

USB4™ USB3 Tunneling

Compliance Test Specification

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1.0	June 2020	First Release
1.1	January 2020	With editorial corrections and test fixes
1.2	October 2021	With corrections and clarifications. References the USB4 Specification, Version 1.0 with Errata and ECN through May 19, 2021.
1.3	October 2022	With corrections and clarifications. References the USB4 Specification, Version 1.0 with Errata and ECN through May 19, 2021.
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2.0		First version of USB4 V2 tests

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Introduction

The tests defined in this test specification verify that a Router is compliant with Chapter 9 of the USB4™ Specification.

Note: This specification only covers USB3 Tunneling testing, it does not cover testing for native USB 3.2 support.

Note: If a USB4 Device, Hub or Dock includes an internal host controller, it also needs to pass xHCI CV testing over the PCIe tunnel using a TBT3 host.

Terminology

The following table describes the terms used in this document.

Analyzer	Test tool that captures and parses packets, transactions, ordered sets, etc.
Compliance Device	<p>A KG USB4 Device that is capable of performing Transport Layer Packet loopback.</p> <p>The KG USB4 Device is configured by USB4 CV (when USB4 CV is upstream of the UUT) or the Exerciser (when the exerciser is upstream of the UUT). Unless specified otherwise, the Compliance Device is configured as an ordinary KG USB4 Device. See the USB4 Connection Manager Guide for more information on how a USB4 Device is configured.</p> <p>The KG USB4 Device supports USB3 Tunneling at both USB 3.2 Gen 2x1 and USB 3.2 Gen 2x2 speeds.</p>
DFP	Downstream Facing Port.
Exerciser	The compliance test tool (hardware and software) that implements USB4 Port functionality and the behavior required for compliance testing.
IOP	Interop Testing. See USB4™ Interop Test Specification.
KG USB4 Device	“Known Good” USB4 Device. A USB4 Device that is known to be compliant with the USB4 Specification.
KG USB4 Host	“Known Good” USB4 Host. A USB4 Host that is known to be compliant with the USB4 Specification.
KG TBT3 Device	A Certified Thunderbolt™ 3 Device.
KG TBT3 Host	A Certified Thunderbolt™ 3 Host.
PUT	Port Under Test. The USB4 Port on a UUT that is the test point for compliance testing.
RUT	Router Under Test. The Router that is being tested for compliance.
UFP	Upstream Facing Port.
USB4 CV	Test tool that implements a Connection Manager with additional functionality to implement compliance tests.

USB4 Product	Refers to a USB4 host, USB4 hub, and/or USB4 device. Includes silicon, reference platforms, and end product.
UUT	Unit Under Test. The Router that is being tested for compliance.
VIF	Vendor Information File. File provided by UUT vendor that provides information about the characteristics and capabilities of the UUT.

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
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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.

USB4 Ver. 1 Assertions

The following Table presents the USB4 Ver. 1 Specification Chapter 9 asserts.

Assertion #	Test	Assertion Description
9 USB3 Tunneling		
9#1	IOP	A USB4 host shall support USB3 tunneling.
9#2	TD 9.001 TD 9.001	The Host Router in a USB4 host shall have one Downstream USB3 Adapter per Downstream Facing Port.
9#3	NT	Each Downstream USB3 Adapter shall interface to a downstream port on the host controller.
9#4	BT	A USB4 hub shall support USB3 tunneling.
9#5	TD 9.018	A USB4 hub shall incorporate an internal USB SuperSpeed Plus hub per the USB 3.2 Specification with the modifications defined in this chapter.
9#6	TD 9.001 TD 9.001	The Device Router in a USB4 hub shall have an Upstream USB3 Adapter that interfaces with the upstream port of the internal USB 3.2 hub.
9#7	NT	The Device Router in a USB4 hub shall have for each Downstream Facing Port, a Downstream USB3 Adapter that interfaces to a downstream port on the internal USB 3.2 hub.
9#8	NT	A USB4 device that supports USB3 tunneling shall incorporate either an internal USB SuperSpeed Plus hub or an internal USB peripheral device per the USB 3.2 Specification with the modifications defined in this chapter.
9#9	TD 9.001 TD 9.001	The Device Router in a USB4 device that supports USB3 tunneling shall have an Upstream USB3 Adapter that interfaces to the upstream port of the internal USB 3.2 peripheral device or internal USB 3.2 hub.
9.1 USB3 Adapter Layer		
9.1.1 Encapsulation		
9.1.1#1	TD 9.002	An LFPS event, a Ordered Set, a Link Command, a Link Management Packet, a Transaction Packet, and an Isochronous Timestamp Packet shall each be encapsulated into a single separate Tunneled Packet.
9.1.1#2	TD 9.008	A Data Packet shall be encapsulated into one or more Tunneled Packets. A Tunneled Packet shall not contain data from more than one Data Packet.
9.1.1#3	NT	Idle Symbols shall be discarded by a USB3 Adapter Layer.

9.1.1#4	TD 9.002 TD 9.003 TD 9.004 TD 9.005	The byte and bit ordering of an LFPS within a Tunneled Packet shall be as described in Section 9.1.1.1.
9.1.1#5	TD 9.002 TD 9.006	The byte and bit ordering of an Ordered Set within a Tunneled Packet shall be as described in Section 9.1.1.2.
9.1.1#6	TD 9.002	The bytes and bits in a Tunneled Packet payload, other than LFPS and Ordered Sets, shall be packed in the same order as the original USB3 construct, including the USB3 framing symbols.
9.1.1#7	Error! Reference source not found. TD 9.007	A USB3 Adapter shall not discard a Tunneled Packet due to lack of credits in the USB4 Fabric.
9.1.1#8	Error! Reference source not found. TD 9.007	When insufficient credits are available, the Router shall queue the Tunneled Packet and shall transport it once sufficient credits are available.
9.1.1#9	TD 9.002 TD 9.008	Table 9-1 defines the PDF values that shall be used for each type of USB construct.
9.1.1#10	NT	If a USB3 Adapter receives a Tunneled Packet with a PDF value other than 0 to 6, it shall discard the Tunneled Packet and shall not send any Packets in response.
9.1.1.1 LFPS Encapsulation		
9.1.1.1#1	TD 9.002 TD 9.003 TD 9.004 TD 9.005	An LFPS Tunneled Packet shall contain a single Doubleword of payload as defined in Table 9-2.
9.1.1.1#2	TD 9.002 TD 9.003 TD 9.004 TD 9.005	An LFPS Tunneled Packet shall have the structure shown in Figure 9-1.
9.1.1.1#3	NT	An LFPS event that is not listed in Table 9-2 shall not be transferred to the Transport Layer.

9.1.1.1#4	TD 9.002 TD 9.003 TD 9.004 TD 9.005	A USB3 Adapter Layer shall set no more than one of bits [22:17] in an LFPS Tunneled Packet.
9.1.1.1.1 CRC		
9.1.1.1.1#1	NT	The <i>CRC</i> field shall cover bits [23:0] of payload.
9.1.1.1.1#2	NT	The <i>CRC</i> field shall be calculated as defined in Section 5.1.2.1.1, using the following bit order: Bit 7 to bit 0; Bit 15 to bit 8; Bit 23 to bit 16
9.1.1.1.1#3	NT	When a USB3 Adapter Layer receives an LFPS Tunneled Packet, it shall verify the <i>CRC</i> field value.
9.1.1.1.1#4	NT	After correcting an error, a Router shall continue on as if the error had never occurred.
9.1.1.1.1#5	NT	When an error is detected but not corrected, the packet with the error shall be dropped and no other action taken on its behalf.
9.1.1.1.2 Rx Term Enable		
9.1.1.1.2#1	TD 9.002	The USB3 Adapter Layer shall send an LFPS Tunneled Packet to the Transport Layer when the local value of Rx termination changes or when the Path Enable bit in the USB3 Adapter Configuration Capability changes from 0b to 1b.
9.1.1.1.2#2	TD 9.002	The LFPS Tunneled Packet shall be sent 3 times.
9.1.1.1.2#3	NT	A Router shall implement a mechanism that allows a USB3 Adapter Layer to indicate far-end receiver termination to the internal USB3 Device.
9.1.1.1.2#4	TD 9.002	A USB3 Adapter Layer shall indicate far-end termination to the internal USB3 device when all of the following are true: Path setup is complete (i.e. the <i>Path Enable</i> bit and the <i>Valid</i> bit in the USB3 Adapter Configuration Capability are both set to 1b); After Path Setup is complete, the USB3 Adapter Layer received an LFPS Tunneled Packet with the <i>Rx Term Enable</i> bit set to 1b and the USB3 Adapter Layer has not received any subsequent LFPS Tunneled Packets with the <i>Rx Term Enable</i> bit set to 0b.
9.1.1.1.2#5	BT	When a Router transitions to Sleep state, a USB3 Adapter Layer shall maintain the same indicator value as before entry to Sleep state.
9.1.1.1.2#6	BT	When the Router exits Sleep state, the USB3 Adapter Layer shall continue to maintain the indicator value until the <i>Valid</i> bit in USB3 Adapter Port Configuration Capability is set to 1b.
9.1.1.1.2#7	BT	After the <i>Valid</i> bit is set to 1b, the USB3 Adapter Layer shall set the indicator as defined above.

9.1.1.1.3 SCD1		
9.1.1.1.3#1	TD 9.002	The USB3 Adapter Layer shall send an LFPS Tunneled Packet to the Transport Layer with the <i>SCD1</i> bit set to 1b when instructed to do so by the internal USB3 device.
9.1.1.1.3#2	TD 9.002	The LFPS Tunneled Packet shall be sent 3 times.
9.1.1.1.3#3	NT	A USB3 Adapter Layer that receives an LFPS Tunneled Packet from the Transport Layer with the <i>SCD1</i> bit set to 1b shall indicate reception of SCD1 to the internal USB3 device until it receives a Tunneled Packet with different contents.
9.1.1.1.4 SCD2		
9.1.1.1.4#1	TD 9.002	The USB3 Adapter Layer shall send an LFPS Tunneled Packet to the Transport Layer with the <i>SCD2</i> bit set to 1b when instructed to do so by the internal USB3 device.
9.1.1.1.4#2	TD 9.002	The packet shall be sent 3 times.
9.1.1.1.4#3	NT	A USB3 Adapter Layer that receives an LFPS Tunneled Packet from the Transport Layer with the <i>SCD2</i> bit set to 1b shall indicate reception of SCD2 to the internal USB3 device until it receives a Tunneled Packet with different contents.
9.1.1.1.5 U2 Exit		
9.1.1.1.5#1	TD 9.003	The USB3 Adapter Layer shall send an LFPS Tunneled Packet to the Transport Layer with the <i>U2 Exit</i> bit set to 1b when the internal USB3 device indicates a U2 Exit event.
9.1.1.1.5#2	TD 9.003	The packet shall be sent 3 times.
9.1.1.1.5#3	TD 9.003	A USB3 Adapter Layer that receives an LFPS Tunneled Packet from the Transport Layer with the <i>U2 Exit</i> bit set to 1b shall indicate reception of a U2 Exit LFPS to the internal USB3 device until it receives a Tunneled Packet with different contents.
9.1.1.1.6 U3 Wakeup		
9.1.1.1.6#1	TD 9.004	When the internal USB3 device indicates the start of a U3 Wakeup event and a USB3 Path is enabled, a USB3 Adapter Layer shall send 3 LFPS Tunneled Packets to the Transport Layer. Each LFPS Tunneled Packet shall have the <i>U3 Wakeup</i> bit set to 1b.
9.1.1.1.6#2	TD 9.4	If a USB3 Adapter Layer detects the beginning of a U3 Wakeup event before a USB3 Path is enabled, it shall ignore the USB3 Wakeup event and shall not send any LFPS Tunneled Packets for that event.

9.1.1.1.6#3	NT	A USB3 Adapter Layer that receives an LFPS Tunneled Packet from the Transport Layer with the <i>U3 Wakeup</i> bit set to 1b shall indicate reception of a U3 Wakeup LFPS to the internal USB3 device until it receives a Tunneled Packet with different contents.
9.1.1.1.7 Warm Reset		
9.1.1.1.7#1	NT	When Warm Reset is asserted by the internal USB3 device, the Downstream USB3 Adapter Layer shall: Discard any queued Tunneled Packets.
9.1.1.1.7#2	TD 9.005	When Warm Reset is asserted by the internal USB3 device, the Downstream USB3 Adapter Layer shall: Send an LFPS Tunneled Packet to the Transport Layer with the Warm Reset bit set to 1b.
9.1.1.1.7#3	TD 9.005	The LFPS Tunneled Packet shall be sent 3 times.
9.1.1.1.7#4	NT	While Warm Reset is active, a Downstream USB3 Adapter shall discard any Tunnel Packets it receives and clear any indication of LFPS reception towards the internal USB3 device.
9.1.1.1.7#5	NT	An Upstream USB3 Adapter Layer that receives an LFPS Tunneled Packet with the Warm Reset bit set to 1b shall indicate assertion of a Warm Reset to the internal USB3 device until it receives a Tunneled Packet with different contents.
9.1.1.1.7#6	TD 9.005	The Downstream USB3 Adapter Layer shall send an LFPS Tunneled Packet to the Transport Layer with the Warm Reset bit set to 0b when Warm Reset is de-asserted by the internal USB3 device.
9.1.1.1.7#7	TD 9.005	The LFPS Tunneled Packet shall be sent 3 times.
9.1.1.1.7#8	NT	An Upstream USB3 Adapter Layer that receives an LFPS Tunneled Packet from the Transport Layer with the Warm Reset bit set to 0b shall indicate de-assertion of a Warm Reset to the internal USB3 device until it receives a Tunneled Packet with different contents.
9.1.1.1.7#9	NT	After Warm Reset is de-asserted, a USB3 Adapter Layer shall not forward any Ordered Sets, packets, or events to the internal USB3 device that were received before or during Warm Reset assertion.
9.1.1.1.8 LBPM		
9.1.1.1.8#1	TD 9.002	The USB3 Adapter Layer shall send an LFPS Tunneled Packet to the Transport Layer with the <i>LBPM Enable</i> bit set to 1b when instructed to do so by the internal USB3 device.
9.1.1.1.8#2	TD 9.002	The LBPM field shall contain the USB3 LBPM construct. Bits[7:0] of the USB3 LBPM are mapped to Bits[7:0] of the LBPM field, respectively.
9.1.1.1.8#3	TD 9.002	The LFPS Tunneled Packet shall be sent 3 times.

9.1.1.1.8#4	NT	A USB3 Adapter Layer that receives an LFPS Tunneled Packet with the <i>LBPM Enable</i> bit set to 1b shall do the following until it receives a Tunneled Packet with different contents: Indicate reception of LBPM to the internal USB3 device.
9.1.1.1.8#5	NT	A USB3 Adapter Layer that receives an LFPS Tunneled Packet with the <i>LBPM Enable</i> bit set to 1b shall do the following until it receives a Tunneled Packet with different contents: Communicate the value in the <i>LBPM</i> field to the internal USB3 device.
9.1.1.1.9 LFPS Stop		
9.1.1.1.9#1	TD 9.004	A USB3 Adapter Layer shall send an LFPS Tunneled Packet to the Transport Layer with bits [22:17] equal 00h for the following cases: The Internal USB3 device indicates no LFPS Response Timeout for U3 Exit
9.1.1.1.9#2	TD 9.005	A USB3 Adapter Layer shall send an LFPS Tunneled Packet to the Transport Layer with bits [22:17] equal 00h for the following cases: The Internal USB3 device indicates Warm Reset done
9.1.1.1.9#3	TD 9.004 TD 9.005	The LFPS Tunneled Packet shall be sent 3 times.
9.1.1.2 Ordered Set Encapsulation		
9.1.1.2#1	TD 9.002 TD 9.006	An Ordered Set Tunneled Packet shall have the single Doubleword payload defined in Table 9-3.
9.1.1.2#2	TD 9.002 TD 9.006	An Ordered Set Tunneled Packet shall have the structure shown in Figure 9-2.
9.1.1.2#3	TD 9.002 TD 9.006	A USB3 Adapter Layer shall set one and no more than one of bits [2:0] in an Ordered Set Tunneled Packet.
9.1.1.2#4	TD 9.002 TD 9.006	TS1 or TS2 Ordered Sets shall contain the USB3 Link Functionality construct. Bits[7:0] of the USB3 Link Functionality are mapped to Bits[7:0] of the Link Functionality field, respectively. TSEQ Ordered Set – set to 00h by the USB3 Adapter Layer. SDS Ordered Set – set to 00h by the USB3 Adapter Layer.
9.1.1.2#5	TD 9.002 TD 9.006	When a USB3 Adapter Layer receives a TSEQ, TS1, TS2, or SDS Ordered Set from the internal USB3 device that is not identical to the previous Ordered Set received from the internal USB3 device, it shall send 3 copies of an Ordered Set Tunneled Packet to the Transport Layer, with the respective fields set per Table 9-3.
9.1.1.2#6	NT	All other Ordered Sets received from the internal USB3 device shall be discarded by the USB3 Adapter Layer and shall not cause an Ordered Set Tunneled Packet to be sent to the Transport Layer.

9.1.1.2#7	NT	A USB3 Adapter Layer shall only send Ordered Sets that target Lane 0 to the Transport Layer.
9.1.1.2#8	NT	A USB3 Adapter Layer shall discard Ordered Sets that target a non-zero Lane so that they are not sent over the USB4 Fabric.
9.1.1.2#9	NT	When a USB3 Adapter Layer receives an Ordered Set Tunneled Packet, it shall verify the <i>CRC</i> field value.
9.1.1.2#10	NT	When an error is detected but not corrected, the packet with the error shall be dropped and no other action taken on its behalf.
9.1.1.2#11	IOP	After verifying the <i>CRC</i> field value: If the <i>TS1</i> bit in the received Ordered Set Tunneled Packet is set to 1b, the USB3 Adapter Layer shall indicate reception of TS1 Ordered Set to the internal USB3 device.
9.1.1.2#12	IOP	After verifying the <i>CRC</i> field value: If the <i>TS2</i> bit in the received Ordered Set Tunneled Packet is set to 1b, the USB3 Adapter Layer shall indicate reception of TS2 Ordered Set to the internal USB3 device.
9.1.1.2#13	IOP	After verifying the <i>CRC</i> field value: If the <i>SDS</i> bit in the received Ordered Set Tunneled Packet is set to 1b, a USB3 Adapter Layer shall indicate reception of SDS Ordered Set to the internal USB3 device.
9.1.1.3 Link Command Encapsulation		
9.1.1.3#1	IOP	A USB3 Adapter Layer that receives a Link Command from the internal USB3 device shall send a Link Command Tunneled Packet to the Transport Layer with a 2-Doubleword payload.
9.1.1.3#2	IOP	The Link Command Tunneled Packet payload shall contain the Link Command.
9.1.1.3#3	NT	Upon receiving a Link Command Tunneled Packet from the Transport Layer, a USB3 Adapter Layer shall transfer the Link Command Tunneled Packet to the internal USB Port.
9.1.1.4 Idle Symbols		
9.1.1.4#1	NT	A USB3 Adapter Layer shall drop any Idle Symbols received from the internal USB3 device.
9.1.1.5 LMP Encapsulation		
9.1.1.5#1	IOP	A USB3 Adapter Layer that receives a USB3 Link Management Packet (LMP) from the internal USB3 device shall send an LMP Tunneled Packet to the Transport Layer with a 5 Doubleword payload.
9.1.1.5#2	IOP	The LMP Tunneled Packet payload shall contain the framed LMP.
9.1.1.5#3	NT	Upon receiving an LMP Tunneled Packet from the Transport Layer, a USB3 Adapter Layer shall transfer the LMP to the internal USB device.

9.1.1.6 TP Encapsulation		
9.1.1.6#1	IOP	A USB3 Adapter Layer that receives a USB3 Transaction Packet (TP) from the internal USB3 device shall send a TP Tunneled Packet to the Transport Layer with a 5 Doubleword payload.
9.1.1.6#2	IOP	The TP Tunneled Packet payload shall contain the framed TP.
9.1.1.6#3		If the USB3 Adapter Layer receives a Deferred DPH from the internal USB3 device, it shall send a TP Tunneled Packet to the Transport Layer with a 5 Doubleword payload.
9.1.1.6#4		The payload shall contain the Deferred DPH and its USB3 framing symbols.
9.1.1.6#5	NT	Upon receiving a TP Tunneled Packet from the Transport Layer, a USB3 Adapter Layer shall transfer the TP to the internal USB3 device.
9.1.1.7 ITP Encapsulation		
9.1.1.7#1	NT	A Downstream USB3 Adapter Layer that receives an Isochronous Timestamp Packet (ITP) from the internal USB3 device shall: set the TMU Time Capture field to the nanosecond portion of the current Host Router Time (t_g).
9.1.1.7#2	TD 9.010	A Downstream USB3 Adapter Layer that receives an Isochronous Timestamp Packet (ITP) from the internal USB3 device shall: send an ITP Tunneled Packet with the format defined in Figure 9-4 to the Transport Layer.
9.1.1.7#3	TD 9.010	An Upstream USB3 Adapter Layer that receives an ITP Tunneled Packet from the Transport Layer shall: (2) Else, update the Delta field of the ITP according to the formula below: Updated Delta = Delta + (Host Router time Nanosecond – TMU Time Capture) / tIsochTimeStampGranularity
9.1.1.7#4	TD 9.010	A USB3 Adapter Layer shall meet the required accuracy of the <i>Delta</i> field in the ITP as defined by Section 8.7 of the USB 3.2 Specification.
9.1.1.7#5	NT	An Upstream USB3 Adapter Layer that receives an ITP Tunneled Packet from the Transport Layer shall: (3) Update the <i>CRC-16</i> field in the ITP.
9.1.1.7#6	NT	An Upstream USB3 Adapter Layer that receives an ITP Tunneled Packet from the Transport Layer shall: (4) Forward the ITP to the internal USB device.
9.1.1.7#7	TD 9.010	If the Time Disruption bit is set to 1b in Router Configuration Space, an Upstream USB3 Adapter Layer shall set the Delayed bit in the Link Control Word to 1b.
9.1.1.7#8	NT	A USB3 Adapter Layer shall recalculate the CRC5 field within the Link Control Word if it modified the Delayed bit.

9.1.1.7#9	NT	An Upstream USB3 Adapter Layer that receives an ITP Tunneled Packet from the Transport Layer shall: (1) If the Router does not support the Time Synchronization Protocol, proceed to step 4.
9.1.1.8 Data Packet (DP) Encapsulation		
9.1.1.8#1	TD 9.008	If the size of a USB3 Data Packet is 252 bytes or less, then the USB3 Adapter Layer shall send a single Tunneled Packet of type Start DP Segment to the Transport Layer.
9.1.1.8#2	TD 9.008	The Tunneled Packet shall carry the unsegmented USB3 Data Packet as payload and any padding needed for DW alignment.
9.1.1.8#3	TD 9.008	If the size of a USB3 Data Packet is larger than 252 bytes, the USB3 Data Packet shall be segmented into multiple Tunneled Packets as shown in Figure 9-6.
9.1.1.8#4	TD 9.008	When a USB3 Adapter Layer segments a USB3 Data Packet into Multiple Tunneled Packets, it shall follow the rules: All Tunneled Packets with the possible exception of the last packet shall include 252 bytes of payload.
9.1.1.8#5	TD 9.008	When a USB3 Adapter Layer segments a USB3 Data Packet into Multiple Tunneled Packets, it shall follow the rules: The first Tunneled Packet shall be of type Start DP Segment.
9.1.1.8#6	TD 9.008	When a USB3 Adapter Layer segments a USB3 Data Packet into Multiple Tunneled Packets, it shall follow the rules: Any following Tunneled Packets other than the last Tunneled Packet shall be of type Middle DP Segment.
9.1.1.8#7	TD 9.007 NT	When a USB3 Adapter Layer segments a USB3 Data Packet into Multiple Tunneled Packets, it shall follow the rules: The last Tunneled Packet shall be of type End DP Segment.
9.1.1.8#8	TD 9.007 NT	When a USB3 Adapter Layer segments a USB3 Data Packet into Multiple Tunneled Packets, it shall follow the rules: The last Tunneled Packet shall pad the payload to be Doubleword aligned.
9.1.1.8#9	TD 9.007 NT	When a USB3 Adapter Layer segments a USB3 Data Packet into Multiple Tunneled Packets, it shall follow the rules: The last Tunneled Packet shall have payload size that does not exceed 252 bytes.
9.1.1.8#10	NT	When a USB3 Adapter Layer segments a USB3 Data Packet into Multiple Tunneled Packets, it shall follow the rules: The Tunneled Packets shall be sent to the Transport layer such that the byte ordering of the original USB3 Data Packet is maintained.
9.1.1.8#11	TD 9.009	When re-assembling Tunneled Packets into USB3 Data Packets, the USB3 Adapter Layer shall: Drop a Tunneled Packet of type Middle DP Segment that comes immediately after a Tunneled Packet of type End DP Segment.

9.1.1.8#12	TD 9.009	When re-assembling Tunneled Packets into USB3 Data Packets, the USB3 Adapter Layer shall: Drop a Tunneled Packet of type End DP Segment that comes immediately after a Tunneled Packet of type End DP Segment.
9.1.1.8#13	TD 9.009	When re-assembling Tunneled Packets into USB Data Packets, the USB3 Adapter Layer shall: Nullify or partially nullify a USB3 Data Packet when both of the following are true: A Tunneled packet of type Start DP Segment is received and the length information in the USB3 DPH indicates it does not fit into a single Tunneled Packet; A Tunneled Packet of type End DP Segment is not received within tReassemble from the reception of the Tunneled Packet of type Start DP Segment.
9.1.2 Bandwidth Negotiation		
9.1.2#1	TD 9.011	When the <i>Host Controller Ack</i> field = 0: The value in the <i>Consumed Upstream Bandwidth</i> field shall not exceed the value in the <i>Allocated Upstream Bandwidth</i> field.
9.1.2#2	TD 9.012	When the <i>Host Controller Ack</i> field = 0: The value in the <i>Consumed Downstream Bandwidth</i> field shall not exceed the value in the <i>Allocated Downstream Bandwidth</i> field.
9.1.2#3	NT	When the <i>Host Controller Ack</i> field = 1: The internal host controller shall not read the <i>Allocated Upstream Bandwidth</i> or <i>Allocated Downstream Bandwidth</i> fields
9.1.2#4	NT	When the <i>Host Controller Ack</i> field = 1: The internal host controller shall not update <i>Consumed Upstream Bandwidth</i> or <i>Consumed Downstream Bandwidth</i> fields.
9.1.2#5	TD 9.011 TD 9.012	The internal host controller shall negotiate bandwidth as shown in Figure 9-7.
9.1.2#6	TD 9.002	When the USB3 link reaches U0, a USB3 Adapter Layer shall: Set the <i>Actual Link Rate</i> field to indicate the established link rate.
9.1.2#7	TD 9.002	When the USB3 link reaches U0, a USB3 Adapter Layer shall: Set the <i>USB3 Link Valid</i> field to 1b.
9.1.2#8	TD 9.003 TD 9.004	When the USB3 link is not in U0, Recovery, U2 or U3, a USB3 Adapter Layer shall set the <i>USB3 Link Valid</i> field to 0b.
9.1.3 Timing Parameters		
9.1.3#1	TD 9.009	Time between Tunneled Packets which is used to determine loss of a USB3 Data Packet segment.
9.2 Internal USB3 Device		

9.2#1	NT	A USB3 Physical Layer is not needed in a USB3 port that interfaces with a USB3 Adapter. Therefore, Physical Layer scrambling is not performed, regardless of the value of the Disable Scrambling bit in a received TS Ordered Set.
9.2.1 Link Layer		
9.2.1#1	IOP	An internal USB3 device port that interfaces to a USB3 Adapter Layer shall implement a USB Link Layer as defined in the USB 3.2 Specification with the modifications, configurations, and parameters described in this section.
9.2.1#2	TD 9.002	The Link Layer shall support Gen 2 single-Lane (2x1) and may support Gen 2 dual-Lane (2x2).
9.2.1#3	NT	No other Link capabilities shall be supported.
9.2.1#4	TD 9.002	An Internal USB3 device shall not send a LBPM PHY Capability with a value of 0 in bits [3:2].
9.2.1.1 Link Training and Status State Machine (LTSSM)		
9.2.1.1#1	NT	The Link Layer shall implement a Link Training and Status State Machine (LTSSM) with the following adjustments: Loopback state shall not be supported.
9.2.1.1#2	NT	The Link Layer shall implement a Link Training and Status State Machine (LTSSM) with the following adjustments: Compliance Mode state shall not be supported.
9.2.1.1#3	NT	The Link Layer shall implement a Link Training and Status State Machine (LTSSM) with the following adjustments: U1 state shall not be supported.
9.2.1.1#4	NT	The Link Layer shall implement a Link Training and Status State Machine (LTSSM) with the following adjustments: When the LTSSM of an Upstream Facing Port is in Disabled state, it shall unconditionally transition to the Rx.Detect state.
9.2.1.1#5	BT	The Link Layer shall implement a Link Training and Status State Machine (LTSSM) with the following adjustments: TS1 and TS2 shall not be scrambled.
9.2.1.2 Timers and Timeouts		
9.2.1.2#1	TD 9.014 TD 9.015 TD 9.016	An internal USB3 device shall use the parameter values in Table 9-4.
9.2.2 USB3 Protocol Layer		

9.2.2#1	NT	The internal USB3 device shall implement a Protocol Layer as defined in the USB3.2 Specification with the following adjustments: LDM Protocol shall not be supported over ports that interfaces a USB3 Adapter
9.2.3 Descriptors		
9.2.3#1	IOP	The internal USB3 device shall implement Descriptors as defined in the USB 3.2 Specification with the following adjustments: If a Router supports entering CL1 or CL2 when the USB3 link between the USB3 Adapter and the internal USB3 device is in U2 state, then the value for wU2DevExitLat shall include the maximum sum of the Router enter and exit time from the supported CLx.
9.3 Paths		
9.3#1	NT	A USB3 Adapter Layer shall put HopID=8 in the header of an outgoing Tunneled Packet before handing it off to the Transport Layer for routing.
9.3.1 Path Setup		
9.3.2 Path Teardown		
9.3.2#1	TD 9.013	When a Router detects a disconnect on a Downstream Facing Port, it shall set the Path Enable bit to 0b in the USB3 Adapter Configuration Capability of the corresponding USB3 Adapter.
9.3.2#2	TD 9.013	When the Path Enable bit is set to 0b and the Valid bit is set to 1b in the USB3 Adapter Configuration Capability the USB3 Adapter Layer shall: Not issue any Tunneled Packets to the Transport Layer
9.3.2#3	NT	When the Path Enable bit in a Downstream USB3 Adapter is set to 0b and the Valid bit is set to 1b in the USB3 Adapter Configuration Capability the Downstream USB3 Adapter Layer shall: Remove far-end receiver termination to the internal USB3 device as defined in Section 9.1.1.1.2.
9.3.2#4	IOP	The internal USB3 device port shall detect a disconnect within 500ms.
9.3.2#5		When a Device Router either detects a disconnect on an Upstream Facing Port, or the Path Enable bit in the Upstream USB3 Adapter is set to 0b and the Valid bit is set to 1b in the USB3 Adapter Configuration Capability: The Upstream USB3 Adapter Layer shall: Not issue any Tunneled Packets to the Transport Layer; Remove far-end receiver termination to the internal USB3 device as defined in Section 9.1.1.1.2.
9.3.2#6		When a Device Router either detects a disconnect on an Upstream Facing Port, or the Path Enable bit in the Upstream USB3 Adapter is set to 0b and the Valid bit is set to 1b in the USB3 Adapter Configuration Capability: The internal USB3 device port shall detect a disconnect within 500 ms.

9.3.2#7		<p>When a Device Router either detects a disconnect on an Upstream Facing Port, or the Path Enable bit in the Upstream USB3 Adapter is set to 0b and the Valid bit is set to 1b in the USB3 Adapter Configuration Capability: The integrated Enhanced SuperSpeed Hub within the Device Router shall ensure that any SuperSpeed or Enhanced SuperSpeed devices on its downstream-facing ports transition to the default state.</p>
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USB4 Ver. 2 Assertions

The following Table presents the USB4 Ver. 2 Specification Chapter 9 asserts.

Assertion #	Test	Assertion Description
9 USB3 Tunneling		
9#1	IOP	A USB4 host shall support USB3 Gen X tunneling.
9#2	TD 9.001 TD 9.001	The Host Router in a USB4 host shall have one Downstream USB3 Gen X Adapter per Downstream Facing Port.
9#3	NT	Each Downstream USB3 Gen X Adapter shall interface to a downstream port on the host controller.
9#4	BT	A USB4 hub shall support USB3 Gen X tunneling.
9#5	TD 9.018	A USB4 hub shall incorporate an internal USB SuperSpeed Plus hub per the USB 3.2 Specification with the modifications defined in this chapter.
9#6	TD 9.001 TD 9.001	The Device Router in a USB4 hub shall have: an Upstream USB3 Gen X Adapter that interfaces with the upstream port of the internal USB 3.2 hub.
9#7	NT	The Device Router in a USB4 hub shall have: for each Downstream Facing Port, a Downstream USB3 Gen X Adapter that interfaces to a downstream port on the internal USB 3.2 hub.
9#8	NT	A USB4 device that supports USB3 Gen X tunneling shall incorporate either an internal USB SuperSpeed Plus hub or an internal USB peripheral device per the USB 3.2 Specification with the modifications defined in this chapter.
9#9	TD 9.001 TD 9.001	The Device Router in a USB4 device that supports USB3 Gen X tunneling shall have an Upstream USB3 Gen X Adapter that interfaces to the upstream port of the internal USB 3.2 peripheral device or internal USB 3.2 hub.
9#10		The Host Router in a USB4 Host that supports Gen T tunneling shall have one Downstream USB3 Gen T Adapter per Downstream Facing Port.
9#11		Each Downstream USB3 Gen T Adapter shall interface to at least one downstream USB3 Gen T Port on the host controller.
9#12		A USB4-Based Dock may optionally support USB3 Gen T tunneling. A USB4-Based Dock that supports USB3 Gen T tunneling shall: Incorporate one or more USB3 Gen T Ports where each USB3 Gen T Port is connected to an Internal USB3 Gen T Peripheral.
9#13		A USB4-Based Dock may optionally support USB3 Gen T tunneling. A USB4-Based Dock that supports USB3 Gen T tunneling shall: Have a single Upstream USB3 Gen T Adapter that interfaces to each of the USB3 Gen T Port(s).

9#14		A USB4-Based Dock may optionally support USB3 Gen T tunneling. A USB4-Based Dock that supports USB3 Gen T tunneling shall: Support Gen X tunneling to all Internal USB3 Gen T Peripherals.
9#15		A USB4-Based Dock may optionally support USB3 Gen T tunneling. A USB4-Based Dock that supports USB3 Gen T tunneling shall: Support native USB 3.2 operation to all Internal USB3 Gen T Peripherals.
9#16		A USB4 Device that supports USB3 Gen T tunneling shall: Incorporate one or more USB3 Gen T Ports where each USB3 Gen T Port is connected to an Internal USB3 Gen T Peripheral.
9#17		A USB4 Device that supports USB3 Gen T tunneling shall: Have a single Upstream USB3 Gen T Adapter that interfaces to each of the USB3 Gen T Port(s).
9#18		A USB4 Device that supports USB3 Gen T tunneling shall: Support Gen X tunneling to all Internal USB3 Gen T Peripherals.
9#19		A USB4 Device that supports USB3 Gen T tunneling shall: Support native USB 3.2 operation to all Internal USB3 Gen T Peripherals.
9#20		An Internal USB3 Hub shall not contain any USB3 Gen T Ports.
9.1 USB3 Adapter Layer		
9.1.1 Encapsulation		
9.1.1#1	TD 9.002	A USB3 Adapter Layer shall follow the rules below when encapsulating a USB3 construct into a Tunneled Packet: An LFPS event, a Ordered Set, an Out of Band Message, a Link Management Packet, a Transaction Packet, and an Isochronous Timestamp Packet shall each be encapsulated into a single separate Tunneled Packet.
9.1.1#2	TD 9.008	A USB3 Adapter Layer shall follow the rules below when encapsulating a USB3 construct into a Tunneled Packet: A Data Packet shall be encapsulated into one or more Tunneled Packets. A Tunneled Packet shall not contain data from more than one Data Packet.
9.1.1#3	NT	A USB3 Adapter Layer shall follow the rules below when encapsulating a USB3 construct into a Tunneled Packet: Idle Symbols shall be discarded by a USB3 Adapter Layer.
9.1.1#4	TD 9.002 TD 9.003 TD 9.004 TD 9.005	A USB3 Adapter Layer shall follow the rules below when encapsulating a USB3 construct into a Tunneled Packet: The byte and bit ordering of an LFPS within a Tunneled Packet shall be as described in Section 9.1.1.1.
9.1.1#5	TD 9.002 TD 9.006	A USB3 Adapter Layer shall follow the rules below when encapsulating a USB3 construct into a Tunneled Packet: The byte and bit ordering of an Ordered Set within a Tunneled Packet shall be as described in Section 9.1.1.2.

9.1.1#6	TD 9.002	A USB3 Adapter Layer shall follow the rules below when encapsulating a USB3 construct into a Tunneled Packet: The bytes and bits in a Tunneled Packet payload, other than LFPS, Out of Band Messages, and Ordered Sets, shall be packed in the same order as the original USB3 construct, including the USB3 framing symbols.
9.1.1#7	TD 9.007	Moved to 9.1.3#1.
9.1.1#8	TD 9.007 Error! Reference source not found.	Moved to 9.1.3#2.
9.1.1#9	TD 9.002 TD 9.008	Table 9-2 defines the PDF values that shall be used for each type of USB construct.
9.1.1#10	NT	If a USB3 Adapter receives a Tunneled Packet with a PDF value that is Rsvd, it shall discard the Tunneled Packet and shall not send any Packets in response.
9.1.1#11		A USB3 Adapter Layer shall follow the rules below when encapsulating a USB3 construct into a Tunneled Packet: A Link Command for Gen X and a Coalesced Link Command for Gen T shall each be encapsulated into a single separate Tunneled Packet.
9.1.1#12		A USB3 Adapter Layer shall follow the rules below when encapsulating a USB3 construct into a Tunneled Packet: The byte and bit ordering of an Out of Band Message within a Tunneled Packet shall be as described in Section 9.1.1.10.
9.1.1.1 LFPS Encapsulation (Gen X Only)		
9.1.1.1#1	TD 9.002 TD 9.003 TD 9.004 TD 9.005	An LFPS Tunneled Packet shall contain a single Doubleword of payload as defined in Table 9-3.
9.1.1.1#2	TD 9.002 TD 9.003 TD 9.004 TD 9.005	An LFPS Tunneled Packet shall have the structure shown in Figure 9-1.
9.1.1.1#3	NT	A USB3 Gen X Adapter Layer shall not transfer an LFPS event to the Transport Layer unless that event is listed in Table 9-3.

9.1.1.1#4	TD 9.002 TD 9.003 TD 9.004 TD 9.005	A USB3 Gen X Adapter Layer shall set no more than one of bits [22:17] in an LFPS Tunneled Packet to 1b.
9.1.1.1.1 CRC		
9.1.1.1.1#1	NT	The <i>CRC</i> field shall cover bits [23:0] of payload.
9.1.1.1.1#2	NT	The <i>CRC</i> field shall be calculated as defined in Section 5.1.2.1.1, using the following bit order: Bit 7 to bit 0; Bit 15 to bit 8; Bit 23 to bit 16
9.1.1.1.1#3	NT	When a USB3 Gen X Adapter Layer receives an LFPS Tunneled Packet, it shall verify the <i>CRC</i> field value.
9.1.1.1.1#4	NT	After correcting an error, a Router shall continue on as if the error had never occurred.
9.1.1.1.1#5	NT	When an error is detected but not corrected, the packet with the error shall be dropped and no other action taken on its behalf.
9.1.1.1.2 Rx Term Enable		
9.1.1.1.2#1	TD 9.002	The USB3 Gen X Adapter Layer shall send an LFPS Tunneled Packet to the Transport Layer when the local value of Rx termination changes or when the Path Enable bit in the USB3 Gen X Adapter Configuration Capability changes from 0b to 1b.
9.1.1.1.2#2	TD 9.002	The LFPS Tunneled Packet shall be sent 3 times.
9.1.1.1.2#3	NT	A Router shall implement a mechanism that allows a USB3 Gen X Adapter Layer to indicate far-end receiver termination to the Internal USB3 ComponentComponent.
9.1.1.1.2#4	TD 9.002	When a Router is not in sleep state and is not in the process of transitioning into or out of sleep state, a USB3 Gen X Adapter Layer shall indicate far-end receiver termination to the Internal USB3 Component when all the following are true: Path Setup is complete; The USB3 Gen X Adapter Layer received an LFPS Tunneled Packet with the <i>Rx Term Enable</i> bit set to 1b and the USB3 Gen X Adapter Layer has not received any subsequent LFPS Tunneled Packets with the <i>Rx Term Enable</i> bit set to 0b.
9.1.1.1.2#5	BT	When a Router transitions to Sleep state, a USB3 Gen X Adapter Layer shall maintain the same indicator value as before entry to Sleep state.
9.1.1.1.2#6	BT	When the Router exits Sleep state, the USB3 Gen X Adapter Layer shall continue to maintain the indicator value until the <i>Valid</i> bit in USB3 Adapter Port Configuration Capability is set to 1b.
9.1.1.1.2#7	BT	After the <i>Valid</i> bit is set to 1b, the USB3 Gen X Adapter Layer shall set the indicator as defined above.

9.1.1.1.3 SCD1		
9.1.1.1.3#1	TD 9.002	The USB3 Gen X Adapter Layer shall send an LFPS Tunneled Packet to the Transport Layer with the <i>SCD1</i> bit set to 1b when instructed to do so by the Internal USB3 Component.
9.1.1.1.3#2	TD 9.002	The LFPS Tunneled Packet shall be sent 3 times.
9.1.1.1.3#3	NT	A USB3 Gen X Adapter Layer that receives an LFPS Tunneled Packet from the Transport Layer with the <i>SCD1</i> bit set to 1b shall indicate reception of SCD1 to the Internal USB3 Component until it receives a Tunneled Packet with different contents.
9.1.1.1.4 SCD2		
9.1.1.1.4#1	TD 9.002	The USB3 Gen X Adapter Layer shall send an LFPS Tunneled Packet to the Transport Layer with the <i>SCD2</i> bit set to 1b when instructed to do so by the Internal USB3 Component.
9.1.1.1.4#2	TD 9.002	The packet shall be sent 3 times.
9.1.1.1.4#3	NT	A USB3 Gen X Adapter Layer that receives an LFPS Tunneled Packet from the Transport Layer with the <i>SCD2</i> bit set to 1b shall indicate reception of SCD2 to the Internal USB3 Component until it receives a Tunneled Packet with different contents.
9.1.1.1.5 U2 Exit		
9.1.1.1.5#1	TD 9.003	The USB3 Gen X Adapter Layer shall send an LFPS Tunneled Packet to the Transport Layer with the <i>U2 Exit</i> bit set to 1b when the Internal USB3 Component indicates a U2 Exit event.
9.1.1.1.5#2	TD 9.003	The packet shall be sent 3 times.
9.1.1.1.5#3	TD 9.003	A USB3 Gen X Adapter Layer that receives an LFPS Tunneled Packet from the Transport Layer with the <i>U2 Exit</i> bit set to 1b shall indicate reception of a U2 Exit LFPS to the Internal USB3 Component until it receives a Tunneled Packet with different contents.
9.1.1.1.6 U3 Wakeup		
9.1.1.1.6#1	TD 9.004	When the Internal USB3 Component indicates the start of a U3 Wakeup event and a USB3 Path is enabled, a USB3 Gen X Adapter Layer shall send 3 LFPS Tunneled Packets to the Transport Layer. Each LFPS Tunneled Packet shall have the <i>U3 Wakeup</i> bit set to 1b.
9.1.1.1.6#2	TD 9.4	If a USB3 Gen X Adapter Layer detects the beginning of a U3 Wakeup event before a USB3 Path is enabled, it shall ignore the USB3 Wakeup event and shall not send any LFPS Tunneled Packets for that event.

9.1.1.1.6#3	NT	A USB3 Gen X Adapter Layer that receives an LFPS Tunneled Packet from the Transport Layer with the <i>U3 Wakeup</i> bit set to 1b shall indicate reception of a U3 Wakeup LFPS to the Internal USB3 Component until it receives a Tunneled Packet with different contents.
9.1.1.1.7 Warm Reset		
9.1.1.1.7#1	NT	When Warm Reset is asserted by the Internal USB3 Component, the Downstream USB3 Gen X Adapter Layer shall: Discard any queued Tunneled Packets.
9.1.1.1.7#2	TD 9.005	When Warm Reset is asserted by the Internal USB3 Component, the Downstream USB3 Gen X Adapter Layer shall: Send an LFPS Tunneled Packet to the Transport Layer with the Warm Reset bit set to 1b.
9.1.1.1.7#3	TD 9.005	The LFPS Tunneled Packet shall be sent 3 times.
9.1.1.1.7#4	NT	While Warm Reset is active, a Downstream USB3 Adapter shall discard any Tunnel Packets it receives and clear any indication of LFPS reception towards the Internal USB3 Component.
9.1.1.1.7#5	NT	An Upstream USB3 Gen X Adapter Layer that receives an LFPS Tunneled Packet with the Warm Reset bit set to 1b shall indicate assertion of a Warm Reset to the Internal USB3 Component until it receives a Tunneled Packet with different contents.
9.1.1.1.7#6	TD 9.005	The Downstream USB3 Gen X Adapter Layer shall send an LFPS Tunneled Packet to the Transport Layer with the Warm Reset bit set to 0b when Warm Reset is de-asserted by the Internal USB3 Component.
9.1.1.1.7#7	TD 9.005	The LFPS Tunneled Packet shall be sent 3 times.
9.1.1.1.7#8	NT	An Upstream USB3 Gen X Adapter Layer that receives an LFPS Tunneled Packet from the Transport Layer with the Warm Reset bit set to 0b shall indicate de-assertion of a Warm Reset to the Internal USB3 Component until it receives a Tunneled Packet with different contents.
9.1.1.1.7#9	NT	After Warm Reset is de-asserted, a USB3 Gen X Adapter Layer shall not forward any Ordered Sets, packets, or events to the Internal USB3 Component that were received before or during Warm Reset assertion.
9.1.1.1.8 LBPM		
9.1.1.1.8#1	TD 9.002	The USB3 Gen X Adapter Layer shall send an LFPS Tunneled Packet to the Transport Layer with the <i>LBPM Enable</i> bit set to 1b when instructed to do so by the Internal USB3 Component.
9.1.1.1.8#2	TD 9.002	The LBPM field shall contain the USB3 LBPM construct. Bits[7:0] of the USB3 LBPM are mapped to Bits[7:0] of the LBPM field, respectively.
9.1.1.1.8#3	TD 9.002	The LFPS Tunneled Packet shall be sent 3 times.

9.1.1.1.8#4	NT	A USB3 Gen X Adapter Layer that receives an LFPS Tunneled Packet with the <i>LBPM Enable</i> bit set to 1b shall do the following until it receives a Tunneled Packet with different contents: Indicate reception of LBPM to the Internal USB3 Component.
9.1.1.1.8#5	NT	A USB3 Gen X Adapter Layer that receives an LFPS Tunneled Packet with the <i>LBPM Enable</i> bit set to 1b shall do the following until it receives a Tunneled Packet with different contents: Communicate the value in the <i>LBPM</i> field to the Internal USB3 Component.
9.1.1.1.9 LFPS Stop		
9.1.1.1.9#1	TD 9.004	A USB3 Gen X Adapter Layer shall send an LFPS Tunneled Packet to the Transport Layer with bits [22:17] equal 00h for the following cases: The Internal USB3 Component indicates no LFPS Response Timeout for U3 Exit
9.1.1.1.9#2	TD 9.005	A USB3 Gen X Adapter Layer shall send an LFPS Tunneled Packet to the Transport Layer with bits [22:17] equal 00h for the following cases: The Internal USB3 Component indicates Warm Reset done
9.1.1.1.9#3	TD 9.004 TD 9.005	The LFPS Tunneled Packet shall be sent 3 times.
9.1.1.2 Ordered Set Encapsulation (Gen X Only)		
9.1.1.2#1	TD 9.002 TD 9.006	An Ordered Set Tunneled Packet shall have the single Doubleword payload defined in Table 9-3.
9.1.1.2#2	TD 9.002 TD 9.006	An Ordered Set Tunneled Packet shall have the structure shown in Figure 9-2.
9.1.1.2#3	TD 9.002 TD 9.006	A USB3 Gen X Adapter Layer shall set one and no more than one of bits [2:0] in an Ordered Set Tunneled Packet.
9.1.1.2#4	TD 9.002 TD 9.006	TS1 or TS2 Ordered Sets shall contain the USB3 Link Functionality construct. Bits[7:0] of the USB3 Link Functionality are mapped to Bits[7:0] of the Link Functionality field, respectively: TSEQ Ordered Set – set to 00h by the USB3 Adapter Layer; SDS Ordered Set – set to 00h by the USB3 Adapter Layer.
9.1.1.2#5	TD 9.002 TD 9.006	When a USB3 Adapter Layer receives a TSEQ, TS1, TS2, or SDS Ordered Set from the USB3 Gen X Port that is not identical to the previous Ordered Set received from the USB3 Gen X Port, it shall send 3 copies of an Ordered Set Tunneled Packet to the Transport Layer, with the respective fields set per Table 9-4.
9.1.1.2#6	NT	All other Ordered Sets received from the Internal USB3 Component shall be discarded by the USB3 Gen X Adapter Layer and shall not cause an Ordered Set Tunneled Packet to be sent to the Transport Layer.

9.1.1.2#7	NT	A USB3 Gen X Adapter Layer shall only send Ordered Sets that target Lane 0 to the Transport Layer.
9.1.1.2#8	NT	A USB3 Gen X Adapter Layer shall discard Ordered Sets that target a non-zero Lane so that they are not sent over the USB4 Fabric.
9.1.1.2#9	NT	When a USB3 Gen X Adapter Layer receives an Ordered Set Tunneled Packet, it shall verify the <i>CRC</i> field value.
9.1.1.2#10	NT	When an error is detected but not corrected, the packet with the error shall be dropped and no other action taken on its behalf.
9.1.1.2#11	IOP	After verifying the <i>CRC</i> field value: If the <i>TS1</i> bit in the received Ordered Set Tunneled Packet is set to 1b, the USB3 Adapter Layer shall indicate reception of TS1 Ordered Set to the Internal USB3 Component.
9.1.1.2#12	IOP	After verifying the <i>CRC</i> field value: If the <i>TS2</i> bit in the received Ordered Set Tunneled Packet is set to 1b, the USB3 Adapter Layer shall indicate reception of TS2 Ordered Set to the Internal USB3 Component.
9.1.1.2#13	IOP	After verifying the <i>CRC</i> field value: If the <i>SDS</i> bit in the received Ordered Set Tunneled Packet is set to 1b, a USB3 Adapter Layer shall indicate reception of SDS Ordered Set to the Internal USB3 Component.
9.1.1.3 Link Command Encapsulation		
9.1.1.3.1 Gen X Link Command Encapsulation		
9.1.1.3.1#1	IOP	A USB3 Gen X Adapter Layer that receives a Link Command from the Internal USB3 Component shall send a Link Command Tunneled Packet to the Transport Layer with a 2-Doubleword payload. [Note: same as 9.1.1.3#1 for Ver. 1]
9.1.1.3.1#2	IOP	The Link Command Tunneled Packet payload shall contain the Link Command. [Note: same as 9.1.1.3#2 for Ver. 1]
9.1.1.3.1#3	NT	Upon receiving a Link Command Tunneled Packet from the Transport Layer, a USB3 Adapter Layer shall transfer the Link Command Tunneled Packet to the internal USB Port. [Note: same as 9.1.1.3#3 for Ver. 1]
9.1.1.3.2 Gen T Link Command Encapsulation		
9.1.1.3.2#1		A Gen T Adapter that receives a Coalesced Link Command from the Internal USB3 Component shall send a Link Command Tunneled Packet with one of the formats shown in Figure 9-4.
9.1.1.3.2#2		Upon receiving a Link Command Tunneled Packet from the Transport Layer, a USB3 Gen T Adapter Layer shall extract the Coalesced Link Command from the Tunneled Packet and send the Coalesced Link Command to the Internal USB3 Component.
9.1.1.4 Idle Symbols		

9.1.1.4#1	NT	A USB3 Adapter Layer shall drop any Idle Symbols received from the Internal USB3 Component.
9.1.1.5 LMP Encapsulation (Gen X Only)		
9.1.1.5#1	IOP	A USB3 Gen X Adapter Layer that receives a USB3 Link Management Packet (LMP) from the Internal USB3 Component shall send an LMP Tunneled Packet to the Transport Layer with a 5 Doubleword payload.
9.1.1.5#2	IOP	The LMP Tunneled Packet payload shall contain the framed LMP.
9.1.1.5#3	NT	Upon receiving an LMP Tunneled Packet from the Transport Layer, a USB3 Adapter Layer shall transfer the LMP to the internal USB device.
9.1.1.6 TP Encapsulation		
9.1.1.6#1	IOP	A USB3 Adapter Layer that receives a USB3 Transaction Packet (TP) from the Internal USB3 Component shall send a TP Tunneled Packet to the Transport Layer.
9.1.1.6#2	IOP	The TP Tunneled Packet payload shall contain the framed TP.
9.1.1.6#3		If the USB3 Adapter Layer receives a Deferred DPH from the Internal USB3 Component, it shall send a TP Tunneled Packet to the Transport Layer.
9.1.1.6#4		The payload shall contain the Deferred DPH and its USB3 framing symbols.
9.1.1.6#5	NT	Upon receiving a TP Tunneled Packet from the Transport Layer, a USB3 Adapter Layer shall transfer the TP to the Internal USB3 Component.
9.1.1.6#6		For a USB3 Gen X Adapter Layer, the [TP Tunneled Packet] payload shall contain the framed TP.
9.1.1.6#7		For a USB3 Gen X Adapter Layer, the [TP Tunneled Packet] payload shall contain the Deferred DPH and its USB3 framing symbols
9.1.1.7 ITP Encapsulation		
9.1.1.7#1	NT	A Downstream USB3 Adapter Layer that receives an Isochronous Timestamp Packet (ITP) from the Internal USB3 Component shall: set the TMU Time Capture field to the nanosecond portion of the current Host Router Time (t_g).
9.1.1.7#2	TD 9.010	A Downstream USB3 Adapter Layer that receives an Isochronous Timestamp Packet (ITP) from the Internal USB3 Component shall: send an ITP Tunneled Packet with the format defined in Figure 9-5 (for Gen X) or Figure 9-6 (for Gen T) to the Transport Layer. The payload contains the ITP, followed by 2 Doublewords of the <i>TMU Time Capture</i> field. For a USB3 Gen X Adapter Layer, the ITP shall include the four framing symbols.

9.1.1.7#3	TD 9.010	An Upstream USB3 Adapter Layer that receives an ITP Tunneled Packet from the Transport Layer shall: [if the Router supports the Time Synchronization Protocol] Update the Delta field of the ITP according to the formula below: $\text{Updated Delta} = \text{Delta} + (\text{Host Router time Nanosecond} - \text{TMU Time Capture}) / \text{tIsochTimeStampGranularity}$
9.1.1.7#4	TD 9.010	A USB3 Adapter Layer shall meet the required accuracy of the <i>Delta</i> field in the ITP as defined by Section 8.7 of the USB 3.2 Specification.
9.1.1.7#5	NT	An Upstream USB3 Adapter Layer that receives an ITP Tunneled Packet from the Transport Layer shall: If the Adapter Layer is a USB3 Gen X Adapter Layer, update the <i>CRC-16</i> field in the ITP.
9.1.1.7#6	NT	An Upstream USB3 Adapter Layer that receives an ITP Tunneled Packet from the Transport Layer shall: Forward the ITP to the internal USB device.
9.1.1.7#7	TD 9.010	If the Time Disruption bit is set to 1b in Router Configuration Space, an Upstream USB3 Adapter Layer shall set the Delayed bit in the Link Control Word to 1b.
9.1.1.7#8	NT	A USB3 Adapter Layer shall recalculate the CRC5 field within the Link Control Word if it modified the Delayed bit.
9.1.1.7#9		An Upstream USB3 Adapter Layer that receives an ITP Tunneled Packet from the Transport Layer shall: If the Router does not support the Time Synchronization Protocol, proceed to step 4.
9.1.1.8 Data Packet (DP) Encapsulation		
9.1.1.8#1	TD 9.008	If the size of a USB3 Data Packet is 252 bytes or less, then the USB3 Adapter Layer shall send a single Tunneled Packet of type Start DP Segment to the Transport Layer.
9.1.1.8#2	TD 9.008	The Tunneled Packet shall carry the unsegmented USB3 Data Packet as payload and any padding needed for DW alignment.
9.1.1.8#3	TD 9.008	If the size of a USB3 Data Packet is larger than 252 bytes, the USB3 Data Packet shall be segmented into multiple Tunneled Packets as shown in Figure 9-6.
9.1.1.8#4	TD 9.008	When a USB3 Adapter Layer segments a USB3 Data Packet into Multiple Tunneled Packets, it shall follow the rules: All Tunneled Packets with the possible exception of the last packet shall include 252 bytes of payload.
9.1.1.8#5	TD 9.008	When a USB3 Adapter Layer segments a USB3 Data Packet into Multiple Tunneled Packets, it shall follow the rules: The first Tunneled Packet shall be of type Start DP Segment.
9.1.1.8#6	TD 9.008	When a USB3 Adapter Layer segments a USB3 Data Packet into Multiple Tunneled Packets, it shall follow the rules: Any following Tunneled Packets other than the last Tunneled Packet shall be of type Middle DP Segment.

9.1.1.8#7	TD 9.007 NT	When a USB3 Adapter Layer segments a USB3 Data Packet into Multiple Tunneled Packets, it shall follow the rules: The last Tunneled Packet shall be of type End DP Segment.
9.1.1.8#8	TD 9.007 NT	When a USB3 Adapter Layer segments a USB3 Data Packet into Multiple Tunneled Packets, it shall follow the rules: The last Tunneled Packet shall pad the payload to be Doubleword aligned.
9.1.1.8#9	TD 9.007 NT	When a USB3 Adapter Layer segments a USB3 Data Packet into Multiple Tunneled Packets, it shall follow the rules: The last Tunneled Packet shall have payload size that does not exceed 252 bytes.
9.1.1.8#10	NT	When a USB3 Adapter Layer segments a USB3 Data Packet into Multiple Tunneled Packets, it shall follow the rules: The Tunneled Packets shall be sent to the Transport layer such that the byte ordering of the original USB3 Data Packet is maintained.
9.1.1.8#11	TD 9.009	When re-assembling Tunneled Packets into USB3 Data Packets, the USB3 Adapter Layer shall: Drop a Tunneled Packet of type Middle DP Segment that comes immediately after a Tunneled Packet of type End DP Segment.
9.1.1.8#12	TD 9.009	When re-assembling Tunneled Packets into USB3 Data Packets, the USB3 Adapter Layer shall: Drop a Tunneled Packet of type End DP Segment that comes immediately after a Tunneled Packet of type End DP Segment.
9.1.1.8#13	TD 9.009	When re-assembling Tunneled Packets into USB Data Packets, the USB3 Adapter Layer shall: Nullify or partially nullify a USB3 Data Packet when both of the following are true: A Tunneled packet of type Start DP Segment is received and the length information in the USB3 DPH indicates it does not fit into a single Tunneled Packet; A Tunneled Packet of type End DP Segment is not received within tReassemble from the reception of the Tunneled Packet of type Start DP Segment.
9.1.1.9 Nullified DP (Gen T Only)		
9.1.1.9#1		A USB3 Gen T Adapter Layer that receives a nullified USB3 Data Packet (NDP) from the Internal USB3 Component shall send an NDP Tunneled Packet to the Transport Layer.
9.1.1.9#2		Upon receiving an NDP Tunneled Packet from the Transport Layer, a USB3 Gen T Adapter Layer shall transfer the nullified USB3 Data Packet to the Internal USB3 Component.
9.1.1.10 OOBM Encapsulation (Gen T Only)		
9.1.1.10#1		An OOBM Tunneled Packet shall contain a single Doubleword of payload as defined in Table 9-5 and shall have the structure shown in Figure 9-11.
9.1.1.10#2		A USB3 Gen T Adapter shall only set one of bits 5, 6, 7, 20, 21, and 23 in an OOBM Tunneled Packet payload.
9.1.1.10#3		The CRC shall be calculated as defined in Section 9.1.1.1.1.

9.1.1.10.1 CRC		
9.1.1.10.1#1		The CRC field shall be calculated as defined in Section 9.1.1.1.1, using the following bit order: 1) Bit 7 to bit 0; 2) Bit 15 to bit 8; 3) Bit 23 to bit 16.
9.1.1.10.1#2		When a USB3 Gen T Adapter Layer receives an OOBM Tunneled Packet, it shall verify the CRC field value.
9.1.1.10.1#3		After correcting an error, a Router shall continue on as if the error had never occurred.
9.1.1.10.1#4		When an error is detected but not corrected, the packet with the error shall be dropped and no other action taken on its behalf.
9.1.1.10.2 Link Error		
9.1.1.10.2#1		An Upstream USB3 Gen T Adapter Layer shall send an OOBM Tunneled Packet to the Transport Layer with the Link Error bit set to 1b when it receives a link error indication from the Internal USB3 Component.
9.1.1.10.2#2		When a Downstream USB3 Gen T Adapter Layer receives an OOBM Tunneled Packet from the Transport Layer with the Link Error bit set to 1b, it shall indicate reception of link error to the Internal USB3 Component.
9.1.1.10.3 Port Disabled		
9.1.1.10.3#1		A USB3 Gen T Adapter Layer shall send an OOBM Tunneled Packet to the Transport Layer with the Port Disabled bit set to 1b when it receives a port disabled indication from the Internal USB3 Component.
9.1.1.10.3#2		When a USB3 Gen T Adapter Layer receives an OOBM Tunneled Packet from the Transport Layer with the Port Disabled bit set to 1b, it shall indicate reception of port disabled to the Internal USB3 Component
9.1.1.10.4 Port Reset Done		
9.1.1.10.4#1		An Upstream USB3 Gen T Adapter Layer shall send an OOBM Tunneled Packet to the Transport Layer with the Port Reset Done bit set to 1b when it receives a port reset done indication from the Internal USB3 Component.
9.1.1.10.4#2		When a Downstream USB3 Gen T Adapter Layer receives an OOBM Tunneled Packet from the Transport Layer with the Port Reset Done bit set to 1b, it shall indicate reception of port reset done to the Internal USB3 Component.
9.1.1.10.5 U3 Resume		
9.1.1.10.5#1		An Upstream USB3 Gen T Adapter Layer shall send an OOBM Tunneled Packet to the Transport Layer with the U3 Resume bit set to 1b when it receives a U3 resume indication from the Internal USB3 Component.

9.1.1.10.5#2		When a Downstream USB3 Gen T Adapter Layer receives an OOBM Tunneled Packet from the Transport Layer with the U3 Resume bit set to 1b, it shall indicate reception of U3 resume to the Internal USB3 Component.
9.1.1.10.6 Port Reset		
9.1.1.10.6#1		A Downstream USB3 Gen T Adapter Layer shall send an OOBM Tunneled Packet to the Transport Layer with the Port Reset bit set to 1b when it receives a port reset indication from the Internal USB3 Component.
9.1.1.10.6#2		When an Upstream USB3 Gen T Adapter Layer receives an OOBM Tunneled Packet from the Transport Layer with the Port Reset bit set to 1b, it shall indicate reception of port reset to the Internal USB3 Component.
9.1.1.10.7 Link Ready		
9.1.1.10.7#1		A USB3 Gen T Adapter Layer shall send an OOBM Tunneled Packet to the Transport Layer with the Link Ready bit set to 1b when it receives a link ready indication from the Internal USB3 Component.
9.1.1.10.7#2		When a USB3 Gen T Adapter Layer receives an OOBM Tunneled Packet from the Transport Layer with the Link Ready bit set to 1b, it shall indicate reception of link ready to the Internal USB3 Component.
9.1.2 Bandwidth Negotiation (Gen X Only)		
9.1.2#1	TD 9.011	When the <i>Host Controller Ack</i> field = 0: The value in the <i>Consumed Upstream Bandwidth</i> field shall not exceed the value in the <i>Allocated Upstream Bandwidth</i> field.
9.1.2#2	TD 9.012	When the <i>Host Controller Ack</i> field = 0: The value in the <i>Consumed Downstream Bandwidth</i> field shall not exceed the value in the <i>Allocated Downstream Bandwidth</i> field.
9.1.2#3	NT	When the <i>Host Controller Ack</i> field = 1: The internal host controller shall not read the <i>Allocated Upstream Bandwidth</i> or <i>Allocated Downstream Bandwidth</i> fields
9.1.2#4	NT	When the <i>Host Controller Ack</i> field = 1: The internal host controller shall not update <i>Consumed Upstream Bandwidth</i> or <i>Consumed Downstream Bandwidth</i> fields.
9.1.2#5	TD 9.011 TD 9.012	The internal host controller shall negotiate bandwidth as shown in Figure 9-7.
9.1.2#6	TD 9.002	When the USB3 link reaches U0, a USB3 Adapter Layer shall: Set the <i>Actual Link Rate</i> field to indicate the established link rate.
9.1.2#7	TD 9.002	When the USB3 link reaches U0, a USB3 Adapter Layer shall: Set the <i>USB3 Link Valid</i> field to 1b.

9.1.2#8	TD 9.003 TD 9.004	When the USB3 link is not in U0, Recovery, U2 or U3, a USB3 Adapter Layer shall set the <i>USB3 Link Valid</i> field to 0b.
9.1.2#9		A Router shall set the Host Controller Ack bit to 1b within tSetHCA time after the Connection Manager Request bit is set to 1b
9.1.3 Flow Control		
9.1.3#1	TD 9.007 TD 9.009	A USB3 Adapter shall not discard a Tunneled Packet due to lack of credits in the USB4 Fabric.
9.1.3#2	TD 9.007 NT	When insufficient credits are available, the Router shall queue the Tunneled Packet and shall transport it once sufficient credits are available.
9.1.4 PM Packet (Gen T Only)		
9.1.4#1		When a USB3 Gen T Port transitions to the U2 state, the USB3 Gen T Adapter shall send a PM Packet over the Path that corresponds to the USB3 Gen T Port.
9.1.4#2		If the U2CL2 Enable bit is set to 1b in the Gen T Port Configuration Space, then the CLx State field shall be set to 11b (both CL1 and CL2 are allowed). Otherwise, the CLx State field shall be set to 01b.
9.1.4#3		When a USB3 Gen T Port transitions to the U3 state, the USB3 Gen T Adapter shall send a PM Packet over the Path that corresponds to the USB3 Gen T Port.
9.1.4#4		The CLx State field shall be set to 11b (both CL1 and CL2 are allowed).
9.1.5 Path Established (Gen T Only)		
9.1.5#1		A USB3 Gen T Adapter shall implement a mechanism that indicates that a Path is established to the Internal USB3 Gen T Component.
9.1.5#2		When a Router is not in sleep state and is not in the process of transitioning into or out of sleep state, a USB3 Gen T Adapter Layer shall set the Path Established indicator towards the corresponding USB3 Gen T Port according to the following rules: Path Established = true when the Path Enable bit is set to 1b and Valid bit is set to 1b; Path Established = false when the Path Enable bit is set to 0b and Valid bit is set to 1b; Path Established retains its value when the Valid bit is set to 0b.
9.1.5#3		When a Router transitions to sleep state, a USB3 Gen T Adapter Layer shall maintain the same Path Established indicator value as before entry to sleep state.
9.1.5#4		When the Router exits sleep state, the USB3 Gen T Adapter Layer shall continue to maintain the indicator value until the Valid bit in the USB3 Gen T Adapter Configuration Capability is set to 1b.
9.1.5#5		After the Valid bit is set to 1b, it shall set the Path Established indicator as defined above.

9.1.6 Timing Parameters		
9.1.6#1	TD 9.009	Time between Tunneled Packets which is used to determine loss of a USB3 Data Packet segment. [Note: same as 9.1.3#1 for Ver. 1]
9.2 Internal USB3 Gen X Component		
9.2#1	NT	A USB3 Physical Layer is not needed in a USB3 port that interfaces with a USB3 Gen X Adapter. Therefore, Physical Layer scrambling is not performed, regardless of the value of the Disable Scrambling bit in a received TS Ordered Set.
9.2.1 Link Layer		
9.2.1#1	IOP	An Internal USB3 Component port that interfaces to a USB3 Gen X Adapter Layer shall implement a USB Link Layer as defined in the USB 3.2 Specification with the modifications, configurations, and parameters described in this section.
9.2.1#2	TD 9.002	The Link Layer shall support Gen 2 single-Lane (2x1) and may support Gen 2 dual-Lane (2x2).
9.2.1#3	NT	No other Link capabilities shall be supported.
9.2.1#4	TD 9.002	An Internal USB3 Component shall not send a LBPM PHY Capability with a value of 0 in bits [3:2].
9.2.1.1 Link Training and Status State Machine (LTSSM)		
9.2.1.1#1	NT	The Link Layer shall implement a Link Training and Status State Machine (LTSSM) with the following adjustments: Loopback state shall not be supported.
9.2.1.1#2	NT	The Link Layer shall implement a Link Training and Status State Machine (LTSSM) with the following adjustments: Compliance Mode state shall not be supported.
9.2.1.1#3	NT	The Link Layer shall implement a Link Training and Status State Machine (LTSSM) with the following adjustments: U1 state shall not be supported.
9.2.1.1#4	NT	The Link Layer shall implement a Link Training and Status State Machine (LTSSM) with the following adjustments: When the LTSSM of an Upstream Facing Port is in Disabled state, it shall unconditionally transition to the Rx.Detect state.
9.2.1.1#5	BT	The Link Layer shall implement a Link Training and Status State Machine (LTSSM) with the following adjustments: TS1 and TS2 shall not be scrambled.
9.2.1.2 Timers and Timeouts		

9.2.1.2#1	TD 9.014 TD 9.015 TD 9.016	An Internal USB3 Component shall use the parameter values in Table 9-4.
9.2.2 USB3 Protocol Layer		
9.2.2#1	NT	The Internal USB3 Component shall implement a Protocol Layer as defined in the USB3.2 Specification with the following adjustments: LDM Protocol shall not be supported over ports that interfaces a USB3 Adapter
9.2.3 Descriptors		
9.2.3#1	IOP	The Internal USB3 Component shall implement Descriptors as defined in the USB 3.2 Specification with the following adjustments: If a Router supports entering CL1 or CL2 when the USB3 link between the USB3 Gen X Adapter and the Internal USB3 Component is in U2 state, then the value for wU2DevExitLat shall include the maximum sum of the Router enter and exit time from the supported CLx.
9.3 USB Gen X Paths		
9.3#1	NT	A USB3 Gen X Adapter Layer shall put HopID=8 in the header of an outgoing Tunneled Packet before handing it off to the Transport Layer for routing.
9.3.1 Path Setup		
9.3.2 Path Teardown		
9.3.2#1		Deprecated.
9.3.2#2	TD 9.013	When a Device Router either detects a disconnect on an Upstream Facing Port, or the <i>Path Enable</i> bit in the Upstream USB3 Gen X Adapter is set to 0b and the <i>Valid</i> bit is set to 1b in the USB3 Gen X Adapter Configuration Capability: The Upstream USB3 Gen X Adapter Layer shall: Not issue any Tunneled Packets to the Transport Layer.
9.3.2#3	NT	When a Device Router either detects a disconnect on an Upstream Facing Port, or the <i>Path Enable</i> bit in the Upstream USB3 Gen X Adapter is set to 0b and the <i>Valid</i> bit is set to 1b in the USB3 Gen X Adapter Configuration Capability: The Upstream USB3 Gen X Adapter Layer shall: Remove far-end receiver termination to the Internal USB3 Component as defined in Section 9.1.1.1.2.
9.3.2#4	IOP	When a Device Router either detects a disconnect on an Upstream Facing Port, or the <i>Path Enable</i> bit in the Upstream USB3 Gen X Adapter is set to 0b and the <i>Valid</i> bit is set to 1b in the USB3 Gen X Adapter Configuration Capability: The Internal USB3 Component port shall detect a disconnect within 500 ms.

9.3.2#5		When a Device Router either detects a disconnect on an Upstream Facing Port, or the <i>Path Enable</i> bit in the Upstream USB3 Gen X Adapter is set to 0b and the <i>Valid</i> bit is set to 1b in the USB3 Gen X Adapter Configuration Capability: The integrated Enhanced SuperSpeed Hub within the Device Router shall ensure that any SuperSpeed or Enhanced SuperSpeed devices on its downstream-facing ports transition to the default state.
9.3.2#6		When the Path Enable bit in a Downstream USB3 Gen X Adapter is set to 0b (including a Downstream Facing Port disconnect - see Section 4.4.5.2.1) and the Valid bit is set to 1b in the USB3 Gen X Adapter Configuration Capability: The Downstream USB3 Gen X Adapter Layer shall: Not issue any Tunneled Packets to the Transport Layer.
9.3.2#7		When the Path Enable bit in a Downstream USB3 Gen X Adapter is set to 0b (including a Downstream Facing Port disconnect - see Section 4.4.5.2.1) and the Valid bit is set to 1b in the USB3 Gen X Adapter Configuration Capability: The Downstream USB3 Gen X Adapter Layer shall: Remove far-end receiver termination to the Internal USB3 Component as defined in Section 9.1.1.1.2.
9.3.2#8		When the Path Enable bit in a Downstream USB3 Gen X Adapter is set to 0b (including a Downstream Facing Port disconnect - see Section 4.4.5.2.1) and the Valid bit is set to 1b in the USB3 Gen X Adapter Configuration Capability: The Internal USB3 Component port shall detect a disconnect within 500 ms.
9.4 Internal USB3 Gen T Component		
9.4#1		An Internal USB3 Gen T Component shall operate according to the rules for SuperSpeedPlus operation as defined in the USB 3.2 Specification with the modifications defined in this section.
9.4.1 Link Layer		
9.4.1.1 USB3 Gen T Packet Framing		
9.4.1.1#1		An Internal USB3 Gen T Component shall not use DPHP, SDP, SHP, SLC and these framing symbols are deprecated.
9.4.1.1#2		EPF along with END and EDB shall still be used to indicate whether a DPP is good (END) or bad (EDB).
9.4.1.1#3		The length field replica in a DPHP shall not be transmitted in a USB3 Gen T Tunneled Packet.
9.4.1.2 Link Command Word Definition		
9.4.1.2#1		The Link Command Word shall be 16 bits long and shall have the format shown in Table 9-8.
9.4.1.3 Link Control Word		
9.4.1.3#1		The Link Control Word shall have the format shown in Figure 9-14.

9.4.1.4 Link Credits and Burst Size		
9.4.1.5 Link Command Aggregation and Coalescing		
9.4.1.5#1		An Internal USB3 Gen T Component shall support Link Command Aggregation and Coalescing.
9.4.1.5#2		Once the link is in LTSSM.U0, the Internal USB3 Gen T Component shall turn on Link Command Aggregation if the Link Commands Aggregation Enable bit is set to 1b in the USB3 Gen T Adapter Configuration Space.
9.4.1.5#3		An Internal USB3 Gen T Component shall send a Link Command (if it has one to send) without waiting for tLC_AggrThreshold upon any of the following: Entry into LTSSM.U0; After a tLC_AggrThreshold time interval passes without any Link Commands; If the Link Command is not an LGOOD_n, LCRD1_x, or LCRD2_y.
9.4.1.5#4		All subsequent Link Commands shall be sent at tLC_AggrThreshold intervals except as listed above.
9.4.1.5#5		The Internal USB3 Gen T Component shall send the last LGOOD_n/LCRD1_x/LCRD2_y Link Commands as per the Header Packets received during the tLC_AggrThreshold period.
9.4.1.5#6		In addition, if the Internal USB3 Gen T Component frees up any Header Buffers, it shall send the LCRD1_x/LCRD2_y corresponding to the last Header Buffer that was freed.
9.4.1.5#7		In addition to Link Command Aggregation, an Internal USB3 Gen T Component shall perform Link Command Coalescing.
9.4.1.5#8		A Coalesced Link Command Packet shall contain either two or four Link Commands.
9.4.1.5#9		The ordering rules of the Link Commands within a Coalesced Link Command Packet are detailed below: A Gen T Port shall send 2 DWs if both LCRD1_x and LCRD2_y are present, or if there is a Link Command which is not LGOOD_n/LCRD1_x/LCRD2_y, otherwise it shall send a single DW.
9.4.1.5#10		The ordering rules of the Link Commands within a Coalesced Link Command Packet are detailed below: First word (Word0 in DW0): If LGOOD_n is present then LGOOD_n, else NOP.
9.4.1.5#11		The ordering rules of the Link Commands within a Coalesced Link Command Packet are detailed below: Second word (Word1 in DW0): If LCRD1_x is present then LCRD1_x, else if LCRD2_y is present then LCRD2_y, else NOP.
9.4.1.5#12		The ordering rules of the Link Commands within a Coalesced Link Command Packet are detailed below: Third word (Word0 in DW1): If LCRD2_y is present and was not included in the second word then LCRD2_y, else NOP,

9.4.1.5#13		The ordering rules of the Link Commands within a Coalesced Link Command Packet are detailed below: Fourth word (Word1 in DW1): If any other Link Command present then that Link Command, else NOP.
9.4.1.6 Link Training and Status State Machine (LTSSM)		
9.4.1.6#1		A USB3 Gen T Port shall support the LTSSM shown in Figure 9-16.
9.4.1.6.1 LTSSM.DISCONNECT		
9.4.1.6.1#1		A USB3 Gen T Port shall remain in this state until the USB3 Gen T Adapter indicates that Path Established is true.
9.4.1.6.1#2		When Path Established is true, the USB3 Gen T Port shall send an OOBM.LinkReady message to the link partner and start the tOOBMPolling timer.
9.4.1.6.1#3		Once the Link Ready handshake is successful, the LTSSM shall move to U0 state.
9.4.1.6.1#4		The LTSSM shall transition to the DISCONNECT state upon any of the following conditions: After POR.
9.4.1.6.1#5		The LTSSM shall transition to the DISCONNECT state upon any of the following conditions: For a USB3 Gen T downstream port, from the LTSSM.DISABLED state when directed to enable the port and Path Established is false.
9.4.1.6.1#6		The LTSSM shall transition to the DISCONNECT state upon any of the following conditions: For a USB3 Gen T downstream port (from any state other than DISABLED) or a USB3 Gen T upstream port, when Path Established is false in the corresponding USB3 Gen T Adapter.
9.4.1.6.2 LTSSM.U0		
9.4.1.6.2#1		A USB3 Gen T Port shall enter the LTSSM.U0 state as follows: From the LTSSM.DISCONNECT state: When Path Established is true and a Link Ready handshake is successful.
9.4.1.6.2#2		A USB3 Gen T Port shall enter the LTSSM.U0 state as follows: From the LTSSM.U2 and LTSSM.U3 states: After a Link Ready handshake is successful.
9.4.1.6.2#3		The USB3 Gen T Port shall continue to send OOBM.LinkReady messages at tOOBMPolling intervals until it receives an OOBM.LinkReady from the link partner.
9.4.1.6.2#4		After receiving at least one OOBM.LinkReady from the link partner, a USB3 Gen T Port shall send one last OOBM.LinkReady.
9.4.1.6.2#5		The last OOBM.LinkReady shall be sent within tOOBMPolling time of receiving an OOBM.LinkReady from the link partner.

9.4.1.6.2#6		After the Link Ready Handshake completes, a USB3 Gen T Port shall transition into the U0 state and shall set its Type 1 and Type 2 Header Buffer Credit Count to 63.
9.4.1.6.2#7		A USB3 Gen T Port shall set its initial Header Sequence Number and Header Buffer Credit Number as described below: If the USB3 Gen T Port enters LTSSM.U0 from LTSSM.DISCONNECT, LTSSM.PORTRESET and LTSSM.DISABLED, the Header Sequence Number shall be set to zero, and the Header Buffer Credit Number to 1.
9.4.1.6.2#8		A USB3 Gen T Port shall set its initial Header Sequence Number and Header Buffer Credit Number as described below: If the USB3 Gen T Port enters LTSSM.U0 from LTSSM.U2 or LTSSM.U3, the Header Sequence Number and the Header Buffer Credit Number are preserved to the values prior to entry into LTSSM.U2 or LTSSM.U3.
9.4.1.6.2#9		A USB3 Gen T Port shall complete the Link Ready Handshake within tPortReadyTimeout.
9.4.1.6.2#10		If an error occurs while in LTSSM.U0 the USB3 Gen T Port shall transition to the LTSSM.ERROR state.
9.4.1.6.2#11		A USB3 Gen T Port shall not support the LRTY Link command and shall not implement any header retry mechanism.
9.4.1.6.3 LTSSM.U3		
9.4.1.6.3#1		A USB3 Gen T Port shall enter the LTSSM.U3 state as defined in the USB 3.2 Specification.
9.4.1.6.3#2		A USB3 Gen T Port in LTSSM.U3 shall not transmit any packets and it shall not accept any packets.
9.4.1.6.3#3		A Remote Wake capable Internal USB3 Gen T Component shall request a wake by sending an OOBM.U3Resume message while staying in U3.
9.4.1.6.3#4		It shall send OOBM.U3Resume at tOOBMPolling intervals until it receives an OOBM.LinkReady from the Host.
9.4.1.6.3#5		Once it receives the OOBM.LinkReady, it shall complete the Link Ready handshake and transition into LTSSM.U0.
9.4.1.6.3#6		When directed to do so by system software, a USB3 Gen T downstream port shall initiate the LTSSM.U3 exit flow by sending OOBM.LinkReady to the link partner at tOOBMPolling intervals.
9.4.1.6.3#7		It shall then wait for an OOBM.LinkReady from the link partner and complete the Link Ready handshake and transition into LTSSM.U0.
9.4.1.6.3#8		If an error occurs while in LTSSM.U3 (expired tPortReadyTimeout), the USB3 Gen T Port shall transition to the LTSSM.ERROR state.
9.4.1.6.4 LTSSM.U2		

9.4.1.6.4#1		A USB3 Gen T Port shall enter the LTSSM.U2 state as defined in the USB 3.2 Specification.
9.4.1.6.4#2		A USB3 Gen T Port in LTSSM.U2 shall not transmit any packets and it shall not accept any packets.
9.4.1.6.4#3		If the Internal USB3 Gen T Component has data to transfer, it shall wake up the USB3 Gen T Component that it is connected to by sending OOBM.LinkReady to its link partner at tOOBMPolling intervals.
9.4.1.6.4#4		It shall then wait for an OOBM.LinkReady from the link partner and complete the Link Ready handshake and transition into LTSSM.U0.
9.4.1.6.4#5		If an error occurs while in LTSSM.U2 (expired tPortReadyTimeout), the USB3 Gen T Port shall transition to the LTSSM.ERROR state.
9.4.1.6.5 LTSSM.ERROR		
9.4.1.6.5#1		A USB3 Gen T upstream port shall send one OOBM.LinkError to the USB3 Gen T downstream port upon entering the LTSSM.ERROR state.
9.4.1.6.5#2		The USB3 Gen T Port shall not transmit any additional packets and it shall not accept any packets while in this state.
9.4.1.6.5#3		A USB3 Gen T downstream port shall indicate that it is in the LTSSM.ERROR state to system software in order for it to take appropriate action.
9.4.1.6.5#4		A USB3 Gen T Port shall enter the LTSSM.ERROR state if any of the following occur: Expired tPortReadyTimeout (Link Ready handshake failure).
9.4.1.6.5#5		A USB3 Gen T Port shall enter the LTSSM.ERROR state if any of the following occur: Expired PENDING_HP_TIMER or expired CREDIT_HP_TIMER.
9.4.1.6.5#6		A USB3 Gen T Port shall enter the LTSSM.ERROR state if any of the following occur: Packet decode error (Protocol Error).
9.4.1.6.5#7		A USB3 Gen T Port shall enter the LTSSM.ERROR state if any of the following occur: LGOOD_n with unexpected Header Sequence Number.
9.4.1.6.5#8		A USB3 Gen T Port shall enter the LTSSM.ERROR state if any of the following occur: Link Command Word Header Sequence Number Error.
9.4.1.6.5#9		A USB3 Gen T Port shall enter the LTSSM.ERROR state if any of the following occur: Reception of OOBM.LinkError (only for USB3 Gen T downstream port)
9.4.1.6.6 LTSSM.DISABLED		
9.4.1.6.6#1		A USB3 Gen T downstream port shall send one OOBM.PortDisabled upon entering the LTSSM.DISABLED state if Path Established is true.

9.4.1.6.6#2		The USB3 Gen T Port shall not transmit any additional packets and it shall not accept any packets from its link partner while in the LTSSM.DISABLED state.
9.4.1.6.6#3		A USB3 Gen T downstream port shall transition to the LTSSM.DISABLED state when directed to do so by system software.
9.4.1.6.6#4		A USB3 Gen T upstream port shall transition to the LTSSM.DISABLED state upon reception of an OOBM.PortDisabled.
9.4.1.6.6#5		A USB3 Gen T downstream port shall exit from the LTSSM.DISABLED state when directed to do so by system software.
9.4.1.6.6#6		A USB3 Gen T upstream port shall exit from the LTSSM.DISABLED state either upon receiving an OOBM.PortReset or when Path Established is false.
9.4.1.6.7 LTSSM.PORTRESET		
9.4.1.6.7#1		A USB3 Gen T downstream port shall enter the LTSSM.PORTRESET state as directed by system software.
9.4.1.6.7#2		When performing a Port Reset, the USB3 Gen T downstream port shall do the following: 1) Upon entering this state, send an OOBM.PortReset message to the link partner and start the <i>tOOBMPolling</i> timer. The USB3 Gen T downstream port shall send an OOBM.PortReset at <i>tOOBMPolling</i> intervals.
9.4.1.6.7#3		When performing a Port Reset, the USB3 Gen T downstream port shall do the following: 2) Wait for an OOBM.PortResetDone from the link partner.
9.4.1.6.7#4		When performing a Port Reset, the USB3 Gen T downstream port shall do the following: 3) Transition to the LTSSM.DISCONNECT state.
9.4.1.6.7#5		When a USB3 Gen T upstream port receives an OOBM.PortReset, it shall: 1) Complete its internal reset flow.
9.4.1.6.7#6		When a USB3 Gen T upstream port receives an OOBM.PortReset, it shall: 2) Respond back with an OOBM.PortResetDone.
9.4.1.6.7#7		When a USB3 Gen T upstream port receives an OOBM.PortReset, it shall: 3) Transition to the LTSSM.DISCONNECT state.
9.4.1.6.7#8		If the Port Reset handshake fails to complete within <i>tPortReadyTimeout</i> time, the USB3 Gen T Port shall transition to the LTSSM.ERROR state.
9.4.1.6.8 Error Checking		
9.4.1.6.8#1		An Internal USB3 Gen T Component shall process errors using the error checking mechanism and flow defined in the USB 3.2 Specification.
9.4.1.6.8#2		However, there shall be no recovery for errors in Link Command transactions.

9.4.1.6.8#3		Upon detecting an error or a timeout, the USB3 Gen T Port shall transition to the LTSSM.ERROR state.
9.4.1.6.9 USB3 Gen T Link Timing Parameters		
9.4.1.6.9#1		tLC_AggrThreshold: Maximum time before any pending Link Commands shall be sent.
9.4.1.6.9#2		PM_ENTRY_TIMER: Time that an Internal USB3 Gen T Component that sends LAU shall enter Ux.
9.4.2 USB3 Protocol Layer		
9.4.2.1 Transaction, Data, Isochronous Timestamp Packets		
9.4.2.1#1		The <i>CRC-16</i> field in all TP ,DPH, and ITP packets is deprecated and shall be set to zero.
9.4.2.1#2		An ACK TP shall have the format shown in Figure 9-24 with the modified fields described in Table 9-13
9.4.2.1#3		The value in [the Number of Packets] field shall be less than or equal to the maximum burst size supported by the endpoint as determined by the value in the bMaxBurst field in the Endpoint Companion Descriptor.
9.4.2.1#4		An ERDY TP shall have the format shown in Figure 9-25.
9.4.2.1#5		The SUBLINK_SPEED Device Notification TP is deprecated and shall not be sent by a USB4 Device tunneling USB3 Gen T traffic.
9.4.2.1#6		A Data Packet shall have the format shown in Figure 9-26 with the modified fields is described in Table 9-14.
9.4.2.2 Ping TPs		
9.4.2.3 USB3 Gen T Burst Transactions		
9.4.2.3#1		A USB3 Gen T Port shall not exceed tGenTMaxBurstInterval time between DP bursts from a device endpoint to the host or from the host to a device endpoint.
9.4.2.3#2		A USB3 Gen T Port shall not exceed tGenTMaxDeviceMultiPacketInterval time between concurrent DP bursts from different device endpoints to the host.
9.4.2.4 USB3 Gen T Bulk/Interrupt IN and OUT Transactions		
9.4.2.4#1		An Internal USB3 Gen T Component shall follow the rules defined in the USB 3.2 Specification for a SuperSpeedPlus Device with respect to Bulk and Interrupt IN/OUT transactions, except that the sequence number shall wrap around at 127 instead of 31.
9.4.2.5 USB3 Gen T Control Transactions		

9.4.2.5#1		An Internal USB3 Gen T Component shall follow the rules defined in the USB 3.2 Specification for a SuperSpeedPlus Device with respect to Control transactions, except that the sequence number shall wrap around at 127 instead of 31.
9.4.2.6 USB3 Gen T Isochronous Transactions		
9.4.2.6#1		An Internal USB3 Gen T Component shall follow the rules defined in the USB 3.2 Specification for a SuperSpeedPlus Device with respect to Isochronous transactions, except for the following: The sequence number shall wrap around at 127 instead of 31; A USB3 Gen T Host Port shall be able to accept and send up to 96 DPs per endpoint per bus interval when tunneling USB3 Gen T traffic.
9.4.2.7 USB3 Gen T Protocol Timing Parameters		
9.4.2.7#1		Table 9-15 lists the timing parameters that an Internal USB3 Gen T Component shall adhere to when responding to ACKs while bursting.
9.4.3 Framework Layer		
9.4.3.1 USB Peripheral Device States		
9.4.3.1#1		A USB4 Peripheral Device that supports USB3 Tunneling shall follow the USB Peripheral Operational Device State machine as shown in Figure 9-27.
9.4.3.1#2		When an Internal USB3 Gen T Peripheral is first powered on, it shall come up in the Attached state.
9.4.3.1#3		The device shall stay in the Attached state until Path Established is true and the USB3 Link is initialized (LinkInitialized = 1b).
9.4.3.1#4		After USB3 link initialization, the Internal USB3 Gen T Peripheral shall transition to the Default state.
9.4.3.1#5		If the Internal USB3 Gen T Peripheral receives an OOBM.PortReset at any time, it shall transition to the Attached state.
9.4.3.1#6		The behavior in each state shall follow the requirements defined in Section 9.1 of the USB 3.2 Specification.
9.4.3.2 USB3 Gen T Device Capability Descriptor		
9.4.3.2#1		An Internal USB3 Gen T Peripheral shall return a USB3 Gen T Device Capability Descriptor as part of its BOS Descriptor.
9.4.3.2#2		The USB3 Gen T Device Capability Descriptor shall have the format defined in Table 9-16.
9.4.3.3 SuperSpeedPlus USB Device Capability Descriptor		
9.4.3.3#1		An Internal USB3 Gen T Peripheral shall return a SuperSpeedPlus USB Device Capability Descriptor as part of its BOS Descriptor.

9.4.3.3#2		The SuperSpeedPlus USB Device Capability Descriptor shall have the same definition as described in the USB 3.2 Specification except for the bmSublinkSpeedAttr field, which shall have the format described in Table 9-17.
9.4.3.3#3		[The Lane Speed Exponent] field defines the base 10 exponent times 3, that shall be applied to the Lane Speed Mantissa (LSM) when calculating the maximum bit rate represented by this Lane Speed Attribute
9.4.3.3#4		Note that the Sublink Speed Attributes shall be paired, i.e. an Rx immediately followed by a Tx, and both Attributes shall define the same value for the SSID.
9.4.3.3#5		[The Lane Speed Mantissa] field defines the mantissa that shall be applied to the LSE when calculating the maximum bit rate represented by Lane Speed Attribute.
9.4.3.4 SuperSpeed Endpoint Companion Descriptor		
9.4.3.4#1		An Internal USB3 Gen T Peripheral shall return a SuperSpeed Endpoint Companion Descriptor as part of its Configuration Descriptor.
9.4.3.4#2		The SuperSpeed Endpoint Companion Descriptor shall have the same definition as described in the USB 3.2 Specification except for the bMaxBurst field, which shall have the format described in Table 9-19.
9.4.3.5 SuperSpeedPlus Isochronous Endpoint Companion Descriptor		
9.4.3.5#1		An Internal USB3 Gen T Peripheral shall return a SuperSpeed Isochronous Endpoint Companion Descriptor as part of its Configuration Descriptor if it includes an Isochronous Endpoint.
9.4.3.5#2		The SuperSpeed Isochronous Endpoint Companion Descriptor shall have the same definition as described in the USB 3.2 Specification with the maximum value in the dwBytesPerInterval field limited to (MAX_ISO_BYTES_PER_BI_GEN1 x 2).
9.5 USB3 Gen T Paths		
9.5#1		A USB3 Gen T Adapter shall support a Path and implement a Path Configuration Space for each USB3 Gen T Port that it interfaces with.
9.5#2		The Gen T Port Index shall start at 0 and increment up by 1 for each additional USB3 Gen T Port that the USB3 Gen T Adapter Layer interfaces with.
9.5#3		When a USB3 Gen T Adapter Layer encapsulates traffic from a USB3 Gen T Port, it shall set the HopID in the resulting Tunneled Packet to (8 + n), where n = the Gen T Index of the USB3 Gen T Port.
9.5#4		When a USB3 Gen T Adapter Layer receives a Tunneled Packet with the HopID = (8 + n), it shall route the payload from the Tunneled Packet to the USB3 Gen T Adapter with a Gen T Index = n.

9.5#5		In a Host Router, when the Connection Manager sets the Path Enable bit and the Valid bit to 1b (Path Established is true), all the other Downstream USB3 Gen T Adapters that interface to the same USB3 Gen T Port shall set the Port Available bit of the corresponding USB3 Gen T Port to 0b.
9.5#6		When the Connection Manager sets the Path Enable bit to 0b and the Valid bit to 1b (Path Established is false), all the other Downstream USB3 Gen T Adapters that interface to the same USB3 Gen T Port shall set the Port Available bit of the corresponding USB3 Gen T Port to 1b.
9.5.1 Path Setup		
9.5.1#1		When the <i>Path Enable</i> bit and the <i>Valid</i> bit in the USB3 Gen T Adapter Configuration Capability are set to 1b, a USB3 Gen T Adapter Layer shall indicate that Path Established is true the corresponding USB3 Gen T Port.
9.5.2 Path Teardown		
9.5.2#1		When a Device Router either detects a disconnect on an Upstream Facing Port, or a Path Enable bit is set to 0b and the Valid bit is set to 1b in the Upstream USB3 Gen T Adapter Configuration Capability, the Upstream USB3 Gen T Adapter Layer shall: Not issue any Tunneled Packets to the Transport Layer for that Path.
9.5.2#2		When a Device Router either detects a disconnect on an Upstream Facing Port, or a Path Enable bit is set to 0b and the Valid bit is set to 1b in the Upstream USB3 Gen T Adapter Configuration Capability, the Upstream USB3 Gen T Adapter Layer shall: Indicate to the corresponding USB3 Gen T Port that Path Established is false
9.5.2#3		When a Path Enable bit in a Downstream USB3 Gen T Adapter (including a Downstream Port Disconnect - see Section 4.4.5.2.1) is set to 0b and the Valid bit is set to 1b in the USB3 Gen T Adapter Configuration Capability, the USB3 Gen T Adapter Layer shall: Not issue any Tunneled Packets for that Path to the Transport Layer.
9.5.2#4		When a Path Enable bit in a Downstream USB3 Gen T Adapter (including a Downstream Port Disconnect - see Section 4.4.5.2.1) is set to 0b and the Valid bit is set to 1b in the USB3 Gen T Adapter Configuration Capability, the USB3 Gen T Adapter Layer shall: Indicate to the corresponding USB3 Gen T Port that Path Established is false.
9.6 Maximum Delay Requirements		
9.6.1 Maximum Forward Delay Requirements (USB4 Gen X Only)		
9.6.1#1		When a USB4 Hub forwards a USB3 Data Packet from one USB-C port to another USB-C port, and both ports operate in USB4 mode, the USB4 Hub shall send the first bit of the Tunneled USB3 Data Packet within $t_{USB3GenXPktFwd_DP}$ time after receiving the last bit of the last segment of the Tunneled USB3 Data Packet.

9.6.1#2		When a USB4 Hub forwards a USB3 ACK Packet from one USB-C port to another USB-C port, and both ports operate in USB4 mode, the USB4 Hub shall send the first bit of the Tunneled USB3 ACK Packet within $t_{USB3GenXPktFwd_ACK}$ time after receiving the last bit of the Tunneled USB3 ACK Packet.
9.6.1#3		When a USB4 Hub forwards a USB3 Data Packet from one USB-C port to another USB-C port, and one port operates in USB3 mode while the other operates in USB4 mode, the USB4 Hub shall send the first bit of the USB3 Data Packet within $t_{USB3GenXPktFwd_DP_Native}$ time after receiving the last bit of the USB3 Data Packet
9.6.1#4		When a USB4 Hub forwards a USB3 ACK Packet from one USB-C port to another USB-C port, and one port operates in USB3 mode while the other operates in USB4 mode, the USB4 Hub shall send the first bit of the USB3 ACK Packet within $t_{USB3GenXPktFwd_ACK_Native}$ from receiving the last bit of the USB3 ACK Packet
9.6.2 Maximum Response Delay Requirements		
9.6.2.1 Maximum Response Delay Requirements for USB4-Based Docks and Peripheral Devices		
9.6.2.1#1		When a USB4-Based Dock or USB4 Peripheral Device receives a USB3 Data Packet that is targeted to one of its embedded USB3 Endpoints, it shall respond with an ACK Packet within $t_{USB3DeviceDPtoACK}$ time after receiving the packet. The time is measured from reception of the last bit of the last segment of the Tunneled USB3 Data Packet to sending the first bit of the Tunneled USB3 ACK Packet.
9.6.2.1#2		When a USB4-Based Dock or a USB4 Peripheral Device receives a USB3 ACK Packet that is targeted to one of its embedded USB3 endpoints, it shall respond with a Data Packet within $t_{USB3DeviceACKtoDP}$ time after receiving the packet. The time is measured from reception of the last bit of the Tunneled USB3 ACK Packet to sending the first bit of the first segment of the Tunneled USB3 Data Packet.
9.6.2.2 Maximum Response Delay Requirements for a USB4 Host		
9.6.2.2#1		When a USB4 Host receives a USB3 Data Packet, it shall respond with an ACK Packet within $t_{USB3HostDPtoACK}$ time after receiving the packet. The time is measured from reception of the last bit of the last segment of the Tunneled USB3 Data Packet to sending the first bit of the Tunneled USB3 ACK Packet.
9.6.2.2#2		When a USB4 Host receives a USB3 ACK Packet, it shall respond with a Data Packet within $t_{USB3HostACKtoDP}$ time after receiving the packet. The time is measured from reception of the last bit of the Tunneled USB3 ACK Packet to sending the first bit of the first segment of the Tunneled USB3 Data Packet.
9.7 Timing Parameters		

Test Requirements

Hardware

The following test equipment is needed to perform the tests in this specification:

- KG USB4 Host (1)
- USB4 Compliance Device (2)
- USB4 Analyzer (1)
- USB4 Exerciser (1)
- KG USB 3.2 device (1)

Software

The following software tools are needed to perform the tests in this specification:

- USB4 CV

Test Setups

This section defines the test setups for a Router that is part of a USB4™ host, hub, or device.

Note: A USB4-Based Dock is tested as a USB4 hub.

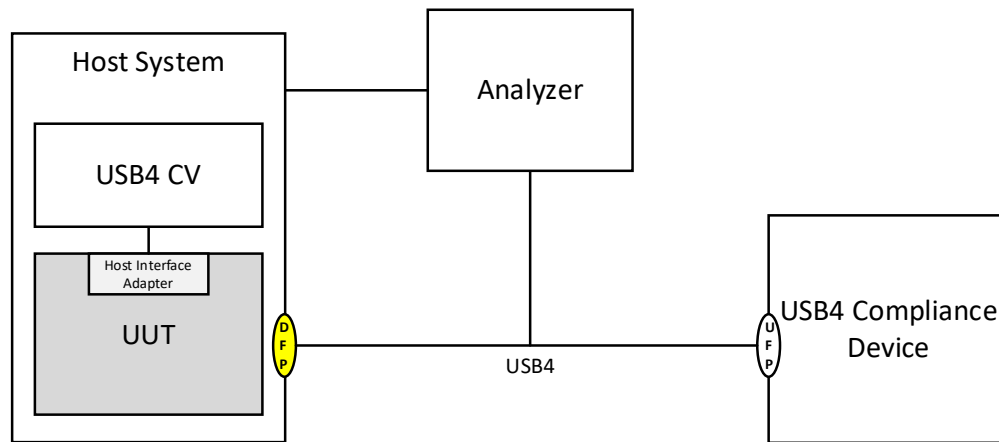
Host

This section defines the test setups for a Host. The Port Under Test (PUT) is highlighted in each figure.

AN_HOST_DFP1—USB3_01

Description:

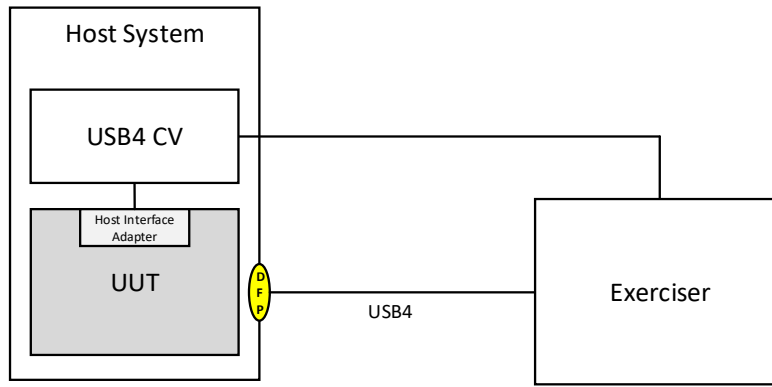
- The UFP of the Compliance Device is connected to the DFP of the UUT.
- The USB4 Analyzer is connected between the UUT and the Compliance Device.



EX_HOST_DFP1—USB3_02

Description:

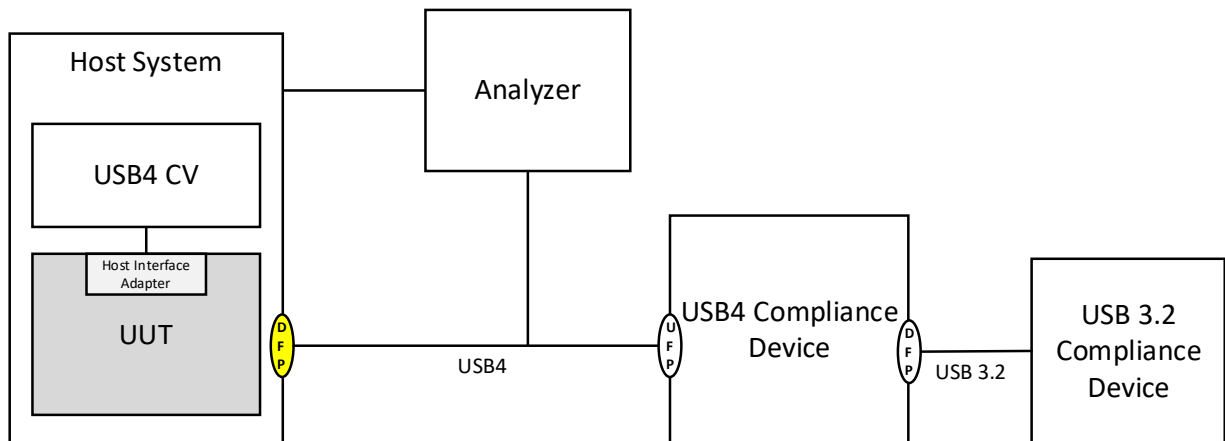
- The Exerciser is connected to the DFP of the UUT.
- Unless specified otherwise, the Exerciser is in USB4 device mode and presents as UFP.



AN_HOST_DFP2—USB3_03

Description:

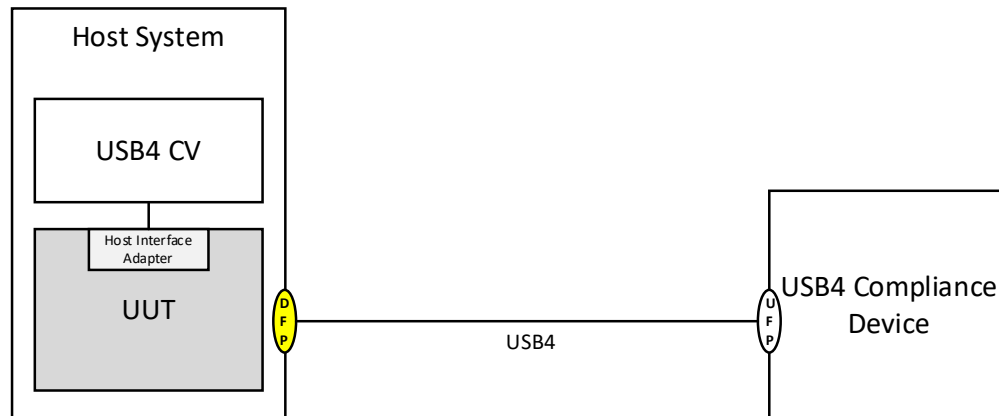
- The UFP of the USB4 Compliance Device is connected to the DFP of the UUT.
- The USB4 Analyzer is connected between the UUT and the USB4 Compliance Device.
- A USB 3.2 Compliance Device is connected downstream of the USB4 Compliance Device



DC_HOST_DFP1—USB3_04

Description:

- The UFP of the Compliance Device is connected to the DFP of the UUT.
- Test steps requiring an Analyzer are skipped.



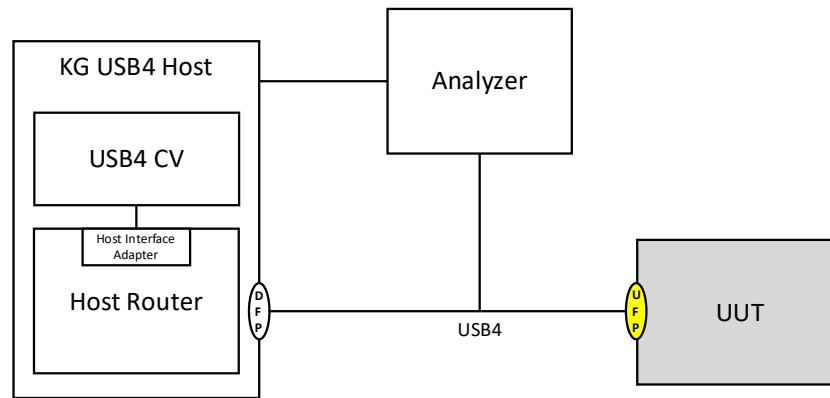
Hub

This section describes the test setups for a Hub. The Port Under Test (PUT) is highlighted in each figure.

AN_HUB_UFP1—USB3_01

Description:

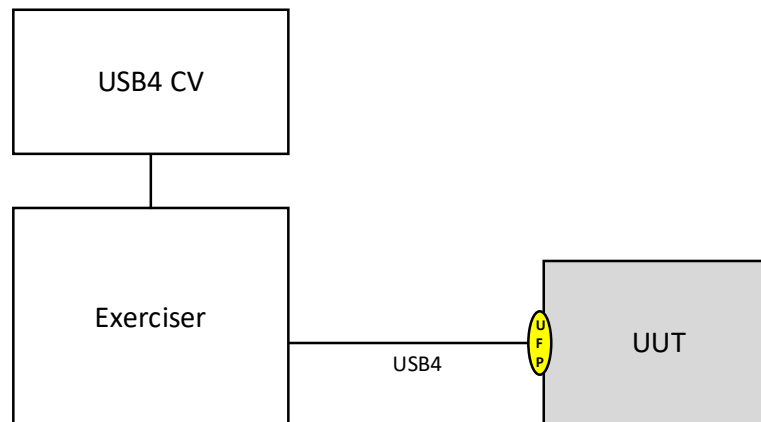
- The DFP on the KG USB4 Host connects to the UFP of the UUT.
- The Analyzer is connected between the KG USB4 Host and the UUT.



EX_HUB_UFP1—USB3_02

Description:

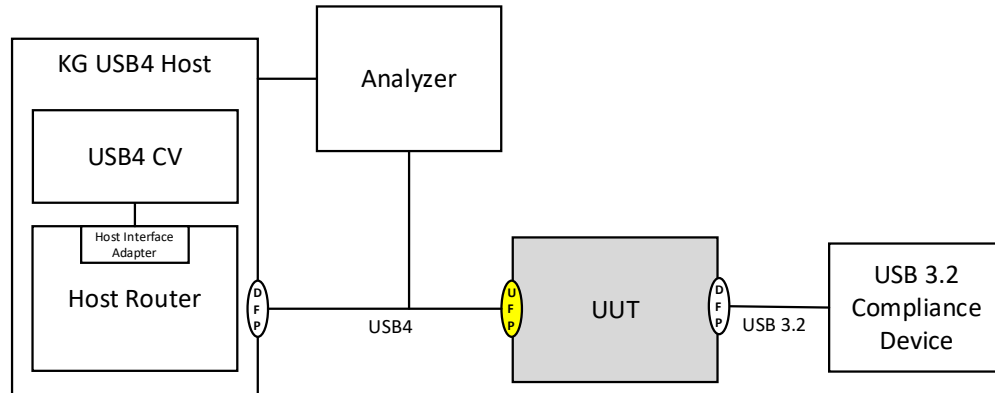
- The Exerciser connects to the UFP of the UUT.
- The Exerciser is in USB4 Host mode and presents as DFP.



AN_HUB_UFP2—USB3_06

Description:

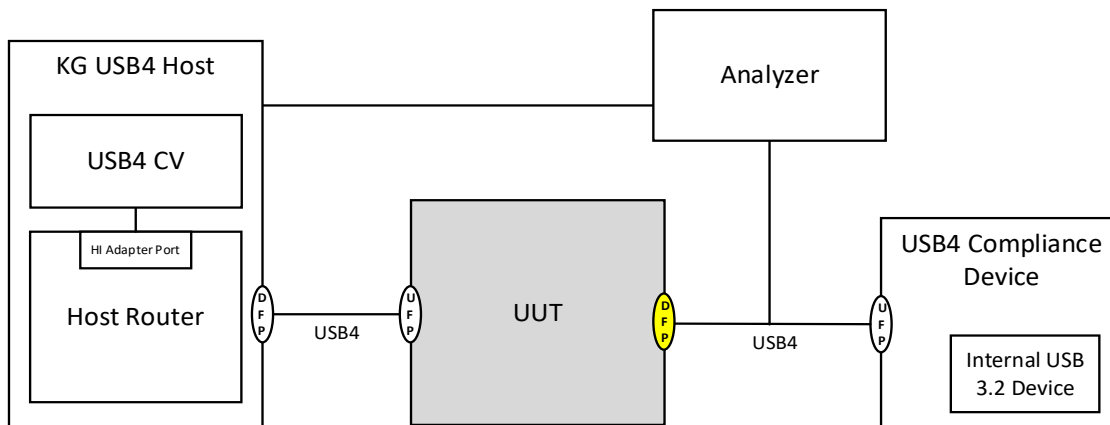
- The DFP on the KG USB4 Host connects to the UFP of the UUT.
- The Analyzer is connected between the KG USB4 Host and the UUT.
- A USB 3.2 Compliance Device is connected downstream of the UUT.



AN_HUB_DFP1—USB3_03

Description:

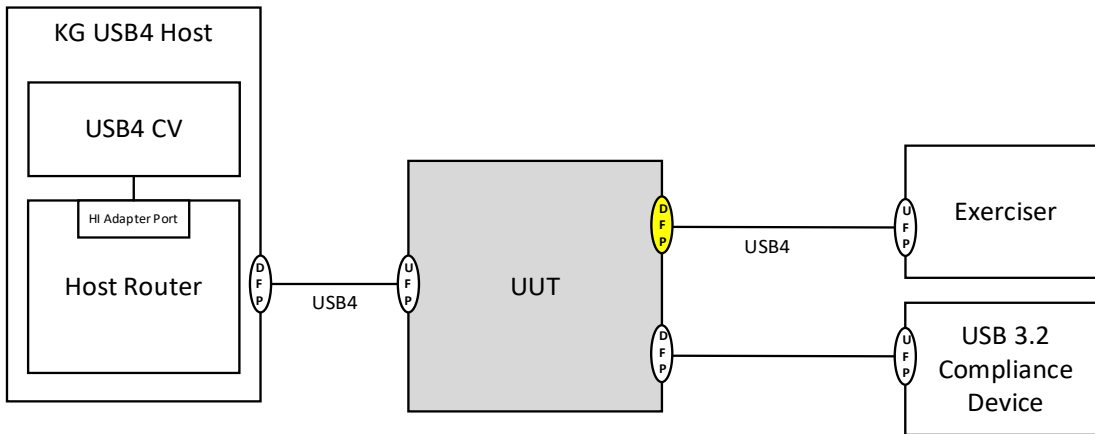
- DFP on KG USB4 Host connects to UFP of the UUT.
- UFP of Compliance Device connects to DFP of the UUT.
- Analyzer is connected between the UUT and Compliance Device.



EX_HUB_DFP1—USB3_04

Description:

- DFP on KG USB4 Host connects to UFP of the UUT.
- The Exerciser connects to DFP of the UUT.
- The Exerciser is in USB4 Device mode and presents as UFP.

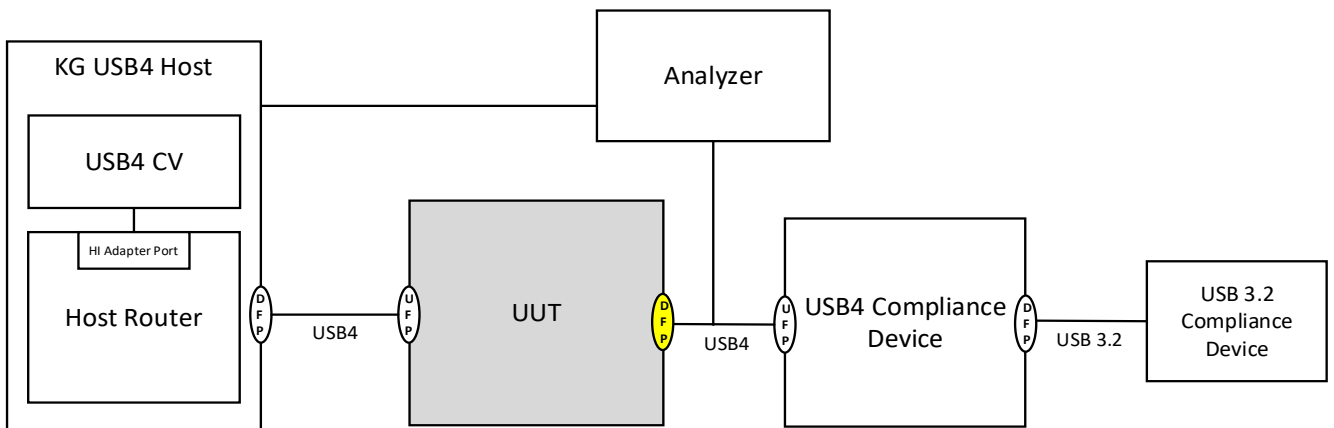


Note: Unless specified otherwise, the xHCI CV driver is used as the Host Controller Driver.

AN_HUB_DFP2—USB3_05

Description:

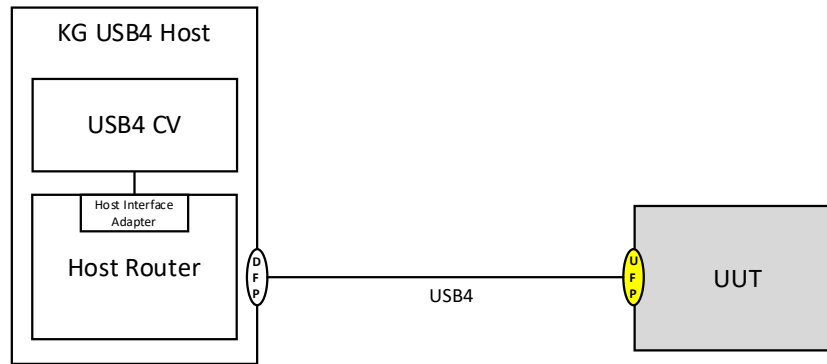
- The UFP of the USB4 Compliance Device is connected to the DFP of the UUT.
- The USB4 Analyzer is connected between the UUT and the USB4 Compliance Device.
- A USB 3.2 Compliance Device is connected downstream of the USB4 Compliance Device.



DC_HUB_UFP1—USB3_07

Description:

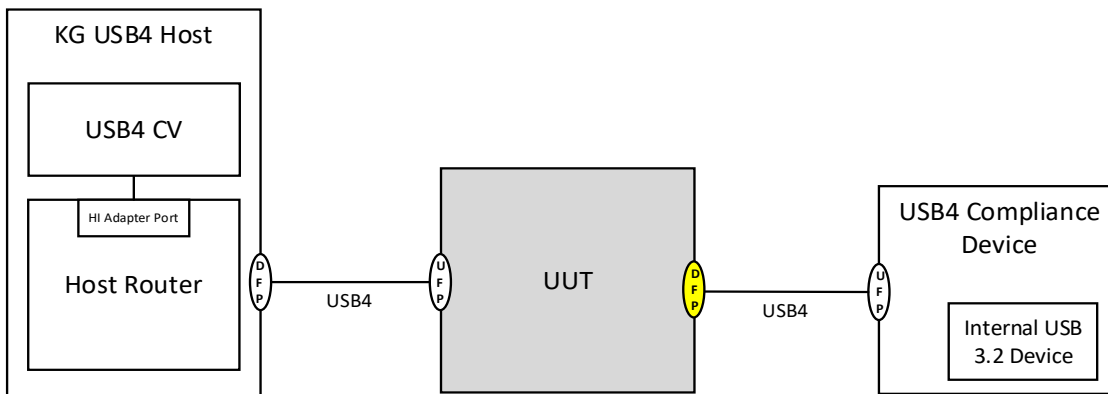
- The DFP on the KG USB4 Host connects to the UFP of the UUT.
- Test steps requiring an Analyzer are skipped.



DC_HUB_DFP1—USB3_08

Description:

- DFP on KG USB4 Host connects to UFP of the UUT.
- UFP of Compliance Device connects to DFP of the UUT.
- Test steps requiring an Analyzer are skipped.



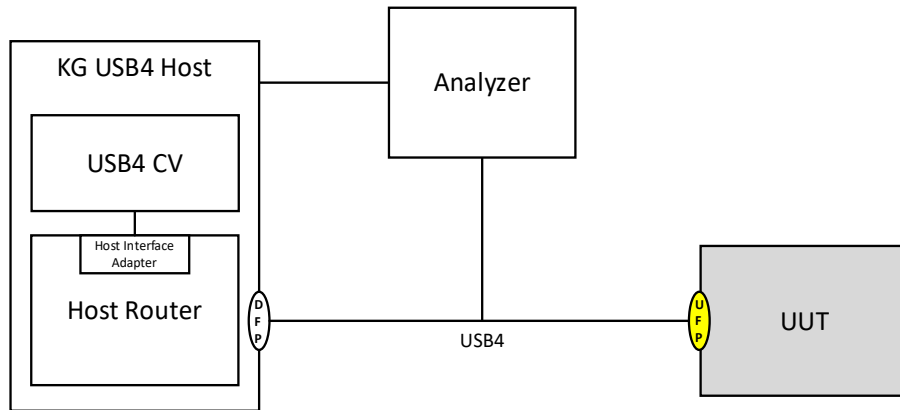
Peripheral Device

This section describes the test setups for a Peripheral Device. The Port Under Test (PUT) is highlighted in each figure.

AN_DEV_UFP1—USB3_01

Description:

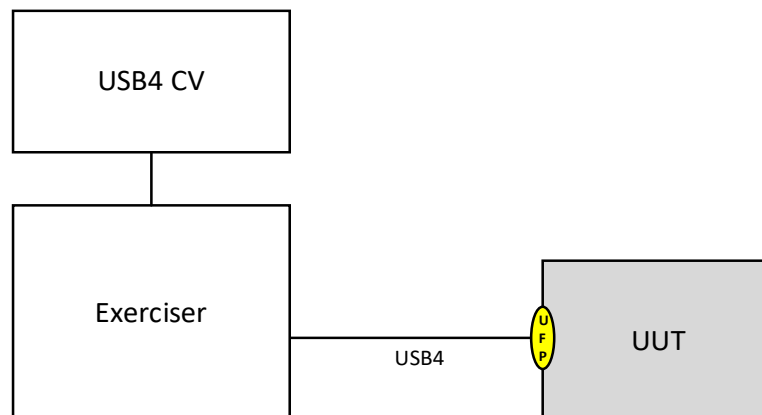
- The DFP on the KG USB4 Host connects to the UFP of the UUT.
- The Analyzer is connected between the KG USB4 Host and the UUT.



EX_DEV_UFP1—USB3_02

Description:

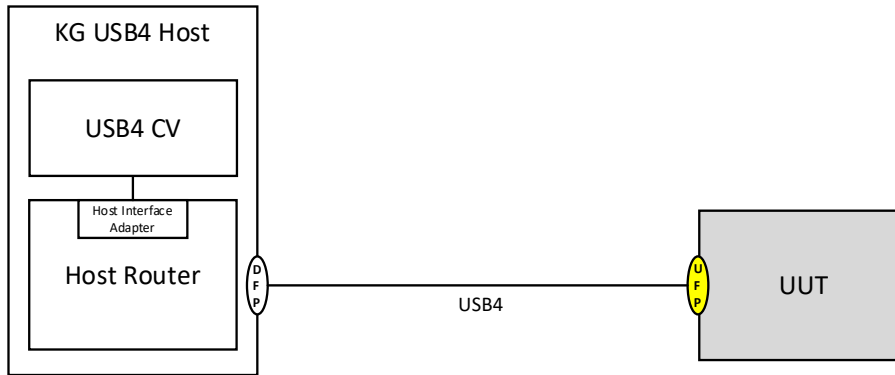
- The Exerciser connects to the UFP of the UUT.
- The Exerciser is in USB4 Host mode and presents as DFP.



DC_DEV_UFP1—USB3_03

Description:

- The DFP on the KG USB4 Host connects to the UFP of the UUT.
- Test steps requiring an Analyzer are skipped.

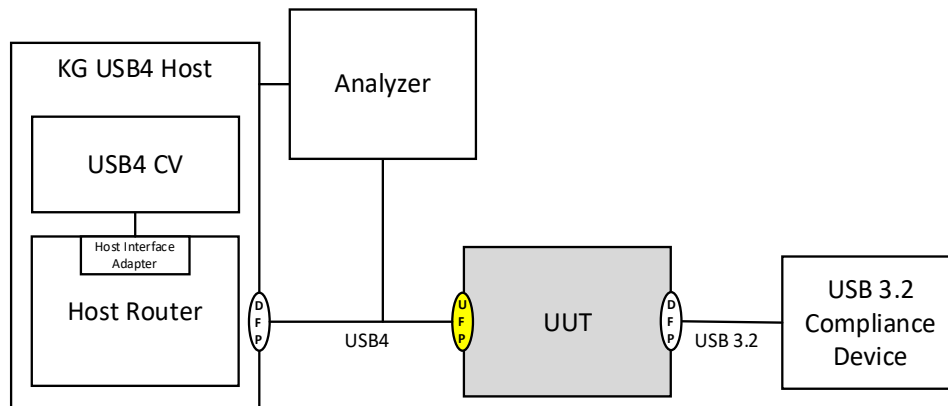


AN_DEV_UFP2—USB3_04

Description:

- The DFP on the KG USB4 Host connects to the UFP of the UUT.
- The Analyzer is connected between the KG USB4 Host and the UUT.
- A USB 3.2 Compliance Device is connected downstream of the UUT.

Note: This setup is only used for a UUT that has one or more non-USB4 DFP that support USB 3.2.



Tests

Unless specified otherwise, the tests in this section are repeated on each Port on the UUT.

Unless specified otherwise, a test will timeout if it takes more than 1 second to go from one step to the next step. It is a test failure if a test step times out.

For a USB4 Hub, The tests in this section are repeated with the following configurations:

- The Link on the UFP and the DFP are USB4
- The Link on the UFP is USB4 and the Link on the DFP is USB 3.2

Unless specified otherwise, a USB3 device is in the Configured state when the tests in this section are run.

TD 9.001 USB3 Adapter Scan Test

Note: This test is only performed once on the UUT.

- A. Purpose:
 - For USB4 hosts and hubs, verify that there is one Downstream USB3 Adapter for each USB4 Downstream facing port
 - For USB4 hubs and devices, verify that there is one Upstream USB3 Adapter
- B. Asserts:
 - 9#4, 9#8, 9#11
- C. Setup:
 - AN_HOST_DFP1—USB3_01/DC_HOST_DFP1—USB3_04 (Host)
 - AN_HUB_UFP1—USB3_01/DC_HUB_UFP1—USB3_07 (Hub UFP)
 - AN_HUB_DFP1—USB3_03/DC_HUB_DFP1—USB3_08 (Hub DFP)
 - AN_DEV_UFP1—USB3_01/DC_DEV_UFP1—USB3_03 (Peripheral Device)
- D. Procedure:
 1. USB4 CV scans all the USB3 Adapters in the UUT
 2. USB4 CV verifies that the number of the Downstream USB3 Adapters is equal to the number of the Downstream USB4 ports on the UUT
 3. If UUT is a USB4 Hub or Peripheral Device, USB4 CV verifies that the UUT has one Upstream USB3 Adapter

TD 9.002 Link Initialization Test

- A. Purpose:
 - Verify that the UUT performs USB3 Tunnel link initialization correctly
- B. Asserts:
 - 9.1.1#1
- C. Setup:
 - AN_HOST_DFP1—USB3_01 (Host)
 - AN_HUB_UFP1—USB3_01 (Hub UFP)
 - AN_HUB_DFP1—USB3_03 (Hub DFP)
 - AN_DEV_UFP1—USB3_01 (Peripheral Device)
- D. Procedure:
 1. USB4 CV enumerates the USB4 topology according to the CM Guide
 2. USB4 CV performs USB3 Path setup according to the USB4 specification and CM Guide

Part 1 – LFPS Handshake

3. USB4 CV verifies that the PUT sends at least 3 LFPS Packets with:
 - a. Rx Term Enable field set to 1
 - b. All other LFPS Tunneled Packet Payload fields (except the CRC field) set to 0
4. KG Router responds with LFPS Packets with:
 - a. Rx Term Enable field set to 1
 - b. All other LFPS Tunneled Packet Payload fields (except the CRC field) set to 0
5. USB4 CV verifies that the PUT responds with at least 3 LFPS Packets with:
 - a. Rx Term Enable field set to 1
 - b. SCD1 field set to 1
 - c. All other LFPS Tunneled Packet Payload fields (except the CRC field) set to 0
6. KG Router responds with LFPS Packets with:
 - a. Rx Term Enable field set to 1
 - b. SCD1 field set to 1
 - c. All other LFPS Tunneled Packet Payload fields (except the CRC field) set to 0
7. USB4 CV verifies that the PUT responds with at least 3 LFPS Packets with:
 - a. Rx Term Enable field set to 1
 - b. SCD2 field set to 1
 - c. All other LFPS Tunneled Packet Payload fields (except the CRC field) set to 0
8. KG Router responds with LFPS Packets with:
 - a. Rx Term Enable field set to 1
 - b. SCD2 field set to 1
 - c. All other LFPS Tunneled Packet Payload fields (except the CRC field) set to 0
9. USB4 CV verifies that the PUT responds with at least 3 LFPS Packets with:
 - a. Rx Term Enable field set to 1
 - b. LBMP Enable field set to 1
 - c. LBMP field type equal to PHY Capability
 - d. LBPM field subtype not equal to 0
 - e. All other LFPS Tunneled Packet Payload fields (except the CRC field) set to 0
10. KG Router responds with LFPS Packets with:
 - a. Rx Term Enable field set to 1
 - b. LBMP Enable field set to 1
 - c. LBMP field type equal to PHY Capability
 - d. LBPM field subtype equal to highest support capability
 - e. All other LFPS Tunneled Packet Payload fields (except the CRC field) set to 0
11. USB4 CV verifies that the PUT responds with at least 3 LFPS Packets with:

- a. Rx Term Enable field set to 1
 - b. LBMP Enable field set to 1
 - c. LBMP field type equal to PHY Ready
 - d. LBPM field subtype in the first LBPM Capability Packet is equal to the highest support capability
 - e. All other LFPS Tunneled Packet Payload fields (except the CRC field) set to 0
12. KG Router responds with LFPS Packets with:
- a. Rx Term Enable field set to 1
 - b. LBMP Enable field set to 1
 - c. LBMP field type equal to PHY Ready
 - d. LBPM field subtype equal to highest support capability
 - e. All other LFPS Tunneled Packet Payload fields (except the CRC field) set to 0

Part 2 – Ordered Set handshake

13. USB4 CV verifies that the PUT sends at least 3 Order Set Tunneled Packets with:
- a. TS1 field set to 1
 - b. All other Order Set Tunneled Packet Payload fields set to 0 except:
 - i. bit 3 in the link functionality set to 1b in the last 3 packets (disable scrambling asserted)
 - ii. CRC field
14. KG Router responds with Ordered Set Tunneled Packets with:
- a. TS1 field set to 1
 - b. All other Order Set Tunneled Packet Payload fields set to 0 except:
 - i. bit 3 in the link functionality set to 1b in the last 3 packets (disable scrambling asserted)
 - ii. CRC field
15. USB4 CV verifies that the PUT sends at least 3 Order Set Tunneled Packets with:
- a. TS2 field is set to 1
 - b. All other Order Set Tunneled Packet Payload fields set to 0 except:
 - i. bit 3 in the Link Functionality field set to 1b (disable scrambling asserted)
 - ii. bit 0 in the Link Functionality field may be set to 1b (Reset bit asserted)
 - iii. CRC field
16. KG Router responds with Ordered Set Tunneled Packets with:
- a. TS2 field set to 1
 - b. All other Order Set Tunneled Packet Payload fields set to 0 except:
 - i. bit 3 in the Link Functionality field set to 1b (disable scrambling asserted)
 - ii. bit 0 in the Link Functionality field may be set to 1b (Reset bit asserted)
 - iii. CRC field
17. USB4 CV verifies that the PUT sends at least 3 Order Set Tunneled Packets with:
- a. SDS field set to 1
 - b. All the other Order Set Tunneled Packet Payload fields (except the CRC field) set to 0
18. KG Router responds with Ordered Set Tunneled Packets with:
- a. SDS field set to 1
 - b. All other Order Set Tunneled Packet Payload fields (except the CRC field) set to 0

Part 3 – Link in U0

19. During Part 3 USB4 CV verifies the following for each USB3 Tunneled Packet:
- a. The PDF is between 2 and 6 (inclusive)
20. USB4 CV verifies that the PUT does not go through USB 3.2 link training any additional times
21. USB4 CV verifies that the PUT stays in U0 at least 1 sec

22. USB4 CV verifies that the *Actual Link Rate* field in ADP_USB_CS_4 is equal to the minimum between *Maximum Supported Link Rate* field in both the USB3 Downstream Adapter and the USB3 Upstream Adapter
23. USB4 CV verifies that the *USB Link Valid* field in ADP_USB_CS_4 is set and the *PLS* field value is 0h

TD 9.003 U2 Enter and Exit Test

A. Purpose

- Verify that the PUT can enter and exit from U2

B. Asserts:

- 9.1.1.1.5#1#2

C. Setup:

- AN_HOST_DFP1—USB3_01 (Host)
- AN_HUB_UFP1—USB3_01 (Hub UFP)
- AN_HUB_DFP1—USB3_03 (Hub DFP)
- AN_DEV_UFP1—USB3_01 (Peripheral Device)

D. Procedure:

Note: It is not a test failure if the Link Partner sends LFPS Packets before the PUT.

UUT is a USB4 Host

Part 1 – Entry to U2

1. Perform link initialization according to TD 9.002
 2. USB4 CV enables U2 in the Compliance Device and in the UUT
- Note: The xHCI driver initiates the transition to U2 as follows:*
1. The xHCI driver writes the U2 Timeout value in the PORTPMSC register
 2. The xHCI driver sends a U2 enable command to the device
3. USB4 CV verifies that the PUT either requests or accepts entry to U2
 4. USB4 CV verifies that there are no USB3 Tunneled Packets for 1 sec after the PUT enters U2 state
 5. USB4 CV verifies that the Actual Link Rate field in ADP_USB_CS_4 is equal to the minimum between Maximum Supported Link Rate field in both the USB3 Downstream Adapter and the USB3 Upstream Adapter
 6. USB4 CV verifies that the USB Link Valid field in ADP_USB_CS_4 in the UUT and in the Compliance Device is set and the PLS field value is 2h

Part 2 – Exit U2 from the UUT

7. USB4 CV initiates exit from U2 from the UUT by writing 0x0 to U2 Timeout in PORTPMSC register in the xHCI interface
8. USB4 CV verifies that the UUT sends at least 3 LFPS Packets with:
 - a. PDF set to 0
 - b. Rx Term Enable field set to 1
 - c. U2 Exit bit set to 1
 - d. All other LFPS Tunneled Packet Payload fields (except the CRC field) set to 0
9. The Compliance Device responds with at least 3 LFPS Packets with:
 - a. PDF set to 0
 - b. Rx Term Enable field set to 1
 - c. U2 Exit bit set to 1
 - d. All other LFPS Tunneled Packet Payload fields (except the CRC field) set to 0
10. USB4 CV verifies link initialization according to Part 2 and Part 3 in TD 9.002

Part 3 – Exit U2 from the Compliance Device

11. USB4 CV initiates U2 entry according to Part 1
12. Initiate U2 exit request from the Compliance Device as follows:
 - a. Wake from the device if possible
 - b. If wake from the device is not possible, Analyzer initiates U2 exit
13. USB4 CV verifies that the UUT sends at least 3 LFPS Packets with:
 - a. PDF set to 0
 - b. Rx Term Enable field set to 1
 - c. U2 Exit bit set to 1
 - d. All other LFPS Tunneled Packet Payload fields (except the CRC field) set to 0
14. The Compliance Device responds with at least 3 LFPS Packets with:
 - a. PDF set to 0
 - b. Rx Term Enable field set to 1
 - c. U2 Exit bit set to 1
 - d. All other LFPS Tunneled Packet Payload fields (except the CRC field) set to 0
15. USB4 CV verifies link initialization according to Part 2 and Part 3 in TD 9.002

UUT is a USB4 Peripheral Device

Part 1 – Entry to U2

1. Perform link initialization according to TD 9.002
2. USB4 CV enables U2 in the PUT
3. USB4 CV verifies that the PUT requests entry to U2
4. USB4 CV enables U2 in the USB4 Host Router
5. USB4 CV verifies that the PUT accepts entry to U2
6. USB4 CV verifies that there are no USB3 Tunneled Packets for 1 sec after the PUT enters U2 state
7. USB4 CV verifies that the *Actual Link Rate* field in ADP_USB_CS_4 is equal to the minimum between *Maximum Supported Link Rate* field in both the USB3 Downstream Adapter and the USB3 Upstream Adapter
8. USB4 CV verifies that the *USB Link Valid* field in ADP_USB_CS_4 in the UUT and in the KG USB4 Host is set and the *PLS* field value is 2h

Part 2 – Exit U2 from the KG USB4 Host

9. USB4 CV initiates exit from U2 from the KG USB4 Host by writing 0x0 to U2 Timeout in PORTPMSC register in the xHCI interface
10. The KG USB4 Host sends at least 3 LFPS Packets with:
 - a. PDF set to 0
 - b. Rx Term Enable field set to 1
 - c. U2 Exit bit set to 1
 - d. All other LFPS Tunneled Packet Payload fields (except the CRC field) set to 0
11. USB4 CV verifies that the UUT responds with at least 3 LFPS Packets with:
 - a. PDF set to 0
 - b. Rx Term Enable field set to 1
 - c. U2 Exit bit set to 1
 - d. All other LFPS Tunneled Packet Payload fields (except the CRC field) set to 0
12. USB4 CV verifies Link Initialization according to Part 2 and Part 3 in TD 9.002

Part 3 – Exit U2 from the UUT

Note: Only perform Part 3 if wake from the UUT is supported

13. Perform U2 entry according to Part 1
14. Perform wake from the UUT
15. USB4 CV verifies that the UUT sends at least 3 LFPS Packets with:
 - a. PDF set to 0
 - b. Rx Term Enable field set to 1
 - c. U2 Exit bit set to 1
 - d. All other LFPS Tunneled Packet Payload fields (except the CRC field) set to 0
16. The KG USB4 Host responds with at least 3 LFPS Packets with:
 - a. PDF set to 0
 - b. Rx Term Enable field set to 1
 - c. U2 Exit bit set to 1
 - d. All other LFPS Tunneled Packet Payload fields (except the CRC field) set to 0
17. USB4 CV verifies link initialization according to Part 2 and Part 3 in TD 9.002

UUT is a USB4 Hub (UFP)

Note: PUT is the Upstream Facing Port of the UUT

Parts 1 through 3 are repeated with:

- All downstream ports disconnected
- All downstream ports connected and in U2
- All downstream ports connected and in U3
- If the UUT has more than 2 two downstream ports:
 - One downstream ports disconnected
 - One downstream ports connected and in U2
 - One downstream ports connected and in U3

Part 1 – Entry to U2

1. Perform link initialization according to TD 9.002
2. USB4 CV enables U2 in the PUT
3. USB4 CV verifies that the PUT requests entry to U2
4. USB4 CV enables U2 in the USB4 Host Router
5. USB4 CV verifies that the PUT accepts entry to U2
6. USB4 CV verifies that there are no USB3 Tunneled Packets for 1 sec after the PUT enters U2 state
7. USB4 CV verifies that the *Actual Link Rate* field in ADP_USB_CS_4 is equal to the minimum between *Maximum Supported Link Rate* field in both the USB3 Downstream Adapter and the USB3 Upstream Adapter
8. USB4 CV verifies that the *USB Link Valid* field in ADP_USB_CS_4 in the UUT and in the KG USB4 Host is set and the *PLS* field value is 2h

Part 2 – Exit U2 from the USB4 KG Host

9. USB4 CV initiates exit from U2 from the USB4 KG Host by writing to 0x0 to U2 Timeout in PORTPMSC register in the xHCI interface

10. USB4 CV verifies that the USB4 KG Host sends at least 3 LFPS Packets with:
 - a. PDF set to 0
 - b. Rx Term Enable field set to 1
 - c. U2 Exit bit set to 1
 - d. All other LFPS Tunneled Packet Payload fields (except the CRC field) set to 0
11. USB4 CV verifies that the UUT responds with at least 3 LFPS Packets with:
 - a. PDF set to 0
 - b. Rx Term Enable field set to 1
 - c. U2 Exit bit set to 1
 - d. All other LFPS Tunneled Packet Payload fields (except the CRC field) set to 0
12. USB4 CV verifies link initialization according to Part 2 and Part 3 in TD 9.002
13. USB4 CV verifies that all connected downstream ports return to U0

Part 3 – Exit U2 from the UUT

14. Perform U2 entry according to Part 1
15. Perform wake from the UUT by:
 - a. Disconnect on each DFP
 - b. Connect on each DFP
 - c. Wake from the Compliance Device connected to each DFP
16. USB4 CV verifies that the UUT send at least 3 LFPS Packets with:
 - a. PDF set to 0
 - b. Rx Term Enable field set to 1
 - c. U2 Exit bit set to 1
 - d. All other LFPS Tunneled Packet Payload fields (except the CRC field) set to 0
17. USB4 CV verifies that the USB4 KG Host responds with at least 3 LFPS Packets with:
 - a. PDF set to 0
 - b. Rx Term Enable field set to 1
 - c. U2 Exit bit set to 1
 - d. All other LFPS Tunneled Packet Payload fields (except the CRC field) set to 0
18. USB4 CV verifies link initialization according to Part 2 and Part 3 in TD 9.002
19. USB4 CV verifies that all connected downstream ports return to U0

UFP is a USB4 Hub (DFP):

Note: PUT is the Downstream Facing Port of the UUT

Part 1 – Entry to U2

1. Perform link initialization on the UFP of the UUT and on the PUT according to TD 9.002
2. USB4 CV enables U2 in the PUT on the UUT
3. USB4 CV verifies that the PUT requests entry to U2
4. USB4 CV enables U2 in the Compliance Device that connected to the PUT
5. USB4 CV verifies that the PUT accepts entry to U2
6. USB4 CV verifies there are no USB3 Tunneled Packets for 1 sec after the PUT enters U2 state
7. USB4 CV verifies that the *Actual Link Rate* field in ADP_USB_CS_4 is equal to the minimum between *Maximum Supported Link Rate* field in both the USB3 Downstream Adapter and the USB3 Upstream Adapter
8. USB4 CV verifies that *USB Link Valid* field in ADP_USB_CS_4 in the PUT and in the Compliance Device is set and the *PLS* field value is 2h

Part 2– Exit U2 from the Compliance Device

9. Compliance Device requests wake from U2 by issuing a wake
10. Compliance Device sends at least 3 LFPS Packets with:
 - a. PDF set to 0
 - b. Rx Term Enable field set to 1
 - c. U2 Exit bit set to 1
 - d. All other LFPS Tunneled Packet Payload fields (except the CRC field) set to 0
11. USB4 CV verifies that the PUT responds with at least 3 LFPS Packets with:
 - a. PDF set to 0
 - b. Rx Term Enable field set to 1
 - c. U2 Exit bit set to 1
 - d. All other LFPS Tunneled Packet Payload fields (except the CRC field) set to 0
12. USB4 CV verifies link initialization according to Part 2 and Part 3 in TD 9.002
13. USB4 CV verifies that all connected ports return to U0

Part 3 – Exit U2 from the PUT

14. USB4 CV performs wake to the PUT as follows:
 - a. Disable U2 in the port features
 - b. Send data to the Compliance Device that connected to the PUT
15. USB4 CV verifies that the PUT sends at least 3 LFPS Packets with:
 - a. PDF set to 0
 - b. Rx Term Enable field set to 1
 - c. U2 Exit bit set to 1
 - d. All other LFPS Tunneled Packet Payload fields (except the CRC field) set to 0
16. USB4 CV verifies that the Compliance Device responds with at least 3 LFPS Packets with:
 - a. PDF set to 0
 - b. Rx Term Enable field set to 1
 - c. U2 Exit bit set to 1
 - d. All other LFPS Tunneled Packet Payload fields (except the CRC field) set to 0
17. USB4 CV verifies link initialization according to Part 2 and Part 3 in TD 9.002
18. USB4 CV verifies that all connected ports return to U0

TD 9.004 U3 Enter and Exit Test

A. Purpose

- Verify that the PUT can enter and exit from U3
- Verify that the PUT can handle U3 timeout

B. Asserts:

- 9.1.1.1.6#1, 9.1.1.1.6#2, 9.1.1.1.6#4, 9.1.1.1.6#6

C. Setup:

- AN_HOST_DFP1—USB3_01 (Host)
- AN_HUB_UFP1—USB3_01 (Hub UFP)
- AN_HUB_DFP1—USB3_03 (Hub DFP)
- AN_DEV_UFP1—USB3_01 (Peripheral Device)

D. Procedure:

Note: It is not a test failure if the Link Partner sends LFPS Packets before the PUT.

UUT is a USB4 Host or USB4 Peripheral Device

Part 1 – Entry to U3

1. Perform link initialization according to TD 9.002
2. USB4 CV requests entry to U3 in the USB4 Host
3. USB4 CV verifies that the USB4 Host requests entry to U3
4. USB4 CV verifies that the USB4 Device accepts entry to U3
5. USB4 CV verifies there are no USB3 Tunneled Packets for 1 sec after entering to U3
6. USB4 CV verifies that the *Actual Link Rate* field in ADP_USB_CS_4 is equal to the minimum between *Maximum Supported Link Rate* field in both the USB3 Downstream Adapter and the USB3 Upstream Adapter
7. USB4 CV verifies that the *USB Link Valid* field in ADP_USB_CS_4 in the UUT is set and the *PLS* field value is 3h

Part 2 – Exit U3 from the USB4 Host

8. Initiate U3 entry according to Part 1
9. Transition the system to S3 state
10. Perform system resume
11. USB4 CV enumerates the USB4 Device and the USB4 Host but does not set up a USB3 Path
12. USB4 CV Initiates exit from U3 from the USB4 Host by writing to PORTSC in the xHCI interface
13. USB4 CV verifies that there are no USB3 Tunneled Packets
14. USB4 CV sets up a USB3 Path
15. USB4 CV verifies that the USB4 Host sends at least 3 LFPS Packets with:
 - a. PDF set to 0
 - b. Rx Term Enable field set to 1
 - c. U3 Exit bit set to 1
 - d. All other LFPS Tunneled Packet Payload fields (except the CRC field) set to 0
16. USB4 CV verifies that the USB4 Device responds with at least 3 LFPS Packets with:
 - a. PDF set to 0
 - b. Rx Term Enable field set to 1
 - c. U3 Exit bit set to 1
 - d. All other LFPS Tunneled Packet Payload fields (except the CRC field) set to 0
17. USB4 CV verifies link initialization according to Part 2 and Part 3 in TD 9.002

Part 3 – Exit U3 from the USB4 Device

18. Initiate U3 entry according to Part 1
19. Transition the system to S3 state
20. Perform wake from the KG USB4 Device
21. USB4 CV enumerates the USB4 Device and the USB4 Host, but does not set up a USB3 Path
22. USB4 CV verifies that there are no USB3 Tunneled Packets for 5 sec
23. USB4 CV sets up a USB3 Path
24. USB4 CV verifies that the USB4 Device sends at least 3 LFPS Packets with:
 - a. PDF set to 0
 - b. Rx Term Enable field set to 1
 - c. U3 Exit bit set to 1
 - d. All other LFPS Tunneled Packet Payload fields (except the CRC field) set to 0
25. USB4 CV writes to PORTSC in the xHCI interface back to U0
26. USB4 CV verifies that the USB4 Host responds with at least 3 LFPS Packets with:
 - a. PDF set to 0
 - b. Rx Term Enable field set to 1
 - c. U3 Exit bit set to 1
 - d. All other LFPS Tunneled Packet Payload fields (except the CRC field) set to 0
27. USB4 CV verifies link initialization according to Part 2 and Part 3 in TD 9.002.

Part 4 – Exit U3 from the USB4 Device with Retry

28. Initiate U3 entry according to Part 1
29. Perform wake from the KG USB4 Device
30. USB4 CV verifies that the USB4 Device sends at least 3 LFPS Packets with:
 - a. PDF set to 0
 - b. Rx Term Enable field set to 1
 - c. U3 Exit bit set to 1
 - d. All other LFPS Tunneled Packet Payload fields (except the CRC field) set to 0
31. Analyzer wait 10ms and verify that the USB4 Device sends at least 3 LFPS Packets with:
 - a. PDF set to 0
 - b. Rx Term Enable field set to 1
 - c. U3 Exit bit set to 0
 - d. All other LFPS Tunneled Packet Payload fields (except the CRC field) set to 0
32. Analyzer wait 100ms and verify that the USB4 Device sends at least 3 LFPS Packets with:
 - a. PDF set to 0
 - b. Rx Term Enable field set to 1
 - c. U3 Exit bit set to 1
 - d. All other LFPS Tunneled Packet Payload fields (except the CRC field) set to 0
33. USB4 CV writes to PORTSC in the xHCI interface back to U0
34. USB4 CV verifies that the USB4 Host responds with at least 3 LFPS Packets with:
 - a. PDF set to 0
 - b. Rx Term Enable field set to 1
 - c. U3 Exit bit set to 1
 - d. All other LFPS Tunneled Packet Payload fields (except the CRC field) set to 0
35. USB4 CV verifies link initialization according to Part 2 and Part 3 in TD 9.002

UUT is USB4 Hub (UFP)

Note: PUT is the Upstream Facing Port of the UUT

Parts 1 through 4 are repeated with:

- All downstream ports disconnected
- All downstream ports connected and in U2
- All downstream ports connected and in U3
- If the UUT has more than 2 two downstream ports:
 - One downstream ports disconnected
 - One downstream ports connected and in U2
 - One downstream ports connected and in U3

Part 1 – Entry to U3

1. Perform link initialization according to TD 9.002
2. USB4 CV transitions all of the downstream ports to U3
3. Initiate U3 entry for the upstream port of the UUT according to Part 1

Part 2 – Exit U3 from the KG USB4 Host

4. USB4 CV initiates exit from U3 from the KG USB4 Host by writing to PORTCS register in the xHCI interface
5. USB4 CV verifies that the KG USB4 Host sends at least 3 LFPS Packets with:
 - a. PDF set to 0
 - b. Rx Term Enable field set to 1
 - c. U3 Exit bit set to 1
 - d. All other LFPS Tunneled Packet Payload fields (except the CRC field) are set to 0
6. USB4 CV verifies that the UUT responds with at least 3 LFPS Packets with:
 - a. PDF set to 0
 - b. Rx Term Enable field set to 1
 - c. U3 Exit bit set to 1
 - d. All other LFPS Tunneled Packet Payload fields (except the CRC field) are set to 0
7. USB4 CV verifies link initialization of the UUT upstream port according to Part 2 and Part 3 in TD 9.002
8. USB4 CV verifies that all connected downstream ports are still in U3
9. USB4 CV performs U3 exit for all the UUT downstream ports
10. USB4 CV verifies that the UUT sends at least 3 LFPS Packets on each connected downstream port with:
 - a. PDF set to 0
 - b. Rx Term Enable field set to 1
 - c. U3 Exit bit set to 1
 - d. All other LFPS Tunneled Packet Payload fields (except the CRC field) set to 0
11. USB4 CV verifies link initialization of the UUT downstream port according to Part 2 and Part 3 in TD 9.002

Part 3 – Exit U3 from the UUT

12. Initiate U3 entry according to Part 1
13. Perform wake from the UUT by:
 - a. Disconnect on each downstream port
 - b. Connect on each downstream port
 - c. Wake from the USB4 Device connected on each downstream port
14. USB4 CV verifies that the UUT sends at least 3 LFPS Packets with:
 - a. PDF set to 0
 - b. Rx Term Enable field set to 1
 - c. U3 Exit bit set to 1
 - d. All other LFPS Tunneled Packet Payload fields (except the CRC field) set to 0
15. USB4 CV writes to PORTSC in the xHCI interface back to U0
16. USB4 CV verifies that the KG USB4 Host responds with at least 3 LFPS Packets with:
 - a. PDF set to 0
 - b. Rx Term Enable field set to 1
 - c. U3 Exit bit set to 1
 - d. All other LFPS Tunneled Packet Payload fields (except the CRC field) set to 0
17. USB4 CV verifies link initialization according to Part 2 and Part 3 in TD 9.002
18. USB4 CV verifies that all connected downstream ports return to U0

Part 4 – Exit U3 from the UUT with Retry

19. Initiate U3 entry according to Part 1
20. Perform wake from the UUT by:
 - a. Disconnect on each downstream port
 - b. Connect on each downstream port
 - c. Wake from the USB4 Device connected on each downstream port
21. USB4 CV verifies that the UUT sends at least 3 LFPS Packets with:
 - a. PDF set to 0
 - b. Rx Term Enable field set to 1
 - c. U3 Exit bit set to 1
 - d. All other LFPS Tunneled Packet Payload fields (except the CRC field) set to 0
22. Analyzer waits 10ms and verifies that the UUT sends at least 3 LFPS Packets with:
 - a. PDF set to 0
 - b. Rx Term Enable field set to 1
 - c. U3 Exit bit set to 0
 - d. All other LFPS Tunneled Packet Payload fields (except the CRC field) set to 0
23. Analyzer waits 100ms and verifies that the UUT sends at least 3 LFPS Packets with:
 - a. PDF set to 0
 - b. Rx Term Enable field set to 1
 - c. U3 Exit bit set to 1
 - d. All other LFPS Tunneled Packet Payload fields (except the CRC field) set to 0
24. USB4 CV writes to PORTSC in the xHCI interface back to U0
25. USB4 CV verifies that the KG USB4 Host responds with at least 3 LFPS Packets with:
 - a. PDF set to 0
 - b. Rx Term Enable field set to 1
 - c. U3 Exit bit set to 1
 - d. All other LFPS Tunneled Packet Payload fields (except the CRC field) set to 0
26. USB4 CV verifies link initialization according to Part 2 and Part 3 in TD 9.002

UUT is a USB4 Hub (DFP)

Note: PUT is the downstream facing port of the UUT

Part 1 – Entry to U3

1. Perform link initialization in the upstream port of the UUT and in PUT according to TD 9.002
2. USB4 CV enables U3 in the PUT
3. USB4 CV verifies that the PUT requests entry to U3
4. USB4 CV verifies that the PUT accepts entry to U3
5. USB4 CV verifies there are no USB3 Tunneled Packets for 1 sec after entering to U3 state
6. USB4 CV verifies that the *Actual Link Rate* field in ADP_USB_CS_4 is equal to the minimum between *Maximum Supported Link Rate* field in both the USB3 Downstream Adapter and the USB3 Upstream Adapter
7. USB4 CV verifies that the *USB Link Valid* field in ADP_USB_CS_4 in the PUT and in the Compliance Device is set and the *PLS* field value is 3h

Part 2 – Exit U3 from the UUT

8. USB4 CV requests wake from U3 by issue set feature request to the PUT
9. USB4 CV verifies that the PUT sends at least 3 LFPS Packets with:
 - a. PDF set to 0
 - b. Rx Term Enable field set to 1
 - c. U3 Exit bit set to 1
 - d. All other LFPS Tunneled Packet Payload fields (except the CRC field) set to 0
10. Compliance Device responds with at least 3 LFPS Packets with:
 - a. PDF set to 0
 - b. Rx Term Enable field set to 1
 - c. U3 Exit bit set to 1
 - d. All other LFPS Tunneled Packet Payload fields (except the CRC field) set to 0
11. USB4 CV verifies link initialization according to Part 2 and Part 3 in TD 9.002

Part 3 – Exit U3 from the Compliance Device with Retry

12. Perform entry to U3 according to Part 1
13. Perform wake from U3 from the Compliance Device by issue wake
14. Compliance Device sends at least 3 LFPS Packets with:
 - a. PDF set to 0
 - b. Rx Term Enable field set to 1
 - c. U3 Exit bit set to 1
 - d. All other LFPS Tunneled Packet Payload fields (except the CRC field) set to 0
15. USB4 CV verifies that the PUT responds with at least 3 LFPS Packets with:
 - a. PDF set to 0
 - b. Rx Term Enable field set to 1
 - c. U3 Exit bit set to 1
 - d. All other LFPS Tunneled Packet Payload fields (except the CRC field) set to 0
16. USB4 CV verifies link initialization according to Part 2 and Part 3 in TD 9.002

TD 9.005 Warm Reset Test

A. Purpose

- Verify that the UUT can send and receive warm reset

B. Asserts:

- 9.1.1.1.7#2, 9.1.1.1.7#3, 9.1.1.1.7#6, 9.1.1.1.7#7

C. Setup:

- AN_HOST_DFP1—USB3_01 (Host)
- AN_HUB_UFP1—USB3_01 (Hub UFP)
- AN_HUB_DFP1—USB3_03 (Hub DFP)
- AN_DEV_UFP1—USB3_01 (Peripheral Device)

D. Repetitions:

- Repeat with a USB4 KG Device that supports:
 - USB3 Tunneling at USB 3.2 Gen2x1 speed
 - USB3 Tunneling at USB 3.2 Gen2x2 speed
- Repeat the test while the PUT is in:
 - U0
 - U2
 - U3

E. Procedure:

Note: It is not a test failure if the Link Partner sends LFPS Packets before the PUT.

PUT is a DFP

1. Perform link initialization according to TD 9.002
2. Transition the PUT to the desired Ux state (see repetitions)
3. Start Analyzer
4. USB4 CV requests warm reset
 - a. UUT is a USB4 Host: Using PORTSC in the USB4 Host
 - b. UUT is a USB4 Hub: Using SetPortFeature(PORT_BH_RESET)
5. Wait for 1 second and stop Analyzer
6. Warm Reset Start: USB4 CV verifies that the PUT sends 3 LFPS Packets with:
 - a. PDF set to 0
 - b. Rx Term Enable field set to 1
 - c. Warm Reset bit set to 1
 - d. All other LFPS Tunneled Packet Payload fields (except the CRC field) set to 0
7. Warm Reset End: USB4 CV verifies that the next USB3 Tunneled Packets that the PUT sends are 3 LFPS Packets with:
 - a. PDF set to 0
 - b. Rx Term Enable field set to 1
 - c. All other LFPS Tunneled Packet Payload fields (except the CRC field) set to 0
8. Verify that the time from Warm Reset Start to Warm Rest End is between 80ms to 120ms.
9. USB4 CV verifies that the *USB Link Valid* field in ADP_USB_CS_4 in the UUT is set to 1
10. USB4 CV verifies that the *Actual Link Rate* field in ADP_USB_CS_4 is equal to the minimum between *Maximum Supported Link Rate* field in both the USB3 Downstream Adapter and the USB3 Upstream Adapter
11. USB4 CV verifies that the link returns to U0

PUT is a UFP

1. Perform link initialization according to TD 9.002
2. Transition the PUT to the desired Ux state (see repetitions)
3. Start Analyzer
4. USB4 CV requests warm reset using PORTSC in the USB4 Host
5. Wait 1 second and stop Analyzer
6. Warm Reset Start: USB4 CV identifies 3 LFPS Packets with:
 - a. PDF set to 0
 - b. Rx Term Enable field set to 1
 - c. Warm Reset bit set to 1
 - d. All other LFPS Tunneled Packet Payload fields (except the CRC field) set to 0
7. Warm Reset End: USB4 CV identifies 3 LFPS Packets with:
 - a. PDF set to 0
 - b. Rx Term Enable field set to 1
 - c. All other LFPS Tunneled Packet Payload fields (except the CRC field) set to 0
8. USB4 CV verifies that the *USB Link Valid* field in ADP_USB_CS_4 in the UUT is set to 1
9. USB4 CV verifies that the *Actual Link Rate* field in ADP_USB_CS_4 is equal to the minimum between *Maximum Supported Link Rate* field in both the USB3 Downstream Adapter and the USB3 Upstream Adapter
10. USB4 CV verifies that the link returns to U0

TD 9.006 Hot Reset Test (Hosts and Hubs Only)

Note: This test is only performed on the DFP

- A. Purpose
 - Verify that the UUT can send hot reset
- B. Asserts:
 - 9.1.1.2#1, 9.1.1.2#2, 9.1.1.2#3, 9.1.1.2#4
- C. Setup:
 - AN_HOST_DFP1—USB3_01 (Host)
 - AN_HUB_DFP1—USB3_03 (Hub DFP)
- D. Procedure:

Note: It is not a test failure if the Link Partner sends LFPS Packets before the PUT.

1. Perform link initialization according to TD 9.002
2. Start Analyzer
3. USB4 CV requests hot reset
 - a. UUT is a USB4 Host: using PORTSC in the USB3 downstream port
 - b. UUT is a USB4 Hub: using SetPortFeature(PORT_RESET)
4. Wait 1 second and stop Analyzer
5. USB4 CV verifies that the USB3 Downstream Adapter sends at least 3 OS Tunneled Packets with:
 - a. PDF set to 1
 - b. TS1 field set to 1
 - c. All other OS Tunneled Packet Payload fields (except the CRC field) set to 0
6. USB4 CV verifies that the USB4 Device responds with at least 3 OS Tunneled Packets with:
 - a. PDF set to 1
 - b. TS1 field set to 1
 - c. All other OS Tunneled Packet Payload fields (except the CRC field) set to 0
7. USB4 CV verifies that the USB3 Downstream Adapter sends at least 3 OS Tunneled Packets with:
 - a. PDF set to 1
 - b. TS2 field set to 1
 - c. Link Functionality bit 0 set to 1
 - d. All other OS Tunneled Packet Payload fields (except the CRC field) set to 0
8. The Compliance Device responds with at least 3 OS Tunneled Packets with:
 - a. PDF set to 1
 - b. TS2 field set to 1
 - c. Link Functionality bit 0 set to 1
 - d. All other OS Tunneled Packet Payload fields (except the CRC field) set to 0
9. USB4 CV verifies that the USB3 Downstream Adapter sends at least 3 OS Tunneled Packets with:
 - a. PDF set to 1
 - b. TS2 field set to 1
 - c. All other OS Tunneled Packet Payload fields (except the CRC field) set to 0
10. The Compliance Device responds with at least 3 OS Tunneled Packets with:
 - a. PDF set to 1
 - b. TS2 field set to 1
 - c. All other OS Tunneled Packet Payload fields (except the CRC field) set to 0
11. USB4 CV verifies that the link returns to U0

12. USB4 CV verifies that the *Actual Link Rate* field in ADP_USB_CS_4 is equal to the minimum between *Maximum Supported Link Rate* field in both the USB3 Downstream Adapter and the USB3 Upstream Adapter
13. USB4 CV verifies that the *USB Link Valid* field in ADP_USB_CS_4 in the UUT set to 1

TD 9.007 Limited Bandwidth Test

A. Purpose

- Verify that the UUT doesn't drop any USB3 Tunneled Packets when bandwidth is limited

B. Asserts:

- 9.1.1#8

C. Setup:

- AN_HOST_DFP1—USB3_01/DC_HOST_DFP1—USB3_04 (Host)
- AN_HUB_UFP1—USB3_01/DC_HUB_UFP1—USB3_07 (Hub UFP)
- AN_HUB_DFP1—USB3_03/DC_HUB_DFP1—USB3_08 (Hub DFP)
- AN_DEV_UFP1—USB3_01/DC_DEV_UFP1—USB3_03 (Peripheral Device)

D. Procedure:

1. USB4 CV sets up a USB3 Path with 1 credit in the USB3 Adapters
2. Perform link initialization according to TD 9.002
3. USB4 CV transmits data from the USB4 Host to the USB4 Device for at least 1 minute
4. USB4 CV receives data between the USB4 Device and the USB4 Host for at least 1 minute
5. During the data transfer,USB4 CV verifies that there are no recoveries over the USB3 tunnel

TD 9.008 Data Packet Traffic Test

Note: This test requires a USB 3.2 Gen 2x1 Device that generates data packets in different sizes. This can be done using the loopback device that is used for USB 3.2 certification (SuperMUTT-compatible device)

Note: For a USB4 peripheral device, this test is only run if the peripheral has one or more non-USB4 DFP that support USB 3.2.

A. Purpose

- Verify that the UUT can handle all data packet sizes

B. Asserts:

- 9.1.1#2, 9.1.1#9, 9.1.1.8#1, 9.1.1.8#2, 9.1.1.8#3, 9.1.1.8#4, 9.1.1.8#5, 9.1.1.8#6

C. Setup:

- AN_HOST_DFP2—USB3_03 (Host)
- AN_HUB_UFP2—USB3_06 (Hub UFP)
- AN_HUB_DFP2—USB3_05 (Hub DFP)
- AN_DEV_UFP2—USB3_04 (Peripheral Device)

D. Procedure:

1. Perform link initialization according to TD 9.002
2. Start Analyzer
3. USB4 CV transmits data to and from the Compliance Device
 - a. Data is transmitted in data packets that carry between 1B and 1028B of data, where the first data packet contains 1B of data, the second data packet contains 4B of data, and each subsequent data packet contains an additional 4B of data (8B, 12B, etc.)
 - b. The data packet can be generated using any USB device
4. Wait 30 seconds
5. Stop Analyzer
6. USB4 CV verifies that all packets were received correctly.
7. USB4 CV verifies that there were no USB3 recoveries or retransmissions in the trace
8. USB4 CV verifies the following:
 - a. All data packets between 1B to 216B are transmitted as a single data packet that includes the DPH and DPP in the same packet. The type of the USB3 Tunneled Packet is Start DP Segment using PDF 4
 - b. All data packets between 217B to 468B are transmitted as two USB3 Tunneled Packets:
 - i. The first Tunneled Packet includes the DPH and part of DPP in the same packet. The type of the Tunneled Packet is Start DP Segment using PDF 4. The size of the Tunneled Packet is 256B
 - ii. The second Tunneled Packet includes the remaining data. The type of the Tunneled Packet is End DP Segment using PDF 6
 - c. All data packets between 469B to 1024B are transmitted as at least 3 USB3 Tunneled Packets:
 - i. The first Tunneled Packet includes the DPH and part of the DPP. The type of the Tunneled Packet is Start DP Segment using PDF 4. The size of the Tunneled Packet is 256B
 - ii. Any middle-Tunneled Packets include the continued data from the data packet. The type of the Tunneled Packet is Start DP Segment using PDF 5. The size of the Tunneled Packet is 256B
 - iii. The last USB3 Tunneled Packet includes any remaining data. The type of the Tunneled Packet is End DP Segment using PDF 6
 - d. Data packet 1028B:
 - i. Transit at least 3 USB3 Tunneled Packets containing the first 1024 bytes:

1. The first Tunneled Packet includes the DPH and part of the DPP. The type of the Tunneled Packet is Start DP Segment using PDF 4. The size of the Tunneled Packet is 256B
 2. Any middle-Tunneled Packets include the continued data from the data packet. The type of the Tunneled Packet is Start DP Segment using PDF 5. The size of the Tunneled Packet is 256B
 3. The last USB3 Tunneled Packet includes any remaining data. The type of the Tunneled Packet is End DP Segment using PDF 6
- ii. Transmit a Start DP Segment using PDF4 that contains the last 4 bytes of data

TD 9.009 Re-assembling Data Packet Test

A. Purpose

- Verify that the UUT can re-assembling USB3 Tunneled Packets into USB 3.2 Data Packets

B. Asserts:

- 9.1.1.8#11, 9.1.1.8#12, 9.1.1.8#13
- 9.1.3#1

C. Setup:

- EX_HOST_DFP1—USB3_02 (Host)
- EX_HUB_UFP1—USB3_02 (Hub UFP)
- EX_HUB_DFP1—USB3_04 (Hub DFP)
- EX_DEV_UFP1—USB3_02(Peripheral Device)

D. Procedure:

- *Note: When the Exerciser skips a Tunneled Packet during this test, it is meant to simulate the Tunneled Packet being dropped. Each Tunneled Packet should contain the payload as if the whole USB3 Data Packet and all corresponding Tunneled packets were sent. For example, if a Start DP Segment is skipped, the USB3 DPH and start of payload is not sent. If a Middle DP Segment is skipped, the corresponding payload is not sent. And, if an End DP Segment is skipped, the last of the payload and CRC are not sent.*

Part 0 – Link Init and Good Data Packets

1. Perform link initialization according to TD 9.002 between the UUT and the Exerciser
2. Exerciser transmits a USB3 Data Packet (Good Data Packet) with 1024B of payload data, where the Exerciser encapsulates the USB3 Data Packet into the following Tunneled Packets:
 - a. One Start DP Segment
 - b. Three Middle DP Segment
 - c. One End DP Segment
3. Exerciser verifies that there is a link command from the UUT that responds successfully to the packet with LGOOD and LCRD

Part 1 – Missing Start DP Segment

- 4.
5. Exerciser transmits a USB3 Data Packet with 1024B of payload data, however, when sending the Tunneled Packets, the Exerciser omits the Start DP Segment packet and sends only the following packets for the USB3 Data Packet:
 - a. Three Middle DP Segment with PDF 5
 - b. One End DP Segment with PDF 6
6. For 1 sec, Exerciser verifies that there is no link command from the UUT that responds to the packet
7. Exerciser transmits a Good Data Packet (same as step 2)
8. Exerciser verifies that the UUT initiates recovery, and train the link back to U0
9. Exerciser transmits two Good Data Packets with the correct sequence numbers
10. Exerciser verifies that there is a link command from the UUT that responds successfully to the packets with LGOOD and LCRD

Part 2 – Missing All Middle DP Segments

11. Exerciser transmits a USB3 Data Packet with 1024B of payload data, however, when sending the Tunneled Packet, the Exerciser omits all of the Middle DP Segment packets and sends only the following packets for the USB3 Data Packet:
 - a. One Start DP Segment with PDF 4
 - b. One End DP Segment with PDF 6
12. Exerciser verifies that the UUT does one of the following:
 - a. Sends an ACK with *Retry Data Packet* (rty) bit set to 1b
 - b. Initiates recovery. In this case the Exerciser trains the link back to U0.
13. Exerciser retransmits the same Data Packet without omitting any of the segments.
14. Exerciser verifies that there is a link command from the UUT that responds successfully to the packets with LGOOD and LCRD
15. Exerciser verifies that the UUT sends an ACK with *Retry Data Packet* (rty) bit set to 0b

Part 3 – Missing a Single Middle DP Segment

16. Repeat Part 2, but instead of omitting all Middle DP Segments, Exerciser omits only one of the Middle DP Segment packets, therefore it sends the following packets for the USB3 Data Packet:
 - a. One Start DP Segment with PDF 4
 - b. Two Middle DP Segment with PDF 5
 - c. One End DP Segment with PDF 6

Part 4 – Missing End DP Segment followed by Good Packet

17. Exerciser transmits a USB3 Data Packet, however, when sending the Tunneled Packets, the Exerciser omits the End DP Segment packet and sends only the following packets for the USB3 Data Packet:
 - a. One Start DP Segment with PDF 4
 - b. Three Middle DP Segment with PDF 5
18. Exerciser transmits a Good Data Packet (Same as step 2)
19. Exerciser verifies that the UUT does one of the following:
 - a. Sends an ACK with *Retry Data Packet* (rty) bit set to 1b
 - b. Initiates recovery. In this case the Exerciser trains the link back to U0.
20. Exerciser retransmits the last two Data Packets without omitting the End Segment and with the correct sequence numbers
21. Exerciser verifies that there is a link command from the UUT that responds successfully to the packets with LGOOD and LCRD
22. Exerciser verifies that the UUT sends two ACK packets with *Retry Data Packet* (rty) bit set to 0b

Part 5 – Missing End DP Segment with Timeout

23. Exerciser transmits a USB3 Data Packets with 1024B of payload data, however, when sending the Tunneled Packets, the Exerciser omits the End DP Segment packet and sends only the following packets:
 - a. One Start DP Segment with PDF 4
 - b. Three Middle DP Segment with PDF 5
24. Exerciser verifies that the UUT sends an ACK with *Retry Data Packet* (rty) bit set to 1b no sooner than tReassemble time after injecting the Start DP Segment
25. Exerciser transmits two Good Data Packets with the correct sequence numbers
26. Exerciser verifies that there is a link command from the UUT that responds successfully to the packets with LGOOD and LCRD

27. Exerciser verifies that the UUT sends two ACK packets with *Retry Data Packet* (rty) bit set to 0b

TD 9.010 ITP Packet Test

A. Purpose:

- Verify that a USB4 Host/Hub handles the ITP correctly

B. Asserts:

- 9.1.1.7#2, 9.1.1.7#3, 9.1.1.7#4, 9.1.1.7#7

C. Setup:

- AN_HOST_DFP1—USB3_01 (Host)
- AN_HUB_UFP1—USB3_01 (Hub UFP)
- AN_HUB_DFP1—USB3_03 (Hub DFP)
- AN_DEV_UFP1—USB3_01 (Peripheral Device)

D. Procedure:

Part 1 – Encapsulation Format

1. Perform link initialization according to TD 9.002 between the UUT and the Analyzer
2. Read the Time Synchronization Protocol Not Supported bit from TMU_RTR_CS_0
3. If the Time Synchronization Protocol Not Supported bit is 1b, end test here.
4. While the link is in U0, the Analyzer captures packets for 1 sec
5. Find the first ITP packet in the trace and verify that:
 - a. PDF is 3
 - b. Length of the ITP packet is 0x1C
 - c. TMU Time Capture value is greater than zero
6. For each additional ITP packet in the trace, verify:
 - a. PDF is 3
 - b. Length of the ITP packet is 0x1C
 - c. TMU Time Capture value is greater than zero
 - d. Verify the following:
$$(\text{Current TMU time} - \text{Current Delta time}) - (\text{Previous TMU time} - \text{Previous Delta time}) == 125\mu \pm 1\mu\text{s}$$

Part 2 – Delta Check for Hub DFP (Hubs Only)

7. Perform link initialization according to TD 9.002 between the UUT UFP and the Analyzer
8. Perform link initialization according to TD 9.002 between the UUT DFP and the Analyzer
9. While the link is in U0, the Analyzer captures packets for 1 sec
10. USB4 Analyzer sends ITP packet with current TMU time + 125 μ s
11. Find the ITP packet in the downstream trace and verify that:
 - a. PDF is 3
 - b. Length of the ITP packet is 0x1C
 - c. TMU Time Capture value is greater than zero
 - d. Delay bit is set to 1

TD 9.011 Upstream BW Management Test (Hosts Only)

A. Purpose:

- Verify that the UUT implements Bandwidth Negotiation correctly

B. Asserts:

- 9.3.2#1, 9.3.2#5

C. Setup:

- AN_HOST_DFP1—USB3_01 (Host)

D. Procedure:

1. Perform Link Initialization according to TD 9.2
2. USB4 CV verifies that *Host Controller Ack* field is set to 0
3. USB4 CV verifies that *Consumed Upstream Bandwidth* field \leq *Allocated Upstream Bandwidth* field
4. USB4 CV sets the *Connection Manager Request* field to 1
5. USB4 CV waits until the *Host Controller Ack* field is set to 1
6. For a Ver. 2 Router, Verify that the *Host Controller Ack* field was set to 1 within (10ms + tSetHCA) time from setting the *Connection Manager Request* field to 1
7. USB4 CV sets the *Allocated Upstream Bandwidth* field to be equal to the *Consumed Upstream Bandwidth* field
8. USB4 CV clears the *Connection Manager Request* field
9. USB4 CV waits until the *Host Controller Ack* field is clear
10. USB4 CV verifies that *Consumed Upstream Bandwidth* field \leq *Allocated Upstream Bandwidth* field
11. USB4 CV connects a USB 3.2 isochronous device to the topology
12. USB4 CV verifies that *Consumed Upstream Bandwidth* field \leq *Allocated Upstream Bandwidth* field
13. USB4 CV verifies that the USB 3.2 isochronous device did not enumerate

TD 9.012 Downstream BW Management Test (Hosts Only)

A. Purpose:

- Verify that the UUT implements Bandwidth Negotiation correctly

B. Asserts:

- 9.3.2#2, 9.3.2#5

C. Setup:

- AN_HOST_DFP1—USB3_01 (Host)

D. Procedure:

1. Perform Link Initialization according to TD 9.2
2. USB4 CV verifies that *Host Controller Ack* field is set to 0
3. USB4 CV verifies that *Consumed Downstream Bandwidth* field \leq *Allocated Downstream Bandwidth* field
4. USB4 CV sets the *Connection Manager Request* field to 1
5. USB4 CV waits until the *Host Controller Ack* field is set to 1
6. For a Ver. 2 Router, Verify that the *Host Controller Ack* field was set to 1 within (10ms + tSetHCA) time from setting the *Connection Manager Request* field to 1
7. USB4 CV sets the *Allocated Downstream Bandwidth* field to be equal to the *Consumed Downstream Bandwidth* field
8. USB4 CV clears the *Connection Manager Request* field
9. USB4 CV waits until the *Host Controller Ack* field is clear
10. USB4 CV verifies that *Consumed Downstream Bandwidth* field \leq *Allocated Downstream Bandwidth* field
11. USB4 CV connects a USB 3.2 isochronous device to the topology
12. USB4 CV verifies that the *Consumed Downstream Bandwidth* field \leq *Allocated Downstream Bandwidth* field
13. USB4 CV verifies that the USB 3.2 isochronous device did not enumerate

TD 9.013 Path Teardown Test (Hosts and Hubs Only)

A. Purpose:

- Verify that the UUT handles Path Teardown correctly after the *Path Enable* bit in a DFP is set to 0b

B. Asserts:

- 9.3.2#1, 9.3.2#2

C. Setup:

- AN_HOST_DFP1—USB3_01/DC_HOST_DFP1—USB3_04 (Host)
- AN_HUB_DFP1—USB3_03/DC_HUB_DFP1—USB3_08 (Hub DFP)

D. Procedure:

Part 1 – DFP Disconnect

1. Perform Link Initialization according to TD 9.2
2. USB4 CV waits at least 500ms after setting up the USB3 Path
3. Disconnect the USB4 Device from the PUT
4. USB4 CV waits 500ms from the disconnect
5. USB4 CV reads ADP_USB3_CS_0 and verifies that the *Path Enable* bit is 0
6. USB4 CV reads ADP_USB3_CS_4 and verifies that the *PLS* field is 5h (RxDetect state)
7. USB4CV completes USB3 Path Teardown for each path that traverses through the disconnected DFP
8. USB4 CV waits 1 second

Part 2 – Path Teardown

9. Reconnect the USB4 Device to the PUT
10. Perform Link Initialization according to TD 9.2
11. USB4 CV waits at least 500ms after setting up the USB3 Path
12. USB4 CV performs path teardown according to the CM guide
13. 13. USB4 CV waits 500msUSB4 CV reads ADP_USB3_CS_4 and verifies that the *PLS* field is 5h (RxDetect state)
14. USB4 CV waits 1 second
15. USB4 CV verifies that the PUT did not send any USB3 Tunneled Packets
16. Perform USB3 Path setup according to the USB4 specification and CM Guide
17. Verify that all USB4 and USB 3.2 Devices enumerate at the correct speed

TD 9.014 tPortConfiguration Test

A. Purpose:

- Verify that the tPortConfiguration timer is implemented correctly

B. Asserts:

- 9.2.1.2#1

C. Setup:

- EX_HOST_DFP1—USB3_02 (Host)
- EX_HUB_UFP1—USB3_02(Hub UFP)
- EX_HUB_DFP1—USB3_04 (Hub DFP)
- EX_DEV_UFP1—USB3_02 (Peripheral Device)

D. Procedure:

Part 1 – Delayed Port Capability LMP Packet

1. Perform Link Initialization according to TD 9.2 between the UUT and the Exerciser
2. Exerciser verifies that the UUT sent a Port Capability LMP Packet in less than tPortConfiguration time from entering U0
3. Exerciser sends a Port Capability LMP Packet (tPortConfiguration – 1μs) time after entering U0
4. If the PUT is a DFP
 - a. Exerciser verifies the UUT sends a Port Configuration LMP Packet in less than tPortConfiguration time from when the Exerciser sent the Port Capability LMP Packet
 - b. Exerciser sends a Port Configuration Response LMP Packet
5. If the PUT is a UFP
 - a. Exerciser sends a Port Configuration LMP Packet
 - b. Exerciser verifies the UUT sends a Port Configuration Response LMP Packet in less than tPortConfiguration time from when the Exerciser sent the Port Configuration LMP Packet
6. Exerciser verifies that the link stays in U0 at lease for 1 sec

Part B – No LMP Packet

7. Perform Link Initialization according to TD 9.2 between the UUT and the Exerciser
8. Exerciser verifies that the UUT sends Port Configuration LMP Packet within tPortConfiguration time
9. Exerciser doesn't send a Port Configuration LMP Packet
10. Exerciser verifies that the link goes to recovery within tPortConfiguration + 1μs

Part C – LMP Packet (DFP Only)

11. Perform Link Initialization according to TD 9.2 between the UUT and the Exerciser
12. Exerciser verifies that the UUT sent a Port Configuration LMP Packet within tPortConfiguration time
13. Exerciser sends a Port Configuration LMP Packet within tPortConfiguration
14. Exerciser verifies that the link goes to recovery within tPortConfiguration + 1μs

Part 2 – Delayed Port Configuration LMP Packet

15. Perform Link Initialization according to TD 9.2 between the UUT and the Exerciser

16. Exerciser sends a Port Capability LMP Packet and verifies that the UUT sent a Port Capability LMP Packet in less than tPortConfiguration time from entering U0
17. If the PUT is a DFP
 - a. Exerciser verifies the UUT sends a Port Configuration LMP Packet in less than tPortConfiguration time from when the Exerciser sent the Port Capability LMP Packet
 - b. Exerciser sends a Port Configuration Response LMP Packet (tPortConfiguration – 1μs) time after it received the Port Configuration LMP Packet
18. If the PUT is a UFP
 - a. Exerciser sends a Port Configuration LMP Packet (tPortConfiguration – 1μs) time after it received the Port Capabilities LMP Packet
 - b. Exerciser verifies the UUT sends a Port Configuration Response LMP Packet in less than tPortConfiguration time from when the Exerciser sent the Port Configuration LMP Packet
19. Exerciser verifies that the link stays in U0 at lease for 1 sec

Part 3 – No Port Capability LMP Packet

20. Perform Link Initialization according to TD 9.2 between the UUT and the Exerciser
21. Exerciser verifies that the UUT sends Port Capability LMP Packet within tPortConfiguration time from entering U0
22. Exerciser doesn't send a Port Capability LMP Packet
23. If the PUT is a DFP, USB4CV verifies that the PUT goes to Inactive state within (tPortConfiguration + 10μs) from receiving the Port Capability LMP Packet
24. If the PUT is a UFP, USB4CV verifies that the PUT goes to Rx.Detect state within (tPortConfiguration + 10μs) from receiving the Port Capability LMP Packet

Part 4 – No Port Configuration LMP Packet

25. Perform Link Initialization according to TD 9.2 between the UUT and the Exerciser
26. Exerciser sends a Port Capability LMP Packet and verifies that the UUT sent a Port Capability LMP Packet in less than tPortConfiguration time from entering U0
27. If the PUT is a DFP
 - a. Exerciser verifies the UUT sends a Port Configuration LMP Packet in less than tPortConfiguration time from when the Exerciser sent the Port Capability LMP Packet
 - b. Exerciser doesn't send a Port Configuration Response LMP Packet
 - c. USB4CV verifies that the PUT goes to Inactive state within (tPortConfiguration + 10μs) from receiving the Port Configuration LMP Packet
28. If the PUT is a UFP
 - a. Exerciser doesn't send a Port Configuration LMP Packet
 - b. USB4CV verifies that the PUT goes to Rx.Detect state within (tPortConfiguration + 10μs) from receiving the Port Capability LMP Packet

TD 9.015 PENDING_HP_TIMER Test

A. Purpose:

- Verify that PENDING_HP_TIMER is implemented correctly

B. Asserts:

- 9.2.1.2#1

C. Setup:

- EX_HOST_DFP1—USB3_02 (Host)
- EX_HUB_UFP1—USB3_02 (Hub UFP)
- EX_HUB_DFP1—USB3_04 (Hub DFP)
- EX_DEV_UFP1—USB3_02 (Peripheral Device)

D. Procedure:

Part 1 – Delayed Response

1. Perform Link Initialization according to TD 9.2 between the UUT and the Exerciser
2. Exerciser verifies that the UUT sent a Port Configuration LMP packet within tPortConfiguration time
3. Exerciser responds with LGOOD_N for Port Configuration LMP 500ns prior to the PENDING_HP_TIMER deadline
4. Exerciser continues the LMP handshake
5. Verify that the link stays in U0 for at least 1 sec

Part 2 – No Response

6. Perform Link Initialization according to TD 9.2 between the UUT and the Exerciser
7. Exerciser verifies that the UUT sent a Port Configuration LMP packet within tPortConfiguration time
8. Exerciser doesn't respond with LGOOD_N for Port Configuration LMP
9. Exerciser sends a Port Configuration LMP packet within tPortConfiguration time
10. If the PUT is a DFP, the Exerciser sends a Port Configuration LMP Response. Else skip to next step
11. Verify that the link goes to recovery after the PENDING_HP_TIMER deadline and before the next PENDING_HP_TIMER expires

TD 9.016 PM_LC_TIMER Test (Hosts and Hubs Only)

- A. Purpose:
 - Verify that PM_LC_TIMER is implemented correctly
- B. Asserts:
 - 9.2.1.2#1
- C. Setup:
 - EX_HOST_DFP1—USB3_02 (Host)
 - EX_HUB_DFP1—USB3_04 (Hub)
- D. Procedure:

Part 1 – Delayed Response

1. Perform Link Initialization according to TD 9.2 between the UUT and the Exerciser
2. USB4 CV enables U2 on the PUT
3. Exerciser verifies that the PUT sends a LGO_U2 Packet
4. Exerciser responds with a LAU before the PM_LC_TIMER deadline
5. Verify that the PUT transmits an LPMA after receiving the LAU
6. Verify that the link transitions to U2 for at least 1 sec

Part 2 – No Response

7. Perform Link Initialization according to TD 9.2 between the UUT and the Exerciser
8. USB4 CV enables U2 on the PUT
9. Exerciser verifies that the PUT sends LGO_U2 Packet
10. Exerciser doesn't respond with LAU
11. Verify that the link transition to recovery after PM_LC_TIMER deadline and back to U0

TD 9.017 PM_ENTRY_TIMER Test (Hubs and Devices Only)

A. Purpose:

- Verify that PM_ENTRY_TIMER is implemented correctly

B. Asserts:

- 9.2.1.2#1

C. Setup:

- EX_HUB_UFP1—USB3_02 (Hub)
- EX_DEV_UFP1—USB3_02 (Peripheral Device)

D. Procedure:

1. Perform Link Initialization according to TD 9.2 between the UUT and the Exerciser
2. USB4 CV enables U2 on the PUT
3. Exerciser sends a LGO_U2 Packet
4. Exerciser verifies that the PUT responds with a LAU to go to U2
5. Exerciser doesn't respond with LPMA
6. Verify that the PUT transitions to U2 after PM_ENTRY_TIMER expires
7. Verify that the link transitions to U2 for at least 1 sec

TD 9.018 USB3 DFP Test (Hubs and Peripherals Only)

A. Purpose:

- Verify that the UUT incorporates an internal USB SuperSpeed Plus hub per the USB 3.2 Specification with the modifications defined in the USB4 Specification

B. Asserts:

- 9#5

C. Procedure:

1. The downstream ports that support USB 3.2 runs USB 3.2 link layer certification as defined in the USB 3.2 CTS while the UFP is in USB4 mode
2. Verify that all tests pass

TD 9.019 TBT3 Compatibility Mode Test (Hubs and Peripherals Only)

Note: This test is only run if the UUT supports TBT3-Compatibility.

A. Purpose:

- Verify that the internal Host Controller in a TBT3-Compatible UUT is compliant to the USB 3.2 specification and xHCI specification

B. Asserts:

- TBD

C. Procedure:

1. Connect the UUT to a KG TBT3 Host
2. Establish TBT3 link with PCIe tunnel
3. Run xHCI certification on the internal Host Controller of the UUT

TD 9.020 Get Container ID Test (Hub or Device Only)

Note: This test was previously part of the Protocol CTS as TD 8.018. This test is only run if the UUT contains an internal USB 3.2 hub.

A. Purpose:

- Verify that a Router handles a Get Container ID Operation correctly

B. Asserts:

- 8.3.1.3.5#1-4

C. Test Setup:

- AN_HUB_UFP1—USB3_01/DC_HUB_UFP1—USB3_07 (Hub)
- AN_DEV_UFP1—USB3_01//DC_DEV_UFP1—USB3_03 (Device)

D. Procedure:

Note: If any field in the Metadata or Data DW is Reserved or not used (i.e. marked as “none” in the test below) then USB4 CV writes all 0s to that field.

USB4 CV performs the following test steps:

1. Start Analyzer
2. Reset UUT
3. Enumerate UUT
4. Read the Container ID from the internal USB 3.2 hub
5. Initiate a GET_CONTAINER_ID Operation by writing the following to Router Configuration Space:
 - a. *Opcode* = 36h
 - b. *Metadata* = none
 - c. *Data* = none
 - d. *Operation Valid* = 1b
6. Poll the *Operation Valid* bit in ROUTER_CS_26 until it is set to 0b
7. Read the ROUTER_CS_25 and ROUTER_CS_26 bytes from Router Configuration Space
8. Verify that the *Operation Not Supported* bit is 0b (8.3.1.3.5#1, 8.3.1.3.5#2)
 9. Verify that *Status* field is 0h (8.3.1.3.5#4)
 10. Read Data DW 0 through Data DW 3
 11. Verify that the Data DWs contain the same Container ID as read from the internal USB 3.2 hub (8.3.1.3.5#3)

TD 9.101 Get Container ID Test (Hub or Device Only)

Note: This test is only performed if the Router supports Version 2.0 of the USB4 Specification.

Note: This test only applies to a USB4 Hub that supports all of the following:

- USB3 Tunneling Gen2x2 operation on the UFP
- USB3 Tunneling and USB3 Native Gen 2x2 operation on one or more DFP

A. Purpose:

- Verify that the USB4 Hub meets the maximum forward timing requirements

B. Asserts:

- TBD

C. Setup:

- AN_HUB_DFP1—USB3_05
- AN_HUB_DFP1—USB3_06

D. Repetitions:

- The following repetitions are performed at Gen 3 and Gen 4 speeds:
 - USB4 Compliance device with file Write (Setup AN_HUB_DFP1—USB3_05)
 - USB4 Compliance device with file Read (Setup AN_HUB_DFP1—USB3_05)
 - KG USB 3.2 device with file Write (Setup AN_HUB_DFP1—USB3_06)
 - KG USB 3.2 device with file Read (Setup AN_HUB_DFP1—USB3_06)

E. Procedure:

1. Perform Link Initialization according to TD 9.2 between the UUT and the KG USB4 Host
2. If a USB4 Compliance device is connected downstream of the UUT (see repetitions), perform Link Initialization according to TD 9.2 between the UUT and the USB4 Compliance device
3. Start Analyzers
4. If initiating a Write (see repetitions), copy a large file from the host to the USB3 device
5. If initiating a Read (see repetitions), copy a large file from the USB3 device to the host
6. Stop Analyzers
7. Generate a list of Data Packet Forward delays where each entry is the delay from the last received bit of a Data Packet to the first transmitted bit of the same Data Packet.
 - a. In case a different Packet was transmitted by the PUT between the reception of the Data Packet and the transmission of the same Data Packet – The Data Packet Forward delay is ignored and is not added to the list.
8. Verify the Data Packet Forward delays:
 - a. If a USB4 Compliance device is connected downstream of the UUT (see repetitions) – Verify that none of the Data Packet Forward delays in the list exceeds tUSB3GenXPktFwd_DP.
 - b. If a KG USB 3.2 device is connected downstream of the UUT (see repetitions) – Verify that none of the Data Packet Forward delays in the list exceeds tUSB3GenXPktFwd_DP_Native.
9. Generate a list of ACK Packet Forward delays where Each entry is the delay from the last received bit of an ACK Packet to the first transmitted bit of the same ACK Packet.
 - a. In case a different Packet was transmitted by the PUT between the reception of the ACK Packet and the transmission of the same ACK Packet – The ACK Packet Forward delay is ignored and is not added to the list.

10. Verify the ACK Packet Forward delays:
 - a. If a USB4 Compliance device is connected downstream of the UUT (see repetitions) – Verify that none of the ACK Packet Forward delay in the list exceeds $t_{USB3GenXPktFwd_ACK}$.
 - b. If a KG USB 3.2 device is connected downstream of the UUT (see repetitions) – Verify that none of the ACK Packet Forward delays in the list exceeds $t_{USB3GenXPktFwd_ACK_Native}$.

TD 9.102 Maximum Device Response Delay Requirements Test (USB4-Based Docks and Peripheral Devices Only)

Note: This test is only performed if the Router supports Version 2.0 of the USB4 Specification.

Note: This test only apply for USB4-Based Docks and Peripheral Devices that contains an embedded USB3 endpoint that supports USB3 Tunneling at Gen 2x2 speed.

A. Purpose:

- Verify that the USB4-Based Docks and Peripheral Devices meets the maximum response timing requirements

B. Asserts:

- TBD

C. Setup:

- AN_DEV_UFP1—USB3_01
- AN_HUB_UFP1—USB3_01

D. Repetitions:

- All USB4 links at Gen 4 speed
- All USB4 links at Gen 3 speed

E. Procedure:

1. Perform Link Initialization according to TD 9.2 between the UUT and the KG USB4 Host
2. If the UUT supports a USB3 OUT endpoint, perform Part 1
3. If the UUT supports a USB3 IN endpoint, perform Part 2

Part 1 – OUT Endpoints

4. Start Analyzer
5. Create continuous OUT traffic to UUT for 10 seconds
6. Stop Analyzer
7. Generate a list of ACK Response delays where each entry is the delay from the last received bit of a Data Packet to the first transmitted bit of the ACK Packet for the Data Packet.
 - a. In case a different Packet was transmitted by the PUT between the reception of the Data Packet and the transmission of the ACK Packet (Excluding the LCRD and LGOOD that are sent as a response for the Data Packet itself) – The ACK Response delay is ignored and is not added to the list.
8. Verify that none of the ACK Response delays in the list exceeds $t_{USB3DeviceDPtoACK}$.

Part 2 – IN Endpoints

9. Start Analyzer
10. Create continuous IN traffic from UUT for 10 seconds
11. Stop Analyzer
12. Generate a list of Data Packet Response delays where each entry is the delay from the last received bit of an ACK Packet to the first transmitted bit of the Data Packet.
 - a. In case a different Packet was transmitted by the PUT between the reception of the ACK Packet and the transmission of the Data Packet (excluding the LCRD and LGOOD that are sent as a response for the ACK Packet itself) – The Data Packet Response delay is ignored and is not added to the list.
13. Verify that none of the Data Packet Response delays in the list exceeds $t_{USB3DeviceACKtoDP}$.

TD 9.103 Maximum Host Response Delay Requirements Test (Host Only)

Note: This test is only performed if the Router supports Version 2.0 of the USB4 Specification.

Note: This test only apply for a USB4 Host that supports USB3 Tunneling in Gen T and in Gen2x2.

A. Purpose:

- Verify that the USB4 Host meets the maximum response timing requirments

B. Asserts:

- TBD

C. Setup:

- AN_HOST_DFP1—USB3_01

D. Repetitions

- All USB4 links at Gen 4 speed
- All USB4 links at Gen 3 speed

E. Procedure:

1. Perform Link Initialization according to TD 9.2 between the UUT and the Compliance Device

Part 1 – OUT Traffic

2. Start Analyzer
3. Create continous OUT traffic to the Compliance device for 10 seconds
4. Stop Analyzer
5. Generate a list of Data Packet Response delays where each entry is the delay from the last received bit of an ACK Packet to the first transmitted bit of the Data Packet.
 - a. In case a different Packet was transmitted by the PUT between the reception of the ACK Packet and the trasmission of the Data Packet (Excluding the LCRD and LGOOD that are sent as a response for the ACK Packet itself) – The Data Packet Response delay is ignored and is not added to the list
6. Verify that none of the Data Packet Response delays in the list exceeds tUSB3HostACKtoDP

Part 2 – IN Traffic

7. Start Analyzer
8. Create continous IN traffic from the Compliance device for 10 seconds
9. Stop Analyzer
10. Generate a list of ACK Response delays where Each entry is the delay from the last received bit of a Data Packet to the first transmitted bit of the ACK Packet for the Data Packet
 - a. In case a different Packet was transmitted by the PUT between the reception of the Data Packet and the trasmission of the ACK Packet (Excluding the LCRD and LGOOD that are sent as a response for the Data Packet itself) – The ACK Response delay is ignored and is not added to the list
11. Verify that none of the ACK Response delays in the list exceeds tUSB3HostDPtoACK