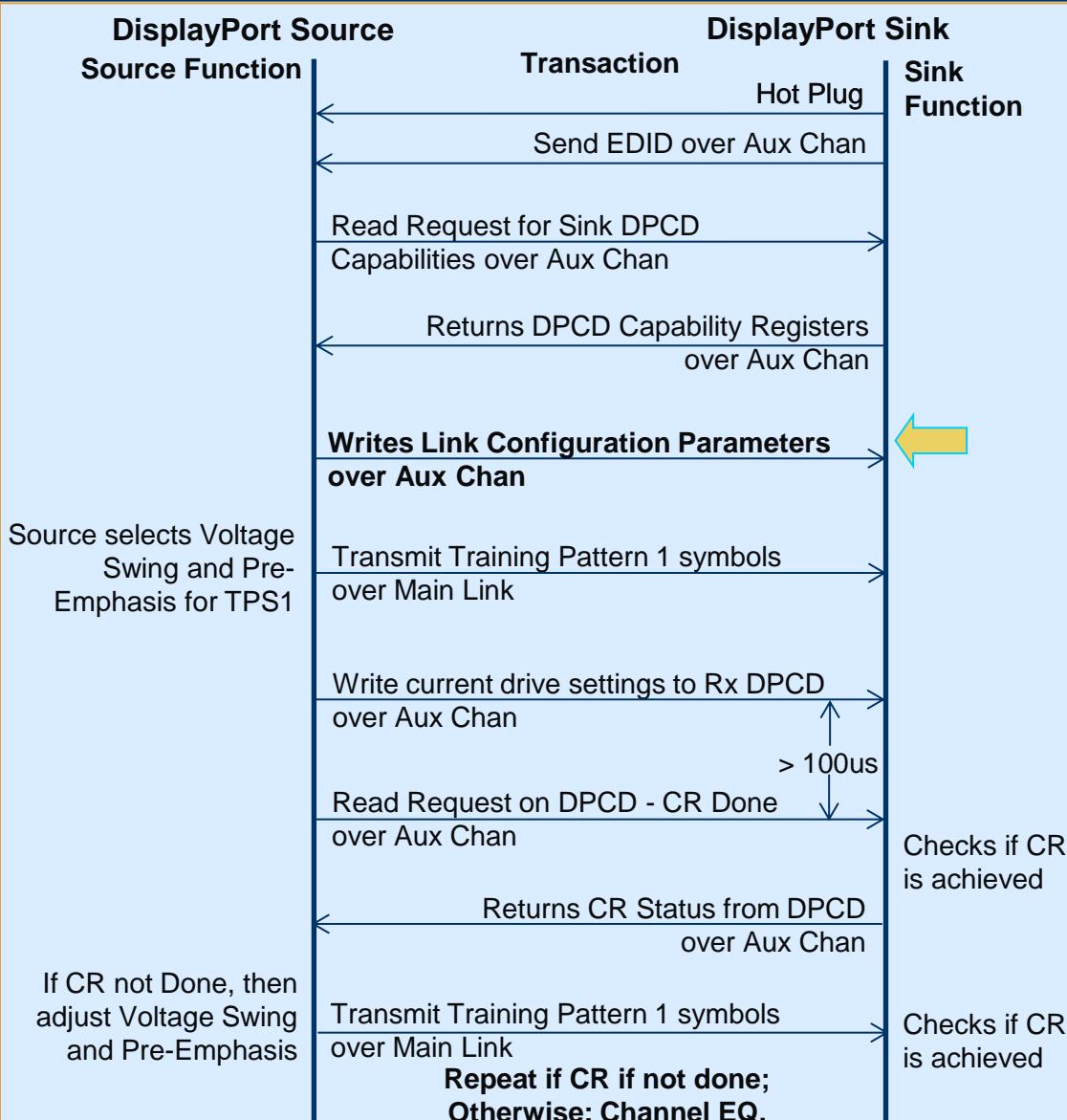


DisplayPort Protocols – Link Training

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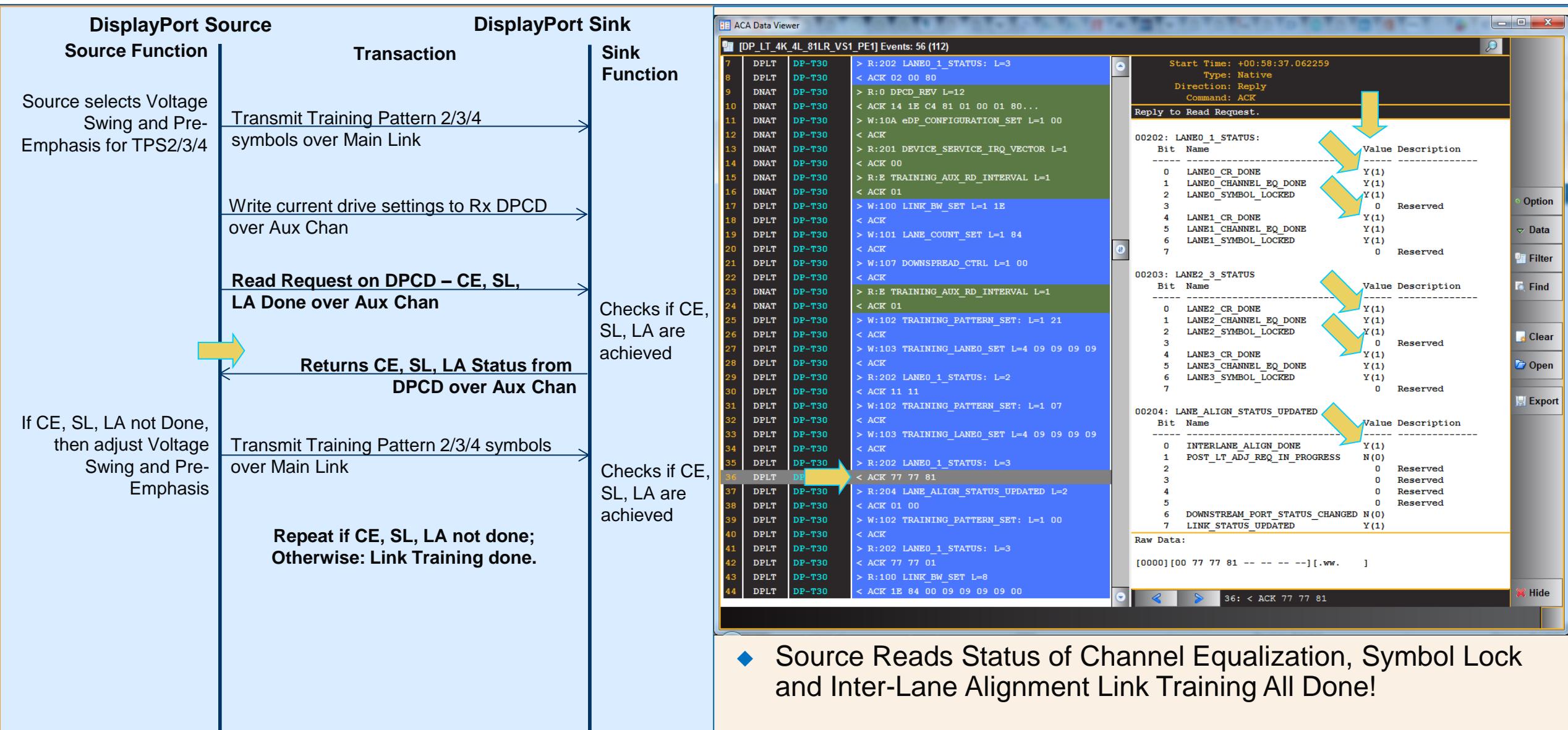


Connection Sequence – Link Training Clock Recovery Sequence



- ◆ Source Writing Link Rate (8.1Gbps) to Sink DPCD Registers to Begin Link Training

Connection Sequence – Link Training Channel EQ, Symbol Lock, Interlane Alignment



Source Link Layer Compliance – Test 4.3.1.1 Successful Link Training

Compliance Test Results Viewer
DP 1.4 Source (1.4 Core R1.0) Compliance Test Results

Results Name: 03_27_2018_15_01_26 Manufacturer:
Date Tested: March 27, 2018 3:01 PM Model Name:
Overall Status: CTS 1.4 Core R1.0 - Fail Port Tested: 1 [HTML Report](#)

Test Name / Details

4.3.1.1: Successful Link Training at All Supported Lane Counts and Link Speeds.

Iter 01:

- 01: [1] Link Training test for lane count = 1 and lane rate = 1.62
- 02: [2] Link Training test for lane count = 2 and lane rate = 1.62
- 03: [3] Link Training test for lane count = 4 and lane rate = 1.62
- 04: [4] Link Training test for lane count = 1 and lane rate = 2.70
- 05: [5] Link Training test for lane count = 2 and lane rate = 2.70
- 06: [6] Link Training test for lane count = 4 and lane rate = 2.70
- 07: [7] Link Training test for lane count = 1 and lane rate = 5.40
- 08: [8] Link Training test for lane count = 2 and lane rate = 5.40
- 09: [9] Link Training test for lane count = 4 and lane rate = 5.40
- 10: [10] Link Training test for lane count = 1 and lane rate = 8.10
- 11: [11] Link Training test for lane count = 2 and lane rate = 8.10
- 12: [12] Link Training test for lane count = 4 and lane rate = 8.10

Source DUT start link training..
Source DUT sets link bw and lane count before TP1 is set.
Source DUT sets same link bw for link rate under test.
Source DUT sets correct lane count for lane count under test.
Source DUT sets TP1 on all active lanes.
Source DUT starts with voltage swing 0 on all active lanes.
Source DUT starts with pre-emphasis 0 on all active lanes.
CR Lock succeeded on all active lanes.
Training pattern 2 or 3 or 4 detected after Training pattern 1.
For HBR3 source Training pattern 4 detected.
Equalization succeeded on all active lanes.
Symbol lock succeeded on all active lanes.
All Lanes are Aligned and skewed.
Link compliance training test completed successfully.

Link training completed in 20.00 ms, which exceeds the 10ms guideline.

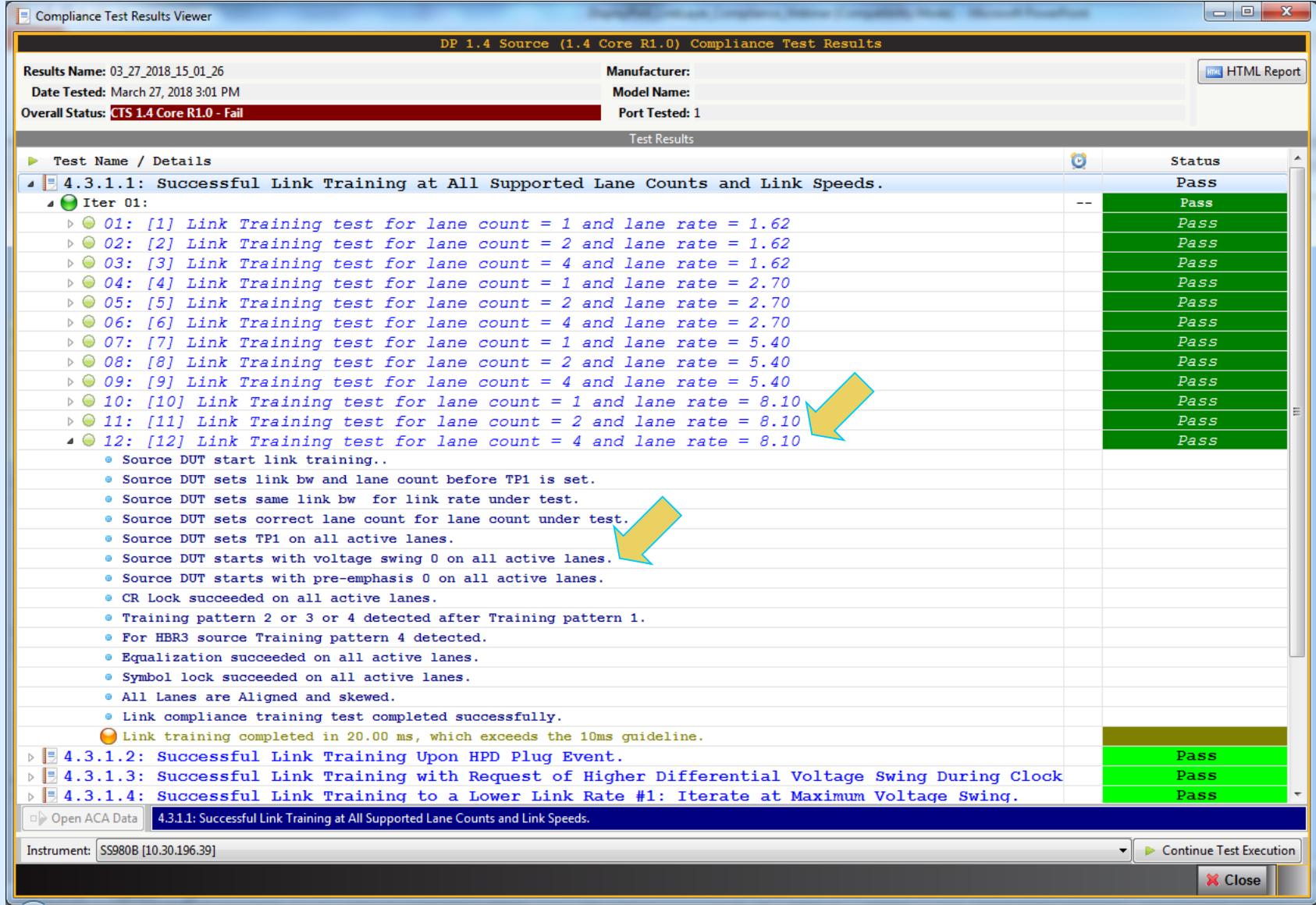
4.3.1.2: Successful Link Training Upon HPD Plug Event.

4.3.1.3: Successful Link Training with Request of Higher Differential Voltage Swing During Clock

4.3.1.4: Successful Link Training to a Lower Link Rate #1: Iterate at Maximum Voltage Swing.

[Open ACA Data](#) 4.3.1.1: Successful Link Training at All Supported Lane Counts and Link Speeds.

Instrument: SS980B [10.30.196.39] Continue Test Execution Close



- ◆ Example shows sample test results.
- ◆ Shows details of subtest 12 for link training at 8.1 Gb/s link rate on four (4) lanes.

Source Link Layer Compliance – Test 4.3.2.2 Re-Training After IRQ

Compliance Test Results Viewer

DP 1.4 Source (1.4 Core R1.0) Compliance Test Results

Results Name: 04_23_2018_11_25_17
Date Tested: April 23, 2018 11:25 AM
Overall Status: CTS 1.4 Core R1.0 - Pass

Manufacturer: Model Name: Port Tested: 1

Test Results

	Status
4.3.1.10: Unsuccessful Link Training due to Failure in Channel Equalization Sequence (loop count > 5).	Pass
4.3.1.11: Successful Link Training with Simultaneous Request for Differential Voltage Swing during Clock Recovery	Pass
4.3.2.1: Successful Link Re-training After IRQ HPD Pulse Due to Loss of Symbol Lock.	Pass
4.3.2.2: Successful Link Re-training After IRQ HPD Pulse Due to Loss of Clock Recovery Lock.	Pass
Iter 01:	--
01: [1] Link Maintenance test for lane count = 4 and lane rate = 8.10	Pass
• Source DUT start link training.	
• Source DUT sets link bandwidth and lane count before TP1 is set.	
• Source DUT sets same link bandwidth for link rate under test.	
• Source DUT sets correct lane count for lane count under test.	
• Source DUT sets TP1 on all active lanes.	
• Source DUT starts with voltage swing 0 on all active lanes.	
• Source DUT starts with pre-emphasis 0 on all active lanes.	
• CR Lock succeeded on all active lanes.	
• Training pattern 2 or 3 or 4 detected after Training pattern 1.	
• Equalization succeeded on all active lanes.	
• Symbol lock succeeded on all active lanes.	
• All Lanes are Aligned and skewed.	
• Link compliance training test completed successfully.	
● Link training completed in 20.11 ms, which exceeds the 10ms guideline.	
02: [2] After clock lock error on lane 1, Link Maintenance test for lane count = 4 and lane rate = 8.10	Pass
• After loss of Clock Lock on lane 1.	
• Link re-training starts after IRQ pulse.	
• Source DUT reads DPCD address 0200-0205h.	
• Source DUT read link status within 100ms.	
• Source DUT start link training.	
• Source DUT sets link bandwidth and lane count before TP1 is set.	
• Source DUT sets TP1 on all active lanes.	
• CR Lock succeeded on all active lanes.	
• Training pattern 2 or 3 or 4 detected after Training pattern 1.	
• Equalization succeeded on all active lanes.	
• Symbol lock succeeded on all active lanes.	
• All Lanes are Aligned and skewed.	
• Link compliance training test completed successfully.	
● Link training completed in 20.61 ms, which exceeds the 10ms guideline.	
03: [3] After clock lock error on lane 2, Link Maintenance test for lane count = 4 and lane rate = 8.10	Pass
04: [4] After clock lock error on lane 3, Link Maintenance test for lane count = 4 and lane rate = 8.10	Pass
05: [5] After clock lock error on lane 4, Link Maintenance test for lane count = 4 and lane rate = 8.10	Pass
4.3.2.3: Successful Link Re-training After IRQ HPD Pulse Due to Loss of Inter-lane Alignment Lock.	Pass
4.3.2.4: Handling of IRQ HPD Pulse with No Error Status Bits Set.	Pass

Open ACA Data 4.3.1.1: Successful Link Training at All Supported Lane Counts and Link Speeds.

Instrument: SS980B [10.30.196.39]

Continue Test Execution Close

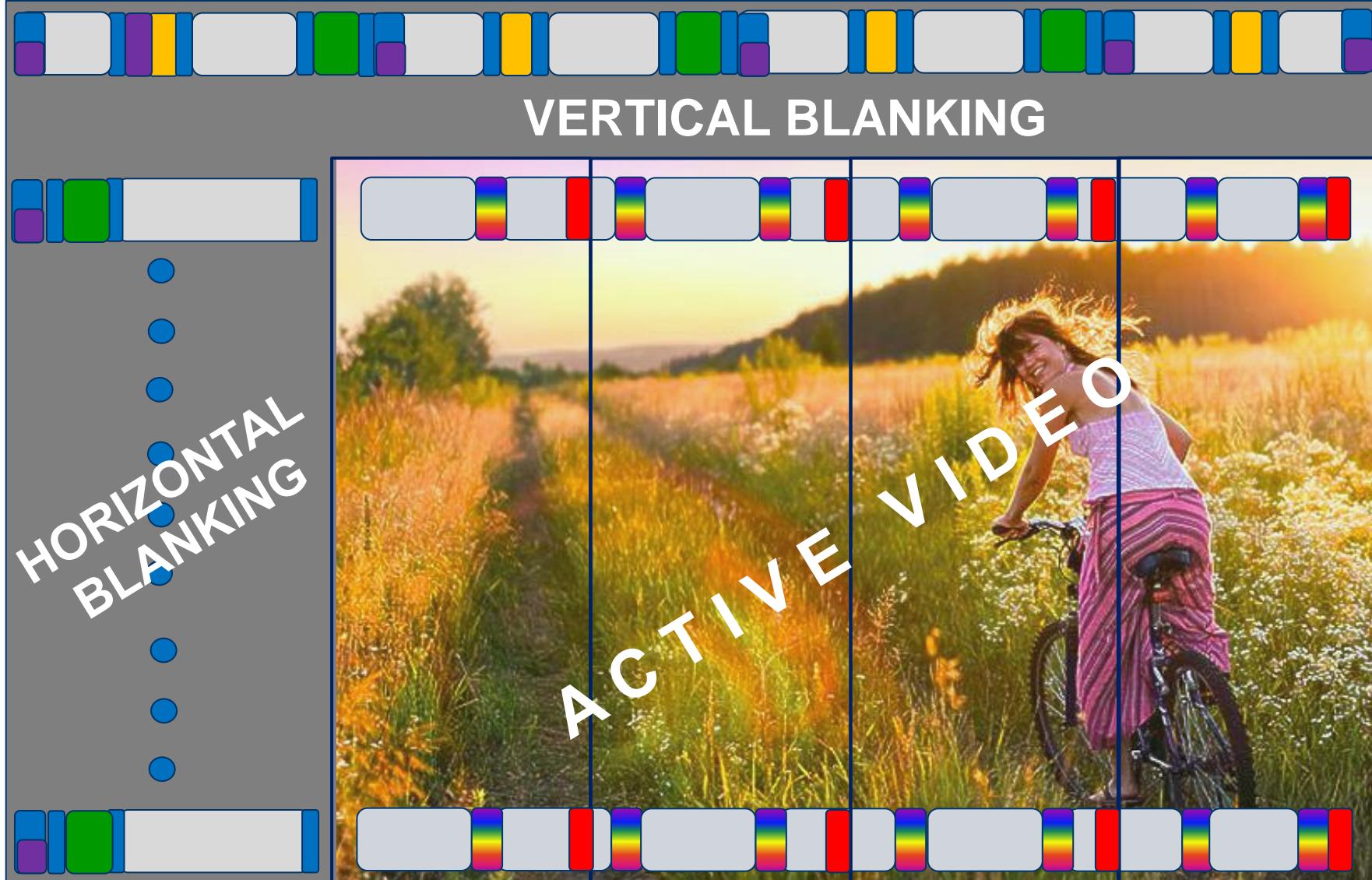
- ◆ Example shows details of IRQ test at 8.1Gb/s link rate with a loss of clock recover on Lane 1.

DisplayPort Protocols – Main Link

December – 2018



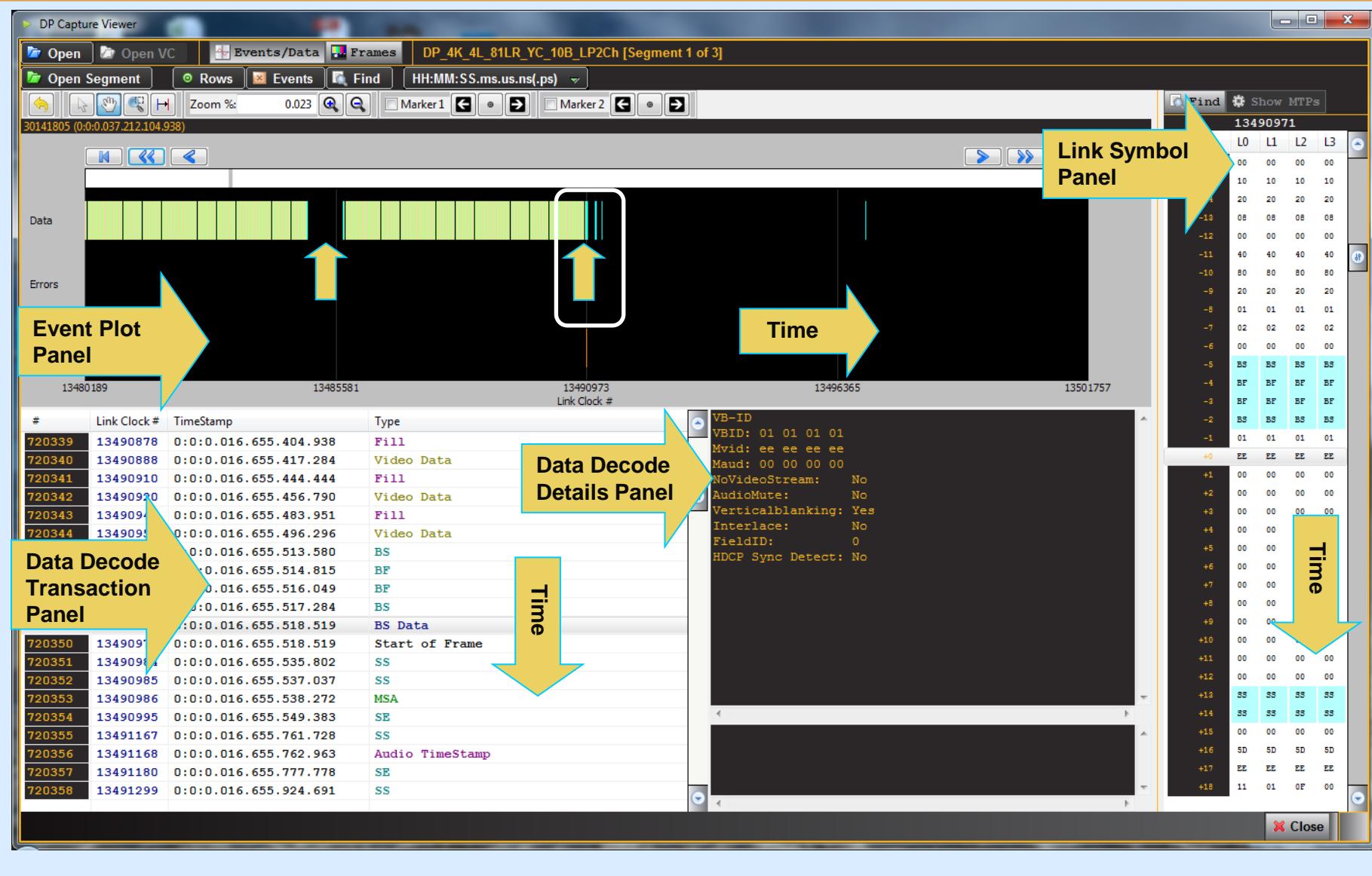
DisplayPort Main Link Protocol – One Video Frame



- Video packets occur during the active video period.
- Metadata: Main Stream Attributes (MSA) and Secondary Data Packets (SDP) occur during the vertical blanking period.
- There is a lot of **over capacity**. **Fill characters** are zeros for filling up (stuffing) the unused link symbols.

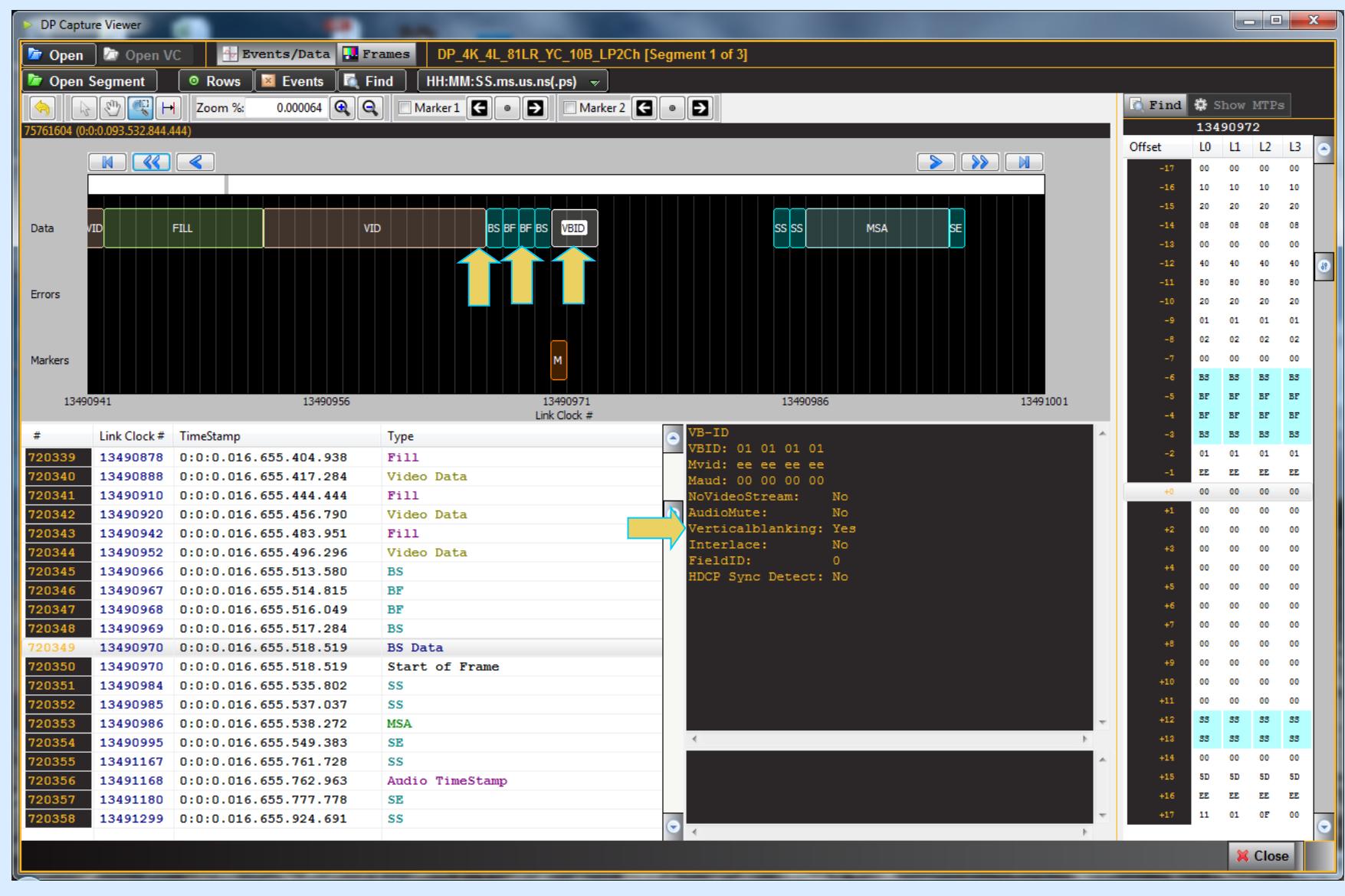
Video	Fill Characters
Metadata	Control Symbols
Audio (SD)	Control VBID w/ Compression
PPS	EoC

DisplayPort Main Link Protocol – Framing Control Symbols



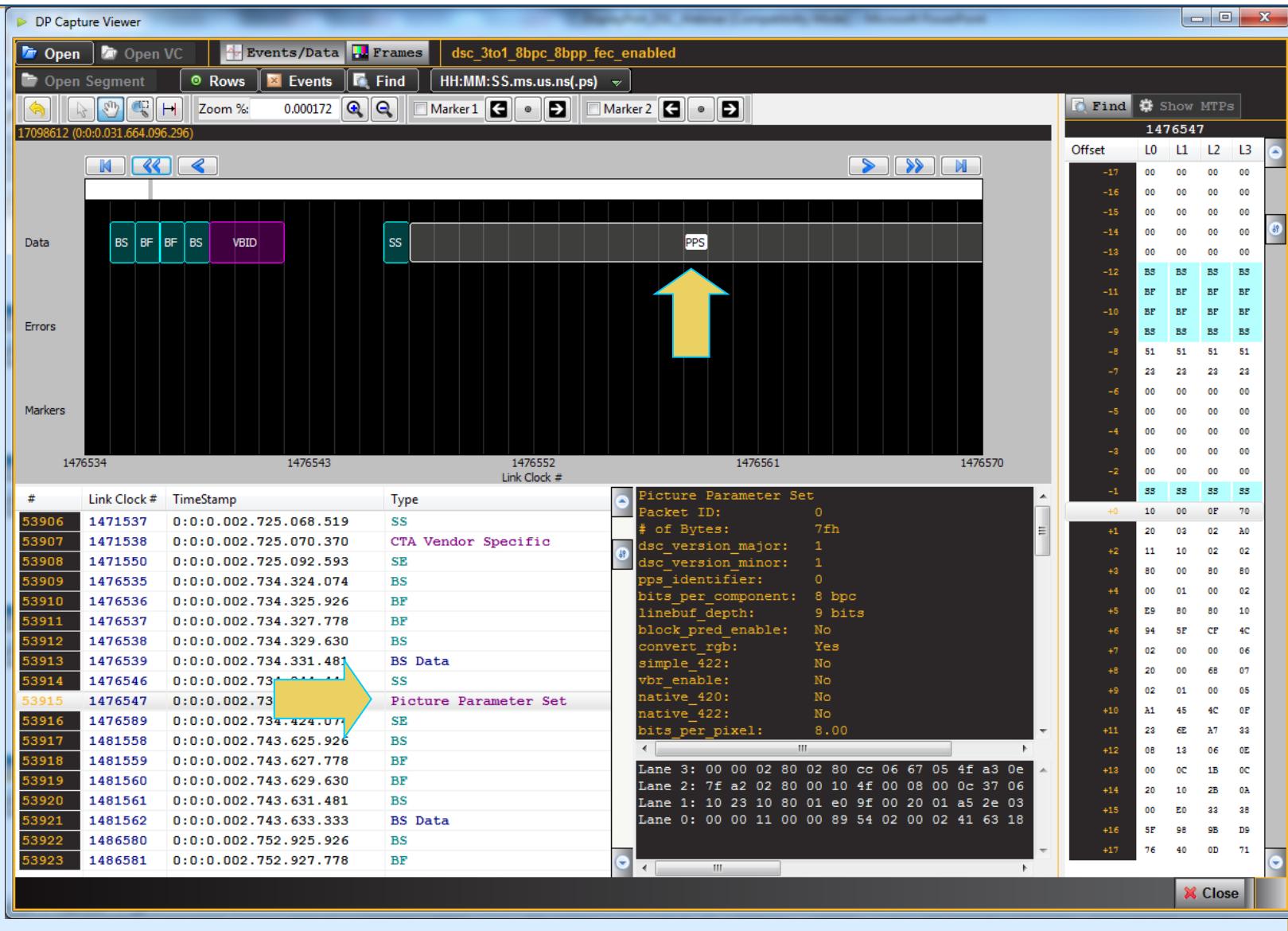
- Showing end of Video Display Frame, beginning of vertical blanking.
- Also showing the horizontal blanking region.

DisplayPort Main Link Protocol – Framing Control Symbols



- Showing end of Video Display Frame, beginning of vertical blanking.
- Last video element is preceded by a set of Fill Characters.
- Then the four (4) character sequence of Blanking Start (BS), Blanking Fill (BF) followed by the VBID.
- VBID details shown in Data Decode Details panel indicating Vertical Blanking = Yes.

Display Stream Compression – Picture Parameter Set



- Picture Parameter Set showing the following parameters:
 - Bits per Pixel – Specifies the target bits per pixel the encoder uses.
 - Picture Height – Number of lines in the video frame being encoded.
 - Picture Width – Number of pixels per line of the video frame being encoded.
 - Slice Height – Number of lines in each Slice.
 - Slice Width – Number of pixels per line of each Slice.
 - Chunk Size – Number of bytes (pixels) in a chunk. This is a function of the slice width.

Sink Link Layer Compliance – Test 5.4.1.3 Stream Unpacking/Unstuffing

Compliance Test Results Viewer

DP 1.4 Sink (1.4 Core R1.0) Compliance Test Results

Results Name: 04_23_2018_11_55_18_sink
Date Tested: April 23, 2018 11:55 AM
Overall Status: CTS 1.4 Core R1.0 - Pass

Manufacturer:
Model Name:
Port Tested: 1

HTML Report

Test Results

	Status
5.4.1.2: Main Stream Data Unpacking and Unstuffing - Least Packed TU	Pass
5.4.1.3: Main Stream Data Unpacking and Unstuffing - Most Packed TU	Pass
	Pass
Iter 01:	Pass
01: Link Training at lane count = 1 and low lane rate	Pass
HPD is asserted	Pass
Reference Source receives AUX_ACK at 1 attempts	Pass
Reference Source receives AUX ACK from either write request	Pass
AUX Read 0x2201 (MAX_LINK_RATE) = 0x1	Pass
AUX Read 0x2202 (MAX_LANE_COUNT) = 0xc4	Pass
Link Training at lane count 1 and link rate 1.62 successful	Pass
02: Test validation when lane count = 1	Pass
03: Link Training at lane count = 2 and low lane rate	Pass
04: Test validation when lane count = 2	Pass
05: Link Training at lane count = 4 and low lane rate	Pass
HPD is asserted	Pass
Reference Source receives AUX_ACK at 1 attempts	Pass
Reference Source receives AUX ACK from either write request	Pass
AUX Read 0x2201 (MAX_LINK_RATE) = 0x1	Pass
AUX Read 0x2202 (MAX_LANE_COUNT) = 0xc4	Pass
Link Training at lane count 4 and link rate 1.62 successful	Pass
06: Test validation when lane count = 4	Not Judged

Open ACA Data

5.4.1.3: Main Stream Data Unpacking and Unstuffing - Most Packed TU

Instrument: SS980B [10.30.196.39]

Continue Test Execution

Close



- ◆ Example shows Main Stream Data Unpacking Test Results.
- ◆ **Most Packed** means more video than fill characters per transfer unit.
- ◆ Test uses high resolution format on 4 lanes at 1.62Gb/s link rate.

Sink Link Layer Compliance – Test 5.4.1.1 Pixel Data Reconstruction

Compliance Test Results Viewer

DP 1.4 Sink (1.4 Core R1.0) Compliance Test Results

Results Name: 03_27_2018_16_07_26_sink
Date Tested: March 27, 2018 4:07 PM
Overall Status: CTS 1.4 Core R1.0 - Pass

Manufacturer:
Model Name:
Port Tested: 1

HTML Report

Test Results

Test Name / Details

5.4.1.1: Pixel Data Reconstruction

Iter 01:

- 01: Link Training at lane count = 1 and low lane rate
- 02: Test validation when lane count = 1 and 6 bpc
- 03: Test validation when lane count = 1 and 8 bpc
- 04: Test validation when lane count = 1 and 10 bpc
- 05: Test validation when lane count = 1 and 12 bpc
- 06: Test validation when lane count = 1 and 16 bpc
- 07: Link Training at lane count = 2 and low lane rate
- 08: Test validation when lane count = 2 and 6 bpc
- 09: Test validation when lane count = 2 and 8 bpc
- 10: Test validation when lane count = 2 and 10 bpc
- 11: Test validation when lane count = 2 and 12 bpc
- 12: Test validation when lane count = 2 and 16 bpc
- 13: Link Training at lane count = 4 and low lane rate
- 14: Test validation when lane count = 4 and 6 bpc
- 15: Test validation when lane count = 4 and 8 bpc
 - TEST_CRC_R_Cr field equals to the Reference Source's internal CRC calculations (0xF58C).
 - TEST_CRC_G_Y field equals to the Reference Source's internal CRC calculations (0xA3D3).
 - TEST_CRC_B_Cb field equals to the Reference Source's internal CRC calculations (0x0720).
- 16: Test validation when lane count = 4 and 10 bpc
- 17: Test validation when lane count = 4 and 12 bpc
- 18: Test validation when lane count = 4 and 16 bpc

5.4.1.2: Main Stream Data Unpacking and Unstuffing - Least Packed TU

Iter 01:

- 01: Initial Link Training at maximum link rate and lane count success
 - HPD is asserted
 - Reference Source receives AUX_ACK at 1 attempts
 - Reference Source receives AUX ACK from either write request

Open ACA Data 5.4.1.1: Pixel Data Reconstruction

Instrument: SS980B [10.30.196.39]

Continue Test Execution Close



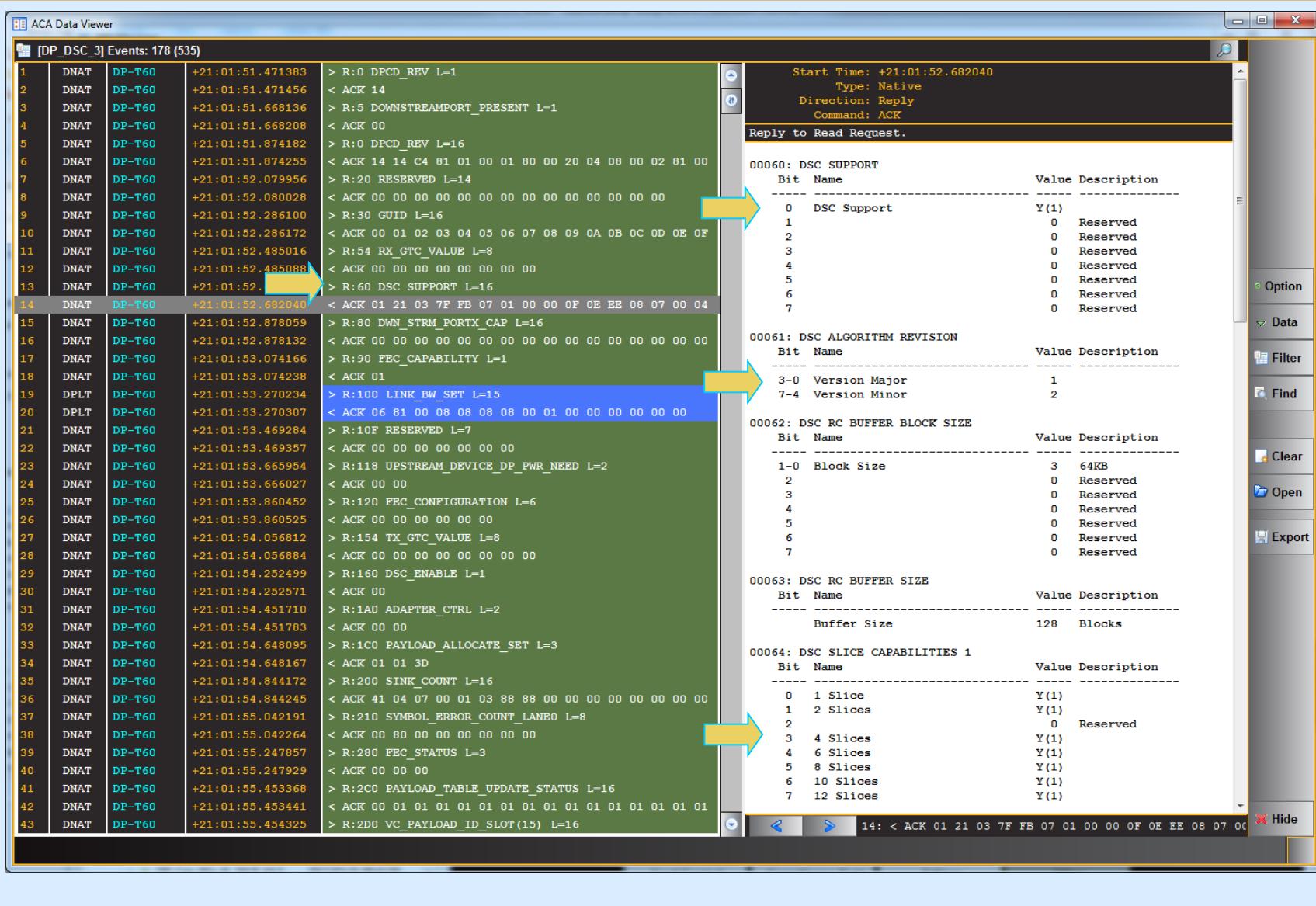
- ◆ Example test results for pixel data reconstruction.
- ◆ CRC check and visual check of received video data.
- ◆ Read CRC values in DPCD registers.
- ◆ Details show subtest with Lane count of 4 with 8 bits per component.

DisplayPort Protocols – Display Stream Compression (DSC) & Forward Error Correction (FEC)

December – 2018

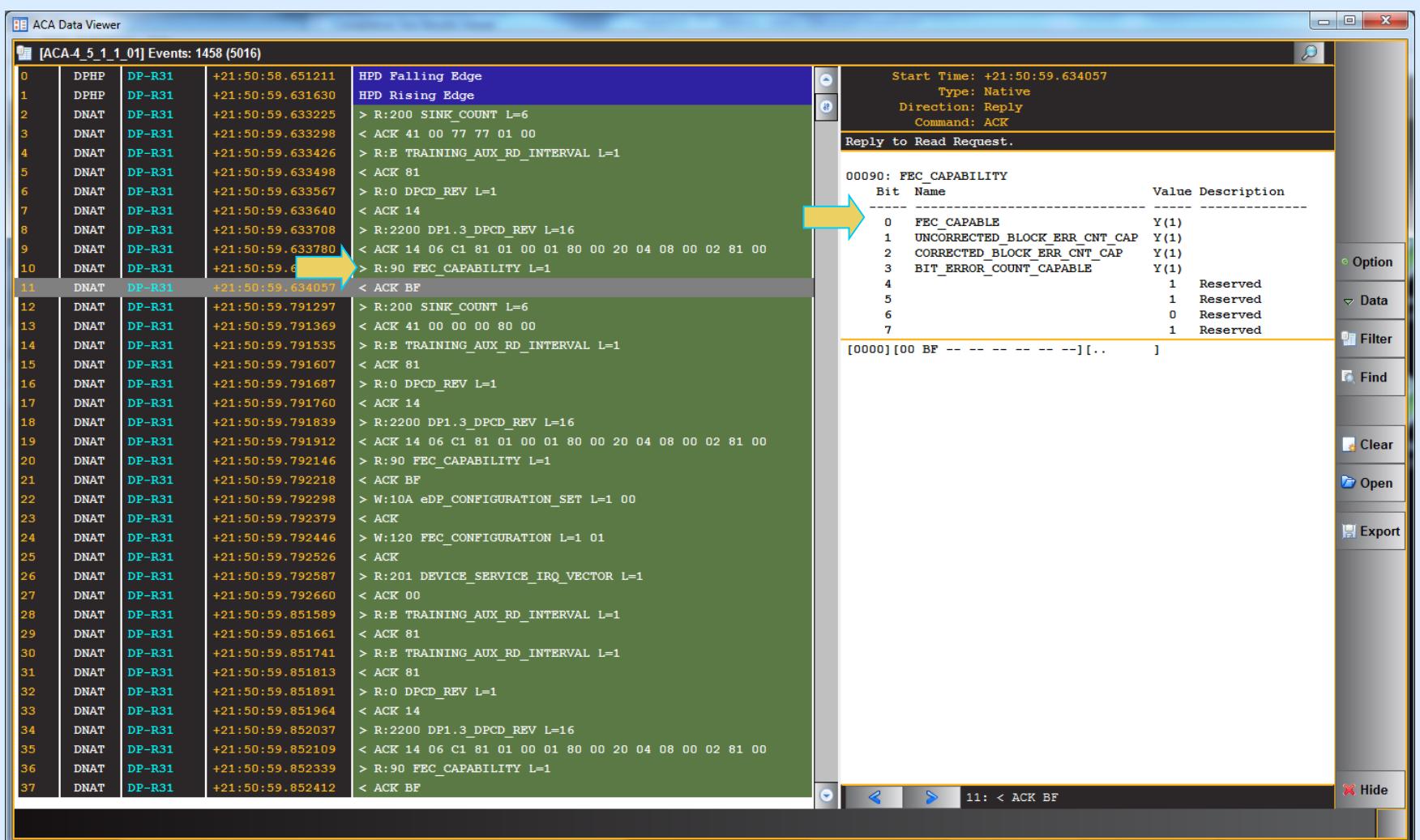


Connection Sequence – Read Sink DSC-Related DPCD Capabilities



- Source reads sink DPCD registers to determine DSC capabilities of sink.
- Example showing the following registers:
 - **DSC Support.** Indicates if DSC is supported in the DP sink.
 - **DSC Algorithm Revision.** Version of DSC supported.
 - **DSC Rate Control Buffer Block Size.** Block size of the memory blocks in the Rate Control Buffer.
 - **DSC Rate Control Buffer Size** – Number of RC memory blocks.
 - **DSC Slice Capabilities** – Indicates the number of slices supported.

Connection Sequence – Read Sink FEC Capabilities in DPCD Registers



- Source reads sink DPCD FEC Capability registers to determine if sink is FEC capable.
- Source also verifies that sink has declared the FEC register counters.

Sink FEC Compliance Test – Correctable Bit Errors - Test ID# 5.5.1.5

Compliance Test Results Viewer

DP 1.4a Sink (Core R1.0) Compliance Test Results

Results Name: 980_LB_FEC **Manufacturer:**

Date Tested: October 19, 2018 9:33 AM **Model Name:**

Overall Status: CTS Core R1.0 - Fail **Port Tested:** 1

Test Results

▶ **Test Name / Details**

▷ 5.5.1.2: Successful Link Training at All Supported Lane Counts

▷ 5.5.1.3: Uncorrectable Block error count

▷ 5.5.1.4: Correctable Block error count

▲ 5.5.1.5: Correctable Bit error count

● Iter 01:

- ▷ 01: Link Training test for lane count = 1 and lane rate
- ▷ 02: Link Training test for lane count = 2 and lane rate
- ▷ 03: Link Training test for lane count = 4 and lane rate
- ▷ 04: Link Training test for lane count = 1 and lane rate
- ▷ 05: Link Training test for lane count = 2 and lane rate
- ▷ 06: Link Training test for lane count = 4 and lane rate
- ▷ 07: Link Training test for lane count = 1 and lane rate
- ▷ 08: Link Training test for lane count = 2 and lane rate
- ▷ 09: Link Training test for lane count = 4 and lane rate
- ▷ 10: Link Training test for lane count = 1 and lane rate
- ▲ 11: Link Training test for lane count = 2 and lane rate
 - HPD is asserted
 - Reference Source receives AUX_ACK at 1 attempts of SET_POWER
 - Reference Source receives AUX ACK from either write request of SET_POWER or read request of MAX_LINK_RATE
 - Reference Source receives AUX ACK from either write request of FECC or read request of MAX_LANE_COUNT
 - AUX Read 0x2201 (MAX_LINK_RATE) = 0x1e
 - AUX Read 0x2202 (MAX_LANE_COUNT) = 0xc4
 - Link Training at lane count 2 and link rate 8.1 successful
 - FEC Decode enable link symbol sequence detected over main link. (1)
 - ==> On Lane 1, after inserting 1000 FEC correctable bit errors.
 - ----- Lane 1 FEC correctable bit errors in range (998), ----- Lane 2 Reported FEC correctable bit errors (2).
 - ==> On Lane 2, after inserting 1000 FEC correctable bit errors.
 - ----- Lane 2 FEC correctable bit errors in range (1000).
 - Sink DUT reports, FEC Decode disable link symbol sequence detected
- ▷ 12: Link Training test for lane count = 4 and lane rate

▷ 5.5.1.6: Correctable Parity Block error count

□ Open ACA Data

5.5.1.2: Successful Link Training at All Supported Lane Counts and Link Rates with FEC Encoding

Instrument: SS980B [10.30.196.39]

ACA Data Viewer

[ACA-5_5_1_5_01] Events: 1870 (4666)			
1635	DPLT	DP-T30	+22:14:45
1636	DNAT	DP-T30	+22:14:45
1637	DNAT	DP-T30	+22:14:45
1638	DNAT	DP-T30	+22:14:45
1639	DNAT	DP-T30	+22:14:45
1640	DNAT	DP-T30	+22:14:45
1641	DNAT	DP-T30	+22:14:45
1642	DNAT	DP-T30	+22:14:45
1643	DNAT	DP-T30	+22:14:45
1644	DNAT	DP-T30	+22:14:45
1645	DNAT	DP-T30	+22:14:45
1646	DNAT	DP-T30	+22:14:45
1647	DNAT	DP-T30	+22:14:45
1648	DNAT	DP-T30	+22:14:45
1649	DNAT	DP-T30	+22:14:45
1650	DNAT	DP-T30	+22:14:45
1651	DNAT	DP-T30	+22:14:45
1652	DNAT	DP-T30	+22:14:45
1653	DNAT	DP-T30	+22:14:45
1654	DNAT	DP-T30	+22:14:45
1655	DNAT	DP-T30	+22:14:45
1656	DNAT	DP-T30	+22:14:45
1657	DNAT	DP-T30	+22:14:45
1658	DNAT	DP-T30	+22:14:45
1659	DNAT	DP-T30	+22:14:45
1660	DNAT	DP-T30	+22:14:45
1661	DNAT	DP-T30	+22:14:45
1662	DNAT	DP-T30	+22:14:45
1663	DNAT	DP-T30	+22:14:45
1664	DNAT	DP-T30	+22:14:45
1665	DNAT	DP-T30	+22:14:45
1666	DNAT	DP-T30	+22:14:45
1667	DNAT	DP-T30	+22:14:45
1668	DPLT	DP-T30	+22:14:45
1669	DPLT	DP-T30	+22:14:45

◆ Test verifies that sink can count correctable Bit errors. Bit errors

The screenshot shows two windows. The left window is titled 'ACB-5_1_5_01 Events: 1870 (4666)' and displays a list of network events. The right window is a detailed view of a specific event, showing its start time, type, direction, and command. It also shows the reply to a read request for FEC_Error_Counts, with two entries: 00281 (Count7:0) and 00282 (Count14:8). A yellow arrow points from the event in the list to the corresponding entry in the details window.

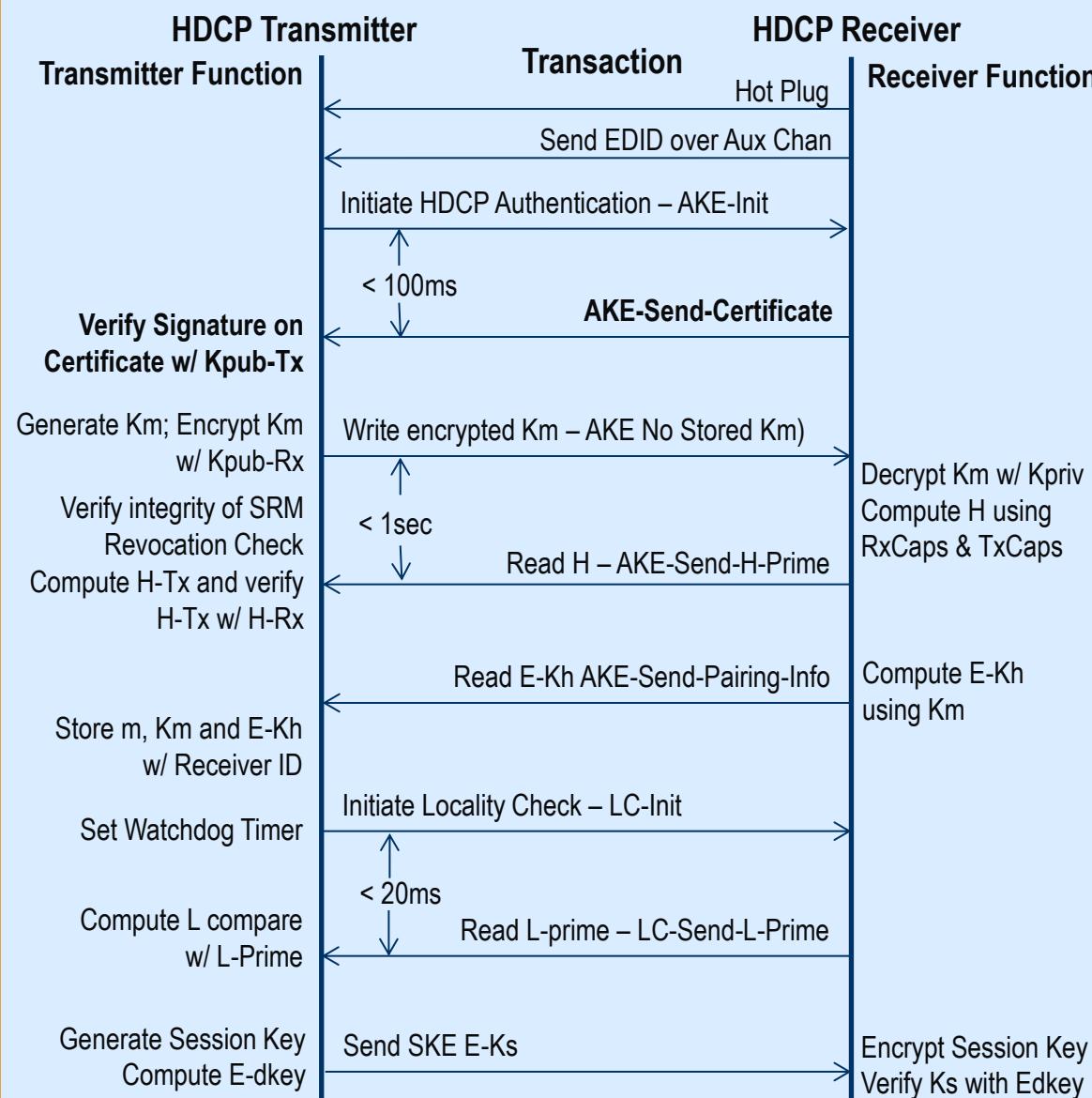
Event ID	Source	Destination	Time	Message
1635	DPLT	DP-T30	+22:14:46.387294	< ACK 1E 82
1636	DNAT	DP-T30	+22:14:46.507891	> R:280 FEC_STATUS L=1
1637	DNAT	DP-T30	+22:14:46.507963	< ACK 01
1638	DNAT	DP-T30	+22:14:46.508034	> W:120 FEC_CONFIGURATION L=1 01
1639	DNAT	DP-T30	+22:14:46.508115	< ACK
1640	DNAT	DP-T30	+22:14:46.508184	> W:120 FEC_CONFIGURATION L=1 07
1641	DNAT	DP-T30	+22:14:46.508265	< ACK
1642	DNAT	DP-T30	+22:14:46.509326	> W:120 FEC_CONFIGURATION L=1 01
1643	DNAT	DP-T30	+22:14:46.509407	< ACK
1644	DNAT	DP-T30	+22:14:46.509582	> W:120 FEC_CONFIGURATION L=1 07
1645	DNAT	DP-T30	+22:14:46.509662	< ACK
1646	DNAT	DP-T30	+22:14:48.548895	> W:120 FEC_CONFIGURATION L=1 07
1647	DNAT	DP-T30	+22:14:48.548975	< ACK
1648	DNAT	DP-T30	+22:14:48.549036	> R:281 FEC_ERROR_COUNT0 L=2
1649	DNAT	DP-T30	+22:14:48.549109	< ACK E6 83
1650	DNAT	DP-T30	+22:14:48.549194	> W:120 FEC_CONFIGURATION L=1 17
1651	DNAT	DP-T30	+22:14:48.549275	< ACK
1652	DNAT	DP-T30	+22:14:48.549340	> R:281 FEC_ERROR_COUNT0 L=2
1653	DNAT	DP-T30	+22:14:48.549495	< ACK 02 80
1654	DNAT	DP-T30	+22:14:48.549495	> W:120 FEC_CONFIGURATION L=1 01
1655	DNAT	DP-T30	+22:14:48.549576	< ACK
1656	DNAT	DP-T30	+22:14:48.549742	> W:120 FEC_CONFIGURATION L=1 07
1657	DNAT	DP-T30	+22:14:48.549822	< ACK
1658	DNAT	DP-T30	+22:14:50.586622	> W:120 FEC_CONFIGURATION L=1 07
1659	DNAT	DP-T30	+22:14:50.586702	< ACK
1660	DNAT	DP-T30	+22:14:50.586767	> R:281 FEC_ERROR_COUNT0 L=2
1661	DNAT	DP-T30	+22:14:50.586840	< ACK 00 80
1662	DNAT	DP-T30	+22:14:50.586925	> W:120 FEC_CONFIGURATION L=1 17
1663	DNAT	DP-T30	+22:14:50.587006	< ACK
1664	DNAT	DP-T30	+22:14:50.587068	> R:281 FEC_ERROR_COUNT0 L=2
1665	DNAT	DP-T30	+22:14:50.587140	< ACK E8 83
1666	DNAT	DP-T30	+22:14:50.587223	> W:280 FEC_STATUS L=1 FF
1667	DNAT	DP-T30	+22:14:50.587303	< ACK
1668	DPLT	DP-T30	+22:14:50.590684	> R:100 LINK_BW_SET L=2
1669	DPLT	DP-T30	+22:14:50.590756	< ACK 1E 82
1670	DPLT	DP-T30	+22:14:50.699524	> R:100 LINK_BW_SET L=2
1671	DPLT	DP-T30	+22:14:50.699597	< ACK 1E 82
1672	DNAT	DP-T30	+22:14:50.809877	> R:280 FEC_STATUS L=1

DisplayPort Connection Sequence HDCP 2.2 Authentication Protocol

December – 2018



HDCP 2.2 Sequence – Transmitter Reads Receiver Certificate



ACA Data Viewer

[HDCP_22_Snk_CT_2C_01] Events: 216 (489)

```

109 DHDCP DP-T61 < ACK FD ED E7 73 60 82 9D 1C
110 DHDCP DP-T61 > R:691A3 cert_rx(408) L=8
111 DHDCP DP-T61 < ACK FA 31 E6 B3 85 E9 BC 09
112 DHDCP DP-T61 > R:691AB cert_rx(416) L=8
113 DHDCP DP-T61 < ACK B8 BD 2D AD F5 58 0F DB
114 DHDCP DP-T61 > R:691B3 cert_rx(424) L=8
115 DHDCP DP-T61 < ACK C9 A6 EC 1F DE 91 B1 19
116 DHDCP DP-T61 > R:691BB cert_rx(432) L=8
117 DHDCP DP-T61 < ACK 90 3F 0F D9 E7 48 4F F3
118 DHDCP DP-T61 > R:691C3 cert_rx(440) L=8
119 DHDCP DP-T61 < ACK A8 5F CE FD F0 0B F3 B8
120 DHDCP DP-T61 > R:691CB cert_rx(448) L=8
121 DHDCP DP-T61 < ACK 2C E9 06 6C 43 B4 6F AA
122 DHDCP DP-T61 > R:691D3 cert_rx(456) L=8
123 DHDCP DP-T61 < ACK 89 00 4D F2 96 1D AA 88
124 DHDCP DP-T61 > R:691DB cert_rx(464) L=8
125 DHDCP DP-T61 < ACK 42 13 DB 71 C1 A9 79 75
126 DHDCP DP-T61 > R:691E3 cert_rx(472) L=8
127 DHDCP DP-T61 < ACK CA 30 61 67 52 CE D1 96
128 DHDCP DP-T61 > R:691EB cert_rx(480) L=8
129 DHDCP DP-T61 < ACK 6A 5F 9F B2 C9 EA 7C DA
130 DHDCP DP-T61 > R:691F3 cert_rx(488) L=8
131 DHDCP DP-T61 < ACK 3D 88 A0 E3 82 CD 99 AB
132 DHDCP DP-T61 > R:691FB cert_rx(496) L=8
133 DHDCP DP-T61 < ACK 0F 94 AA B3 3F DF CE 91
134 DHDCP DP-T61 > R:69203 cert_rx(504) L=8
135 DHDCP DP-T61 < ACK B6 F2 9F 18 A5 3F 60 5C
136 DHDCP DP-T61 > R:6920B cert_rx(512) L=8
137 DHDCP DP-T61 < ACK F4 76 93 03 6B A9 E8 E7
138 DHDCP DP-T61 > R:69213 cert_rx(520) L=8
139 DHDCP DP-T61 < ACK 9C 09 D7 8C 7F 01 D8 49
140 DHDCP DP-T61 > R:6921B r_rx(6) L=5
141 DHDCP DP-T61 < ACK 67 D5 02 00 02
142 DHDS DP-T61 < AKE_Sent_Cert
143 DHDCP DP-T61 > W:69220 Ekpib_Km L=8 89 F3 27 5D 45...
144 DHDCP DP-T61 < ACK
145 DHDCP DP-T61 > W:69228 Ekpib_Km(8) L=8 78 94 0A EA...
146 DHDCP DP-T61 < ACK

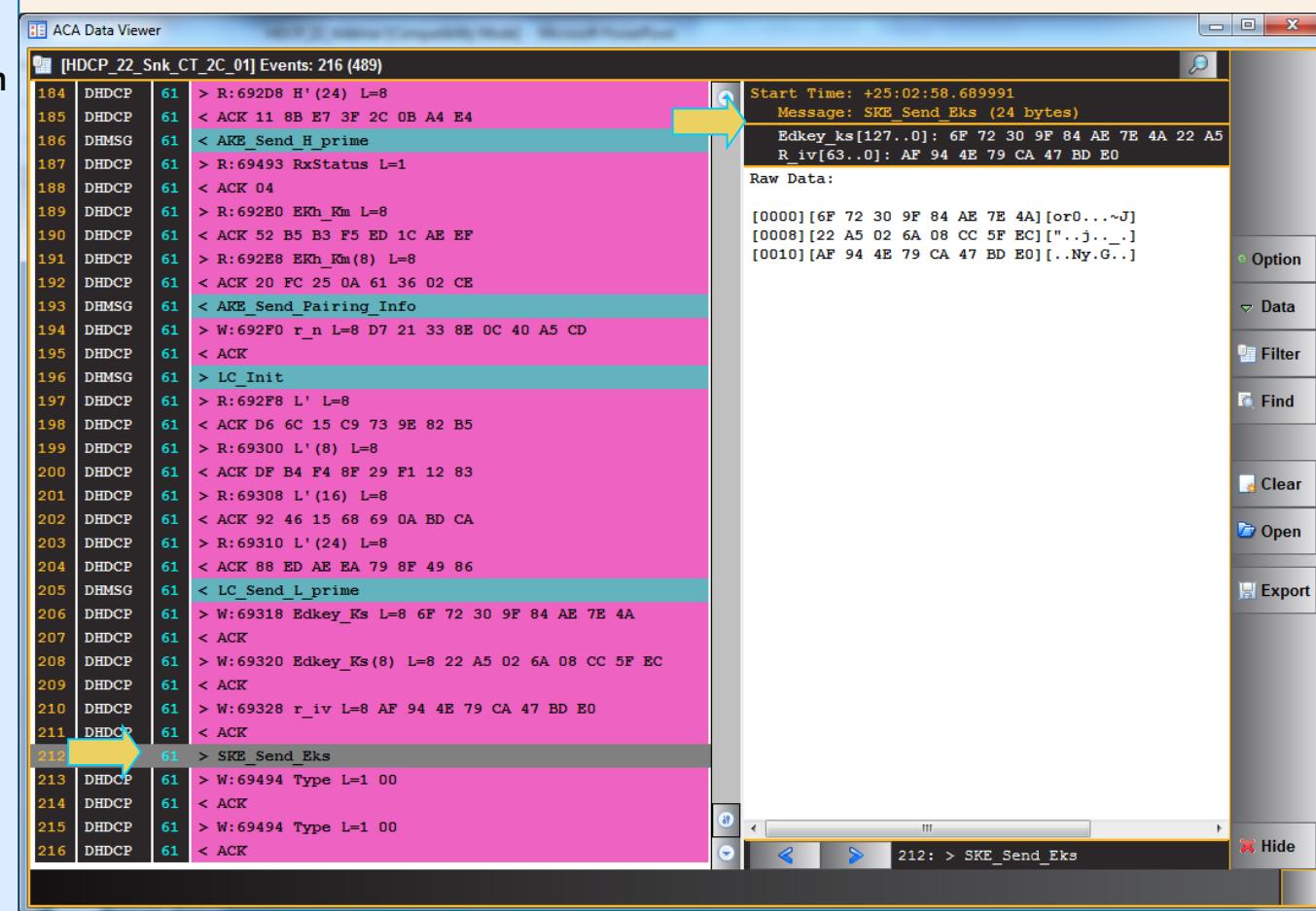
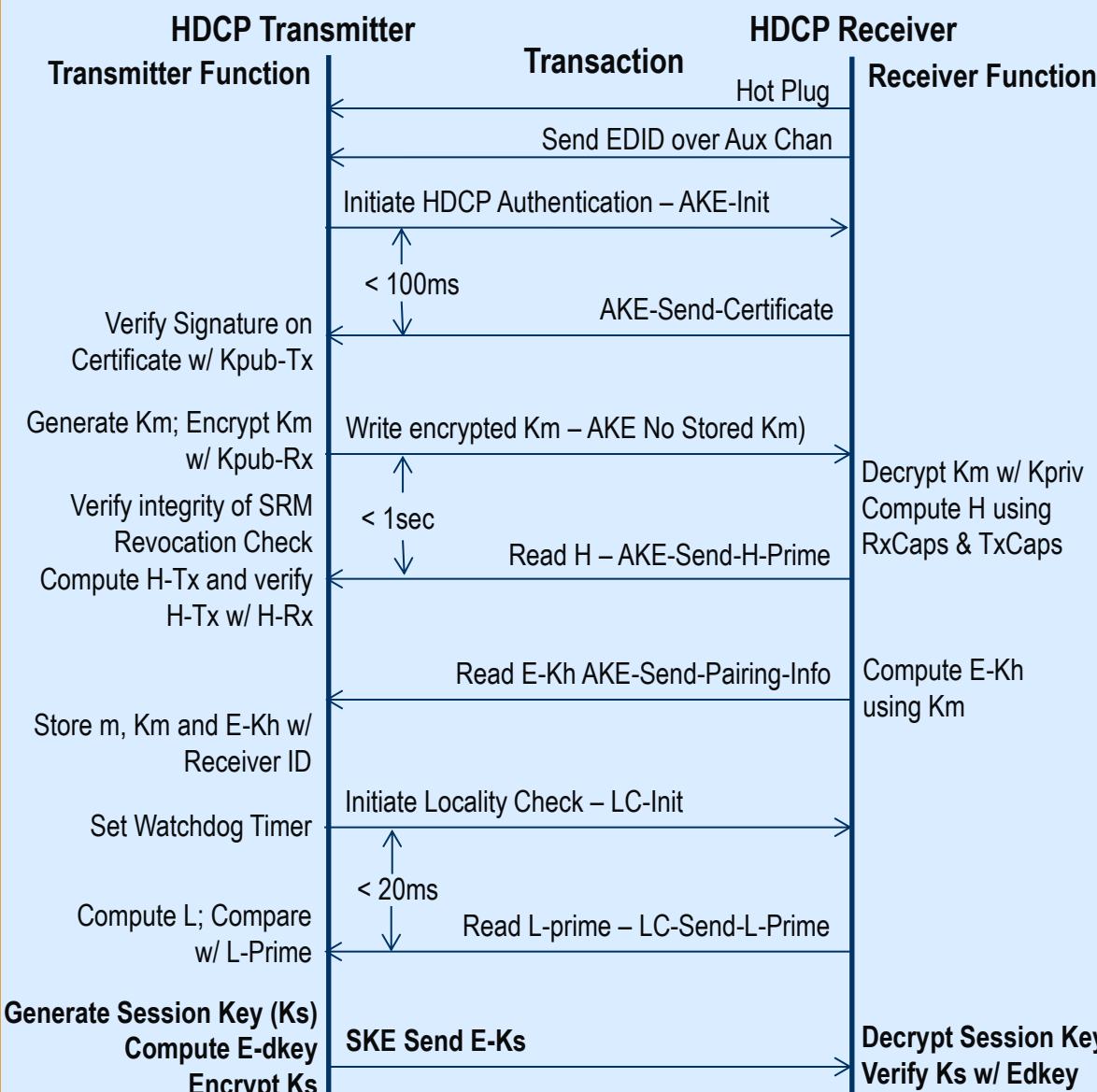
```

Start Time: +25:02:58.654548
Message: AKE Send Cert (533 bytes)
cert_rx:[4175.0]
Receiver ID: 4B 22 7D 48 5F
Receiver Public Key:
DA 49 6F BA 60 64 4B 09 D7 0E 57 80 BD F3 4C C0
39 C4 9F CC 75 34 A1 DE OD 06 3E A3 0C ED 20 5D
A8 96 11 88 49 9A 9D 8B BC D7 20 7D 62 0C 93 94 46
F3 17 DB 5D 4B 13 0C 1C B5 4F 5A DB 3C AA 46 9F
F1 AC 77 C6 E0 75 18 2F A9 1B 3B 65 BB 77 AA
F1 DD 25 E2 8A A1 AE 69 14 2D CF F6 7D C5 BB 08
79 44 7A FB 3E F2 83 6D DD 1A 03 16 5F F4 45 9B
40 4B 6B 1E A6 91 C4 1F A3 DA 44 1C F8 41 BE 6F
01 00 01
RESERVED: 00 00
DCP LLC Signature:
84 84 BB 6B 0D 32 D6 B2 9A 45 E7 80 66 78 68 38
4D F0 A8 B6 6B F3 38 F2 9C 31 EC B0 D4 2E FD FC
C5 D2 77 9F 9C BC 9C 63 13 A6 F5 E3 94 5C 3A EF
A7 E2 A4 77 1A BB 58 88 9B BE 69 44 22 E8 1C B3
AF 5C 6E FD A6 CF AD D6 CE D1 0F 85 75 8E EA OB
5C 19 C8 25 D8 5A 4C B0 33 04 41 CE 82 EF 9A 1C
FF E7 1F 1B AE ED 58 32 97 0A D8 06 F8 C1 F9
3B C2 C5 B1 5A 0D E2 AA 3E 13 61 04 0A 6B BA 41
81 F4 EA 8A 44 CB 9A F8 8A AD EE 29 47 4D 55 27
D9 C7 D9 3C 15 15 50 66 50 5B C8 76 05 1F 35 0R
BD DA C2 0B E7 6D CA 8D 5E EC 07 24 CB 5E C5 F8
BA 67 B7 39 57 9B F1 72 15 93 B6 E6 51 9B 08 1C
55 31 3C 2B CF 62 4B BB 7B D9 36 1A 4C FE 94 B2
90 22 26 71 1B 1B 91 20 01 3B 69 4C DD DC RE DF
2E 00 2F A0 FT C9 82 E5 3A 48 36 BE 69 D2 5F F3
25 80 BF PC 74 E1 CF FA CA 5F 94 8C 11 F5 B8 97
1F 24 A2 78 65 20 FD ED E7 73 60 82 9D 1C FA 31
E6 B3 85 E9 BC 09 B8 BD 2D AD F5 58 0F DB C9 A6
EC 1F DB 91 B1 19 90 3F 0F D9 E7 48 4F F3 A8 5F
CE FD F0 0B PC 83 B2 E9 06 6C 43 B4 6F AA 89 00
4D F2 96 1D AA 88 4E 13 DE 71 C1 A9 79 75 CA 30
61 67 52 CE D1 96 6A 5E 9F B2 C9 EA 7C DA 3D 88
A0 B3 82 CD 99 AB OF 94 AA B3 3F DF CR 91 B6 F2
9F 18 A5 3F 60 5C F4 76 93 03 6B A9 E8 E7 9C 09
r_rx[63..0]: 7E 8C 7F 01 D8 49 67 D5
RxCaps: 02 00 02
REPEATER: false
CAP MASK: 0000h
HDCP_CAPABLE: true (DisplayPort Only, not HDMI)
VERSION: 2

142: < AKE_Sent_Cert

- Transmitter reads Receiver Certificate. Certificate contains:
 - Receiver ID – Unique receiver ID; 40 bits: 20 ones & 20 zeros
 - Receiver Public Key – Unique 1040 bit RSA public key ($k_{pub_{rx}}$).
 - DCP signature – Calculated over all fields in certificate.
 - Rrx pseudo-random number used for verifying Master Key exchange, exchanging Session key and encrypting A/V content.

HDCP 2.2 Sequence – Session Key Generation and Exchange



- ◆ Transmitter generates true random Session Key (Ks).
- ◆ The Session Key is AES-encrypted using Master Key (Km)
- ◆ Transmitter sends Session Key (Km) to Receiver with a pseudo-random number (Riv) in SKE E-Ks write message.

HDCP 2.2 Compliance Test – Example Test 1A-06 Failure

Compliance Test Results Viewer

HDMI HDCP 2.2 TX (1.0) Compliance Test Results

Results Name: HDMI_HDCP_22_PC Manufacturer: ACME
Date Tested: May 17, 2016 3:57 PM Model Name: XYZ
Overall Status: CTS 1.0 - Fail Port Tested: 1

Test Results

Test Name / Details Status

1A-01: Regular Procedure: With previously connected Receiver (With stored Km)	Pass
1A-02: Regular Procedure: With newly connected Receiver (Without stored Km)	Pass
1A-03: Regular Procedure: Receiver disconnect after AKE Init	Pass
1A-04: Regular Procedure: Receiver disconnect after Km	Pass
1A-05: Regular Procedure: Receiver disconnect after locality check	Pass
1A-06: Regular Procedure: Receiver disconnect after Ks	Fail
Iter 01:	Fail

1A-01: Regular Procedure: With previously connected Receiver (With stored Km)

1A-02: Regular Procedure: With newly connected Receiver (Without stored Km)

1A-03: Regular Procedure: Receiver disconnect after AKE Init

1A-04: Regular Procedure: Receiver disconnect after Km

1A-05: Regular Procedure: Receiver disconnect after locality check

1A-06: Regular Procedure: Receiver disconnect after Ks

Iter 01:

- Clear Ready
- RX HPD Deasserted regular ts:5115282636.80 us
- RX HPD Asserted regular ts:5115432673.28 us
- RX UNAUTH::ENTER
- RX UNAUTH:HDMI/VIDEO Present
- RX UNAUTH:MSG RD:ENC_DIS ts:5115992064.00 us
- RX UNAUTH:RCVD:AKE_Init ts:0.00 us
- RX UNAUTH:**Test Cond.** hpd
- RX AKE:MSG SND:AKE_Send_Cert ts:5117223004.16 us
- RX AKE:MSG RCV:AKE_No_Stored_km ts:5118022901.76 us
- RX PAIR::ENTER
- RX PAIR:MSG RD:AKE_Send_H_Prime ts:5118037442.56 us
- RX LC:MSG SND:AKE_Send_Pairing_Info ts:5118050856.96 us
- RX LC:MSG RCV:LC_Init ts:5118052044.80 us
- RX LC:MSG SND:LC_Send_L_prime ts:5118058301.44 us
- RX LC:MSG RCV:SKE_Send_Eks ts:5118072350.72 us
- RX SKE::ENTER
- RX SKE:MSG RCV:SKE_Send_Eks ts:5118072350.72 us
- RX HPD Deasserted irregular ts:5118072606.72 us
- RX HPD Asserted irregular ts:5118272634.88 us
- RX UNAUTH:MSG RD:ENC_EN ts:5118292039.68 us

Encryption Enabled

- ◆ Example shows details of test 1A-06 where there is a failure.
- ◆ The point of failure is identified. In this case, after disconnection cycle, encryption pulse was enabled following a connection cycle. The Transmitter should have terminated the encryption and re-initiated authentication.

1A-07: Regular Procedure: Receiver sends REAUTH REQ after Ks	Pass
1A-08: Irregular Procedure: Rx certificate not received.	Pass
1A-09: Irregular Procedure: Verify Receiver Certificate	Pass
1A-11: Irregular Procedure: Invalid H'	Pass
1A-12: Irregular Procedure: Pairing Failure	Pass
1A-13: Irregular Procedure: Locality Failure	Pass
1B-01: Regular Procedure: With Repeater	Pass
1B-02: Irregular Procedure: Timeout of Receiver ID list	Pass
1B-03: Irregular Procedure: Verify V'	Pass
1B-04: Irregular Procedure: MAX DEVS EXCEEDED	Pass
1B-05: Irregular Procedure: MAX CASCADE EXCEEDED	Pass
1B-06: Irregular Procedure: Incorrect seq num V	Pass

1A-01: Regular Procedure: With previously connected Receiver (With stored Km)

Instrument: My980 [10.30.196.32] Continue Test Execution Close

Thank you for your Attention

Please contact me, Neal Kendall at:

neal.kendall@teledyne.com

If you have any questions.



980B Test Platform
equipped with
980 DisplayPort 1.4
USB-C/eDP Video
Generator / Protocol
Analyzer module

The most comprehensive solution for testing DP 1.4 HBR3 sources and sinks with DSC/FEC for deep analysis and compliance testing including HDCP 2.2 compliance.

- ◆ Please Check out our DisplayPort “Essentials of” Webinars:
 - ◆ [Essentials of DisplayPort Protocols](#)
 - ◆ [Essentials of HDCP 2.2 Protocols](#)
 - ◆ [Essentials of DisplayPort Display Stream \(DSC\) Protocols](#)
 - ◆ [Essentials of DisplayPort Link Layer Compliance Testing](#)
 - ◆ [Essentials of DisplayPort Forward Error Correction \(FEC\)](#)
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