

USB4™ DP Tunneling Compliance Test Specification

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|----------|---------------|---|
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Introduction

The tests in this specification verify that a USB4 Product is compliant with Chapter 10 of the USB4™ Specification.

Reference Documents

- Universal Serial Bus 4 (USB4™) Specification Version 1.0 August, 2019 ([USB4 Specification](#))
- VESA DisplayPort (DP) Standard Version 1.4a 19 April, 2018 ([DP 1.4a Specification](#))
- VESA DisplayPort v1.4a Link Layer Compliance Test Specification Revision 1.0 June 12, 2019 ([DP Link CTS](#))
- VESA DP 1.4a Link CTS rev 1.0 Errata E3 Published 11/15/19 include for DPTXs: ([DP Link CTS Errata](#))
 - DisplayPort DSC Link Layer Compliance Test Specification
 - DSC Link Layer Compliance Test Rev 1.0 SCR on Simple 422 CRC
 - DSC Link Layer Compliance Test Rev 1.0 SCR on Line Buffer Bit Depth
 - DP1.4a Link CTS r1.0 SCR AUX reply timeout d2
- High-bandwidth Digital Content Protection Revision 2.3 on DisplayPort Compliance Test Specification Revision 1.1 4 March 2019 ([HDCP CTS for DP](#))
- Universal Serial Bus 4 (USB4™) Connection Manager Guide

Assertions

Compliance criteria are provided as a list of assertions that describe specific characteristics or behaviors that must be met. Each assertion provides a reference to the USB4 specification or other documents from which the assertion was derived. In addition, each assertion provides a reference to the specific test description(s) where the assertion is tested.

Each test assertion is formatted as follows:

| Assertion # | Test # | Assertion Description |
|-------------|--------|-----------------------|
|-------------|--------|-----------------------|

Assertion#: Unique identifier for each spec requirement. The identifier is in the form USB4_SPEC_SECTION_NUMBER#X, where X is a unique integer for a requirement in that section.

Assertion Description: Specific requirement from the specification

Test #: A label for a specific test description in this specification that tests this requirement. Test # can have one of the following values:

- NT This item is not explicitly tested in a test description. Items can be labeled NT for several reasons – including items that are not testable, not important to test for interoperability, or are indirectly tested by other operations performed by the compliance test.
- X.X This item is covered by the test described in test description X.X in this specification.
- IOP This assertion is verified by the USB4 Interoperability Test Suite.

Test descriptions provide a high level overview of the tests that are performed to check the compliance criteria. The descriptions are provided with enough detail so that a reader can understand what the test does. The descriptions do not describe the actual step-by-step procedure to perform the test.

The following Table presents the USB4 Specification Chapter 10 asserts.

| Assertion # | How to Test | Assertion Description |
|---------------------------------|-------------|--|
| 10 DisplayPort Tunneling | | |
| 10#1 | TD 10.003 | A USB4 host shall support DP tunneling. |
| 10#2 | TD 10.003 | A Host Router shall contain at least one DP IN Adapter and may optionally contain one or more DP OUT Adapters. |
| 10#3 | TD 10.003 | A USB4 hub shall support DP Tunneling. |
| 10#4 | TD 10.003 | A USB4 Hub shall contain at least one DP OUT Adapter and may optionally contain one or more DP IN Adapters. |

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| 10#5 | NT | If a USB4 peripheral device supports DP Tunneling, it shall contain at least one DP Adapter. |
| 10.1 DP Adapter Port Protocol Stack | | |
| 10.1.1 Transport Layer | | |
| 10.1.2 Protocol Adapter Layer | | |
| 10.1.3 DP Physical Layer | | |
| 10.1.3#1 | TD 10.003 TD 10.003 | A DP Adapter Port shall either implement the DisplayPort Physical Layer as defined in the DisplayPort 1.4a Specification or shall implement its functional equivalent (e.g. DP Adapter Port is connected to a DPRX or a DPTX as part of an SoC). |
| 10.1.3#2 | NT | A DP IN Adapter Port which does not implement a Physical Layer shall generate a stream of DisplayPort Tunneled packets as if a Physical Layer exists. |
| 10.2 DP Adapter States | | |
| 10.2.1 Reset | | |
| 10.2.1#1 | TD 10.003 TD 10.003 | While in the Reset state, a DP Adapter shall set all Configuration Spaces to their default values. |
| 10.2.1#2 | NT | A DP IN Adapter shall drive HPD signal low. |
| 10.2.1#3 | NT | A DP OUT Adapter shall not apply DP_PWR. |
| 10.2.2 Present | | |
| 10.2.2#1 | TD 10.003 TD 10.003 | While in the Present state, a DP Adapter shall set all Configuration Spaces to their default values. |
| 10.2.2#2 | NT | A DP IN Adapter Port shall drive HPD signal low. |
| 10.2.2#3 | NT | A DP OUT Adapter Port shall not apply DP_PWR. |
| 10.2.3 Plugged | | |
| 10.2.3#1 | NT | While in the Plugged state, a DP IN Adapter shall drive HPD signal low. |

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| 10.2.4 Paired | | |
| 10.3 Interfaces | | |
| 10.3.1 DisplayPort | | |
| 10.3.1#1 | NT | A DP Adapter shall support three modes of operation: <u>LTTTPR Non-Transparent</u> – LT-tunable PHY Repeater (Non-Transparent Mode); <u>LTTTPR Transparent</u> – LT-tunable PHY Repeater (Transparent Mode); <u>Non-LTTTPR</u> – Non-LT-tunable PHY Repeater. |
| 10.3.1#2 | NT | After reset, a DP Adapter shall operate in Non-LTTTPR mode. |
| 10.3.1#3 | NT | A DP Adapter shall transition between the three modes as described in Section 10.4.6.1. |
| 10.3.1#4 | NT | A DP Adapter shall transition to Non-LTTTPR mode upon exit from the Paired state. |
| 10.3.1.1 LTTTPR Non-Transparent | | |
| 10.3.1.1#1 | NT | A DP IN Adapter shall implement LTTTPR UFP. |
| 10.3.1.1#2 | NT | A DP OUT Adapter shall implement LTTTPR DFP. |
| 10.3.1.2 Non-LTTTPR | | |
| 10.3.1.2#1 | NT | A DP IN Adapter shall implement Non-LTTTPR Non-Transparent UFP. |
| 10.3.1.2#2 | NT | A DP OUT Adapter shall implement Non-LTTTPR Non-Transparent DFP. |
| 10.3.1.3 LTTTPR Transparent | | |
| 10.3.2 Programming Model | | |
| 10.3.2.1 Adapter Configuration Space | | |
| 10.3.2.2 Path Configuration Space | | |
| 10.3.2.2#1 | TD 10.003 TD 10.003 | A DP Adapter shall implement a Path Configuration Space as defined in Section 8.2.3. |
| 10.3.2.2#2 | NT | A DP Adapter shall support one MAIN-Link Path, one AUX Ingress Path, and one AUX Egress Path. |

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| 10.3.3 Hot Plug and Hot Removal Events | | |
| 10.3.3.1 DP OUT Adapters | | |
| 10.3.3.1#1 | NT | When a DP OUT Adapter detects a Plug Event (as defined in the DisplayPort 1.4a Specification), it shall: Send a Hot Plug Event Packet with the UPG bit set to 0b as described in Section 6.8 within tDPPlug. |
| 10.3.3.1#2 | NT | When a DP OUT Adapter detects a Plug Event (as defined in the DisplayPort 1.4a Specification), it shall: Set the Plugged bit to 1b. |
| 10.3.3.1#3 | NT | When a DP OUT Adapter detects an Unplug Event (as defined in the DisplayPort 1.4a Specification), it shall: Send a Hot Plug Event Packet with the UPG bit set to 1b as described in Section 6.8 within tDPPlug. |
| 10.3.3.1#4 | NT | When a DP OUT Adapter detects an Unplug Event (as defined in the DisplayPort 1.4a Specification), it shall: Set the Plugged bit to 0b |
| 10.3.3.2 DP IN Adapters | | |
| 10.3.3.2#1 | NT | A Router shall send a Hot Plug Event Packet as described in Section 6.8 within tDPPlug of when both of the following are true: A DP IN Adapter detects a Source (as defined in the DisplayPort 1.4a Specification); The DP IN Adapter that detected the Plug Event has sufficient DP stream resources available to support a DP stream. |
| 10.3.3.2#2 | NT | A Router shall send a Hot Plug Event Packet with the <i>UPG</i> bit set to 1b as described in Section 6.8 within tDPPlug of when either of the following are true: A DP IN Adapter detects the removal of a Source (as defined in the DisplayPort 1.4a Specification); The Router has freed the DP stream resources allocated to the DP IN Adapter such that the DP IN Adapter can no longer support a DP stream. |
| 10.3.3.2.1 DP Stream Resource Allocation | | |
| 10.3.3.2.1#1 | NT | A Router shall support the DP Stream Resource Commands listed in Table 10-3 (QUERY_DP_RESOURCE, ALLOCATE_DP_RESOURCE, DEALLOCATE_DP_RESOURCE) |
| 10.3.4 DisplayPort Over USB4 Fabric | | |
| 10.3.4.1 DisplayPort Data Packet Types | | |
| 10.3.4.1#1 | NT | The Tunneled Packets types defined in Table 10-4 shall only be used for the AUX Path. |
| 10.3.4.1#2 | NT | The Tunneled Packet Types defined in Table 10-5 shall only be used for the Main-Link Path. |
| 10.3.4.1#3 | NT | If a DP Adapter receives a Tunneled Packet on the AUX Path with a PDF value other than 0 to 3, it shall discard the Tunneled Packet and shall not send any Packets in response. |

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| 10.3.4.1#4 | NT | If a DP OUT Adapter receives a Tunneled Packet on the Main-Link Path with a PDF value other than 1 to 7, it shall discard the Tunneled Packet and shall not send any Packets in response. |
| 10.3.4.2 AUX Path Packets | | |
| 10.3.4.2#1 | NT | When generating an AUX Path Packet, a DP Adapter Layer shall put the value in the <i>AUX Tx HopID</i> field into the <i>HopID</i> field of the Tunneled Packet header. |
| 10.3.4.2#2 | NT | When a DP Adapter Layer receives a Tunneled Packet with a HopID that is equal to the <i>AUX Rx HopID</i> field, it shall treat that packet as an AUX Path Packet. |
| 10.3.4.2.1 AUX Packets | | |
| 10.3.4.2.1#1 | NT | An AUX Packet shall have the format shown in Table 10-7. |
| 10.3.4.2.1#2 | NT | The Tunneled Packet Header for an AUX Packet shall have the <i>PDF</i> field set to 0. |
| 10.3.4.2.1#3 | NT | AUX Packet payload shall contain the following: CRC : See Section 10.3.4.2.1.1. |
| 10.3.4.2.1#4 | NT | AUX Packet payload shall contain the following: AUX Payload : Shall contain the bytes contained between the <SYNC> and <STOP> framing bytes of a DisplayPort AUX transaction. The number of bytes in this field varies between 1 and 20. |
| 10.3.4.2.1#5 | NT | AUX Packet payload shall contain the following: Reserved : Shall be one byte set to 00h. |
| 10.3.4.2.1.1 CRC | | |
| 10.3.4.2.1.1#1 | NT | The CRC32 computation in an AUX Packet shall be based on the following CRC: Width: 32 Poly: 1EDC 6F41h Init: FFFF FFFFh RefIn: True RefOut: True XorOut: FFFF FFFFh |
| 10.3.4.2.1.1#2 | NT | If the AUX Payload is less than 21 bytes in length, a DP Adapter shall add the required number of zero-padding bytes for the computation of the CRC. |
| 10.3.4.2.1.1#3 | NT | The padding bytes shall not be transmitted in the AUX Packet. |

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| 10.3.4.2.1.1#4 | NT | The CRC32 shall be generated by the DP Adapter that creates the AUX Packet and shall be checked by the DP Adapter that receives the AUX Packet |
| 10.3.4.2.1.1#5 | NT | A DP Adapter that receives an AUX Packet with a CRC error shall drop that packet. |
| 10.3.4.2.2 HPD Packets | | |
| 10.3.4.2.2#1 | NT | An HPD Packet shall have the format shown in Figure 10-8. |
| 10.3.4.2.2#2 | NT | The <i>PDF</i> field in the header shall be set to 1 and the <i>Length</i> field shall be 4. |
| 10.3.4.2.2#3 | NT | HPD Packet payload shall contain the following: ECC [7:0] : Error correction field that is calculated over bits [31:8] of the HPD Packet payload. |
| 10.3.4.2.2#4 | NT | HPD Packet payload shall contain the following: Reserved [30:8] : Shall be set to 0. |
| 10.3.4.2.2#5 | NT | HPD Packet payload shall contain the following: Plug (P) Flag [Bit 31] : Shall be set to 0 if the HPD signal is low for more than 2 ms. Shall be set to 1 if the HPD signal is high. |
| 10.3.4.2.2#6 | NT | When a DP IN Adapter receives an HPD Packet, it shall check the <i>ECC</i> field of the packet payload. |
| 10.3.4.2.2#7 | NT | The DP IN Adapter shall correct single-bit errors in the HPD Tunneled Packet payload. |
| 10.3.4.2.2#8 | NT | If an uncorrectable error is detected, the HPD Packet shall be dropped. |
| 10.3.4.2.2#9 | NT | Otherwise the DP IN Adapter shall: Generate a Plug/Re-plug HPD event if the P Flag in the HPD Packet payload is set to 1b. |
| 10.3.4.2.2#10 | NT | Otherwise the DP IN Adapter shall: Generate an Unplug HPD event if the <i>P Flag</i> in the HPD Packet payload is set to 0b. |
| 10.3.4.2.2#11 | NT | Otherwise the DP IN Adapter shall: Acknowledge the HPD Packet by sending an ACK Packet to the DP OUT Adapter within tDPackResponse of receiving the HPD Packet. |
| 10.3.4.2.3 SET_CONFIG Packet | | |
| 10.3.4.2.3#1 | NT | A SET_CONFIG Packet shall have the format shown in Figure 10-9. |
| 10.3.4.2.3#2 | NT | The <i>PDF</i> field in the header shall be set to 2 and the <i>Length</i> field shall be 4. |

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| 10.3.4.2.3#3 | NT | SET_CONFIG Packet payload shall contain the following: ECC [7:0] : Error correction field that is calculated over bits [31:8] of the SET_CONFIG Packet payload. |
| 10.3.4.2.3#4 | NT | SET_CONFIG Packet payload shall contain the following: Link Rate 0 (LR0) [8] . |
| 10.3.4.2.3#5 | NT | SET_CONFIG Packet payload shall contain the following: Lane Count (LC) [11:9] . |
| 10.3.4.2.3#6 | NT | SET_CONFIG Packet payload shall contain the following: Reserved [12] : This field shall be set to 1b by sender and ignored by receiver. |
| 10.3.4.2.3#7 | NT | SET_CONFIG Packet payload shall contain the following: Link Rate 1 (LR1) [13] . |
| 10.3.4.2.3#8 | NT | SET_CONFIG Packet payload shall contain the following: Training Pattern Support (TPS) [15:14] : This field shall specify the supported TPS which can be used in EQ Phase in Non-LTTPR and LTTPR Transparent link training. |
| 10.3.4.2.3#9 | NT | SET_CONFIG Packet payload shall contain the following: TPS3 Support [14] . |
| 10.3.4.2.3#10 | NT | SET_CONFIG Packet payload shall contain the following: TPS4 Support [15] . |
| 10.3.4.2.3#11 | NT | SET_CONFIG Packet payload shall contain the following: MSG Data [31:24] . |
| 10.3.4.2.3#12 | NT | SET_CONFIG Packet payload shall contain the following: MSG Data [31:24] . |
| 10.3.4.2.3#13 | NT | The MSG Data shall match the MSG Type of the packet as set forth in Table 10-5. |
| 10.3.4.2.3#14 | NT | A DP IN Adapter shall set the <i>LC</i> and <i>LR</i> fields in all SET_CONFIG Packets to be the same as the last SET_LINK SET_CONFIG Packet it sent. |
| 10.3.4.2.3#15 | NT | A DP OUT Adapter shall set the <i>LC</i> and <i>LR</i> fields in all SET_CONFIG Packets to be the same as the last SET_LINK SET_CONFIG Packet it received. |
| 10.3.4.2.3#16 | NT | After a DP Adapter sends a SET_CONFIG Packet, it shall wait for an ACK Packet with the <i>Type</i> field equal to 0h. |
| 10.3.4.2.3#17 | NT | After receiving an ACK Packet with the <i>Type</i> field set to 0h, the DP Adapter shall wait tDPSetConfigGap before sending the next SET_CONFIG Packet. |
| 10.3.4.2.3#18 | NT | When a DP Adapter receives a SET_CONFIG Packet, it shall check the <i>ECC</i> field of the packet payload. |

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| 10.3.4.2.3#19 | NT | The DP Adapter shall correct single-bit errors in the SET_CONFIG Packet payload. |
| 10.3.4.2.3#20 | NT | If an uncorrectable error is detected, the SET_CONFIG Packet shall be dropped. |
| 10.3.4.2.3#21 | NT | Otherwise, the DP Adapter shall respond with an ACK Packet with the <i>Type</i> field equal to 0h. |
| 10.3.4.2.3#22 | NT | The ACK Packet shall be sent within tDPAckResponse of receiving the SET_CONFIG Packet. |
| 10.3.4.2.3#23 | NT | A DP Adapter that receives a SET_CONFIG Packet with a value in the <i>Type</i> field that is not listed in Table 10-5 shall respond with an ACK packet with the <i>Type</i> field equal to 0h. |
| 10.3.4.2.4 ACK Packet | | |
| 10.3.4.2.4#1 | NT | An ACK Packet shall have the format shown in Figure 10-10. |
| 10.3.4.2.4#2 | NT | The <i>PDF</i> field in the header shall be set to 3 and the <i>Length</i> field shall be 4. |
| 10.3.4.2.4#3 | NT | ACK Packet payload shall contain the following: ECC [7:0] : Error correction field that is calculated over bits [31:8] of the ACK Packet payload. |
| 10.3.4.2.4#4 | NT | ACK Packet payload shall contain the following: Reserved [27:8] : Shall be set to 0. |
| 10.3.4.2.4#5 | NT | ACK Packet payload shall contain the following: Type [31:28]: Shall be set to 8h to acknowledge the receipt of a HPD Packet. Shall be set to 0h to acknowledge the receipt of a SET_CONFIG Packet. All other values are reserved. |
| 10.3.4.3 MAIN-Link Path Packet Formats | | |
| 10.3.4.3#1 | NT | When generating a Main-Link Path Packet, a DP IN Adapter Layer shall put the value in the <i>Video HopID</i> field into the <i>HopID</i> field of the Tunneled Packet header. |
| 10.3.4.3#2 | NT | When a DP OUT Adapter Layer receives a Tunneled Packet with a HopID that is equal to the <i>Video HopID</i> field, it shall treat that packet as a Main-Link Path Packet. |

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| 10.4 System Flows | | |
| 10.4.1 Connection Manager Discovery | | |
| 10.4.2 Path Configuration | | |
| 10.4.2.1 Setup | | |
| 10.4.2.1#1 | NT | A DP OUT Adapter shall poll the DP_STATUS.CMHS field and DP_REMOTE_CAP.Protocol Adapter Version field for as long as the values in those fields are both 0. |
| 10.4.2.1#2 | NT | When either DP_STATUS.CMHS = 1 or DP_REMOTE_CAP.Protocol Adapter Version > 0, the DP OUT Adapter shall do the following: If DP_REMOTE_CAP.Protocol Adapter Version was set to non-zero value while DP_STATUS_CTRL.CMHS remained zero, a DP OUT Adapter shall conclude it is a TBT3 Connection Manager and shall continue the flow as defined in Section 13.8.3. |
| 10.4.2.1#3 | NT | When either DP_STATUS.CMHS = 1 or DP_REMOTE_CAP.Protocol Adapter Version > 0, the DP OUT Adapter shall do the following: If DP_STATUS_CTRL.CMHS is set to 1 and DP_STATUS_CTRL.UF is zero, a DP OUT Adapter shall conclude it is a TBT3 DP IN Adapter and shall continue the flow as defined in Section 13.8.3. |
| 10.4.2.1#4 | NT | When either DP_STATUS.CMHS = 1 or DP_REMOTE_CAP.Protocol Adapter Version > 0, the DP OUT Adapter shall do the following: If DP_STATUS_CTRL.CMHS is set to 1 and DP_STATUS_CTRL.UF is set to one, a DP OUT Adapter shall reset DP_STATUS_CTRL.CMHS to zero. |
| 10.4.2.1#5 | TD 10.1 TD 10.9 | A DP Adapter shall set the DP_COMMON_CAP register, to reflect the lowest common capability between DP_LOCAL_CAP and DP_REMOTE_CAP fields. |
| 10.4.2.2 Tear-down | | |
| 10.4.2.2#1 | TD 10.1 TD 10.9 | When the ADP_DP_CS_0.AE bit and the ADP_DP_CS_0.VE bit are both set to 0, a DP Adapter shall set all the fields in its DP Adapter Configuration Capability to their default values. |
| 10.4.3 HPD Event Propagation | | |
| 10.4.3.1 HPD Plug | | |
| 10.4.3.1#1 | NT | After a Path is setup between a DP OUT Adapter and a DP IN Adapter per 10.4.2.1, the DP OUT Adapter shall send an HPD Packet with the <i>P Flag</i> set to 1b. |
| 10.4.3.1#2 | NT | Upon receiving an HPD Packet with the <i>P Flag</i> set to 1b, the DP IN Adapter shall respond with an ACK Packet, execute the DP Adapter Init flow as defined in Section 10.4.5, and then drive HPD signal high on the DisplayPort interface |

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| 10.4.3.1#3 | NT | After the DP IN Adapter drives HPD high, both DP Adapters shall be ready to handle AUX transactions. |
| 10.4.3.2 HPD Unplug | | |
| 10.4.3.2#1 | NT | Upon unplug detection, the DP OUT Adapter shall send an HPD Packet with the <i>P Flag</i> set to 0b to the DP IN Adapter. |
| 10.4.3.2#2 | NT | The DP IN Adapter shall respond with an ACK Packet and drive the HPD signal low. |
| 10.4.3.2#3 | NT | When the HPD signal is low, a DP IN Adapter may disable its DP Link receiver. |
| 10.4.3.3 IRQ | | |
| 10.4.3.3#1 | NT | Upon IRQ detection, a DP OUT Adapter shall send a SET_CONFIG Packet of MSG type IRQ to the DP IN Adapter. |
| 10.4.3.3#2 | NT | A DP IN Adapter that receives a SET_CONFIG Packet of MSG type IRQ shall respond with an ACK Packet and drive the IRQ event (according to the DisplayPort 1.4a Specification) towards the DPTX. |
| 10.4.3.3#3 | NT | However, if Link training is in process or it just ended, a DP OUT Adapter shall wait tIRQDelay after it sent a SET_CONFIG Packet to the DP IN Adapter (reporting that Link training is completion) before sending the IRQ SET_CONFIG Packet. |
| 10.4.3.4 HPD Delay Requirements | | |
| 10.4.3.4#1 | NT | Table 10-7 defines the maximum propagation delay through the DP Adapters that shall be used for HPD Events. |
| 10.4.3.4#2 | NT | The propagation delay through the DP OUT Adapter shall be measured from when the event is detected by the DP OUT Adapter to when the last bit of the corresponding packet, SET_CONFIG or HPD, is sent over the AUX Path. |
| 10.4.3.4#3 | NT | The propagation delay through the DP IN Adapter shall be measured from when the last bit of an HPD Event Packet, SET_CONFIG or HPD, arrives at the DP IN Adapter to when event is driven on the HPD signal. |
| 10.4.3.4#4 | NT | A DP OUT Adapter shall send HPD packet with the <i>P Flag</i> set to 1b within tDPPlug of transitioning to the Paired state. |
| 10.4.3.5 Manual HPD Control | | |
| 10.4.3.5#1 | TD 10.003 | When HPDC transitions from 0b to 1b, a DP IN Adapter shall drive the DisplayPort HPD signal low. |
| 10.4.3.5#2 | TD 10.003 | When HPDS transitions from 0b to 1b, a DP IN Adapter shall drive the DisplayPort HPD signal high. |

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| 10.4.3.5#3 | TD 10.003 | The DisplayPort HPD signal level shall be set according to the most recent event, whether it is HPDS set, HPDC set, IRQ SET_CONFIG Packet or HPD Packet. |
| 10.4.4 AUX Request and Response Handling | | |
| 10.4.4.1 LTTPR Non-Transparent Mode | | |
| 10.4.4.1.1 DP IN Adapter Requirements | | |
| 10.4.4.1.1#1 | NT | Upon reception of a DisplayPort AUX request, a DP IN Adapter shall send an AUX Packet containing the request over the AUX Path. |
| 10.4.4.1.1#2 | NT | The AUX request coming from the DPTX shall not be modified by the DP IN Adapter. |
| 10.4.4.1.1#3 | NT | For Target transactions, the DP IN Adapter shall set the AUX_PEND flag as defined in the DisplayPort 1.4a Specification – Section 3.6.5.3.2, and take the appropriate action when the request comes back according to the DisplayPort 1.4a Specification – Section 3.6.5.3.2. |
| 10.4.4.1.1#4 | NT | When a DP IN Adapter updates the DP OUT Adapter as the results of a Snoop or Target transaction, it shall perform the update only after receiving an AUX ACK response for all cases beside SET_CONFIG Packet of type SET_VSPE. |
| 10.4.4.1.1#5 | NT | The update shall be done by sending SET_CONFIG Packets to the DP OUT Adapter. |
| 10.4.4.1.2 DP OUT Adapter Requirements | | |
| 10.4.4.1.2#1 | TD 10.005 | A DP OUT Adapter shall convert an incoming AUX Packet received from the USB4 Fabric into a DisplayPort AUX request. |
| 10.4.4.1.2#2 | TD 10.005 | The content of the request shall not be modified by the DP OUT Adapter. |
| 10.4.4.1.2#3 | TD 10.005 | A DP OUT Adapter shall convert an incoming DisplayPort AUX response into an AUX Packet and send it on the AUX Path. |
| 10.4.4.1.2#4 | TD 10.005 | The content of the response shall not be changed by the DP OUT Adapter. |
| 10.4.4.2 Non-LTTPR Mode | | |
| 10.4.4.2#1 | TD 10.004 | A DP IN Adapter shall implement AUX Replier. |
| 10.4.4.2#2 | TD 10.004 | A DP OUT Adapter shall implement AUX Requester. |
| 10.4.4.2.1 AUX Timeout Timers | | |
| 10.4.4.2.1#1 | TD 10.004 | The AUX Response Timeout timer in a DP IN Adapter shall be set to 300μs. |

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| 10.4.4.2.1#2 | TD 10.004 | The AUX Reply Timeout timer in a DP OUT Adapter shall be set to 400 μ s. |
| 10.4.4.2.2 DP IN Adapter Port Requirements | | |
| 10.4.4.2.2#1 | TD 10.004 | A DP IN Adapter that receives an AUX Request shall classify the AUX Transaction as one of the three following types: 1) Internal AUX Transaction – AUX Request which targets only DPCD addresses that are defined as internal in Table 10-8; 2) External AUX Transaction – AUX Request which targets only DPCD addresses that are not defined as internal in Table 10-8; 3) Combined AUX Transaction – AUX Request which targets both Internal and External DPCD addresses. The AUX Response is initially generated by the DPRX and altered by the DP IN Adapter. |
| 10.4.4.2.2#2 | TD 10.004 | For Internal AUX Transactions, a DP IN Adapter shall not send the AUX Request downstream and shall self-generate the AUX Response. |
| 10.4.4.2.2#3 | TD 10.004 | For External and Combined AUX Transactions, a DP IN Adapter shall send the AUX Request downstream to the DP OUT Adapter. |
| 10.4.4.2.2#4 | TD 10.004 | The DP IN Adapter shall generate an AUX DEFER if the Response timer expires while waiting for the AUX Response. |
| 10.4.4.2.2#5 | TD 10.004 | A DP IN Adapter shall not send an AUX Request to a DP OUT Adapter while the AUX Reply to the preceding AUX Request is outstanding. |
| 10.4.4.2.2#6 | TD 10.004 | DP IN Adapter shall increment AUX_REQ_CNTR by 1 on every received AUX request from DPTX and shall reset to zero on transition to IDLE state. |
| 10.4.4.2.2#7 | TD 10.004 | Table 10-10: DP IN Adapter Port AUX Handling State Machine |
| 10.4.4.2.3 DP OUT Adapter Requirements | | |
| 10.4.4.2.3#1 | TD 10.004 | A DP OUT Adapter that receives a DPTX initiated AUX Request while handling a DP OUT Adapter Initiated AUX Transaction, shall send the DPTX initiated AUX Request as soon as it is in Talk Mode. |
| 10.4.4.2.3.1 DPTX Initiated AUX Transactions | | |
| 10.4.4.2.3.1#1 | TD 10.004 | A DP OUT Adapter that receives an AUX Request from a DP IN Adapter shall initiate the AUX Request as soon as it is in Talk Mode. |
| 10.4.4.2.3.1#2 | TD 10.004 | A DP OUT Adapter that receives an AUX Response shall send the AUX Response over the AUX Path to the DP IN Adapter. |
| 10.4.4.2.3.1#3 | TD 10.004 | If the AUX Reply Timer expires before an AUX Response is received, a DP OUT Adapter shall send a SET_CONFIG of type SET_AUX_INIT and shall not retry the AUX Request. |

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| 10.4.4.2.3.2 DP OUT Adapter Initiated AUX Transactions | | |
| 10.4.4.3 LTTTPR Transparent Mode | | |
| 10.4.4.3#1 | NT | A DP IN Adapter shall implement AUX Replier. |
| 10.4.4.3#2 | NT | A DP OUT Adapter shall implement AUX Requester. |
| 10.4.4.3.1 AUX Timeout Timers | | |
| 10.4.4.3.1#1 | NT | The AUX Response Timeout timer in a DP IN Adapter shall not be activated. |
| 10.4.4.3.1#2 | NT | The AUX Reply Timeout timer in a DP OUT Adapter shall be set to 3.2ms. |
| 10.4.4.3.2 DP IN Adapter Requirements | | |
| 10.4.4.3.2#1 | NT | A DP IN Adapter that receives an AUX Request shall classify the AUX Transaction as one of the following types: Internal AUX Transaction – AUX Request which targets only DPCD addresses that are defined as internal in Table 10-9; External AUX Transaction – AUX Request which targets only DPCD addresses that are not defined as internal in Table 10-9; Combined AUX Transaction – AUX Request which targets both Internal and External DPCD addresses. The AUX Response is initially generated by the DPRX and altered by the DP IN Adapter. |
| 10.4.4.3.2#2 | NT | For External and Combined AUX Transactions, a DP IN Adapter shall send the AUX Request downstream to the DP OUT Adapter. |
| 10.4.4.3.2#3 | NT | A DP IN Adapter shall not: Generate AUX DEFER; Gate any External or Combined AUX Request sent by the DPTX; Gate any AUX Response sent by the DPRX. |
| 10.4.4.3.3 DP OUT Adapter Requirements | | |
| 10.4.4.3.3#1 | NT | A DP OUT Adapter that receives a DPTX initiated AUX Request while handling a DP OUT Adapter Initiated AUX Transaction, shall send the DPTX initiated AUX Request as soon as it is in Talk Mode. |
| 10.4.4.3.3.1 DP TX Initiated AUX Transactions | | |
| 10.4.4.3.3.1#1 | NT | A DP OUT Adapter that receives an AUX Request from a DP IN Adapter shall initiate the AUX Request as soon as it is in Talk Mode. |
| 10.4.4.3.3.1#2 | NT | A DP OUT Adapter that receives an AUX Response shall send the AUX Response over the AUX Path to the DP IN Adapter. |
| 10.4.4.3.3.1#3 | NT | If the AUX Reply Timer expires before an AUX Response is received, a DP OUT Adapter shall send a SET_CONFIG of type SET_AUX_INIT and shall not retry the AUX Request. |

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| 10.4.4.3.3.2 DP OUT Adapter Initiated AUX Transactions | | |
| 10.4.4.4 AUX Delay Requirements | | |
| 10.4.4.4#1 | TD 10.004 | The DP-to-USB4 Fabric delay shall be measured from the time the last bit arrives at the DP Adapter from the DisplayPort interface to the time when the first bit is sent to the USB4 Fabric. |
| 10.4.4.4#2 | TD 10.004 | USB4 Fabric-to-DP delay shall be measured from the time when the last bit of the AUX Packet arrives at the DP Adapter to the time when the first bit is sent to the DisplayPort Interface, assuming the DP Adapter is in Talk Mode. |
| 10.4.4.5 Aggregation DisplayPort Capabilities | | |
| 10.4.4.5#1 | TD 10.003 TD 10.004 | A DP IN Adapter shall update its DP_LOCAL_CAP and DP_COMMON_CAP registers if it receives an AUX Read Response that has lower parameter values than the registers currently contain. |
| 10.4.4.5#2 | TD 10.003 TD 10.004 | Before transmitting the AUX Read Response, the DP IN Adapter shall update the AUX Read Response to reflect the aggregated DisplayPort Capabilities as shown in Table 10-11. |
| 10.4.4.6 DPCD DP Tunneling over USB4 | | |
| 10.4.4.6#1 | NT | When a DP IN Adapter receives an AUX Request targeting the DP Tunneling over USB4 Field DPCDs, it shall respond with its internal data. |
| 10.4.4.6#2 | NT | A DP IN Adapter shall set the <i>DP Tunneling Support</i> bit to 1b in the DP TUNNELING_CAPABILITIES DPCD (Address E000Dh bit offset 0). |
| 10.4.5 DP Adapters Init Flow | | |
| 10.4.5#1 | TD 10.007 | A DP IN Adapter in the Paired state shall do the following after receiving a first HPD Packet with the <i>P flag</i> set to 1b: Update MFDP Mode inner variable according to Section 10.4.5.1. |
| 10.4.5#2 | TD 10.007 | A DP IN Adapter in the Paired state shall do the following after receiving a first HPD Packet with the <i>P flag</i> set to 1b: Send a SET_CONFIG Packet of type SET_AUX_INIT. |
| 10.4.5#3 | TD 10.007 | The DP IN Adapter shall not drive HPD high on the DisplayPort Interface until after it performs the steps above. |
| 10.4.5.1 Multi-Function DP | | |
| 10.4.5.1#1 | TD 10.007 | If a DP IN Adapter is not connected as part of a Multi-Function (as defined in the DisplayPort Alt Mode Specification), it shall send a SET_CONFIG Packet of type SET_MFDP with the MFDP Enable bit set to 0b. |

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| 10.4.5.1#2 | TD 10.007 | A DP OUT Adapter which receives a SET_CONFIG Packet of type SET_MFDP shall respond with a SET_CONFIG Packet of type SET_MFDP within tDPInit. |
| 10.4.5.1#3 | TD 10.007 | If the DP OUT Adapter is connected as part of Multi-Function as defined in the DisplayPort 1.4a Specification, then the MFDP Enable bit shall be set to 1b, otherwise it shall be set to 0b. |
| 10.4.6 DP Source Discovery | | |
| 10.4.6.1 LTTPR Recognition and Modes Change | | |
| 10.4.6.1#1 | NT | A DP IN Adapter shall modify the resulting AUX read response as defined in Section 10.4.4.5. |
| 10.4.6.1#2 | NT | If DP_COMMON_CAP.LTTPR <i>Not Supported</i> is set to 1b, a DP Adapter shall operate only in Non-LTTPR mode. |
| 10.4.6.1#3 | NT | A DP IN Adapter shall do the following before transitioning to LTTPR Transparent mode: Complete the AUX Transaction according to the current operation mode; Send a SET_CONFIG Packet of type SET_LTTPR_MODE with LTTPR_Mode set to 0b. |
| 10.4.6.1#4 | NT | A DP IN Adapter shall do the following before transitioning to LTTPR Non-Transparent mode: Complete the AUX Transaction according to the current operation mode; Send a SET_CONFIG Packet of type SET_LTTPR_MODE with LTTPR_Mode set to 1b. |
| 10.4.6.2 DPRX Capabilities Read | | |
| 10.4.6.2#1 | NT | The DPRX Capabilities read is performed by the DPTX. In response to a DPRX Capabilities read, a DP IN Adapter shall: 1) Snoop the read response and record the values of the DPCD_REV, MAX_LINK_RATE, MAX_LANE_COUNT, TPS3_SUPPORTED and TPS4_SUPPORTED fields located at DPCD addresses 00000h, 00001h, 00002h and 00003h respectively. |
| 10.4.6.2#2 | NT | The DPRX Capabilities read is performed by the DPTX. In response to a DPRX Capabilities read, a DP IN Adapter shall: 2) Update the Maximal DPCD Rev, Maximal Link Rate, Maximal Lane Count, TPS3 Capability and TPS4 Capability fields in the DP_LOCAL_CAP and DP_COMMON_CAP registers to reflect the lowest common capabilities between the existing values of those registers and the recorded values from step 1. |
| 10.4.6.2#3 | NT | The DPRX Capabilities read is performed by the DPTX. In response to a DPRX Capabilities read, a DP IN Adapter shall: 3) Send a SET_CONFIG Packet of type SET_CMN_DPRX with MSG Data equal to the snooped DPCD_REV which reflects the DPRX DPCD_REV. |

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| 10.4.6.2#4 | NT | The DPRX Capabilities read is performed by the DPTX. In response to a DPRX Capabilities read, a DP IN Adapter shall: 4) Set the <i>DPRX Capabilities Read Done</i> field in the DP_COMMON_CAP register to 1b. Note that this field is set to 1b regardless of whether or not the values in the <i>Maximal Link Rate</i> and <i>Maximal Lane Count</i> fields in Step 2 were changed. |
| 10.4.6.3 Sink Count Read | | |
| 10.4.6.3#1 | TD 10.003 | When DPCD addresses 00200h or 02002h are read by the DPTX, a DP IN Adapter shall snoop the read response and record the value of the SINK_COUNT. |
| 10.4.6.3#2 | TD 10.003 | When the recorded SINK_COUNT value is zero, the DP IN Adapter shall send a SET_CONFIG Packet of type SET_SINK_COUNT, reflecting the recorded value. |
| 10.4.6.3#3 | TD 10.003 | When a DP OUT Adapter receives a SET_CONFIG Packet of type SET_SINK_COUNT with the SINK_COUNT value equal to zero, the DP OUT Adapter shall: Report an Unplug event as defined in Section 10.3.3. |
| 10.4.6.3#4 | TD 10.003 TD 10.004 | When a DP OUT Adapter receives a SET_CONFIG Packet of type SET_SINK_COUNT with the SINK_COUNT value equal to zero, the DP OUT Adapter shall: Set the ADP_DP_CS_2.HPD Status to 0b in the <i>DP OUT Adapter Configuration Capability</i> Field. |
| 10.4.6.3#5 | TD 10.003 TD 10.004 | While a DP OUT Adapter is Unplugged and has the ADP_DP_CS_2.HPD Status set to 0b in the <i>DP OUT Adapter Configuration Capability</i> Field, it shall do the following upon IRQ detection: Report a Plug event as defined in Section 10.3.3. |
| 10.4.6.3#6 | TD 10.003 TD 10.004 | While a DP OUT Adapter is Unplugged and has the ADP_DP_CS_2.HPD Status set to 0b in the <i>DP OUT Adapter Configuration Capability</i> Field, it shall do the following upon IRQ detection: Set the ADP_DP_CS_2.HPD Status to 1b in the <i>DP OUT Adapter Configuration Capability</i> Field. |
| 10.4.7 Down-Spread Control | | |
| 10.4.7#1 | NT | When DPCD address 00107h is written by a DPTX, a DP IN Adapter, operating in Non-LTTPR or LTTPR Transparent Modes, shall respond with AUX ACK and shall send a SET_CONFIG Packet of type SET_DOWNSPREAD. |
| 10.4.7#2 | NT | The <i>MSG Data</i> field in the SET_CONFIG Packet shall be equal to the value written by the DPTX. |
| 10.4.7#3 | NT | A DP OUT Adapter that receives a SET_CONFIG Packet of type SET_DOWNSPREAD shall initiate an AUX write request to DPCD address 00107h with the value received in the MSG Data of the SET_CONFIG Packet. |

| 10.4.8 Stream Mode Set | | |
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| 10.4.8#1 | NT | If the DPTX writes to DPCD address 00111h, a DP IN Adapter shall snoop the write request and record the value of the MST_EN bit. |
| 10.4.8#2 | NT | A DP IN Adapter shall send a SET_CONFIG Packet of type SET_STREAM_MODE, reflecting the recorded value of the MST_EN bit when a new recorded MST_EN value is different than the previous value |
| 10.4.8#3 | NT | The MST_EN default value at the DP Adapters shall be as defined in the DisplayPort 1.4a Specification. |
| 10.4.8#4 | NT | A DP OUT Adapter that receives a SET_CONFIG Packet of type SET_STREAM_MODE shall respond with a SET_CONFIG Packet of type SET_STREAM_MODE, to signify the acknowledgment of the mode change. |
| 10.4.8#5 | NT | The value of the <i>MSG Data</i> field in the return packet has no meaning and shall be ignored by the DP IN Adapter. |
| 10.4.9 DSC and FEC Enable | | |
| 10.4.9#1 | NT | If the DPTX writes to DPCD address 00120h, a DP IN Adapter shall snoop the write request and record the values of the <i>FEC_READY</i> , <i>FEC_ERROR_COUNT_SEL</i> and <i>LANE_SELECT</i> fields. |
| 10.4.9#2 | NT | A DP IN Adapter shall send a SET_CONFIG Packet of type SET_FEC_READY, reflecting the recorded value of the FEC_READY bit when a new recorded FEC_READY value is different than the previous value. |
| 10.4.9# | NT | The FEC_READY default value at the DP Adapters shall be as defined in the DisplayPort 1.4a Specification. |
| 10.4.9# | NT | A DP OUT Adapter that receives a SET_CONFIG Packet of type SET_FEC_READY shall respond with a SET_CONFIG Packet of type SET_FEC_READY within tDPInit, to signify the acknowledgment of the mode change. |
| 10.4.9# | NT | The value of the <i>MSG Data</i> field in the return packet has no meaning and shall be ignored by the DP IN Adapter. |

| 10.4.10 DP Link Training | | |
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| 10.4.10.1 LTTPR | | |
| 10.4.10.1#1 | NT | The DP IN and DP OUT Adapters shall follow the LTTPR Non-Transparent link training as defined in the DisplayPort 1.4a Specification while noting the following points: <u>DP IN as UFP and DFP</u> – As described in Section 10.4.4, the DP IN Adapter serves as UFP and DFP for AUX handling, therefore it updates the DP OUT Adapter with the different stages of the LTTPR Non-Transparent link training through SET_CONFIG Packets; <u>Training Patterns</u> – Training Patterns are not carried over the USB4 Fabric. |
| 10.4.10.1.1 DP IN Adapter Requirements | | |
| 10.4.10.1.1#1 | NT | After DP Link training is finished on the UFP, a DP IN Adapter shall maintain symbol lock and lane alignment in its receiver while DPTX trains the rest of downstream DP Links |
| 10.4.10.1.1#2 | NT | A DP IN Adapter shall send a SET_CONFIG Packet of type SET_LINK after DPTX writes TPS1 to the DP IN Adapter TRAINING_PATTERN_SET_PHY_REPEATERx DPCD register. |
| 10.4.10.1.1#3 | NT | The SET_CONFIG packet shall have the following values: LC = LANE_COUNT_SET value written by DPTX; LR = LINK_BW_SET value written by the DPTX; MSG Data = 1b, representing DP Link Training Mode = LTTPR Non-Transparent. |
| 10.4.10.1.1#4 | NT | A DP IN Adapter shall send a SET_CONFIG Packet of type SET_TRAINING with TS = 0xFF after DPTX writes 0x0 to the DP IN Adapter TRAINING_PATTERN_SET_PHY_REPEATERx DPCD register. |
| 10.4.10.1.1#5 | NT | A DP IN Adapter shall send a SET_CONFIG Packet of type SET_TRAINING with TS = 0x0 after DPTX writes 0x0 to the DPRX TRAINING_PATTERN_SET DPCD register. |
| 10.4.10.1.1#6 | NT | After DP Link training is finished on the UFP, a DP IN Adapter shall detect a Training pattern on its receiver. |
| 10.4.10.1.1#7 | NT | After detecting the Training pattern, the DP IN Adapter shall send a single corresponding SET_CONFIG Packet of type SET_TRAINING for every change in Training pattern. |
| 10.4.10.1.1#8 | NT | The TS field shall be equal to the detected Training pattern as defined in Table 10-5. |
| 10.4.10.1.1#9 | NT | A DP IN Adapter shall send SET_CONFIG Packet of Type SET_VSPE when DPTX writes the TRAINING_LANE0_SET or TRAINING_LANE0_SET_PHY_REPEATERx DPCD register of the next downstream receiver. |
| 10.4.10.1.1#10 | NT | The MSG Data field shall carry the value in the write request. |

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| 10.4.10.1.1#11 | NT | The SET_VSPE SET_CONFIG Packet shall be sent by the DP IN Adapter before sending the AUX Request Packet. |
| 10.4.10.1.1#12 | NT | A DP Adapter shall have higher priority generating and parsing SET_CONFIG packets over AUX Transaction. |
| 10.4.10.1.1#13 | NT | A DP IN Adapter shall respond to a DPTX that link training has ended successfully only when all the following are true: The DP IN Adapter internal status indicates link training has ended successfully; The DP IN Adapter sent at least nine DP Clock Sync Packets after it sent the SET_CONFIG Packet of type SET_LINK. |
| 10.4.10.1.2 DP OUT Adapter Requirements | | |
| 10.4.10.1.2#1 | NT | A DP OUT Adapter that receives a SET_CONFIG Packet of Type SET_LINK with the DP Link Training Mode bit set to 1b shall start its internal Symbol clock PLL according to the <i>Link Rate</i> field, and start the Lifetime Counter as defined in Section 10.6.1.2. |
| 10.4.10.1.2#2 | NT | A DP OUT Adapter that receives a SET_CONFIG Packet of Type SET_TRAINING with TS field equal to 1, 2, 3 or 7 shall transmit TPS1, TPS2, TPS3 or TPS4 accordingly. Deprecated. |
| 10.4.10.1.2#3 | NT | A DP OUT Adapter that receives a SET_CONFIG Packet of Type SET_TRAINING with TS field equal to 0 shall transmit IDLE pattern according to the DisplayPort 1.4a Specification. |
| 10.4.10.1.2#4 | NT | A DP OUT Adapter shall set its Voltage Swing (VS) and Pre-Emphasis (PE) levels for all enabled lanes upon receiving a SET_CONFIG Packet of type SET_VSPE. The VS and PE levels shall be according to the MSG Data. The DP OUT Adapter shall transition on the 10-bit symbol boundary when: Transitioning from one training pattern to another training pattern; Transitioning to IDLE sequence after DP Link training is done. |
| 10.4.10.1.3 DP Link Training Example | | |
| 10.4.10.1.3.1 LTTTPR - CR_DONE Phase | | |
| 10.4.10.1.3.2 LTTTPR - EQ Phase | | |
| 10.4.10.1.3.3 DPRX - CR_DONE Phase | | |
| 10.4.10.1.3.4 DPRX - EQ Phase | | |
| 10.4.10.2 Non-LTTTPR and LTTTPR Transparent | | |
| 10.4.10.2#1 | NT | A DP Adapter shall perform DisplayPort link training according to the DisplayPort 1.4a Specification with the modifications and requirements defined in Section 10.4.10.2.1 and Section 10.4.10.2.2 |

| 10.4.10.2.1 DP IN Adapter Requirements | | |
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| 10.4.10.2.1#1 | NT | A DP IN Adapter shall send a SET_CONFIG Packet of type SET_LINK after DPTX writes TPS1 to the DP RX TRAINING_PATTERN_SET DPCD register. |
| 10.4.10.2.1#2 | NT | The SET_CONFIG packet shall have the following values: LC = LANE_COUNT_SET value written by DPTX; LR = LINK_BW_SET value written by the DPTX; TPS = Reflects TPS3 and TPS4 support as indicated in the DP_COMMON_CAP register; MSG Data = 0b, representing DP Link Training Mode = Non-LTTPR and LTTPR Transparent modes. |
| 10.4.10.2.1#3 | NT | A DP IN Adapter shall respond to a status read of LANEx_CR_DONE as follows: If a SET_CONFIG Packet of type STATUS_CR_DONE was not received since link training started, set the LANEx_CR_DONE bits to 0b. |
| 10.4.10.2.1#4 | NT | A DP IN Adapter shall respond to a status read of LANEx_CR_DONE as follows: If a SET_CONFIG Packet of type STATUS_CR_DONE was received since link training started, set the LANEx_CR_DONE bits to be the internal DP IN Adapter status for a lane ANDed with the relevant bit present in the last received SET_CONFIG MSG Data. |
| 10.4.10.2.1#5 | NT | A DP IN Adapter shall respond to a DPTX that link training has ended successfully only when all the following are true: The DP IN Adapter internal status indicates link training has ended successfully; The DP IN Adapter received a SET_CONFIG Packet of type SET_LINK, carrying the same LC and LR fields that it sent to the DP OUT Adapter when link training was initiated; The DP IN Adapter sent at least nine DP Clock Sync Packets after it received a SET_CONFIG Packet of type STATUS_CR_DONE. |
| 10.4.10.2.1#6 | NT | While the conditions (as defined in this section) for successful link training are not met, a DP IN Adapter shall respond to a status read of INTERLANE_ALIGN_DONE, LANEx_CHANNEL_EQ_DONE and LANEx_SYMBOL_LOCKED as follows: If a SET_CONFIG Packet of type STATUS_TRAINING_FAIL was received since link training started, set the following bits: INTERLANE_ALIGN_DONE shall be set to 0b. LANEx_CHANNEL_EQ_DONE is equal to the DP IN internal status ANDed with LANEx_CHANNEL_EQ_DONE that was received as MSG Data by the STATUS_TRAINING_FAIL. LANEx_SYMBOL_LOCKED is equal to the DP IN internal status ANDed with LANEx_SYMBOL_LOCKED that was received as MSG Data by the STATUS_TRAINING_FAIL. |
| 10.4.10.2.1#7 | NT | Else, a DP IN Adapter shall use one or more of the methods below to indicate to DPTX that link training has not completed successfully yet: Set INTERLANE_ALIGN_DONE to 0b; Set LANEx_CHANNEL_EQ_DONE to 0b for any of the active lanes; Set LANEx_SYMBOL_LOCKED to 0b for any of the active lanes. |

| 10.4.10.2.2 DP OUT Adapter Requirement | | |
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| 10.4.10.2.2#1 | NT | A DP OUT Adapter receiving a SET_CONFIG Packet of type SET_LINK, with <i>LC</i> field other than 0h shall: Initiate link training with the target Link Rate and Lane Count received from the SET_LINK Packet. |
| 10.4.10.2.2#2 | NT | A DP OUT Adapter receiving a SET_CONFIG Packet of type SET_LINK, with <i>LC</i> field other than 0h shall: Link training proceeds according to the DisplayPort 1.4a spec except that a DP OUT Adapter that concludes that it needs to either reduce the Link Rate or Lane Count shall treat it as link training failure and shall not reduce the Link Rate or Lane Count. |
| 10.4.10.2.2#3 | NT | A DP OUT Adapter which finishes the Clock Recovery Sequence (as defined in the DisplayPort 1.4a Specification) shall send a SET_CONFIG Packet of type STATUS_CR_DONE, reflecting the LANEx_CR_DONE statuses of the active lanes. |
| 10.4.10.2.2#4 | NT | The <i>Phase</i> field shall be set to 0b. |
| 10.4.10.2.2#5 | NT | A DP OUT Adapter in EQ phase which detects that the DP receiver has lost Clock Recovery on one or more of the active lanes shall conclude that link training has failed and shall send a SET_CONFIG Packet of type STATUS_CR_DONE, reflecting the new LANEx_CR_DONE statuses of the active lanes. |
| 10.4.10.2.2#6 | NT | The <i>Phase</i> field shall be set to 1b. |
| 10.4.10.2.2#7 | NT | If link training fails for a reason other than lost Clock Recovery, a DP OUT Adapter shall send a SET_CONFIG Packet of type STATUS_TRAINING_FAIL. |
| 10.4.10.2.2#8 | NT | If link training finishes successfully, a DP OUT Adapter shall send a SET_CONFIG Packet of type SET_LINK, with the same <i>LC</i> and <i>LR</i> fields it received from the DP IN Adapter when link training was initiated. |
| 10.4.10.2.2#9 | NT | If link training finishes successfully, a DP OUT Adapter shall: Generate IDLE pattern (including SR) for both MST and SST DP Links. Deprecated. |
| 10.4.10.2.2#10 | NT | The MSG Data shall be set as follows: LANEx_CHANNEL_EQ_DONE is equal to the value of the last read from LANEx_CHANNEL_EQ_DONE field in DPRX. LANEx_SYMBOL_LOCKED is equal to the value of the last read from LANEx_SYMBOL_LOCKED field in DPRX. |
| 10.4.10.3 Transition to High Speed Tunnel | | |
| 10.4.10.3#1 | NT | A DP IN Adapter shall start converting DisplayPort Main-Link Symbols into Tunneled Packets and sending those Packets over the Main-Link Path when all of the following are true: Link Training has completed successfully; The DP IN Adapter received an SR. |

| 10.4.11 Power States Set | | |
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| 10.4.11#1 | NT | When DPTX writes to DPCD address 00600h, a DP IN Adapter shall snoop the write request and record the value of the <i>SET_POWER_STATE</i> field. |
| 10.4.11#2 | NT | A DP IN Adapter shall send a SET_CONFIG Packet of type SET_POWER, reflecting the recorded value in the following cases: A first DPCD write of address 00600h after an HPD Plug event. |
| 10.4.11#3 | NT | A DP IN Adapter shall send a SET_CONFIG Packet of type SET_POWER, reflecting the recorded value in the following cases: The new recorded SET_POWER_STATE is different than the previous value. |
| 10.4.12 DP Main-Link Disable | | |
| 10.4.12#1 | NT | DP OUT Adapter which receives a Main-Link disable message shall disable its transmitters. |
| 10.4.13 Link-Init | | |
| 10.4.13#1 | NT | Upon Link-Init activation, a DP IN Adapter shall turn off its DisplayPort receivers and stop any transmission of Tunneled Packets over the Main-Link Path until the end of the next successful Link training, as defined in Section 10.4.10.3. |
| 10.4.13#2 | NT | Upon Link-Init activation, a DP OUT Adapter shall turn off its DisplayPort transmitters. |
| 10.4.14 DP PHY Testability | | |
| 10.4.14.1 DP IN Adapter PHY Layer Testing | | |
| 10.4.14.1#1 | NT | The PHY layer of a DP IN Adapter shall be tested as described in the DisplayPort 1.4a PHY CTS with the changes listed below: Before entering DP IN PHY Test Mode: Connect a Router with a DP OUT Adapter and a DPRX. Both the DP OUT Adapter and the DPRX need to support the Link Rate and Lane Count required by the test; Verify that a DP Link is established. |
| 10.4.14.1#2 | NT | The PHY layer of a DP IN Adapter shall be tested as described in the DisplayPort 1.4a PHY CTS with the changes listed below: Entering DP IN PHY Test Mode: The DP IN Adapter shall enter DP IN PHY Test Mode when the DPTX writes a non-zero value to LINK_QUAL_LANE _{Ex} _SET in the DPCD registers. |
| 10.4.14.1#3 | NT | The PHY layer of a DP IN Adapter shall be tested as described in the DisplayPort 1.4a PHY CTS with the changes listed below: While in DP IN PHY Test Mode: The DP IN Adapter shall keep the Hot Plug Detect signal high; The DP IN Adapter shall respond to all AUX transactions related to the PHY layer testing. |

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| 10.4.14.1#4 | NT | The PHY layer of a DP IN Adapter shall be tested as described in the DisplayPort 1.4a PHY CTS with the changes listed below: Exiting DP IN PHY Test Mode: The DP IN Adapter shall exit DP IN PHY Test Mode when the DPTX initiates DP Link Training. |
| 10.4.14.2 DP OUT Adapter PHY Layer Testing | | |
| 10.4.14.2#1 | NT | The PHY layer of a DP OUT Adapter shall be tested as described in the DisplayPort 1.4a PHY CTS with the changes listed below: Before entering DP OUT PHY Test Mode: Connect a Router with a DP IN Adapter and a DPTX. Both the DP IN Adapter and the DPTX need to support the test required Link Rate and Lane Count; Verify that a DP Link is established. |
| 10.4.14.2#2 | NT | The PHY layer of a DP OUT Adapter shall be tested as described in the DisplayPort 1.4a PHY CTS with the changes listed below: Entering DP OUT PHY Test Mode: When the DPTX reads the following sequence, the DP IN Adapter shall send a SET_CONFIG Packet of Type SET_PHY_TEST_MODE and enter DP OUT PHY Test Mode: AUTOMATED_TEST_REQUEST is set to 1b (DPCD 00201h or 02003h bit 1); PHY_TEST_PATTERN is set to 1b (DPCD 00218h bit 3). The DP OUT Adapter shall enter DP OUT PHY Test Mode when it receives a SET_CONFIG Packet of type SET_PHY_TEST_MODE. |
| 10.4.14.2#3 | NT | The PHY layer of a DP OUT Adapter shall be tested as described in the DisplayPort 1.4a PHY CTS with the changes listed below: While in DP OUT PHY Test Mode: The DP OUT Adapter shall act as the DPTX under test; The DP OUT Adapter shall send HPD Packet with Plug Flag set to 0b; The DP IN Adapter shall not forward any AUX Transactions to the DP OUT Adapter. |
| 10.4.14.2#4 | NT | The PHY layer of a DP OUT Adapter shall be tested as described in the DisplayPort 1.4a PHY CTS with the changes listed below: Exiting DP OUT PHY Test Mode: Upon a DPRX HPD signal de-assertion: The DP OUT Adapter shall exit DP OUT PHY Test Mode; The Connection Manager tears down the DP Paths, causing both of the DP Adapters to enter the Present State. |
| 10.5 High Speed Tunneling | | |
| 10.5.1 SST Tunneling | | |
| 10.5.1.1 Video Data Packet | | |
| 10.5.1.1.1 Transfer Unit Set | | |
| 10.5.1.1.1#1 | NT | A DP IN Adapter shall pack the active pixel data of a TU into either one or two TU Sets. |
| 10.5.1.1.1#2 | NT | When EOC control link symbols are present in a TU, a DP IN Adapter shall pack the EOC symbols using the same scheme as for active pixel symbols. |

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| 10.5.1.1.1# | NT | The EOC symbols shall be packed in their 8-bit value representation (DCh). |
| 10.5.1.1.1# | NT | Each TU Set shall be prepended with a TU Set Header. |
| 10.5.1.1.1# | NT | The header in Figure 10-26(A) shall be used for a TU Set that contains a TU with no EOC Symbol. |
| 10.5.1.1.1# | NT | The header in Figure 10-26(B) shall be used for a TU Set that contains a TU with an EOC symbol. |
| 10.5.1.1.1# | NT | The fields forming the TU Set Header shall be as defined below: ECC [7:0] : Error correction field that is calculated over bits [31:8] of the TU Set Header. |
| 10.5.1.1.1# | NT | The fields forming the TU Set Header shall be as defined below: Video Count [13:8] : This field shall contain the number of active video symbols per lane. A value of zero represents 64. The total number of active video symbols in the TU Set is equal to (Video Count * Number of Lanes). |
| 10.5.1.1.1# | NT | The fields forming the TU Set Header shall be as defined below: (No EOC) Fill Count [27:14] : This field shall have the value as defined in 10.5.1.5. |
| 10.5.1.1.1# | NT | The fields forming the TU Set Header shall be as defined below: (EOC) Fill Count [21:14] : This field shall have the value as defined in 10.5.1.5. |
| 10.5.1.1.1# | NT | The fields forming the TU Set Header shall be as defined below: (EOC) EOC Index [27:22] : This field shall contain the index of the EOC symbol inside the TU Set. Symbols within a TU Set are indexed starting with zero (for the first symbol) and ending with (Video Count – 1) for the last symbol. |
| 10.5.1.1.1# | NT | The fields forming the TU Set Header shall be as defined below: L [Bit 28] : Last TU Flag. This flag shall be set to 1b if the TU is the last TU Set of a line. Otherwise shall be set to 0b. |
| 10.5.1.1.1# | NT | The fields forming the TU Set Header shall be as defined below: RSV [30:29] : Reserved. |
| 10.5.1.1.1# | NT | The fields forming the TU Set Header shall be as defined below: RSV [30:29] : Reserved. |
| 10.5.1.1.2 Packet Format | | |
| 10.5.1.1.2#1 | NT | A Video Data Packet shall have the format shown in Figure 10-28. |
| 10.5.1.1.2#2 | NT | All TU Set headers within the Video Data Packet payload shall be aligned to 32-bits by adding padding bytes at the end of the TU set payload if necessary. |

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| 10.5.1.1.2#3 | NT | A DP IN Adapter shall follow the rules below when constructing a Video Data Packet: A Video Data Packet shall contain at least 1 TU Set and no more than 16 TU Sets. If a TU cannot fit within a single Video Data Packet, it shall be split into two TU sets. |
| 10.5.1.1.2#4 | NT | A DP IN Adapter shall follow the rules below when constructing a Video Data Packet: When a TU is split into two TU Sets, the remainder of the active pixel symbols shall be sent in the first TU Set in the next Video Data Packet. The <i>Fill Count</i> field in the TU Set Header of the second Video Data Packet for a TU that is split into multiple Video Data Packets shall be set to 0. |
| 10.5.1.1.2#5 | NT | A DP IN Adapter shall follow the rules below when constructing a Video Data Packet: The length of all TU Set Padding is included when calculating the <i>Length</i> field in the Tunneled Packet header. |
| 10.5.1.2 Main Stream Attribute Packet | | |
| 10.5.1.2#1 | NT | A Main Stream Attribute Packet shall consist of an MSA header followed by packet payload. |
| 10.5.1.2#2 | NT | The packet payload shall contain the encoding of the 36-byte attribute information following the <SS, SS> control symbol pair. |
| 10.5.1.2#3 | NT | The fields forming an MSA Header shall be as defined below: ECC [7:0] : Error correction field that is calculated over bits [31:8] of the MSA Header. |
| 10.5.1.2# | NT | The fields forming an MSA Header shall be as defined below: Fill Count [24:8] : This field shall contain the fill count as defined in Section 10.5.1.5. |
| 10.5.1.2# | NT | The fields forming an MSA Header shall be as defined below: Reserved [31:25] : Reserved. |
| 10.5.1.2# | NT | Upon receiving a Main Stream Attribute Packet, a DP OUT Adapter shall do the following: Verify the <i>ECC</i> field in the MSA header. If an uncorrectable error has occurred, the Main Stream Attribute Packet shall be dropped and ignored. |
| 10.5.1.2# | NT | Upon receiving a Main Stream Attribute Packet, a DP OUT Adapter shall do the following: Send Fill Count number of Stuffing Symbols on all lanes of the DP Main-Link according to Section 10.5.1.5. |
| 10.5.1.2# | NT | Upon receiving a Main Stream Attribute Packet, a DP OUT Adapter shall do the following: Send the control symbol pair <SS, SS> on all lanes of the DP Main-Link. |
| 10.5.1.2# | NT | Upon receiving a Main Stream Attribute Packet, a DP OUT Adapter shall do the following: Send the stream attribute information contained in the first 36 bytes of the payload of the Main Stream Attribute Packet by steering bytes from the payload onto the lanes of the DP Main-Link in a round robin fashion starting with lane 0. |

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| 10.5.1.2# | NT | Upon receiving a Main Stream Attribute Packet, a DP OUT Adapter shall do the following: Send the control symbol <SE> on all lanes of the DP Main-Link. |
| 10.5.1.3 Blank Start Packet | | |
| 10.5.1.3#1 | NT | A Blank Start Packet shall consist of a Blank Start header followed by packet payload. |
| 10.5.1.3#2 | NT | The packet payload shall contain the encoding of all 4 sets of <VB-ID, Mvid 7:0, Maud 7:0>. |
| 10.5.1.3#3 | NT | The fields forming the Blank Start header shall be as defined below: ECC [7:0] : Error correction field that is calculated over bits [31:8] of the Blank Start Header. |
| 10.5.1.3#4 | NT | The fields forming the Blank Start header shall be as defined below: Fill Count [24:8] : This field shall have the value as defined in Section 10.5.1.5. |
| 10.5.1.3#5 | NT | The fields forming the Blank Start header shall be as defined below: Reserved [29:25] : Reserved. |
| 10.5.1.3#6 | NT | The fields forming the Blank Start header shall be as defined below: CP [30] : Content Protection Flag shall be set to 1b if Blank Start DP Control Link Symbols sequence were <BS,CP,CP,BS> or <SR,CP,CP,SR>. |
| 10.5.1.3#7 | NT | The fields forming the Blank Start header shall be as defined below: SR [31] : Scrambler Reset Flag shall be set to 1b if Blank Start DP Control Link Symbols sequence were <SR,BF,BF,SR> or <SR,CP,CP,SR>. |
| 10.5.1.3#8 | NT | Upon receiving a Blank Start Packet, a DP OUT Adapter shall perform the following operations: 1) Verify the <i>ECC</i> field at the Blank Start Header. If an uncorrectable error has occurred, the Blank Start Packet shall be dropped. |
| 10.5.1.3#9 | NT | Upon receiving a Blank Start Packet, a DP OUT Adapter shall perform the following operations: 2) Generate Stuffing Symbols on each lane of the DP Main-Link according to the <i>Fill Count</i> field in the Blank Start Header and Section 10.5.1.5. |
| 10.5.1.3#10 | NT | Upon receiving a Blank Start Packet, a DP OUT Adapter shall perform the following operations: 3) Generate control symbols on each lane of the DP Main-Link marking the start of the blanking period based on the <i>SR Flag</i> and <i>CP Flag</i> as shown in Table 10-12. |
| 10.5.1.3#11 | NT | Upon receiving a Blank Start Packet, a DP OUT Adapter shall perform the following operations: 4) Steer the three double-words of Blank Start Packet payload starting with the second double-word onto the Main-Link by interleaving a byte at a time onto the lanes of the DP Main-Link starting with lane 0. |

| 10.5.1.4 Secondary Data Packet | | |
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| 10.5.1.4.1 Secondary Transfer Unit | | |
| 10.5.1.4.1#1 | NT | A DP IN Adapter shall pack secondary data into one or more Secondary Tus. |
| 10.5.1.4.1# | NT | Each Secondary TU shall be prepended with a Secondary TU Header. |
| 10.5.1.4.1# | NT | The fields forming the Secondary TU Header shall be as defined below: ECC [7:0] : Error correction field that is calculated over bits [31:8] of the Secondary TU Header. |
| 10.5.1.4.1#5 | NT | The fields forming the Secondary TU Header shall be as defined below: Secondary Count [13:8] : This field shall contain the number of secondary data symbols per lane. A value of zero represent 64 if ND bit equals 0. The total number of secondary data symbols in the Secondary TU is equal to (Secondary Count * Number of Lanes). |
| 10.5.1.4.1#6 | NT | The fields forming the Secondary TU Header shall be as defined below: Fill Count [27:14] : This field shall have the value as defined in Section 10.5.1.5. When both the <i>NSS</i> and <i>NSE</i> fields are 0b, the <i>Fill Count</i> field is extended by one bit and is constructed as {EFC, Fill Count} where EFC is the most significant bit. |
| 10.5.1.4.1#7 | NT | The fields forming the Secondary TU Header shall be as defined below: L [Bit 28] : Last TU Flag. This flag shall be set to 1b if the Secondary TU is either the last TU before a split or the TU represents the Secondary End Symbol. Otherwise it shall be set to 0b. |
| 10.5.1.4.1#8 | NT | The fields forming the Secondary TU Header shall be as defined below: NSE [Bit 29] : No Secondary End. This bit shall be set to 1b if Last TU Flag is set to 1b and a Secondary End Control symbol is not present at the DP Main-link. Otherwise it shall be set to 0b. |
| 10.5.1.4.1#9 | NT | The fields forming the Secondary TU Header shall be as defined below: NSS [Bit 30] : No Secondary Start. This bit shall be set to 1b if this is the first Secondary TU after a non-Secondary Tunneled Packet and a Secondary Start Control symbol is not present at the DP Main-Link. Otherwise it shall be set to 0b. |
| 10.5.1.4.1#10 | NT | The fields forming the Secondary TU Header shall be as defined below: EFC/ND [31] : Extended Fill Count/No Data. This bit shall be set to 1b if the Secondary TU does not have any Secondary data. |
| 10.5.1.4.1#11 | NT | The fields forming the Secondary TU Header shall be as defined below: EFC : When both the <i>NSS</i> and <i>NSE</i> fields are 0b, this bit is used as an extension to the Fill Count field. |

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| 10.5.1.4.1#12 | NT | The fields forming the Secondary TU Header shall be as defined below: ND: When either the <i>NSS</i> or <i>NSE</i> fields are 1b, this bit is used to indicate whether or not the Secondary TU has any Secondary data. This bit shall be set to 1b if the Secondary TU does not contain Secondary data. If the Secondary TU contains Secondary data, this bit shall be set to 0b. |
| 10.5.1.4.1#13 | NT | A DP IN Adapter shall start packing secondary data into a Secondary TU in the following cases: A single Secondary Start Control symbol <SS> is present on the DP Main-link. |
| 10.5.1.4.1#14 | NT | A DP IN Adapter shall start packing secondary data into a Secondary TU in the following cases: The previous Secondary TU has reached the maximum capacity and the secondary data continues. |
| 10.5.1.4.1#15 | NT | A DP IN Adapter shall start packing secondary data into a Secondary TU in the following cases: The secondary data is split (as defined by the DisplayPort 1.4a Specification) by a non-Secondary Data Packet and this packet has now ended. |
| 10.5.1.4.1#16 | NT | A DP IN Adapter shall stop packing secondary data into a Secondary TU upon one of the following cases: Secondary End Control symbol <SE> is present on the DP Main-link. |
| 10.5.1.4.1#17 | NT | A DP IN Adapter shall stop packing secondary data into a Secondary TU upon one of the following cases: Maximum capacity is reached: For 1-Lane and 2-Lanes links: maximum capacity is reached when the <i>Secondary Count</i> field is 64; For 4-Lane links: maximum capacity is reached when the <i>Secondary Count</i> field is 62. |
| 10.5.1.4.1#18 | NT | A DP IN Adapter shall stop packing secondary data into a Secondary TU upon one of the following cases: Secondary data stream was split by MSA, BS or Active video as defined in the DisplayPort 1.4a Specification. |
| 10.5.1.4.1#19 | NT | Upon receiving a Secondary Data Packet, a DP OUT Adapter shall do the following for each Secondary TU: 1) Verify the <i>ECC</i> field in the Secondary TU Header. If an uncorrectable error has occurred, the whole Secondary TU and the subsequent TUs within that packet shall be dropped and ignored. |
| 10.5.1.4.1#20 | NT | Upon receiving a Secondary Data Packet, a DP OUT Adapter shall do the following for each Secondary TU: 2) Send Fill Count number of Stuffing Symbols on all lanes of the DP Main-Link according to Section 10.5.1.5. |
| 10.5.1.4.1#21 | NT | Upon receiving a Secondary Data Packet, a DP OUT Adapter shall do the following for each Secondary TU: 3) If this Secondary TU is the first Secondary TU to follow a non-Secondary Data Packet and the <i>NSS</i> bit is not set in the Secondary TU Header, send the control symbol <SS> on all lanes of the DP Main-Link. |

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| 10.5.1.4.1#22 | NT | Upon receiving a Secondary Data Packet, a DP OUT Adapter shall do the following for each Secondary TU: 4) Send the secondary data contained in the Secondary TU. The number of cycles of data shall be as according to the <i>Secondary Count</i> field in the Secondary TU Header. The secondary data shall be sent on the DP Main-Link by steering bytes from the payload onto the lanes in a round robin fashion starting with lane 0. |
| 10.5.1.4.1#23 | NT | Upon receiving a Secondary Data Packet, a DP OUT Adapter shall do the following for each Secondary TU: 5) If the <i>L Flag</i> is set and the <i>NSE</i> bit is not set in the Secondary TU header, send the control symbol <SE> on all lanes of the DP Main-Link. |
| 10.5.1.4.2 Packet Format | | |
| 10.5.1.4.2#1 | NT | A Tunneled Secondary Data Packet shall have the format shown in Figure 10-34. |
| 10.5.1.4.2#2 | NT | A Tunneled Secondary Data Packet shall not include Secondary TUs from more than one DisplayPort SDP. |
| 10.5.1.4.2#3 | NT | All Secondary TU Headers within the Tunneled Secondary Data Packet payload shall be aligned to 32-bits by adding Secondary TU Padding bytes at the end of the Secondary TU payload if necessary. |
| 10.5.1.4.3 Secondary Data to Secondary TU Mapping Examples | | |
| 10.5.1.5 Fill Count | | |
| 10.5.1.5#1 | NT | DP IN Adapter shall calculate the <i>Fill Count</i> field according to the following formula: <i>Fill Count</i> field = Act_Fill_Count + DP_K_Prev_Pkt – Prev_Factor |
| 10.5.1.5#2 | NT | The following cycles shall be counted as the Act_Fill_Count: Stuffing Symbols; BE - Blanking End; FS - Filling Start; FE - Filling End. |
| 10.5.1.5#3 | NT | A DP OUT Adapter shall use the following formula to calculate the actual number of Stuffing Symbols to be driven over the DP link: Act_Fill_Count = <i>Fill Count</i> field + Prev_Factor – DP_K_Prev_Pkt |
| 10.5.1.5#4 | NT | A DP OUT Adapter shall ignore the <i>Fill Count</i> field in the first Tunneled Packet sent on the Main-Link Path after DP link training. |
| 10.5.2 MST Tunneling | | |
| 10.5.2.1 Sub-MTP TU | | |
| 10.5.2.1#1 | NT | A Sub-MTP TU Header shall have the format shown in Figure 10-38. |
| 10.5.2.1#2 | NT | The fields forming the Sub-MTP TU Header shall be as defined below: ECC [7:0] : Error correction field that is calculated over bits [23:8] of the Sub-MTP TU Header. |

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| 10.5.2.1#3 | NT | The fields forming the Sub-MTP TU Header shall be as defined below: Data Count[13:8] : This field shall contain the number of Data symbols per lane. The total number of Data symbols in the Sub-MTP TU is equal to (<i>Data Count</i> * Number of Lanes). |
| 10.5.2.1#4 | NT | The fields forming the Sub-MTP TU Header shall be as defined below: Type[17:14] : This field shall contain the Type encoding of the Sub-MTP TU. |
| 10.5.2.1#5 | NT | The fields forming the Sub-MTP TU Header shall be as defined below: Slot Number[23:18] : This field shall contain the first slot number in the MTP which this Sub-MTP TU Header is describing. |
| 10.5.2.1#6 | NT | A DP IN Adapter that receives an MST stream shall perform the DisplayPort PHY layer and De-scrambler functions defined in the DisplayPort 1.4a Specification. |
| 10.5.2.1#7 | NT | Upon reception of the first SR after link training completion, a DP IN Adapter shall: Track the total number of allocated MST slots by snooping any DPCD AUX transactions that configure the VC Payload ID Table. |
| 10.5.2.1#8 | NT | Upon reception of the first SR after link training completion, a DP IN Adapter shall: Start mapping MTP from the DP Main-Link into Sub-MTP TUs. |
| 10.5.2.1#9 | NT | When a Parameter includes a Data byte, the DP IN Adapter shall append the de-scrambled Data byte as the Parameter. |
| 10.5.2.1#10 | NT | A DP IN Adapter shall pack the Data bytes by selecting a byte from each Lane of the Main-Link in a cyclic way, starting with lane 0. |
| 10.5.2.1#11 | NT | A DP IN Adapter shall follow the rules below when constructing a Sub-MTP TU: A Sub-MTP TU is byte-aligned. |
| 10.5.2.1#12 | NT | A DP IN Adapter shall follow the rules below when constructing a Sub-MTP TU: The total length of a Sub-MTP TU (Header + Parameter Bytes + Data Bytes) does not exceed 252 Bytes. |
| 10.5.2.1#13 | NT | A DP IN Adapter shall follow the rules below when constructing a Sub-MTP TU: Slot 0 always starts a new Sub-MTP TU. |
| 10.5.2.1#14 | NT | A DP IN Adapter shall follow the rules below when constructing a Sub-MTP TU: A Sub-MTP TU includes data from one MTP only. |
| 10.5.2.1#15 | NT | A DP IN Adapter shall follow the rules below when constructing a Sub-MTP TU: A DP IN Adapter shall map an MTP into the minimum possible number of Sub-MTP TU. |
| 10.5.2.1#16 | NT | A DP IN Adapter shall follow the rules below when constructing a Sub-MTP TU: A Sub-MTP TU shall be split into 2 Sub-MTP TUs if it does not fit into an MTP packet according to Section 10.5.2.3. |

| 10.5.2.2 MTP to Sub-MTP TU Examples | | |
|-------------------------------------|----|---|
| 10.5.2.2.2 Shifting SR | | |
| 10.5.2.2.2#1 | NT | Upon detecting a sequence of four consecutive SR with 216 time-slot intervals, a DP IN Adapter shall switch to the new SR location. |
| 10.5.2.2.2#2 | NT | The first three SR that are not at Slot Zero's original location shall be mapped to a non-zero Slot Type 8 (1 K-Symbol), for the case of 1-lane, carrying Parameter byte = 8 (as defined in Table 10-17). |
| 10.5.2.2.2#3 | NT | The fourth SR shall be mapped to a non-zero Slot Type 1 (Shifting SR) forcing the next slot to be slot number 1. |
| 10.5.2.2.2#4 | NT | For the case of 2-Lane DP links, the first three SR shall be mapped to Type 9 (2 K-Symbols). |
| 10.5.2.2.2#5 | NT | For the case of and 4-Lane DP links, the first three SR shall be mapped to Type 11 (4 K-Symbols). |
| 10.5.2.2.3 ACT | | |
| 10.5.2.2.4 SF and VCPF | | |
| 10.5.2.2.4#1 | NT | A DP IN Adapter shall not map a SF sequence into a Sub-MTP TU unless the SF sequence comes immediately after a VCPF sequence. |
| 10.5.2.3 MST Packet Format | | |
| 10.5.2.3#1 | NT | An MST Packet shall have the format shown in Figure 10-46. |
| 10.5.2.3#2 | NT | A DP IN Adapter shall follow the rules below when constructing an MST Packet: The first 3 bytes of the MST Packet payload contains the first Sub-MTP TU Header. |
| 10.5.2.3#3 | NT | A DP IN Adapter shall follow the rules below when constructing an MST Packet: When concatenating two Sub-MTP TUs, the first TU is not be padded. |
| 10.5.2.3#4 | NT | A DP IN Adapter shall follow the rules below when constructing an MST Packet: The maximum number of MTPs packed into one MST Packet does not exceed 17. |
| 10.5.2.3#5 | NT | A DP IN Adapter shall follow the rules below when constructing an MST Packet: The <i>Length</i> field in the Tunneled Packet Header does not include padding bytes. |
| 10.5.2.3#6 | NT | A DP IN Adapter shall follow the rules below when constructing an MST Packet: The Payload of the Tunneled Packet shall be between 230 and 252 Bytes (inclusive), unless the Payload contains <u>at least 16</u> MTPs. |

| 10.5.2.4 MST Packets to DP MTP | | |
|--|----|--|
| 10.5.2.4#1 | NT | A DP OUT Adapter shall analyze each Sub-MTP TU Header and recreate the MTP K-Code and data bytes according to Table 10-16 (for slot zero) or Table 10-17 (for non-zero slots). |
| 10.5.2.4#2 | NT | If a DP OUT Adapter has a slot for which it lacks sufficient information to recreate the MTP K-Code and/or data bytes, it shall follow the rules below: If the last Sub-MTP TU Header was VCPF, insert VCPF. |
| 10.5.2.4#3 | NT | If a DP OUT Adapter has a slot for which it lacks sufficient information to recreate the MTP K-Code and/or data bytes, it shall follow the rules below: If the last Sub-MTP TU Header was Unallocated, insert unallocated (data bytes equal zero). |
| 10.5.2.4#4 | NT | If a DP OUT Adapter has a slot for which it lacks sufficient information to recreate the MTP K-Code and/or data bytes, it shall follow the rules below: For all other cases, insert SF. |
| 10.5.2.4#5 | NT | After creating the MTPs, the DP OUT Adapter shall follow all the PHY Layer functions required functions by the DisplayPort 1.4a Specification. |
| 10.5.3 FEC | | |
| 10.5.3.1 SR Count | | |
| 10.5.3.1#1 | NT | A DP Adapter shall implement the SR Count counter, which counts the number of cycles that have elapsed since the last SR. |
| 10.5.3.1#2 | NT | A DP IN Adapter shall initiate the SR Count at the first cycle after receiving an SR. |
| 10.5.3.1#3 | NT | A DP OUT Adapter shall initiate the SR Count at the first cycle after transmitting an SR. |
| 10.5.3.2 DP IN Adapter Requirements | | |
| 10.5.3.2#1 | NT | A DP IN Adapter shall: Implement FEC Decoding as defined in the DisplayPort 1.4a Specification. |
| 10.5.3.2#2 | NT | A DP IN Adapter shall: Construct an FEC_DECODE Packet as defined in Section 10.5.3.4 upon FEC_DECODE_EN or FEC_DECODE_DIS sequence detection. |
| 10.5.3.2#3 | NT | A DP IN Adapter shall: The Adapter Layer shall prioritize the FEC_DECODE Packet over all other Main-Link Path packets when pass it to the Transport Layer. |
| 10.5.3.2#4 | NT | A DP IN Adapter shall not: Tunnel any FEC-related symbols including FEC_PARITY_MARKER, FEC_DECODE & FEC_PARITY_PH. |
| 10.5.3.2#5 | NT | A DP IN Adapter shall not: Count the Link cycles of FEC Symbols for fill count purposes. |

| 10.5.3.3 DP OUT Adapter Requirements | | |
|--------------------------------------|----|--|
| 10.5.3.3#1 | NT | A DP OUT Adapter shall: Implement FEC Encoding as defined in the DisplayPort 1.4a Specification. |
| 10.5.3.3#2 | NT | A DP OUT Adapter shall: Apply majority voting for the repeated fields with in the FEC_DECODE Packet: SR Count; FEN; FDS. |
| 10.5.3.3#3 | NT | A DP OUT Adapter shall: Generate FEC_DECODE_EN and FEC_DECODE_DIS upon reception of a FEC_DECODE Packet. |
| 10.5.3.3#4 | NT | FEC_DECODE_EN sequence shall be generated if <i>FEN</i> field in the FEC_DECODE Packet is 1b. |
| 10.5.3.3#5 | NT | FEC_DECODE_DIS sequence shall be generated if <i>FDS</i> fields in the FEC_DECODE Packet is 1b. |
| 10.5.3.3#6 | NT | The first symbol of the FEC_DECODE_EN and FEC_DECODE_DIS sequences shall be transmitted according to the <i>SR Count</i> field of the FEC_DECODE Packet, i.e. the FEC_DECODE_EN and FEC_DECODE_DIS sequence shall be transmitted <i>SR Count</i> link clock cycles after the most recently transmitted SR. |
| 10.5.3.3#7 | NT | When a FEC_DECODE Packet is received, a DP OUT Adapter compares the Packet SR Count and the Counter SR Count as follows: If Packet SR Count > Counter SR Count the DP OUT Adapter waits for the Counter SR Count to be equal to Packet SR Count then generate the FEC sequence. |
| 10.5.3.3#8 | NT | When a FEC_DECODE Packet is received, a DP OUT Adapter compares the Packet SR Count and the Counter SR Count as follows: Else, a DP OUT Adapter waits for next SR to be transmitted, then waits for the Counter SR Count to be equal to Packet SR Count then generate the FEC sequence. |
| 10.5.3.3#9 | NT | A DP OUT Adapter shall not: Count the Link cycles of FEC Symbols for fill count purposes. |
| 10.5.3.4 FEC_DECODE Packet | | |
| 10.5.3.4#1 | NT | A FEC_DECODE Packet shall have the format shown in Figure 10-47. |
| 10.5.3.4#2 | NT | The <i>PDF</i> field in the header shall be set to 7 and the <i>Length</i> field shall be 14h. |
| 10.5.3.4#3 | NT | An FEC Command shall have the format defined in Figure 10-48. |
| 10.5.3.4#4 | NT | The three FEC Commands in an FEC_DECODE Packet shall be identical to each other. |

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| 10.5.3.4#5 | NT | The fields in an FEC Command shall contain the following: SR Count [29:0] : This field contains the number of DP Link clock cycles between the last received SR and the first FEC_DECODE_EN or FEC_DECODE_DIS sequences. The minimum value for this field is 1h. (occurs when SR is immediately followed by FEC_DECODE sequence). |
| 10.5.3.4#6 | NT | The fields in an FEC Command shall contain the following: FEC DISABLE (FDS) [30] : This field shall be set to 1b if a FEC_DECODE_DIS sequence was detected. In all other cases it shall be set to 0b. |
| 10.5.3.4#7 | NT | The fields in an FEC Command shall contain the following: FEC ENABLE (FEN) [31] : This field shall be set to 1b if a FEC_DECODE_EN sequence was detected. In all other cases it shall be set to 0b. |
| 10.5.4 DP OUT Adapter Buffer | | |
| 10.5.4#1 | NT | A DP OUT Adapter shall implement a buffer that can be used to compensate for the jitter in the latency of the received Tunneled Packets. |
| 10.5.4#2 | NT | After the DP link is successfully trained, a DP OUT Adapter shall start generating idle pattern as described in the DisplayPort 1.4a Specification. Deprecated. |
| 10.5.4#3 | NT | The DP OUT Adapter transitions from sending self-generated idle pattern to reconstructing the DP Main-Link from the Tunneled Packets after completing the following steps: 1) The DP OUT Adapter shall adjust the PLL frequency at least once as a result of an Adjust PLL event as described in Section 10.6. |
| 10.5.4#4 | NT | The DP OUT Adapter transitions from sending self-generated idle pattern to reconstructing the DP Main-Link from the Tunneled Packets after completing the following steps: 2) The DP OUT Adapter ensures, in an implementation specific manner, that within eight PLL frequency adjustments the link symbol clock frequency difference between its own and the DPTX is such that buffer overflow and buffer underrun is avoided. |
| 10.5.4#5 | NT | The DP OUT Adapter transitions from sending self-generated idle pattern to reconstructing the DP Main-Link from the Tunneled Packets after completing the following steps: 3) The DP OUT Adapter shall wait to receive an SR from the DP IN Adapter. |
| 10.5.4#6 | NT | All Main-Link Path Tunneled Packets, besides DP Clock Sync Packets, are dropped by the DP OUT Adapter until reception of the SR. |
| 10.5.4#7 | NT | After the next step is completed, the received SR, shall be the first symbol driven by the DP OUT Adapter as the reconstructed Main-link. |
| 10.5.4#8 | NT | The DP OUT Adapter transitions from sending self-generated idle pattern to reconstructing the DP Main-Link from the tunneled packets after completing the following steps: 4) The DP OUT Adapter delays sending the SR in Step 3 for a number of Accumulation Cycles. |

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| 10.5.4#9 | NT | During the delay, the DP OUT Adapter shall accumulate the DP Main-Link traffic from the DP IN Adapter. |
| 10.5.4.1 Buffer Operation | | |
| 10.5.4.1#1 | NT | If the buffer becomes empty, a DP OUT Adapter shall continue to drive Dummy Symbols on the DP Main Link, assuming that the next Main-Link Path Tunneled Packet holds a Fill Count value larger than the driven Dummy Cycles. |
| 10.5.4.2 Accumulation Cycles | | |
| 10.5.4.2#1 | NT | A DP OUT Adapter shall report the Maximum Accumulation Cycles it performs. |
| 10.5.5 HDCP | | |
| 10.5.5#1 | NT | A DP IN Adapter shall not perform HDCP decryption. |
| 10.5.5#2 | NT | It shall not drop or modify an AUX Request or AUX Response associated with HDCP functionality. |
| 10.5.5#3 | NT | A DP OUT Adapter shall not perform HDCP encryption. |
| 10.6 DP Link Clock Sync | | |
| 10.6.1 Synchronization Method | | |
| 10.6.1.1 Events | | |
| 10.6.1.1.1 Measuring Events | | |
| 10.6.1.1.2 Adjust PLL Event | | |
| 10.6.1.2 Lifetime Counter | | |
| 10.6.1.2#1 | NT | A DP OUT Adapter shall start counting as soon as Link Symbol clock is stable for starting link training with DPRX. |
| 10.6.1.2#1 | NT | A DP IN Adapter shall start counting as soon as it completed its equalization process. |
| 10.6.1.2#3 | NT | In order to filter out the variation introduced by spread-spectrum modulation, the LC shall be filtered using a first order IIR filter. |
| 10.6.1.2#4 | NT | The filtering operation shall be done with 8-bit truncation at the fraction part to assure reproducible result. |
| 10.6.1.2#5 | NT | All operands of IIR filter shall have the same format of 64 bits of integer followed by 8 bits of fraction. |

| 10.6.1.3 DP Clock Sync Packet | | |
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| 10.6.1.3#1 | NT | A DP Clock Sync Packet shall have the format shown in Figure 10-53. |
| 10.6.1.3#2 | NT | The fields forming a DP Clock Sync Packet shall be as defined below: Reserved: This field is reserved and shall be set to 0. |
| 10.6.1.3#3 | NT | The fields forming a DP Clock Sync Packet shall be as defined below: Window Count: This field is defined in Section 10.6.2.1. The <i>Window Count</i> field structure is shown in Figure 10-52(A). |
| 10.6.1.3#4 | NT | The fields forming a DP Clock Sync Packet shall be as defined below: FLC: This field contains the snapshot of the Filtered Lifetime Counter at the time the Window Measured Event occurred. |
| 10.6.1.3#5 | NT | The fields forming a DP Clock Sync Packet shall be as defined below: CRC32: This field contains a CRC32 computed over the entire payload using the following DW order: DW1, DW3, DW2, DW7, DW6, DW5, DW4. The following CRC shall be used: Width: 32; Poly: 1EDC 6F41h; Init: FFFF FFFFh; RefIn: True; RefOut: True; XorOut: FFFF FFFFh. |
| 10.6.2 DP Adapter Requirements | | |
| 10.6.2.1 DP IN Adapter Requirements | | |
| 10.6.2.1#1 | NT | A DP IN Adapter shall: Implement a Lifetime Counter as described in Section 10.6.1.1.2. |
| 10.6.2.1#2 | NT | A DP IN Adapter shall: Implement the logic to perform the LC filtering. |
| 10.6.2.1#3 | NT | A DP IN Adapter shall: Update FLC upon an Update Counter Event. |
| 10.6.2.1#4 | NT | A DP IN Adapter shall: Upon the first Measure Window Event: Capture the current FLC; Store the current captured FLC to be used as previous captured FLC at the next Measure Window Even. |
| 10.6.2.1#5 | NT | A DP IN Adapter shall: Upon each subsequent Measure Window Event: Capture the current FLC; Compute the Window Count by calculating the current captured FLC minus the FLC that was captured at the previous Measure Event; Construct a DP Clock Sync Packet and send it over the Main-Link Path within tDPClockSync after the Measure Window Event; Store the current captured FLC to be used as previous captured FLC at the next Measure Window Event. |
| 10.6.2.2 DP OUT Adapter Requirements | | |
| 10.6.2.2#1 | NT | A DP OUT Adapter shall: Implement a Lifetime Counter as described in Section 10.6.1.2. |
| 10.6.2.2#2 | NT | A DP OUT Adapter shall: Implement the logic to perform the LC filtering. |
| 10.6.2.2#3 | NT | A DP OUT Adapter shall: Update FLC upon an Update Counter Event. |

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| 10.6.2.2#4 | NT | A DP OUT Adapter shall: Upon a Measure Window Event: Capture the current FLC; Compute the Window Count as described in Section 10.6.1.3. |
| 10.6.2.2#5 | NT | A DP OUT Adapter shall: Upon receiving a DP Clock Sync Packet after the Measure Window Event and before the PLL Adjust Event, compute the PLL frequency adjustment. The method for computing the PLL frequency adjustment is outside the scope of this specification. |
| 10.6.2.2#6 | NT | A DP OUT Adapter shall: Upon an Adjust PLL Event, adjust the PLL frequency based on the computation performed at the Measure Window Event. |
| 10.6.2.2#7 | NT | If a DP OUT Adapter receives a DP Clock Sync Packet after an Adjust PLL Event but before the next Measure Window Event, it shall not adjust the PLL and shall silently discard the packet. |
| 10.6.2.2#8 | NT | If a DP OUT Adapter receives a DP Clock Sync Packet before it computed the first Window Count, it shall not adjust the PLL and shall silently discard the packet. |
| 10.6.2.2#9 | NT | When a DP OUT Adapter changes the DisplayPort Main-Link transmitter frequency as a result of adjusting the PLL frequency, it shall adhere to the DisplayPort 1.4a Specification. |
| 10.6.2.2#10 | NT | The PLL frequency adjustment shall be completed within tDPPLLAdjust after the Adjust PLL Event. |
| 10.7 DP BW Allocation Mode | | |
| 10.7#1 | | If a DP IN Adapter supports DP BW Allocation Mode, it shall do so as defined in this section. |
| 10.7.1 DP BW Allocation Mode Enablement | | |
| 10.7.1#1 | | If a DP IN Adapter supports DP BW Allocation Mode, it shall: Set the DP_LOCAL_CAP.DP_IN_BW_Allocation Mode Support bit to 1b. |
| 10.7.1#2 | | If a DP IN Adapter supports DP BW Allocation Mode, it shall: Update the AUX Response for DPCD DP TUNNELING and PANEL REPLAY OPTIMIZATION SUPPORT. DP_IN_BW_Allocation_Mode_Support (E000Dh, bit 7) to 1b. |
| 10.7.1#3 | | If a DP IN Adapter supports DP BW Allocation Mode, it shall: Update the AUX Response for DPCD USB4_DRIVER_BW_CAPABILITY.USB4_Driver_BW Allocation Mode Support (E0020h, bit 7) to have the same value as ADP_DP_CS_2.CM BW Allocation Mode Support. |
| 10.7.1#4 | | When a Connection Manager changes ADP_DP_CS_2.CM BW Allocation Mode Support bit, a DP IN Adapter shall: Set the BW_Allocation_Capability_Changed field to 1b in DP_TUNNELING_STATUS DPCD register. |

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| 10.7.1#5 | | When a Connection Manager changes ADP_DP_CS_2.CM BW Allocation Mode Support bit, a DP IN Adapter shall: Set DP_TUNNELING_IRQ bit (Bit 5 of LINK_SERVICE_IRQ_VECTOR_ESI0 register at DPCD 02005h) |
| 10.7.1#6 | | When a Connection Manager changes ADP_DP_CS_2.CM BW Allocation Mode Support bit, a DP IN Adapter shall: If Unmask_BW_Allocation_IRQ is 1b, generate an IRQ_HPDP. |
| 10.7.1#7 | | When DPTX sets DPTX_BW_ALLOCATION_MODE_CONTROL.DP_Display_Driver_BW_Allocation_Mode_Enable (E0030h, bit 7) to 1b, a DP IN Adapter shall: Enable DP BW Allocation Mode. |
| 10.7.1#8 | | When DPTX sets DPTX_BW_ALLOCATION_MODE_CONTROL.DP_Display_Driver_BW_Allocation_Mode_Enable (E0030h, bit 7) to 1b, a DP IN Adapter shall: Send the Connection Manager a Notification Packet with Event Code = DP_BW as defined in Table 6-11. |
| 10.7.2 Interaction with DPTX | | |
| 10.7.2#1 | | When a DP IN Adapter receives a DPCD AUX Write transaction that targets a DPCD register within Table 10-23, and the targeted DPCD field Type is Read/Write, it shall update the corresponding field in Adapter configuration space with the value of the write transaction. |
| 10.7.2#2 | | When a DP IN Adapter receives a DPCD AUX Read transaction that targets a DPCD register within Table 10-23, and the targeted DPCD field Type is Read Only, it shall update the read transaction with the value in the corresponding field in Adapter Configuration Space. |
| 10.7.2#3 | | When DPTX sends a DPCD AUX write transaction that targets the REQUESTED_BW register, a DP IN Adapter shall: Store the current Allocated BW in an internal variable. |
| 10.7.2#4 | | When DPTX sends a DPCD AUX write transaction that targets the REQUESTED_BW register, a DP IN Adapter shall: If the recovery timer is advancing, stop and reset it. |
| 10.7.2#5 | | When DPTX sends a DPCD AUX write transaction that targets the REQUESTED_BW register, a DP IN Adapter shall: Initiate a bandwidth request handshake with the Connection Manager as defined in Section 10.7.3. |
| 10.7.2#6 | | When a Connection Manager writes a value to the Allocated BW field that is equal to or greater than the Requested BW, a DP IN Adapter shall: Set the BW Request Succeeded field to 1b in DP_TUNNELING_STATUS DPCD register. |

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| 10.7.2#7 | | When a Connection Manager writes a value to the Allocated BW field that is equal to or greater than the Requested BW, a DP IN Adapter shall: Set DP_TUNNELING_IRQ bit (Bit 5 of LINK_SERVICE_IRQ_VECTOR_ESI0 register at DPCD 02005h). |
| 10.7.2#8 | | When a Connection Manager writes a value to the Allocated BW field that is equal to or greater than the Requested BW, a DP IN Adapter shall: If Unmask_BW_Allocation_IRQ is 1b, generate an IRQ_HPD. |
| 10.7.2#9 | | When a Connection Manager writes a value to the Allocated BW field that is equal to or greater than the Requested BW, a DP IN Adapter shall: If the ESTIMATED_BW field was locked for updates due to bandwidth request failure, unlock it. |
| 10.7.2#10 | | When a Connection Manager writes a value to the Allocated BW field that is smaller than the Requested BW, a DP IN Adapter shall: Set the ESTIMATED_BW field to the Allocated BW, and lock its value (i.e. ignore any changes in the Estimated_BW field). |
| 10.7.2#11 | | When a Connection Manager writes a value to the Allocated BW field that is smaller than the Requested BW, a DP IN Adapter shall: Set the BW Request Failed to 1b in DP_TUNNELING_STATUS DPCD register. |
| 10.7.2#12 | | When a Connection Manager writes a value to the Allocated BW field that is smaller than the Requested BW, a DP IN Adapter shall: Set DP_TUNNELING_IRQ bit (Bit 5 of LINK_SERVICE_IRQ_VECTOR_ESI0 register at DPCD 02005h). |
| 10.7.2#13 | | When a Connection Manager writes a value to the Allocated BW field that is smaller than the Requested BW, a DP IN Adapter shall: If Unmask_BW_Allocation_IRQ is 1b, generate an IRQ_HPD. |
| 10.7.2#14 | | When a Connection Manager writes a value to the Allocated BW field that is smaller than the Requested BW, a DP IN Adapter shall: Start the recovery timer. |
| 10.7.2#15 | | When a Connection Manager writes a value to the Allocated BW field that is smaller than the Requested BW, a DP IN Adapter shall: If the recovery timer has reached tDPBWRecoveryTimeout, the DP IN Adapter initiates a bandwidth allocation request. The DP BW that a DP IN Adapter requests shall be the same bandwidth as before the failed bandwidth allocation (i.e. the same value as in the Allocated BW field before the DPTX last updated the DPCD Requested BW register). |
| 10.7.2.1 Estimated Bandwidth | | |
| 10.7.2.1#1 | | Upon a change in the Estimated BW field, a DP IN adapter shall: Set Estimated BW Changed bit in the DPCD DP_TUNNELING_STATUS register to 1b. |

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| 10.7.2.1#2 | | Upon a change in the Estimated BW field, a DP IN adapter shall: Set DP_TUNNELING_IRQ bit (Bit 5 of LINK_ |
| 10.7.2.1#3 | | Upon a change in the Estimated BW field, a DP IN adapter shall: If Unmask_BW_Allocation_IRQ is 1b, generate an IRQ_HPD. |
| 10.7.3 Interaction with the Connection Manager | | |
| 10.7.3#1 | | When DPTX sends a DPCD AUX write transaction that targets the REQUESTED_BW field, a DP IN Adapter shall: 1)Set the ADP_DP_CS_8.DPTX Req field to 1b; 2) Send the Connection Manager a Notification Packet with Event Code = DP_BW as defined in Table 6-11; 3)Wait for the Connection Manager to set the ADP_DP_CS_2.CM Ack bit to 1b; 4) Set the ADP_DP_CS_8.DPTX Req field to 0b. |
| 10.8 Timing Parameters | | |

| <u>Assertion #</u> | <u>How to Test</u> | <u>Assertion Description</u> |
|---|--------------------|--|
| <u>13 TBT3 Compatibility</u> | | |
| <u>13.8.1.1 DP IN Adapter Requirements</u> | | |
| <u>13.8.1.1#1</u> | <u>TBD</u> | <u>A DP IN Adapter operating in TBT3-Compatible mode follows the requirements listed in Section 10.4.4.2.1 except the following: The Link Status DPCD registers, as defined in Table 10-9, shall be mapped statically as Internal registers.</u> |
| <u>13.8.1.1#2</u> | <u>TBD</u> | <u>A DP IN Adapter operating in TBT3-Compatible mode follows the requirements listed in Section 10.4.4.2.1 except the following: DPCD address 00600h is mapped as Internal register.</u> |
| <u>13.8.1.1#3</u> | <u>TBD</u> | <u>A DP IN Adapter operating in TBT3-Compatible mode follows the requirements listed in Section 10.4.4.2.1 except the following: An AUX Read Transaction to the LTTPR DPCD Field, addresses F0000h-F02FFh, are mapped as Internal registers. A DP IN Adapter shall set the data of the AUX Response to 0h.</u> |
| <u>13.8.1.1#4</u> | <u>TBD</u> | <u>A DP IN Adapter operating in TBT3-compatible mode follows the requirements listed in Section 10.4.4.5 except the following: DSC Support field in the DSC SUPPORT DPCD register shall always be set to 0b.</u> |
| <u>13.8.1.1#5</u> | <u>TBD</u> | <u>A DP IN Adapter operating in TBT3-compatible mode follows the requirements listed in Section 10.4.4.5 except the following: FEC CAPABLE field in FEC CAPABILITY DPCD register shall always be set to 0b.</u> |

Test Setups

Host Router with DP IN Adapter

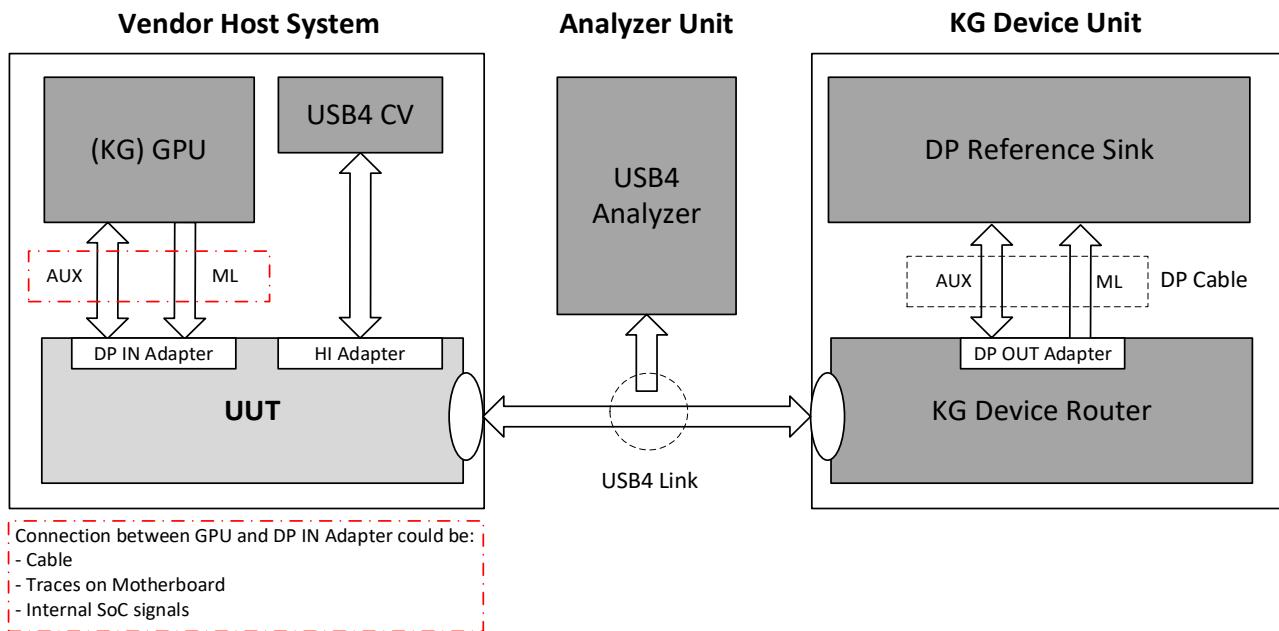
This section describes the test setups for a Host Router that contains a DP IN Adapter.

AN_HOST_DFP1—DPIN_01

This section describes the test setup for a Host Router that is running DP IN Adapter general testing.

- Vendor provides host system for UUT with a Host Router and a GPU in one of the following configurations:
 - The Host Router and the GPU are integrated into the same SoC
 - The Host Router and the GPU are both down on the motherboard
 - The Host Router is an Add-in Card connected to a KG GPU (or DP Source) through a cable
- KG GPU (or DP Source) is VESA compliant and is LTTTPR Aware (provides the 3.2 ms AUX Timeout)
- In such cases where the KG GPU (or DP Source) is connected to the DP IN Adapter by way of a removable cable, the KG GPU(s) (or DP Source) shall meet the capability requirements outlined in Table 16
- USB4 CV should be installed on the Vendor host system
- KG Device Unit connects to the UUT and presents as UFP
- KG Device Unit contains:
 - KG Device Router
 - DP Reference Sink CTS tools

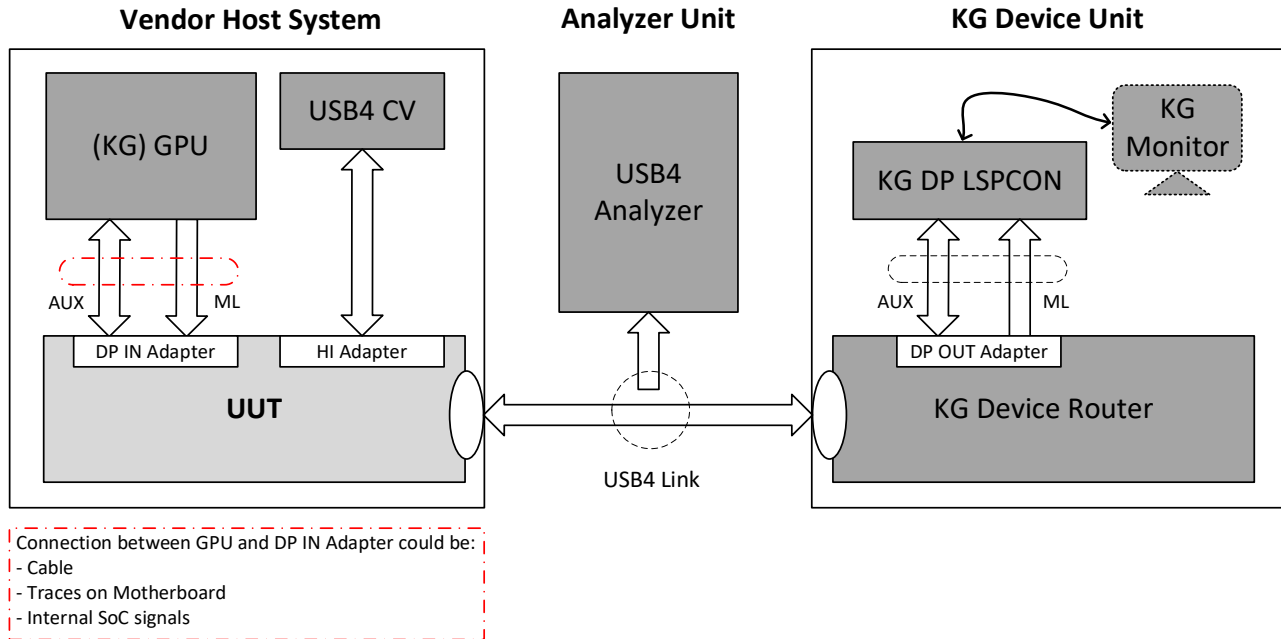
As USB4 Host must support DP Alt mode on its DFPs, a full VESA CTS shall be run on the Host system with a DP Reference Sink in DP Alt Mode.



AN_HOST_DFP1—DPIN_02

This section describes the test setup for a Host Router running DP IN Adapter specific testing.

- Vendor provides host system for UUT with a Host Router and a GPU in one of the following configurations:
 - The Host Router and the GPU are integrated into the same SoC
 - The Host Router and the GPU are both down on the motherboard
 - The Host Router is an Add-in Card connected to a KG GPU (or DP Source) through a cable
- KG GPU (or DP Source) is VESA compliant and is LTTPR Aware (provides the 3.2 ms AUX Timeout)
- In such cases where the KG GPU (or DP Source) is connected to the DP IN Adapter by way of a removable cable, the KG GPU(s) (or DP Source) shall meet the capability requirements outlined in Table 16
- USB4 CV should be installed on the Vendor host system
- KG Device Unit connects to the UUT and presents as UFP
- KG Device Unit contains:
 - KG Device Router
 - KG DP LSPCON dongle and KG monitor



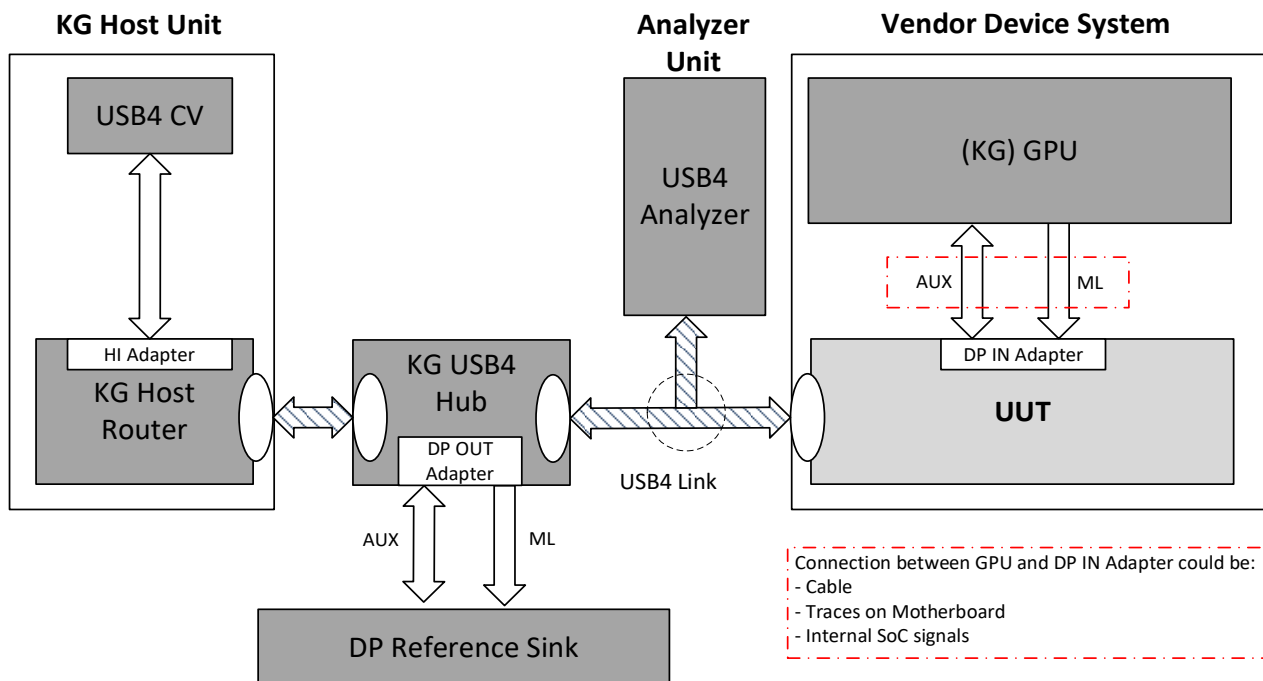
Device Router with DP IN Adapter

This section describes the test setups for a Device Router that contains a DP IN Adapter and no USB4 DFP.

AN_DEV_UFP1—DPIN_03

This section describes the test setup for a Device Router running DP IN Adapter general testing.

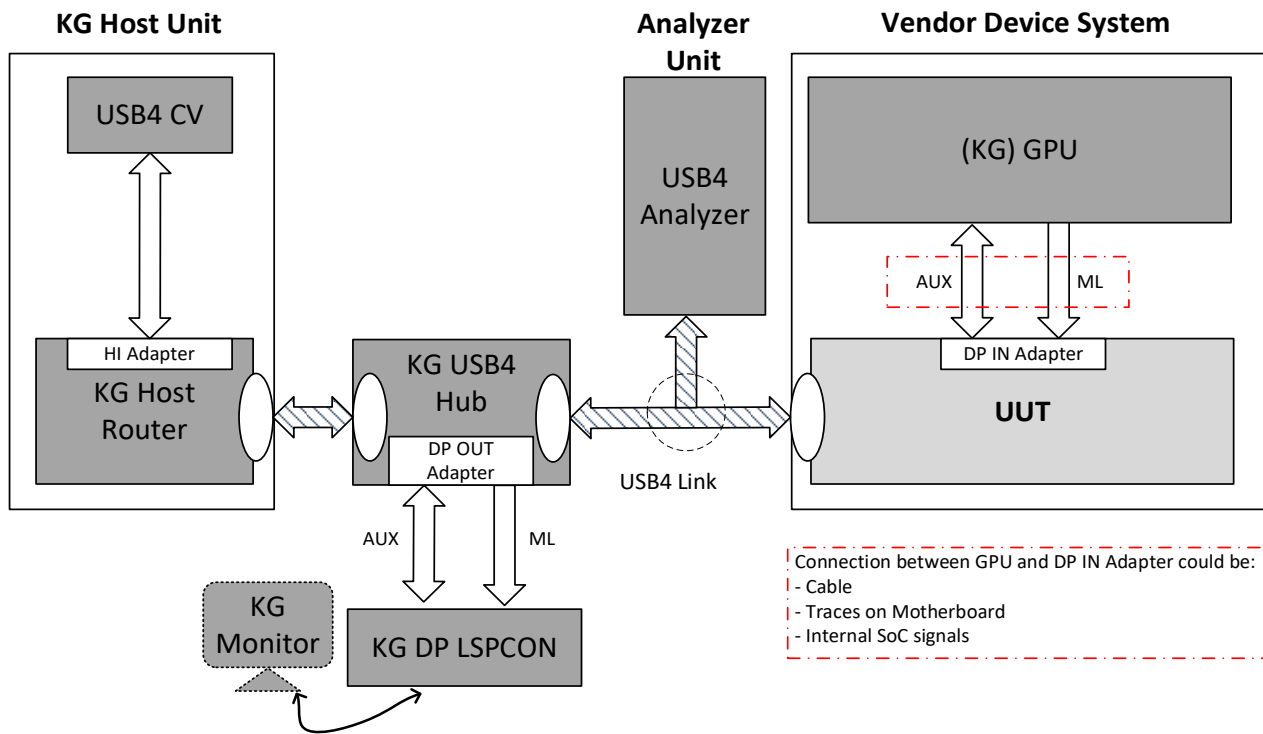
- Vendor provides Device System for UUT with a Device Router and a GPU in one of the following configurations:
 - The Device Router and the GPU are integrated into the same SoC
 - The Device Router and the GPU are both down on a motherboard
 - The Device Router is connected to a KG GPU (or DP Source) through a cable
- KG GPU (or DP Source) is VESA compliant and is LTTPR Aware (provides the 3.2 ms AUX Timeout)
- In such cases where the KG GPU (or DP Source) is connected to the DP IN Adapter by way of a removable cable, the KG GPU(s) (or DP Source) shall meet the capability requirements outlined in Table 16
- KG Host Unit with USB4 CV installed
- KG USB4 Hub with at least two USB4 DFPs
- DP Reference Sink CTS tools



AN_DEV_UFP1—DPIN_04

This section describes the test setup for a Device Router running DP IN Adapter specific testing.

- Vendor provides Device System for UUT with a Device Router and a GPU in one of the following configurations:
 - The Device Router and the GPU are integrated into the same SoC
 - The Device Router and the GPU are both down on a motherboard
 - The Device Router is connected to a KG GPU (or DP Source) through a cable
- KG GPU (or DP Source) is VESA compliant and is LTTPR Aware (provides the 3.2 ms AUX Timeout)
- In such cases where the KG GPU (or DP Source) is connected to the DP IN Adapter by way of a removable cable, the KG GPU(s) (or DP Source) shall meet the capability requirements outlined in Table 16
- KG Host Unit with USB4 CV installed
- KG USB4 Hub with at least two USB4 DFPs
- KG DP LSPCON Dongle and KG monitor



Hub with DP IN Adapter

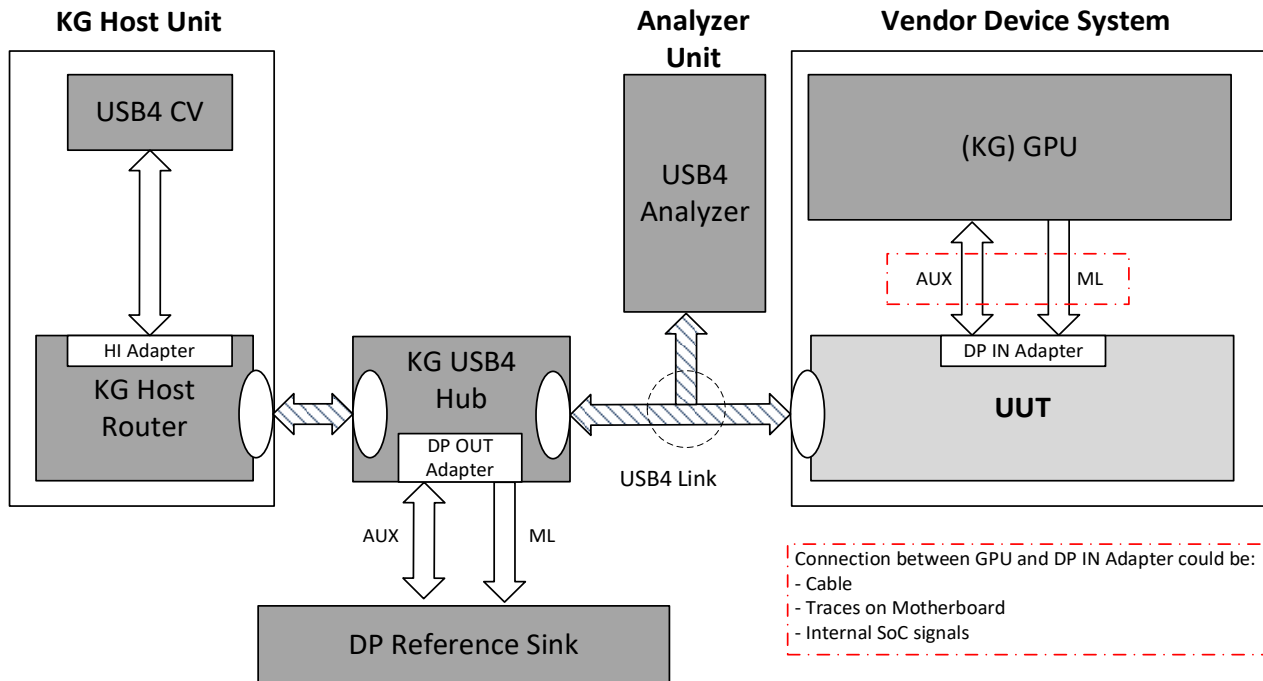
This section describes the test setups for a Device Router that contains a DP IN Adapter and one or more USB4 DFP.

AN_HUB_UFP1—DPIN_05

This section describes the test setup for a Device Router running DP IN Adapter general testing.

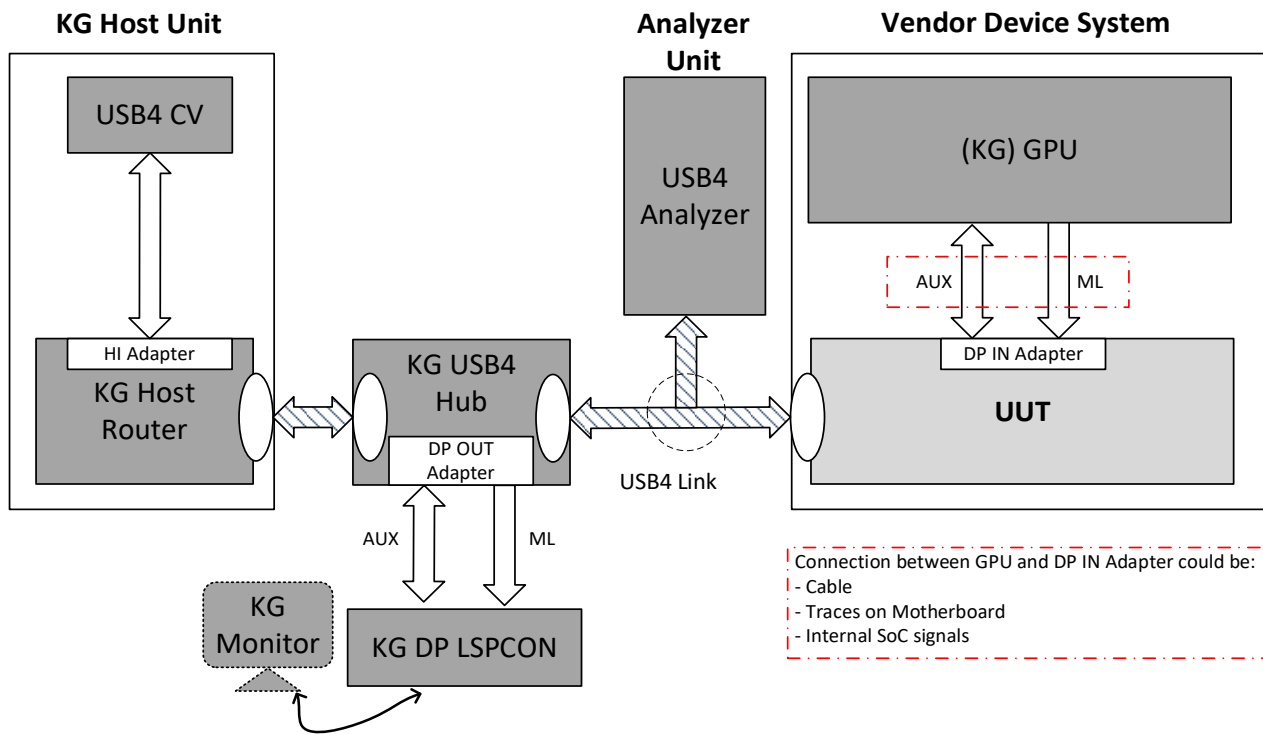
- Vendor provides Device System for UUT with a Device Router and a GPU in one of the following configurations:

- The Device Router and the GPU are integrated into the same SoC
- The Device Router and the GPU are both down on a motherboard
- The Device Router is connected to a KG GPU (or DP Source) through a cable
- KG GPU (or DP Source) is VESA compliant and is LTTPR Aware (provides the 3.2 ms AUX Timeout)
- In such cases where the KG GPU (or DP Source) is connected to the DP IN Adapter by way of a removable cable, the KG GPU(s) (or DP Source) shall meet the capability requirements outlined in Table 16
- KG Host Unit with USB4 CV installed
- KG USB4 Hub with at least two USB4 DFPs
- DP Reference Sink CTS tools



This section describes the test setup for a Device Router running DP IN Adapter specific testing.

- Vendor provides Device System for UUT with a Device Router and a GPU in one of the following configurations:
 - The Device Router and the GPU are integrated into the same SoC
 - The Device Router and the GPU are both down on a motherboard
 - The Device Router is connected to a KG GPU (or DP Source) through a cable
- KG GPU (or DP Source) is VESA compliant and is LTTPR Aware (provides the 3.2 ms AUX Timeout)
- In such cases where the KG GPU (or DP Source) is connected to the DP IN Adapter by way of a removable cable, the KG GPU(s) (or DP Source) shall meet the capability requirements outlined in Table 16
- KG Host Unit with USB4 CV installed
- KG USB4 Hub with at least two USB4 DFPs
- KG DP LSPCON Dongle and KG monitor



Host Router with DP OUT Adapter

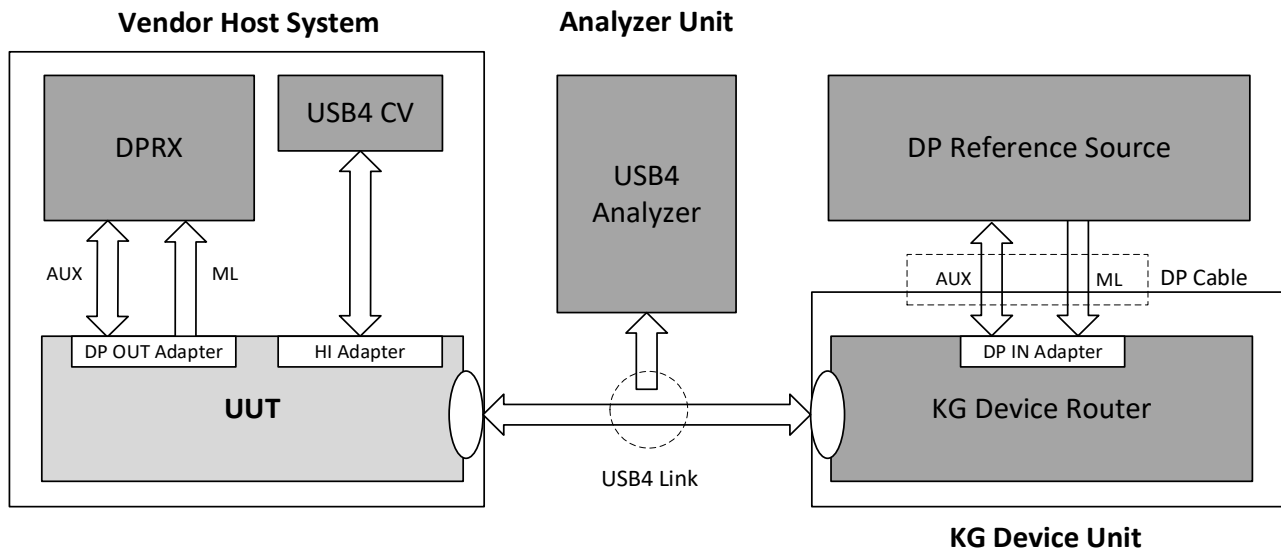
This section describes the test setups for a Host Router that contains a DP OUT Adapter. This setup is for a DP OUT Adapter that is integrated with a DPRX.

AN_HOST_DFP1—DPOUT_01

This section describes the test setup for a Host Router running DP OUT Adapter general testing.

- Vendor provides host system for UUT with an integrated DPRX connected to the DP OUT Adapter.
- USB4 CV should be installed on the Vendor host system
- KG Device Unit connects to UUT and presents as UFP
- KG Device Unit contains a KG Device Router with a DP IN Adapter that connects to an exposed connector
- DP Reference Source CTS tools

Note: A KG Device Router with a DP IN Adapter is not available yet. This test setup is not currently used.



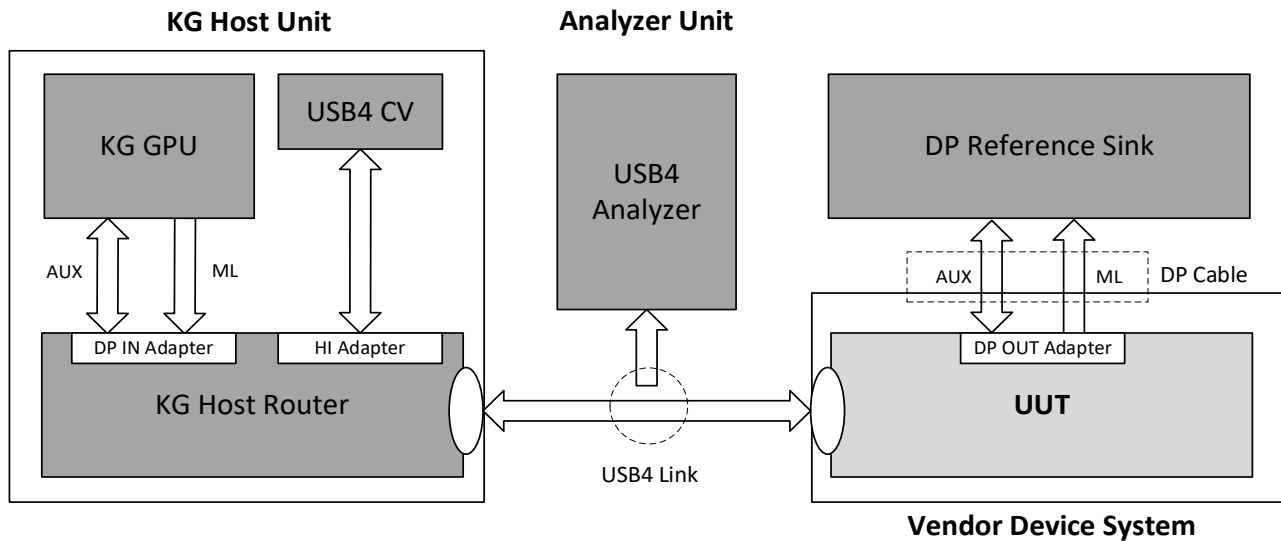
Device Router with DP OUT Adapter

This section describes the test setups for a Device Router that contains a DP OUT Adapter and no USB4 DFP.

AN_DEV_UFP1—DPOUT_02

This section describes the test setup for a Device Router running DP OUT Adapter general testing. This setup is for a DP OUT that connects to an exposed connector.

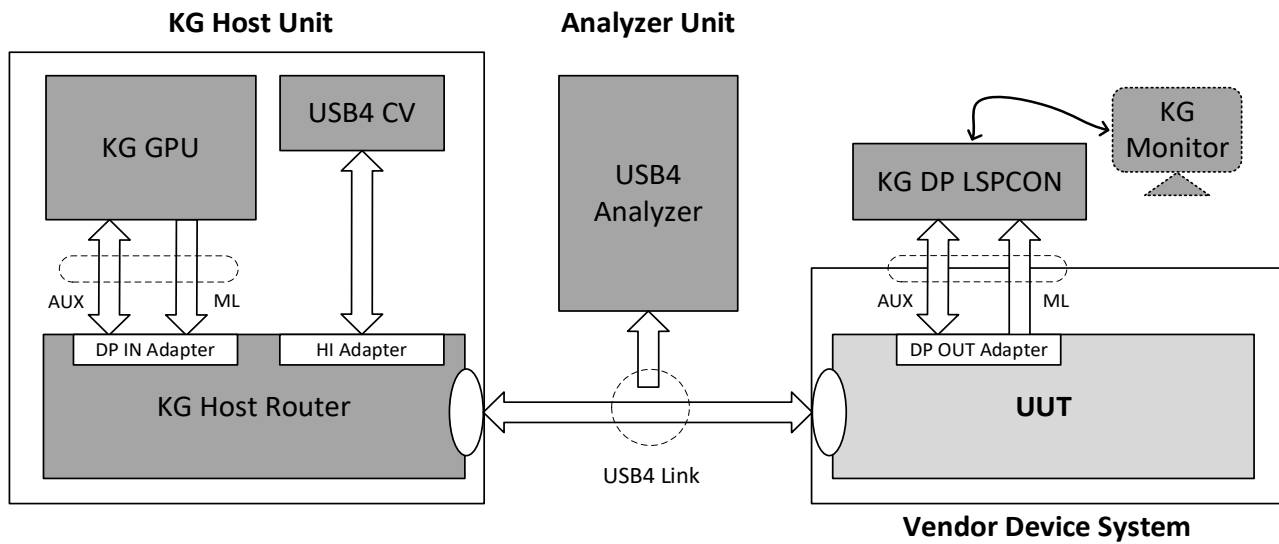
- Vendor provides Device System for UUT with an exposed connector
- DP Reference Sink CDT tools
- KG Host Unit connects to UUT and presents as DFP
- KG Host Unit contains:
 - KG Host Router
 - KG GPU
 - USB4 CV
- KG GPU(s) (or DP Source) are VESA compliant and LTTPR Aware (provides the 3.2 ms AUX Timeout) and shall meet the capability requirements outlined in Table 16



AN_DEV_UFP1—DPOUT_03

This section describes the test setup for a Device Router running DP OUT Adapter specific testing. This setup is for a DP OUT that connects to an exposed connector.

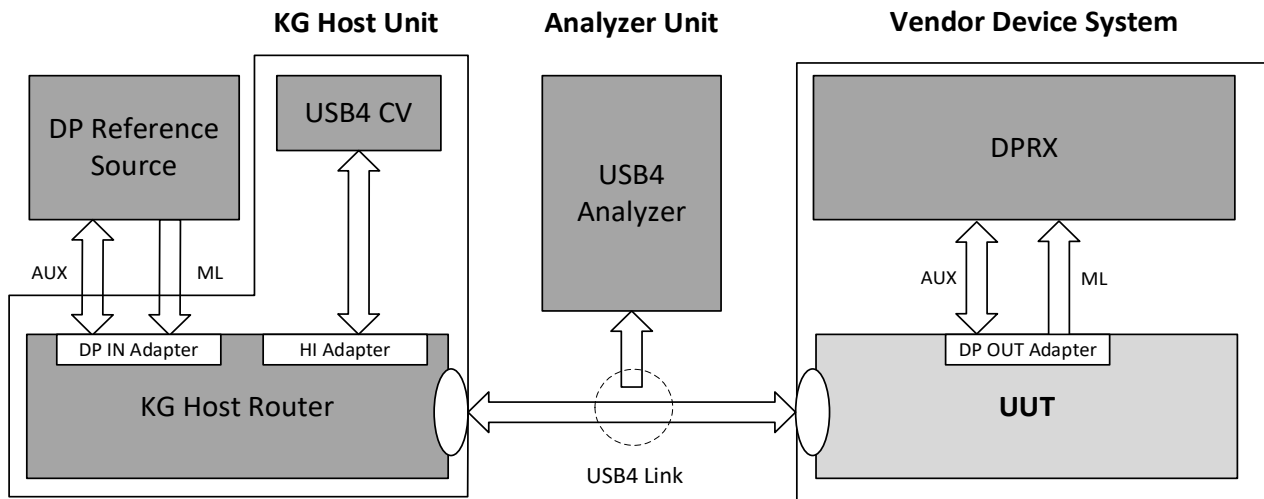
- Vendor provides Device System for UUT with an exposed connector
- KG DP LSPCON Dongle and KG monitor
- KG Host Unit connects to UUT and presents as DFP
- KG Host Unit contains:
 - KG Host Router
 - KG GPU
 - USB4 CV
- KG GPU(s) (or DP Source) are VESA compliant and LTTPR Aware (provides the 3.2 ms AUX Timeout) and shall meet the capability requirements outlined in Table 16



AN_DEV_UFP1—DPOUT_04

This section describes the test setup for a Device Router running DP OUT Adapter general testing. This setup is for a DP OUT Adapter that is integrated with a DPRX.

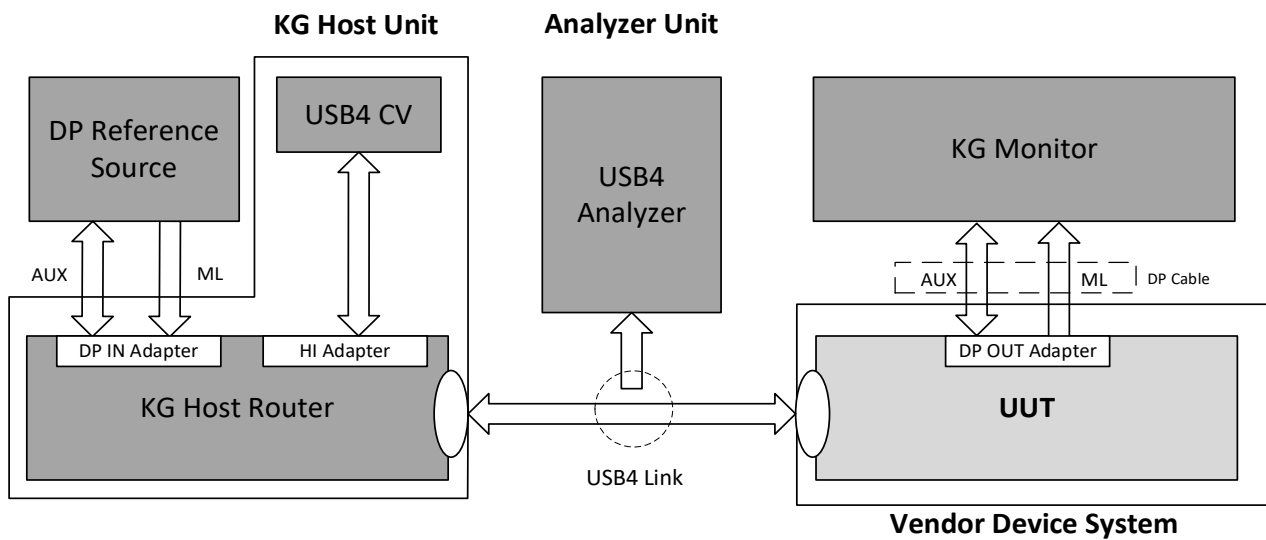
- Vendor provides Device System for UUT with an integrated DPRX
- DP Reference Source CTS tools
- KG Host Unit connects to UUT and presents as DFP
- KG Host Unit contains:
 - KG Host Router
 - USB4 CV



AN_DEV_UFP1—DPOUT_05

This section describes the test setup for a Device Router running DP OUT Adapter general testing. This setup is for a DP OUT that connects to an exposed connector.

- Vendor provides Device System for UUT with an exposed connector
- KG Monitor
- DP Reference Source CTS tools
- KG Host Unit connects to UUT and presents as DFP
- KG Host Unit contains:
 - KG Host Router
 - USB4 CV



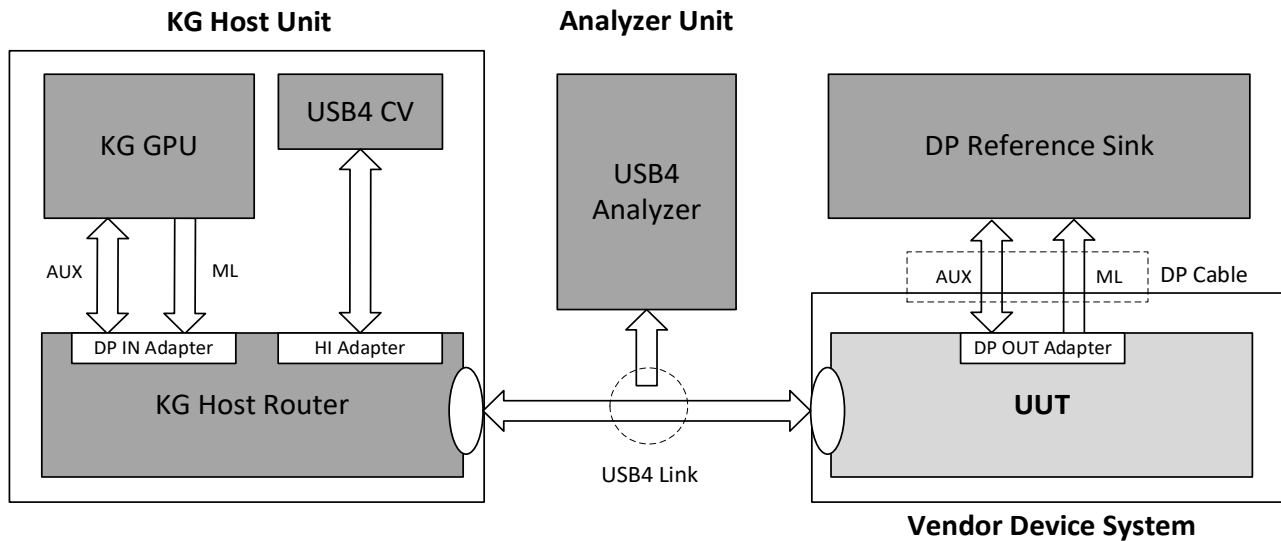
Hub with DP OUT Adapter

This section describes the test setups for a Device Router that contains a DP OUT Adapter and one or more USB4 DFP.

AN HUB UFP1—DPOUT 06

This section describes the test setup for a Device Router running DP OUT Adapter general testing. This setup is for a DP OUT that connects to an exposed connector.

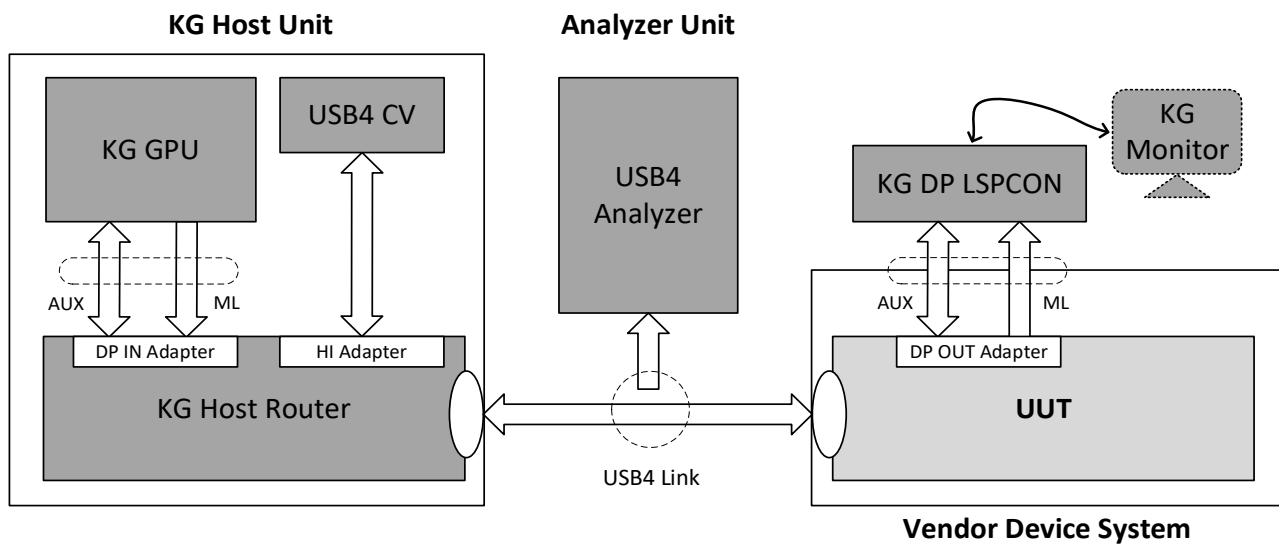
- Vendor provides Device System for UUT with an exposed connector
- DP Reference Sink CDT tools
- KG Host Unit connects to UUT and presents as DFP
- KG Host Unit contains:
 - KG Host Router
 - KG GPU
 - USB4 CV
- KG GPU(s) (or DP Source) are VESA compliant and LTTPR Aware (provides the 3.2 ms AUX Timeout) and shall meet the capability requirements outlined in Table 16



AN HUB UFP1—DPOUT 07

This section describes the test setup for a Device Router running DP OUT Adapter specific testing. This setup is for a DP OUT that connects to an exposed connector.

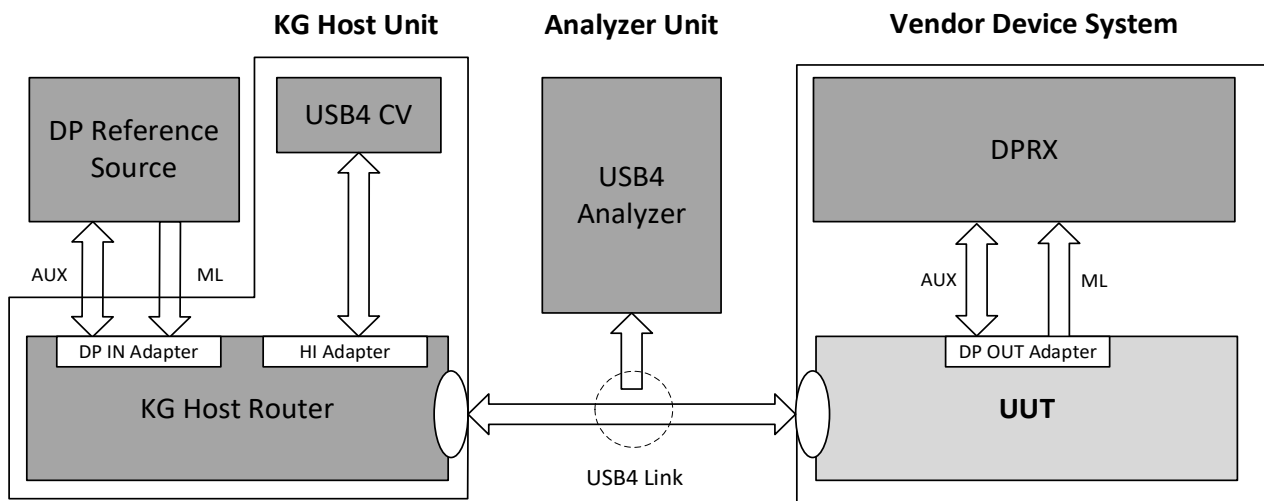
- Vendor provides Device System for UUT with an exposed connector
- KG DP LSPCON Dongle and KG monitor
- KG Host Unit connects to UUT and presents as DFP
- KG Host Unit contains:
 - KG Host Router
 - KG GPU
 - USB4 CV
- KG GPU(s) (or DP Source) are VESA compliant and LTTPR Aware (provides the 3.2 ms AUX Timeout) and shall meet the capability requirements outlined in Table 16



AN HUB UFP1—DPOUT 08

This section describes the test setup for a Device Router running DP OUT Adapter general testing. This setup is for a DP OUT Adapter that is integrated with a DPRX.

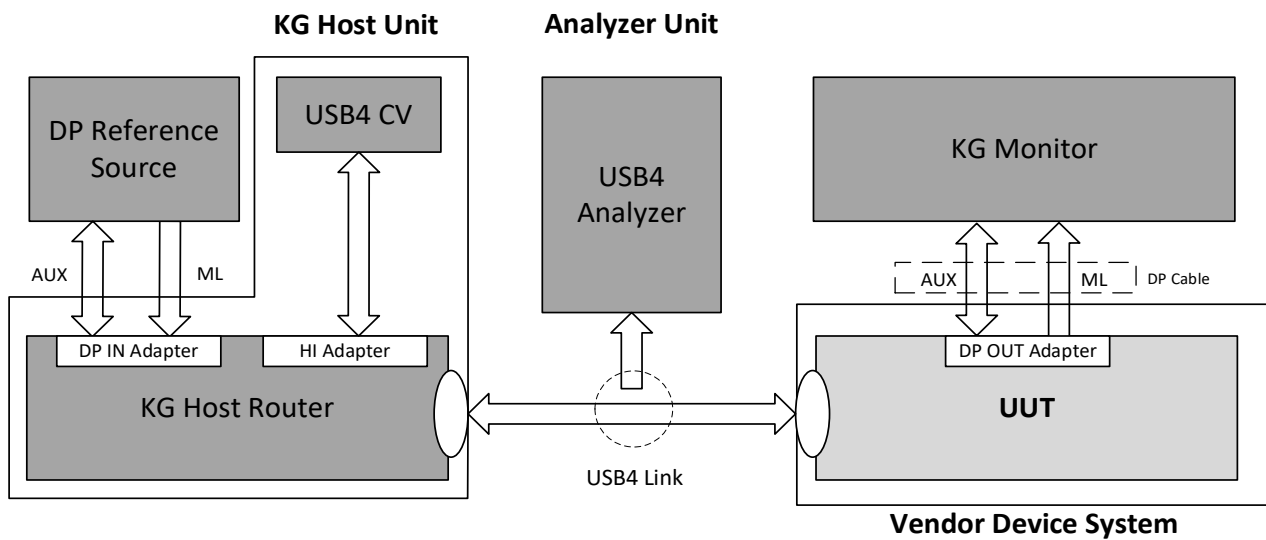
- Vendor provides Device System for UUT with an integrated DPRX
- DP Reference Source CTS tools
- KG Host Unit connects to UUT and presents as DFP
- KG Host Unit contains:
 - KG Host Router
 - USB4 CV



AN HUB UFP1—DPOUT 09

This section describes the test setup for a Device Router running DP OUT Adapter general testing. This setup is for a DP OUT that connects to an exposed connector.

- Vendor provides Device System for UUT with an exposed connector
- KG Monitor
- DP Reference Source CTS tools
- KG Host Unit connects to UUT and presents as DFP
- KG Host Unit contains:
 - KG Host Router
 - USB4 CV



USB4 Naming Conventions Changes:

- DisplayPort DP Reference Sink – USB4 DP Sink.
- Source DUT functionality is split between DP IN Adapter in UUT and DP OUT Adapter in KG Device Router.
- In DP CTS tests including a Source DUT writes to Exerciser DP Sink DPCD, The writes are performed by the DP OUT Adapter in KG Device Router.

DP Question List

DP IN Adapter Capability Question List

| Question | Answer |
|--|---|
| What is the maximum supported lane count? | 1 lane 2 lanes 4 lanes |
| What is the maximum supported link rate (and associated bit rate)? | 1.62Gbps/lane (RBR) 2.7Gbps/lane (HBR) 5.4Gbps/lane (HBR2) 8.1Gbps/lane (HBR3) |
| What is the Maximal DPCD Rev? | DPCD r1.1 DPCD r1.2 DPCD r1.3 DPCD r1.4a |
| Does Router support MST? | Not supported Supported |
| Does Router Support FEC? | Not supported Supported |
| Does Router support SST SDP Split | Not supported Supported |
| Does Router support LTTTPR? | Not supported Supported |
| Does Router support DSC? | Not supported Supported |
| Does Router support HDCP | Not supported Supported |

DP OUT Adapter Capability Question List

| Question | Answer |
|--|---|
| What is the maximum supported lane count? | 1 lane 2 lanes 4 lanes |
| What is the maximum supported link rate (and associated bit rate)? | 1.62Gbps/lane (RBR) 2.7Gbps/lane (HBR) 5.4Gbps/lane (HBR2) 8.1Gbps/lane (HBR3) |
| What is the Maximal DPCD Rev? | DPCD r1.1 DPCD r1.2 DPCD r1.3 DPCD r1.4a |
| Does Router support MST? | Not supported Supported |
| Does Router Support FEC? | Not supported Supported |
| Does Router support SST SDP Split | Not supported Supported |
| Does Router support LTTPR? | Not supported Supported |
| Does Router support DSC? | Not supported Supported |
| Does Router support HDCP | Not supported Supported |
| Does the DP OUT Adapter connect to a USB Type-C connector | Not supported Supported |

Test Descriptions

DP IN Adapter Tests

TD 10.001 DP IN Adapter Configuration Capability TD_DP IN_1

A. Purpose:

- Verify that a DP IN Adapter contains the correct values in the Adapter Configuration Space Basic Attributes and DP Configuration Capability

B. Asserts:

- 10.2.1#1
- 10.2.2#1
- 10.3.2.2#1
- 10.4.2.1#5
- 10.4.2.2#1
- 10.4.3.5#1
- 10.4.3.5#2
- 10.4.3.5#3

C. Setup:

- AN_HOST_DFP1—DPIN_01 or AN_HOST_DFP1—DPIN_02
- AN_DEV_UFP1—DPIN_03
- AN_HUB_UFP1—DPIN_05

D. Procedure:

USB4 CV performs the following steps:

Part 1 – Verify Default Values

1. Connect the setup without the DP Reference Sink
2. Read the Adapter Configuration Space of DP IN Adapter on the UUT
3. Basic Attributes shell have the values as in Table 1
4. DP Configuration Capability shell have the values as in Table 2
5. Connect the DP Reference Sink to the KG Device Router
6. Configure DP path after getting a HOT Plug Event Packet from the DP OUT Adapter, according to Universal Serial Bus 4 (USB4™) Connection Manager Guide section 5.4.
7. It is a test failure if the DPRX capabilities Read Done bit is not 1b within 5 sec
8. Read the Adapter Configuration Space of the DP IN on the UUT
9. Verify that the Basic Attributes have the values in Table 1
10. Verify that the DP Configuration Capability has the values in Table 2

Part 2 –Verify Configuration Bits

11. Wait for the DP link to be stable
12. Set the SWLI bit to 1b in the DP IN Adapter in the UUT
13. Verify that the DP IN Adapter initiates Link training
14. Wait for the DP link to be stable
15. Write to HPDC in the DP IN Adapter in the UUT
16. Verify that the HPD toggles between DP IN Adapter and DPTX.
17. Write to HPDS in the DP IN Adapter in the UUT
18. Verify that HPD is set between DP IN Adapter and DPTX

Part 3 – Verify Default Values After Path Teardown

19. Disconnect the DP Reference Sink from the KG Device Router
20. After receiving a Hot Unplug Event Packet from the DP OUT Adapter, tear down the DP Path as described in Section 5.4 of the Universal Serial Bus 4 (USB4™) Connection Manager Guide
21. Read the Adapter Configuration Space of the DP IN Adapter in the UUT
22. Verify that the Basic Attributes have the default values described in Table 1
23. Verify that the DP Configuration Capability has the values described in Table 2

Table 1 – Adapter Configuration Space Basic Attributes

| DW | Register Name | Bit(s) | Field Name and Description | Type | Default Value | | Paired |
|----|---------------|--------|---|-------|----------------|------------|--------|
| 0 | ADP_CS_0 | 31:0 | Vendor Defined | VD | Vendor Defined | | VD |
| 1 | ADP_CS_1 | 7:0 | Next Capability Pointer | RO | Vendor Defined | | VD |
| | | 18:8 | Max Counter Sets | RO | Vendor Defined | | VD |
| | | 19 | Counters Configuration Space (CCS) Flag | RO | Vendor Defined | | VD |
| | | 31:20 | Reserved | Rsvd | 0 | | 0 |
| 2 | ADP_CS_2 | 7:0 | Adapter Type Sub-type | RO | IN 01h | OUT 02h | 01/02 |
| | | 15:8 | Adapter Type Version | RO | 01h | | 01 |
| | | 23:16 | Adapter Type Protocol | RO | 0Eh | | 0E |
| | | 31:24 | Reserved | Rsvd | 01h | | 01h |
| 3 | ADP_CS_3 | 19:0 | Reserved | Rsvd | 0 | | 0 |
| | | 25:20 | Adapter Number | RO | Vendor Defined | | VD |
| | | 28:26 | Reserved | Rsvd | 0 | | 0 |
| | | 29 | HEC Error (HE) | R/Clr | 0 | | 0 |
| | | 30 | Flow Control Error (FCE) | R/Clr | 0 | | 0 |
| | | 31 | Shared Buffering Capable (SBC) | RO | Vendor Defined | | VD |
| 4 | ADP_CS_4 | 9:0 | Non-Flow Controlled Buffers | R/W | Vendor Defined | | VD |
| | | 19:10 | Reserved | Rsvd | 0 | | 0 |

| | | | | | | |
|---|----------|-------|----------------------------------|-------|----------------|----|
| | | 29:20 | Total Buffers | RO | Vendor Defined | VD |
| | | 30 | Plugged | RO | 0 | 0 |
| | | 31 | Lock (LCK) | R/W | 0 | 0 |
| 5 | ADP_CS_5 | 10:0 | Max Input HopID | RO | Vendor Defined | VD |
| | | 21:11 | Max Output HopID | R/W | Vendor Defined | VD |
| | | 28:22 | Link Credits Allocated | R/W | 0 | |
| | | 29 | HEC Error Enable (HEE) | R/W | 0 | |
| | | 30 | Flow Control Error Enable (FCEE) | R/W | 0 | |
| | | 31 | Disable Hot Plug Events (DHP) | R/W | 0 | |
| 6 | ADP_CS_6 | 31:0 | HEC Errors | W/Clr | 0 | |
| 7 | ADP_CS_7 | 31:0 | Invalid HopID Errors | W/Clr | 0 | 0 |
| 8 | ADP_CS_8 | 31:0 | ECC Errors | W/Clr | 0 | 0 |

Table 2 – DP IN Adapter Configuration Capability Fields

| DW | Register Name | Bit(s) | Field Name and Description | Type | Default Value | After Paired |
|----|---------------|--------|----------------------------|------|----------------|--------------|
| 0 | ADP_DP_CS_0 | 7:0 | Next Capability pointer | RO | Vendor Defined | VD |
| | | 15:8 | Capability ID | RO | 04h | 04h |
| | | 26:16 | Video HopID | RO | 9 | 9h |
| | | 29:27 | Reserved | Rsvd | 0 | 0 |
| | | 30 | AUX enable (AE) | R/W | 0 | 1 |
| | | 31 | Video Enable (VE) | R/W | 0 | 1 |
| 1 | ADP_DP_CS_1 | 10:0 | AUX Tx HopID | RO | 8 | 8 |
| | | 21:11 | AUX Rx HopID | RO | 8 | 8 |
| | | 31:22 | Reserved | Rsvd | 0 | 0 |

| | | | | | | |
|---|--------------|-------|---|------------|----------------|----|
| 2 | ADP_DP_CS_2 | 2:0 | Reserved No_red Maximal Lane Count Similar to remote without BW reeducation by CM | Rsvd RW | 0 | 0 |
| | | 3 | SW Link Init (SWLI) | R/W | 0 | 0 |
| | | 5:4 | Reserved | RsvdZ | 0 | 0 |
| | | 6 | HPD Status | RO | 0 | 1 |
| | | 31:7 | Reserved | RW | 0 | 0 |
| | | 9:7 | No red Maximal Link Rate Similar to remote without BW reeducation by CM | | | 0 |
| | | 10 | Ack bits | R/W | 0 | 0 |
| | | 12:11 | Granularity | R/W | 0 | 0 |
| | | 15:13 | Group_ID | R/W | 0 | 0 |
| | | 19:16 | CM_ID | R/W | 0 | 0 |
| | | 20 | CM Mode support | R/W | 0 | 0 |
| | | 23:21 | Reserved | Rsvd | 0 | 0 |
| | | 31:24 | Estimate BW | R/W | 0 | 0 |
| 3 | ADP_DP_CS_3 | 8:0 | Vendor Defined | VD | Vendor Defined | VD |
| | | 9 | HPD Output Clear (HPDC) | R/W | 0 | 0 |
| | | 10 | HPD Output Set (HPDS) | R/W | 0 | 0 |
| | | 31:11 | Vendor Defined | VD | Vendor Defined | VD |
| 4 | DP_LOCAL_CAP | 3:0 | Protocol Adapter Version | RO | 4 | 4 |
| | | 7:4 | Maximal DPCD Rev | RO | 3 | 3 |
| | | 11:8 | Maximal Link Rate | RO | Vendor Defined | VD |
| | | 14:12 | Maximal Lane Count | RO | Vendor Defined | VD |
| | | 15 | MST Capability | RO | Vendor Defined | VD |
| | | 21:16 | Reserved | Rsvd | 0 | 0 |

| | | | | | | |
|---|---------------|-------|----------------------------|-------|----------------|------------|
| | | 22 | TPS3 Capability | RO | Vendor Defined | VD |
| | | 23 | Reserved | Rsvd | 1 | 1 |
| | | 24 | TPS4 Capability | RO | Vendor Defined | VD |
| | | 25 | FEC Not Supported | RO | Vendor Defined | VD |
| | | 26 | Secondary Split Capability | RO | Vendor Defined | VD |
| | | 27 | LTTTPR Not Supported | RO | Vendor Defined | VD |
| | | 28 | Reserved | Rsvd | 0 | 0 |
| | | 29 | DSC Not Supported | RO | Vendor Defined | VD |
| | | 31:30 | Reserved | Rsvd | 0 | 0 |
| 5 | DP_REMOTE_CAP | 3:0 | Protocol Adapter Version | R/W | 0 | 4 |
| | | 7:4 | Maximal DPCD Rev | R/W | 0 | 3 |
| | | 11:8 | Maximal Link Rate | R/W | 0 | 3 |
| | | 14:12 | Maximal Lane Count | R/W | 0 | 2 |
| | | 15 | MST Capability | R/W | 0 | 1 |
| | | 21:16 | Reserved | RsvdZ | 0 | 0 |
| | | 22 | TPS3 Capability | R/W | 0 | 1 |
| | | 23 | Reserved | VD | VD | VD |
| | | 24 | TPS4 Capability | R/W | 0 | 1 |
| | | 25 | FEC Not Supported | R/W | 0 | 0 |
| | | 26 | Secondary Split Capability | R/W | 0 | 1 |
| | | 27 | LTTTPR Not Supported | R/W | 0 | 0 |
| | | 28 | Reserved | RsvdZ | 0 | 0 |
| | | 29 | DSC Not Supported | RO | 0 | 0 |
| | | 31:30 | Reserved | RsvdZ | 0 | 0 |
| 6 | DP_STATUS | 2:0 | Lane Count | RO | 0 | NA (debug) |

| | | | | | | |
|---|---------------|-------|-----------------------------|------|----|----------------------------------|
| | | 7:3 | Reserved | Rsvd | 0 | 0 |
| | | 11:8 | Link Rate | RO | 0 | NA (debug) |
| | | 23:12 | Reserved | Rsvd | 0 | 0 |
| | | 31:24 | Allocate BW | R/W | 0 | 0 |
| 7 | DP_COMMON_CAP | 3:0 | Protocol Adapter Version | RO | 0 | 4 |
| | | 7:4 | Maximal DPCD Rev | RO | 0 | 3 |
| | | 11:8 | Maximal Link Rate | RO | 0 | = DP_Local_cap11:8 |
| | | 14:12 | Maximal Lane Count | RO | 0 | = DP_Local_cap14:12 |
| | | 15 | MST Capability | RO | 0 | = DP_Local_cap15 |
| | | 21:16 | Reserved | Rsvd | 0 | 0 |
| | | 22 | TPS3 Capability | RO | 0 | = DP_Local_cap22 |
| | | 23 | Reserved | VD | VD | VD |
| | | 24 | TPS4 Capability | RO | 0 | = DP_Local_cap24 |
| | | 25 | FEC Not Supported | RO | 0 | = DP_Local_cap25 |
| | | 26 | Secondary Split Capability | RO | 0 | = DP_Local_cap26 |
| | | 27 | LTTPR Not Supported | RO | 0 | = DP_Local_cap27 |
| | | 28 | Reserved | Rsvd | 0 | 0 |
| | | 29 | DSC Not Supported | RO | 0 | = DP_Local_cap29 |
| | | 30 | Reserved | Rsvd | 0 | 0 |
| | | 31 | DPRX Capabilities Read Done | RO | 0 | 1 within 5 Sec after Tunnel pair |

| | | | | | | |
|---|-------------|------|---|------|---|---|
| 8 | ADP_DP_CS_8 | 31:0 | Reserved | Rsvd | 0 | 0 |
| | | 7:0 | Request/consume BW (uC address 0x24) | RO | 0 | 0 |
| | | 29:8 | Reserved | Rsvd | 0 | 0 |
| | | 30 | Mode Set Indicate GPU mode support (uC address 0x27 bit 6) | RO | 0 | 0 |
| | | 31 | Request bit (uC address 0x27 bit 7) | RO | 0 | 0 |

Note: This test does not use USB4 CV. It can be run with any software-based Connection Manager.

A. Purpose:

- Verify that the DP IN Adapter passes the compliance tests defined in the DP Link CTS

B. Asserts:

- 10#1
- 10#2
- 10.1.3#1

C. Setup:

- AN_HOST_DFP1—DPIN_01
- AN_DEV_UFP1—DPIN_03
- AN_HUB_UFP1—DPIN_05

D. Procedure:

- For AN_HOST_DFP1—DPIN_01 setup
 - The DP Link Layers tests to be executed are the ones marked as ‘Yes’ in the “DP Tunneling Subset” column for Source Testing in Table 5 to Table 9.
- For AN_DEV_UFP1—DPIN_03 setup
 - The DP Link Layers tests for Source Testing that are defined in Table 5 to Table 9 are executed. If the only method to utilize the DPTX is through DP Tunneling, then the executed tests are the ones marked as ‘Yes’ in the “DP Tunneling Only” column, otherwise the executed tests are the ones marked as ‘Yes’ in the “DP Tunneling Subset” column.

USB4 CV performs the following steps:

Part 1 –Source Device Services Test Procedures

1. Connect test setup
2. Run the tests in Table 5
3. Follow plug/unplug for pair/teardown the tunnel
4. Verify that the UUT passes all of the tests in Table 5

Part 2 –Source Device Link Services Test Procedures

5. Connect test setup
6. Run the tests in Table 6
7. Follow plug/unplug for pair/teardown the tunnel
8. Verify that the UUT passes all of the tests in Table 6

Part 3 – USB4 DP CTS Source Isochronous Transport Services Test Procedures

9. Connect test setup
10. Run the tests in Table 7
11. Follow plug/unplug for pair/teardown the tunnel
12. Verify that the UUT passes all of the tests in Table 7

Part 4 – USB4 DP CTS Source Devices FEC Test Procedures

13. Connect test setup

14. Run the tests in Table 8
15. Follow plug/unplug for pair/teardown the tunnel
16. Verify that the UUT passes all of the tests in Table 8

Part 5 – USB4 DP CTS Source Devices DSC Test Procedures

17. Connect test setup
18. Run the tests in Table 9
19. Follow plug/unplug for pair/teardown the tunnel
20. Verify that the UUT passes all of the tests in Table 9
 - a. Run 4.6.1.3 with format 2k@120Hz, Reduced Blanking 2 (rb2)
 - b. Run 4.6.1.3 with format 5k@30Hz, Reduced Blanking 1 (rb1)
 - c. Run 4.6.1.7 with format 2k@30Hz, CTA

A. Purpose:

- Verify that the DP IN Adapter works in both LTTTPR and Non-LTTTPR modes

B. Asserts:

- TBD

C. Setup:

- AN_HOST_DFP1—DPIN_01
- AN_DEV_UFP1—DPIN_03
- AN_HUB_UFP1—DPIN_05

D. Procedure:

USB4 CV performs the following steps:

Part 1 – LTTTPR Transparent/Non-Transparent Mode with Max Supported Lanes and Speed

1. Connect test setup
2. Configure the DP Reference Source to run LT with LTTTPR functionality
3. Parse the AUX log at the DP Reference Sink in the Device Router and verify use of DPCD LTTTPR as follows:
 - a. Read of DPCD LTTTPR Capability and ID (F0000h – F000Fh)
 - b. If DPTX write F0003h PHY_REPEATER_MODE = AAh Non-transparent mode continue as non-transparent below:
 - i. Write of DPCD LTTTPR TRAINING_PATTERN_SET_PHY_REPEATER1 F0010h
 - ii. Read of DPCD LTTTPR TRAINING_AUX_RD_INTERVAL_PHY_REPEATER1 F0020h
 - iii. Read of LTTTPR LT status:
 - a. LANE0_1_STATUS_PHY_REPEATER1 F0030h
 - b. LANE2_3_STATUS_PHY_REPEATER1 F0031h
 - c. LANE_ALIGN_STATUS_UPDATED_PHY_REPEATER1 F0032h
 - c. Else if DPTX, keep F0003h PHY_REPEATER_MODE = 55h transparent mode continue as transparent below:
 - i. Parse the AUX Log at the DP Reference Sink in the Device Router and verify LTTTPR transparent functionality as follows:
 - a. LT done by DPCD register 102h-107h, 202h-207h
 - b. From writing DPCD 102h=0x01 till 102h=0x00 no access to any other DPCD register beside LT DPCD registers
4. Verify that the picture on the screen is stable

Part 2 – LTTTPR Non-Transparent Mode with 2 Lanes and HBR Speed

5. Limit DP IN Adapter as follows:
 - a. Read DP_LOCAL_CAP from DP OUT Adapter and record the values
 - b. Set bits 14:12 to 001b (2 lanes) in the DP_LOCAL_CAP values read from the DP OUT Adapter
 - c. Set bits 11:8 to 0001b (HBR) in the DP_LOCAL_CAP values read from the DP OUT Adapter
6. Copy the DP_LOCAL_CAP values (with bits 14:8 change) to the DP_REMOTE_CAP register in the DP IN Adapter

7. Connect the test setup
8. Configure DP Reference Source to run LT with LTTTPR functionality
9. Parse the AUX Log at the DP Reference Sink in the Device Router use DPCD LTTTPR as follows:
 - a. Read of DPCD LTTTPR Capability and ID
 - b. If DPTX write F00003h PHY_REPEATER_MODE = AAh Non-transparent mode continue as non-transparent below:
 - i. Write of DPCD LTTTPR TRAINING_PATTERN_SET_PHY_REPEATER1 F0010h.
 - ii. Read of DPCD LTTTPR TRAINING_AUX_RD_INTERVAL_PHY_REPEATER1 F0020h.
 - iii. Read of LTTTPR LT status:
 - a. LANE0_1_STATUS_PHY_REPEATER1 F0030h
 - b. LANE2_3_STATUS_PHY_REPEATER1 F0031h
 - c. LANE_ALIGN_STATUS_UPDATED_PHY_REPEATER1 F0032h
 - c. Else if DPTX keep F00003h PHY_REPEATER_MODE = 55h transparent mode continue as transparent below:
 - i. Parse the AUX Log at the DP Reference Sink in the Device Router and verify LTTTPR transparent functionality as follows:
 - a. No access to any DPCD LTTTPR register besides LTTTPR capability
 - b. LT done by DPCD register 102h-107h, 202h-207h
 - c. From writing DPCD 102h=0x01 till 102h=0x00 no access to any other DPCD register beside LT DPCD registers
10. Verify that the picture on the screen is stable with HBR and 2 lanes maximum

A. Purpose:

- Verify DP IN Adapter DP MST functionality (if supported)

B. Asserts:

- TBD

C. Setup:

- AN_HOST_DFP1—DPIN_01
- AN_DEV_UFP1—DPIN_03
- AN_HUB_UFP1—DPIN_05

D. Repetitions:

At each iteration repeat 'Part 1' - Configure the DP Reference Sink as MST with the following parameters:

- a. Link: HBR2 x 4 Lanes ; Monitors: Two FHD (1080p)
- b. Link: HBR3 x 4 Lanes ; Monitors: Two 4K 8 pbc
- c. Link: HBR2 x 2 Lanes ; Monitors: One FHD (1080p)
- d. Link: RBR x 4 Lanes ; Monitors: One FHD (1080p)
- e. Link: HBR3 x 1 Lane ; Monitors: One FHD (1080p)

E. Procedure:

USB4 CV performs the following steps:

Part 1 – MST Check

11. Configure the DP Reference Sink as MST with the maximal Lane Count and Link Rate according to the iteration parameters.
12. Configure the DP Reference Sink to support the Monitors according to the iteration.
13. Verify that the streams were activated and are stable over the DP Reference Sink
14. For the cases of two monitors, Configure the Reference Sink to disconnect one of the monitors and verify that the other stream is stable over the DP Reference Sink.

Part 2 – Disable MST

15. Keep Reference Sink configured to the last iteration parameters and monitors
16. Tear down the DP Paths
17. While setting up the DP Path, disable MST function as follows:
 - a. Read DP_LOCAL_CAP from DP OUT Adapter and record the values
 - b. Set bits 15 to 0b (disable MST) in the DP_LOCAL_CAP values read from the DP OUT Adapter
 - c. Copy the DP_LOCAL_CAP values (with bits 15 set to 0b) to the DP_REMOTE_CAP register in the DP IN Adapter
18. Verify that the DP IN Adapter and DP OUT Adapter pair without MST functionality

A. Purpose:

- Verify that the DP IN Adapter correctly follows sink_count

B. Asserts:

- 10.4.6.3#1
- 10.4.6.3#2

C. Setup:

- AN_HOST_DFP1—DPIN_02
- AN_DEV_UFP1—DPIN_04
- AN_HUB_UFP1—DPIN_06

D. Procedure:

USB4 CV performs the following steps:

Part 1 – Teardown Tunnel upon Sink Count Equal 0

1. Connect test setup without the monitor
2. Verify that DP IN Adapter and DP OUT Adapter are paired and Path is set up
3. Wait for the DP Reference Source to read DPCD 00200h with value 0
4. Verify that the path is torn down after reading the 0 value from DPCD 00200h

Part 2 – Pair upon Monitor Connect to DP Dongle

5. Connect the monitor to DP dongle
6. Wait for the HPD IRQ from the monitor connection
7. Verify that the picture on the monitor is stable

Part 3 – Teardown Tunnel when Sink Count Goes to 0

8. Disconnect the monitor from the DP dongle
9. Wait for DP Reference Source get HPD_IRQ and read DPCD 00200h with value 0
10. Verify that path is torn down immediately after reading the 0 value from DPCD 00200h

A. Purpose:

- Verify that the DP IN Adapter reduces the number of lanes to 2 with MFDP

B. Asserts:

- TBD

C. Setup:

- AN_HOST_DFP1—DPIN_02
- AN_DEV_UFP1—DPIN_04
- AN_HUB_UFP1—DPIN_06

Note: DP LSPCON is a Multi-Function DP Dongle

D. Procedure:

USB4 CV performs the following steps:

Part 1 – Reduce Lanes to 2 with MFDP

1. Connect test setup
2. Verify that the DP IN Adapter and DP OUT Adapter are paired and Path is set up between them
3. Verify that the DP IN Adapter sends SET_CONFIG Packet of type SET_MFDP with *MFDP Enable* bit set to 0b.
4. Verify that the number of lanes is 2 by reading DP_STATUS.Lane Count (bits 2:0) in both DP Adapters. Value is set to 2h.
5. Verify that the picture on the monitor is stable

A. Purpose:

- Verify that the DP IN Adapter reply to tunnel specific DPCD registers

B. Asserts:

- TBD

C. Setup:

- AN_HOST_DFP1—DPIN_01
- AN_DEV_UFP1—DPIN_03
- AN_HUB_UFP1—DPIN_05

D. Procedure:

USB4 CV performs the following steps:

1. Connect test setup
2. Verify that the picture on the monitor is stable
3. DP Reference Source reads DPCD 0xE0000 to 0xE000F and verifies the followings values:
 - a. 0xE0002 – 0xE0000 IEEE_OUI = non zero
 - b. 0xE0008 – 0xE0003 Device Identification String – non zero
 - c. 0xE0009 – Hardware Revision – non zero
 - d. 0xE000A – Firmware Major Revision – non Zero
 - e. 0xE000B - Firmware Minor Revision – Don't care
 - f. 0xE000D – DP Tunneling and Panel Replay – Bit 0 must be set, all other shall be clear for this version.
 - g. 0xE000E – 0xE000F – reserved read with value 0

A. Purpose:

- Verify that the DP IN Adapter passes DP HDCP CTS tests (if supported)

B. Asserts:

- TBD

C. Setup:

- AN_HOST_DFP1—DPIN_01
- AN_DEV_UFP1—DPIN_03
- AN_HUB_UFP1—DPIN_05

D. Procedure:

USB4 CV performs the following steps:

Part 1 – USB4 DP CTS HDCP Downstream Procedure with Receiver

1. Connect the setup
2. Run the tests 1A-XX Source Device HDCP Downstream procedure with Receiver define in HDCP CTS for DP reference above
3. Follow plug/unplug for pair/teardown the tunnel
4. Verify that the UUT passes all tests

Part 2 – USB4 DP CTS HDCP Downstream Procedure with Repeater

5. Connect the setup
6. Run the tests 1B-XX Source Device HDCP Downstream Procedure with Repeater define in HDCP CTS for DP reference above
7. Follow plug/unplug for pair/teardown the tunnel
8. Verify that the UUT passes all of the tests

DP OUT Adapter tests

TD 10.009 DP OUT Adapter Configuration Capability TD_DP OUT_1

A. Purpose:

- Verify that a DP OUT Adapter contains the correct values in the Adapter Configuration Space Basic and DP Configuration Capability

B. Asserts:

- 10.2.1#1
- 10.2.2#1
- 10.3.2.2#1
- 10.4.2.1#5
- 10.4.2.2#1
- 10.4.6.3#4
- 10.4.6.3#5
- 10.4.6.3#6

C. Setup:

- AN_HOST_DFP1—DPOUT_01
- AN_DEV_UFP1—DPOUT_02
- AN_DEV_UFP1—DPOUT_04
- AN_HUB_UFP1—DPOUT_06
- AN_HUB_UFP1—DPOUT_08

D. Procedure:

USB4 CV performs the following steps:

Part 1 – Verify Default Values

1. Connect the test setup. For AN_DEV_UFP1—DPOUT_02 do not connect the DP Reference Sink
2. Read the Adapter Configuration Space of the DP OUT Adapter on the UUT
3. Verify that the Basic Attributes have the values in Table 3
4. Verify that the DP Configuration Capability has the values in Table 4
5. For AN_DEV_UFP1—DPOUT_02, connect the DP Reference Sink to the DP OUT Adapter in the UUT
6. Configure DP path, after UUT sends a Hot Plug Event Packet for the DP OUT Adapter after detecting the connection, according to Universal Serial Bus 4 (USB4™) Connection Manager Guide section 5.4.
7. It is a test failure if the DPRX capabilities Read Done bit is not 1b within 5 sec.
8. Read the Adapter Configuration Space of the DP OUT Adapter on the UUT
9. Verify that the Basic Attributes has the values in Table 3
10. Verify that the DP Configuration Capability has the values in Table 4

Part 2 – USB4 Verify Specific Configuration Bits

11. Wait for the DP link to be stable
12. Set the SWLI bit to 1b in the DP OUT Adapter in the UUT
13. Verify that Link training was Re-initiated.
14. Wait for the DP link to be stable

Part 3 – Verify Default Values After Path Teardown

15. For AN_DEV_UFP1—DPOUT_02:
 - a. Disconnect the DP Reference Sink from the KG Device Router

- b. After receiving a Hot Unplug Event Packet from the DP OUT Adapter continue to step 16
16. Tear down the DP Path as described in Section 5.4 of the Universal Serial Bus 4 (USB4™) Connection Manager Guide
 17. Read the Adapter Configuration Space of the DP OUT Adapter in the UUT
 18. Verify the that the Basic Attributes have the values described in Table 3
 19. Verify that the DP Configuration Capability has the values described in Table 4

Table 3 – Adapter Configuration Space Basic Attributes

| DW | Register Name | Bit(s) | Field Name and Description | Type | Default Value | | Paired |
|----|---------------|--------|---|-------|----------------|------------|--------|
| 0 | ADP_CS_0 | 31:0 | Vendor Defined | VD | Vendor Defined | | VD |
| 1 | ADP_CS_1 | 7:0 | Next Capability Pointer | RO | Vendor Defined | | VD |
| | | 18:8 | Max Counter Sets | RO | Vendor Defined | | VD |
| | | 19 | Counters Configuration Space (CCS) Flag | RO | Vendor Defined | | VD |
| | | 31:20 | Reserved | Rsvd | 0 | | 0 |
| 2 | ADP_CS_2 | 7:0 | Adapter Type Sub-type | RO | IN 01h | OUT 02h | 01/02 |
| | | 15:8 | Adapter Type Version | RO | 01h | | 01 |
| | | 23:16 | Adapter Type Protocol | RO | 0Eh | | 0E |
| | | 31:24 | Reserved | Rsvd | 01h | | 01h |
| 3 | ADP_CS_3 | 19:0 | Reserved | Rsvd | 0 | | 0 |
| | | 25:20 | Adapter Number | RO | Vendor Defined | | VD |
| | | 28:26 | Reserved | Rsvd | 0 | | 0 |
| | | 29 | HEC Error (HE) | R/Clr | 0 | | 0 |
| | | 30 | Flow Control Error (FCE) | R/Clr | 0 | | 0 |
| | | 31 | Shared Buffering Capable (SBC) | RO | Vendor Defined | | VD |
| 4 | ADP_CS_4 | 9:0 | Non-Flow Controlled Buffers | R/W | Vendor Defined | | VD |
| | | 19:10 | Reserved | Rsvd | 0 | | 0 |

| | | | | | | |
|---|----------|-------|----------------------------------|-------|----------------|----|
| | | 29:20 | Total Buffers | RO | Vendor Defined | VD |
| | | 30 | Plugged | RO | 0 | 1 |
| | | 31 | Lock (LCK) | R/W | 0 | 0 |
| 5 | ADP_CS_5 | 10:0 | Max Input HopID | RO | Vendor Defined | VD |
| | | 21:11 | Max Output HopID | R/W | Vendor Defined | VD |
| | | 28:22 | Link Credits Allocated | R/W | 0 | |
| | | 29 | HEC Error Enable (HEE) | R/W | 0 | |
| | | 30 | Flow Control Error Enable (FCEE) | R/W | 0 | |
| | | 31 | Disable Hot Plug Events (DHP) | R/W | 0 | |
| 6 | ADP_CS_6 | 31:0 | HEC Errors | W/Clr | 0 | |
| 7 | ADP_CS_7 | 31:0 | Invalid HopID Errors | W/Clr | 0 | 0 |
| 8 | ADP_CS_8 | 31:0 | ECC Errors | W/Clr | 0 | 0 |

Table 4 – DP OUT Adapter Configuration Capability Fields

| DW | Register Name | Bit(s) | Field Name and Description | Type | Default Value | After paired |
|----|---------------|--------|----------------------------|------|----------------|--------------|
| 0 | ADP_DP_CS_0 | 7:0 | Next Capability pointer | RO | Vendor Defined | VD |
| | | 15:8 | Capability ID | RO | 04h | 04h |
| | | 26:16 | Video HopID | RO | 9 | 09h |
| | | 29:27 | Reserved | Rsvd | 0 | 0 |
| | | 30 | AUX enable (AE) | R/W | 0 | 1 |
| | | 31 | Video Enable (VE) | R/W | 0 | 1 |
| 1 | ADP_DP_CS_1 | 10:0 | AUX Tx HopID | RO | 8 | 8 |
| | | 21:11 | AUX Rx HopID | RO | 8 | 8 |
| | | 31:22 | Reserved | Rsvd | 0 | 0 |

| | | | | | | |
|---|---------------|-------|-----------------------------|-------|----------------|----|
| 2 | ADP_DP_CS_2 | 2:0 | Reserved | Rsvd | 0 | 0 |
| | | 3 | SW Link Init (SWLI) | R/W | 0 | 0 |
| | | 5:4 | Reserved | RsvdZ | 0 | 0 |
| | | 6 | HPD Status | RO | 0 | 1 |
| | | 7 | Reserved | Rsvd | 0 | 0 |
| | | 23:8 | Maximum Accumulation Cycles | RO | Vendor Defined | VD |
| | | 31:24 | Reserved | Rsvd | 0 | 0 |
| 3 | ADP_DP_CS_3 | 31:0 | Vendor Defined | VD | Vendor Defined | VD |
| 4 | DP_LOCAL_CAP | 3:0 | Protocol Adapter Version | RO | 4 | 4 |
| | | 7:4 | Maximal DPCD Rev | RO | Vendor Defined | VD |
| | | 11:8 | Maximal Link Rate | RO | Vendor Defined | VD |
| | | 14:12 | Maximal Lane Count | RO | Vendor Defined | VD |
| | | 15 | MST Capability | RO | Vendor Defined | VD |
| | | 21:16 | Reserved | Rsvd | 0 | 0 |
| | | 22 | TPS3 Capability | RO | Vendor Defined | VD |
| | | 23 | Reserved | Rsvd | 1 | 1 |
| | | 24 | TPS4 Capability | RO | Vendor Defined | VD |
| | | 25 | FEC Not Supported | RO | Vendor Defined | VD |
| | | 26 | Secondary Split Capability | RO | Vendor Defined | VD |
| | | 27 | LTTTPR Not Supported | RO | Vendor Defined | VD |
| | | 28 | Reserved | Rsvd | 0 | 0 |
| | | 29 | DSC Not Supported | RO | Vendor Defined | VD |
| | | 31:30 | Reserved | Rsvd | 0 | 0 |
| 5 | DP_REMOTE_CAP | 3:0 | Protocol Adapter Version | R/W | 0 | 4 |
| | | 7:4 | Maximal DPCD Rev | R/W | 0 | 3 |

| | | | | | | |
|---|---------------|-------|------------------------------|-------|----|------------|
| | | 11:8 | Maximal Link Rate | R/W | 0 | 3 |
| | | 14:12 | Maximal Lane Count | R/W | 0 | 2 |
| | | 15 | MST Capability | R/W | 0 | 1 |
| | | 21:16 | Reserved | RsvdZ | 0 | 0 |
| | | 22 | TPS3 Capability | R/W | 0 | 1 |
| | | 23 | Reserved | VD | VD | VD |
| | | 24 | TPS4 Capability | R/W | 0 | 1 |
| | | 25 | FEC Not Supported | R/W | 0 | 0 |
| | | 26 | Secondary Split Capability | R/W | 0 | 1 |
| | | 27 | LTTTPR Not Supported | R/W | 0 | 0 |
| | | 28 | Reserved | RsvdZ | 0 | 0 |
| | | 29 | DSC Not Supported | RO | 0 | 0 |
| | | 31:30 | Reserved | RsvdZ | 0 | 0 |
| 6 | DP_STATUS | 2:0 | Lane Count | RO | 0 | NA (Debug) |
| | | 7:3 | Reserved | Rsvd | 0 | 0 |
| | | 11:8 | Link Rate | RO | 0 | NA (Debug) |
| | | 24:12 | Reserved | Rsvd | 0 | 0 |
| | | 25 | CM Handshake (CMHS) | R/W | 0 | 0 |
| | | 26 | DP IN Adapter USB4 Flag (UF) | R/W | 0 | 1 |
| | | 31:27 | Reserved | Rsvd | 0 | 0 |
| 7 | DP_COMMON_CAP | 3:0 | Protocol Adapter Version | RO | 0 | 4 |
| | | 7:4 | Maximal DPCD Rev | RO | 0 | 3 |
| | | 11:8 | Maximal Link Rate | RO | 0 | = DP_Local |
| | | 14:12 | Maximal Lane Count | RO | 0 | = DP_Local |
| | | 15 | MST Capability | RO | 0 | = DP_Local |
| | | 21:16 | Reserved | Rsvd | 0 | 0 |

| | | | | | | |
|---|-------------|-------|----------------------------|------|----|------------|
| | | 22 | TPS3 Capability | RO | 0 | = DP_Local |
| | | 23 | Reserved | VD | VD | VD |
| | | 24 | TPS4 Capability | RO | 0 | = DP_Local |
| | | 25 | FEC Not Supported | RO | 0 | = DP_Local |
| | | 26 | Secondary Split Capability | RO | 0 | = DP_Local |
| | | 27 | LTTPR Not Supported | RO | 0 | = DP_Local |
| | | 28 | Reserved | Rsvd | 0 | 0 |
| | | 29 | DSC Not Supported | RO | 0 | = DP_Local |
| | | 31:30 | Reserved | Rsvd | 0 | 0 |
| 8 | ADP_DP_CS_8 | 31:0 | Reserved | Rsvd | 0 | 0 |

Note: This test does not use USB4 CV. It can be run with any software-based Connection Manager.

A. Purpose:

- Verify that the DP OUT Adapter passes the compliance tests defined in the DP Link CTS

B. Asserts:

- 10#3
- 10#4
- 10.1.3#1

C. Setup:

- AN_HOST_DFP1—DPOUT_01
- AN_DEV_UFP1—DPOUT_02
- AN_DEV_UFP1—DPOUT_04
- AN_DEV_UFP1—DPOUT_05
- AN_HUB_UFP1—DPOUT_06
- AN_HUB_UFP1—DPOUT_08
- AN_HUB_UFP1—DPOUT_09

D. Procedure:

- For a DP OUT Adapter with an exposed connector, both of the below setups shall be executed:
 - AN_DEV_UFP1—DPOUT_02 setup
 - The DP Link Layers tests to be executed are the ones marked as ‘Yes’ in the “DP OUT Adapter UUT” column for Source Testing in Table-5 to Table-9.
 - AN_DEV_UFP1—DPOUT_05 setup
 - The DP Link Layers tests to be executed are the ones marked as ‘Yes’ in the “DP Tunneling only” column for Sink Testing in Table-12.
 - The LTTTPR tests to be executed are the ones marked as ‘Yes’ in the “Tested” column for LTTTPR Testing in Table-15
- For the AN_DEV_UFP1—DPOUT_04 & AN_HOST_DFP1—DPOUT_01 setups
 - The DP Link Layers tests for Sink Testing that are defined in Table-10 to Table-14 are executed. If the only method to utilize the DPRX is through DP Tunneling, then the executed tests are the ones marked as ‘Yes’ in the “DP Tunneling Only” column, otherwise the executed tests are the ones marked as ‘Yes’ in the “DP Tunneling Subset” column.

USB4 CV performs the following steps:

Part 1 –Device Services Test Procedures

1. Connect test setup
2. Run the tests in Table 5/Table 10
3. Follow plug/unplug for pair/teardown the tunnel
4. Verify that the UUT passes all of the tests in Table 5/Table 10

Part 2 –Device Link Services Test Procedures

5. Connect test setup
6. Run the tests in Table 6/Table 11
7. Follow plug/unplug for pair/teardown the tunnel
8. Verify that the UUT passes all of the tests in Table 6/Table 11

Part 3 – USB4 DP CTS Isochronous Transport Services Test Procedures

9. Connect test setup
10. Run the tests in Table 7/Table 12
11. Follow plug/unplug for pair/teardown the tunnel
12. Verify that the UUT passes all of the tests in Table 7/Table 12

Part 4 – USB4 DP CTS Devices FEC Test Procedures

13. Connect test setup
14. Run the tests in Table 8/Table 13
15. Follow plug/unplug for pair/teardown the tunnel
16. Verify that the UUT passes all of the tests in Table 8/Table 13

Part 5 – USB4 DP CTS Devices DSC Test Procedures

17. Connect test setup
18. Run the tests in Table 9/Table 14
19. Follow plug/unplug for pair/teardown the tunnel
20. Verify that the UUT passes all of the tests in Table 9/Table 14

Part 6 – Sink Device Embedded LTTPR Test Procedures

For AN_DEV_UFP1—DPOUT_05 setup only:

1. Connect test setup
2. Run the tests in Table 15
3. Follow plug/unplug for pair/teardown the tunnel
4. Verify that the UUT passes all of the tests in Table 15

TD 10.011 DP OUT Adapter LTTPR test TD_DP OUT_3

A. Purpose:

- Verify that the DP OUT Adapter works in both LTTPR and Non-LTTPR modes

B. Asserts:

- TBD

C. Setup:

- AN_DEV_UFP1—DPOUT_02
- AN_HUB_UFP1—DPOUT_06

D. Procedure:

USB4 CV performs the following steps:

Part 1 – LTTPR Transparent/Non-Transparent Mode with Max Support Lanes and Speed

1. Connect test setup
2. Configure the DP Reference Source to run LT with LTTPR functionality
3. Parse the AUX Log at the DP Reference Sink in the UUT device and verify use of DPCD LTTPR as follows:
 - a. Read of DPCD LTTPR Capability and ID (F0000h – F000Fh)
 - b. If DPTX write F0003h PHY_REPEATER_MODE = AAh Non-transparent mode, continue as non-transparent below:
 - i. Write of DPCD LTTPR TRAINING_PATTERN_SET_PHY_REPEATER1 F0010h
 - ii. Write of DPCD LTTPR TRAINING_LANE_x_SET_PHY_REPEATER1 F0011h-F0014h
 - iii. Read of DPCD LTTPR TRAINING_AUX_RD_INTERVAL_PHY_REPEATER1 F0020h
 - iv. Read of LTTPR LT status:
 - a. LANE0_1_STATUS_PHY_REPEATER1 F0030h
 - b. LANE2_3_STATUS_PHY_REPEATER1 F0031h
 - c. LANE_ALIGN_STATUS_UPDATED_PHY_REPEATER1 F0032h
 - c. Else, if DPTX keep F0003h PHY_REPEATER_MODE = 55h transparent mode, continue as transparent below:
 - i. Parse the AUX Log at the DP Reference Sink in the Device Router and verify LTTPR transparent functionality as follows:
 - a. No access to any DPCD LTTPR register besides LTTPR capability
 - b. LT done by DPCD register 102h-106h, 202h-207h
 - c. From writing DPCD 102h=0x01 till 102h=0x00 no access to any other DPCD register beside LT DPCD registers
4. Verify that the Picture on screen is stable

Part 2 – LTTPR Mode with 2 Lanes and HBR Speed

5. Configure the DP IN Adapter as follows:
 - a. Set bits 14:12 in the DP_LOCAL_CAP register to 001b (2 Lanes)
 - b. Set bits 11:8 in the DP_LOCAL_CAP register to 0001b (HBR)
6. Connect test setup
7. Configure the DP Reference Source to run LT with LTTPR functionality

8. Parse the AUX Log at the DP Reference Sink in the UUT device and verify use of DPCD LTTPR as follows:
 - a. Read of DPCD LTTPR Capability and ID
 - b. If DPTX write F0003h PHY_REPEATER_MODE = AAh Non-transparent mode continue as non-transparent below:
 - i. Write of DPCD LTTPR TRAINING_PATTERN_SET_PHY_REPEATER1 F0010h
 - ii. Read of DPCD LTTPR TRAINING_AUX_RD_INTERVAL_PHY_REPEATER1 F0020h
 - iii. Read of LTTPR LT status:
 - a. LANE0_1_STATUS_PHY_REPEATER1 F0030h
 - b. LANE2_3_STATUS_PHY_REPEATER1 F0031h
 - c. LANE_ALIGN_STATUS_UPDATED_PHY_REPEATER1 F0032h
 - c. Else if DPTX, keep F0003h PHY_REPEATER_MODE = 55h transparent mode continue as transparent below:
 - i. Parse the AUX Log at the DP Reference Sink in the Device Router and verify LTTPR transparent functionality as follows:
 - a. LT done by DPCD register 102h-107h, 202h-207h
 - b. From writing DPCD 102h=0x01 till 102h=0x00 no access to any other DPCD register beside LT DPCD registers
9. Verify that the Picture on screen is stable with HBR and 2 lanes maximum.

A. Purpose:

- Verify DP OUT Adapter DP MST functionality (if supported)

B. Asserts:

- TBD

C. Setup:

- AN_DEV_UFP1—DPOUT_02
- AN_HUB_UFP1—DPOUT_06

D. Repetitions:

At each iteration Configure the DP Reference Sink as MST with the following parameters:

- a. Link: HBR2 x 4 Lanes ; Monitors: Two FHD (1080p)
- b. Link: HBR3 x 4 Lanes ; Monitors: Two 4K 8 pbc
- c. Link: HBR2 x 2 Lanes ; Monitors: One FHD (1080p)
- d. Link: RBR x 4 Lanes ; Monitors: One FHD (1080p)
- e. Link: HBR3 x 1 Lane ; Monitors: One FHD (1080p)

E. Procedure:

USB4 CV performs the following steps:

1. Configure the DP Reference Sink as MST with the maximal Lane Count and Link Rate according to the iteration parameters
2. Configure the DP Reference Sink to support the Monitors according to the iteration.
3. Verify that the streams were activated and are stable over the DP Reference Sink
4. For the cases of two monitors, configure the Reference Sink to disconnect one of the monitors and verify that the other stream is stable over the DP Reference Sink.

A. Purpose:

- Verify that the DP OUT Adapter correctly follows sink_count

B. Asserts:

- 10.4.6.3#3
- 10.4.6.3#4
- 10.4.6.3#5
- 10.4.6.3#6

C. Setup:

- AN_DEV_UFP1—DPOUT_03
- AN_HUB_UFP1—DPOUT_07

D. Procedure:

USB4 CV performs the following steps:

Part 1 – Teardown Tunnel upon Sink Count Equal 0

1. Connect the setup without the monitor
2. Verify that the DP IN Adapter and the DP OUT Adapter are paired and a Path is set up
3. Wait for the GPU to read DPCD 00200h with value 0
4. Verify that the Path is torn down after reading the 0 value from DPCD 00200h

Part 2 – Pair upon Monitor Connect to Dongle

5. Connect monitor to the DP dongle
6. Wait for HPD IRQ from Monitor connection
7. Verify that the picture on the monitor is stable

Part 3 – Teardown Tunnel when Sink Count Goes to 0

8. Disconnect the monitor from the DP dongle
9. Verify that the path torn down after reading the 0 value from DPCD 00200h

A. Purpose:

- Verify that the DP OUT Adapter reduces number of lanes to 2 with MFDP (if exposed connector is a USB Type-C connector)

B. Asserts:

- TBD

C. Setup:

- AN_DEV_UFP1—DPOUT_03
- AN_HUB_UFP1—DPOUT_07

Note: DP LSPCON is a Multi-Function DP Dongle

D. Procedure:

USB4 CV performs the following steps:

Part 1 – USB4 DP Teardown Tunnel upon Sink Count Equal 0

1. Connect the setup
2. Before setting up the DP Paths, read DP_LOCAL_CAP register from DP OUT Adapter and verify that *Maximal Lane Count* field is set to 1h (2 lanes).
3. Verify that the DP IN Adapter and DP OUT Adapter are paired and Path is set between them
4. Verify that the DP OUT Adapter sends SET_CONFIG Packet of type SET_MFDP with *MFDP Enable* bit set to 1b.
5. Verify that the number of lanes is 2 by reading DP_STATUS.Lane Count (bits 2:0) in both DP Adapters. Value is set to 2h.
6. Verify that the picture on the monitor is stable

A. Purpose:

- Verify that the DP OUT Adapter pass DP HDCP CTS tests (if supported)

B. Asserts:

- TBD

C. Setup:

- AN_DEV_UFP1—DPOUT_02
- AN_HUB_UFP1—DPOUT_06

D. Procedure:

USB4 CV performs the following steps:

Part 1 – USB4 DP CTS HDCP Downstream Procedure with Receiver

1. Connect the setup
2. Run the tests 1A-XX Source Device HDCP Downstream procedure with Receiver define in HDCP CTS for DP reference above
3. Follow plug/unplug for pair/teardown the tunnel
4. Verify that the UUT passes all tests

Part 2 – USB4 DP CTS HDCP Downstream Procedure with Repeater

5. Connect the setup
6. Run the tests 1B-XX Source Device HDCP Downstream Procedure with Repeater define in HDCP CTS for DP reference above
7. Follow plug/unplug for pair/teardown the tunnel
8. Verify that the UUT passes all of the tests

Part 3 – USB4 DP CTS HDCP Upstream procedure with Transmitter

9. Connect the setup
10. Run the tests 2C-XX Sink Device HDCP Upstream procedure with Transmitter define in HDCP CTS for DP reference above
11. Follow plug/unplug for pair/teardown the tunnel
12. Verify that the UUT passes all of the tests

TBT3-Compatibility Tests

TD 10.016 DP IN Adapter LTTPR Test TD_DP IN_3

A. Purpose:

- Verify that a TBT3-Compatible DP IN Adapter works with DP OUT Adapter that Only Supports Non-LTTPR Mode

B. Asserts:

- TBD

C. Setup:

- TBD

D. Procedure:

USB4 CV performs the following steps:

1. Disable LTTPR functionality as follows:
 - a. Read DP_LOCAL_CAP from DP OUT Adapter and record the values
 - b. Set bit 27 to 1b in the DP_LOCAL_CAP values read from the DP OUT Adapter
 - c. Copy the DP_LOCAL_CAP values (with bit 27 = 1b) to the DP_REMOTE_CAP register in the DP IN Adapter
2. Connect test setup
3. Configure the DP Reference Source to run LT with LTTPR functionality
4. Parse the AUX Log at the DP Reference Sink in the Device Router and verify LTTPR functionality as follows:
 - a. Read of DPCD LTTPR Capability and ID (F0000h – F000Fh):
 - i. Parse the AUX log at the DP Reference Sink in the Device Router and verify that UUT did not try LT by LTTPR
 - i. No access to any DPCD LTTPR register besides LTTPR capability
 - ii. No Access to F0010h-F02FFh
 - b. Verify that the picture on the screen is stable

DP CTS Link Layer Tests

Below is the meaning of the tests classifications:

- Yes – The test is required to run as part of the Compliance certification.
- Skipped – The test is not required to run as part of the Compliance certification, but there should not be any technical barrier to execute it over DP Tunneling setup.
- NA – The test cannot be executed over DP Tunneling

Source Testing Tables

- For DP IN Adapter UUT:
 - If the DPTX can be tested in a manner other than DP Tunneling, then the full Source Testing according to VESA CTS shall be used in the alternative manner and the test to run as part of DP Tunneling CTS are the tests which states ‘Yes’ in the “DP Tunneling Subset” column, otherwise the tests to run are the tests which states ‘Yes’ in the “DP Tunneling Only”.
- For DP OUT Adapter UUT:
 - The test to run as part of DP Tunneling CTS are the tests which states ‘Yes’ in the “DP OUT Adapter UUT” column.

Table 5 – DP CTS Source Device Services Test Procedures

| DP CTS Test Number | Test Name | DP Tunneling Subset | DP Tunneling Only | DP OUT Adapter UUT |
|--------------------------------------|---|---------------------|-------------------|--------------------|
| 4.2.1 AUX Reads after HPD Plug Event | | | | |
| 4.2.1.1 | Source DUT Retry on No-Reply During AUX Read after HPD Plug Event | Yes | Yes | Yes |
| 4.2.1.2 | Source Retry on Invalid Reply During AUX Read after HPD Plug Event | Skipped | Yes | Yes |
| 4.2.1.3 | Source Device HPD Event Pulse Length Test | Skipped | Yes | Yes |
| 4.2.1.4 | Source Device IRQ HPD Pulse Length Test | Skipped | Yes | Yes |
| 4.2.1.5 | Source Device Inactive HPD / Inactive AUX Test | Skipped | Yes | Yes |
| 4.2.2 EDID and DPCD Reads | | | | |
| 4.2.2.1 | DPCD Receiver Capability and EDID Read upon HPD Plug Event | Yes | Yes | Yes |
| 4.2.2.2 | DPCD Extended Receiver Capability and EDID Read upon HPD Plug Event | Yes | Yes | Yes |
| 4.2.2.3 | EDID Read | Yes | Yes | Yes |
| 4.2.2.4 | EDID Read Failure #1: I2C-Over-AUX NACK | Yes | Yes | Skipped |

| | | | | |
|----------|---|---------|-----|---------|
| 4.2.2.5 | EDID Read Failure #2: I2C-Over-AUX DEFER | Yes | Yes | Skipped |
| 4.2.2.6 | EDID Corruption Detection | Skipped | Yes | Skipped |
| 4.2.2.7 | Branch Device Detection upon HPD Plug Event | Skipped | Yes | Skipped |
| 4.2.2.8 | EDID Read on IRQ HPD Event after Branch Device Detection | Yes | Yes | Yes |
| 4.2.2.9 | E-DDC Four Block EDID Read | Skipped | Yes | Skipped |
| 4.2.2.10 | Link Status/Adjust Request AUX read interval during Link Training | Yes | Yes | Yes |

Table 6 – DP CTS Source Device Link Services Test Procedures

| DP CTS Test Number | Test Name | DP Tunneling Subset | DP Tunneling Only | DP OUT Adapter UUT |
|----------------------------|---|----------------------------|--------------------------|---------------------------|
| 4.3.1 Link Training | | | | |
| 4.3.1.1 | Successful Link Training at All Supported Lane Counts and Link Speeds | Yes | Yes | Yes |
| 4.3.1.2 | Successful Link Training Upon HPD Plug Event | Skipped | Yes | Skipped |
| 4.3.1.3 | Successful Link Training with Request of Higher Differential Voltage Swing during Clock Recovery Sequence | Skipped | Yes | Yes |
| 4.3.1.4 | Successful Link Training to a Lower Link Rate #1: Iterate at Maximum Voltage Swing | Yes | Yes | Yes |
| 4.3.1.5 | Successful Link Training to a Lower Link Rate #2: Iterate at Minimum Voltage Swing | Yes | Skipped | Yes |
| 4.3.1.6 | Successful Link Training with Request of a Higher Pre-emphasis Setting during Channel Equalization Sequence | Yes | Skipped | Yes |
| 4.3.1.7 | Successful Link Training at Lower Link Rate Due to Loss of Symbol Lock during Channel Equalization Sequence | Yes | Yes | Yes |
| 4.3.1.8 | Unsuccessful Link Training at Lower Link Rate #1: Iterate at Maximum Voltage Swing | Yes | Yes | Yes |
| 4.3.1.9 | Unsuccessful Link Training at Lower Link Rate #2: Iterate at Minimum Voltage Swing | Yes | Yes | Yes |

| | | | | |
|-----------------------------------|---|---------|------|---------|
| 4.3.1.10 | Unsuccessful Link Training due to Failure in Channel Equalization Sequence (loop count > 5) | Yes | Yes | Yes |
| 4.3.1.11 | Successful Link Training with Simultaneous Request for Differential Voltage Swing and Pre-emphasis during Clock Recovery Sequence | Yes | Yes | Yes |
| 4.3.1.12 | Source Device Link Training CR Fallback Test | Skipped | Yes | Yes |
| 4.3.1.13 | Source Device Link Training EQ Fallback Test | Skipped | Yes | Yes |
| 4.3.2 Link Maintenance | | | | |
| 4.3.2.1 | Successful Link Re-training after IRQ_HPD Pulse Due to Loss of Symbol Lock | Yes | Yes | Yes |
| 4.3.2.2 | Successful Link Re-training after IRQ_HPD Pulse Due to Loss of Clock Recovery Lock | Yes | Yes | Yes |
| 4.3.2.3 | Successful Link Re-training after IRQ_HPD Pulse Due to Loss of Inter-lane Alignment Lock | Yes | Yes | Yes |
| 4.3.2.4 | Handling of IRQ_HPD Pulse with No Error Status Bits Set | Skipped | Yes | Skipped |
| 4.3.2.5 | Lane Count Reduction | NA | NA | NA |
| 4.3.3 Video Time Stamp Generation | | | | |
| 4.3.3.1 | Video Time Stamp Generation | Yes* | Yes* | Yes* |

* Not include empty TU: VIC=1 over HBR3*4L, HBR3*2L, HBR2*4L

Table 7 – Source Isochronous Transport Services Test Procedures

| DP CTS Test Number | Test Name | DP Tunneling Subset | DP Tunneling Only | DP OUT Adapter UUT |
|--------------------------------|--|---------------------|-------------------|--------------------|
| 4.4.1 Main Stream Data Mapping | | | | |
| 4.4.1.1 | Pixel Data Packing and Steering | Yes | Yes | Yes |
| 4.4.1.2 | Main Stream Data Packing and Stuffing– Least Packed TU | Yes* | Yes* | Yes |
| 4.4.1.3 | Main Stream Data Packing and Stuffing – Most Packed TU | Yes | Yes | Yes |
| 4.4.2 | Main Video Stream Format Change Handling | Yes | Yes | Yes |

| | | | | |
|--|--|---------|------|---------|
| 4.4.3 | Power Management | NA | NA | NA |
| 4.4.4 Audio Stream Transmission over Secondary Packets | | | | |
| 4.4.4.1 | Configuring Video and Audio Parameters | Skipped | Yes* | Skipped |
| 4.4.4.2 | Audio Stream Header Synchronization | Skipped | Yes* | Skipped |
| 4.4.4.3 | Audio Time Stamp Generation | Yes* | Yes* | Yes |
| 4.4.4.4 | Audio INFOFRAME Packet | Skipped | Yes* | Skipped |
| 4.4.4.5 | Audio Stream Transmission | Yes* | Yes* | Yes |
| 4.4.4.6 | Audio Start Sequence | Skipped | Yes* | Yes |

Table 8 – Source Device FEC Test Procedures

| DP CTS Test Number | Test Name | DP Tunneling Subset | DP Tunneling Only | DP OUT Adapter UUT |
|---------------------------|---|---------------------|-------------------|--------------------|
| 4.5.1 Source FEC Protocol | | | | |
| 4.5.1.1 | FEC Enable Verification for All Supported Lane Count and Link Speed | Yes | Yes | Yes |
| 4.5.1.2 | FEC Ready Verification for Non FEC Capable Sink | Skipped | Yes | Skipped |

Table 9 – Source Device DSC Test Procedures

| DP CTS Test Number | Test Name | DP Tunneling Subset | DP Tunneling Only | DP OUT Adapter UUT |
|---------------------------|---|---------------------|-------------------|--------------------|
| 4.6.1 Source DSC Protocol | | | | |
| 4.6.1.1 | DSC enable sequence verification | Skipped | Yes | Yes |
| 4.6.1.2 | DSC PPS block prediction flag verification | Skipped | Yes | Yes |
| 4.6.1.3 | DSC PPS convert RGB flag verification | Yes | Yes | Yes |
| 4.6.1.4 | DSC PPS (YCbCr 4:4:4 convert RGB = 0) flag verification | Skipped | Yes | Yes |
| 4.6.1.5 | DSC PPS Simple 4:2:2 flag verification | Skipped | Yes | Yes |

| | | | | |
|---------|--|---------|-----|-----|
| 4.6.1.6 | DSC PPS Native 4:2:2 flag verification | Skipped | Yes | Yes |
| 4.6.1.7 | DSC PPS Native 4:2:0 flag verification | Yes | Yes | Yes |
| 4.6.1.8 | DSC PPS convert RGB flag verification for DSC Algorithm Revision 1.1 | Skipped | Yes | Yes |
| 4.6.1.9 | DSC PPS (YCbCr 4:4:4 convert RGB = 0) flag verification for DSC Algorithm Revision 1.1 | Skipped | Yes | Yes |

Sink Testing Tables

If the DPRX can be tested in a manner other than DP Tunneling, then the full Sink Testing according to VESA CTS shall be used in the alternative manner and the test to run as part of DP Tunneling CTS are the tests which states ‘Yes’ in the “DP Tunneling Subset” column, otherwise the tests to run are the tests which states ‘Yes’ in the “DP Tunneling Only”.

Table 10 – DP CTS Sink Device Services Test Procedures

| DP CTS Test Number | Test Name | DP Tunneling Subset | DP Tunneling Only |
|------------------------------|--|----------------------------|--------------------------|
| 5.2.1 AUX_CH Protocol | | | |
| 5.2.1.1 | Read One Byte from Valid DPCD Address | Skipped | Skipped |
| 5.2.1.2 | DPCD Receiver Capability Read (Read 12 Bytes from Valid DPCD Address) | Skipped | Skipped |
| 5.2.1.3 | Write One Byte to Valid DPCD Address | Skipped | Skipped |
| 5.2.1.4 | Write Nine Bytes to Valid DPCD Addresses | Skipped | Skipped |
| 5.2.1.5 | Write EDID Offset (One Byte I2C-over-AUX Write) | Skipped | Skipped |
| 5.2.1.6 | Read One EDID Byte (One Byte I2C-over-AUX Read) | Skipped | Skipped |
| 5.2.1.7 | EDID Read (1 Byte I2C -over-AUX Segment Write, 1 Byte I2C-over-AUX Offset Write, 128 Byte I2C-over-AUX Read) | Skipped | Skipped |
| 5.2.1.8 | Illegal AUX Request Syntax | Skipped | Skipped |
| 5.2.1.9 | Glitch Rejection | Skipped | Skipped |
| 5.2.1.10 | Interleaved EDID and DPCD Receiver Capability Read | Yes | Yes |

| | | | |
|---|---|---------|-----|
| 5.2.1.11 | Downstream Stop on MOT Reset | Skipped | Yes |
| 5.2.1.12 | Downstream Stop on Timeout | Skipped | Yes |
| 5.2.2 Sink Device DPCD Field Implementation | | | |
| 5.2.2.1 | Sink Organizationally Unique Identifier (OUI) | Skipped | Yes |
| 5.2.2.2 | Sink Count | Skipped | Yes |
| 5.2.2.3 | Sink Status | Skipped | Yes |
| 5.2.2.4 | Sink Error Count (Deprecated) | Skipped | Yes |
| 5.2.2.5 | DPCD Address Range | Skipped | Yes |
| 5.2.2.6 | Number of Receiver Ports | Skipped | Yes |
| 5.2.2.7 | Main-Link Channel Coding | Skipped | Yes |
| 5.2.2.8 | ESI Field Mapping | Skipped | Yes |
| 5.2.2.9 | Sink Device Symbol Error Count | Skipped | Yes |

Table 11 – DP CTS Sink Device Link Services Test Procedures

| DP CTS Test Number | Test Name | DP Tunneling Subset | DP Tunneling Only |
|---------------------|---|---------------------|-------------------|
| 5.3.1 Link Training | | | |
| 5.3.1.1 | Successful Link Training at All Supported Lane Counts and Link Speeds | Yes | Yes |
| 5.3.1.2 | Successful Link Training with Request of Higher Differential Voltage Swing during Clock Recovery Sequence | NA | NA |
| 5.3.1.3 | Successful Link Training to a Lower Link Rate Due to Clock Recovery Lock Failure during Clock Recovery Sequence | NA | NA |
| 5.3.1.4 | Successful Link Training with Request of a Change to Pre-Emphasis and/or Voltage Swing Setting during Channel Equalization Sequence | NA | NA |

| | | | |
|-------------------------------|---|---------|---------|
| 5.3.1.5 | Successful Link Training at Lower Link Rate Due to Loss of Symbol Lock during Channel Equalization Sequence | Skipped | Skipped |
| 5.3.1.6 | Lane Count Reduction | NA | NA |
| 5.3.1.7 | Lane Count Increase | NA | NA |
| 5.3.1.8 | Sink Device 2-Lane Link Training CR/EQ Fallback Test | Skipped | Skipped |
| 5.3.1.9 | Sink Device 1-Lane Link Training CR/EQ Fallback Test | Skipped | Skipped |
| 5.3.2 Link Maintenance | | | |
| 5.3.2.1 | IRQ_HPDP Pulse Due to Loss of Symbol Lock and Clock Recovery Lock | Yes | Yes |
| 5.3.2.2 | IRQ_HPDP Pulse Due to Loss of Inter-lane Alignment Lock | NA | NA |

Table 12 – Sink Isochronous Transport Services Test Procedures

| DP CTS Test Number | Test Name | DP Tunneling Subset | DP Tunneling Only |
|---|---|----------------------------|--------------------------|
| 5.4.1 Main Video Stream Reconstruction | | | |
| 5.4.1.1 | Pixel Data Reconstruction | Yes | Yes |
| 5.4.1.2 | Main Stream Data Unpacking and Unstuffing – Least Packed TU | Yes | Yes |
| 5.4.1.3 | Main Stream Data Unpacking and Unstuffing – Most Packed TU | Yes | Yes |
| 5.4.1.4 | Pixel Clock Recovery | Yes | Yes |
| 5.4.2 | Main Video Stream Format Change Handling | Yes | Yes |
| 5.4.3 Power Management | | | |
| 5.4.3.1 | Entering and Exiting Power Save Mode | Yes | Yes |
| 5.4.3.2 | Resumption of Main-Link Activity after Extended Idle | Yes | Yes |

| 5.4.4 Main Audio Stream Reconstruction | | | |
|--|---------------------------------|-----|-----|
| 5.4.4.1 | Audio Test Patterns | Yes | Yes |
| 5.4.4.2 | Audio Startup and Format Change | Yes | Yes |
| 5.4.4.3 | RS Error Correction | Yes | Yes |
| 5.4.4.4 | Audio INFOFRAME Packet | Yes | Yes |
| 5.4.4.5 | Audio Clock Recovery | Yes | Yes |
| 5.4.4.6 | Audio Stream Reception | Yes | Yes |

Table 13 – Sink Device FEC Test Procedures

| DP CTS Test Number | Test Name | DP Tunneling Subset | DP Tunneling Only |
|-------------------------|--|---------------------|-------------------|
| 5.5.1 Sink FEC Protocol | | | |
| 5.5.1.1 | Sink Device FEC Capability Verification | Skipped | Skipped |
| 5.5.1.2 | Successful Link Training at All Supported Lane Counts and Link Rates with FEC Enable | Yes | Yes |
| 5.5.1.3 | Uncorrectable Block Error Count | Skipped | Skipped |
| 5.5.1.4 | Correctable Block Error Count | Skipped | Skipped |
| 5.5.1.5 | Correctable Bit Error Count | Skipped | Skipped |
| 5.5.1.6 | Correctable Parity Block Error Count | Skipped | Skipped |
| 5.5.1.7 | Correctable Parity Bit Error Count | Skipped | Skipped |

Table 14 – Sink Device DSC Test Procedures

| DP CTS Test Number | Test Name | DP Tunneling Subset | DP Tunneling Only |
|-------------------------|-----------------------------|---------------------|-------------------|
| 5.6.1 Sink DSC Protocol | | | |
| 5.6.1.1 | DSC capability verification | Skipped | Yes |
| 5.6.1.2 | DSC RGB Color Depth Test | Skipped | Yes |

| | | | |
|-----------------------------------|--|---------|-----|
| 5.6.1.3 | DSC RGB Block Prediction Test | Skipped | Yes |
| 5.6.1.4 | DSC RGB bits-per-pixel Test | Yes | Yes |
| 5.6.1.5 | DSC RGB slice Test | Yes | Yes |
| 5.6.1.6 | DSC RGB lane Test | Yes | Yes |
| 5.6.1.7 | DSC YCbCr 4:4:4 Color Depth Test | Skipped | Yes |
| 5.6.1.8 | DSC YCbCr 4:4:4 Block Prediction Test | Skipped | Yes |
| 5.6.1.9 | DSC YCbCr 4:4:4 bits-per-pixel Test | Skipped | Yes |
| 5.6.1.10 | DSC YCbCr 4:4:4 slice Test | Skipped | Yes |
| 5.6.1.11 | DSC YCbCr 4:4:4 lane Test | Skipped | Yes |
| 5.6.1.12 | DSC Simple 4:2:2 Color Depth Test | Skipped | Yes |
| 5.6.1.13 | DSC Simple 4:2:2 Block Prediction Test | Skipped | Yes |
| 5.6.1.14 | DSC Simple 4:2:2 bits-per-pixel Test | Skipped | Yes |
| 5.6.1.15 | DSC Simple 4:2:2 slice Test | Skipped | Yes |
| 5.6.1.16 | DSC Simple 4:2:2 lane Test | Skipped | Yes |
| 5.6.1.17 | DSC Native 4:2:2 Color Depth Test | Skipped | Yes |
| 5.6.1.18 | DSC Native 4:2:2 Block Prediction Test | Skipped | Yes |
| 5.6.1.19 | DSC Native 4:2:2 bits-per-pixel Test | Yes | Yes |
| 5.6.1.20 | DSC Native 4:2:2 slice Test | Yes | Yes |
| 5.6.1.21 | DSC Native 4:2:2 lane Test | Yes | Yes |
| 5.6.1.22 | DSC Native 4:2:0 Color Depth Test | Skipped | Yes |
| 5.6.1.23 | DSC Native 4:2:0 Block Prediction Test | Skipped | Yes |
| 5.6.1.24 | DSC Native 4:2:0 bits-per-pixel Test | Yes | Yes |
| 5.6.1.25 | DSC Native 4:2:0 slice Test | Yes | Yes |
| 5.6.1.26 | DSC Native 4:2:0 lane Test | Yes | Yes |
| 5.6.2 Sink DSC Protocol Extension | | | |

| | | | |
|----------|--|---------|-----|
| 5.6.2.1 | DSC Height Test | Skipped | Yes |
| 5.6.2.2 | DSC Padding Test | Yes | Yes |
| 5.6.2.3 | DSC RGB min and max bits-per-pixel Test | Yes | Yes |
| 5.6.2.4 | DSC YCbCr 4:4:4 min and max bits-per-pixel Test | Skipped | Yes |
| 5.6.2.5 | DSC Simple 4:2:2 min and max bits-per-pixel Test | Skipped | Yes |
| 5.6.2.6 | DSC Native 4:2:2 min and max bits-per-pixel Test | Yes | Yes |
| 5.6.2.7 | DSC Native 4:2:0 min and max bits-per-pixel Test | Yes | Yes |
| 5.6.2.8 | DSC RGB most pack Test | Yes | Yes |
| 5.6.2.9 | DSC Native 4:2:2 most pack Test | Yes | Yes |
| 5.6.2.10 | DSC Native 4:2:0 most pack Test | Yes | Yes |
| 5.6.2.11 | DSC one corrupt slice Test | Skipped | Yes |
| 5.6.2.12 | DSC interrupt test for Chunk Length error | Skipped | Yes |
| 5.6.2.13 | DSC interrupt test for RC buffer under-run error | Skipped | Yes |
| 5.6.2.14 | DSC interrupt test for RC buffer overflow error | Skipped | Yes |

Table 15 – Sink Device Embedded LTTTPR Test Procedures

| DP CTS Test Number | Test Name | Tested |
|-------------------------------------|--|---------|
| 5.9.1 Sink Embedded LTTTPR protocol | | |
| 5.9.1.1 | LTTTPR global configuration verification | Skipped |
| 5.9.1.2 | LTTTPR configuration and status field verification | Skipped |
| 5.9.1.3 | LTTTPR AUX read/write reply time budget verification | Skipped |
| 5.9.1.4 | LTTTPR 8b10b transparent link training for lane count and link rate | Yes |
| 5.9.1.5 | LTTTPR 8b10b non-transparent link training for lane count and link rate | Yes |
| 5.9.1.6 | LTTTPR 128b132b non-transparent link training for lane count and link rate | Skipped |
| 5.9.1.7 | LTTTPR 8b10b transparent successful Link Training (Higher Differential Voltage Swing during Clock Recovery) | Skipped |
| 5.9.1.8 | LTTTPR 8b10b non-transparent successful Link Training (Higher Differential Voltage Swing during Clock Recovery) | Skipped |
| 5.9.1.9 | LTTTPR 8b10b transparent successful Link Training (Lower Link bandwidth During Clock Recovery) | Skipped |
| 5.9.1.10 | LTTTPR 8b10b non-transparent successful Link Training (Lower Link bandwidth During Clock Recovery) | Skipped |
| 5.9.1.11 | LTTTPR 8b10b transparent successful Link Training (Lower Link Bandwidth Channel Equalization) | Skipped |
| 5.9.1.12 | LTTTPR 8b10b non-transparent successful Link Training (Lower Link Bandwidth Channel Equalization) | Skipped |
| 5.9.1.13 | LTTTPR 128b132b non-transparent successful Link Training to Lower Link Rate, due to failure in EQ Phase of UHBR | Skipped |
| 5.9.1.14 | LTTTPR 128b132b non-transparent successful Link Training to Lower Link Rate, due to failure in CDS Phase of UHBR | Skipped |
| 5.9.1.15 | LTTTPR 128b132b non-transparent successful Link Training to lower bandwidth, due to no start of CDS sequence Phase of UHBR Link Training | Skipped |

Known Good GPU(s) Capabilities

The test coverage provided by DP Link Layer Compliance Tests executed in Test Setups that make use of a Known Good (KG) GPU highly depends on the capabilities of the KG GPU(s) (or DP Source). The KG GPU(s) (or DP Source) used for testing shall support the capabilities outlined in Table 16.

Table 16 – Known Good GPU(s) or DP Source Capabilities Requirements

| Capability | Support Level |
|--|--|
| Maximum Supported Lane Count | 4 (Lanes 0, 1, 2, 3) |
| Maximum Supported Link Rate | 8.1Gbps/lane (HBR3) |
| Device Test Automation DPCD extension | Yes |
| Spread-spectrum Clocking (SSC) | Yes |
| Video format change without link retraining | Yes |
| Supported Pixel Encoding/Colorimetry Formats | RGB YCbCr 4:4:4 YCbCr 4:2:2 YCbCr 4:2:0 |
| Maximum bits per component (bpc) | 16 bpc |
| FEC | Yes |
| Audio Transmission with Video | Yes |
| Audio Sample Rates Supported | 32 kHz 44.1 kHz 48 kHz 88.2 kHz 96 kHz 176.4 kHz 192 kHz |
| DSC Support | Yes |
| DSC Colorimetry | RGB YCbCr 4:4:4 Simple 4:2:2 |

| | | |
|-----------------|-----|--------------|
| | | Native 4:2:2 |
| | | Native 4:2:0 |
| DSC Maximum BPC | 12 | |
| HDCP and CP_IRQ | Yes | |