

USB4™ Time Synchronization Compliance Test Specification

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Revision History:

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Introduction

The following tests check that a Router is compliant with Chapter 7 of the USB4 Base Specification.

System compliance purposes are:

- Test TMU standalone functionality:
 - Statistics
 - Time sync handshake
 - Time accuracy
- Check compliance of time sensitive protocols: ITP, PTM and DisplayPort over challenging setups.

Terminology

The following table describes the terms used in this document.

Compliance Device	A KG USB4 Device that is capable of performing Transport Layer Packet loopback.
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.
UFP	Upstream Facing Port
USB4 CV	USB4 Command Verifier software. The software that runs compliance tests and analyzes the results.
USB4 Product	Refers to a USB4 Host, USB4 Hub, and/or USB4 Peripheral Device. Includes silicon and end product.
UUT	Unit Under Test. The Router Assembly 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.

Chapter 4

The following Table presents the USB4 Specification Chapter 4 asserts tested in this CTS.

Assertion #	Test	Assertion Description
4.2.1.6.3 Objections		
4.2.1.6.3#1	NT	A USB4 Port shall assert an objection to enter CL2 state if: Entry to CL2 state would delay a pending Time Sync handshake.
4.2.1.6.3#2	NT	This objection shall be asserted until the Time Sync handshake is complete.
4.2.1.6.3#3	NT	A USB4 Port shall assert an objection to enter CL1 state if: Entry to CL1 state would delay a pending Time Sync handshake.
4.2.1.6.3#4	NT	The objection shall be asserted until the Time Sync handshake is complete.

Chapter 7

The following Table presents the USB4 Specification Chapter 7 asserts.

Assertion #	Test	Assertion Description
7 Time Synchronization		
7#1	NT	A Router shall support the USB4 Time Synchronization Protocol described in this chapter.
7.1 Time Synchronization Architecture		
7.1.1 Synchronization Hierarchy		
7.1.1.1 Intra-Domain Hierarchy		
7.1.1.2 Inter-Domain Hierarchy		
7.1.2 Time Sync Parameters		
7.1.2.1 Local Time		
7.1.2.1#1	NT	A Router shall provide a free-running clock for use in capturing the time stamps needed for the Time Synchronization Protocol.
7.1.2.1#2	NT	The Local Clock shall run at a frequency of 125 MHz or greater with an accuracy of +/- 100ppm relative to the nominal Local Clock frequency
7.1.2.1#3	NT	The Local Clock shall not be spread-spectrum.
7.1.2.1#4	Stat Sub #1	A Router shall use an 80-bit Local Time counter with the format shown in Figure 7-2 to track Local Time.
7.1.2.1#5	Stat Sub #1	The Local Time counter shall be incremented up with the Local Clock.
7.1.2.2 Time Offset		
7.1.2.2#1	NT	The TimeOffsetFromGM TimeOffsetFromHR register shall have the format shown in Figure 7-3.
7.1.2.2#2	Stat Sub #2	The TimeOffsetFromGM TimeOffsetFromHR register shall be updated at the conclusion of every Time Sync Handshake.
7.1.2.3 Frequency Offset		
7.1.2.3#1	NT	The frequency offset shall be computed according to Equation 7-2.
7.1.2.3#2	Stat Sub #3	The FreqOffsetFromGM FreqOffsetFromHR register shall be updated at the conclusion of every Time Sync Handshake.

7.2 Time Stamp Measurement		
7.2#1	Protocol Check #3	USB4 Port shall generate a time stamp whenever it either sends or receives a Time Sync Notification Ordered Set (TSNOS).
7.2#2	NT	A USB4 Port shall use the value in the Local Time counter to capture time stamps.
7.2#3	NT	A time stamp shall be taken at the Time Stamp Point of the First TSNOS.
7.2#4	Protocol Check #3	If one or more back-to-back TSNOS are received immediately after the first TSNOS, they shall be ignored.
7.2#5	NT	The same transmit reference pLane shall be used for all transmitted TSNOS and the same receive reference pLane shall be used for all received TSNOS.
7.2#6	Protocol Check #3	The time stamp measurement shall have a resolution of at least 8 ns (i.e. the period of the Local Clock).
7.2#7	NT	The time stamp in a Time Sync Packet shall have the format shown in Figure 7-2.
7.2.1 Asymmetry Corrections		
7.2.1#1	<u>Time Calculation</u> #2 <u>Time Calculation #2</u>	Time stamps shall be corrected for asymmetry between transmit and receive paths.
7.2.1#2	<u>Time Calculation</u> #2 <u>Time Calculation #2</u>	The Slave <u>An Upstream Facing Port (UFP)</u> shall correct for asymmetry by performing the following computations: $t1 = \text{Delay Request Sent Time Stamp} + \text{TxTimeToWire}$; $t4 = \text{Delay Response Received Time Stamp} - \text{RxTimeToWire}$; where, TxTimeToWire is the value in the TxTimeToWire field of the TMU_ADP_CS_1 register of the Slave Port <u>UFP</u> and RxTimeToWire is the value in the RxTimeToWire field of the TMU_ADP_CS_2 register of the Slave Port <u>UFP</u> .
7.2.1#3	<u>Time Calculation</u> #2 <u>Time Calculation #2</u>	The Master <u>A Downstream Facing Port (DFP)</u> shall correct for asymmetry by performing the following computations: $t2 = \text{Delay Request Received Time Stamp} - \text{RxTimeToWire}$; $t3 = \text{Delay Response Sent Time Stamp} + \text{TxTimeToWire}$; where, TxTimeToWire is the value in the TxTimeToWire field of the TMU_ADP_CS_1 register of the Master Port <u>DFP</u> and RxTimeToWire is the value in the RxTimeToWire field of the TMU_ADP_CS_2 register of the Master Port <u>DFP</u> .
7.2.1#4	<u>Time Calculation</u> #2 <u>Time Calculation #2</u>	The time duration between when a USB4 Port generates a time stamp and when it transmits first bit of a TSNOS on the wire shall be equal to the value in the TxTimeToWire field of the TMU_ADP_CS_1 register.
7.2.1#5	<u>Time Calculation</u> #2 <u>Time Calculation #2</u>	The time duration between when a USB4 Port receives the first bit of a TSNOS on the wire and when it generates a time stamp shall be equal to the value in the RxTimeToWire field of the TMU_ADP_CS_2 register.

7.3 Time Sync Protocol		
7.3.1 Time Sync Handshake		
7.3.1#1	Protocol Check #1	A Router shall support Bi-Directional Time Sync Handshakes in HiFi Mode.
7.3.1#2	NT	A Router shall support Uni-Directional Time Sync Handshakes in HiFi Mode and LowRes Mode.
7.3.1#3	NT	When the USB4 Ports are connected by a Single-Lane Link, a Time Sync Handshake shall occur over that Link.
7.3.1#4	NT	When the USB4 Ports are connected by a Dual-Lane Link, the Delay Request and Delay Response Ordered Sets in the Time Sync Handshake shall be sent on both the Lane 0 and Lane 1.
7.3.1#5	NT	The Follow-Up Packet shall be sent using both Lanes (i.e. alternating bytes across Lanes).
7.3.1#6	NT	The timestamp shall be taken when the first Ordered Set from the Link Partner is received.
7.3.1#7	NT	A Receiver shall ignore a TSNOS that arrives back-to-back after another TSNOS.
7.3.1.1 Bi-Directional Time Sync Handshake		
7.3.1.1#1	Protocol Check #1	A Master Port DFP shall not initiate a Bi-Directional Time Sync Handshake
7.3.1.1#2	Protocol Check #1	A Slave Port UFP shall send a Delay Request to the Master Port DFP at the interval specified in the TSPacketInterval field in the TMU_RTR_CS_3 register in Router Configuration space.
7.3.1.1#3	Protocol Check #1	A Master Port DFP shall transmit a Delay Response Packet within 1 μ s of receiving a Delay Request Packet.
7.3.1.1#4	Protocol Check #1	A Master Port DFP shall transmit a Follow-Up Packet within SendTimeout of transmitting the associated Delay Response Packet.
7.3.1.1#5	Stat Sub #6 Stat Sub #6	A Slave Port UFP shall generate time stamp t1 upon transmission of a Delay Request and shall generate time stamp t4 upon reception of a Delay Response.
7.3.1.1#6	Protocol Check #2	A Master Port DFP shall generate time stamp t2 upon receipt of a Delay Request and shall generate time stamp t3 upon transmission of a Delay Response.
7.3.1.1#7	NT	If an error occurs during the transmission or reception of a Time Sync Packet, the entire Time Sync Handshake shall be voided (i.e. neither time stamps nor values from the Follow-Up Packet shall be used).

7.3.1.1#8	NT	When using Bi-Directional Time Sync Handshake, a Master DFP shall do the following upon receiving a Delay Request: 1. Take the t2 timestamp
7.3.1.1#9	NT	When using Bi-Directional Time Sync Handshake, a Master DFP shall do the following upon receiving a Delay Request: 2. Send a Delay Response.
7.3.1.1#10	NT	Delay Response shall be sent within RespTimeout time or receiving the Delay Request
7.3.1.1#11	NT	The Master DFP shall take the t3 timestamp upon Delay Response transmission
7.3.1.1#12	NT	When using Bi-Directional Time Sync Handshake, a Master DFP shall do the following upon receiving a Delay Request: 3. Compute the updated TimeOffsetFromGrandMaster TimeOffsetFromHR parameter according to Equation 7-6 using the t3 timestamp from Step 2b
7.3.1.1#13	NT	When using Bi-Directional Time Sync Handshake, a Master DFP shall do the following upon receiving a Delay Request: 4. Send Follow-Up Packet with the TimeOffsetFromGrandMaster TimeOffsetFromHR calculated in Step 3
7.3.1.2 Uni-Directional Time Sync Handshake		
7.3.1.2#1	Protocol Check #3	When using Uni-Directional Time Sync Handshake, only the Master Port DFP shall initiate a Time Sync Handshake
7.3.1.2#2	Protocol Check #3	A Master Port DFP shall send a Delay Response to the Slave Port UFP at the interval specified in the TSPacketInterval field in the TMU_RTR_CS_3 register in Router Configuration space.
7.3.1.2#3	Protocol Check #3	A Master Port DFP shall transmit a Follow-Up Packet within SendTimeout after transmitting the associated Delay Response Packet
7.3.1.2#4	Protocol Check #3	Uni-Directional Time Sync Handshake shall be used when the following conditions are true: Both Link Partners support Uni-Directional Time Sync Handshake; Both Link Partners have the EnableUniDirectionalMode field in the TMU_ADP_CS_3 register in Adapter Configuration Space set to 1b.
7.3.2 Inter-Domain Time Sync		
7.3.2#1	Protocol Check #1	A USB4 Port shall perform Time Sync Handshakes as described in Section 7.3.1 across the Inter-Domain Link when either the IDM IDTR bit or IDS IDTI bit is set to 1b.
7.3.2#2	Protocol Check #1	A USB4 Port with the IDM bit set to 1b shall act as Master Port and a USB4 Port with IDS bit set to 1b shall act as the Slave Port.
7.3.2# 3 2	Protocol Check #1	After completing a Time Sync Handshake across an Inter-Domain Link, the Inter-Domain Slave IDTI Port shall calculate the following: The Inter-Domain time stamp (see Section 7.4.2.1); The Inter-Domain frequency offset (see Section 7.4.2.2); The Inter-Domain time offset (see Section 7.4.2.3).

7.3.2# 43	Protocol Check #1	After calculating the Inter-Domain time offset, Inter-Domain frequency offset and Inter-Domain time stamp, the Inter-Domain SlaveIDTI Port shall update the InterDomainTimeStamp, FreqOffsetFromInterDomainGM FreqOffsetFromInterDomainHR and TimeOffsetFromInterDomainGM TimeOffsetFromInterDomainHR fields in Router Configuration Space.
7.3.2# 54	Protocol Check #5 Protocol Check #5	If the Inter-Domain SlaveIDTI Port is <u>part of</u> a Device Router, it shall prepare an Inter-Domain Time Stamp Packet as described in Section 7.3.3.3.
7.3.2# 65	Protocol Check #5 Protocol Check #5	If the TSInterDomainInterval field in Router Configuration Space is 0, the Inter-Domain SlaveIDTI Port shall send the Host Router an Inter-Domain Time Stamp Packet after each Inter-Domain Time Sync Handshake.
7.3.2# 76	Protocol Check #5 Protocol Check #5	If the TSInterDomainInterval field in Router Configuration Space is not 0, the Inter-Domain SlaveIDTI Port shall send the Host Router an Inter-Domain Time Stamp Packet at time intervals equal to $(TSInterDomainInterval + 1) * TSPacketInterval$ number of microseconds.
7.3.2# 87	NT	When a Host Router receives an Inter-Domain Time Stamp Packet: If the IDE bit in the TMU_RTR_CS_0 register of the Host Router's TMU Router Configuration Capability is set to 1b, the Host Router shall update its TimeOffsetFromInterDomainGM and FreqOffsetFromInterDomainGM TimeOffsetFromInterDomainHR and FreqOffsetFromInterDomainHR registers using the time offset and frequency offset respectively contained in the Inter-Domain Time Stamp Packet.
7.3.2# 98	NT	When a Host Router receives an Inter-Domain Time Stamp Packet: If the IDE bit in the Host Router is set to 0b, the Host Router shall drop the Inter-Domain Time Stamp Packet and shall not update its TimeOffsetFromInterDomainGM TimeOffsetFromInterDomainHR or FreqOffsetFromInterDomainGM FreqOffsetFromInterDomainHR registers
7.3.3 Packet Formats		
7.3.3.1 Time Sync Notification Ordered Set Format		
7.3.3.1#1	Protocol Check #1	Both a Delay Request and a Delay Response shall consist of the Time Sync Notification Ordered Set (TSNOS) defined in Section 4.4.7.
7.3.3.2 Follow-Up Packet Format		
7.3.3.2#1	Protocol Check #2	A Follow-Up Packet shall have the format shown in Figure 7-13.
7.3.3.2#2	Protocol Check #2	A Follow-Up Packet shall have the PDF field set to 1, the HopID set to 3, and the Length set to 60.
7.3.3.2#3	Protocol Check #2	The payload shall contain the fields in Table 7-3.

7.3.3.2#4	<u>Time Calculation</u> #2Time <u>Calculation #2</u>	For Bi-Directional Time Sync Handshakes: The time stamp shall include the asymmetry corrections performed at the MasterDFP as specified in Section 7.2.1.
7.3.3.2#5	Protocol Check #2	For Bi-Directional Time Sync Handshakes: The RequestReceiptTS field shall have the format shown in Figure 7-2
7.3.3.2#6	<u>Protocol Check</u> #4Protocol Check <u>#4</u>	For Uni-Directional Time Sync Handshakes: The RequestReceiptTS field shall contain the same value as the ResponseOriginTS field.
7.3.3.2#7	<u>Time Calculation</u> #2Time <u>Calculation #2</u>	The time stamp shall include the asymmetry corrections performed at the MasterDFP as specified in Section 7.2.1.
7.3.3.2#8	Protocol Check #2	The ResponseOriginTS field shall have the format shown in Figure 7-2.
7.3.3.2#9	Protocol Check #2	The TimeOffsetFromGMT <u>TimeOffsetFromHR</u> field shall have the format shown in Figure 7-3.
7.3.3.2#10	Protocol Check #2	The FreqOffsetFromGM <u>FreqOffsetFromHR</u> shall have the format shown in Figure 7-4.
7.3.3.2#11	Protocol Check #2	Bits 31:16 of DW8 are reserved and shall be set to 0.
7.3.3.2#12	Protocol Check #2	For a Host Router: If IDE bit is set to 0b, then the IDTimeStamp field shall be set to 0.
7.3.3.2#13	Protocol Check #2	For a Device Router: The IDTimeStamp field shall contain the IDTimeStamp value from the last Follow-Up Packet that the SlaveIDTI Port on the Router Received.
7.3.3.2#14	Protocol Check #2	For a Host Router: If IDE bit is set to 0b, then the FreqOffsetFromInterDomainGM <u>FreqOffsetFromInterDomainHR</u> field shall be set to 0.
7.3.3.2#15	Protocol Check #2	For a Device Router: The FreqOffsetFromInterDomainGM <u>FreqOffsetFromInterDomainHR</u> field shall contain the FreqOffsetFromInterDomainGM <u>FreqOffsetFromInterDomainHR</u> value in the last Follow-Up Packet that the SlaveIDTI Port on the Router Received.
7.3.3.2#16	NT	The CRC32 computation shall be based on the following specification: Width: 32; Poly: 1EDC 6F41h; Init: FFFF FFFFh; RefIn: True; RefOut: True; XorOut: FFFF FFFFh;
7.3.3.3 Inter-Domain Time Stamp Packet		
7.3.3.3#1	<u>Protocol Check</u> #5Protocol Check <u>#5</u>	An Inter-Domain Time Stamp Packet shall have the format shown in Figure 7-14.

7.3.3.3#2	<u>Protocol Check</u> #5Protocol Check #5	An Inter-Domain Time Stamp Packet shall have the PDF set to 2, the HopID set to 3, and the Length set to 28.
7.3.3.3#3	<u>Protocol Check</u> #5Protocol Check #5	The payload shall contain the fields in Table 7-4.
7.3.3.3#4	<u>Protocol Check</u> #5Protocol Check #5	The IDTimestamp field shall have the format shown in Figure 7-2.
7.3.3.3#5	<u>Protocol Check</u> #5Protocol Check #5	The TimeOffsetFromInterDomainGM <u>TimeOffsetFromInterDomainHR</u> field shall have the format shown in Figure 7-3.
7.3.3.3#6	<u>Protocol Check</u> #5Protocol Check #5	The FreqOffsetFromInterDomainGM <u>FreqOffsetFromInterDomainHR</u> field shall have the format shown in Figure 7-4.
7.3.3.3#7	NT	The CRC32 computation shall be based on the following specification: Width: 32; Poly: 1EDC 6F41h; Init: FFFF FFFFh; RefIn: True; RefOut: True; XorOut: FFFF FFFFh;
7.4 Time Computations		
7.4#1	NT	A Router shall be able to compute the Grandmaster <u>Host Router</u> Time at any instant in time.
7.4.1 Intra-Domain Equations		
7.4.1#1	Stat Sub #3	A Router shall use the following series of computations to deduce the current Grandmaster <u>Host Router</u> Time within a single Domain: The SlaveUFP uses Equation 7-1 to compute the frequency ratio between itself and its Master <u>DFP</u> .
7.4.1#2	Stat Sub #3 Stat Sub #3	A Router shall use the following series of computations to deduce the current Grandmaster <u>Host Router</u> Time within a single Domain: The SlaveUFP uses Equation 7-2 to compute the frequency offset. The SlaveUFP uses the frequency ratio obtained in Step 1 as input to the computation.
7.4.1#3	Stat Sub #3 Stat Sub #3	A Router shall use the following series of computations to deduce the current Grandmaster <u>Host Router</u> Time within a single Domain: The SlaveUFP uses Equation 7-3 to compute the frequency ratio between itself and the Domain-Grandmaster <u>Host Router</u> . The SlaveUFP uses the FreqOffsetFromGM <u>FreqOffsetFromHR</u> value in the last Follow-Up Packet received from the Master <u>DFP</u> as input to the computation.

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7.4.1#4	Stat Sub #3 Stat Sub #3	A Router shall use the following series of computations to deduce the current Grandmaster Host Router Time within a single Domain: The Slave UFP uses Equation 7-4 to compute the frequency offset between itself and the Domain Grandmaster Host Router . The Slave use UFP uses the frequency ratio computed in Step 3 as input to the computation.
7.4.1#5	Stat Sub #5 Stat Sub #5	A Router shall use the following series of computations to deduce the current Grandmaster Host Router Time within a single Domain: The Slave UFP uses Equation 7-5 to compute the propagation delay of the cable between the Slave UFP and the Master DFP .
7.4.1#6	Stat Sub #2 Stat Sub #2	A Router shall use the following series of computations to deduce the current Grandmaster Host Router Time within a single Domain: The Master Link Partner (i.e. the DFP upstream of the UFP) uses Equation 7-6 to compute the most updated time offset from the Domain Grandmaster Host Router . The Master Link Partner uses the most recent result from Equation 7-9, as input to the computation.
7.4.1#7	Stat Sub #2 Stat Sub #2	A Router shall use the following series of computations to deduce the current Grandmaster Host Router Time within a single Domain: The Slave UFP uses Equation 7-7 (Bi-Directional Time Sync Handshakes) or Equation 7-8 (Uni-Directional Time Sync Handshakes) to compute the time offset from its Master DFP .
7.4.1#8	Stat Sub #4 Stat Sub #4	A Router shall use the following series of computations to deduce the current Grandmaster Host Router Time within a single Domain: The Slave UFP uses Equation 7-9 to compute the time offset from the Domain Grandmaster Host Router . The Slave UFP uses the time offset from Equation 7-7 or Equation 7-8, and the value in the last received Follow-Up Packet as input to the computation.
7.4.1#9	Time Calculation #1 Time Calculation #1	A Router shall use the following series of computations to deduce the current Grandmaster Host Router Time within a single Domain: The Slave UFP uses Equation 7-10 to compute the current time offset from the Domain Grandmaster Host Router . The Slave UFP uses the time offset computed in Equation 7-9 and the frequency offset computed in Equation 7-3 as input to the computation.
7.4.2 Inter-Domain Equations		
7.4.2.1 Inter-Domain Time Stamp Computation		
7.4.2.1#1	NT	Equation 7-11 is used to compute an Inter-Domain time stamp.
7.4.2.2 Inter-Domain Frequency Offset Computation		
7.4.2.2#1	NT	The frequency ratio between the Host Router of in the Slave -Domain with the IDTI Port and the Host Router of the Grandmaster Inter-Domain Time Source is computed using Equation 7-12.
7.4.2.3 Inter-Domain Time Offset Computation		

7.4.2.3#1	Stat Sub #7 Stat Sub #7	The time offset of the Inter-Domain Master IDTR Port that is sent in the Follow-Up Packet at the end of an Inter-Domain Time Sync Handshake is computed using Equation 7-14
7.4.2.3#2	Stat Sub #9 Stat Sub #9	The time offset between the IDTI Port and the Inter-Domain Slave and the Host Router of the Master Domain Time Source is computed using Equation 7-15.
7.4.2.3#3	Stat Sub #9 Stat Sub #9	The time offset between the Host Router of the Slave -Domain <u>with the IDTI Port</u> and the Host Router of the Grandmaster -Inter-Domain <u>Time Source</u> is computed using Equation 7-16.
7.4.2.4 GrandmasterInter-Domain Host Router Time Computation		
7.4.3 Filtering		
7.5 Time Synchronization Accuracy Requirements		
7.5#1	NT	A Router shall reach the required time synchronization accuracy within tConvergeTime after Time Sync Handshakes are enabled.
<u>7.5#2</u>	<u>TBD</u>	<u>If Time Sync Handshakes are paused, a UFP shall reach the required time synchronization accuracy within tConvergeTime after receiving a Delay Response Packet.</u>
7.5.1 Paired Measurement		
7.5.1#1	NT	For Bi-Directional Time Sync Handshake, the Static Offset between two Routers connected to one another shall not add more than 8 ns per Link.
7.5.1#2	NT	In HiFi Mode, the Dynamic Noise between two Routers connected to one another shall not add more than tHiAccuracy.
7.5.1#3	NT	In LowRes Mode, the Dynamic Noise between two Routers connected to one another shall not add more than tLowAccuracy.
7.5.2 Standalone Measurement		
7.5.2#1	NT	In HiFi Mode, the noise between measurement points and the ideal line shall not be more than tHiAccuracy.
7.5.2#2	NT	In LowRes Mode, the noise between measurement points and the ideal line shall not be more than tLowAccuracy.
7.5.2#3	NT	In order to achieve the goal of 1 ns static noise, the budget for TxTimeToWire uncertainty shall not be more than 6.4 ns dynamic noise with no more than 6.4 ns static offset that changes after each power up.
7.5.2#4	NT	RxTimeToWire shall not be more than 12.8 ns dynamic noise with no more than 6.4 ns static offset that changes after each power up.
7.5.2#5	NT	Dynamic uncertainty in TxTimeToWire and RxTimeToWire shall be filtered out during calculations by IRR or other filtering.

7.5.3 Measuring Method		
7.5.4 Accuracy Parameters		
7.6 Software Configuration		
7.6.1 Intra-Domain Time Synchronization Setup		
7.6.1#1	NT	A Router that is hot-plugged to a Domain shall only initiate the Time Sync Handshake on its Upstream Facing Port <u>UFP</u> when the following conditions are true: The physical layer has established the Link between the hot-plugged Router and the Domain; The TSPacketInterval field in the TMU_RTR_CS_3 register in Router Configuration space is greater than 0.
7.6.2 Inter-Domain Time Synchronization Setup		
7.6.3 Post Time Mechanism		
7.6.3#1	NT	A Router shall update its local time when the Post Time is less than or equal to the Nanoseconds field in the Grandmaster <u>Host Router</u> Time Register.
7.6.4 Time Disruption Bit		

Chapter 8

The following Table presents the USB4 Specification Chapter 8 asserts tested in this CTS.

Assertion #	Test	Assertion Description
8.2.1.2 TMU Router Configuration Capability		
8.2.1.2#1		A TMU Router Configuration Capability shall have the structure depicted in Figure 8-3 and the fields defined in Table 8-4.
8.2.1.2#2		Any field that spans across multiple Doublewords (e.g. LocalTime Low, LocalTime Middle, and LocalTime High) shall use the Register Locking Mechanism defined in Section 8.2.1.2.1 and the Register Group Locking Mechanism defined in Section 8.2.1.2.2.
8.2.1.2.1 Register Locking Mechanism		
8.2.1.2.1#1		In order to keep consistent values in these fields, a Router shall update the value in the entire field (i.e. Low, Middle, and High DWs) when the Connection Manager reads the Low DW of the field.
8.2.1.2.1#2		A Router shall not change the value in the Middle and High DWs until the next time the Low DW is read.
8.2.1.2.1#3		The Register Locking Mechanism shall be implemented for following registers: LocalTime {Low, Middle, High}, TimeOffsetFromGM TimeOffsetFromHR {Low, Middle, High}, Inter-Domain Time Stamp {Low, Middle, High}
8.2.1.2.2 Register Group Locking Mechanism		
8.2.1.2.2#1		The value of a locked register group shall change only when the Triggering DW is accessed.
8.2.1.2.2#2		Table 8-5 lists the register groups that shall be locked
8.2.2.2 TMU Adapter Configuration Capability		
8.2.2.2#1		A TMU Lane Adapter Configuration Capability shall have the structure depicted in Figure 8-8 and shall contain the fields defined in Table 8-11.
8.2.2.2#2		For a USB4 Port with two enabled Adapters, the values in the TMU Lane Adapter Configuration Capability of both Adapters shall be identical.
8.2.2.2#3		When a value in the TMU Lane Adapter Configuration Capability of one Adapter is written to, the other Adapter in the USB4 Port shall update its value to match.

Test Requirements

Testing Approach

The USB4 Time Synchronization Protocol is tested using the following methods:

- Indirect measurement by reading and analyzing statistics (TMU registers in Router and Adapter Configuration Spaces)
- Direct measurement by letting KG USB4 Devices synchronize with the UUT and then extracting the system time via Time Serial Interface from the KG USB4 Device
- Protocol testing with USB4 Protocol analyzer
- Functional compliance of time sensitive protocols: ITP, PTM and DisplayPort over different setups

Hardware

Testing TMU requires:

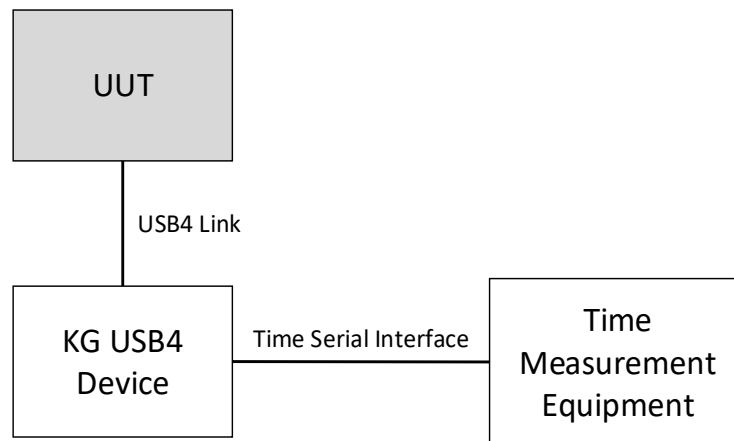
- KG USB4 Host
- KG USB4 Hub
- KG USB4 Device
- TMU CLK OUT Analyzer
- USB4 Link Analyzer
- USB4 CV SW

Measurement Methods

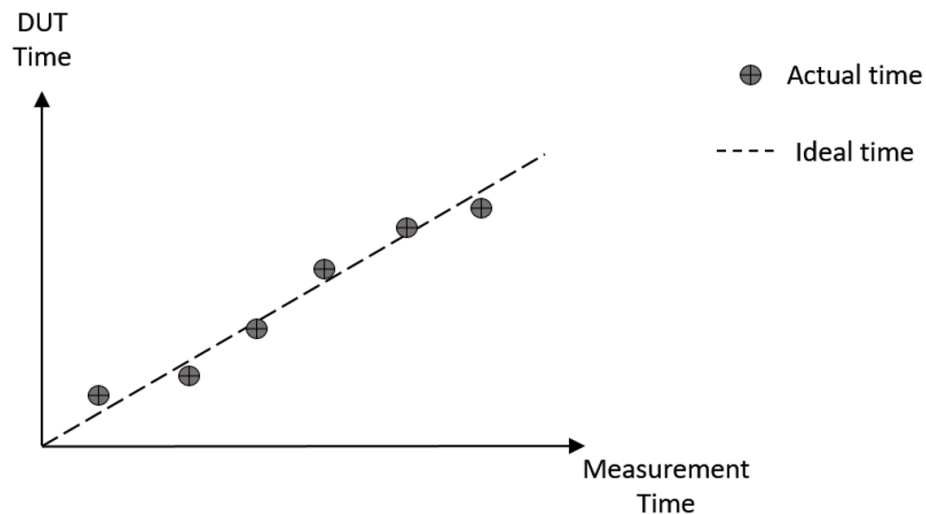
Direct Time Measurement Method

Standalone Time Stream

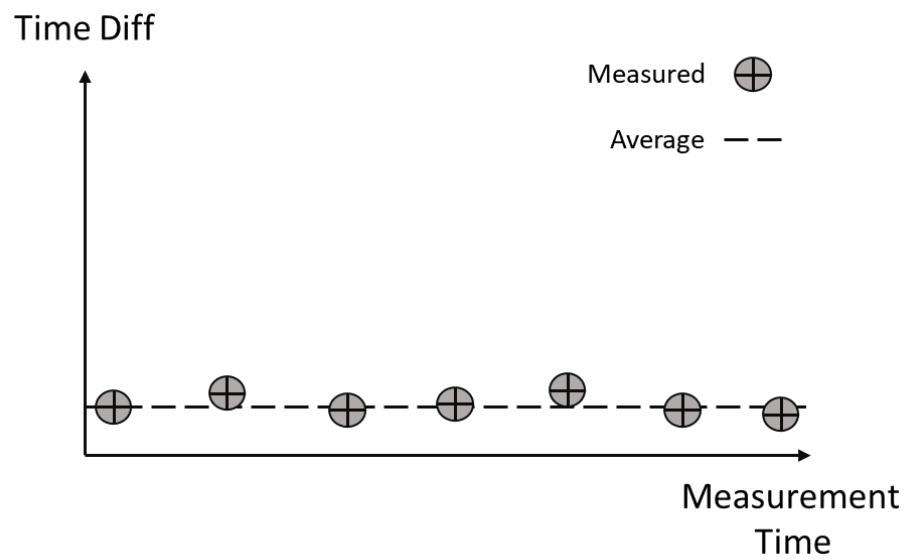
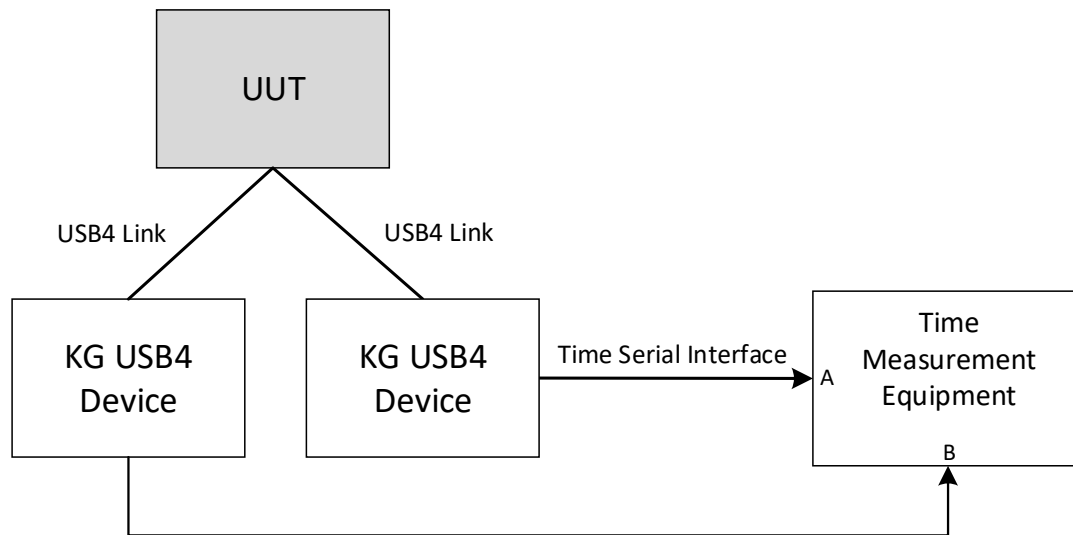
When applicable, time synchronization is measured via Time Serial Interface (TMU CLK OUT) of a KG USB4 Host, KG USB4 Hub or KG USB4 Device in the following manner:



The KG USB4 Device synchronizes to UUT and then extracts the computed ~~Grandmaster~~Host Router time over Time Serial interface, which in turn is fed to Serial Protocol Analyzer. After ~~Grandmaster~~Host Router time is extracted, it is analyzed for consistency.



Comparative Time Measurement



Time Measurement Equipment

The TMU FPGA is used to capture the time stream on the Time Serial Interface. The FPGA is operated through executable (outside the scope of this document).

The command format is:

1. To capture PA input in standalone mode
> TMU_FPGA.bat PA
2. To capture PA input in standalone mode
> TMU_FPGA.bat PB
3. To capture in comparative mode
> TMU_FPGA.bat TDIFF

The output will be in the file “**dump.txt**”

The file location shall be in folder "C:\Users\Public\Documents\TMU_FPGA\USB4_Compliance\"

The file format is list of timestamps in hexadecimal:

```
00000010001
00000050002
000000a0003
000000f0004
00000140005
```

The time format is as specified in Figure 7-2. Local Time Counter Format of the USB4 Specification and shall have exactly 16 hexadecimal digits.

Indirect Measurement Method (SW)

This section describes the registers that participate in analyzing time sync using Indirect method.

\ Device Type Variable	Host Router	Hub	Endpoint
LocalTime	✓	✓	✓
TimeOffsetFromGM <u>TimeOffsetFromHR</u>	X	✓	✓
TimeOffsetFromMaster <u>TimeOffsetFromDFP</u>	X	✓	✓
FreqOffsetFromGM <u>FreqOffsetFromHR</u>	X	✓	✓
FreqOffsetFromMaster <u>FreqOffsetFromDFP</u>	X	✓	✓
Propagation Delay	X	✓	✓
Computation Timestamp	X	✓	✓
InterDomain Computation Timestamp	✓	✓	✓
TimeOffsetFromInterDomainGM <u>TimeOffsetFromInterDomainHR</u>	✓	✓	✓
FreqOffsetFromInterDomainGM <u>FreqOffsetFromInterDomainHR</u>	✓	✓	✓

\ Statistics Port Direction	RX TSNOS Counter	TX TSNOS Counter	RX Packet Counter	TX Packet Counter
Upstream Bidirectional	✓	✓	✓	X
Downstream Bidirectional	✓	✓	X	✓
Upstream Unidirectional	✓	X	✓	X
Downstream Unidirectional	X	✓	X	✓

Where:

X - Register is expected to remain 0

✓ - Register is expected to change

Reading and analyzing relevant registers in different setups gives basic insight into Time Sync functionality using different setups. The exact function are described further.

Testing Subroutines

This section defines subroutines with the test steps that are repeated for multiple tests. The USB4 Test Descriptions reference the subroutines defined in this section.

USB4 Link Configuration

Note: See the USB4 Connection Manager Guide for how to perform a DFP reset, initiate Lane Bonding, and enumerate Routers.

Link Configuration #1 Dual-Lane Link

1. USB4 CV performs a Downstream Port Reset on the DFP of the Host Router
2. USB4 CV initiates Lane Bonding
3. USB4 CV enumerates all Routers in the topology
4. Execute [Time Posting #5](#)

Link Configuration #2 Two Single Lane Links

1. USB4 CV performs a Downstream Port Reset on the DFP of the Host Router
2. USB4 CV does not initiate Lane Bonding
3. USB4 CV enumerates all Routers in the topology
4. Execute [Time Posting #5](#)

Direct Time Measurement

The deviation noise from ideal line is expected to be less than 1 ns per hop in HiFi mode and less than 4 ns in LowRes mode.

Time Calculation #1 System Time Consistency (Parameter N)

1. Parse Serial Time stream.
2. Capture each N -th Serial packet, extract system time.
3. Capture 32K samples of system time.
4. Create data regression on the time stream.
5. Measure system time deviation from average line.
6. Expected deviation is calculated by the following algorithm:

```
// TimeArr [0:L-1] is the array that contains all the values from the sample
// L is the length of the array

//Step#1: compute average step
AvStep=(TimeArr[L-1]-TimeArr[0])/(L-1);

//Step#2: build ideal array
IdealArr[0]=TimeArr[0];
for(i=1;i<L;i++) {
    IdealArr[i]=IdealArr[i-1] + AvStep;
};

#Step#2: compute deviation from ideal
for(i=0;i<L;i++) {
    Diff[i]=TimeArr[i]-IdealArr[i];
};
```

```
//Step#3: find max and min of the Diff  
TMin = min(Diff);  
TMax = max(Diff);
```

```
//Step#4: compute absolute error  
AbsError = Tmax - Tmin;
```

7. Verify that AbsError: (7.4.1#9)
 - a. In HiFi mode less than 1 ns per hop
 - b. In LowRes mode less than 4 ns per hop

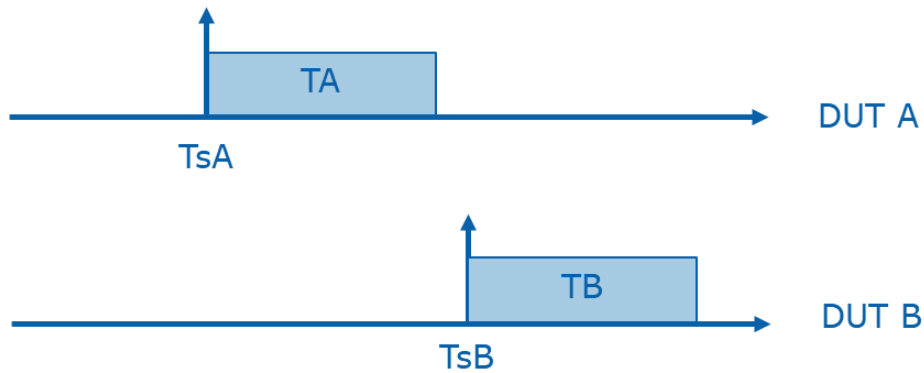
Assertions checked:

- 7.4.1#9

Comparative Time Measurement

Time Calculation #2 System Time Diff (Parameter N)

1. Parse Serial Time stream from UUT A.
2. Parse Serial Time stream from UUT B.
3. Capture each N-th pair.
4. Capture 32K samples.
5. Calculate Time Diff according to the following method:



$$\text{Time Diff} = (TB - TA) - (TsB - TsA)$$

Where TsA and TsB are the timestamps of serial packets

6. The following method is used to calculate the average Time Diff:

```
//TimeDiff[0:L-1] is an array containing the samples  
// L is the length of the array
```

```
for (i=0;i<L;i++) {  
    TimeSum = TimeSum + TimeDiff[i];  
}  
TimeAv = TimeSum/L;
```

7. Verify that TimeDiff doesn't cross the expected amplitude: (7.2.1#1-#5, 7.3.3.2#4, 7.3.3.2#7)
 - a. In HiFi mode less than 2 ns per hop, TimePass = 2
 - b. In LowRes less than 10 ns per hop, TimePass = 10

The method:

```
for(i=0;i<L;i++) {  
    if (abs(TimeDiff[i] - TimeAV) > TimePass) {  
        error = 1;  
    }  
}
```

Assertions checked:

- 7.2.1#1, 7.2.1#2, 7.2.1#3, 7.2.1#4, 7.2.1#5
- 7.3.3.2#4, 7.3.3.2#7

Protocol Validation

The steps in this section are performed by parsing a trace from the USB4 protocol analyzer.

Protocol Check #1: Bi-Directional

Verify that a Bi-Directional Time Sync Handshake is performed according to Figures 7-7 and 7-8 in USB4 specification:

1. Take sample of 250ms.
2. If the Link is Inter-Domain, then:
 - a. If ~~HSIDTI~~ bit ~~on~~ in the ~~slave-side~~ Inter-Domain Time Initiator is not set ~~&~~ and Bi-Directional mode is set, no handshake should be initiated
3. ~~Slave~~UFP initiates handshake every TSPacketInterval (+/- 1%). (7.3.1.1.#2, 7.3.2#1)
4. ~~Master~~DFP does not initiate any handshakes. (7.3.1.1.#1, 7.3.2#1)
5. ~~Master~~DFP responds by TSNOS within RespTimeout. (7.3.1.1.#3, 7.3.2#1)
6. ~~Master~~DFP sends Follow-Up Packet within FPTimeout after OS. (7.3.1.1.#4, 7.3.2#1)

Assertions checked:

- 7.3.1#1
- 7.3.1.1#1, 7.3.1.1#2, 7.3.1.1#3, 7.3.1.1#4
- 7.3.2#1, 7.3.2#2, 7.3.2#3, ~~7.3.2#4~~
- 7.3.3.1#1

Protocol Check #2: Bi-Directional

Take sample of 250ms.

Check the contents of each Follow-Up Packet:

1. Verify that:
 - a. PDF field is set to 1. (7.3.3.2#2)
 - b. HopID is set to 3. (7.3.3.2#2)
 - c. Length is set to 60. (7.3.3.2#2)
2. Verify that T2 and T3 are consistently growing between every two consecutive packets by TSPacketInterval. (7.3.1.1#6)
3. Verify that T2 and T3 variance is less than 32 ns. (7.3.1.1#6)
4. If a packet is sent by Hub Router on the downstream port, verify that:
 - a. ~~TimeOffsetFromGM~~~~TimeOffsetFromHR~~ is consistently growing like in Stat Sub #2. (7.3.3.2#9)
 - b. ~~FreqOffsetFromGM~~~~FreqOffsetFromHR~~ is constant like in Stat Sub #3. (7.3.3.2#10)
 - c. There is correlation between ~~TimeOffsetFromGM~~~~TimeOffsetFromHR~~ and ~~FreqOffsetFromGM~~~~FreqOffsetFromHR~~ same as in Stat Sub #4. (TBD)
5. If a packet is sent by Inter-Domain ~~master~~~~Time Responder~~ or any ~~master~~~~DFP~~ in ~~slave~~Inter-Domain Time Initiator's Domain, verify that the following fields are 0 when IDE bit is set to 0 in Host Router:
 - a. IDTimeStamp. (7.3.3.2#12)
 - b. ~~TimeOffsetFromInterDomainGM~~~~TimeOffsetFromInterDomainHR~~. (TBD)
 - c. ~~FreqOffsetFromInterDomainGM~~~~FreqOffsetFromInterDomainHR~~. (TBD)
 - d. ~~FreqOffsetFromInterDomainGM~~~~FreqOffsetFromInterDomainHR~~. (7.3.3.2#14)
6. Otherwise (IDE bit is set to 1), verify that:
 - a. IDTimeStamp is constantly growing between every two consecutive packets. (7.3.3.2#13)
 - b. TimeOffsetFromInterDomain is consistently growing like in ~~Stat Sub #8~~~~Stat Sub #8~~. (TBD)
 - c. FreqOffsetFromInterDomain is constant like in ~~Stat Sub #9~~~~Stat Sub #9~~. (7.3.3.2#15)
 - d. There is correlation between TimeOffsetFromInterDomain and FreqOffsetFromInterDomain same as in ~~Stat Sub #10~~~~Stat Sub #10~~. (TBD)

Assertions checked:

- 7.3.1.1#6
- 7.3.3.2#1
- 7.3.3.2#2
- 7.3.3.2#3
- 7.3.3.2#5
- 7.3.3.2#8
- 7.3.3.2#9
- 7.3.3.2#10
- 7.3.3.2#11
- 7.3.3.2#12
- 7.3.3.2#13
- 7.3.3.2#14
- 7.3.3.2#15

Protocol Check #3: Uni-Directional

Verify that a Uni-Directional Time Sync Handshake is performed according to Figure 7-10 and 7-11 in the USB4 Specification:

1. Take sample of 250ms.
2. Verify that the ~~Master~~DFP sends a TSNOS every TSPacketInterval (+/-1%). (7.3.1.2#2)
3. Verify that the ~~Master~~DFP sends a Follow-Up Packet within SendTimeout time after sending the TSNOS. (7.3.1.2#3)

Assertions checked:

- 7.2#1
- 7.2#4
- 7.2#6
- 7.3.1.2#1
- 7.3.1.2#2
- 7.3.1.2#3
- 7.3.1.2#4

Protocol Check #4: Uni-Directional

Check the contents of a Follow-Up Packet:

1. Verify that:
 - a. PDF field is set to 1. (7.3.3.2#2)
 - b. HopID is set to 3. (7.3.3.2#2)
 - c. Length is set to 60. (7.3.3.2#2)
2. Verify that T2 is equal to T3 and is consistently growing between every two consecutive packets by TSPacketInterval. (TBD)
3. Verify that T2 is equal to T3 and variance is less than 32 ns.
4. If a packet is sent by Hub Router on the downstream port, verify that:
 - a. ~~TimeOffsetFromGM~~TimeOffsetFromHR is consistently growing like in ~~Stat Sub #2~~Stat Sub #2.
 - b. ~~FreqOffsetFromGM~~FreqOffsetFromHR is constant like in ~~Stat Sub #3~~Stat Sub #3.
 - c. There is correlation between ~~TimeOffsetFromGM~~TimeOffsetFromHR and ~~FreqOffsetFromGM~~FreqOffsetFromHR same as in ~~Stat Sub #4~~Stat Sub #4.
5. If a packet is sent by Inter-Domain ~~master~~Time Responder or any ~~master~~DFP in ~~slave~~Inter-Domain Time Initiator's Domain, verify that the following fields are 0 when IDE bit is set to 0 in Host Router:
 - a. IDTimeStamp. (TBD)
 - b. TimeOffsetFromInterDomain. (TBD)
 - c. FreqOffsetFromInterDomain. (TBD)
6. Otherwise (IDE bit is set to 1), verify that:
 - a. IDTimeStamp is constantly growing between every two consecutive packets. (TBD)
 - b. TimeOffsetFromInterDomain is consistently growing like in ~~Stat Sub #8~~Stat Sub #8. (TBD)
 - c. FreqOffsetFromInterDomain is constant like in ~~Stat Sub #9~~Stat Sub #9. (TBD)
 - d. There is correlation between TimeOffsetFromInterDomain and FreqOffsetFromInterDomain same as in Stat Sub #10. (TBD)

Assertions checked:

- 7.3.3.2#2, 7.3.3.2#6

Protocol Check #5: Inter-Domain Timestamp Packet

1. Verify that Inter-Domain TimeStamp packet is sent every $[(TSInterDomainInterval + 1) * TSPacketInterval]$ μs . (7.3.2#~~76~~)
2. Verify that:
 - a. PDF is set to 2. (7.3.3.3#2)
 - b. HopID is set to 3. (7.3.3.3#2)
 - c. Length is set to 28. (7.3.3.3#2)
3. Verify that Bits 31:16 of DW 0 are set to 0 (reserved). (7.3.3.3#3)
4. Verify that the IDTimeStamp field (DW 2:0) has the format shown in Figure 7-6. (7.3.3.3#4)
5. Verify that:
 - a. IDTimeStamp is constantly growing between every two consecutive packets.
 - b. TimeOffsetFromInterDomain is consistently growing like in ~~Stat Sub #8~~ Stat Sub #8.
 - c. FreqOffsetFromInterDomain is constant like in ~~Stat Sub #9~~ Stat Sub #9.
 - d. There is correlation between TimeOffsetFromInterDomain and FreqOffsetFromInterDomain same as in ~~Stat Sub #10~~ Stat Sub #10.

Assertions checked:

- 7.3.2#~~54~~
- ~~7.3.2#5~~
- 7.3.2#6
- ~~7.3.2#7~~
- 7.3.3.3#1
- 7.3.3.3#2
- 7.3.3.3#3
- 7.3.3.3#4
- 7.3.3.3#5
- 7.3.3.3#6

Statistics Functions

Stat Sub #1 LocalTime Consistency

1. Local Time is checked for consistency.
2. Read LocalTime in loop every second, 60 times.
3. Verify that the Average Time diff between the reads is 1 second (+/- 1%). (7.1.2.1#4, 7.1.2.1#5)

31		0			
I D E	U C A P	Rsvd	Freq Measurement Window	Capability ID	Next Capability Pointer
LocalTime Low 31:0					1
LocalTime High 63:32					2

Assertions checked:

- 7.1.2.1#4
- 7.1.2.1#5

Stat Sub #2 Time Offset

1. Read in loop 60 times with 1 sec delay.
2. Average slope is calculated per read:

$$T_{avgN} = \frac{T_{off}[N] - T_{off}[1]}{N - 1}$$

$$T_{avgN+1} = \frac{T_{off}[N + 1] - T_{off}[1]}{N}$$

$$T_{avgSlopeDrift} = \frac{T_{avgN+1}}{T_{avgN}} - 1$$

3. Verify that:
 - a. Expected behavior is a consistent linear incline or decline (accuracy of 1%). (7.4.1#6, 7.4.1#7)

$$|T_{avgSlopeDrift}| \leq 0.01$$

- b. For 1st hop, ~~TimeOffsetFromGM~~TimeOffsetFromHR is 0. (TBD)
- c. For 2nd hop, ~~TimeOffsetFromGM == TimeOffsetFromMaster~~TimeOffsetFromHR == TimeOffsetFromDFP. (7.1.2.2.#2)

TimeOffsetFromHR 31:0	4
TimeOffsetFromHR 63:32	5
TimeOffsetFromDFP 31:0	6
TimeOffsetFromDFP 63:32	7

Assertions checked:

- 7.1.2.2#1
- 7.1.2.2#2
- 7.1.2.2#3
- 7.4.1#6
- 7.4.1#7

Stat Sub #3 Frequency Offset

Repeat 60 times. For each step:

1. Read ~~FreqOffsetFromGM~~FreqOffsetFromHR. Save value to temporary variable FrequencyOffsetFromReg
2. To convert the value to ppm:


```

Polarity = FrequencyOffsetFromReg >> 31
If (Polarity == 1) { // negative value
    FrequencyOffset = ConvertTwosCompliment(FrequencyOffsetFromReg)
}
Else {
    FrequencyOffset = FrequencyOffsetFromReg
}
FrequencyOffsetPPM = FrequencyOffset * 106/241
      
```
3. Verify that:
 - a. Expected behavior is a constant FrequencyOffsetFromReg value with not more than 1 ppm deviation from the average. (7.4.1#1-#4)
 - b. For 1st hop, ~~FreqOffsetFromGM~~FreqOffsetFromHR is 0. (TBD)
 - c. For 2nd hop, ~~FreqOffsetFromGM == FreqOffsetFromMaster~~FreqOffsetFromHR == FreqOffsetFromDFP. (7.1.2.3#2)

FreqOffsetFromHR	8
FreqOffsetFromDFP	9

Assertions checked:

- 7.4.1#1
- 7.4.1#2
- 7.4.1#3
- 7.4.1#4

Stat Sub #4 Correlation between Frequency and Time Offsets

For both ~~OffsetFromMaster~~OffsetFromDFP and ~~OffsetFromGM~~OffsetFromHR, the following correlation is checked:

- The slope of TimeOffset is expected to be the equal to FreqOffset +/- 10%.
- TimeOffset is read 60 times once per second.
- Average slope is calculated:
 - $\text{Toff}[1]$ – time offset from first read.
 - $\text{Toff}[n]$ – time offset from last read.
 - $A = (\text{Toff}[n] - \text{Toff}[1]) / ((n-1) * 1e9)$.
 - Average Slope = $A * 1e6$ // the units are ppm.
- Compare Average Slope to Frequency Offset from Stat Sub #3 in ppm units.
- Verify the that correlation between the calculated and measured Frequency offset are less than 10.
(7.4.1#8):
 - $\text{Abs}(\text{Average Slope} / \text{Frequency Offset}) - 1 * 100 < 10$.

Assertions checked:

- 7.4.1#8

Stat Sub #5 Propagation Delay

1. Read Propagation Delay 100 times. Compute average.
2. Verify that the Propagation Delay is constant ($\pm 1\%$) (7.4.1#5).
3. Test with KG USB4 Host/Hub/Device.

Propagation Delay 31:0	10
Propagation Delay 63:32	11

Assertions checked:

- 7.4.1#5

Stat Sub #6 Computation Timestamp

1. Read 10 times with period of 1 sec between the reads.
2. Verify that the Computation Timestamp grows by approximately 1 sec relative to previous read value (+/- 2%). (7.3.1.1.#5)

Computation Timestamp 31:0		12
Computation Timestamp 63:32		13
Reserved	Computation Timestamp 79:64	14

Assertions checked:

- 7.3.1.1#5

Stat Sub #7 Inter-Domain Computation Timestamp

1. Read 10 times with period of 1 sec between the reads.
2. Verify that the Computation Timestamp grows by approximately 1 sec relative to previous read value (+/- 1%). (7.4.2.3#1)

InterDomain Computation Timestamp 31:0		16
InterDomain Computation Timestamp 63:32		17
Reserved	InterDomain Computation Timestamp 79:64	18

Assertions checked:

- 7.4.2.3#1

Stat Sub #8 Inter-Domain Time Offset

1. Read in loop 60 times with 1 sec delay.
2. Average slope is calculated per read.
3. Verify that:
 - a. Expected behavior is a consistent linear incline or decline (accuracy of 1%). (TBD)
 - b. For 1st hop, ~~TimeOffsetFromInterDomainGM~~ TimeOffsetFromInterDomainHR is 0. (TBD)
 - c. For 2nd hop, ~~TimeOffsetFromInterDomainGM ==~~
~~TimeOffsetFromInterDomainMaster~~ TimeOffsetFromInterDomainHR ==
TimeOffsetFromInterDomainDFP. (TBD)

Assertions checked:

- TBD

Stat Sub #9 Inter-Domain Frequency Offset

Repeat 60 times. For each step:

1. Read ~~FreqOffsetFromGM~~FreqOffsetFromHR. Save value to temporary variable FrequencyOffsetFromReg.
2. To convert the value to ppm:

```
Polarity = FrequencyOffsetFromReg >> 31
If (Polarity == 1) { // negative value
    FrequencyOffset = ConvertTwosCompliment(FrequencyOffsetFromReg)
}
Else {
    FrequencyOffset = FrequencyOffsetFromReg
}
FrequencyOffsetPPM = FrequencyOffset * 106/241
```
3. Verify that:
 - a. Expected behavior is a constant FrequencyOffsetFromReg value with not more than 1 ppm deviation from the average. (TBD)
 - b. For 1st hop, ~~FreqOffsetFromInterDomainGM~~FreqOffsetFromInterDomainHR is 0. (TBD)
 - c. For 2nd hop, ~~FreqOffsetFromInterDomainGM ==~~
~~FreqOffsetFromInterDomainMaster~~FreqOffsetFromInterDomainHR ==
FreqOffsetFromInterDomainDFP. (TBD)

Assertions checked:

- 7.4.2.3#2
- 7.4.2.3#3

Stat Sub #10 Correlation between Inter-Domain Frequency and Inter-Domain Time Offsets

For both ~~OffsetFromInterDomainMaster and OffsetFromInterDomainGM~~OffsetFromInterDomainDFP and OffsetFromInterDomainHR, the following correlation is checked:

- The slope of TimeOffset is expected to be the equal to FreqOffset.

Test Example:

1. TimeOffset is read every second 60 times once every second.
2. If after averaging out the slope is ~100 ns per second, then the calculated Freq offset should be:

$$219902 = \frac{100}{10^9} * 2^{41}$$

3. FreqOffset is read and compared with calculated value.
4. Verify that the correlation between the calculated and measured Frequency offset are less than 1ppm.
(TBD)

Assertions checked:

- TBD

Stat Sub #11 Port Statistics for Bi-Directional ~~Master~~DFP

1. Read first time to clear.
2. Read 10 times with period of less than 500ms between the reads.
3. If TMU mode is HiFi or LowRes, verify that:
 - a. RX TSNOS counter changes.
 - b. TX TSNOS counter changes.
 - c. TX Packet counter changes.
4. Verify that the change of the three parameters is more than 20,000 counts per second in HiFi mode.
5. Verify that the change of the three parameters is more than 250 counts per second in LowRes mode.
6. If TMU mode is OFF, verify that all four counters are 0 after 1st read.

TX TSNOS counter	RX TSNOS counter	4
TX Packet counter	RX Packet counter	5

Assertions checked:

- TBD

Stat Sub #12 Port Statistics for Bi-Directional ~~Slave~~UFP

1. Read first time to clear.
2. Read 10 times with period of less than 500ms between the reads.
3. If TMU mode is HiFi or LowRes, verify that:
 - a. RX TSNOS counter changes.
 - b. TX TSNOS counter changes.
 - c. RX Packet counter changes.
4. Verify that the change of the three parameters is more than 20,000 counts per second in HiFi mode.
5. Verify that the change of the three parameters is more than 250 counts per second in LowRes mode.
6. If TMU mode is OFF, verify that all four counters are 0 after 1st read.

Assertions checked:

- TBD

Stat Sub #13 Port Statistics for Uni-Directional ~~Master~~DFP

1. Read first time to clear.
2. Read 10 times with period of less than 500ms between the reads.
3. If TMU mode is HiFi or LowRes, verify that:
 - a. TX TSNOS counter changes.
 - b. TX Packet counter changes.
4. Verify that the change of the two parameters is more than 20,000 counts per second in HiFi mode.
5. Verify that the change of the two parameters is more than 250 counts per second in LowRes mode.
6. If TMU mode is OFF, verify that all four counters are 0 after 1st read.

Assertions checked:

- TBD

Stat Sub #14 Port Statistics for Uni-Directional ~~Slave~~UFP

1. Read first time to clear.
2. Read 10 times with period of less than 500ms between the reads.
3. If TMU mode is HiFi or LowRes, verify that:
 - a. RX TSNOS counter changes.
 - b. TX TSNOS counter changes.
 - c. RX Packet counter changes.
4. Verify that the change of the two parameters is more than 20,000 counts per second in HiFi mode.
5. Verify that the change of the two parameters is more than 250 counts per second in LowRes mode.
6. If TMU mode is OFF, verify that all four counters are 0 after 1st read.

Assertions checked:

- TBD

Stat Sub #15 Port Statistics for Inter-Domain Timestamp Packets

Use ~~Stat Sub #13~~ or ~~Stat Sub #14~~ depending on TMU mode on inter-Domain Link.

Apply the Sub on the inter-Domain port.

Assertions checked:

- TBD

Time Posting Functions

Time Posting #1: Immediate Posting – 15 days

1. Read Local time in Host Router.
2. Write value of 15 days to Local time:
 - a. Value 0x83A10000 to Post Local Time Low.
 - b. Value 0x49AB4 to Post Local Time High.
 - c. Value 0xFFFFFFFF to Post Time High.
 - d. Value 0x1 to Post Time Low.
 - e. Value 0x0 to Post Time High.
3. Poll Post Time Low until it becomes 0x0.
4. Read Local time.
5. Verify that values are greater than:
 - a. LocalTime High[63:32] = 0x9AB483XX. (TBD)
 - b. LocalTime High[79:64] = 0x4. (TBD)

Note: LocalTime Low can be any value.

This function only used before enabling TMU in Hub and or Device.

Assertions checked:

- TBD

Time Posting #2: Immediate Posting – 1 hour

1. Read Local time in Host Router
2. Write value of 15 days to Local time:
 - a. Value 0xffff0000 to Post Local Time Low.
 - b. Value 0x0346 to Post Local Time High.
 - c. Value 0xFFFFFFFF to Post Time High.
 - d. Value 0x1 to Post Time Low.
 - e. Value 0x0 to Post Time High.
3. Poll Post Time Low until it becomes 0x0.
4. Read Local time.
5. Verify that values are greater than:
 - a. LocalTime High[63:44] = 0x03470. (TBD)
 - b. LocalTime High[79:64] = 0x0. (TBD)

Note: LocalTime Low can be any value.

This function only used before enabling TMU in Hub and or Device.

Assertions checked:

- TBD

Time Posting #3: Future Posting – 15 days

1. Read Local time in Host Router, Store it in LTH variable.
2. Add 10 sec to LTH.
3. Read current filters values: Freq Measurement Window , DelayAvgConst , OffsetAvgConst, ErrorAvgConst.
4. Set All setup to LowRes Mode
5. Configure all the devices in the setup with following:
 - a. Write value of 15 days to Local time:
 - i. Value 0x83A10000 to Post Local Time Low.
 - ii. Value 0x49AB4 to Post Local Time High.
 - iii. Value 0xFFFFFFFF to Post Time High.
 - iv. Value LTH & 0xFFFFFFFF to Post Time Low.
 - v. Value (LTH >> 32) to Post Time High.
6. Poll Post Time Low in UUT until it becomes 0x0:
 - a. Timeout after 12 seconds (system time) if the posting hasn't occurred. Report error.
 - b. Report error if time posting occurred earlier than 8 seconds (system time).
7. Read Local time in UUT and verify that values are greater than:
 - a. LocalTime High[63:32] = 0x9AB48XXX. (TBD)
 - b. LocalTime High[79:64] = 0x4. (TBD)
8. Restore filters to values from #3.

Note: LocalTime Low can be any value.

This function only used on the whole tree – Host, Hubs, and Peripheral Devices.

Assertions checked:

- TBD

Time Posting #4: Future Posting – 1 hour

1. Read Local time in Host Router, Store it in LTH variable.
2. Add 10 sec to LTH.
3. Read current filters values: Freq Measurement Window , DelayAvgConst , OffsetAvgConst, ErrorAvgConst.
4. Set Filters to low level:
 - a. Freq Measurement Window = 30.
 - b. DelayAvgConst = 4.
 - c. OffsetAvgConst = 4.
 - d. ErrorAvgConst = 4.
5. Configure all the devices in the setup with following:
 - a. Write value of 15 days to Local time:
 - i. Value 0xffff0000 to Post Local Time Low.
 - ii. Value 0x00384 to Post Local Time High.
 - iii. Value 0xFFFFFFFF to Post Time High.
 - iv. Value LTH & 0xFFFFFFFF to Post Time Low.
 - v. Value (LTH >> 32) to Post Time High.
6. Read values of filters from TMU_RTR_CS_15 and store for future reference.
7. Write new filter value to TMU_RTR_CS_15.
8. Poll Post Time Low in UUT until it becomes 0x0.
 - a. Timeout after 12 seconds (system time) if the posting hasn't occurred. Report error.
 - b. Report error if time posting occurred earlier than 8 seconds (system time).
9. Read Local time in UUT and verify that values are greater than:
 - a. LocalTime High[63:44] = 0x03470. (TBD)
 - b. LocalTime High[79:64] = 0x0. (TBD)
10. Restore filters to values from #3.

Note: LocalTime Low can be any value.

This function only used on the whole tree – Host, Hubs, and Peripheral Devices.

Assertions checked:

- TBD

Time Posting #5: Immediate Time Posting Upon Configuration

1. Read Local time in Host Router, Store it in LTH variable.
2. Configure all the devices in the setup with following:
 - a. Write following values to Local time:
 - i. Value LTH & 0xffffffff to Post Local Time Low.
 - ii. Value LTH >> 32 to Post Local Time High.
 - iii. Value 0xFFFFFFFF to Post Time High.
 - iv. Value 0x1 to Post Time Low.
 - v. Value 0x0 to Post Time High.
3. Poll Post Time Low in UUT until it becomes 0x0.
4. Read Local time in UUT.
5. Verify that LocalTime is within 100msec away from LTH

Test Setups

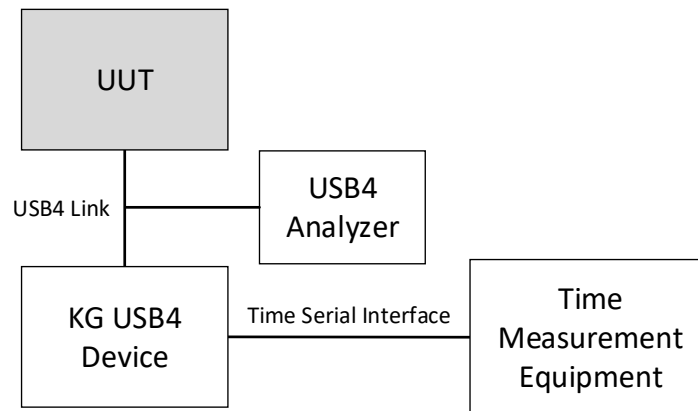
This section describes the test setups for USB4 Hosts, Hubs, and Peripheral Devices.

Single-Port Host

This section describes the test setups for a USB4 Host with one USB4 Port.

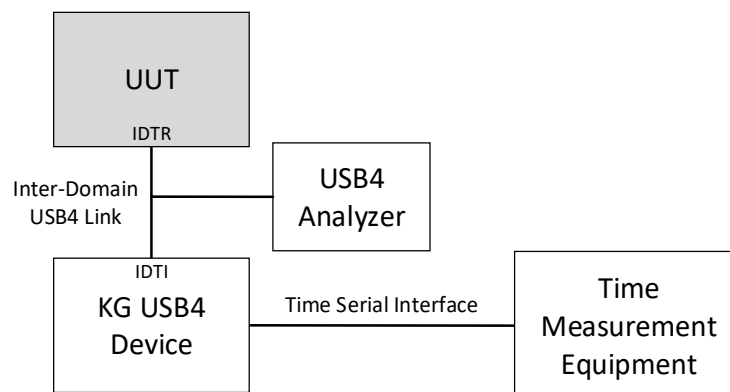
Intra-Domain

Setup #1 Single-Port Host with Single Endpoint

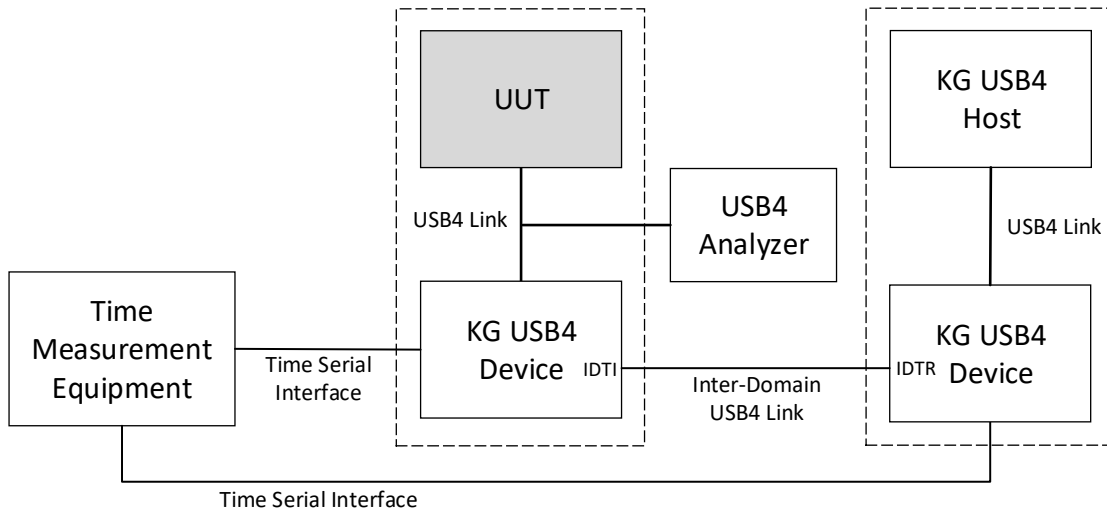


Inter-Domain

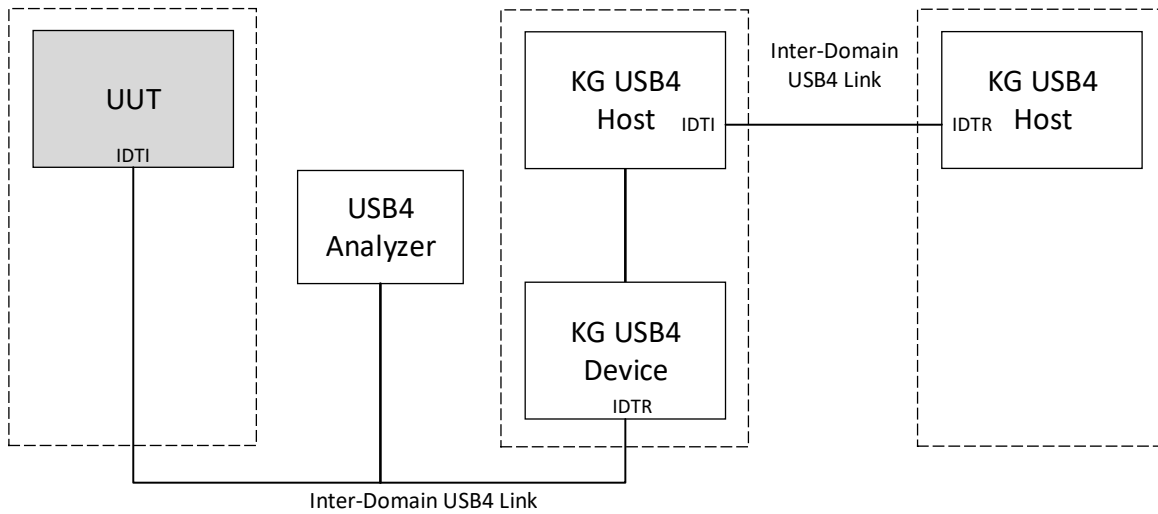
Setup #2 Single-Port Host as Inter-Domain ~~Grandmaster~~ Host Router



Setup #3 Single-Port Host as ~~Grandmaster~~Host Router in ~~Slave~~Inter-DomainTime Initiator Domain



Setup #4 Single-Port Host as ~~Multiple~~Inter-Domain ~~Slave~~Time Initiator

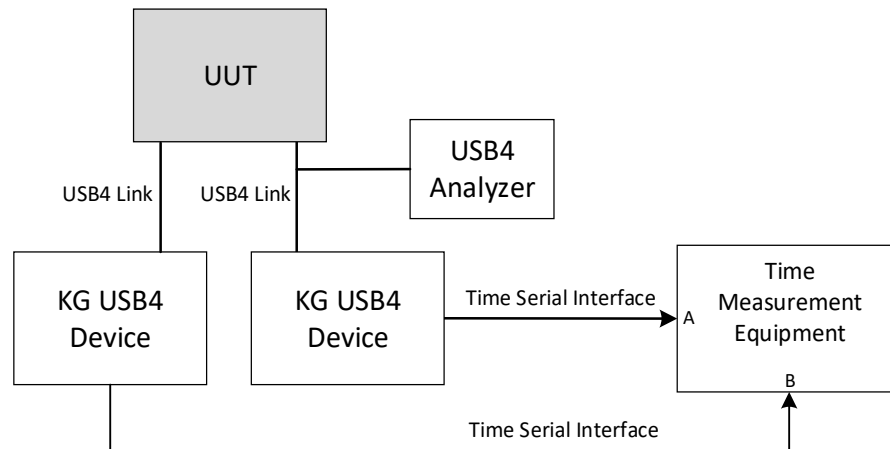


Multi-Port Host

This section describes the test setups for a USB4 Host with more than one USB4 Port.

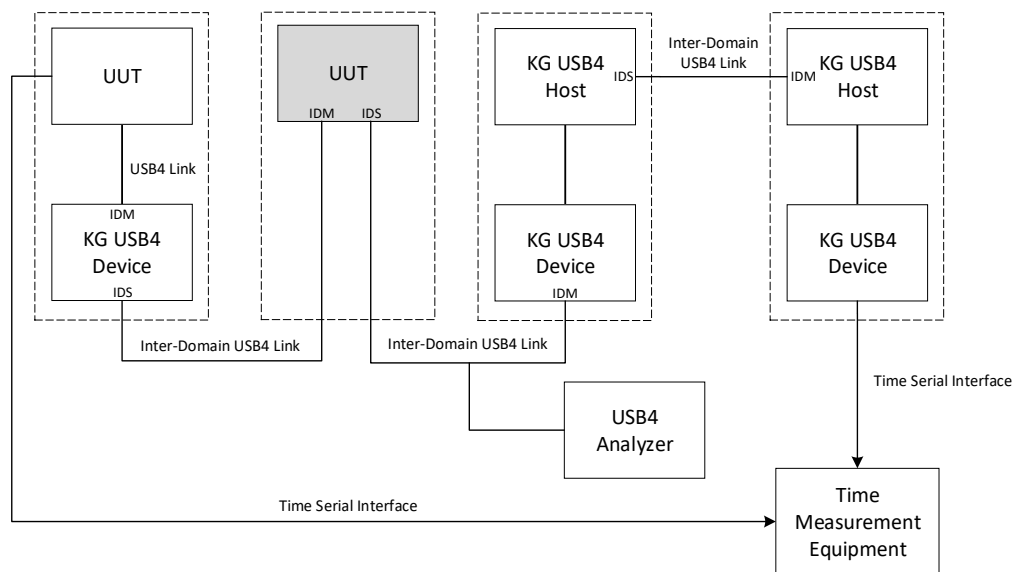
Intra-Domain

Setup #5 Multi-Port Host in Single Domain

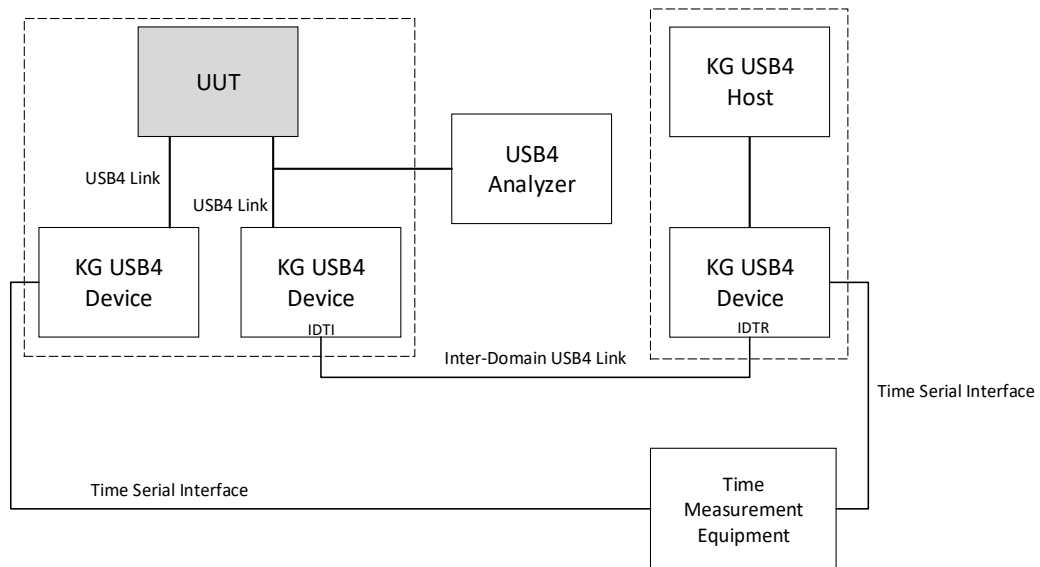


Inter-Domain

Setup #6 Multi-Port Host as Inter-Domain ~~Slave~~Time Initiator and ~~Master~~Time Responder



Setup #7 Multi-Port Host as ~~Master~~ Host Router in ~~Slave~~ Inter-Domain Time Initiator Domain

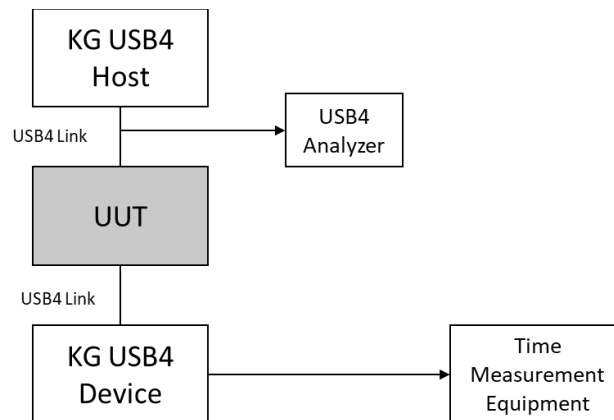


Hub

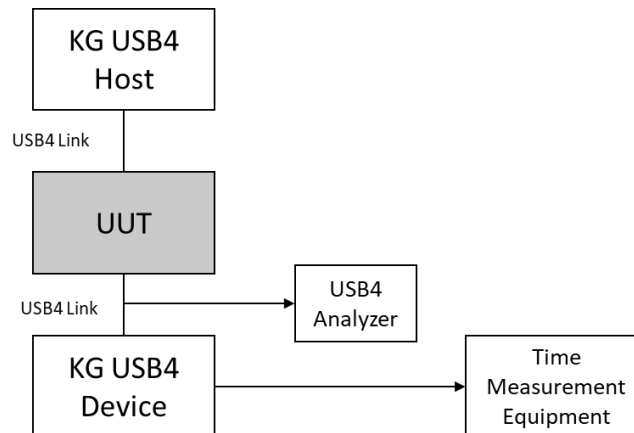
This section describes the test setups for a USB4 Hub.

Intra-Domain

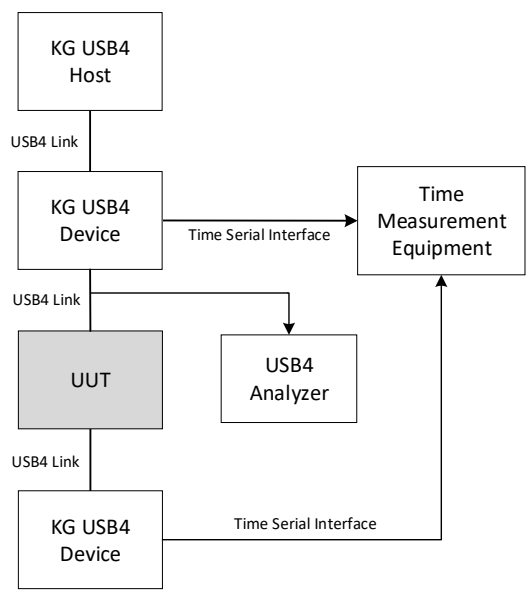
Setup #8 Hub UFP as 2nd Hop



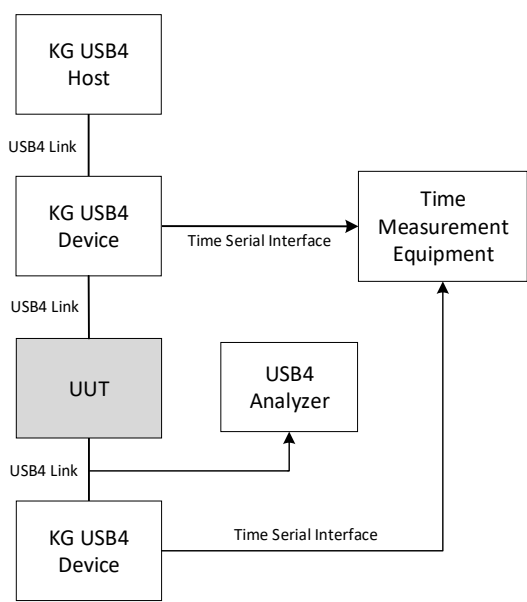
Setup #9 Hub DFP as 2nd Hop



Setup #10 Hub UFP as 3rd Hop

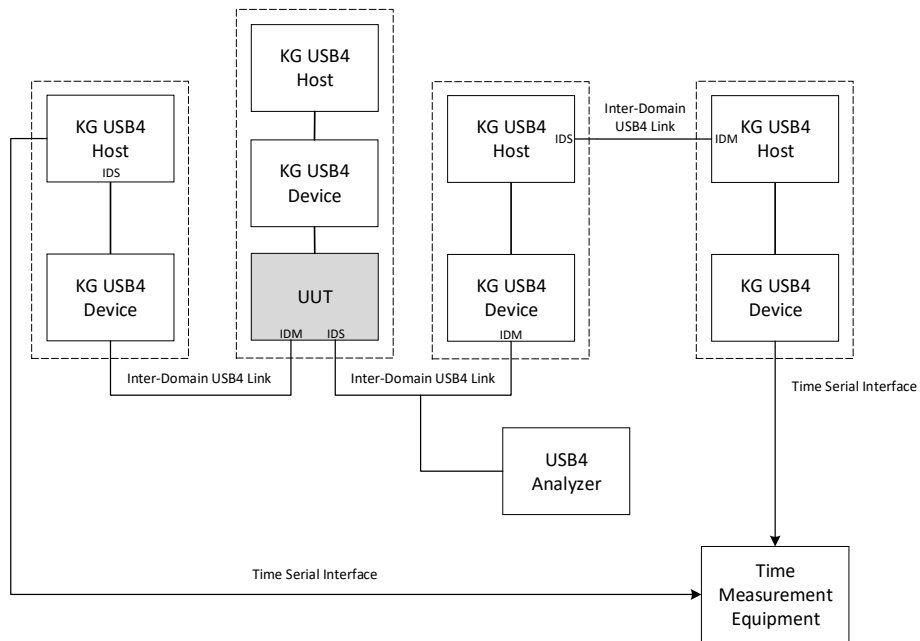


Setup #11 Hub DFP as 3rd Hop

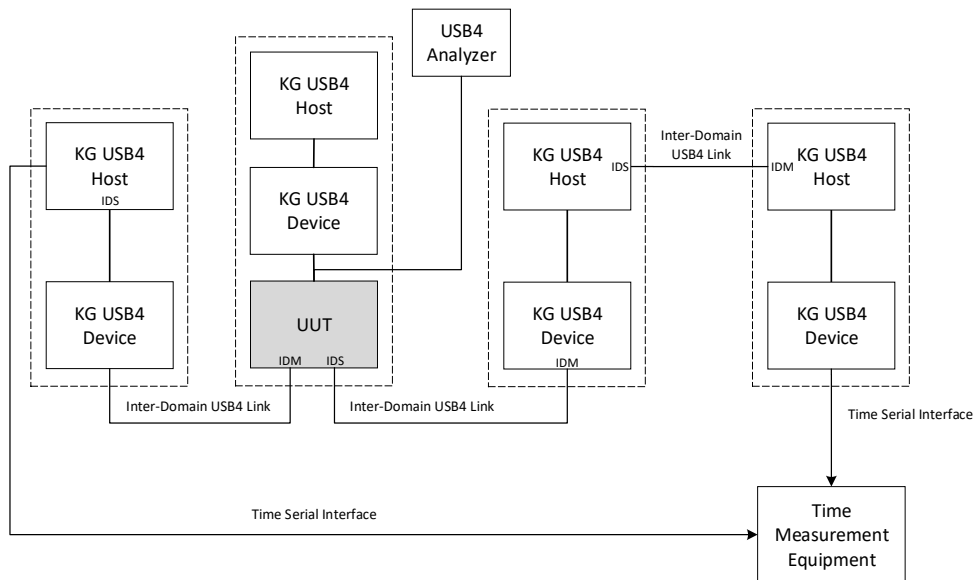


Inter-Domain

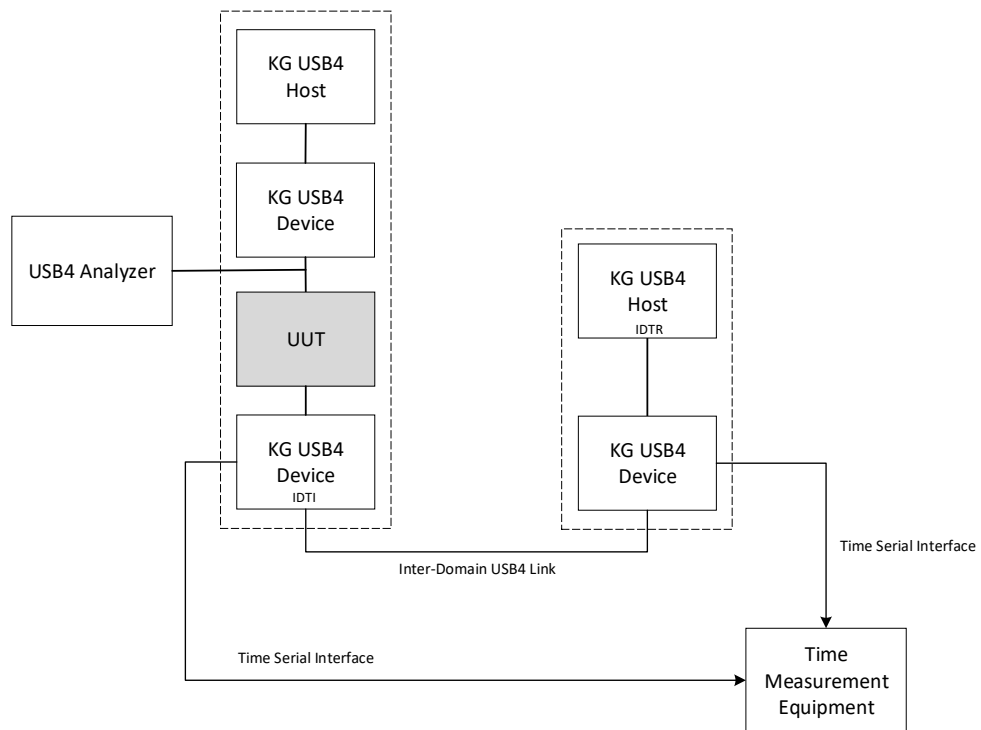
Setup #12 Hub as ~~Inter-Domain Slave~~ IDTI Port (DFP)



Setup #13 Hub as ~~Inter-Domain Slave~~ IDTI Port (UFP)



Setup #14 Hub as ~~Master~~DFP in Inter-Domain ~~Slave~~Time Initiator Domain

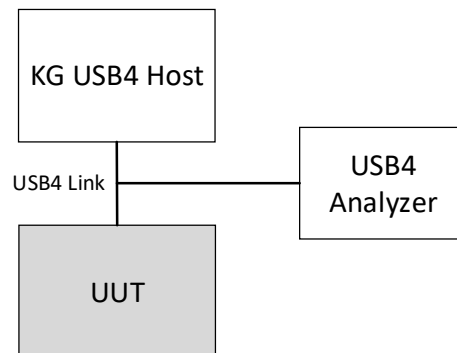


Peripheral Device

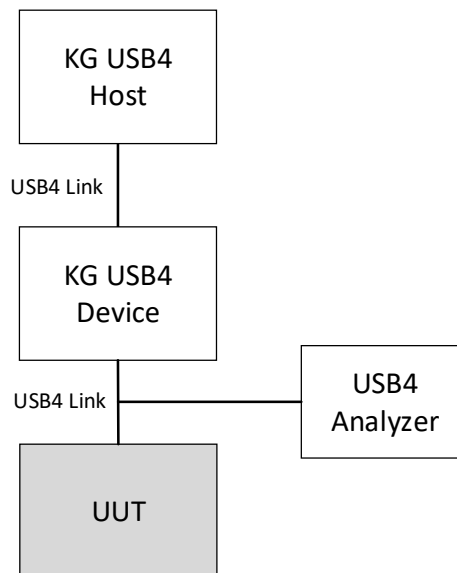
This section describes the test setups for a USB4 Host with one USB4 Port.

Intra-Domain

Setup #15 Peripheral Device as 2nd Hop

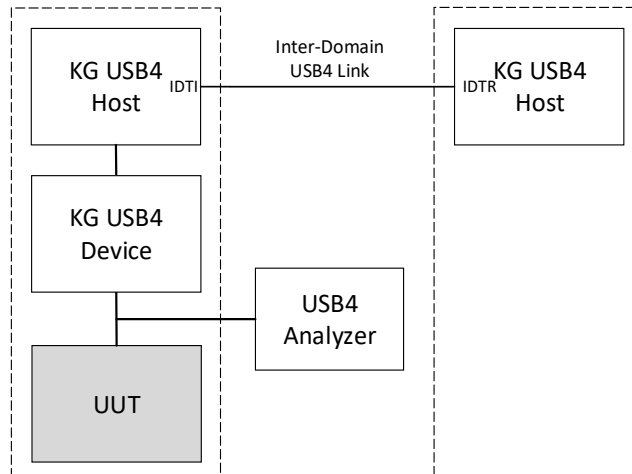


Setup #16 Peripheral Device as 3rd Hop



Inter-Domain

Setup #17 Peripheral Device as 3rd Hop in ~~Slave~~Inter-Domain Time Initiator Domain



USB4 Test Descriptions

Single-Port Host

The tests in this section apply to a USB4 Host that has one USB4 Port.

Intra-Domain

TD 7.1 Bi-Directional HiFi Mode Test (Single-Port Host)

- A. Purpose:
 - Verify that the TMU in a USB4 Host behaves as expected in Bidirectional HiFi Mode
- B. Repetitions:
 - Repeat test with Single-Lane Link and Dual-Lane Link
 - Repeat test at Gen 2 and Gen 3 speeds
- C. Procedure:
 - 1. Connect Setup #1
 - 2. Configure USB4 Link according to Link Configuration #1
 - 3. Configure TMU to Bi-Directional HiFi mode in UUT
 - 4. Configure TMU to Bi-Directional HiFi mode in KG USB4 Device
 - 5. Run ~~Time Calculation #1~~~~Time Calculation #1~~, N=1
 - 6. Run Stat Sub #1 on Host Router
 - 7. Run Stat Sub #2 on KG USB4 Device
 - 8. Run Stat Sub #3 on KG USB4 Device
 - 9. Run Stat Sub #4 on KG USB4 Device
 - 10. Run Stat Sub #5 on KG USB4 Device
 - 11. Run ~~Stat Sub #6~~~~Stat Sub #6~~ on KG USB4 Device
 - 12. Run ~~Stat Sub #11~~~~Stat Sub #11~~ on Host Router
 - 13. Run ~~Stat Sub #12~~~~Stat Sub #12~~ on KG USB4 Device
 - 14. Run Protocol Check #1
 - 15. Run Protocol Check #2

TD 7.2 Uni-Directional HiFi Mode Test (Single-Port Host)

A. Purpose:

- Verify that the TMU in a USB4 Host behaves as expected in Unidirectional HiFi Mode.

B. Procedure:

1. Connect Setup #1
2. Configure USB4 Link according to Link Configuration #1
3. Configure KG USB4 Device to Unidirectional HiFi mode
4. Configure UUT to Unidirectional HiFi mode
5. Run Time Calculation #1~~Time Calculation #1~~, N=1
6. Run Stat Sub #1 on Host Router
7. Run Stat Sub #2 on KG USB4 Device
8. Run Stat Sub #3 on KG USB4 Device
9. Run Stat Sub #4 on KG USB4 Device
10. Run Stat Sub #6~~Stat Sub #6~~ on KG USB4 Device
11. Run Stat Sub #13~~Stat Sub #13~~ on Host Router
12. Run Stat Sub #14~~Stat Sub #14~~ on KG USB4 Device
13. Run Protocol Check #3
14. Run Protocol Check #4~~Protocol Check #4~~

TD 7.3 Uni-Directional LowRes Mode Test (Single-Port Host)

- A. Purpose:
 - Verify that the TMU in a USB4 Host behaves as expected in LowRes Mode
- B. Procedure:
 1. Connect Setup #1
 2. Configure USB4 Link according to Link Configuration #1
 3. Configure KG USB4 Device to Unidirectional LowRes mode
 4. Configure UUT to Unidirectional LowRes mode
 5. Proceed to the next steps as in TD 7.2 starting from step #5

TD 7.4 TMU Mode Change Test (Single-Port Host)

A. Purpose:

- Verify that the TMU Mode change works properly in a USB4 Host

B. Procedure:

1. Connect Setup #1
2. Configure USB4 Link according to Link Configuration #1
3. Configure TMU to Bi-Directional HiFi mode in UUT
4. Configure TMU to Bi-Directional HiFi mode in KG USB4 Device
5. Run Time Calculation #1~~Time Calculation #1~~, N=1
6. Run Stat Sub #1 on Host Router
7. Run Stat Sub #2 on KG USB4 Device
8. Run Stat Sub #3 on KG USB4 Device
9. Run Stat Sub #4 on KG USB4 Device
10. Run Stat Sub #5 on KG USB4 Device
11. Run Stat Sub #6~~Stat Sub #6~~ on KG USB4 Device
12. Run Stat Sub #11~~Stat Sub #11~~ on Host Router
13. Run Stat Sub #12~~Stat Sub #12~~ on KG USB4 Device
14. Run Protocol Check #1
15. Run Protocol Check #2
16. Change TMU mode to Uni-directional HiFi mode both in UUT and Device according to CM mode change flow (see CM guide)
17. Wait 1 sec
18. Repeat steps #5 to #11
19. Run Stat Sub #13~~Stat Sub #13~~ on Host Router on both ports
20. Run Stat Sub #14~~Stat Sub #14~~ on KG USB4 Device on both ports
21. Run Protocol Check #3
22. Run Protocol Check #4~~Protocol Check #4~~
23. Change TMU mode to Uni-directional LowRes mode both in UUT and Device according to CM mode change flow (see CM guide)
24. Wait 1 sec
25. Repeat steps #5 to #11
26. Run Stat Sub #13~~Stat Sub #13~~ on Host Router on both ports
27. Run Stat Sub #14~~Stat Sub #14~~ on KG USB4 Device on both ports
28. Run Protocol Check #3
29. Run Protocol Check #4~~Protocol Check #4~~
30. Change TMU mode to TMU OFF mode both in UUT and Device according to CM mode change flow (see CM guide)
31. Run Stat Sub #11~~Stat Sub #11~~
32. Change TMU mode to Uni-directional LowRes mode both in UUT and Device according to CM mode change flow (see CM guide)
33. Wait 1 sec
34. Repeat steps #5 to #11
35. Run Stat Sub #13~~Stat Sub #13~~ on Host Router on both ports
36. Run Stat Sub #14~~Stat Sub #14~~ on KG USB4 Device on both ports
37. Run Protocol Check #3
38. Run Protocol Check #4~~Protocol Check #4~~
39. Change TMU mode to Bi-Directional HiFi mode both in UUT and Device according to CM mode change flow (see CM guide)
40. Wait 1 sec
41. Repeat steps #5 to #15

TD 7.5 Future Time Posting Test – 15 days (Single-Port Host)

- A. Purpose:
- Verify that Future Time posting works correctly in a USB4 Host
- B. Procedure:
1. Connect Setup #1
 2. Configure USB4 Link according to Link Configuration #1
 3. Configure UUT to Bi-Directional HiFi mode
 4. Configure KG USB4 Device to Bi-Directional HiFi mode
 5. Run Time Posting #3
 6. Run ~~Time Calculation #1~~~~Time Calculation #1~~, N=1
 7. Run Stat Sub #1 on Host Router
 8. Run Stat Sub #2 on KG USB4 Device
 9. Run Stat Sub #3 on KG USB4 Device
 10. Run Stat Sub #4 on KG USB4 Device
 11. Run ~~Stat Sub #6~~~~Stat Sub #6~~ on KG USB4 Device

TD 7.6 Future Time Posting Test – 1 Hour (Single-Port Host)

- A. Purpose:
- Verify that Future Time posting works correctly in a USB4 Host
- B. Procedure:
12. Connect Setup #1
 13. Configure USB4 Link according to Link Configuration #1
 14. Configure UUT to Bi-Directional HiFi mode
 15. Configure KG USB4 Device to Bi-Directional HiFi mode
 16. Run Time Posting #4
 17. Run Time Calculation #1~~Time Calculation #1~~, N=1
 18. Run Stat Sub #1 on Host Router
 19. Run Stat Sub #2 on KG USB4 Device
 20. Run Stat Sub #3 on KG USB4 Device
 21. Run Stat Sub #4 on KG USB4 Device
 22. Run Stat Sub #6~~Stat Sub #6~~ on KG USB4 Device

Inter-Domain

TD 7.7 Inter-Domain ~~Master~~Time Responder in Bi-Directional HiFi Mode Test (Single-Port Host)

- A. Purpose:
 - Verify a USB4 Host behaves properly as Inter-Domain ~~master~~Time Responder
- B. Repetitions:
 - Repeat test with Single-Lane Link and Dual-Lane Link
- C. Procedure:
 1. Connect Setup #2
 2. Configure USB4 Link according to Link Configuration #1
 3. Set KG Host Router as Inter-Domain ~~slave~~Time Initiator by setting ~~IDS~~IDTI bit to 1
 4. Set UUT as Inter-Domain ~~master~~Time Responder by setting ~~IDM~~IDTR bit to 1
 5. Configure KG Host Router to Bi-Directional HiFi mode
 6. Configure UUT to Bi-Directional HiFi mode
 7. Run ~~Time Calculation #1~~Time Calculation #1, N=1 on endpoint
 8. Run Stat Sub #7 on KG USB4 Device
 9. Run ~~Stat Sub #8~~Stat Sub #8 on KG USB4 Device
 10. Run ~~Stat Sub #9~~Stat Sub #9 on KG USB4 Device
 11. Run ~~Stat Sub #10~~Stat Sub #10 on KG USB4 Device
 12. Run ~~Stat Sub #11~~Stat Sub #11 on Host Router
 13. Run ~~Stat Sub #12~~Stat Sub #12 on KG USB4 Device
 14. Run Protocol Check #1
 15. Run Protocol Check #2

TD 7.8 Host Router in Inter-Domain ~~Master-in-Slave~~Time Initiator Domain in Bi-Directional HiFi Mode
Test (Single-Port Host)

- A. Purpose:
- Verify that USB4 Host behaves properly as Inter-Domain ~~master~~Time Responder
- B. Repetitions:
- Repeat test with Single-Lane Link and Dual-Lane Link
- C. Procedure:
1. Connect Setup #3
 2. Configure USB4 Link according to Link Configuration #1
 3. Set KG USB4 Device as Inter-Domain slaveTime Initiator by setting ~~IDS~~IDTI bit to 1
 4. Set KG Host Router as Inter-Domain ~~master~~Time Responder by setting ~~IDM~~IDTR bit to 1
 5. Configure UUT to Bi-Directional HiFi mode
 6. Configure KG USB4 Device to Bi-Directional HiFi mode
 7. Configure KG Host Router to Bi-Directional HiFi mode
 8. Set IDE bit to 1 in UUT
 9. Run Time Calculation #2~~Time Calculation #2~~, N=1 on endpoints
 10. Run Stat Sub #7 on KG USB4 Device
 11. Run Stat Sub #8~~Stat Sub #8~~ on KG USB4 Device
 12. Run Stat Sub #9~~Stat Sub #9~~ on KG USB4 Device
 13. Run Stat Sub #10~~Stat Sub #10~~ on KG USB4 Device
 14. Run Stat Sub #11~~Stat Sub #11~~ on Host Router
 15. Run Stat Sub #12~~Stat Sub #12~~ on KG USB4 Device
 16. Run Protocol Check #1
 17. Run Protocol Check #2

TD 7.9 Inter-Domain ~~Slave~~Time Initiator in Bi-Directional HiFi Mode Test (Single-Port Host)

A. Purpose:

- Verify that USB4 Host behaves properly as Inter-Domain ~~master~~Time Responder

B. Procedure:

1. Connect Setup #4
2. Configure USB4 Link according to Link Configuration #1
3. Set KG USB4 Device as Inter-Domain ~~slave~~Time Initiator by setting ~~IDS~~IDI bit to 1
4. Set KG Host Router as Inter-Domain ~~Grandmaster~~Time Responder by setting ~~IDM~~IDR bit to 1
5. Configure UUT to Bi-Directional HiFi mode
6. Configure KG USB4 Device to Bi-Directional HiFi mode
7. Configure KG Host Router to Bi-Directional HiFi mode
8. Set IDE bit to 1 in UUT
9. Run Stat Sub #7 on KG USB4 Device
10. Run ~~Stat Sub #8~~Stat Sub #8 on KG USB4 Device
11. Run ~~Stat Sub #9~~Stat Sub #9 on KG USB4 Device
12. Run ~~Stat Sub #10~~Stat Sub #10 on KG USB4 Device
13. Run ~~Stat Sub #11~~Stat Sub #11 on Host Router
14. Run ~~Stat Sub #12~~Stat Sub #12 on KG USB4 Device
15. Run Protocol Check #1
16. Run Protocol Check #2

TD 7.10 ~~Master~~Host Router in ~~Slave~~Inter-Domain Time Initiator Domain in Bi-Directional HiFi Mode
Test (Single-Port Host)

A. Purpose:

- Verify that USB4 Host behaves properly as Inter-Domain ~~master~~Time Responder

B. Procedure:

1. Connect Setup #6
2. Configure USB4 Link according to Link Configuration #1
3. Set KG USB4 Device as Inter-Domain ~~slave~~Time Initiator by setting ~~IDSIDI~~ bit to 1
4. Set KG Host Router as Inter-Domain ~~Grandmaster~~Time Responder by setting ~~IDMIDTR~~ bit to 1
5. Configure UUT to Bi-Directional HiFi mode
6. Configure KG USB4 Device to Bi-Directional HiFi mode
7. Configure KG Host Router to Bi-Directional HiFi mode
8. Set IDE bit to 1 in UUT
9. Run ~~Time Calculation #2~~Time Calculation #2, N=1 on devices
10. Run Stat Sub #7 on KG USB4 Device
11. Run ~~Stat Sub #8~~Stat Sub #8 on KG USB4 Device
12. Run ~~Stat Sub #9~~Stat Sub #9 on KG USB4 Device
13. Run ~~Stat Sub #10~~Stat Sub #10 on KG USB4 Device
14. Run ~~Stat Sub #11~~Stat Sub #11 on Host Router
15. Run ~~Stat Sub #12~~Stat Sub #12 on KG USB4 Device
16. Run Protocol Check #1
17. Run Protocol Check #2

Multi-Port Host

The tests in this section apply to a USB4 Host that has more than one USB4 Port.

Intra-Domain

TD 7.11 Bi-Directional HiFi Mode Test (Multi-Port Host)

- A. Purpose:
 - Verify that the TMU in a USB4 Host behaves as expected in Bi-Directional HiFi Mode
- B. Repetitions:
 - Repeat test with Single-Lane Link and Dual-Lane Link
 - Repeat test at Gen 2 and Gen 3 speeds
- C. Procedure:
 1. Connect Setup #5
 2. Configure USB4 Link according to Link Configuration #1
 3. Configure TMU to Bi-Directional HiFi mode
 4. Run ~~Time Calculation #1~~~~Time Calculation #1~~, N=1 on both KG USB4 Devices
 5. Run ~~Time Calculation #2~~~~Time Calculation #2~~, N=1 between the KG USB4 Devices
 6. Run Stat Sub #1 on Host Router
 7. Run Stat Sub #2 on KG USB4 Device
 8. Run Stat Sub #3 on KG USB4 Device
 9. Run Stat Sub #4 on KG USB4 Device
 10. Run Stat Sub #5 on KG USB4 Device
 11. Run ~~Stat Sub #6~~~~Stat Sub #6~~ on KG USB4 Device
 12. Run ~~Stat Sub #11~~~~Stat Sub #11~~ on Host Router on both ports
 13. Run ~~Stat Sub #12~~~~Stat Sub #12~~ on KG USB4 Device on both ports
 14. Run Protocol Check #1
 15. Run Protocol Check #2

TD 7.12 Uni-Directional HiFi Mode Test (Multi-Port Host)

A. Purpose:

- Verify that the TMU in a USB4 Host behaves as expected in Uni-Directional HiFi Mode

B. Procedure:

1. Connect Setup #5
2. Configure USB4 Link according to Link Configuration #1
3. Configure TMU to Bi-Directional HiFi mode
4. Run Time Calculation #1~~Time Calculation #1~~, N=1 on both KG USB4 Devices
5. Run Time Calculation #2~~Time Calculation #2~~, N=1 between the two KG USB4 Devices
6. Run Stat Sub #1 on Host Router
7. Run Stat Sub #2 on KG USB4 Device
8. Run Stat Sub #3 on KG USB4 Device
9. Run Stat Sub #4 on KG USB4 Device
10. Run Stat Sub #6~~Stat Sub #6~~ on KG USB4 Device
11. Run Stat Sub #13~~Stat Sub #13~~ on Host Router on both ports
12. Run Stat Sub #14~~Stat Sub #14~~ on KG USB4 Device on both ports
13. Run Protocol Check #3
14. Run Protocol Check #4~~Protocol Check #4~~

TD 7.13 Uni-Directional LowRes Mode Test (Multi-Port Host)

A. Purpose:

- Verify that the TMU in a USB4 Host behaves as expected in LowRes Mode

B. Procedure:

1. Connect Setup #5
2. Configure USB4 Link according to Link Configuration #1
3. Configure TMU to Unidirectional LowRes mode in UUT and KG USB4 Devices
4. Proceed the next steps as in TD 7.12 starting from step #4

TD 7.14 TMU Mode Change Test (Multi-Port Host)

A. Purpose:

- Verify that the TMU in a USB4 Host behaves as expected in Bi-Directional HiFi Mode

B. Procedure:

1. Connect Setup #5
2. Configure USB4 Link according to Link Configuration #1
3. Configure TMU to Bi-Directional HiFi mode
4. Run Time Calculation #1~~Time Calculation #1~~, N = 1 on both KG USB4 Devices
5. Run Time Calculation #2~~Time Calculation #2~~, N = 1 between the KG USB4 Devices
6. Run Stat Sub #1 on Host Router
7. Run Stat Sub #2 on KG USB4 Device
8. Run Stat Sub #3 on KG USB4 Device
9. Run Stat Sub #4 on KG USB4 Device
10. Run Stat Sub #5 on KG USB4 Device
11. Run Stat Sub #6~~Stat Sub #6~~ on KG USB4 Device
12. Run Stat Sub #11~~Stat Sub #11~~ on Host Router on both ports
13. Run Stat Sub #12~~Stat Sub #12~~ on KG USB4 Device on both ports
14. Run Protocol Check #1
15. Run Protocol Check #2
16. Change TMU mode to Uni-directional HiFi mode both in UUT and Device according to CM mode change flow (see CM guide)
17. Wait 1 sec.
18. Repeat steps #5 to #11
19. Run Stat Sub #13~~Stat Sub #13~~ on Host Router on both ports
20. Run Stat Sub #14~~Stat Sub #14~~ on KG USB4 Device on both ports
21. Run Protocol Check #3
22. Run Protocol Check #4~~Protocol Check #4~~
23. Change TMU mode to Uni-directional LowRes mode both in UUT and Device according to CM mode change flow (see CM guide)
24. Wait 1 sec
25. Repeat steps #5 to #11
26. Run Stat Sub #13~~Stat Sub #13~~ on Host Router on both ports
27. Run Stat Sub #14~~Stat Sub #14~~ on KG USB4 Device on both ports
28. Run Protocol Check #3
29. Run Protocol Check #4~~Protocol Check #4~~
30. Change TMU mode to TMU OFF mode both in UUT and Device according to CM mode change flow (see CM guide)
31. Run Stat Sub #11~~Stat Sub #11~~
32. Change TMU mode to Uni-directional LowRes mode both in UUT and Device according to CM mode change flow (see CM guide)
33. Wait 1 sec
34. Repeat steps #5 to #11
35. Run Stat Sub #13~~Stat Sub #13~~ on Host Router on both ports
36. Run Stat Sub #14~~Stat Sub #14~~ on KG USB4 Device on both ports
37. Run Protocol Check #3
38. Run Protocol Check #4~~Protocol Check #4~~
39. Change TMU mode to Bi-Directional HiFi mode both in UUT and Device according to CM mode change flow (see CM guide)
40. Wait 1 sec
41. Repeat steps #5 to #15

TD 7.15 Future Time Posting Test – 15 days (Multi-Port Host)

- A. Purpose:
- Verify that Future Time posting is working as expected in a USB4 Host
- B. Procedure:
1. Connect Setup #5
 2. Configure USB4 Link according to Link Configuration #1
 3. Configure UUT to Bi-Directional HiFi mode
 4. Configure KG USB4 Device to Bi-Directional HiFi mode
 5. Run Time Posting #3
 6. Run ~~Time Calculation #1~~Time Calculation #1, N=1
 7. Run Stat Sub #1 on Host Router
 8. Run Stat Sub #2 on KG USB4 Device
 9. Run Stat Sub #3 on KG USB4 Device
 10. Run Stat Sub #4 on KG USB4 Device
 11. Run ~~Stat Sub #6~~Stat Sub #6 on KG USB4 Device

TD 7.16 Future Time Posting Test – 1 hour (Multi-Port Host)

A. Purpose:

- Verify that Future Time posting is working as expected in a USB4 Host

B. Procedure:

1. Connect Setup #5
2. Configure USB4 Link according to Link Configuration #1
3. Configure UUT to Bi-Directional HiFi mode
4. Configure KG USB4 Device to Bi-Directional HiFi mode
5. Run Time Posting #4
6. Run Time Calculation #1~~Time Calculation #1~~, N=1
7. Run Stat Sub #1 on Host Router
8. Run Stat Sub #2 on KG USB4 Device
9. Run Stat Sub #3 on KG USB4 Device
10. Run Stat Sub #4 on KG USB4 Device
11. Run Stat Sub #6~~Stat Sub #6~~ on KG USB4 Device

Inter-Domain

TD 7.17 Inter-Domain ~~Slave~~Time Initiator and ~~Master~~Time Responder in Bi-Directional HiFi Mode Test

- A. Purpose:
 - Verify that USB4 Host behaves properly as Inter-Domain ~~master~~Time Responder
- B. Repetitions:
 - Repeat test with Single-Lane Link and Dual-Lane Link
- C. Procedure:
 1. Connect Setup #6
 2. Configure USB4 Link according to Link Configuration #1
 3. Configure the topology to Bi-Directional HiFi mode
 4. Run Time Calculation #1~~Time Calculation #1~~, N=1 on Inter-Domain Time Initiator (KG Host Router ~~Inter-Domain Slave~~)
 5. Run Time Calculation #2~~Time Calculation #2~~, N=1 between Inter-Domain Time Initiator (KG Host Router ~~Inter-Domain Slave~~) and Inter-Domain ~~Grandmaster~~Host Router
 6. Run Stat Sub #7 on UUT
 7. Run Stat Sub #8~~Stat Sub #8~~ on UUT
 8. Run Stat Sub #9~~Stat Sub #9~~ on UUT
 9. Run Stat Sub #10~~Stat Sub #10~~ on UUT
 10. Run Stat Sub #11~~Stat Sub #11~~ on UUT all ports
 11. Run Stat Sub #12~~Stat Sub #12~~ on KG USB4 Device
 12. Run Protocol Check #1 on UUT ports
 13. Run Protocol Check #2 on UUT ports

Hub

The tests in this section apply to a USB4 Hub.

Intra-Domain

TD 7.18 Bi-Directional HiFi Mode as 2nd Hop Test (Hub UFP)

- A. Purpose:
 - Verify that the TMU in a USB4 Hub behaves as expected in Bi-Directional HiFi Mode
- B. Repetitions:
 - Repeat test with Single-Lane Link and Dual-Lane Link
 - Repeat test at Gen 2 and Gen 3 speeds
- C. Procedure:
 1. Connect Setup #8
 2. Configure USB4 Link according to Link Configuration #1
 3. Configure TMU to Bi-Directional HiFi mode
 4. Run Time Calculation #1~~Time Calculation #1~~, N=1 on KG USB4 Device
 5. Run Stat Sub #1 on UUT

Measurements on Hub as ~~Slave~~DFP:

6. Run Stat Sub #2 on UUT
7. Run Stat Sub #3 on UUT
8. Run Stat Sub #4 on UUT
9. Run Stat Sub #5 on UUT upstream port
10. Run Stat Sub #6~~Stat Sub #6~~ on UUT
11. Run:
 - If mode is Bi-directional Stat Sub #11~~Stat Sub #11~~ on KG Router above UUT
 - If mode is Uni-directional Stat Sub #13~~Stat Sub #13~~ on KG Router above UUT
12. Run:
 - If mode is Bi-directional Stat Sub #12~~Stat Sub #12~~ on UUT on upstream port
 - If mode is Uni-directional Stat Sub #14~~Stat Sub #14~~ on KG Router above UUT
13. Run:
 - If mode is Bi-directional Protocol Check #1 on UUT upstream port
 - If mode is Uni-directional Protocol Check #3 on UUT upstream port
14. Run:
 - If mode is Bi-directional Protocol Check #2 on UUT upstream port
 - If mode is Uni-directional Protocol Check #4~~Protocol Check #4~~ on UUT upstream port

TD 7.19 Bi-Directional HiFi Mode as 2nd Hop Test (Hub DFP)

- A. Purpose:
- Verify that the TMU in a USB4 Hub behaves as expected in Bi-Directional HiFi Mode
- B. Repetitions:
- Repeat test with Single-Lane Link and Dual-Lane Link
 - Repeat test at Gen 2 and Gen 3 speeds
- C. Procedure:
1. Connect Setup #9
 2. Configure USB4 Link according to Link Configuration #1
 3. Configure TMU to Bi-Directional HiFi mode
 4. Run Time Calculation #1~~Time Calculation #1~~, N=1 on KG USB4 Device
 5. Run Stat Sub #1 on UUT

Measurements of the effect of Hub as ~~Master~~DFP:

6. Run Stat Sub #2 on KG USB4 Device
7. Run Stat Sub #3 on KG USB4 Device
8. Run Stat Sub #4 on KG USB4 Device
9. Run Stat Sub #5 on KG USB4 Device
10. Run Stat Sub #6~~Stat Sub #6~~ on KG USB4 Device
11. Run:
 - If mode is Bi-directional Stat Sub #11~~Stat Sub #11~~ on UUT on downstream port
 - If mode is Uni-directional Stat Sub #13~~Stat Sub #13~~ on UUT on downstream port
12. Run:
 - If mode is Bi-directional Stat Sub #12~~Stat Sub #12~~ on UUT on upstream port
 - If mode is Uni-directional Stat Sub #14~~Stat Sub #14~~ on KG USB4 Device
13. Run:
 - If mode is Bi-directional Protocol Check #1 on KG USB4 Device
 - If mode is Uni-directional Protocol Check #3 on KG USB4 Device
14. Run:
 - If mode is Bi-directional Protocol Check #2 on KG USB4 Device
 - If mode is Uni-directional Protocol Check #4~~Protocol Check #4~~ on KG USB4 Device

TD 7.20 Uni-Directional HiFi Mode as 2nd Hop Test (Hub UFP)

- A. Purpose:
 - Verify that the TMU in a USB4 Hub behaves as expected in Uni-Directional HiFi Mode
- B. Procedure:
 1. Same as TD 7.18 only with UUT and Host configured to Uni-Directional HiFi mode
 2. All the rest of the tree is configured to Bi-Directional HiFi mode

TD 7.21 Uni-Directional HiFi Mode as 2nd Hop Test (Hub DFP)

- A. Purpose:
 - Verify that the TMU in a USB4 Hub behaves as expected in Uni-Directional HiFi Mode
- B. Procedure:
 - 1. Same as TD 7.19 only with UUT and Host configured to Uni-Directional HiFi mode
 - 2. All the rest of the tree is configured to Bi-Directional HiFi mode

TD 7.22 Uni-Directional LowRes Mode as 2nd Hop Test (Hub UFP)

- A. Purpose:
 - Verify that the TMU in a USB4 Hub behaves as expected in Uni-Directional LowRes Mode
- B. Procedure:
 - 1. Same as TD 7.18 only with UUT and Host configured to Uni-Directional LowRes mode
 - 2. All the rest of the tree is configured to Bi-Directional HiFi mode

TD 7.23 Uni-Directional LowRes Mode as 2nd Hop Test (Hub DFP)

- A. Purpose:
 - Verify that the TMU in a USB4 Hub behaves as expected in Uni-Directional LowRes Mode
- B. Procedure:
 - 1. Same as TD 7.19 only with UUT and Host configured to Uni-Directional LowRes mode
 - 2. All the rest of the tree is configured to Bi-Directional HiFi mode

TD 7.24 Bi-Directional HiFi Mode as 3rd Hop Test (Hub UFP)

- A. Purpose:
- Verify that the TMU in a USB4 Hub behaves as expected in Bi-Directional HiFi Mode
- B. Procedure:
1. Connect Setup #10
 2. Configure USB4 Link according to Link Configuration #1
 3. Configure TMU to Bi-Directional HiFi mode
 4. Run ~~Time Calculation #1~~~~Time Calculation #1~~, N=1 on KG USB4 Device
 5. Run ~~Time Calculation #2~~~~Time Calculation #2~~, N=1 between the KG Router and KG USB4 Device
 6. Run Stat Sub #1 on UUT
- Measurements on Hub as ~~Slave~~~~DFP~~:
7. Run Stat Sub #2 on UUT
 8. Run Stat Sub #3 on UUT
 9. Run Stat Sub #4 on UUT
 10. Run ~~Stat Sub #6~~~~Stat Sub #6~~ on UUT
 11. Run ~~Stat Sub #11~~~~Stat Sub #11~~ on KG Router above UUT
 12. Run ~~Stat Sub #12~~~~Stat Sub #12~~ on UUT on upstream port
 13. Run Protocol Check #1 on UUT upstream port
 14. Run Protocol Check #2 on UUT upstream port

TD 7.25 Bi-Directional HiFi Mode as 3rd Hop Test (Hub DFP)

- A. Purpose:
- Verify that the TMU in a USB4 Hub behaves as expected in Bi-Directional HiFi Mode
- B. Procedure:
1. Connect Setup #11
 2. Configure USB4 Link according to Link Configuration #1
 3. Configure TMU to Bi-Directional HiFi mode
 4. Run Time Calculation #1~~Time Calculation #1~~, N=1 on KG USB4 Device
 5. Run Time Calculation #2~~Time Calculation #2~~, N=1 between the KG Router and KG USB4 Device
 6. Run Stat Sub #1 on UUT
- Measurements of the effect of Hub as ~~Master~~DFP:
7. Run Stat Sub #2 on KG USB4 Device
 8. Run Stat Sub #3 on KG USB4 Device
 9. Run Stat Sub #4 on KG USB4 Device
 10. Run Stat Sub #6~~Stat Sub #6~~ on KG USB4 Device
 11. Run Stat Sub #11~~Stat Sub #11~~ on UUT on downstream port
 12. Run Stat Sub #12~~Stat Sub #12~~ on KG USB4 Device
 13. Run Protocol Check #1 on KG USB4 Device
 14. Run Protocol Check #2 on KG USB4 Device

TD 7.26 TMU Mode Change Test (Hub UFP)

- A. Purpose:
- Verify that the TMU in a USB4 Hub behaves as expected in Bi-Directional HiFi Mode
- B. Procedure:
1. Connect Setup #8
 2. Configure USB4 Link according to Link Configuration #1
 3. Configure TMU to Bi-Directional HiFi mode
 4. Run ~~Time Calculation #1~~~~Time Calculation #1~~, N=1 on KG USB4 Device
 5. Run Stat Sub #1 on UUT

Measurements on Hub as ~~Slave~~DFP:

6. Run Stat Sub #2 on UUT
7. Run Stat Sub #3 on UUT
8. Run Stat Sub #4 on UUT
9. Run Stat Sub #5 on UUT upstream port
10. Run ~~Stat Sub #6~~~~Stat Sub #6~~ on UUT
11. Run:
 - If in Bi-directional mode ~~Stat Sub #11~~~~Stat Sub #11~~ on KG Router above UUT
 - If in Uni-directional mode ~~Stat Sub #13~~~~Stat Sub #13~~ on KG Router above UUT
12. Run:
 - If in Bi-directional mode ~~Stat Sub #12~~~~Stat Sub #12~~ on UUT on upstream port
 - If in Uni-directional mode ~~Stat Sub #14~~~~Stat Sub #14~~ on UUT on upstream port
13. Run:
 - If in Bi-directional mode Protocol Check #1 on UUT upstream port
 - If in Uni-directional mode Protocol Check #3 on UUT upstream port
14. Run:
 - If in Bi-directional mode Protocol Check #2 on UUT upstream port
 - If in Uni-directional mode ~~Protocol Check #4~~~~Protocol Check #4~~ on UUT upstream port
15. Change TMU mode to Uni-Directional HiFi mode both in Host and UUT according to CM mode change flow (see CM guide)
16. Wait 1 sec
17. Repeat steps #4 to #24
18. Change TMU mode to Uni-Directional LowRes mode both in Host and UUT according to CM mode change flow (see CM guide)
19. Wait 1 sec
20. Repeat steps #4 to #24
21. Change TMU mode to OFF mode both in Host and UUT according to CM mode change flow (see CM guide)
22. Wait 1 sec
23. Run ~~Stat Sub #11~~~~Stat Sub #11~~
24. Change TMU mode to Uni-Directional LowRes mode both in Host and UUT according to CM mode change flow (see CM guide)
25. Wait 1 sec
26. Repeat steps #4 to #24

TD 7.27 TMU Mode Change Test (Hub DFP)

- A. Purpose:
- Verify that the TMU in a USB4 Hub behaves as expected in Bi-Directional HiFi Mode
- B. Procedure:
1. Connect Setup #9
 2. Configure USB4 Link according to Link Configuration #1
 3. Configure TMU to Bi-Directional HiFi mode
 4. Run Time Calculation #1~~Time Calculation #1~~, N=1 on KG USB4 Device
 5. Run Stat Sub #1 on UUT

Measurements of the effect of Hub as ~~Master~~DFP:

6. Run Stat Sub #2 on KG USB4 Device
7. Run Stat Sub #3 on KG USB4 Device
8. Run Stat Sub #4 on KG USB4 Device
9. Run Stat Sub #5 on KG USB4 Device
10. Run Stat Sub #6~~Stat Sub #6~~ on KG USB4 Device
11. Run:
 - If in Bi-directional mode Stat Sub #11~~Stat Sub #11~~ on UUT on downstream port
 - If in Uni-directional mode Stat Sub #13~~Stat Sub #13~~ on UUT on downstream port
12. Run:
 - If in Bi-directional mode Stat Sub #12~~Stat Sub #12~~ on KG USB4 Device
 - If in Uni-directional mode Stat Sub #14~~Stat Sub #14~~ on KG USB4 Device
13. Run:
 - If in Bi-directional mode Protocol Check #1 on KG USB4 Device
 - If in Uni-directional mode Protocol Check #3 on KG USB4 Device
14. Run:
 - If in Bi-directional mode Protocol Check #2 on KG USB4 Device
 - If in Uni-directional mode Protocol Check #4~~Protocol Check #4~~ on KG USB4 Device
15. Change TMU mode to Uni-Directional HiFi mode both in Host and UUT according to CM mode change flow (see CM guide)
16. Wait 1 sec
17. Repeat steps #4 to #24
18. Change TMU mode to Uni-Directional LowRes mode both in Host and UUT according to CM mode change flow (see CM guide)
19. Wait 1 sec
20. Repeat steps #4 to #24
21. Change TMU mode to OFF mode both in Host and UUT according to CM mode change flow (see CM guide)
22. Wait 1 sec
23. Run Stat Sub #11~~Stat Sub #11~~
24. Change TMU mode to Uni-Directional LowRes mode both in Host and UUT according to CM mode change flow (see CM guide)
25. Wait 1 sec
26. Repeat steps #4 to #24

TD 7.28 Immediate Time Posting Test – 15 days (Hub)

A. Purpose:

- Verify that Immediate Time posting is working as expected in a in a USB4 Hub

B. Procedure:

1. Connect Setup #8
2. Run Time Posting #1 on Host
3. Configure USB4 Link according to Link Configuration #1
4. Configure UUT to Bi-Directional HiFi mode
5. Configure KG USB4 Device to Bi-Directional HiFi mode
6. Run Time Calculation #1~~Time Calculation #1~~, N=1
7. Run Stat Sub #1 on Host Router
8. Run Stat Sub #2 on KG USB4 Device
9. Run Stat Sub #3 on KG USB4 Device
10. Run Stat Sub #4 on KG USB4 Device
11. Run Stat Sub #6~~Stat Sub #6~~ on KG USB4 Device

TD 7.29 Immediate Time Posting – 1 hour (Hub)

- A. Purpose:
- Verify that Immediate Time posting is working as expected in a USB4 Hub
- B. Procedure:
1. Connect Setup #8
 2. Run ~~Time Posting #2~~Time Posting #2 on Host
 3. Configure USB4 Link according to Link Configuration #1
 4. Configure UUT to Bi-Directional HiFi mode
 5. Configure KG USB4 Device to Bi-Directional HiFi mode
 6. Run ~~Time Calculation #1~~Time Calculation #1, N=1
 7. Run Stat Sub #1 on Host Router
 8. Run Stat Sub #2 on KG USB4 Device
 9. Run Stat Sub #3 on KG USB4 Device
 10. Run Stat Sub #4 on KG USB4 Device
 11. Run ~~Stat Sub #6~~Stat Sub #6 on KG USB4 Device

TD 7.30 Future Time Posting Test – 15 days (Hub)

A. Purpose:

- Verify that Future Time posting is working as expected in a USB4 Hub

B. Procedure:

1. Connect Setup #8
2. Configure USB4 Link according to Link Configuration #1
3. Configure UUT to Bi-Directional HiFi mode
4. Configure KG USB4 Device to Bi-Directional HiFi mode
5. Run Time Posting #3 on whole setup
6. Run Time Calculation #1~~Time Calculation #1~~, N=1
7. Run Stat Sub #1 on Host Router
8. Run Stat Sub #2 on KG USB4 Device
9. Run Stat Sub #3 on KG USB4 Device
10. Run Stat Sub #4 on KG USB4 Device
11. Run Stat Sub #6~~Stat Sub #6~~ on KG USB4 Device

TD 7.31 Future Time Posting Test – 1 hour (Hub)

- A. Purpose:
- Verify that Future Time posting is working as expected in a USB4 Hub
- B. Procedure:
1. Connect Setup #8
 2. Configure USB4 Link according to Link Configuration #1
 3. Configure UUT to Bi-Directional HiFi mode
 4. Configure KG USB4 Device to Bi-Directional HiFi mode
 5. Run Time Posting #4 on whole setup
 6. Run ~~Time Calculation #1~~Time Calculation #1, N=1
 7. Run Stat Sub #1 on Host Router
 8. Run Stat Sub #2 on KG USB4 Device
 9. Run Stat Sub #3 on KG USB4 Device
 10. Run Stat Sub #4 on KG USB4 Device
 11. Run ~~Stat Sub #6~~Stat Sub #6 on KG USB4 Device

Inter-Domain

TD 7.32 Inter-Domain ~~Slave~~Time Initiator and ~~Master~~Time Responder in Bi-Directional HiFi Mode Test (Hub DFP)

- A. Purpose:
- Verify that a USB4 Hub DFP behaves properly as Inter-Domain ~~slave~~Time Initiator and ~~master~~Time Responder
- B. Repetitions:
- Repeat test with Single-Lane Link and Dual-Lane Link
- C. Procedure:
1. Connect Setup #12
 2. Configure USB4 Link according to Link Configuration #1
 3. Configure the topology to Bi-Directional HiFi mode
 4. Run Time Calculation #1~~Time Calculation #1~~, N=1 on Inter-Domain Time Initiator (KG Host Router ~~Inter-Domain Slave~~)
 5. Run Time Calculation #2~~Time Calculation #2~~, N=1 between Inter-Domain Time Initiator (KG Host Router ~~Inter-Domain Slave~~) and Inter-Domain ~~Grandmaster~~Host Router
 6. Run Stat Sub #7 on UUT
 7. Run Stat Sub #8~~Stat Sub #8~~ on UUT
 8. Run Stat Sub #9~~Stat Sub #9~~ on UUT
 9. Run Stat Sub #10~~Stat Sub #10~~ on UUT
 10. Run Stat Sub #15~~Stat Sub #15~~ on UUT ~~HSIDTI~~ port
 11. Run Protocol Check #1 on UUT ~~HSIDTI~~ port
 12. Run Protocol Check #2 on UUT ~~HSIDTI~~ port
 13. Run Protocol Check #4~~Protocol Check #4~~ on UUT ~~HSIDTI~~ port

TD 7.33 Inter-Domain ~~Slave~~Time Initiator and ~~Master~~Time Responder in Bi-Directional HiFi Mode Test (Hub UFP)

- A. Purpose:
- Verify that a USB4 Hub UFP behaves properly as Inter-Domain ~~slave~~Time Initiator and ~~master~~Time Responder
- B. Repetitions:
- Repeat test with Single-Lane Link and Dual-Lane Link
- C. Procedure:
1. Connect Setup #13
 2. Configure USB4 Link according to Link Configuration #1
 3. Configure the topology to Bi-Directional HiFi mode
 4. Run ~~Time Calculation #1~~Time Calculation #1, N=1 on Inter-Domain Time Initiator (KG Host Router ~~Inter-Domain Slave~~)
 5. Run ~~Time Calculation #2~~Time Calculation #2, N=1 between Inter-Domain Time Initiator (KG Host Router ~~Inter-Domain Slave~~) and Inter-Domain ~~Grandmaster~~Host Router
 6. Run Stat Sub #7 on UUT
 7. Run ~~Stat Sub #8~~Stat Sub #8 on UUT
 8. Run ~~Stat Sub #9~~Stat Sub #9 on UUT
 9. Run ~~Stat Sub #10~~Stat Sub #10 on UUT
 10. Run ~~Stat Sub #15~~Stat Sub #15 on UUT ~~IDSIDI~~IDSIDI port
 11. Run Protocol Check #1 on UUT ~~IDSIDI~~IDSIDI port
 12. Run Protocol Check #2 on UUT ~~IDSIDI~~IDSIDI port
 13. Run ~~Protocol Check #4~~Protocol Check #4 on UUT ~~IDSIDI~~IDSIDI port
 14. Run ~~Protocol Check #5~~Protocol Check #5 on UUT upstream port

- A. Purpose:
 - Verify that a USB4 Hub forwards Interdomain Timestamp packets properly
- B. Repetitions:
 - Repeat test with Single-Lane Link and Dual-Lane Link
- C. Procedure:
 1. Connect Setup #14
 2. Configure USB4 Link according to Link Configuration #1
 3. Configure the topology to Bi-Directional HiFi mode
 4. Run Time Calculation #1~~Time Calculation #1~~, N=1 on Inter-Domain Time Initiator (KG Host Router~~Inter-Domain Slave~~)
 5. Run Time Calculation #2~~Time Calculation #2~~, N=1 between Inter-Domain Time Initiator (KG Host Router~~Inter-Domain Slave~~) and Inter-Domain ~~Grandmaster~~Host Router
 6. Run Stat Sub #7 on the upstream KG USB4 Device
 7. Run Stat Sub #8~~Stat Sub #8~~ on the upstream KG USB4 Device
 8. Run Stat Sub #9~~Stat Sub #9~~ on the upstream KG USB4 Device
 9. Run Stat Sub #10~~Stat Sub #10~~ on the upstream KG USB4 Device
 10. Run Stat Sub #11~~Stat Sub #11~~ on the Host Router
 11. Run Stat Sub #12~~Stat Sub #12~~ on the downstream KG USB4 Device
 12. Run Stat Sub #15~~Stat Sub #15~~ on UUT ~~HS~~IDI port
 13. Run Protocol Check #1 on UUT upstream port
 14. Run Protocol Check #2 on UUT upstream port
 15. Run Protocol Check #5~~Protocol Check #5~~ on UUT upstream port

Peripheral Device

The tests in this section apply to a USB4 Peripheral Device.

Intra-Domain

TD 7.35 Bi-Directional HiFi Mode as 2nd Hop Test (Peripheral Device)

- A. Purpose:
 - Verify that the TMU in a USB4 Peripheral Device behaves as expected in Bidirectional HiFi Mode
- B. Repetitions:
 - Repeat test with Single-Lane Link and Dual-Lane Link
 - Repeat test at Gen 2 and Gen 3 speeds
- C. Procedure:
 1. Connect Setup #15
 2. Configure USB4 Link according to Link Configuration #1
 3. Configure TMU to Bi-Directional HiFi mode
 4. Run Stat Sub #1 on UUT
 5. Run Stat Sub #2 on UUT
 6. Run Stat Sub #3 on UUT
 7. Run Stat Sub #4 on UUT
 8. Run Stat Sub #5 on UUT
 9. Run ~~Stat Sub #6~~Stat Sub #6 on UUT
 10. Run ~~Stat Sub #11~~Stat Sub #11 on KG upstream Router
 11. Run ~~Stat Sub #12~~Stat Sub #12 on UUT
 12. Run Protocol Check #1 on UUT
 13. Run Protocol Check #2 on UUT

TD 7.36 Uni-Directional HiFi Mode as 2nd Hop Test (Peripheral Device)

A. Purpose:

- Verify that the TMU in a USB4 Peripheral Device behaves as expected in Uni-Directional HiFi Mode

B. Procedure:

1. Connect Setup #15
2. Configure USB4 Link according to Link Configuration #1
3. Configure TMU to Uni-Directional HiFi mode
4. Run Stat Sub #1 on UUT
5. Run Stat Sub #2 on UUT
6. Run Stat Sub #3 on UUT
7. Run Stat Sub #4 on UUT
8. Run ~~Stat Sub #6~~Stat Sub #6 on UUT
9. Run ~~Stat Sub #14~~Stat Sub #14 on UUT
10. Run Protocol Check #3 on UUT
11. Run ~~Protocol Check #4~~Protocol Check #4 on UUT

TD 7.37 Uni-Directional LowRes Mode as 2nd Hop Test (Peripheral Device)

A. Purpose:

- Verify that the TMU in a USB4 Peripheral Device behaves as expected in Uni-Directional LowRes Mode

B. Procedure:

1. Connect Setup #15
2. Configure USB4 Link according to Link Configuration #1
3. Configure TMU to Uni-Directional HiFi mode
4. Run Stat Sub #1 on UUT
5. Run Stat Sub #2 on UUT
6. Run Stat Sub #3 on UUT
7. Run Stat Sub #4 on UUT
8. Run ~~Stat Sub #6~~ Stat Sub #6 on UUT
9. Run ~~Stat Sub #14~~ Stat Sub #14 on UUT
10. Run Protocol Check #3 on UUT
11. Run ~~Protocol Check #4~~ Protocol Check #4 on UUT

TD 7.38 Uni-Directional HiFi Mode as 3rd Hop Test (Peripheral Device)

A. Purpose:

- Verify that the TMU in a USB4 Peripheral Device behaves as expected in Uni-Directional LowRes Mode

B. Procedure:

1. Connect Setup #16
2. Configure USB4 Link according to Link Configuration #1
3. Configure TMU to Uni-Directional HiFi mode
4. Run Stat Sub #1 on UUT
5. Run Stat Sub #2 on UUT
6. Run Stat Sub #3 on UUT
7. Run Stat Sub #4 on UUT
8. Run ~~Stat Sub #6~~Stat Sub #6 on UUT
9. Run ~~Stat Sub #14~~Stat Sub #14 on UUT
10. Run Protocol Check #3 on UUT
11. Run ~~Protocol Check #4~~Protocol Check #4 on UUT

TD 7.39 Immediate Time Posting Test – 15 days (Peripheral Device)

- A. Purpose:
 - Verify that Immediate Time posting is working as expected in a USB4 Peripheral Device.
- B. Procedure:
 1. Connect Setup #15
 2. Run Time Posting #1 on Host
 3. Configure USB4 Link according to Link Configuration #1
 4. Configure UUT to Bi-Directional HiFi mode
 5. Run Stat Sub #1 on UUT
 6. Run Stat Sub #2 on UUT
 7. Run Stat Sub #3 on UUT
 8. Run Stat Sub #4 on UUT
 9. Run ~~Stat Sub #6~~Stat Sub #6 on UUT
 10. Run ~~Stat Sub #12~~Stat Sub #12 on UUT
 11. Run Protocol Check #1 on UUT
 12. Run Protocol Check #2 on UUT

TD 7.40 Immediate Time Posting Test – 1 hour (Peripheral Device)

- A. Purpose:
- Verify that Immediate Time posting is working as expected in a USB4 Peripheral Device
- B. Procedure:
1. Connect Setup #15
 2. Run Time Posting #2~~Time Posting #2~~ on Host
 3. Configure USB4 Link according to Link Configuration #1
 4. Configure UUT to Bi-Directional HiFi mode
 5. Run Stat Sub #1 on UUT
 6. Run Stat Sub #2 on UUT
 7. Run Stat Sub #3 on UUT
 8. Run Stat Sub #4 on UUT
 9. Run Stat Sub #6~~Stat Sub #6~~ on UUT
 10. Run Stat Sub #12~~Stat Sub #12~~ on UUT
 11. Run Protocol Check #1 on UUT
 12. Run Protocol Check #2 on UUT

TD 7.41 Future Time Posting Test – 15 days (Peripheral Device)

- A. Purpose:
- Verify that Immediate Time posting is working as expected in a USB4 Peripheral Device
- B. Procedure:
1. Connect Setup #15
 2. Configure USB4 Link according to Link Configuration #1
 3. Configure UUT to Bi-Directional HiFi mode
 4. Run Time Posting #3 on whole setup
 5. Run Stat Sub #1 on UUT
 6. Run Stat Sub #2 on UUT
 7. Run Stat Sub #3 on UUT
 8. Run Stat Sub #4 on UUT
 9. Run ~~Stat Sub #6~~Stat Sub #6 on UUT
 10. Run ~~Stat Sub #12~~Stat Sub #12 on UUT
 11. Run Protocol Check #1 on UUT
 12. Run Protocol Check #2 on UUT

TD 7.42 Future Time Posting Test – 1 hour (Peripheral Device)

- A. Purpose:
- Verify that Immediate Time posting is working as expected in a USB4 Peripheral Device
- B. Procedure:
1. Connect Setup #15
 2. Configure USB4 Link according to Link Configuration #1
 3. Configure UUT to Bi-Directional HiFi mode
 4. Run Time Posting #4 on whole setup
 5. Run Stat Sub #1 on UUT
 6. Run Stat Sub #2 on UUT
 7. Run Stat Sub #3 on UUT
 8. Run Stat Sub #4 on UUT
 9. Run ~~Stat Sub #6~~ Stat Sub #6 on UUT
 10. Run ~~Stat Sub #12~~ Stat Sub #12 on UUT
 11. Run Protocol Check #1 on UUT
 12. Run Protocol Check #2 on UUT

Inter-Domain

TD 7.43 Bi-Directional HiFi Mode Test (Peripheral Device) on Inter-~~domain-link~~Domain Link

- A. Purpose:
 - Verify that the TMU in a USB4 Peripheral Device behaves properly as Inter-Domain ~~slave~~Time Initiator
- B. Repetitions:
 - Repeat test with Single-Lane Link and Dual-Lane Link
- C. Procedure:
 1. Connect Setup #17
 2. Configure USB4 Link according to Link Configuration #1
 3. Configure the topology to Bi-Directional HiFi mode
 4. Run Stat Sub #7 on UUT
 5. Run ~~Stat Sub #8~~Stat Sub #8 on UUT
 6. Run ~~Stat Sub #9~~Stat Sub #9 on UUT
 7. Run ~~Stat Sub #10~~Stat Sub #10 on UUT
 8. Run ~~Stat Sub #12~~Stat Sub #12 on UUT

TBT3-Compatibility Test Descriptions

The tests in this section are only performed if the USB4 Product implements TBT3-Compatibility as defined in Chapter 13 of the USB4 Specification.

Host

The tests in this section apply to a USB4 Host with any number of USB4 Ports.

Intra-Domain

TD 7.44 Intra-Domain Two Single-Lane Links Test (Host)

- A. Purpose:
 - Verify that Host Router behaves properly with Two Single-Lane Links
- B. Procedure:
 1. Connect Setup #1
 2. Configure USB4 Link according to Link Configuration #2
 3. Configure Lane 0 and Lane 1 to be active
 4. Continue as in TD 7.1 starting from step #3

TD 7.45 Intra-Domain One Single-Lane Link Test (Host)

Same as TD 7.44 only with Lane 0 deactivated

Inter-Domain

TD 7.46 Inter-Domain Two Single-Lane Links Test (Host)

- A. Purpose:
 - Verify that Host Router behaves properly on Inter-Domain Link
- B. Procedure:
 1. Connect Setup #2
 2. Configure USB4 Link according to Link Configuration #2
 3. Configure Lane 0 and Lane 1 to be active
 4. Continue as in TD 7.7 starting from step #3

TD 7.47 Inter-Domain One Single-Lane Link Test (Host)

Same as TD 7.46 only with Lane 0 deactivated

Hub

Intra-Domain

TD 7.48 Intra-Domain Two Single-Lane Links Test (Hub UFP)

- A. Purpose:
 - Verify that a USB4 Hub behaves properly with Two Single-Lane Links
- B. Procedure:
 1. Connect Setup #8
 2. Configure upstream USB4 Link according to Link Configuration #2
 3. Configure downstream USB4 Link according to Link Configuration #2
 4. Configure Lane 0 and Lane 1 to be active
 5. Continue as in TD 7.18 from step #3

TD 7.49 Intra-Domain Two Single-Lane Links Test (Hub DFP)

- A. Purpose:
 - Verify that a USB4 Hub behaves properly with Two Single-Lane Links
- B. Procedure:
 1. Connect Setup #9
 2. Configure upstream USB4 Link according to Link Configuration #2
 3. Configure downstream USB4 Link according to Link Configuration #2
 4. Configure Lane 0 and Lane 1 to be active
 5. Continue as in TD 7.19 from step #3

TD 7.50 Intra-Domain One Single-Lane Link Test (Hub)

Same as TD 7.48 only with Lane 1 active

Inter-Domain

TD 7.51 Inter-Domain Two Single-Lane Links Test (Hub)

- A. Purpose:
 - Verify that a USB4 Hub behaves properly with Two Single-Lane Links
- B. Procedure:
 1. Connect Setup #12
 2. Configure upstream USB4 Link according to Link Configuration #2
 3. Configure inter-Domain USB4 Link according to Link Configuration #2
 4. Configure Lane 0 and Lane 1 to be active
 5. Configure Bi-Directional mode
 6. Continue as in TD 7.32 from step #4

TD 7.52 Inter-Domain One Single-Lane Link Test (Hub)

Same as TD 7.51 only with Lane 1 active