

USB Implementers Forum

xHCI Interoperability Test Procedures For Peripherals, Hubs and Hosts (Legacy, USB Type-C and Power Delivery)

Revision 1.03 – August 2024

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SUMMARY OF CHANGES

Revision:	Author:	Section:	Change:
0.8	Sydney Fernandes	All	Added HS-5 to all Interop Trees Updated Appendix to include Trees with SSP Hubs, Host and Devices
0.9	Sydney Fernandes	Title Chapter 8	Included verbiage to state Legacy, USB Type-C and Power Delivery
0.95	Sydney Fernandes	Appendix	Removed old Figure 11.4 in Appendix and renumbered Figure 11.5, 11.6, and 11.7
0.96	Sydney Fernandes	Appendix D Chapter 7	Added clarification note for additional USB Type-C Interop testing for xHCI hosts with DP Alt Mode support Section 8 Hybrid Boot Procedure
0.97	Sydney Fernandes	Chapter 8 Chapter 2, 6, Appendix B and C	Added: All configurations of Alt-Mode must be tested For USB4 Hubs/Docks Under Tests in USB 3.2 mode Alt-Mode is allowed on downstream facing ports Added a new test topology: Host-USB 2.0 Hub-DUT. The goal here is to test devices with various USB 2.0 Hubs (that drop upto 4,3,2, or 1 sync bits)
0.98	Sydney Fernandes	Appendix D	Added with Alt-Mode Support to Host in the Tree Diagram
0.99	Sydney Fernandes	Chapter 8 Appendix D All	Corrected Typo from HUT to Hub Change from Windows 10 to Windows 11 Updated how to check system supported power states from command prompt
1.0	Sydney Fernandes	Appendix E Chapter 4 and 5 Figure 11.4	Added Interop Topologies for USB 3.2 Gen 2x2 Host and Device Correct Typo's for LPM Modified Figure to match Results Template
1.01	Sydney Fernandes	Chapter 3 Appendix E	Put a reference Link for UFP Powered Hubs Added Topologies with USB 3.2 Gen 2x2 Hubs

1.02	Sydney Fernandes	Chapter 8	Fast Role Swap
1.03	Sydney Fernandes	Chapter 1 All	Interoperability Testing for Unit Under Test (UUT) with and without External Power In most cases replaced Self-Powered with Externally Powered

1 xHCI Interoperability Testing

xHCI Interoperability testing covers several areas including device framework, demonstrated operation and the device's ability to operate and coexist with other USB devices. It also provides insight into usability issues of the device and the associated software.

xHCI Interoperability testing makes use of an arrangement of USB peripherals known as the SSP Interop Tree. The USB Interoperability Tree consists of these characteristics:

- Provides isochronous, bulk, interrupt and control traffic
- Contains devices behind 5 levels of nested hubs - the maximum allowed
- Contains devices more than 15 meters from an xHCI based controller
- Contains hubs that operate at SuperSpeedPlus, SuperSpeed, Hi-Speed and Full-Speed
- Contains devices that operate at SuperSpeedPlus, SuperSpeed, Hi-Speed, Full-Speed and Low-Speed

The xHCI Interoperability test procedure is generic and should be applicable to the vast majority of devices. This document cannot cover all possible types, configurations and combinations of peripherals, hubs, hosts and embedded devices. Thus, the application of the xHCI Interoperability test procedures may need to be modified in order to adequately test a device for USB compliance. Test guidelines for unique devices that do not fall into categories outlined in this document should be brought to the attention of TechAdmin@usb.org for assistance.

1.1 Equipment

Note that the equipment listed, the test procedure steps, and the actual list of required tests are expected to change periodically. Please refer to <http://www.usb.org/developers/compliance> on the USB-IF, Inc. Web site for the latest updates to the xHCI Interoperability test procedures.

All references to SuperSpeedPlus hubs in this document are actually USB 3.2 Gen 2x1 hubs with USB 2.0, SuperSpeed and SuperSpeedPlus functionality.

Item	Description/Model	Qty
USB host system	1. A computer containing an available slot for a Certified SSP USB xHCI controller or an integrated Certified SSP USB xHCI controller. 2. A multiple core processor is required	1
SSP hub(Externally-powered)	Any Certified SuperSpeedPlus (USB 3.2 Gen 2x1) Externally-powered hub with at least 4 downstream ports	5
SS hub(Externally-powered)	Any Certified SuperSpeed Externally-powered hub with at least 4 downstream ports	1
HS hub w/STT (Externally-powered)	Any Certified USB Externally-powered, high-speed hub with a single TT and at least 4 downstream ports	1
HS hub w/MTT (Externally-powered)	Any Certified USB Externally-powered, high-speed hub with multiple TTs and at least 4 downstream ports	1
HS hub(Externally-powered)	Any Certified USB Externally-powered, high-speed hub with at least 4 downstream ports	1
FS hub (Externally-powered)	Any Certified USB full-speed hub with at least 2 downstream ports	2
SSP UASP drive	Any Certified SuperSpeedPlus UASP USB low-power/Externally-powered mass storage device compliant with the Mass Storage UASP Class	1
SSP video camera	Any Certified SuperSpeedPlus USB video camera compliant with the Video Class	1
FS drive	Any Certified USB high-speed or full-speed mass storage device compliant with the Mass Storage Class	1
HS drive	Any Certified USB high-speed mass storage device compliant with the Mass Storage Class	1
FS video camera	Any Certified USB full-speed or high-speed video camera compliant with the Video Class that can stream video at full-speed	1
Mouse	Any Certified USB low-speed mouse compliant the Human Interface Device (HID)Class	1
Display Adapter	Any Certified USB Display Adapter that can operate at SuperSpeed	1
One meter SSP USB cable	Any Certified SuperSpeedPlus cable assembly	5
Five meter HS USB cable	Any Certified USB 2.0 high-speed cable assembly	5
Keyboard	Any certified USB keyboard	1

The Interop Tree consists of USB-IF certified, off-the-shelf, consumer devices. The tree uses either the captive cables on the certified devices, or certified cables to connect the devices. The USB-IF is

not identifying specific makes and models of USB peripherals for the Interop Tree. Given the very short shelf-life of most consumer products, it is not practical to maintain a list of specific products for the Interop Tree. Thus, the choice of Certified USB products is the responsibility of the tester.

To verify whether a device is Certified USB, go to the USB-IF Integrators List at: <http://www.usb.org/kcompliance/ilist>. Unfortunately, there are numerous uncertified products that illegally display the Certified USB Logo, so please verify that the product is on the Integrators List. Should the tester find an uncertified product displaying the Certified USB Logo, please follow the instructions at <http://compliance.usb.org/index.asp?UpdateFile=Policies#29> to report the violation to the USB-IF.

At the time of this document’s creation, there are not yet Certified SuperSpeedPlus hubs or Certified SuperSpeedPlus USB peripherals for some device classes. Any Certified SuperSpeedPlus hub or peripheral that is required for this testing procedure and not yet prevalent in the ecosystem may be substituted with an equivalent known good SuperSpeedPlus hub or SuperSpeedPlus peripheral.

Furthermore, until the following devices are prevalent in the ecosystem¹, this testing procedure allows substitutions as described in the following table:

If this Certified SuperSpeed USB peripheral is not prevalent	use this peripheral	Description
SSP UASP drive	SSP low power drive	Any Certified SuperSpeedPlus USB low-power/Externally-powered mass storage device compliant with the Mass Storage Class
SSP and SS video camera	HS video camera	Any Certified USB high-speed video camera compliant with the Video Class
SSP USB cable	SSP USB cable	Any available SuperSpeedPlus cable assembly

This document will be updated when substitutions are no longer acceptable and the same will be posted on USB.org.

It is highly recommended that vendors expand in-house interoperability testing to include many more devices and hosts than the minimum required for the SuperSpeedPlus Interop Tree.

The following guidelines will help to select an appropriate product for the SuperSpeedPlus Interop Tree:

All Devices:

All devices in the Interop Tree must allow System Suspend and Hibernation while they are active. Any device that does not allow System Suspend or Hibernation may not be included in the SSP Interop Tree.

USB Host System:

- The system must be a high performance computer that can handle multiple audio, video devices with Driver Verifier enabled.
- The motherboard needs to have an available slot to add the xHCI controller or have the xHCI controller integrated.
- A fast multiple core processor is required.
- Memory and disk storage should be sufficiently large to reduce performance degradation.
- The machine must support S3 suspend (Sleep).
- The machine must support Wake from PCI Express or Wake from Express Card when the xHCI controller is connected through PCI Express or Express Card.
- If the controller has an integrated or embedded hub (as defined in the XHCI specification), please refer to the diagrams with embedded hubs in each section to build the correct interop trees.

USB Hubs:

The Interop Tree exercises five tiers of SSP hubs. The limit to the number of tiers of hubs in a system is five. This limit is determined by specification limits to the turn-around time for signals sent from the xHCI controller to reach the device and return back to the xHCI controller. Any more tiers would not allow these turn-around times to be achievable.

One high-speed hub must have multiple transaction translators (TT), and one high-speed hub must have single TT. This is required to more fully exercise the xHCI controller's scheduling mechanisms.

- To determine whether a hub has a single TT or multiple TTs connect the hub to another system and view the properties of the hub in Device Manager. Under the advanced tab, it will display if the hub has a single TT or multiple TTs.

Demonstrated operation of devices behind full-speed, high-speed, SuperSpeed and SuperSpeedPlus hubs is required.

The SSP, SS and high-speed hubs are required to be Externally-powered, while the compound keyboards are required to be bus-powered. This is to ensure the Interop Tree exercises both Externally-powered and bus-powered hubs.

USB Mass Storage:

Three Certified USB mass storage devices must be used as Interop Tree devices.

- ✓ One SuperSpeedPlus Low Power, one high-speed, and one high-speed or full-speed bulk transport
- ✓ compliant with the USB Mass Storage Class
- To determine if a device is high-power, low-power, or Externally-powered, connect the device to another system (not the Interop Tree system). In Device Manager view devices by connection and select the hub directly upstream of the device and view that hub's properties. The Power tab describes how much power each device uses. A high-power device uses more than 150mA for USB 3.2 devices and more than 100mA for USB 2.0 devices.

- The SuperSpeedPlus USB devices must be compliant with the USB Mass Storage UASP Class when such devices are prevalent in the ecosystem. Otherwise, they must be compliant with the USB Mass Storage Class.

USB Video Camera:

Two Certified USB video cameras must be used as Interop Tree devices.

- ✓ One SuperSpeedPlus and one high-speed or full-speed
- ✓ if a high-speed camera is selected, it must stream video at full-speed correctly
 - To test a high-speed camera, connect the device behind a full-speed hub on another system (not the USB Host System). Use the software provided with the device to see if the video camera displays any video, even if it is at a lower resolution. If it does not display, that video camera cannot work as an Interop Tree device.
- ✓ isochronous transport
 - To determine if a camera uses either isochronous transport or bulk transport, either use a USB bus analyzer or use any USB device analysis software such as USBView.
- ✓ compliant with the USB Video Class

USB Mouse:

One Certified USB mouse must be used as an Interop Tree device.

- ✓ low-speed
- ✓ interrupt transport
- ✓ low-power device
- ✓ compliant with the USB HID Class

USB Display Adapter:

1 Certified USB Display Adapter must be used as an Interop Tree device.

- ✓ bulk transport
- ✓ isochronous transport

USB Headset:

One Certified USB headset must be used as an Interop Tree device.

- ✓ isochronous transport
- ✓ compliant with the USB Audio Class
- ✓ must have both headphones and a microphone in order to generate traffic heading both to and from the device

USB cables:

The USB 2.0 specification allows a maximum of 5 meters for a USB cable, and the longest cables compliant with the USB 3.2 Gen 2 specification are 1 meter in length. To test the worst case propagation delays, the use of Certified USB five meter high-speed cables and Certified USB 3.2 Gen 2 one meter cables is mandatory. The only exception to this is with regards to products that have a micro-B type connector. In this instance the required cable length to connect to the test device is 1 meter. For USB Type-C connectors please refer to USB Type-C specification for various cable lengths

1.1.1 Equipment Setup

Ensure that the latest BIOS and driver updates are installed for the motherboard by visiting the vendor's product support website.

NOTE: U1/U2 MUST BE ENABLED ON BOTH HOSTS AND DEVICES DURING INTEROPERABILITY TESTING.

1.2 Software

For Interoperability tests users are strongly encouraged to test with different operating systems such as: Windows, OS X, Chrome OS, Android, iOS, Linux etcetera. This document details setup for few operating systems. Covering setups of all flavors of operating systems is beyond the scope of this document.

Windows 11

1.2.1 Install the Operating System

Install Windows 11 by either installing a fresh copy or from a previously saved image of the prepared system given by the steps given below.

Install using default installation options. If you decide to choose custom installation options, verify that USB Selective Suspend is enabled.

Turn off User Account Control (UAC). This can be found under Control Panel -> User Accounts -> User Accounts -> Change User Account Control settings and move the slider bar to the bottom to "Never Notify".

Turn on Hybrid Sleep. This can be found under Control Panel -> Hardware and Sound -> Power Options -> Change Plan Settings, then click "Change advanced power settings", then "Sleep" -> "Allow Hybrid Sleep" and make sure it's set to "On".

Perform Windows Update under Settings->Update & security->Windows Update

Install any required platform-specific drivers for the USB Host System. All devices other than the xHCI controller in the USB Host System should be "working properly", *i.e.* no yellow exclamation points visible in Device Manager. There should also be no "unknown devices" shown in the Device Manager.

Use Windows Update to obtain *all* the latest and recommended updates for the operating system.

Enable Driver Verifier on the xHCI controller driver, all drivers for devices in the USB 3.2 Interop Tree, and drivers for the Device Under Test. The list of drivers can be found in Chapter 9 of this document. To enable Driver Verifier for these drivers:

Determine the name of the .sys files for the drivers.

- Connect the xHCI Interoperability Tree to another system running Windows 11 and the same architecture (x86 or x64) as the USB Host System.
- Install the driver for the xHCI controller on the other system.
- For each device in the xHCI Interoperability Tree:
 - Follow the vendor-recommended install procedure on the other system.
 - Open device manager and find the device in the tree.
 - Right click on the device and select to view the device's properties.
 - Under the driver tab, press "Driver Details".
 - Copy down the name of all of the .sys files located in the list.

Move to the System being used for the test.

- Open the run box (press the Windows Key + R together).
- Type the command "Verifier".
- Select "Create custom settings (for code developers)".
- Select "Enable predefined settings"
- Check all of the checkboxes except for "Low resources simulation".
- Select "Select driver names from a list".
- For each driver that was copied down before and isn't in this list:
 - Select "Add currently not loaded drivers to the list".
 - Type in the name of the .sys files for the driver and press "Open".
 - Select that driver in the list
- In the Driver Verifier Manager, check all of the checkboxes for the driver names you added to the list and press "Finish".
- Reboot the machine.

While running the xHCI Interoperability tests if there is a crash in a Microsoft driver, then the test is a tentative fail. The crash will need to be investigated to determine if it's a 3rd party driver issue or a Microsoft driver issue.

1.2.2 Determining System Supported Low-Power States

Some systems do not support all low power states: S3, S4 and Modern Standby. The states a system does support must be tested, however.

To determine what states a system supports:

- Open Command Prompt (Run as Administrator)
- Type: "powercfg /availablesleepstates "
- Press Enter

A list of supported system states will show.

Note: The system used to test peripherals and hubs must support S3 and S4.

It is important to note that some systems may support a state but will not function in that state. It is important to test how USB functions with all states that are supported on a given system.

1.2.3 Software Logistical Overview

Testing must be performed on a new and clean installation of the operating system. Instead of formatting the drive and installing the OS before every test run, using a disk imaging utility to restore a copy of a clean OS is acceptable.

A means of validating the data after transfer to/from the mass storage device is required. Using a utility, such as WinZip Computing Inc.'s WinZip®, which automatically performs a CRC on its

data, or jZip, which can manually validate the data of a .zip file, is acceptable to validate the data.

Three files are required for the data transfers in the xHCI Interoperability tests: A 30MB+ .zip file on the HS Low Power Drive, a 1GB+ .zip file on the HS Drive, and a 2GB+ .zip file on the SS High Power Drive.

The USB host system must be virus scanned ¹before the test can begin. All mass storage devices (including the DUT if applicable) must be virus scanned before beginning the tests.

1.2.4 **OS X**

Install fresh copy of the OS X for Mac systems.
Perform Software Update to install the latest updates.

1.2.5 **Chrome OS**

Install fresh copy of the Chrome OS for Chromebook systems.
Perform Software Update to install the latest updates.

1.3 xHCI Interoperability Logistical Overview

Effectively, **Interoperability is a consumer experience test of the product**. It examines the product's ability to function correctly in normal system configurations. The following discussion is the rationale for the xHCI Interoperability tests so that the procedures can be modified to adequately test a product for compliance.

Because the primary features of USB are its "hot-plugging" and "plug and play" capabilities, the dynamic attachment of a USB peripheral is a tenet of USB certification for peripherals and hosts. All USB capable hosts and USB peripherals must be able to operate correctly on attachment and re-attachment of the peripheral. After the testing system is identified as a stable environment before running test, if any enumeration attempt fails, the test must be recorded as a fail.

No Silent Failure rule - USB devices are not allowed to appear broken without providing feedback to the consumer about the cause of the problem and how to correct. Thus, compliance enforces a "no silent failure" rule on hosts and peripherals in special situations where the device appears broken. Typically, the "no silent failure" is implemented when the peripheral is not supported by the host, there is insufficient bandwidth on the bus for the peripheral to operate, or there is insufficient power available. When implemented, the message must appear on the host machine and not just in documentation. There must be enough information for the consumer to understand why the device does not work. In other words, a USB device is never to appear broken without justification and explanation to the consumer.

Consumer experience is the most important factor when assessing a Pass or Fail result. If the test result yields any kind of negative consumer experience, the test must be recorded as a fail.

Caution should be used when testing out of sequence with the steps outlined. This test

¹ In order not to disrupt test run, virus-scan should be set in manual mode. This prevents auto-scans from happening during the testing.

procedure is scripted and individual steps may be dependent upon previous test steps having been performed.

1.4 Interoperability Testing for Unit Under Test (UUT) with and without External Power

For all Externally Powered Unit Under Test (UUT):

Disconnect the external power supply from the UUT's external power port and check if it enumerates.

If the UUT enumerates with the external power supply disconnected, then UUT needs to be tested in both configurations for Interop:

Interoperability Configuration 1: Run all Interoperability Tests with External Power Supply **Connected** to the UUT.

Interoperability Configuration 2: Repeat all Interoperability Tests with External Power Supply **Disconnected** from the UUT.

2 USB Peripheral Interoperability Test Steps

Construct the Interop Tree as outlined in Figure 2-1. If the host system contains an embedded hub construct the SuperSpeed Interop Tree as outlined in Figure 2-2 instead. Do not attach the Interop Tree to the SSP xHCI host controller.

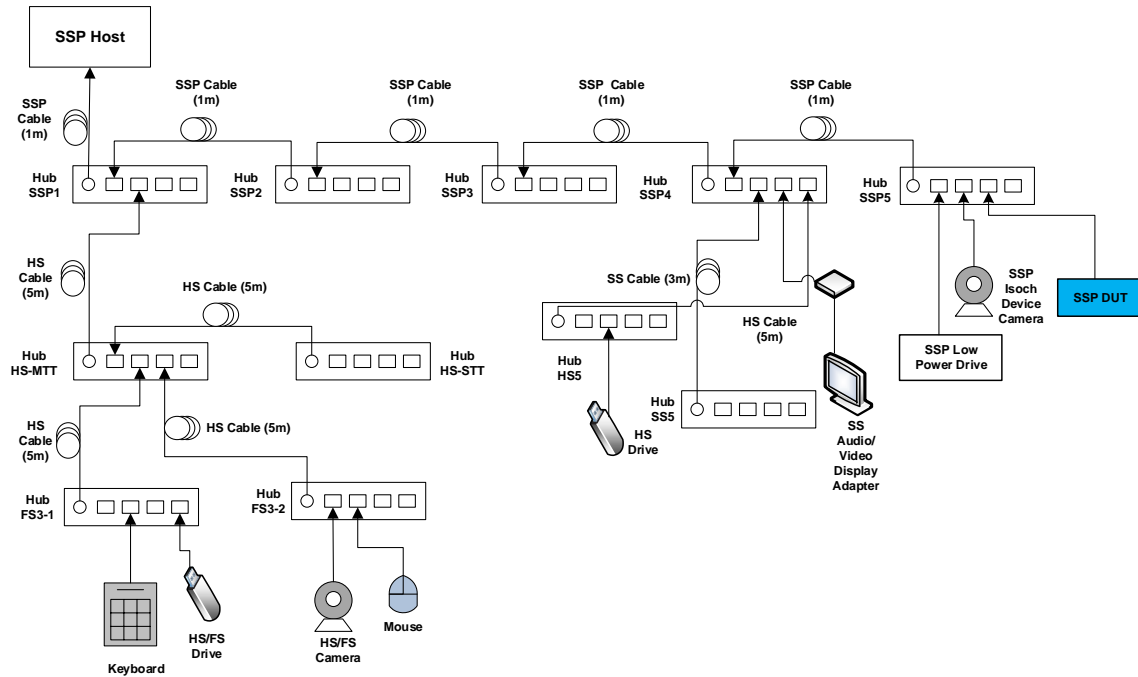


Figure 2-1: Interop Tree with Device Under Test

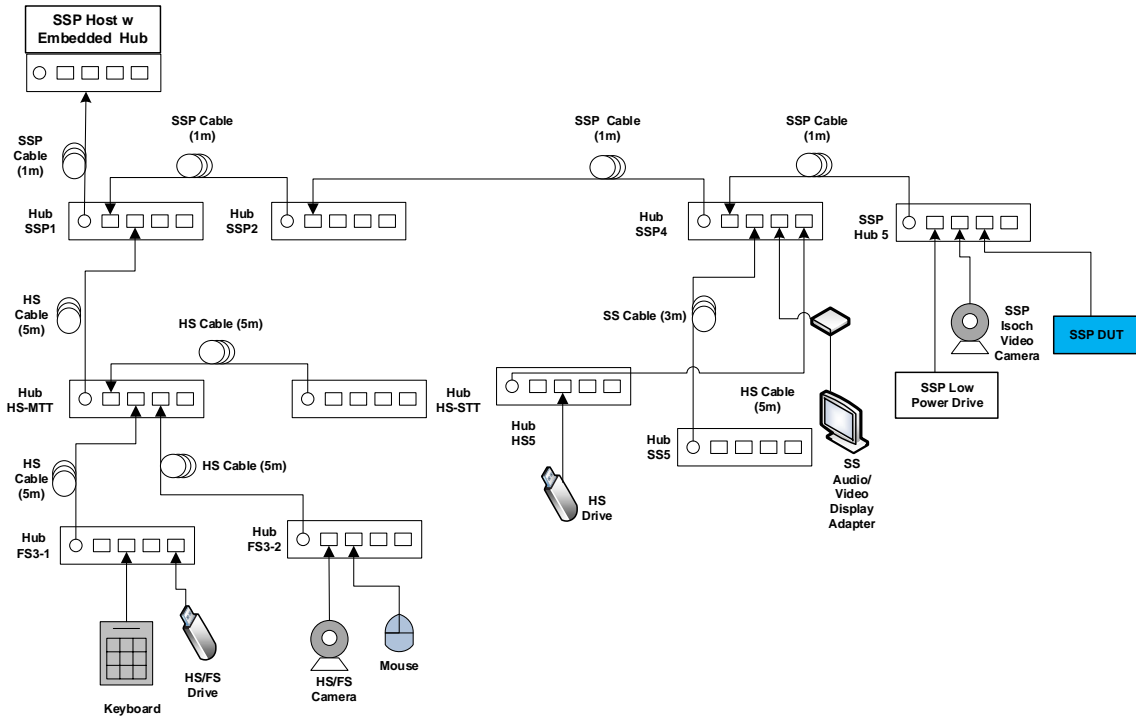


Figure 2-2: Interop Tree with Device Under Test (embedded hub)

Tier	Device
1	<ul style="list-style-type: none"> • Hub SSP1– Externally-powered SuperSpeedPlus Hub attached to the SuperSpeedPlus Host controller
2	<ul style="list-style-type: none"> • Hub SSP2 - Externally-powered SuperSpeedPlus Hub on port 1 of Hub SSP1
3	<ul style="list-style-type: none"> • Hub SSP3 - Externally-powered SuperSpeedPlus Hub on port 1 of Hub SSP2
4	<ul style="list-style-type: none"> • Hub SSP4 - Externally-powered SuperSpeedPlus Hub on port 1 of Hub SSP3
5	<ul style="list-style-type: none"> • Hub SSP5 - Externally-powered SuperSpeedPlus Hub on port 1 of Hub SSP4
	<ul style="list-style-type: none"> • SuperSpeedPlus Low Power Drive on port 1 of Hub SSP5
	<ul style="list-style-type: none"> • SuperSpeedPlus Video Camera on port 2 of Hub SSP5
	<ul style="list-style-type: none"> • Device Under Test on port 3 of Hub SSP5
5	<ul style="list-style-type: none"> • Hub SS5 - Externally-powered SuperSpeed Hub on port 2 of Hub SSP4
	<ul style="list-style-type: none"> • SuperSpeed Display Adapter on Port 3 of SSP4
5	<ul style="list-style-type: none"> • Hub HS5 - Externally-powered high-speed Hub on port 4 of Hub SSP4
	<ul style="list-style-type: none"> • HS Drive on port 2 of Hub HS5
2	<ul style="list-style-type: none"> • Hub HS2-MTT - Externally-powered high-speed Hub with multiple transaction translators on port 2 of Hub SSP1
3	<ul style="list-style-type: none"> • Hub HS3-STT - Externally-powered high-speed Hub with a single transaction translator on port 1 of Hub HS2-MTT
3	<ul style="list-style-type: none"> • Hub FS3-1 – Full-Speed Hub on port 2 of Hub HS2-MTT
	<ul style="list-style-type: none"> • FS Drive on port 4 of Hub FS3-1
	<ul style="list-style-type: none"> • Keyboard on port 2 of FS3-1
3	<ul style="list-style-type: none"> • Hub FS3-2 - Full-Speed Hub on port 3 of Hub HS2-MTT
	<ul style="list-style-type: none"> • FS Video Camera on port 1 of Hub FS3-2
	<ul style="list-style-type: none"> • Mouse on port 2 of Hub FS3-2

2.1 Peripheral Interoperability Tests

1. SSP xHCI Controller Driver Installation

Ensure that the USB Host System has a clean install of the OS and the OS is configured as described in Section 1.2. Turn off the USB Host System and install the SSP xHCI controller into the USB Host System if it is not already integrated.

Power on the USB Host System. One of three scenarios is acceptable for the USB Host System to install the SSP xHCI controller driver:

- The OS identifies and automatically installs the SSP xHCI controller driver.
- The OS displays that it cannot find the driver for the SSP xHCI controller. Follow the vendor-recommended install procedure to complete the driver install.

- If the SSP xHCI controller is already integrated into the USB Host System, then the OS displays nothing, as it has already attempted install for the SSP xHCI controller with the initial install of the OS. Follow the vendor-recommended install procedure to complete the driver install.
- **Pass:**
 1. (The OS identifies and automatically installs the SSP xHCI controller driver
OR
 2. The vendor-recommended install procedure installs the SSP xHCI controller driver)
AND
 3. The SSP xHCI controller driver is installed correctly and operates (no yellow exclamation point is displayed in device manager)
- **Fail:**
 1. The SSP xHCI controller driver does not install
OR
 2. The SSP xHCI controller driver is installed correctly but is non-operational (yellow exclamation point is displayed in device manager)

2. Peripheral Enumeration and Driver Installation

Do not install any drivers or software for any device in the SSP Interop Tree prior to attaching the SSP Interop Tree to the SSP xHCI controller.

Attach the SSP Interop Tree by connecting Hub SSP1 into any port on the SSP xHCI controller.

- If the SSP xHCI controller has an embedded hub, then unplug Hub SSP3 and Hub SSP4; re-plug Hub SSP4 directly into port one of Hub SSP2.

For each device in the Interop Tree (including the DUT) follow the vendor-recommended install procedure. Ensure that all drivers listed for each device in the Interop Tree match what is currently being tested under Driver Verifier (applies to Windows OS). To display the existing drivers being verified by Driver Verifier:

- Open the run box (press the Windows Key + R together).
- Type the command "Verifier".
- Select "Display existing settings"
- **Pass:**
 1. All Interop Tree devices enumerate
AND
 2. All Interop Tree devices drivers are installed either automatically or through the vendor recommended install procedure
AND
 3. All Interop Tree devices do not require a reboot
AND
 4. All Interop Tree devices are correctly identified by Device Manager and no yellow exclamation point is shown for any device
AND
 5. (Software installs without any software crashes or a blue screen
OR
 6. No software required)
- **Fail:**

1. Any device cannot be installed because it requires driver installation or application software BEFORE the device is ever plugged in
OR
2. Any device does not enumerate or blue screens during enumeration
OR
3. Any device requires a reboot
OR
4. Any device is incorrectly identified by Device Manager or any device is flagged as not operational (yellow exclamation point)
OR
5. Installation software crashes or causes a blue screen

3. Interoperability

- Operate all the devices in the Interop Tree.
 - Whenever the **Peripheral Interoperability Test Steps** state to operate all of the devices in the SSP Interop Tree, this involves operating the following steps concurrently:
 - Operate the microphone in the Video Cameras by speaking into the microphone and viewing the input sound monitor
 - This can be found under Control Panel -> Hardware and Sound -> Sound under the "Recording" tab
 - View streaming video from the SSP Video Camera
 - View streaming video from the FS Video Camera

Poor video quality may be seen when Driver Verifier is enabled. If there was poor quality, continue testing with the Driver Verifier enabled for all Interoperability steps. Repeat all Interoperability steps with Driver Verifier off. USB-IF will compare Interoperability results with Driver Verifier Enabled and Disabled to determine Pass/Fail for certification.
Note: Driver Verifier is in reference to Windows OS only.
 - Transfer a 30+ MB file from the SSP Low Power Drive to the FS Drive
 - Transfer a 1+ GB file from the HS Drive to the SSP Low Power Drive
 - Watch video and listen to audio from monitor attached to SS USB Display Adapter
 - Operate the Device Under Test
 - If the DUT is a SSP Mass Storage Device, then transfer a 2GB+file from the SSP Low Power Drive to the DUT and transfer a 1GB+file from the DUT to the HS Drive
 - If the DUT is a device other than Mass Storage Device, then ensure the operation on the DUT overlaps over the period of time that other devices in

the tree are operating.

- Strike keys on keyboard
- Move the mouse
- Verify that all devices are operating concurrently. Verify the Device Speed using the USBView utility (USBView utility runs on Windows OS).
- **Pass:**
All Interop Tree devices operate correctly
- **Fail:**
One or more Interop Tree devices fail to operate correctly

4. All Devices Tests

- Run tests 1-8 as specified in Chapter 7

5. Topology Change 1

- Operate all the devices in the Interop Tree except the Device Under Test.
- While operating the devices, detach the Device Under Test from port 3 on Hub SSP5
- While operating the devices, reattach the Device Under Test to port 1 on Hub SS5 as shown in Figure 2-3 and Figure 2-4.

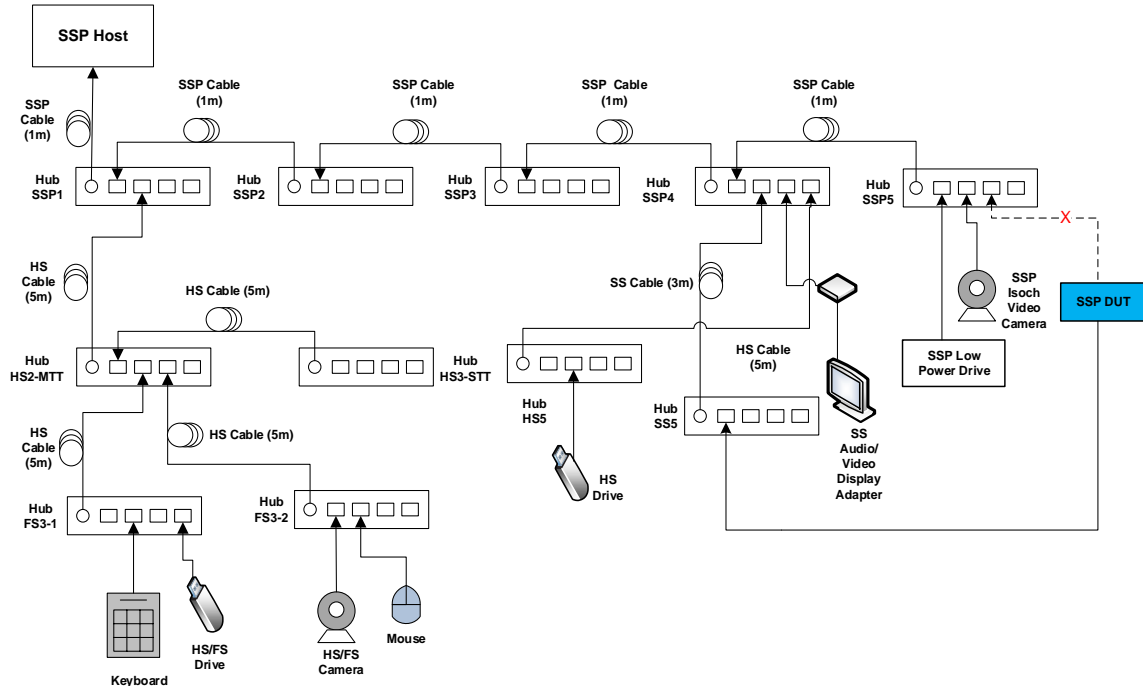


Figure 2-3: Topology Change 1

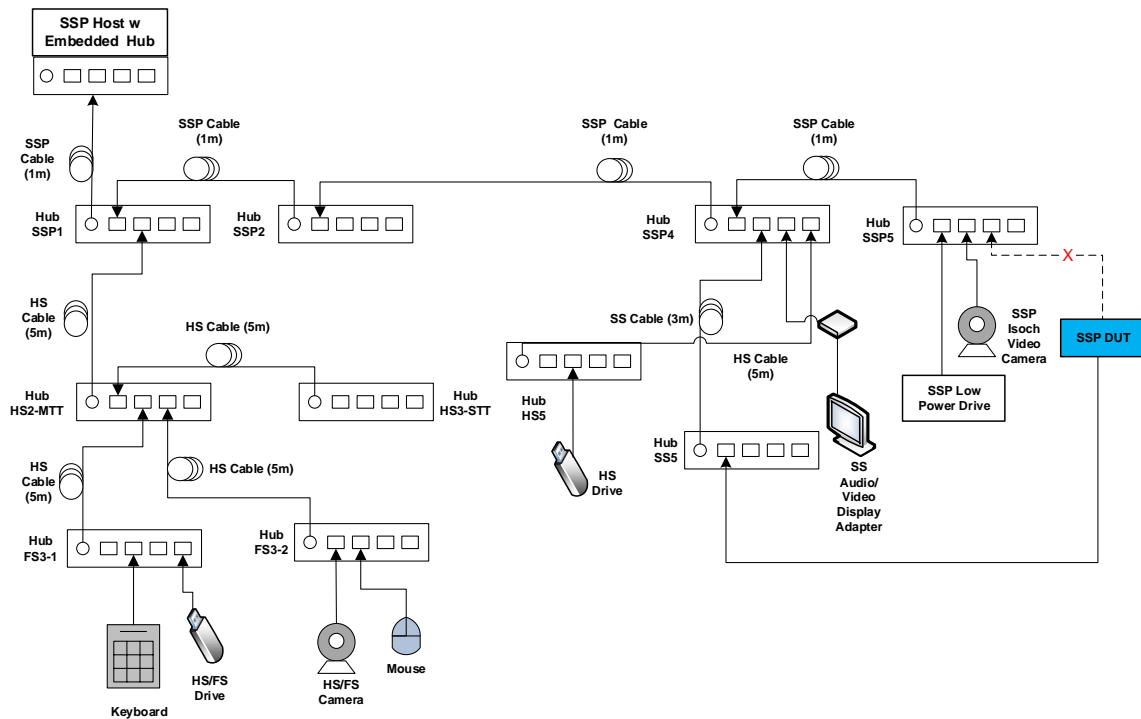


Figure 2-4: Topology Change 1 (embedded hub)

- Verify that all devices except for the Device Under Test continue to operate concurrently.
- Operate the Device Under Test.
- **Pass:**
All Interop Tree devices operate correctly
- **Fail:**
One or more Interop Tree devices fail to operate correctly

6. All Devices Tests

- Run tests 1-8 as specified in Chapter 7

7. Topology Change 2

- Operate all the devices in the Interop Tree except the Device Under Test.
- While operating the devices, detach the Device Under Test from port 1 on Hub SS5.
- While operating the devices, attach the Device Under Test to port 3 on Hub HS5 as shown below in Figure 2-5 and Figure 2-6.

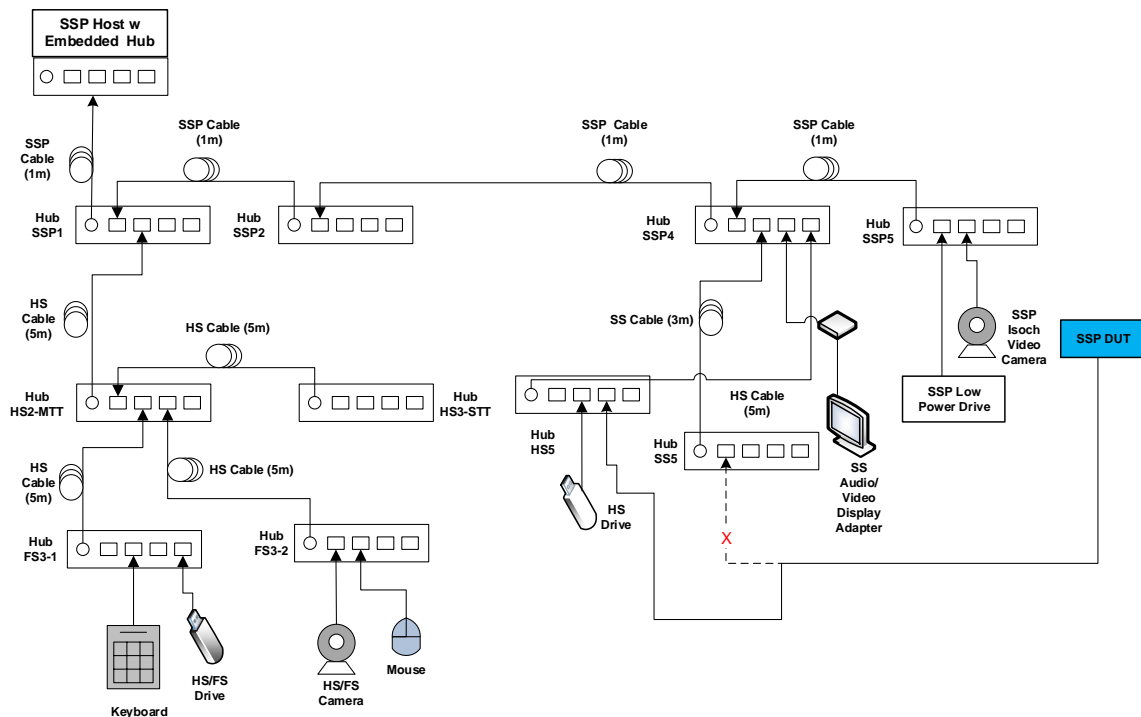


Figure 2-6: Topology Change 2 (embedded hub)

- Verify that all devices except for the Device Under Test are continuing to operate concurrently.
- Operate the Device Under Test.
- Operate all devices in the Interop Tree. Verify that all devices are operating concurrently.
- **Pass:**
All Interop Tree devices operate correctly
- **Fail:**
One or more Interop Tree devices fail to operate correctly

8. All Devices Tests

- Run tests 1-8 as specified in Chapter 7

9. Topology Change 3 (For Low/Full-speed capable USB Devices only)

- Operate all the devices in the Interop Tree except the Device Under Test.
- While operating the devices, detach the Device Under Test from port 3 on Hub HS5.
- While operating the devices, attach the Device Under Test to port 3 on Hub FS3-1 as shown below in Figure 2-7 and Figure 2-8.

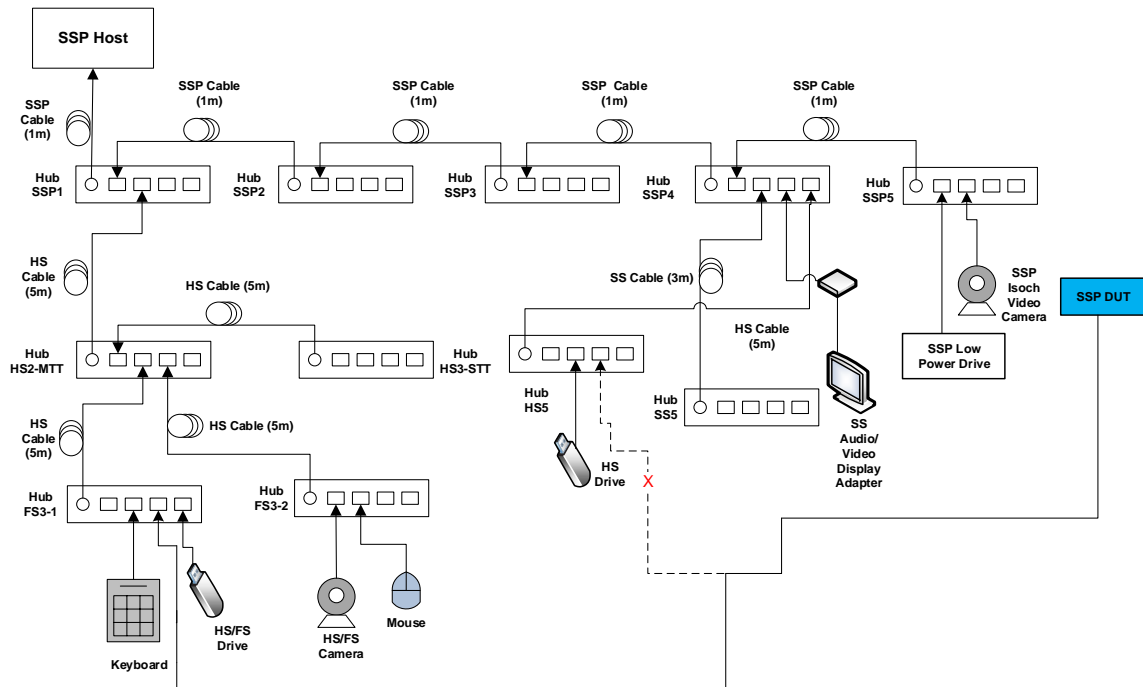


Figure 2-7: Topology Change 3 - Low/Full-Speed capable devices only

1, topology change 2 and topology change 3.

- Disable Driver Verifier:
 - Open the run box (press the Windows Key + R together)
 - Type the command “Verifier”
 - Select “Delete Existing Settings” and press Finish. Press “Yes” and restart the machine.
- Operate all the devices in the SSP Interop Tree. Verify that all devices are operating concurrently.
 - **Pass:**
All Interop Tree devices operate correctly. For certification purposes USB-IF will compare results between Driver Verifier Enabled and Driver Verifier Disabled to determine Pass/Fail.
 - **Fail:**
One or more Interop Tree devices fail to operate correctly

11. Function Wake

- If the DUT supports function remote wake, it should have an interface for users to initiate function wake. To run this test, operate all the devices in the Interop Tree
- While operating the devices, put the system to sleep by going to the Start menu, select the arrow next to the Shut Down button, and then choose Sleep.
- Initiate function wake from one of the functions on the device to wake the system up.
- Upon resuming, verify that the file transfers continue without error.
- Close any software that is used for any Interop Tree device operation and close the “Recording” tab window.
- Operate all the devices in the Interop Tree. Verify that all devices are operating concurrently.
- Repeat this test for all functions that support wake. (The “Device Summary” test of Command Verifier USB3CV identifies all functions (interfaces) that support function wake.
 - **Pass:**
 1. System sleeps
AND
 2. System resumes
AND
 3. File transfers continue without error
AND
 4. All devices can function after resuming
AND
 5. All functions that advertise wake capability will wake the machine

- **Fail:**
 1. System does not sleep
OR
 2. System does not resume
OR
 3. System blue screens / locks up
OR
 4. Any device cannot function after resuming
OR
 5. File transfers do not continue after resuming
OR
 6. Function that supports wake doesn't wake machine

12. Root Port Testing

- Connect DUT to one of the root ports of SSP host. Run tests 1-8 as specified in Chapter 7
- **Pass:**
All the tests 1-8 of Chapter 7 PASS
- **Fail:**
If any of the tests 1-8 of Chapter 7 FAIL

13. DUT testing behind a USB 2.0 Hub (Host--USB2.0 Hub--DUT Topology)

- Connect DUT to the Downstream Facing Port of a USB 2.0 Hub connected to the Host. Run tests 1-8 as specified in Chapter 7
- **Pass:**
All the tests 1-8 of Chapter 7 PASS
- **Fail:**
If any of the tests 1-8 of Chapter 7 FAIL

Repeat test by replacing the USB 2.0 Hub with a different USB 2.0 Hub. Repeat this test with various USB 2.0 Hubs available (the goal here is to test with various USB 2.0 Hubs that drop upto 4, 3, 2 or 1 sync bits).

2.2 Peripheral Current Measurement

Devices operating at Enhanced SuperSpeed GenX are allowed to draw a maximum configured current of 900mA and unconfigured current of 150mA. Devices operating at High-Speed or below may draw a maximum configured current of 500mA and unconfigured current of 100mA*. Devices must report their maximum configured current draw and their power configuration as self or bus powered to the host and must operate within the regions reported. Additionally any device that is in the suspended state may draw no more than 2.5 mA.

If the device has external power, check whether it enumerates without external power. If the Device enumerates without external power, run tests with external power connected and repeat tests with external power disconnected.

- Install USB3CV from the USB-IF [SuperSpeed Tools](#) page.
- Connect a SSP Current Measurement Fixture between DUT and xHCI host as shown in Figure 2-9.
- Set up a Multimeter to measure current drawn from device.
- Run “Current Measurement [USB 3 Gen X Devices]” test in Command Verifier.
- Read meter at each prompt.
- Read the value of “Max Power Consumption” from the log.
- Read device type from the log: bus-powered, self-powered or both.
- Record following values:
 - Bus, Both or Self-Powered
 - The current in un-configured mode
 - Current in configured mode
 - Current in U0
 - Current in U1
 - Current in U2
 - Current in U3
- Reload the xHCI controller driver being used for Interop.
- Operate the device
- Record the highest measured current value

* These tests assume that if the device has a battery, that the battery is a Good Battery, as defined in the Battery Charging Specification, Revision 1.2

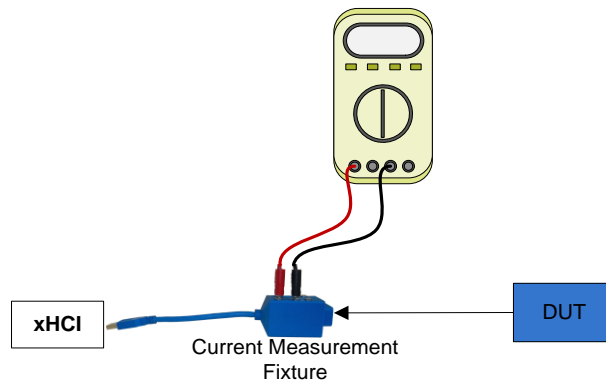


Figure 2-9: Peripheral Current Measurement Topology

- **Pass:**
 1. Device reports Self-Powered while operating as self-powered if supported
AND
 2. Device reports Bus-Powered while operating as bus-powered if supported
AND
 3. Max Power Consumption reported is 900mA or less when operating at SuperSpeedPlus and 500mA or less

- when operating at High-speed or Full-Speed
AND
 - 4. Measured Unconfigured Current is 150mA or less when operating at SuperSpeedPlus and 100mA or less when operating at High-speed or Full-Speed
AND
 - 5. Measured Current during device operation, U0, U1 and U2 is less than or equal to reported Max Power Consumption
AND
 - 6. Measured Current in U3 is less than or equal to 2.5mA and reported Max Power Consumption
- **Fail:**
 1. Device reports Bus-Powered while operating as self-powered
OR
 2. Device reports Self-Powered while operating as bus-powered
OR
 3. Max Power Consumption reported is greater than 900mA when operating at SuperSpeedPlus and greater than 500mA when operating at High-speed or Full-Speed
OR
 4. Measured Unconfigured Current is greater than 150mA when operating at SuperSpeedPlus or greater than 100mA when operating at High-speed or Full Speed
OR
 5. Measured Current during device operation, U0, U1 or U2 is greater than reported Max Power Consumption
OR
 6. Measured Current in U3 is greater than 2.5mA or reported Max Power Consumption

2.3 Peripheral U1/U2 Test Steps

- Connect a SuperSpeedPlus hub to an exposed host port.
 - Connect a DUT to a downstream hub port with a USB Protocol Analyzer between the hub and device.
 - Trace USB traffic including idle device time and normal DUT operation.
 - Verify that the link successfully enters U1 or U2.
 - Verify that the hub correctly sends a deferred packet to the DUT and to the host.
 - Verify that the DUT correctly sends an ERDY after the deferred packet.
 - Verify that the host re-sends the packet with the deferred bit cleared.
 - Verify that the DUT completes the re-sent packet.
- **Pass:**
 1. Link successfully enters U1 or U2
AND
 2. Link returns to U0 and the original packet that was sent during U1/U2 is successfully completed
 - **Fail:**
 1. Link remains in U0
OR
 2. Re-Sent packet does not complete correctly

2.4 Peripheral L1 Test Steps

- Connect a USB Peripheral to the LPM PDK host with a USB Protocol Analyzer in between the device and the LPM PDK host. The USB peripheral is to be connected to

- operate in High-speed mode.
- Operate the device. For example if it's a MSC device, transfer a file to the drive.
 - Trace USB traffic including enumeration, idle device time and normal DUT operation.
 - Verify that the device successfully enters L1.
 - Verify that the device successfully resumes to L0 and functions normally.
- **Pass:**
Device successfully enters and exits L1 and device operates normally
 - **Fail:**
If device does not enter L1 and does not operate normally

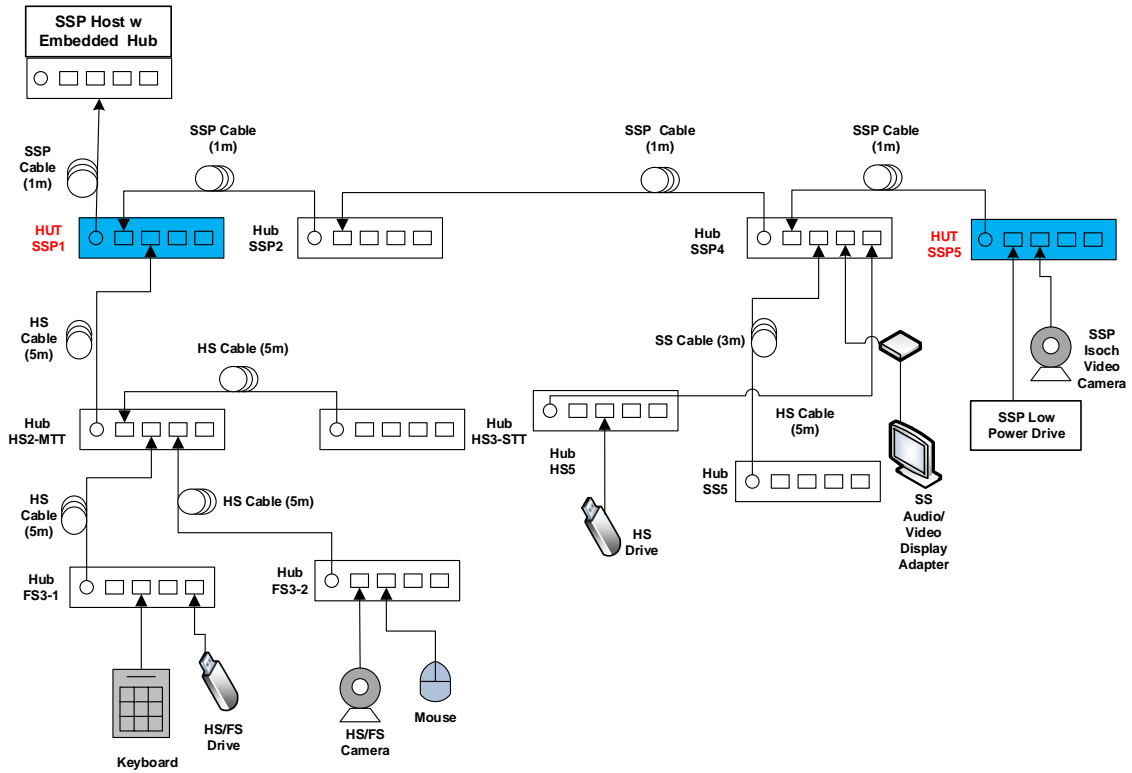


Figure 3-2: Interop Tree with Externally-Powered Hubs Under Test (embedded hub)

Tier	Device
1	<ul style="list-style-type: none"> • HUT SSP1– Externally-powered SuperSpeedPlus Hub Under Test attached to the SuperSpeedPlus Host controller
2	<ul style="list-style-type: none"> • Hub SSP2 - Externally-powered SuperSpeedPlus Hub on port 1 of HUT SSP1
3	<ul style="list-style-type: none"> • Hub SSP3 - Externally-powered SuperSpeedPlus Hub on port 1 of Hub SSP2
4	<ul style="list-style-type: none"> • Hub SSP4 - Externally-powered SuperSpeedPlus Hub on port 1 of Hub SSP3
5	<ul style="list-style-type: none"> • HUT SSP5 - Externally-powered SuperSpeedPlus Hub Under Test on port 1 of Hub SSP4
	<ul style="list-style-type: none"> • SuperSpeedPlus Low Power Drive on port 1 of HUT SSP5
	<ul style="list-style-type: none"> • SuperSpeedPlus Video Camera on port 2 of HUT SSP5
5	<ul style="list-style-type: none"> • Hub SS5 - Externally-powered SuperSpeed Hub on port 2 of Hub SSP4
	<ul style="list-style-type: none"> • SuperSpeed Display Adapter on Port 3 of SSP4
5	<ul style="list-style-type: none"> • Hub HS5 - Externally-powered high-speed Hub on port 4 of Hub SSP4
	<ul style="list-style-type: none"> • HS Drive on port 2 of Hub HS5
2	<ul style="list-style-type: none"> • Hub HS2-MTT - Externally-powered high-speed Hub with multiple transaction translators on port 2 of Hub SSP1
3	<ul style="list-style-type: none"> • Hub FS3-1 – Full-Speed Hub on port 2 of Hub HS2-MTT
4	<ul style="list-style-type: none"> • FS Drive on port 4 of Hub FS3-1
4	<ul style="list-style-type: none"> • Keyboard on port 2 of FS3-1
3	<ul style="list-style-type: none"> • Hub FS3-2 - Full-Speed Hub on port 3 of Hub HS2-MTT
4	<ul style="list-style-type: none"> • FS Video Camera on port 1 of Hub FS3-2
4	<ul style="list-style-type: none"> • Mouse on port 2 of Hub FS3-2

3.1 Externally-Powered Hub Interoperability Tests

1. SSP xHCI Controller Driver Installation

Ensure that the USB Host System has a clean install of the OS and the OS is configured as described in Section 1.2.1. Turn off the USB Host System and install the SSP xHCI controller into the USB Host System if it is not already integrated.

- Ensure that the SSP Interop Tree is not attached to the SSP xHCI controller or embedded hub.

Power on the USB Host System. One of three scenarios is acceptable for the USB Host System to install the xHCI controller driver:

- The OS identifies and automatically installs the SSP xHCI controller driver.
- The OS displays that it cannot find the driver for the SSP xHCI controller. Follow the vendor-recommended install procedure to complete the driver install.
- If the SSP xHCI controller is already integrated into the USB Host System, then the OS displays nothing, as it has already attempted install for the SSP xHCI controller with the initial install of the OS. Follow the vendor-recommended install procedure to complete the driver install.

- **Pass:**

1. (The OS identifies and automatically installs the SSP xHCI controller driver
OR
2. The vendor-recommended install procedure installs the SSP xHCI controller driver)
AND
3. The SSP xHCI controller driver is installed correctly and operates (no yellow exclamation point is displayed in device manager)

- **Fail:**

1. The SSP xHCI controller driver does not install
OR
2. The SSP xHCI controller driver is installed correctly but is non-operational (yellow exclamation point is displayed in device manager)

2. Peripheral Enumeration and Driver Installation

Do not install any drivers or software for any device in the SSP Interop Tree prior to attaching the SSP Interop Tree to the SSP xHCI controller.

Attach the SSP Interop Tree by connecting the Hub Under Test SSP1 into any port on the SSP xHCI controller.

For each device in the SSP Interop Tree follow the vendor-recommended install. Ensure that all drivers listed for each device in the SSP Interop Tree match what is currently being tested under Driver Verifier (applies to Windows OS). To display the existing drivers being verified by Driver Verifier:

- Open the run box (press the Windows Key + R together).
- Type the command "Verifier".

- Select “Display existing settings”
- **Pass:**
 1. All SSP Interop Tree devices enumerate
AND
 2. All SSP Interop Tree devices drivers are installed either automatically or through the vendor recommended install procedure
AND
 3. All SSP Interop Tree devices do not require a reboot
AND
 4. All SSP Interop Tree devices are correctly identified by Device Manager and no yellow exclamation point is shown for any device
AND
 5. (Software installs without any software crashes or a blue screen
OR
 6. No software required)
- **Fail:**
 1. Any device cannot be installed because it requires driver installation or application software BEFORE the device is ever plugged in
OR
 2. Any device does not enumerate or blue screens during enumeration
OR
 3. Any device requires reboot
OR
 4. Any device is incorrectly identified by Device Manager or any device is flagged as not operational (yellow exclamation point)
OR
 5. Installation software crashes or causes a blue screen

3. Interoperability

Examine the Hub Under Test and identify all USB connections.

- Each and every USB port on the Hub Under Test must be able to pass all required tests. The interoperability tests operate three ports of the Hub Under Test at a time. All ports must be tested in at least one topology.
- Operate all the devices in the SSP Interop Tree.
- Whenever the Externally-Powered Hub Interoperability Test Steps state to operate all of the devices in the SSP Interop Tree, this involves operating the following steps concurrently:
 - Operate the microphone in the Video Cameras by speaking into the microphone and viewing its input level
 - This can be found under Control Panel -> Hardware and Sound -> Sound under the “Recording” tab.
 - View streaming video from the SSP Video Camera
 - View streaming video from the FS Video Camera

Poor video quality may be seen when Driver Verifier is enabled. If there was poor quality, continue testing with the Driver Verifier enabled for all

Interoperability steps. Repeat all Interoperability steps with Driver Verifier off. USB-IF will compare Interoperability results with Driver Verifier Enabled and Disabled to determine Pass/Fail for certification.

- Transfer a 30+ MB file from the SSP Low Power Drive to the FS Low Power Drive
 - Transfer a 1+ GB file from the HS Drive to the SS Low Power Drive
 - Watch video and listen to audio from monitor attached to SS USB Display Adapter
 - Strike keys on the keyboard
 - Move the mouse
- Verify that all devices are operating concurrently. Verify the Device Speed using the USBView utility (USBView utility runs on Windows OS).
- **Pass:**
All SSP Interop Tree devices operate correctly
 - **Fail:**
One or more SSP Interop Tree devices fail to operate correctly

4. All Devices Tests

- Run tests 1-8 as specified in Chapter 7

5. Topology Change 1

- Stop all SSP Interop Tree device operation!
- Detach the Hub Under Test SSP1 from the SSP xHCI controller and detach all attached devices from the Hub Under Test SSP1.
- Reattach the Hub Under Test SSP1 to port 3 of Hub SSP2. Then attach Hub HS2-MTT to port 2 of Hub SSP2 and Hub HS3-STT to port 3 of the Hub Under Test SSP1. Then attach Hub FS3-1 to port 1 of the Hub Under Test SSP1. Then attach Hub FS3-2 to port 2 of the Hub Under Test SSP1 as shown in Figure 3-3 and Figure 3-4.

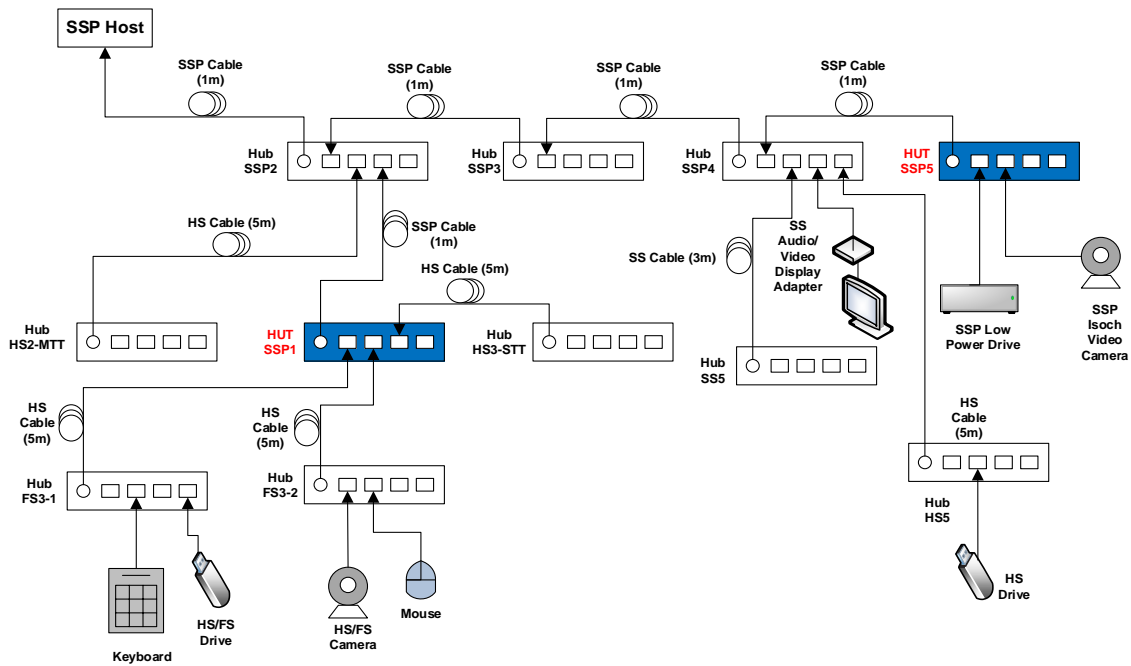


Figure 3-3: Topology Change 1

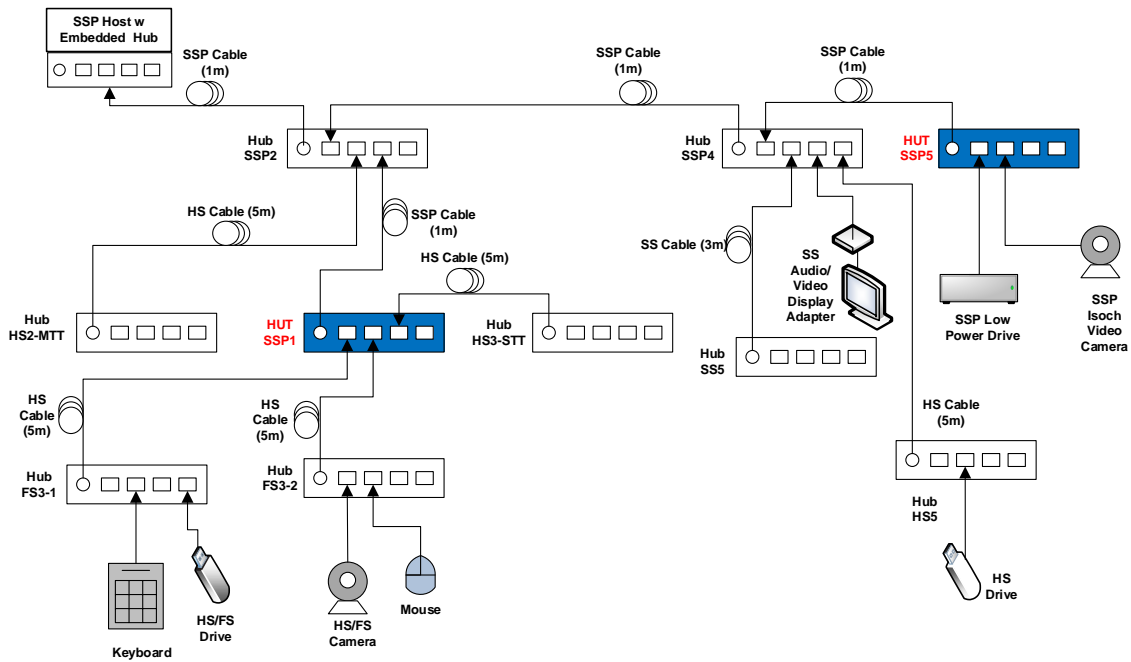


Figure 3-4: Topology Change 1 (embedded hub)

- Operate all devices in the SSP Interop Tree. Verify that all devices are operating concurrently.

- If the Hub Under Test is a Single-TT Hub, then it is acceptable for the headset, microphones, or FS Video Camera to not work, as the configuration may require more bandwidth than the Hub Under Test can provide. The test setup must then be restored to a configuration that has enough bandwidth.
- Detach Hub FS3-2 from port 2 on the Hub Under Test and attach the Hub FS3-2 to port 1 on Hub HS3-S TT. This should set the configuration to what is displayed in Figure 3-5 and Figure 3-6.

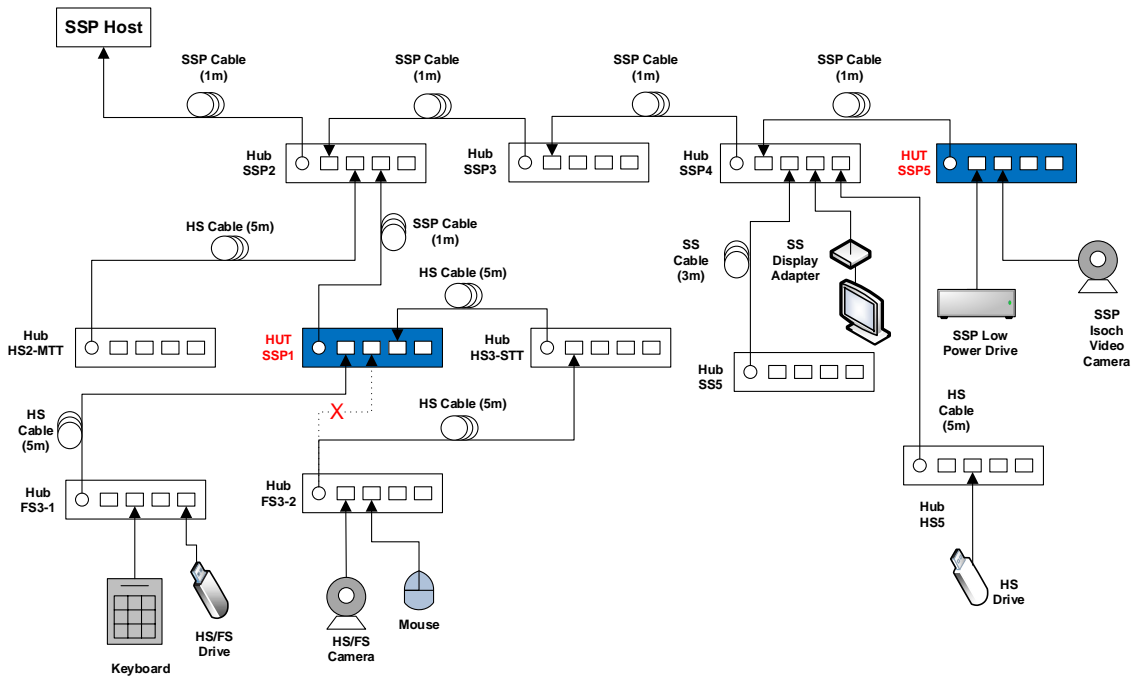


Figure 3-5: Topology Change 1 - Single-TT Hubs Only

- While operating the devices, detach the Hub Under Test from SSP2 and detach all attached devices from the Hub Under Test.
- Detach Hub FS3-1 from Port 1 on Hub SSP1. Attach Hub FS3-1 to Port 1 on HS2-MTT
- Detach HS3-STT from Hub SSP1 and attach Hub HS3-STT to Port 2 of Hub HS2-MTT
- Detach Hub FS3-2 from Hub SSP1 and remove all devices from Hub FS3-2. Attach Hub FS3-2 to port 2 of HS3-STT
- Attach Hub SSP1 to Port 3 of Hub HS3-STT. Attach Mouse and Camera to Ports 1 and 2 of Hub SSP1 as shown in Figure 3-7 and Figure 3-8

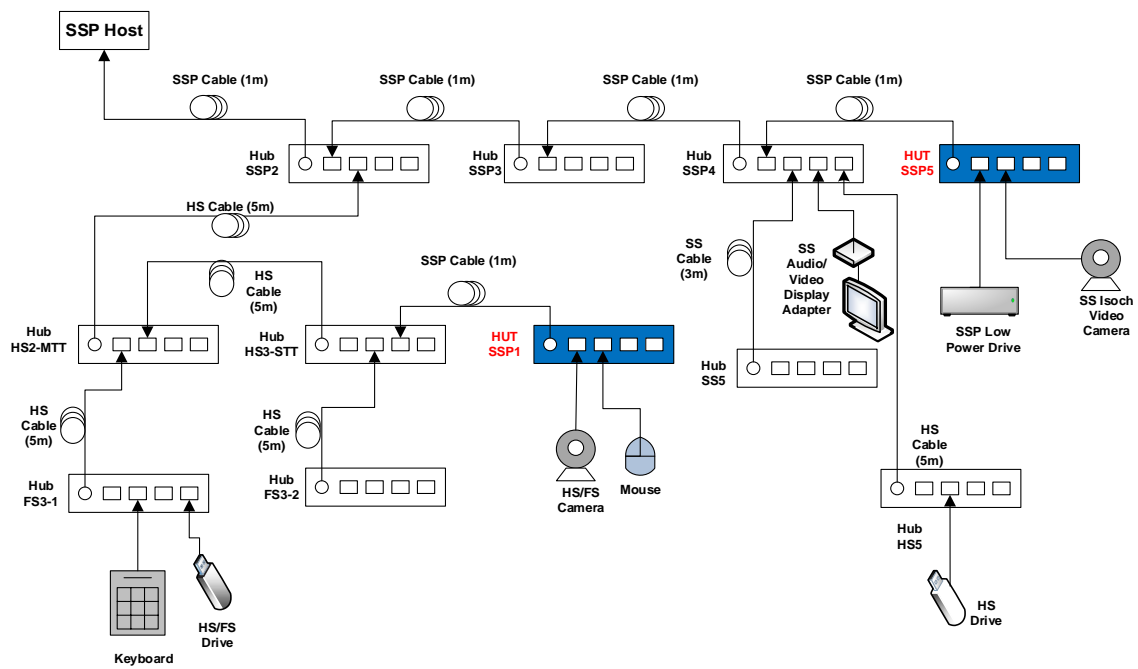


Figure 3-7: Topology Change 2

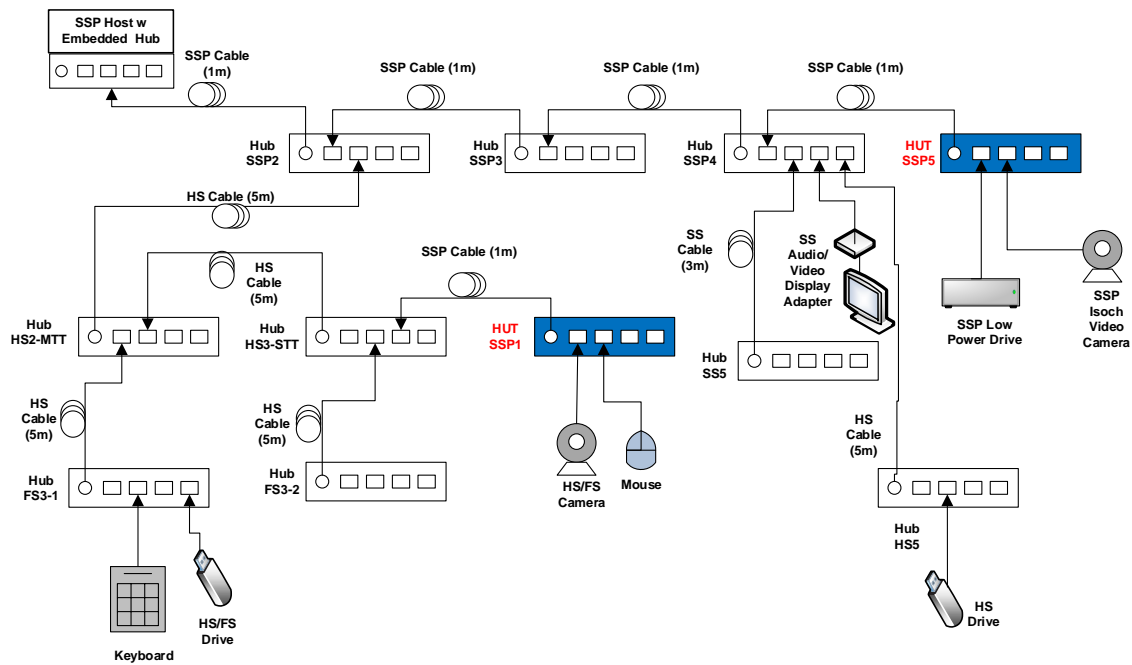


Figure 3-8: Topology Change 2 (embedded hub)

- Verify that the file transfer continues to take place.
- Verify that the SSP Video Camera continues to function.
- Verify that SS Display Adapter continues to show video and play audio.
- Operate all the devices in the SSP Interop Tree. Verify that all devices are operating concurrently.
- **Pass:**
 1. After the topology change the file transfer continued to take place
AND
 2. After the topology change the SSP Video Camera continues to function
AND
 3. After the topology change the SS Display Adapter continues to function
AND
 4. All SSP Interop Tree devices operate correctly
- **Fail:**
 1. After the topology change the file transfer was cancelled
OR
 2. After the topology change the SSP Video Camera stopped functioning
OR
 3. After the topology change the SS Display Adapter stopped functioning
OR
 4. One or more SSP Interop Tree devices fail to operate correctly

8. All Devices Tests

- Run tests 1-8 as specified in Chapter 7

9. Interoperability without Driver Verifier (applies to Windows OS)

- Run this test only if there was poor video or audio quality when operating all of the devices in the SSP Interop Tree. Run this test for each Topology that there was poor video or audio quality.
- Disable Driver Verifier:
 - Open the run box (press the Windows Key + R together)
 - Type the command "Verifier"
 - Select "Delete Existing Settings" and press Finish. Press "Yes" and restart the machine.
- Operate all the devices in the SSP Interop Tree. Verify that all devices are operating concurrently.
 - **Pass:**
All SSP Interop Tree devices operate correctly
 - **Fail:**
One or more SSP Interop Tree devices fail to operate correctly

10. Function Wake

Connect a function-remote-wake capable SSP device to one of hub ports on the 5th SuperSpeedPlus Hub (HUT SSP5)

- Put the system into sleep
- Wake up the system by the function-remote-wake interface on the SuperSpeedPlus device
 - **Pass:**
The system wakes up normally.
 - **Fail:**
The system has any abnormal behaviors.

3.2 Externally-Powered Hub Current Measurement

Externally-Powered Hubs operating at SuperSpeedPlus are allowed to draw a maximum current of 150mA. Externally-Powered Hubs operating at High-speed or below may draw a maximum current of 100mA. Externally-Powered Hubs must report its own maximum current draw and power configuration as Externally-powered to the host and must operate

within the regions reported. Additionally any device that is in the suspended state may draw no more than 2.5mA.

For Externally Powered Hub check whether it enumerates without external power. If Hub enumerates without external power then Run tests with external power connected and repeat tests with external power disconnected.

See Chapter 4 for UFP Powered Hub reference.

- Install USB3CV from the USB-IF [SuperSpeed Tools](#) page.
- Connect a SSP Current Measurement Fixture between HUT and SuperSpeedPlus xHCI host as shown in Figure 3-9.
- Set up a Multimeter to measure current drawn from hub.
- Run “Current Measurement [USB 3 Gen X Devices]” test in Command Verifier.
- Read meter at each prompt.
- Read the value of “Max Power Consumption” from the log.
- Read hub type from the log: bus-powered, self-powered or both.
- Record following values:
 - Bus, Both or Self-Powered
 - The current in un-configured mode.
 - Current in configured mode
 - Current in U0
 - Current in U1
 - Current in U2
 - Current in U3
- Reload the SuperSpeedPlus xHCI controller driver being used for Interop
- Record the highest measured current value
- Repeat all steps again with hub operating at High-speed by changing SuperSpeedPlus cable with High-speed cable (Note: U0, U1, U2 and U3 are not applicable in High-speed mode) use CV tests labeled “Current Measurement Test [2.0 Devices]”

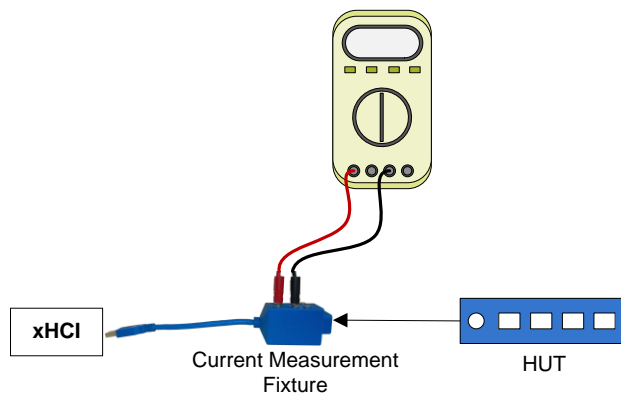


Figure 3-9: Hub Current Measurement Topology

- Pass:

1. Hub reports Self-Powered and does not operate as Bus-Powered
AND
 2. Max Power Consumption reported is 150mA or less when operating at Enhanced SuperSpeed GenX and 100mA or less when operating at High-speed or Full-Speed
AND
 3. Measured Current during device operation, U0, U1 and U2 is less than or equal to reported Max Power Consumption
AND
 4. Measured Current in U3 is less than or equal to 2.5mA and reported Max Power Consumption
- **Fail:**
 1. Hub reports Self-Powered but is capable of enumerating as Bus-Powered
OR
 2. Max Power Consumption reported is greater than 150mA when operating at Enhanced SuperSpeed GenX or greater than 100mA when operating at High-speed or Full-Speed
OR
 3. Measured Current during hub operation, U0, U1 or U2 is greater than reported Max Power Consumption
OR
 4. Measured Current in U3 is greater than 2.5mA or reported Max Power Consumption

3.3 Externally-Powered Hub U1/U2 Test Steps

- Connect the HUT to an exposed host port.
- Connect a KGD to a downstream hub port with a USB Protocol Analyzer between the hub and device.
- Trace USB traffic including idle device time and normal KGD operation.
- Verify that the link successfully enters U1 or U2.
- Verify that the hub correctly sends a deferred packet to the KGD and to the host.
- Verify that the KGD correctly sends an ERDY after the deferred packet.
- Verify that the host re-sends the packet with the deferred bit cleared.
- Verify that the KGD completes the re-sent packet.
- **Pass:**
 1. Link successfully enters U1 or U2
AND
 2. Link returns to U0 and the original packet that was sent during U1/U2 is successfully completed
- **Fail:**
 1. Link remains in U0
OR
 2. Re-sent packet does not complete successfully

3.4 Externally-Powered Hub LPM Tests (applies to Windows OS)

Download the [MUTT Software Package](#) from Microsoft. Double click and install the MSI file. After the install finishes the contents of the package will most likely be found under

C:\Program Files\USBTest\

Choose either the x86 or the x64 folder depending upon the system OS. Inside the folder select the tool labeled **UsbLPM**.

Selective Suspend must be disabled when using the Usb LPM Tool. Go to Control Panel -> Power Options -> Change Plan Settings -> Change advanced power settings. Under "USB settings" choose "USB selective suspend setting" and set it to "Disabled".

Note: The hub is required to be in an equal or higher link state than any device(s) attached to its downstream port(s). If at any time the hub goes to a lower link state than an attached device the hub fails testing.

1. Inactivity U1/U2 Entry Test - Hub Only

Open the Usb LPM Tool

- Configure the Hub Under Test as shown in Figure 3-10 and attach it to an SSP xHCI port.

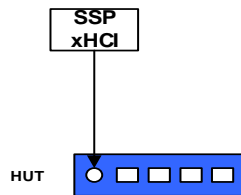


Figure 3-10: Hub Only Topology

Let the hub remain inactive for a few seconds and observe whether it enters U1 or U2.

- **Pass:**
Hub enters U1 or U2
- **Fail:**
Hub remains in U0

2. Inactivity U1/U2 Entry Test - Hub and U1/U2 Enabled Device

- Detach hub from the host.
- Attach a SuperSpeedPlus, U1/U2 enabled device to the hub.
- Attach tree to the host as shown in Figure 3-11.

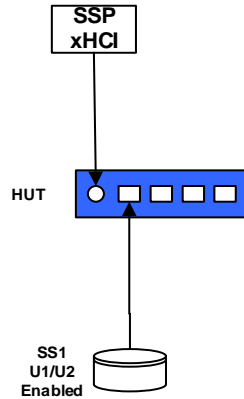


Figure 3-11: Hub and U1/U2 Enabled Device

Allow the devices to remain inactive. Observe the LPM tool, the device should enumerate and both the hub and the device should enter U1 or U2.

- **Pass:**
 1. Both device and hub enter U1 or U2
OR
 2. The hub enters U1 and the device enters U2
- **Fail:**
 1. Either the hub and/or device remain in U0
OR
 2. The device enters U1 while the hub enters U2 or U3
OR
 3. The device enters U2 while the hub enters U3

3. Inactivity U1/U2 Entry Test - Hub and U1/U2 Disabled Device

- Detach hub from the host.
- Attach a SuperSpeedPlus, U1/U2 **disabled** device to the hub.
- Attach tree to the host as shown in Figure 3-12.

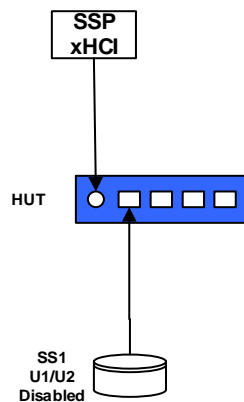


Figure 3-12: Hub and U1/U2 Disabled Device

Allow the devices to remain inactive. Observe the LPM tool, the device should enumerate and the hub should not enter U1 or U2 (assuming device remains in U0).

- **Pass:**
Hub remains in U0 with device
- **Fail:**
Hub enters U1, U2 or U3 while device remains in U0

4. Active LPM Test

The USB LPM Tool has an active mode where it can request the device and hub to enter U1 or U2 and report a pass/fail. Because this test does not necessarily exhaust all possibilities during U1/U2 testing it should be run 10 times.

- Attach the configuration shown in Figure 3-11 to an available SSP xHCI port.
- In the Mode of operation box select the option “testing”.
- Select the SuperSpeedPlus hub from the list as shown in Figure 3-13.
- Click the “Start” button on the right.
- Observe the test report for failures or errors during the test cases.
- Repeat this test 9 more consecutive times
- **Pass:**
All 10 consecutive test cases report “pass”
- **Fail:**
1 or more consecutive test cases reported a “fail” or “error”

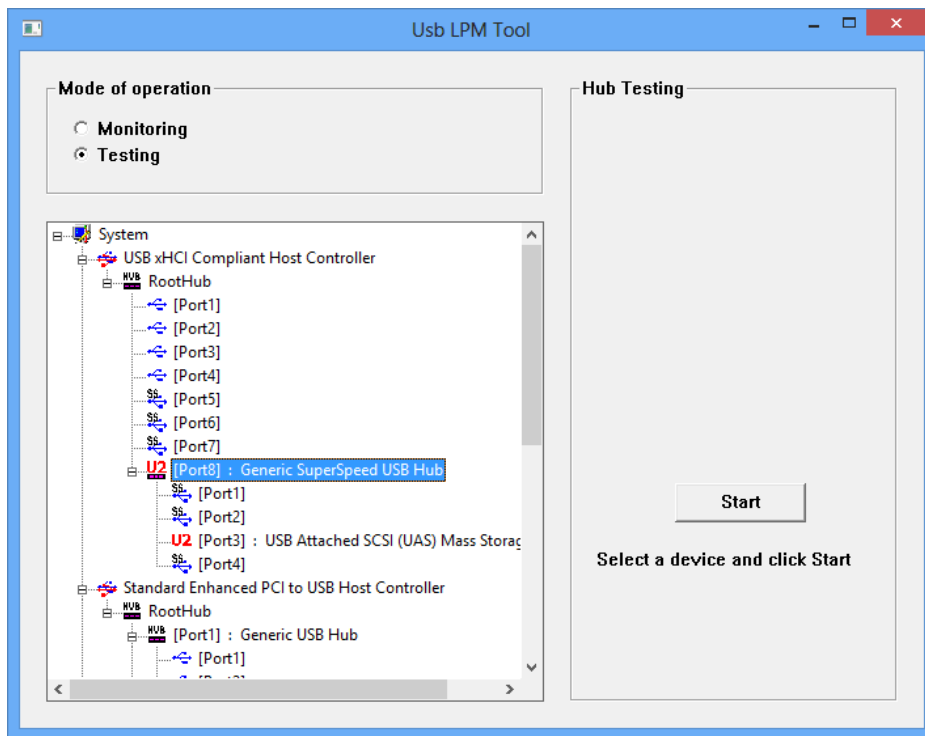


Figure 3-13: Usb LPM Tool Interface

- 4 For UFP Powered Hub please refer to <https://www.usb.org/document-library/usb-upstream-facing-port-powered-hub-white-paper>)**

5 USB Host Interoperability Test Steps

Construct the Interop Tree as outlined in Figure 5-1. If the host under test contains an embedded hub construct the Interop Tree as outlined in Figure 5-2 instead. Do not attach the Interop Tree to the Host Under Test.

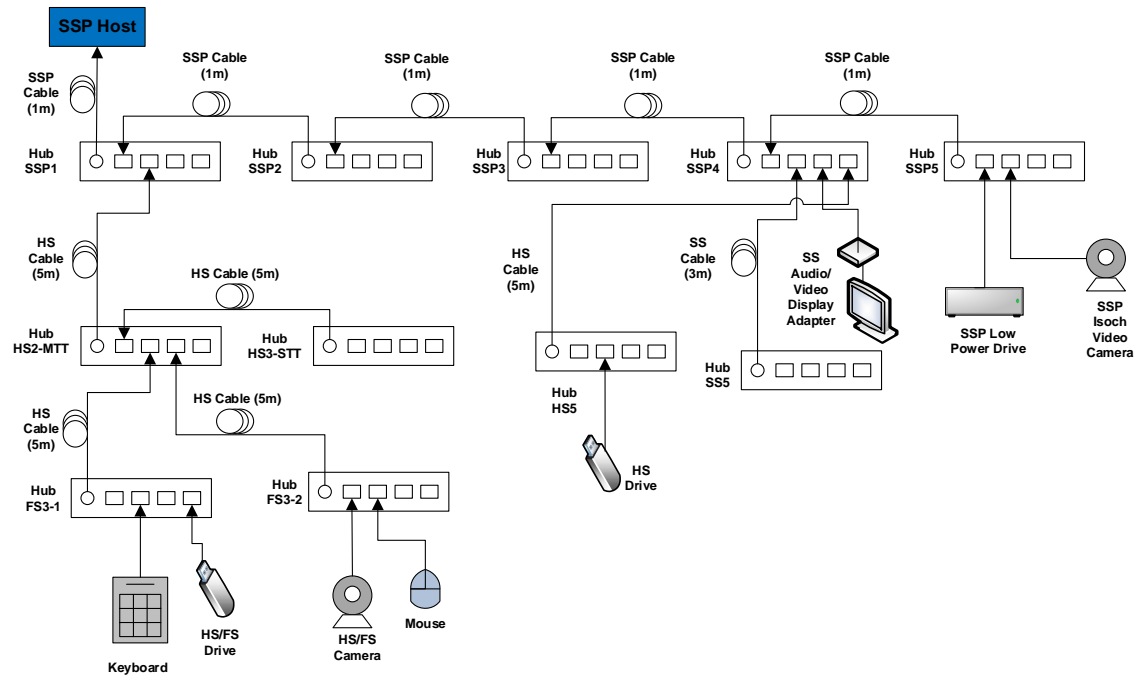


Figure 5-1: Interop Tree with Host Under Test

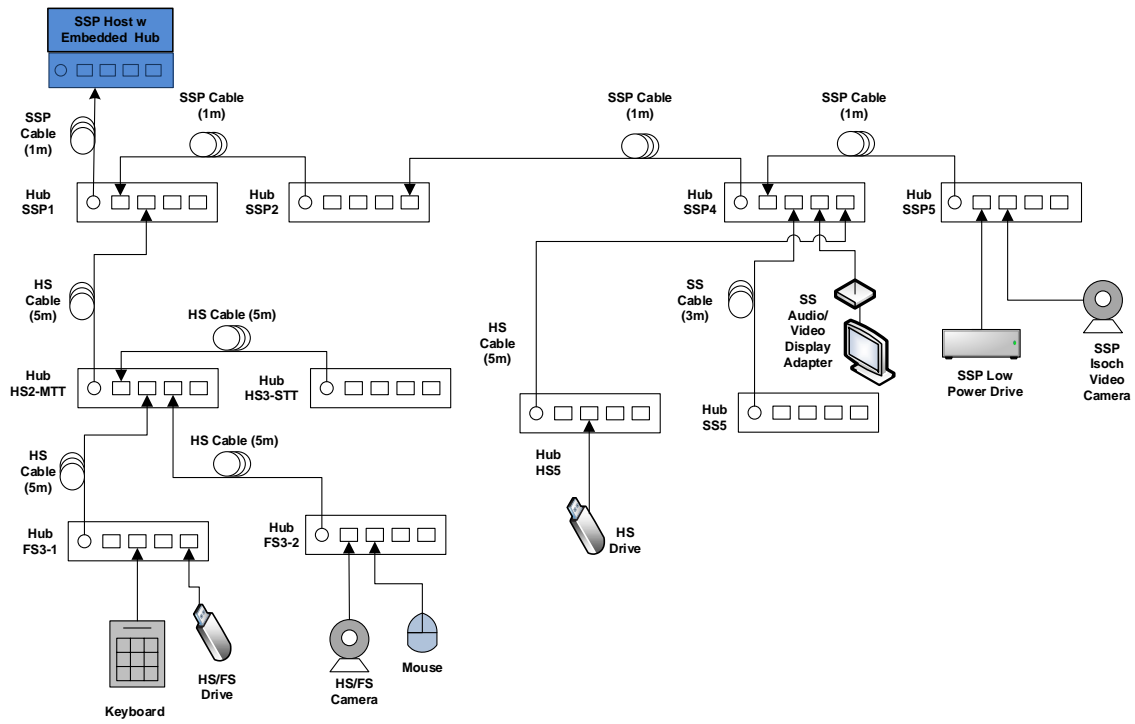


Figure 5-2: Interop Tree with Host Under Test (embedded hub)

Tier	Device
1	<ul style="list-style-type: none"> • HUT SSP1– Externally-powered SuperSpeedPlus Hub Under Test attached to the SuperSpeedPlus Host controller
2	<ul style="list-style-type: none"> • Hub SSP2 - Externally-powered SuperSpeedPlus Hub on port 1 of HUT SSP1
3	<ul style="list-style-type: none"> • Hub SSP3 - Externally-powered SuperSpeedPlus Hub on port 1 of Hub SSP2
4	<ul style="list-style-type: none"> • Hub SSP4 - Externally-powered SuperSpeedPlus Hub on port 1 of Hub SSP3
5	<ul style="list-style-type: none"> • HUT SSP5 - Externally-powered SuperSpeedPlus Hub Under Test on port 1 of Hub SSP4
	<ul style="list-style-type: none"> • SuperSpeedPlus Low Power Drive on port 1 of HUT SSP5
	<ul style="list-style-type: none"> • SuperSpeedPlus Video Camera on port 2 of HUT SSP5
5	<ul style="list-style-type: none"> • Hub SS5 - Externally-powered SuperSpeed Hub on port 2 of Hub SSP4
	<ul style="list-style-type: none"> • SuperSpeed Display Adapter on Port 3 of SSP4
5	<ul style="list-style-type: none"> • Hub HS5 - Externally-powered high-speed Hub on port 4 of Hub SSP4
	<ul style="list-style-type: none"> • HS Drive on port 2 of Hub HS5
2	<ul style="list-style-type: none"> • Hub HS2-MTT - Externally-powered high-speed Hub with multiple transaction translators on port 2 of Hub SSP1
3	<ul style="list-style-type: none"> • Hub HS3-STT - Externally-powered high-speed Hub with a single transaction translator on port 1 of Hub HS2-MTT
	<ul style="list-style-type: none"> • HS Drive on port 4 of Hub HS3-STT
3	<ul style="list-style-type: none"> • Hub FS3-1 – Full-Speed Hub on port 2 of Hub HS2-MTT
	<ul style="list-style-type: none"> • FS Drive on port 4 of Hub FS3-1
	<ul style="list-style-type: none"> • Keyboard on port 2 of FS3-1
3	<ul style="list-style-type: none"> • Hub FS3-2 - Full-Speed Hub on port 3 of Hub HS2-MTT
	<ul style="list-style-type: none"> • FS Video Camera on port 1 of Hub FS3-2
	<ul style="list-style-type: none"> • Mouse on port 2 of Hub FS3-2

5.1 Host Inspection

Examine the Host Under Test and identify all USB connections.

- Each and every USB port on the Host Under Test must be tested and pass all required tests. The Interoperability Tests must be run separately for each USB port on the Host Under Test. If the Host Under Test has an embedded hub, then the tests must also be run for any exposed embedded hub ports.

Select a USB port of the Host Under Test to run the Interoperability Tests on.

5.2 Host Interoperability Tests

1. SSP xHCI Controller Driver Installation

When testing the first port:

Ensure that the USB Host System has a clean install of the OS and the OS is configured as described in Section 1.2. Turn off the USB Host System and install the Host Under Test into the USB Host System if it is not already integrated.

- Ensure that the Interop Tree is not attached to the Host Under Test or embedded hub.

Power on the USB Host System. The SSP xHCI driver is installed with the initial install of the Windows 11 OS (for Windows 11 based systems).

When testing all other additional ports:

No driver install procedure should be necessary, as they use the driver installed for the first selected port. Ensure that Driver Verifier (applies to Windows 11 OS) has been configured as described in Section 1.2.

- Ensure that the Interop Tree is not attached to the Host Under Test or embedded hub.
- **Pass:**
 1. (The OS identifies and automatically installs the Host Under Test driver
OR
 2. The vendor-recommended install procedure installs the Host Under Test driver)
AND
 3. The Host Under Test driver is installed correctly and operates (no yellow exclamation point is displayed in device manager)
- **Fail:**
 1. The Host Under Test driver does not install
OR
 2. The Host Under Test driver is installed correctly but is non-operational (yellow exclamation point is displayed in device manager)

2. Peripheral Enumeration and Driver Installation

When testing the first port:

Do not install any drivers or software for any device in the Interop Tree prior to attaching the Interop Tree to the selected USB port under test.

Attach the Interop Tree by connecting Hub SSP1 into the selected USB port under test.

If the Host Under Test has an embedded hub and the selected USB port under test is an exposed embedded hub port, then unplug Hub SSP3 and Hub SSP4; re-plug Hub SSP4 directly into port one of Hub SSP2.

For each device in the Interop Tree follow the vendor-recommended install. Ensure that all drivers listed for each device in the Interop Tree match what is currently being tested under Driver Verifier (applies to Windows OS). To display the existing drivers being verified by Driver Verifier:

- Open the run box (press the Windows Key + R together).
- Type the command "Verifier".
- Select "Display existing settings"

When testing all other additional ports:

Attach the Interop Tree by connecting Hub SSP1 into the selected USB port under test.

No install procedure should be necessary, as they use the software installed for the first selected port.

- **Pass:**
 1. All Interop Tree devices enumerate
AND
 2. All Interop Tree devices drivers are installed either automatically or through the vendor recommended install procedure
AND
 3. All Interop Tree devices do not require a reboot
AND
 4. All Interop Tree devices are correctly identified by Device Manager and no yellow exclamation point is shown for any device
AND
 5. (Software installs without any software crashes or a blue screen
OR
 6. No software required)
- **Fail:**
 1. Any device cannot be installed because it requires driver installation or application software BEFORE the device is ever plugged in
OR
 2. Any device does not enumerate or blue screens during enumeration
OR
 3. Any device requires reboot
OR
 4. Any device is incorrectly identified by Device Manager or any device is flagged as not operational (yellow exclamation point)
OR
 5. Installation software crashes or causes a blue screen

3. Interoperability

- Operate all the devices in the Interop Tree.
- Whenever the **Host Interoperability Test Steps** state to operate all of the devices in the Interop Tree, this involves operating the following steps concurrently:
 - Operate the microphone in the Video Cameras by speaking into the microphone and viewing its input level
 - This can be found under Control Panel -> Hardware and Sound -> Sound under

the “Recording” tab.

- View streaming video from the SSP Video Camera
- View streaming video from the FS Video Camera

Poor video quality may be seen when Driver Verifier (applies to Windows OS) is enabled. If there was poor quality, continue testing with the Driver Verifier enabled for all Interoperability steps. Repeat all Interoperability steps with Driver Verifier off. USB-IF will compare Interoperability results with Driver Verifier Enabled and Disabled to determine Pass/Fail for certification.

- Transfer a 30+ MB file from the SSP Low Power Drive to the FS Drive
- Transfer a 1+ GB file from the HS Drive to the SSP Low Power Drive
- Watch video and listen to audio from monitor attached to USB Display Adapter
- Strike keys on the keypad
- Move the mouse
- Verify that all devices are operating concurrently. Verify the Device Speed using the USBView utility (USBView runs on Windows OS).
- **Pass:**
All Interop Tree devices operate correctly
- **Fail:**
One or more Interop Tree devices fail to operate correctly

4. All Devices Tests

- Run tests 1-8 as specified in Chapter 7

5. Topology Change 1

- Stop all Interop Tree device operation! Close any software that is used for any Interop Tree device operation and close the “Recording” tab window.

- Operate the following devices concurrently:
 - Operate the microphone(s)
 - View streaming video from the SSP Video Camera
 - Transfer a 30+ MB file from the SSP Low Power Drive to the FS Drive
 - Transfer a 1+ GB file from the HS Drive to the SSP Low Power Drive
 - Watch video from monitor and listen to audio attached to USB Display Adapter
 - Strike keys on the keypad
- While operating the devices, detach the Hub FS3-2 from port 3 on Hub HS2-MTT.
- Reattach Hub FS3-2 to port 2 on Hub HS3-STT as shown in Figure 5-3 and Figure 5-4.

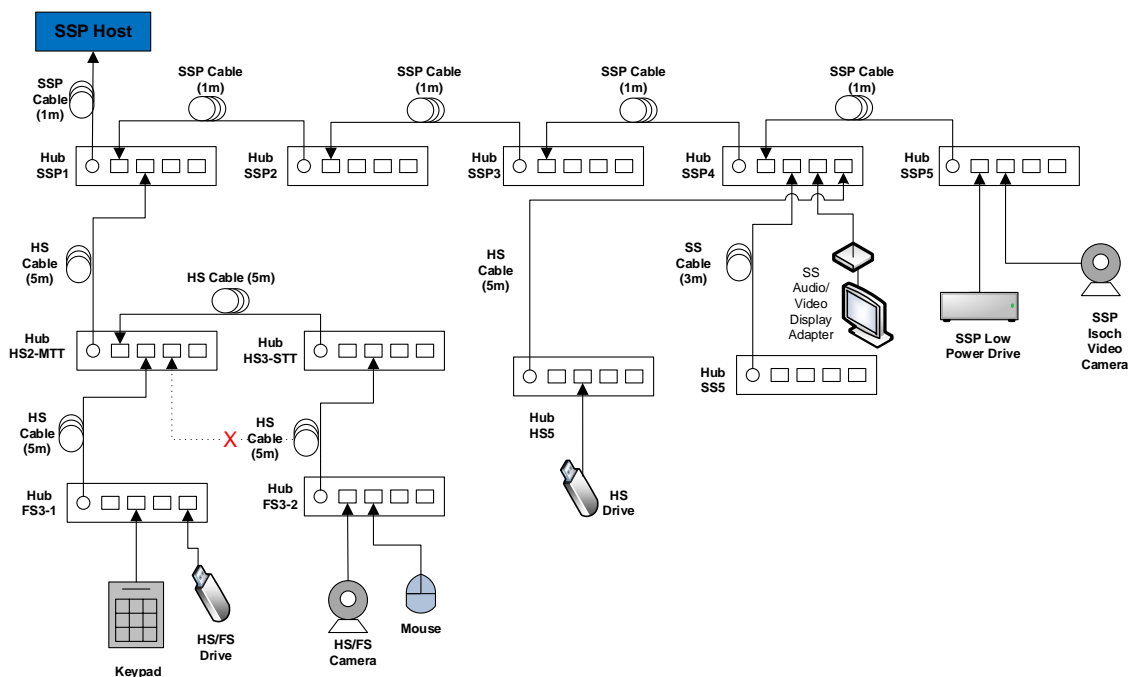


Figure 5-3: Topology Change 1

Tree device operation and close the “Recording” tab window.

- Operate the following devices concurrently:
 - View streaming video from the SSP Video Camera
 - View streaming video from the HS Video Camera
 - Transfer a 1+ GB file from the HS Drive to the SSP Low Power Drive
 - Watch video and listen to audio from monitor attached to USB Display Adapter
 - Move the mouse
- While operating the devices, detach the Hub FS3-1 from port 2 on Hub HS2-MTT.
- Reattach Hub FS3-1 to port 1 on Hub HS3-STT as shown in Figure 5-5 and Figure 5-6.

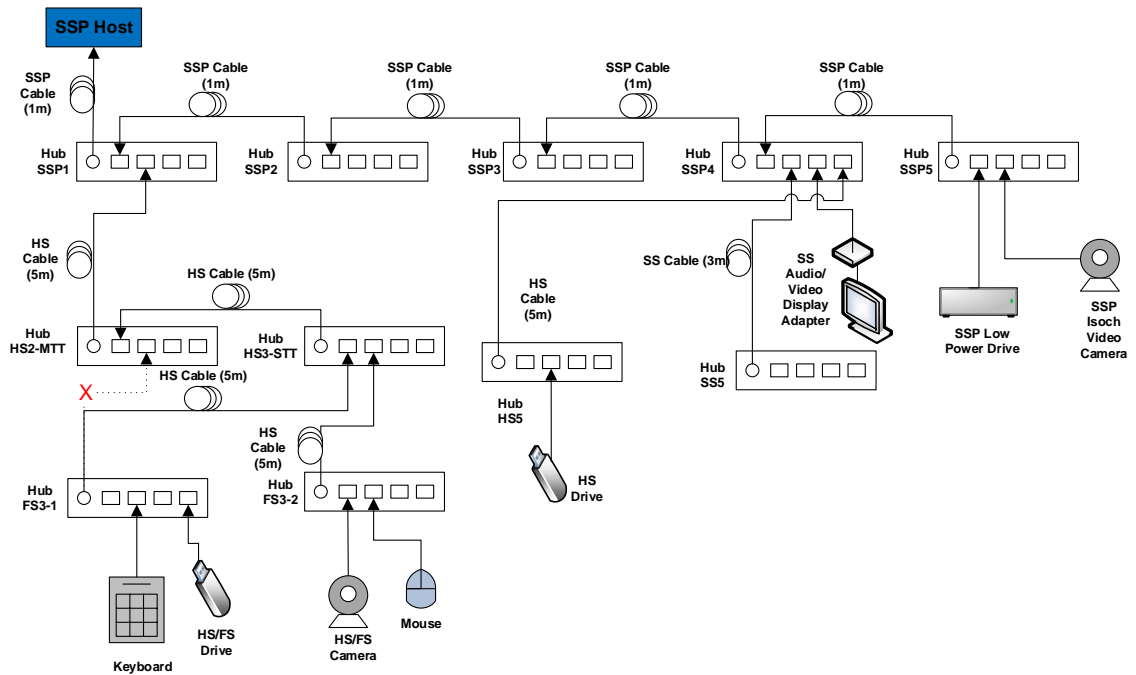


Figure 5-5: Topology Change 2

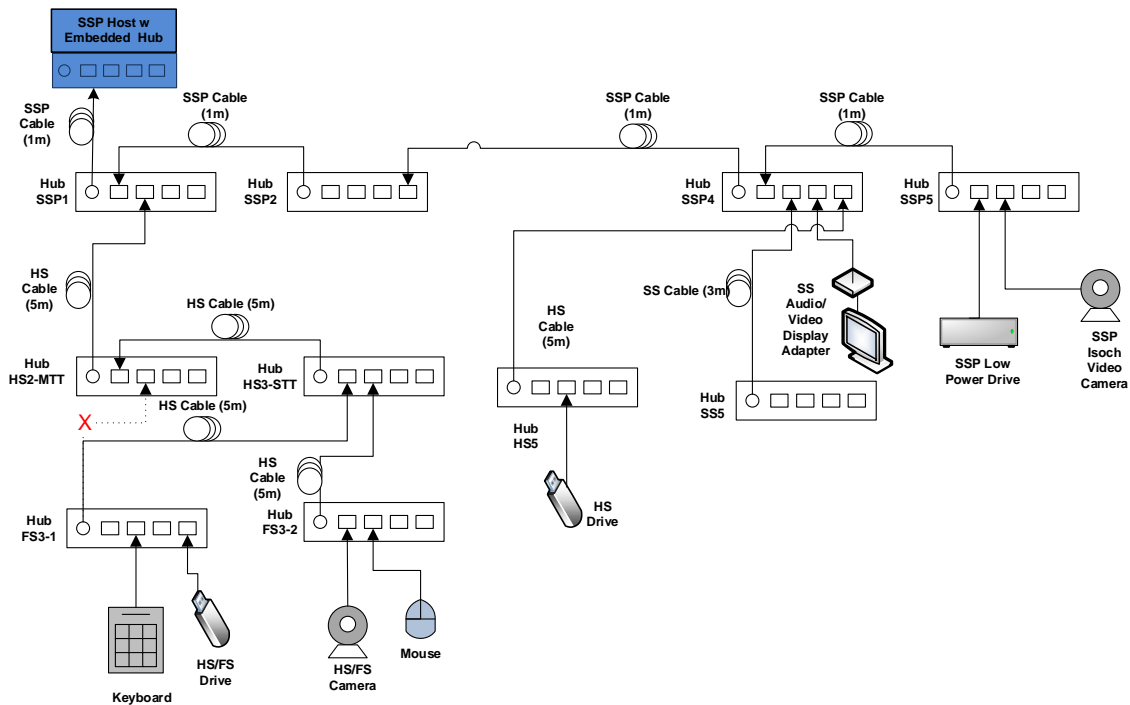


Figure 5-6: Topology Change 2 (embedded hub)

- Verify that both file transfers continue to take place.
- Verify that the SSP Video Camera, HS Video Camera, and mouse continue to function.
- Operate the microphone(s).
 - If the microphones do not work, this is acceptable. The current configuration may require more bandwidth than Hub HS3-STT can provide. The test setup must be restored to a configuration that has enough bandwidth by following the steps below:

Detach Hub FS3-1 from port 1 on Hub HS3-STT and reattach the Hub FS3-1 back to port 2 on Hub HS2-MTT. This should set the configuration back to what is displayed in Figure 5-3 and Figure 5-4.
- Operate all the devices in the SSP Interop Tree. Verify that all devices are operating concurrently.
- **Pass:**
 1. After the topology change the file transfers continued to take place
AND
 2. After the topology change the SSP Video Camera, HS Video Camera, and mouse continue to function
AND
 3. All Interop Tree devices operate correctly
- **Fail:**
 1. After the topology change any file transfer was cancelled
OR
 2. After the topology change the SSP Video Camera, HS Video Camera, or mouse stopped functioning

OR

3. One or more Interop Tree devices fail to operate correctly

8. All Devices Tests (N/A)

- Not necessary for this test procedure.

9. Active ExpressCard Detach (ExpressCard xHCI)

- This test is only run if the Host Under Test is an ExpressCard host.
- Operate all the devices in the Interop Tree. Verify that all devices are operating concurrently.
- While operating the devices, detach the Host Under Test ExpressCard from the USB Host System.
- Reconnect the Host Under Test ExpressCard to the same ExpressCard slot in the USB Host System.
- Close any software that is used for any Interop Tree device operation and close the "Recording" tab window.
- Operate all the devices in the Interop Tree. Verify that all devices are operating concurrently.
- **Pass:**
All Interop Tree devices operate correctly
- **Fail:**
 1. One or more Interop Tree devices fail to operate correctly
OR
 2. System blue screens / locks up

10. Interoperability without Driver Verifier

- Run this test only if there was poor video or audio quality when operating all of the devices in the Interop Tree.
- Disable Driver Verifier:
 - Open the run box (press the Windows Key + R together)
 - Type the command "Verifier"
 - Select "Delete Existing Settings" and press Finish. Press "Yes" and restart the machine.
- Operate all the devices in the Interop Tree. Verify that all devices are operating concurrently.
- **Pass:**

All Interop Tree devices operate correctly

- **Fail:**
One or more Interop Tree devices fail to operate correctly

11. Function Remote Wake

- Connect a function-remote-wake capable SuperSpeedPlus device to one of the root ports.
- Put the system into sleep
- Wake up the system by the function-remote-wake interface on the SuperSpeedPlus device
- **Pass:**
The system wakes up normally.
- **Fail:**
The system has any abnormal behaviors.

12. Tree Enumeration on Each Exposed Port

- Plug in the interop tree to each exposed port of host under test, check all devices are enumerated correctly.
- **Pass:**
The system enumerates all devices
- **Fail:**
Any devices in the tree cannot be enumerated.

13. Each Host Testing

- If the system has multiple xHCI hosts built in, tests 1-12 should be performed on each host.

14. Exposed Port Testing

- Connect a SuperSpeedPlus device other than a Hub to one of exposed ports of xHCI host under test. Run tests 1-8 as specified in Chapter 7
- Repeat this test for each root port of the host.
- **Pass:**
All the tests 1-8 of Chapter 7 PASS
- **Fail:**
If any of the tests 1-8 of Chapter 7 FAIL

5.3 Host U1/U2 Test Steps

- Connect a SuperSpeedPlus hub to an exposed host port.
 - Connect a KGD to a downstream hub port with a USB Protocol Analyzer between the hub and device.
 - Trace USB traffic including idle device time and normal KGD operation.
 - Verify that the link successfully enters U1 or U2.
 - Verify that the hub correctly sends a deferred packet to the KGD and to the host.
 - Verify that the KGD correctly sends an ERDY after the deferred packet.
 - Verify that the host re-sends the packet with the deferred bit cleared.
 - Verify that the KGD completes the re-sent packet.
- **Pass:**
 1. Link successfully enters U1 or U2
AND
 2. Link returns to U0 and the original packet that was sent during U1/U2 is successfully completed
 - **Fail:**
 1. Link remains in U0
OR
 2. Re-Sent packet does not complete correctly

5.4 Host LPM Tests

Download the [MUTT Software Package](#) from Microsoft. Double click and install the MSI file. After the install finishes the contents of the package will most likely be found under

C:\Program Files\USBTest\

Choose either the x86 or the x64 folder depending upon the system OS. Inside the folder select the tool labeled **UsbLPM**.

Selective Suspend must be disabled when using the Usb LPM Tool. Go to Control Panel -> Power Options -> Change Plan Settings -> Change advanced power settings. Under "USB settings" choose "USB selective suspend setting" and set it to "Disabled".

1. Inactivity U1/U2 Entry Test - Hub Only

Open the UsbLPM application

- Configure the hub as shown in Figure 5-7 and attach it to SSP xHCI port.

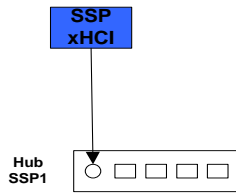


Figure 5-7: Hub Only Topology

Let the hub remain inactive for a few seconds and observe whether it enters U1 or U2.

- **Pass:**
Hub enters U1 or U2
- **Fail:**
Hub remains in U0

2. Inactivity U1/U2 Entry Test – Hub and U1/U2 Enabled Device

- Without detaching hub from the host, attach a SuperSpeedPlus, U1/U2 enabled device as shown in Figure 5-8.

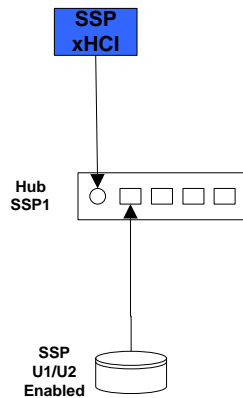


Figure 5-8: Hub and U1/U2 Enabled Device

Allow the devices to remain inactive. Observe the LPM tool, the device should enumerate and both the hub and the device should enter U1 or U2.

- **Pass:**
 1. Both device and hub enter U1 or U2
OR
 2. The hub enters U1 and the device enters U2
- **Fail:**
 1. Either the hub and/or device remain in U0
OR
 2. The device enters U1 while the hub enters U2 or U3
OR
 3. The device enters U2 while the hub enters U3

3. Inactivity U1/U2 Entry Test – Hub and U1/U2 Disabled Device

- Without detaching hub from the host, attach a SuperSpeedPlus, U1/U2 disabled device as shown in Figure 5-9.

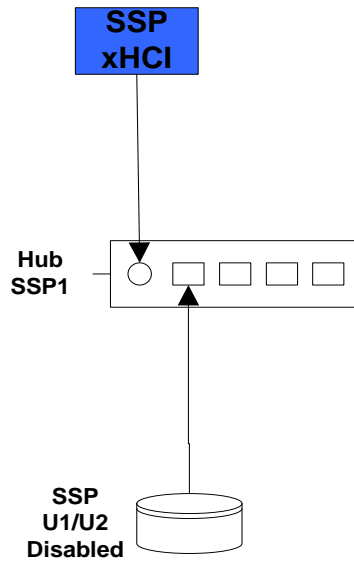


Figure 5-9: Hub and U1/U2 Disabled Device

Allow the devices to remain inactive. Observe the LPM tool, the device should enumerate and the hub should not enter U1 or U2 (assuming device remains in U0).

- **Pass:**
Hub remains in U0 with device
- **Fail:**
Hub enters U1, U2 or U3 while device remains in U0

4. Active LPM Test

The USB LPM Tool has an active mode where it can request the device and hub to enter U1 or U2 and report a pass/fail. Because this test does not necessarily exhaust all possibilities during U1/U2 testing it should be run 10 times.

- Attach the configuration shown in Figure 5-8 to the host.
- In the Mode of operation box select the option “testing”.
- Select the SuperSpeedPlus hub from the list as shown in Figure 5-10.
- Click the “Start” button on the right.
- Observe the test report for failures or errors during the test cases.
- Repeat this test 9 more consecutive times

- **Pass:**
All 10 consecutive test cases report “pass”
- **Fail:**
1 or more consecutive test cases reported a “fail” or “error”

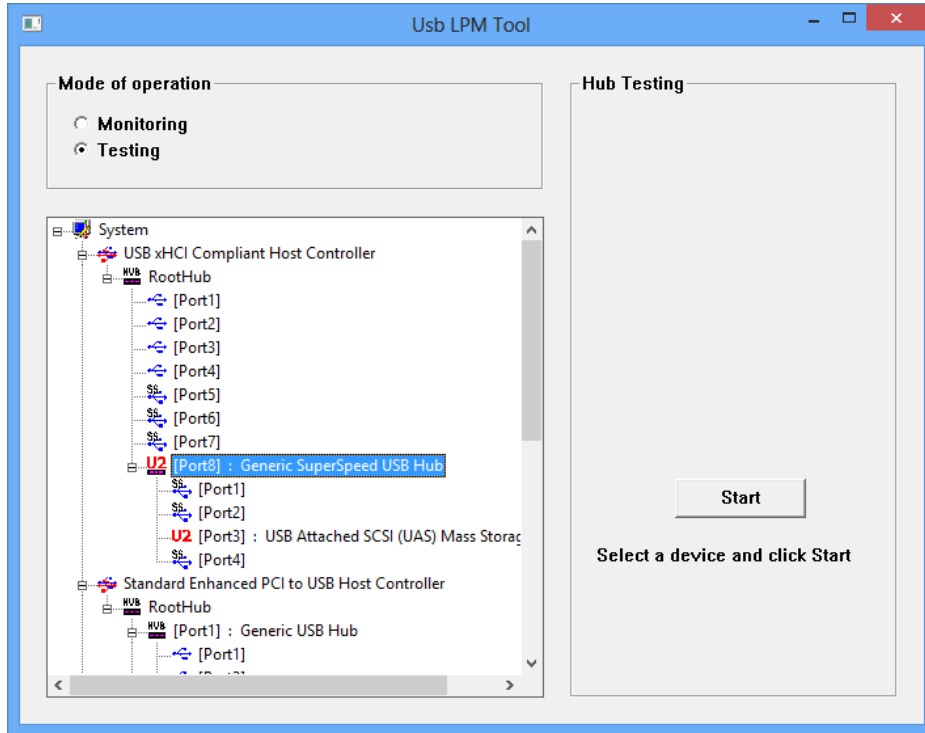


Figure 5-10: Usb LPM Tool Interface

6 Compound Devices

A compound device is any device that contains a hub with at least one device or hub permanently attached downstream. Because a compound device adds hubs to the tree it is necessary to adjust test topologies so the maximum cascaded hub count does not exceed 5.

6.1 Determine Compound Device Configuration

Determine the following about a compound device:

- Internal hub depth
- Hub depth of any downstream ports
- Peripheral number and types (if any)

6.2 Peripheral Test Topology for Compound Devices

1. Compound Device Test Tree - Initial Topology

If the compound device contains only one hub, construct the tree as shown in Figure 6-1, removing SSP2. If the compound contains two hubs, construct the tree in accordance with Figure 6-2, removing both SSP2 and SSP3. In the case where a test system contains an embedded hub replace SSP1 with the embedded hub as shown in Figure 6-3 and Figure 6-4.

If a compound device has exposed ports, attach the SuperSpeedPlus low-power drive to one of the ports on the last hub tier of the compound device. Otherwise connect it to hub SSP5.

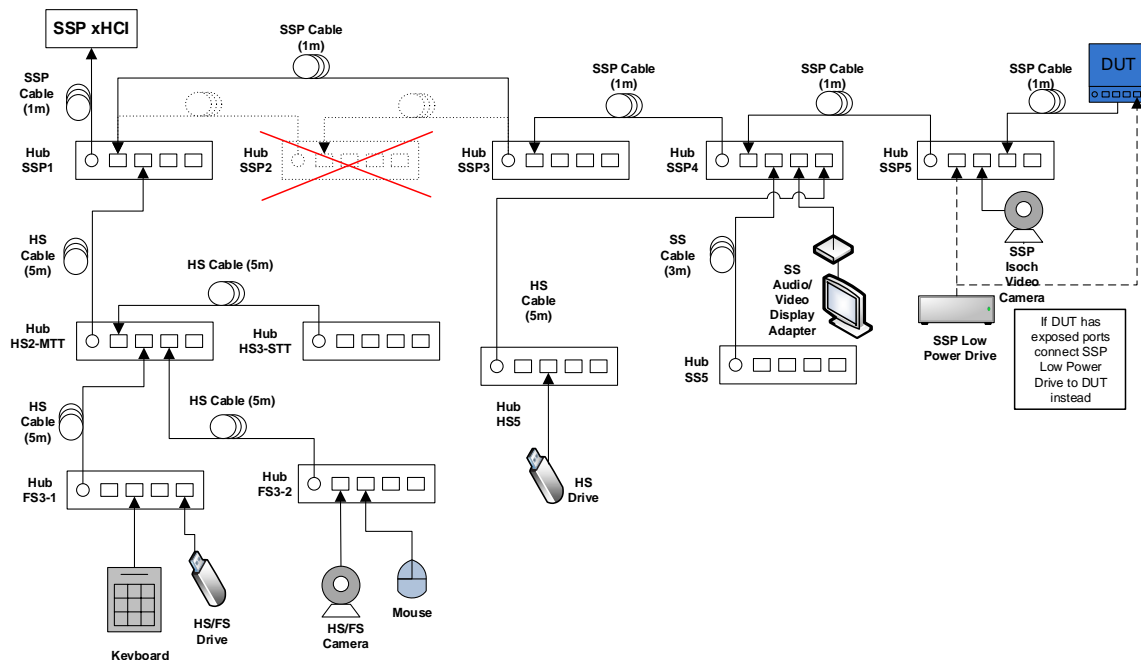


Figure 6-1: Interop Tree with Compound Device

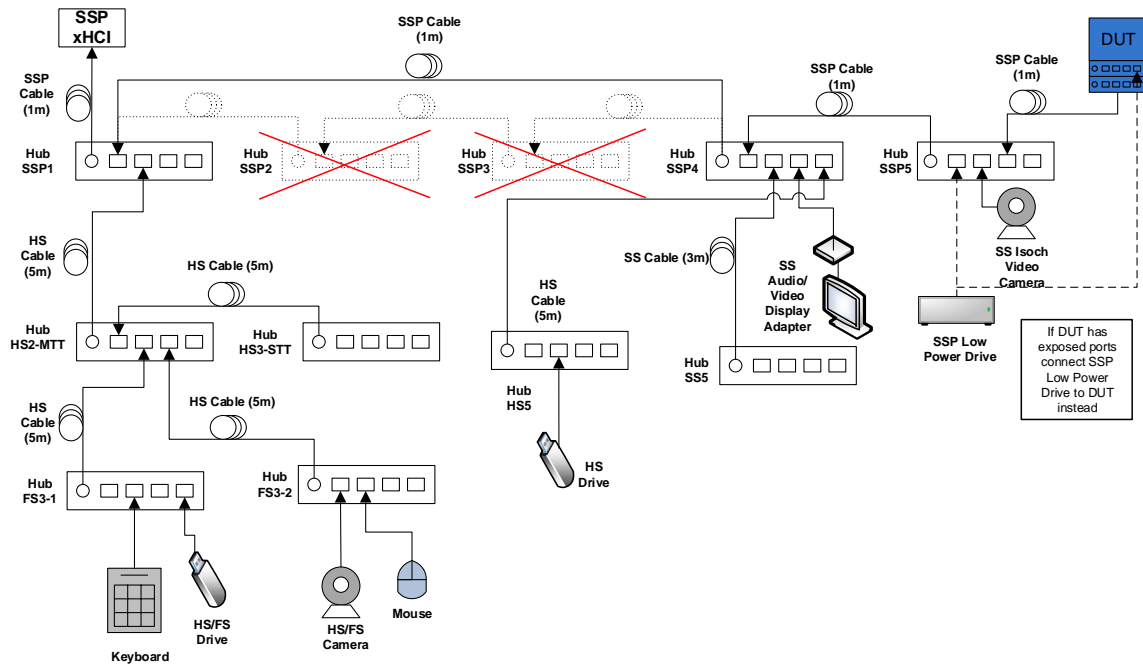


Figure 6-2: Interop Tree with Dual-Hub Compound Device

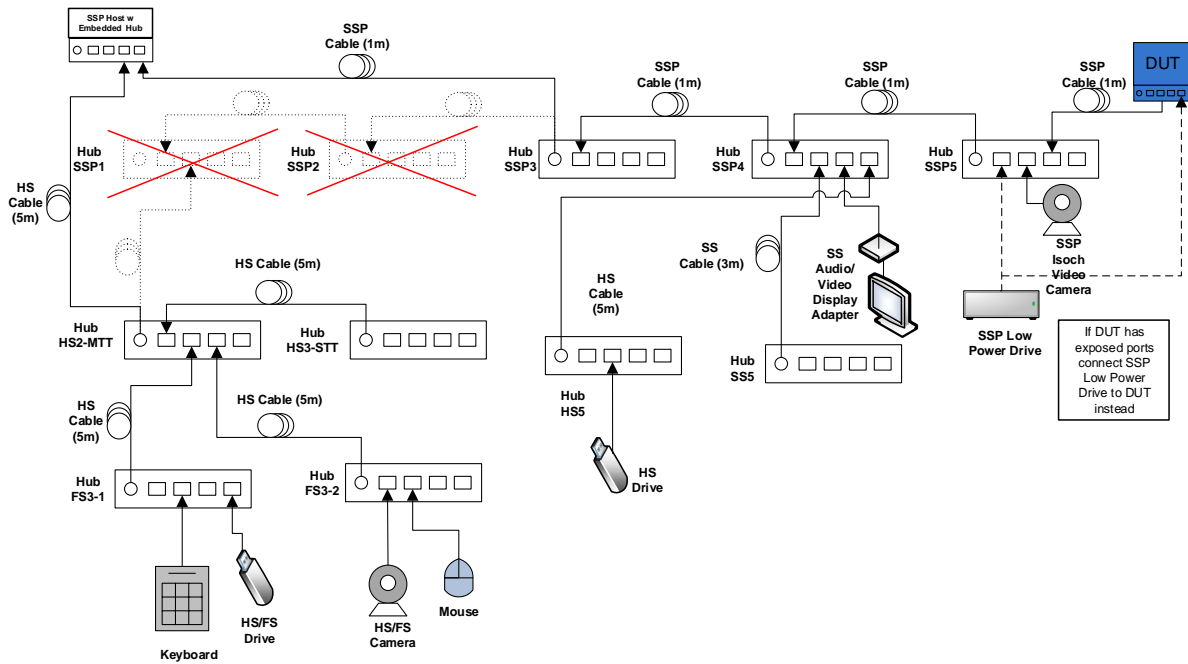


Figure 6-3: Interop Tree with Compound Device - Embedded Hub

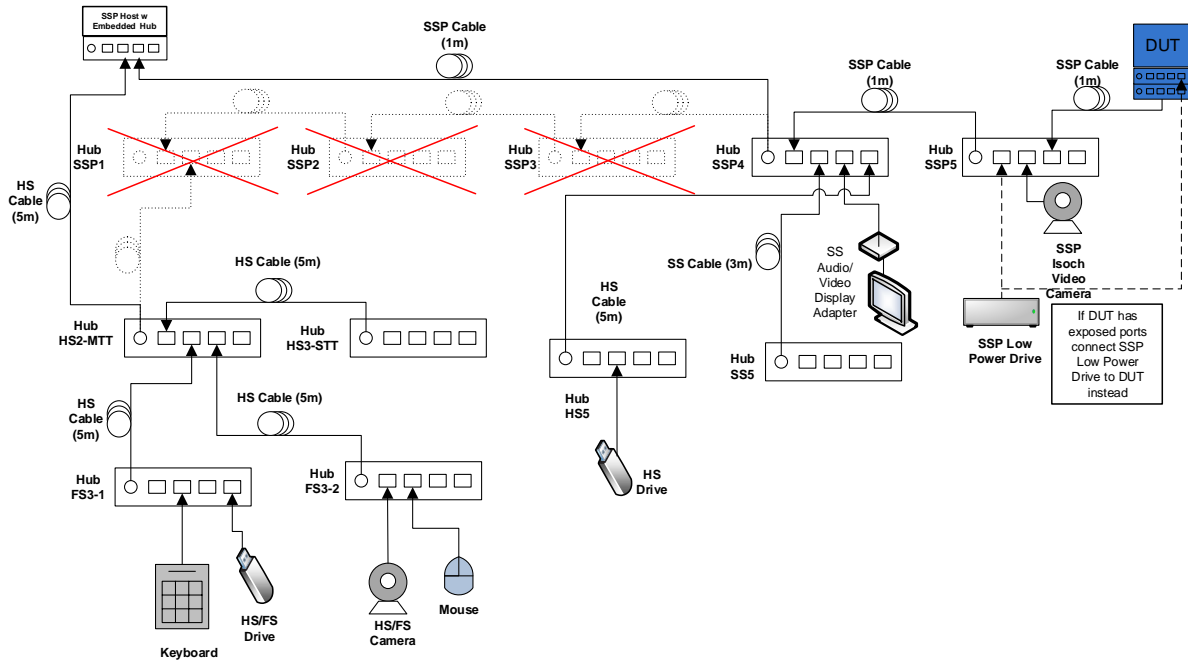


Figure 6-4: Interop Tree with Compound Device (Dual-Hub) - Embedded Hub

2. SSP xHCI Controller Driver Installation

Ensure that the USB Host System has a clean install of the OS and the OS is configured as described in Section 1.2. Turn off the USB Host System and install the SSP xHCI controller into the USB Host System if it is not already integrated.

- Ensure that the Interop Tree is not attached to the SSP xHCI controller or embedded hub.

Power on the USB Host System. One of three scenarios is acceptable for the USB Host System to install the SSP xHCI controller driver:

- The OS identifies and automatically installs the SSP xHCI controller driver.
- The OS displays that it cannot find the driver for the SSP xHCI controller. Follow the vendor-recommended install procedure to complete the driver install.
- If the SSP xHCI controller is already integrated into the USB Host System, then the OS displays nothing, as it has already attempted install for the SSP xHCI controller with the initial install of the OS. Follow the vendor-recommended install procedure to complete the driver install.
- **Pass:**
 1. (The OS identifies and automatically installs the SSP xHCI controller driver
OR
 2. The vendor-recommended install procedure installs the SSP xHCI controller driver)
AND
 3. The SSP xHCI controller driver is installed correctly and operates (no yellow exclamation point is displayed in device manager)

- **Fail:**
 1. The SSP xHCI controller driver does not install
OR
 2. The SSP xHCI controller driver is installed correctly but is non-operational (yellow exclamation point is displayed in device manager)

3. Peripheral Enumeration and Driver Installation

Do not install any drivers or software for any device in the Interop Tree prior to attaching the Interop Tree to the SSP xHCI controller.

Attach the Interop Tree by connecting SSP1 into any port on the SSP xHCI controller.

- If the SSP xHCI controller has an embedded hub, then remove Hub SSP1 and attach HS2-MTT and SSP4 into the embedded hub.

For each device in the Interop Tree (including the DUT) follow the vendor-recommended install procedure. Ensure that all drivers listed for each device in the SSP Interop Tree match what is currently being tested under Driver Verifier. To display the existing drivers being verified by Driver Verifier:

- Open the run box (press the Windows Key + R together).
 - Type the command "Verifier".
 - Select "Display existing settings"
- **Pass:**
 1. All Interop Tree devices enumerate
AND
 2. All Interop Tree devices drivers are installed either automatically or through the vendor recommended install procedure
AND
 3. All Interop Tree devices do not require a reboot
AND
 4. All Interop Tree devices are correctly identified by Device Manager and no yellow exclamation point is shown for any device
AND
 5. (Software installs without any software crashes or a blue screen
OR
 6. No software required)
 - **Fail:**
 1. Any device cannot be installed because it requires driver installation or application software BEFORE the device is ever plugged in
OR
 2. Any device does not enumerate or blue screens during enumeration
OR
 3. Any device requires a reboot
OR
 4. Any device is incorrectly identified by Device Manager or any device is flagged as not operational (yellow exclamation point)
OR
 5. Installation software crashes or causes a blue screen

4. Interoperability

- Operate all the devices in the Interop Tree.
 - Whenever the **Compound Device Interoperability Test Steps** state to operate all of the devices in the SuperSpeed Interop Tree, this involves operating the following steps concurrently:
 - Operate the microphone in the Video Cameras by speaking into the microphone and viewing the input sound monitor
 - This can be found under Control Panel -> Hardware and Sound -> Sound under the "Recording" tab
 - View streaming video from the SSP Video Camera
 - View streaming video from the FS Video Camera

Poor video quality may be seen when Driver Verifier (Driver Verifier applies to Windows OS) is enabled. If there was poor quality, continue testing with the Driver Verifier enabled for all Interoperability steps. Repeat all Interoperability steps with Driver Verifier off. USB-IF will compare Interoperability results with Driver Verifier Enabled and Disabled to determine Pass/Fail for certification.
 - Transfer a 30+ MB file from the SSP Low Power Drive to the FS Drive
 - Transfer a 1+ GB file from the HS Drive to the SSP Low Power Drive
 - Watch video and listen to audio from monitor attached to USB Display Adapter
 - Operate the Compound Device Under Test
 - If the DUT contains SSP Mass Storage Device, then transfer a 2GB+file from the SSP Low Power Drive to the DUT and transfer a 1GB+file from the DUT to the HS Drive
 - If the DUT does not have a Mass Storage Device, then ensure the operation on the DUT overlaps over the period of time that other devices in the tree are operating.
 - Strike keys on keypad
 - Move the mouse
- Verify that all devices are operating concurrently. Verify the Device Speed using the USBView utility (USBView runs on Windows OS).
- Pass:

All Interop Tree devices operate correctly

- **Fail:**
One or more Interop Tree devices fail to operate correctly

5. All Devices Tests

- Run tests 1-8 as specified in Chapter 7

6. Topology Change 1

- Operate all the devices in the Interop Tree except the Device Under Test.
- While operating the devices, detach the Device Under Test from Hub SSP5
- While operating the devices, reattach the Device Under Test to port 4 on Hub SS5 as shown in Figure 6-5 through Figure 6-12.

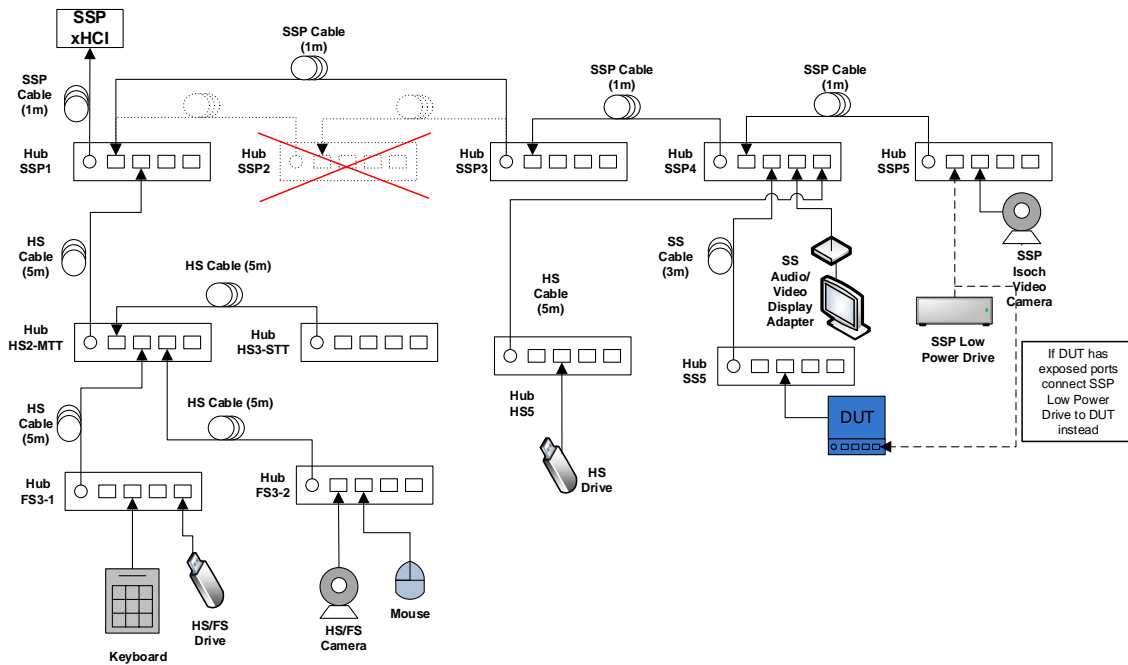


Figure 6-5: Interop Tree with Compound Device - Topology Change 1

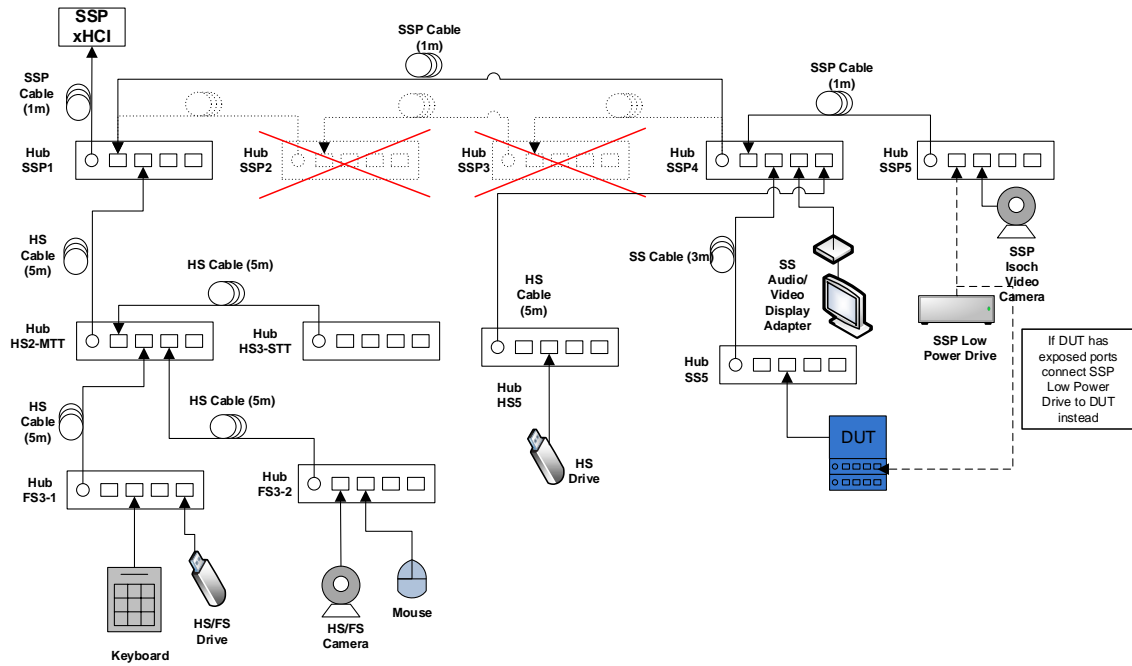


Figure 6-6: Interop Tree with Dual-Hub Compound Device - Topology Change 1

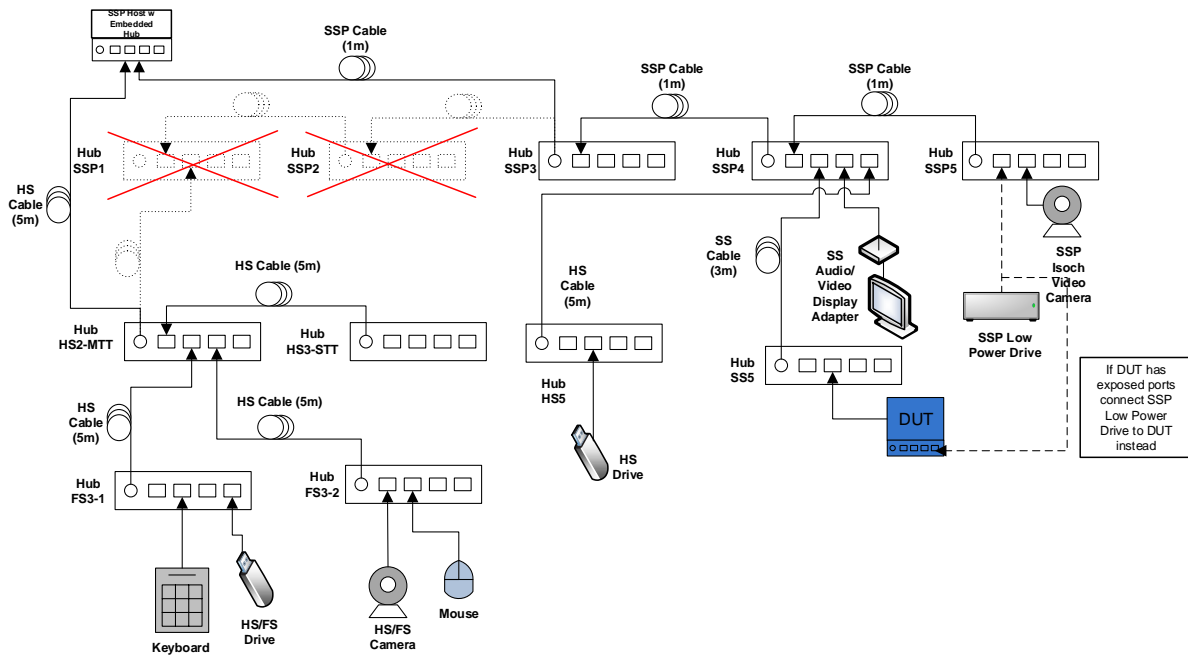


Figure 6-7: Interop Tree with Compound Device - Embedded Hub - Topology Change 1

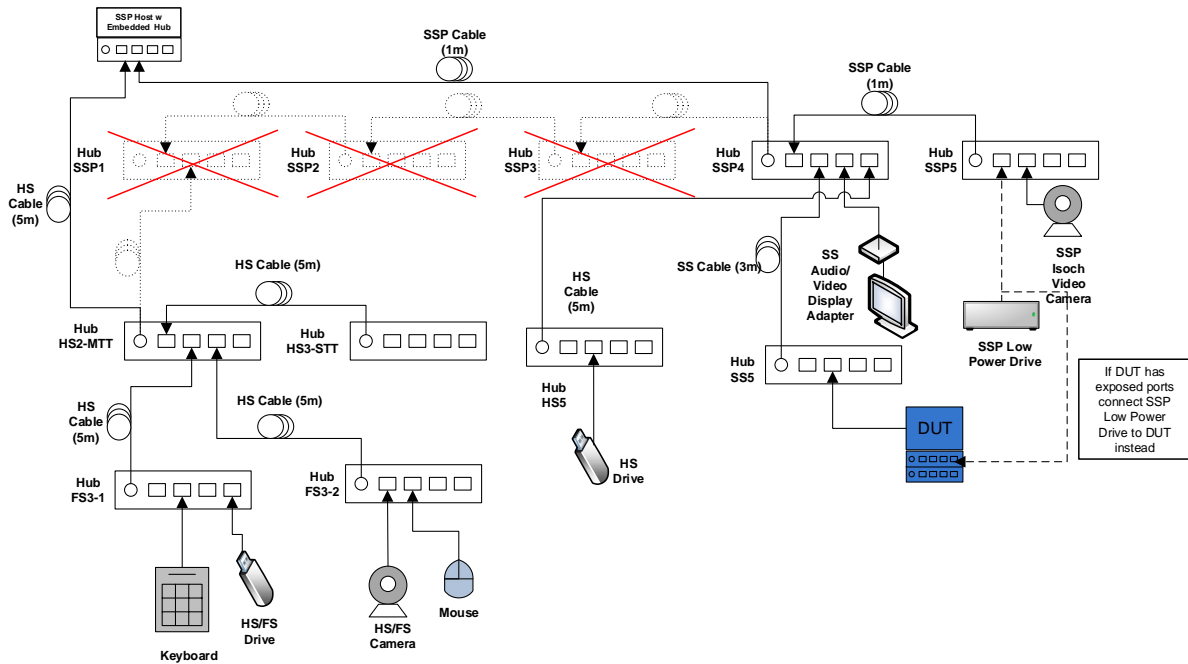


Figure 6-8: Interop Tree with Compound Device (Dual-Hub) - Embedded Hub - Topology Change 1

- Verify that all devices except for the Device Under Test continue to operate concurrently.
- Operate the Device Under Test.
- **Pass:**
All Interop Tree devices operate correctly
- **Fail:**
One or more Interop Tree devices fail to operate correctly

7. All Devices Tests

- Run tests 1-8 as specified in Chapter 7

8. Topology Change 2

- Operate all the devices in the Interop Tree except the Device Under Test.
- While operating the devices, detach the Device Under Test from port 2 on Hub SS5.
- While operating the devices, attach the Device Under Test to port 1 on Hub HS5 as shown below in Figure 6-9 through Figure 6-12.

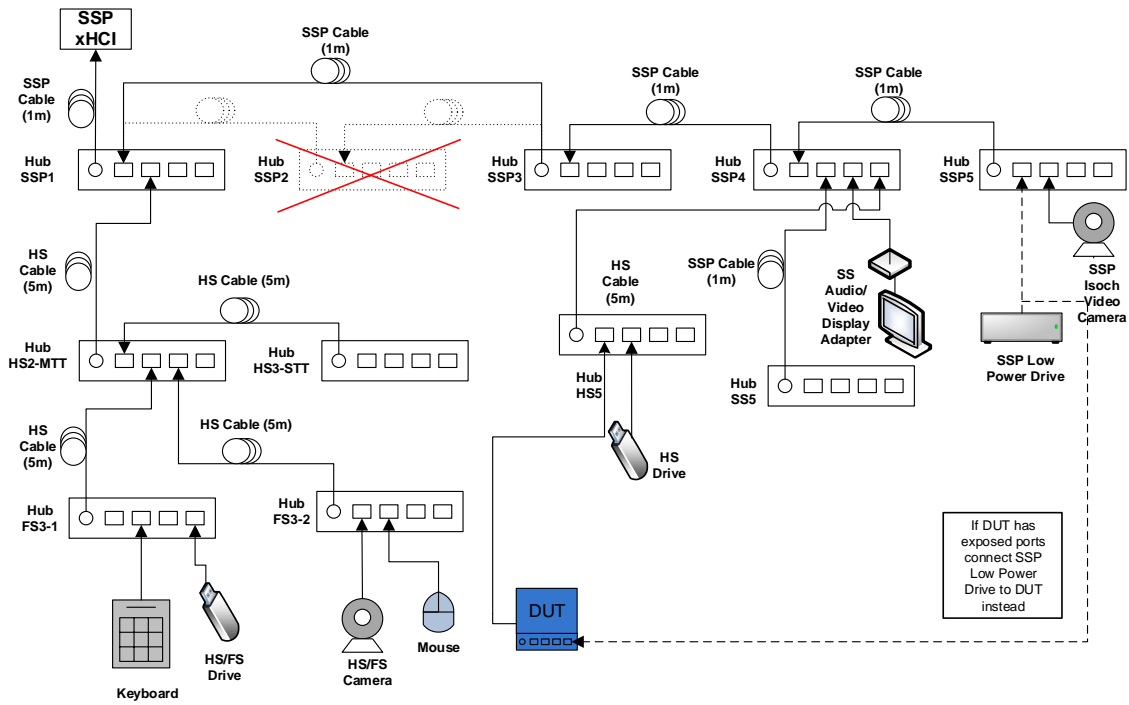


Figure 6-9: Interop Tree with Compound Device - Topology Change 2

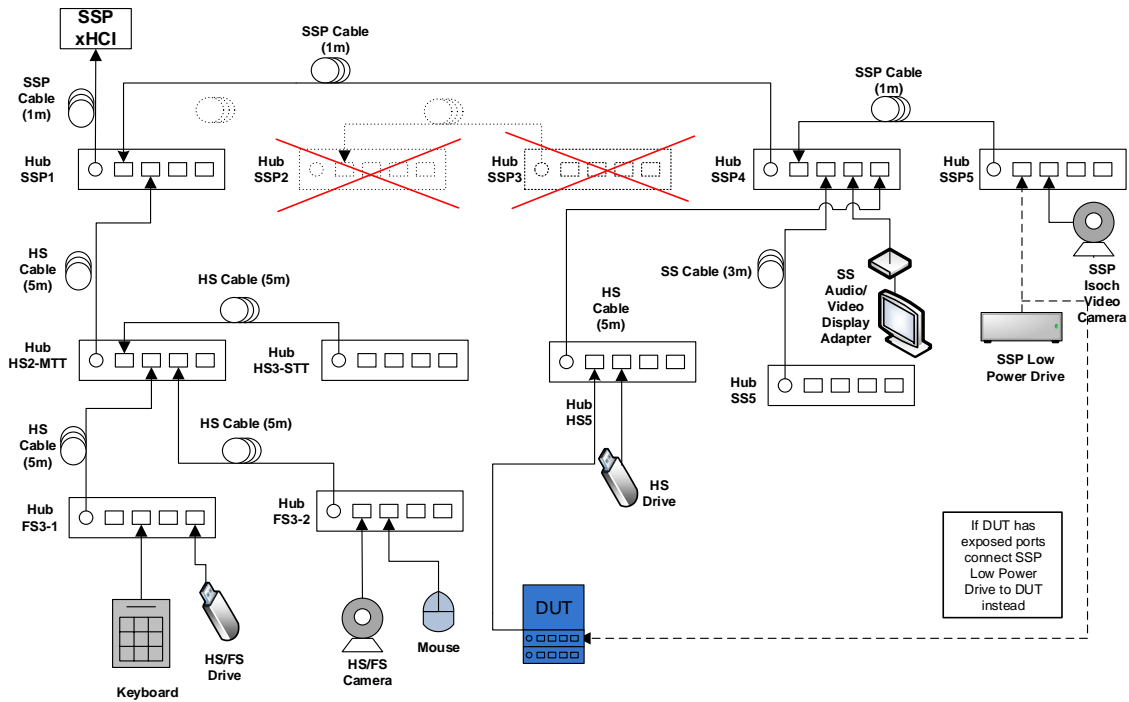


Figure 6-10: Interop Tree with Dual-Hub Compound Device - Topology Change 2

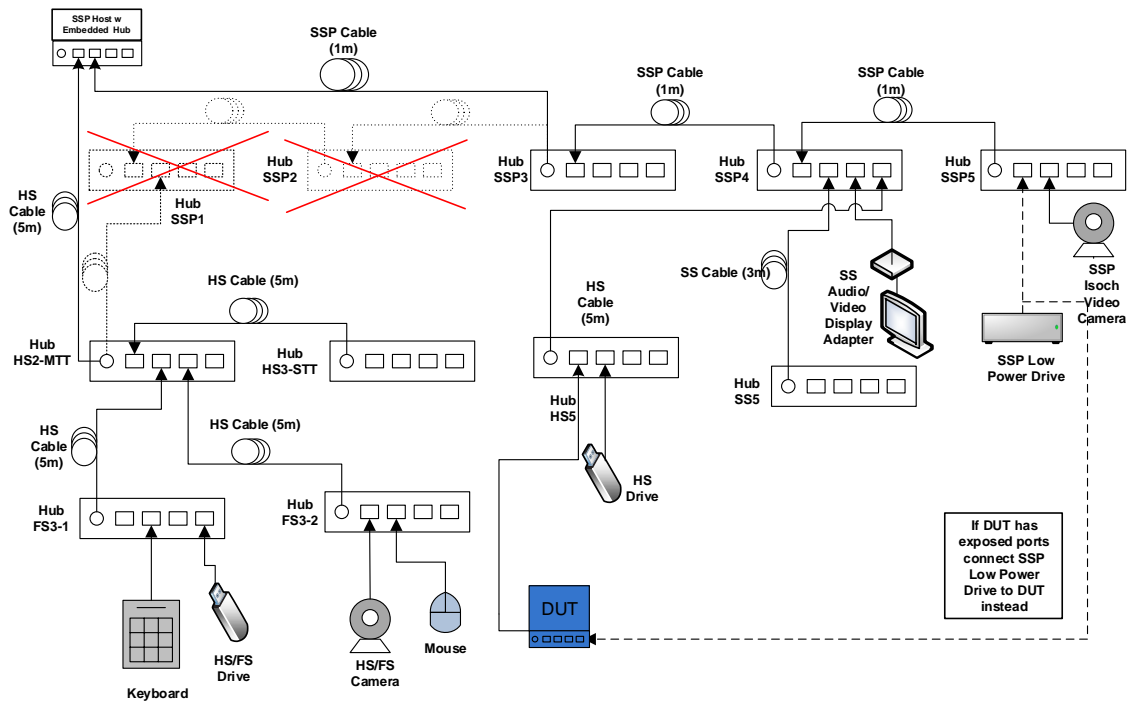


Figure 6-11: Interop Tree with Compound Device - Embedded Hub - Topology Change 2

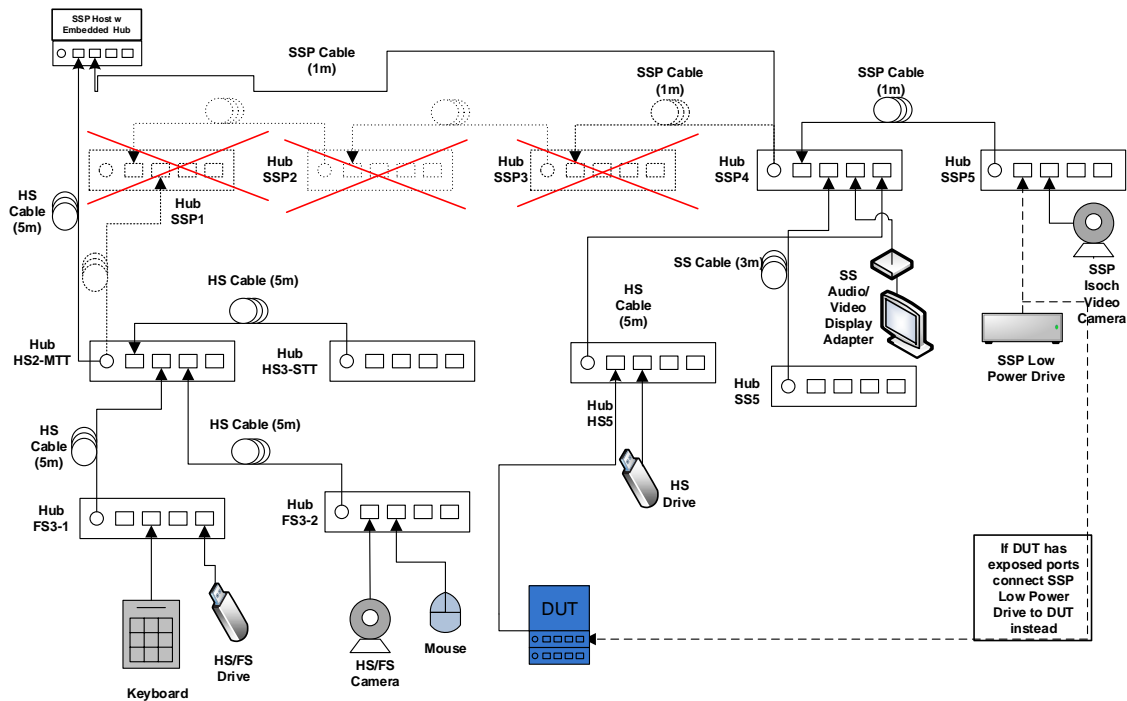


Figure 6-12: Interop Tree with Compound Device (Dual-Hub) - Embedded Hub - Topology Change 2

- Verify that all devices except for the Device Under Test are continuing to operate concurrently.
- Operate the Device Under Test.
- Operate all the devices in the Interop Tree. Verify that all devices are operating concurrently.
- **Pass:**
All Interop Tree devices operate correctly
- **Fail:**
One or more Interop Tree devices fail to operate correctly

9. Topology Change 3 (For Low/Full-speed capable Compound USB Devices only)

- Operate all the devices in the Interop Tree except the Device Under Test.
- While operating the devices, detach the Device Under Test from port 1 on Hub HS5.
- While operating the devices, attach the Device Under Test to port 3 on Hub FS3-1 as shown below in Figure 6-13 through Figure 6-16.

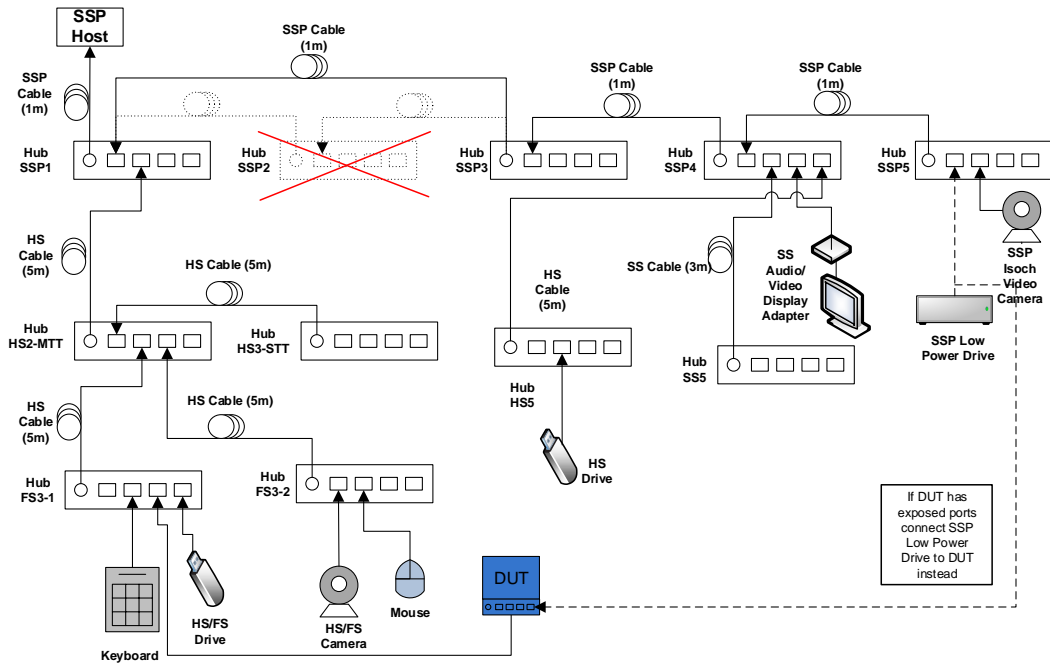


Figure 6-13: Interop Tree with Compound Device - Topology Change 2

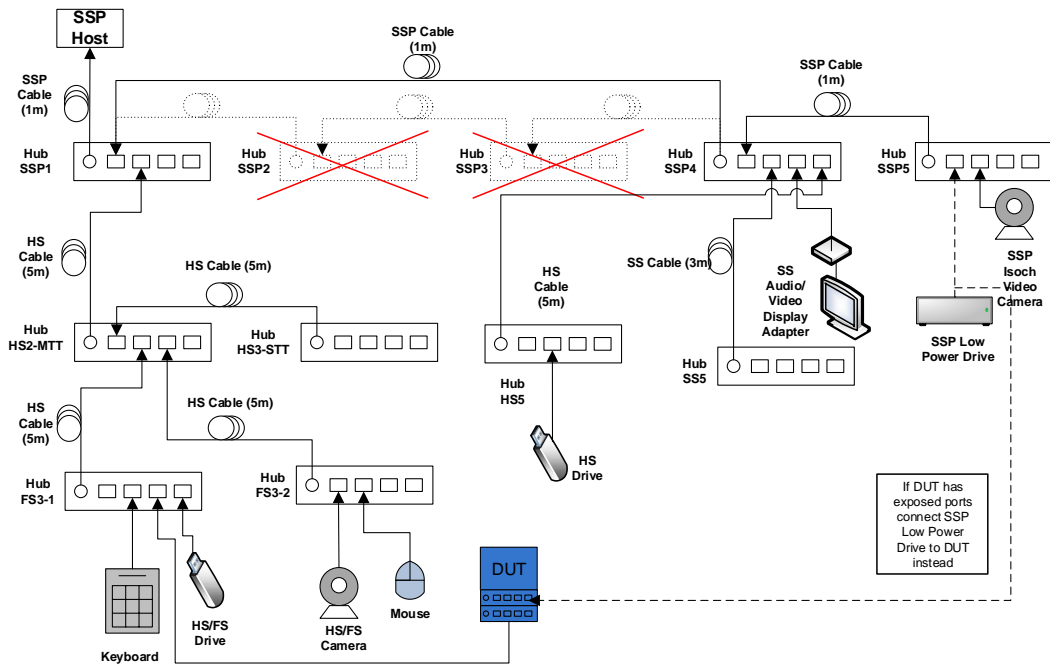


Figure 6-14: Interop Tree with Dual-Hub Compound Device - Topology Change 2

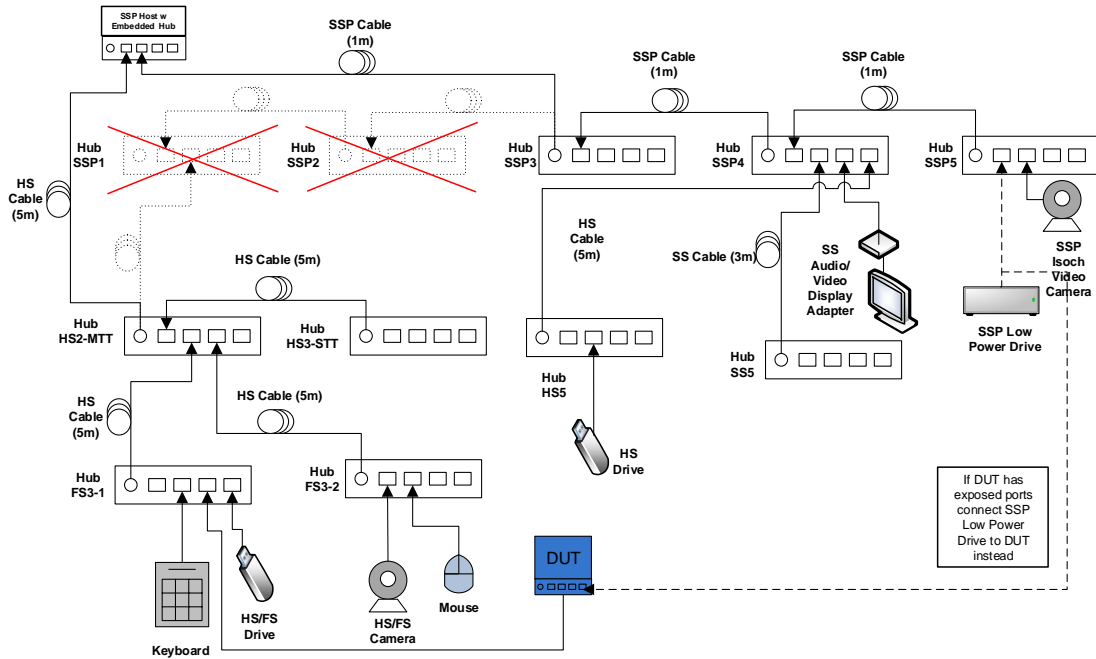


Figure 6-15: Interop Tree with Compound Device - Embedded Hub - Topology Change 2

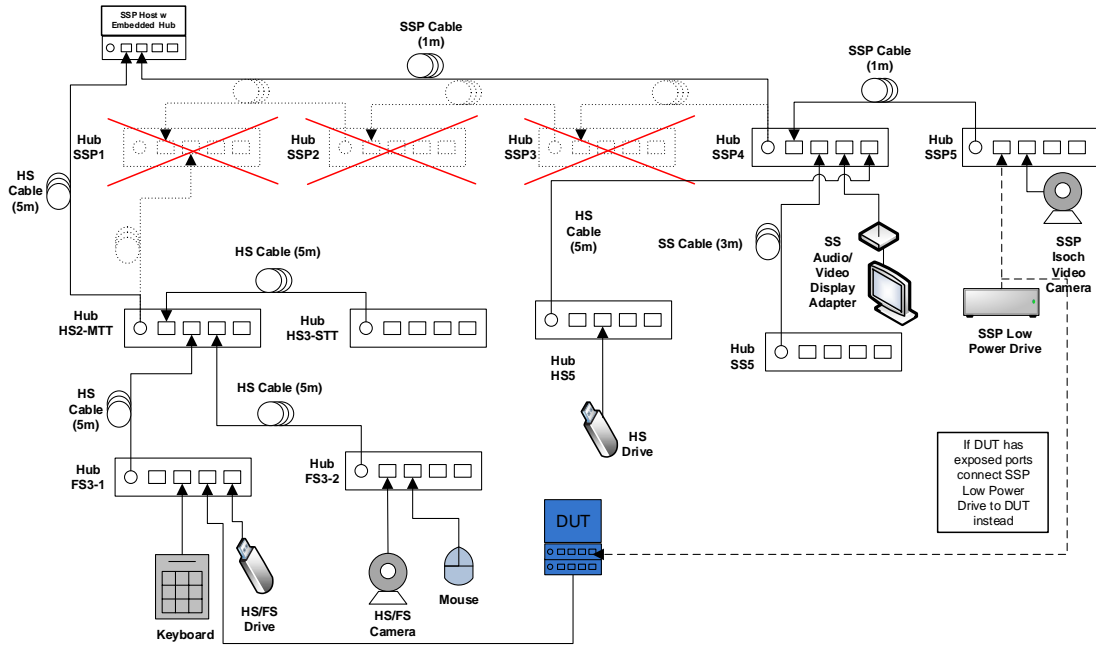


Figure 6-16: Interop Tree with Compound Device (Dual-Hub) - Embedded Hub - Topology Change 2

- Verify that all devices except for the Device Under Test are continuing to operate concurrently.

- Operate the Device Under Test.
- Operate all the devices in the Interop Tree. Verify that all devices are operating concurrently.
- **Pass:**
All Interop Tree devices operate correctly
- **Fail:**
One or more Interop Tree devices fail to operate correctly

10. Interoperability without Driver Verifier

- Run this test only if there was poor video or audio quality when operating all of the devices in the Interop Tree. Run all interoperability test steps including topology change 1, topology change 2 and topology change 3.
- Disable Driver Verifier:
 - Open the run box (press the Windows Key + R together)
 - Type the command "Verifier"
 - Select "Delete Existing Settings" and press Finish. Press "Yes" and restart the machine.
- Operate all devices in the Interop Tree. Verify that all devices are operating concurrently.
- **Pass:**
All Interop Tree devices operate correctly. For certification purposes USB-IF will compare results between Driver Verifier Enabled and Driver Verifier Disabled to determine Pass/Fail.
- **Fail:**
One or more Interop Tree devices fail to operate correctly

11. Function Wake

- If the DUT supports function remote wake, it should have an interface for users to initiate function wake. To run this test, operate all the devices in the Interop Tree.
- While operating the devices, put the system to sleep by going to the Start menu, select the arrow next to the Shut Down button, and then choose Sleep.
- Initiate function wake from one of the functions on the device to wake the system up.
- Upon resuming, verify that the file transfers continue without error.
- Close any software that is used for any Interop Tree device operation and close the "Recording" tab window.
- Operate all the devices in the Interop Tree. Verify that all devices are operating

concurrently.

- Repeat this test for all functions that support wake. (The “Device Summary” test of Command Verifier 3 identifies all functions (interfaces) that support function wake.

- **Pass:**

1. System sleeps
AND
2. System resumes
AND
3. File transfers continue without error
AND
4. All devices can function after resuming
AND
5. All functions that advertise wake capability will wake the machine

- **Fail:**

1. System does not sleep
OR
2. System does not resume
OR
3. System blue screens / locks up
OR
4. Any device cannot function after resuming
OR
5. File transfers do not continue after resuming
OR
6. Function that supports wake doesn't wake machine

12. Root Port Testing

- Connect DUT to one of root ports of SSP xHCI host. Run tests 1-8 as specified in Chapter 7

- **Pass:**

All the tests 1-8 of Chapter 7 PASS

- **Fail:**

If any of the tests 1-8 of Chapter 7 FAIL

13. DUT testing behind a USB 2.0 Hub (Host--USB2.0 Hub--DUT Topology)

- Connect DUT to the Downstream Facing Port of a USB 2.0 Hub connected to the Host. Run tests 1-8 as specified in Chapter 7

- **Pass:**

All the tests 1-8 of Chapter 7 PASS

- **Fail:**

If any of the tests 1-8 of Chapter 7 FAIL

Repeat test by replacing the USB 2.0 Hub with a different USB 2.0 Hub. Repeat this test with various USB 2.0 Hubs available (the goal here is to test with various USB 2.0 Hubs that drop upto 4, 3, 2 or 1 sync bits).

6.3 Compound Devices with Exposed Hub Ports

If a compound device has exposed ports from its embedded hub(s) those ports must also be tested with a variety of traffic types. This must be done in addition to the tests defined in section 6.2.

1. Compound Device Test Tree

Testing a compound device as a hub is shown in Figure 6-17 through Figure 6-20. Construct the correct configuration based on the type of DUT and test system available. This is a subset of the tests required for a hub.

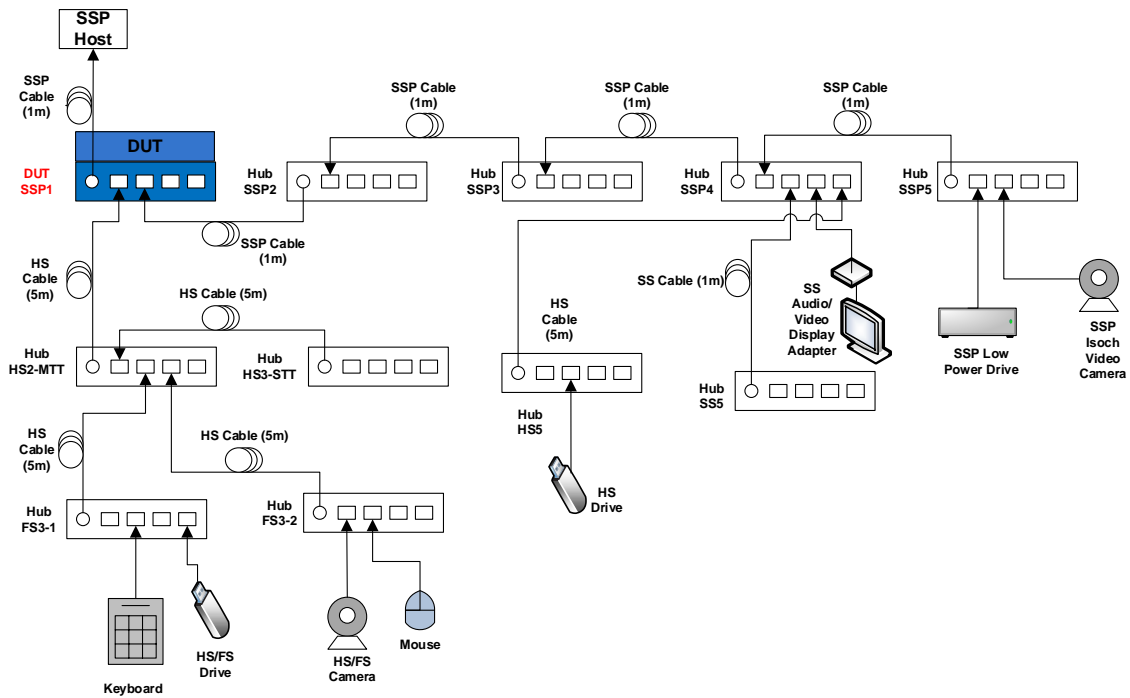


Figure 6-17: Interop Tree with Compound Device Having Exposed Hub Ports

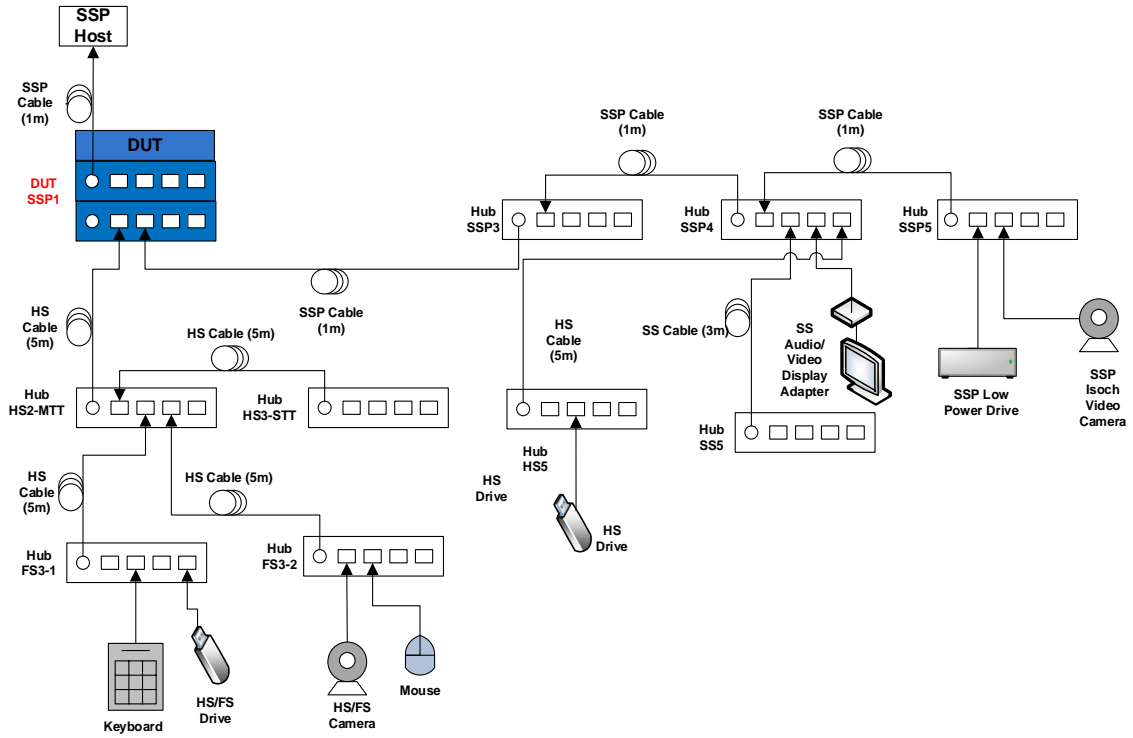


Figure 6-18: Interop Tree with Compound Device (Dual-Hub) Having Exposed Hub Ports

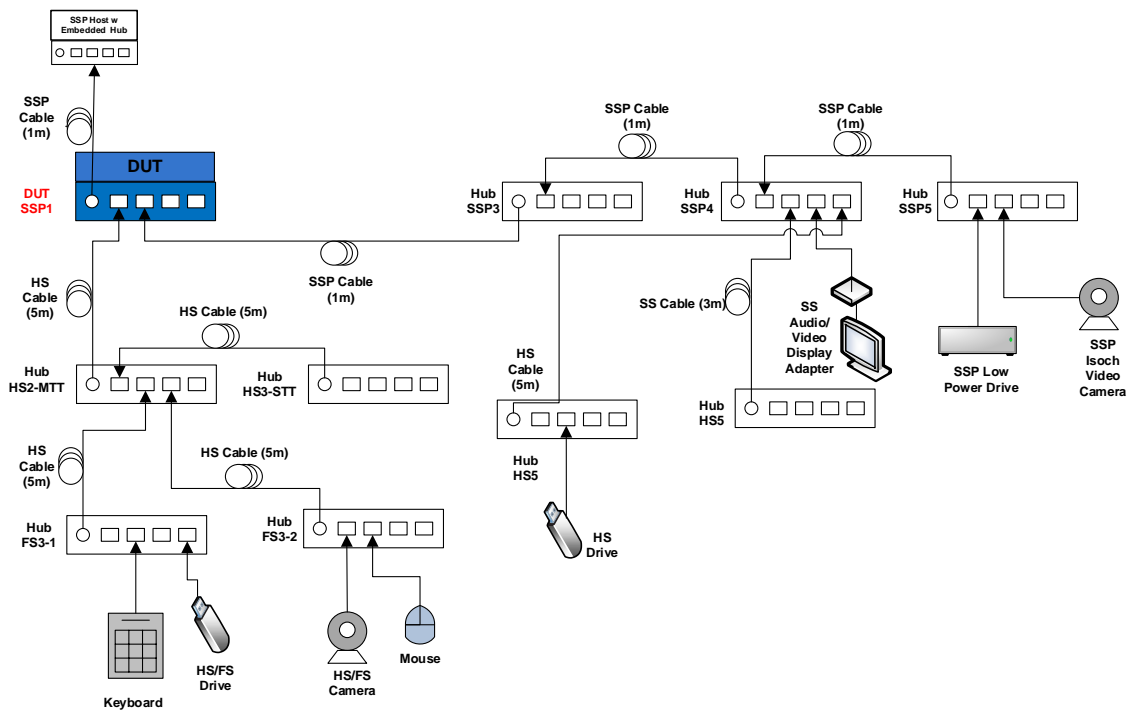


Figure 6-19: Interop Tree with Compound Device Having Exposed Hub Ports - Embedded Hub

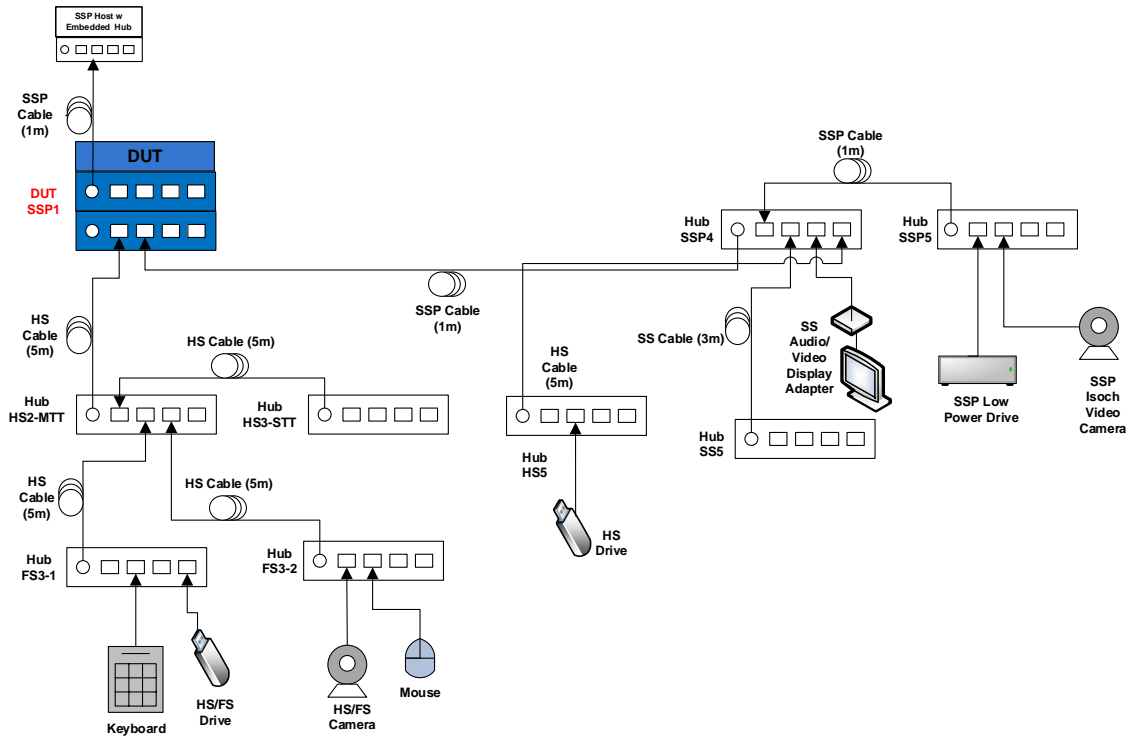


Figure 6-20: Interop Tree with Compound Device (Dual-Hub) Having Exposed Hub Ports - Embedded Hub

- For the above configuration run the tests described in sections 6.2.2 through 6.2.11.
- Note: There are no topology changes for this test.

6.4 Compound Device Current Measurement

Devices operating at Enhanced SuperSpeed GenX are allowed to draw a maximum configured current of 900mA and unconfigured current of 150mA. Devices operating at High-speed or below may draw a maximum configured current of 500mA and unconfigured current of 100mA. Devices must report their maximum configured current draw and their power configuration as self or bus powered to the host and must operate within the regions reported. Additionally any device that is in the suspended state may draw no more than 2.5mA.

If the device has external power, check whether it enumerates without external power. If device enumerates without external power then Run all tests with external power connected and repeat all tests with external power disconnected.

- Install USB3CV from the USB-IF [SuperSpeed Tools](#) page.
- Connect a SSP Current Measurement Fixture between DUT and SSP host as shown in Figure 6-21.
- Set up a Multimeter to measure current drawn from device.
- Run “Current Measurement [USB 3 Gen X Devices]” test in Command Verifier.

- Read meter at each prompt.
- Read the value of “Max Power Consumption” from the log.
- Read device type from the log: bus-powered, self-powered or both.
- Record following values:
 - Bus, Both or Self-Powered
 - The current in un-configured mode
 - Current in configured mode
 - Current in U0
 - Current in U1
 - Current in U2
 - Current in U3
- Reload the xHCI controller driver being used for Interop.
- Operate the device
- Record the highest measured current value
- Repeat all steps again with device operating at High-speed by changing SuperSpeed cable with High-speed cable (Note: U0, U1, U2 and U3 are not applicable in High-speed mode) use CV tests labeled “Current Measurement Test [2.0 Devices]”

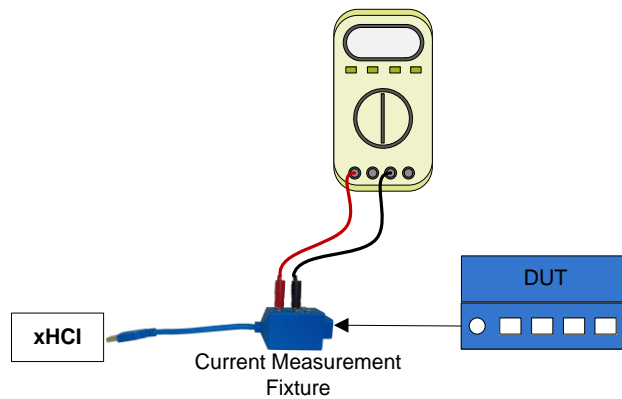


Figure 6-21: Compound Device Current Measurement Topology

- **Pass:**
 1. Device reports Self-Powered and does not operate as Bus-Powered
OR
 2. Device reports Both Self-Powered or Bus-Powered and can operate as Bus-Powered
AND
 3. Max Power Consumption reported is 900mA or less when operating at Enhanced SuperSpeed GenX and 500mA or less when operating at High-speed or Full-Speed
AND
 4. Measured Unconfigured Current is 150mA or less when operating at Enhanced SuperSpeed GenX and 100mA or less when operating at High-speed or Full-Speed
AND
 5. Measured Current during device operation, U0, U1 and U2 is less than or equal to reported Max Power Consumption
AND
 6. Measured Current in U3 is less than or equal to 2.5mA and reported Max Power Consumption
- **Fail:**
 1. Device reports Self-Powered but is capable of enumerating as Bus-Powered
OR

2. Max Power Consumption reported is greater than 900mA when operating at Enhanced SuperSpeed GenX or greater than 500mA when operating at High-speed or Full-Speed
OR
3. Measured Unconfigured Current is greater than 150mA when operating at Enhanced SuperSpeed GenX or greater than 100mA when operating at High-speed or Full Speed
OR
4. Measured Current during device operation, U0, U1 or U2 is greater than reported Max Power Consumption
OR
5. Measured Current in U3 is greater than 2.5mA or reported Max Power Consumption

6.5 Compound Device U1/U2 Test Steps

- Connect a SuperSpeedPlus hub to an exposed host port.
 - Connect a DUT to a downstream hub port with a USB Protocol Analyzer between the hub and device.
 - Trace USB traffic including idle device time and normal DUT operation.
 - Verify that the link successfully enters U1 or U2.
 - Verify that the hub correctly sends a deferred packet to the DUT and to the host.
 - Verify that the DUT correctly sends an ERDY after the deferred packet.
 - Verify that the host re-sends the packet with the deferred bit cleared.
 - Verify that the DUT completes the re-sent packet.
- **Pass:**
 1. Link successfully enters U1 or U2
AND
 2. Link returns to U0 and the original packet that was sent during U1/U2 is successfully completed
 - **Fail:**
 1. Link remains in U0
OR
 2. Re-Sent packet does not complete correctly

6.6 Compound Device LPM Tests (applies to Windows OS)

Download the [MUTT Software Package](#) from Microsoft. Double click and install the MSI file. After the install finishes the contents of the package will most likely be found under

C:\Program Files\USBTest\

Choose either the x86 or the x64 folder depending upon the system OS. Inside the folder select the tool labeled **UsbLPM**.

Selective Suspend must be disabled when using the Usb LPM Tool. Go to Control Panel -> Power Options -> Change Plan Settings -> Change advanced power settings. Under "USB settings" choose "USB selective suspend setting" and set it to "Disabled".

Note: The hub is required to be in an equal or higher link state than any device(s) attached to its downstream port(s). If at any time the hub goes to a lower link state than an attached device the hub fails testing.

1. Inactivity U1/U2 Entry Test - Compound Device Only

Open the Usb LPM Tool

- Configure the Device Under Test as shown in Figure 6-22 and attach it to an xHCI port.

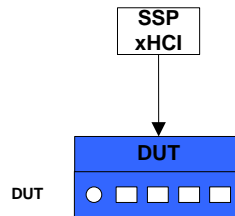


Figure 6-22: Compound Device Only Topology

Let the device remain inactive for a few seconds and observe whether it enters U1 or U2.

- **Pass:**
 1. Both internal device(s) and internal hub(s) enter U1 or U2
OR
 2. The internal hub(s) enter U1 and the internal device(s) enter U2
- **Fail:**
 1. Either the internal hub(s) and/or internal device(s) remain in U0
OR
 2. The internal device(s) enter U1 while the internal hub(s) enter U2 or U3
OR
 3. The internal device(s) enter U2 while the internal hub(s) enter U3

2. Inactivity U1/U2 Entry Test - Compound Device and U1/U2 Enabled Device - Exposed External Ports Only

This test is only applicable to Compound Devices that contain exposed ports.

- Detach device from the host.
- Attach a SuperSpeedPlus, U1/U2 enabled device to one of the exposed downstream ports
- Attach tree to the host as shown in **Error! Reference source not found.**

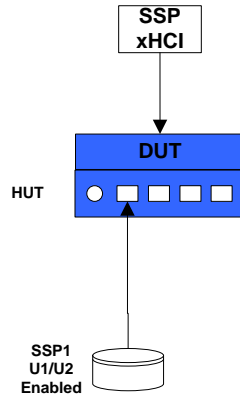


Figure 6-23: Compound Device and U1/U2 Enabled Device

Allow the devices to remain inactive. Observe the LPM tool, all devices should enumerate and both the hub(s) and the device(s) should enter U1 or U2.

- **Pass:**
 1. Both device(s) and internal hub(s) enter U1 or U2
OR
 2. The internal hub(s) enter U1 and device(s) enter U2
- **Fail:**
 1. Either the internal hub(s) and/or devices remain in U0
OR
 2. The device(s) enter U1 while the internal hub(s) enter U2 or U3
OR
 3. The device(s) enter U2 while the internal hub(s) enter U3

3. Inactivity U1/U2 Entry Test - Compound Device and U1/U2 Disabled Device - Exposed External Ports Only

This test is only applicable to Compound Devices that contain exposed ports.

- Detach device from the host.
- Attach a SuperSpeedPlus, U1/U2 **disabled** device to one of the exposed downstream ports.
Attach tree to the host as shown in Figure 6-24.

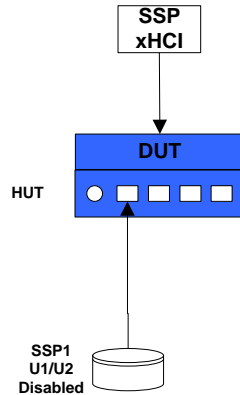


Figure 6-24: Compound Device and U1/U2 Disabled Device

Allow the devices to remain inactive. Observe the LPM tool, the device should enumerate and the hub should not enter U1 or U2 (assuming device remains in U0).

- **Pass:**
 1. internal device(s) enter U1 or U2 and internal hub remains in U0 (external device stays in U0 as expected)
- **Fail:**
 1. The internal hub(s) enter U1, U2 or U3 while external device remains in U0
OR
 2. The internal device(s) remain in U0

4. Active LPM Test

The USB LPM Tool has an active mode where it can request the device and hub to enter U1 or U2 and report a pass/fail. Because of a possible variance of behavior this test must be run and pass 10 consecutive times.

- Attach the configuration shown in Figure 6-22 to an available SSP xHCI port.
- In the Mode of operation box select the option “testing”.
- Select the SuperSpeed hub from the list as shown in Figure 6-25.
- Click the “Start” button on the right.
- Observe the test report for failures or errors during the test cases.
- Repeat this test 9 more consecutive times
- **Pass:**

All 10 consecutive test cases report “pass”
- **Fail:**

1 or more consecutive test cases reported a “fail” or “error”

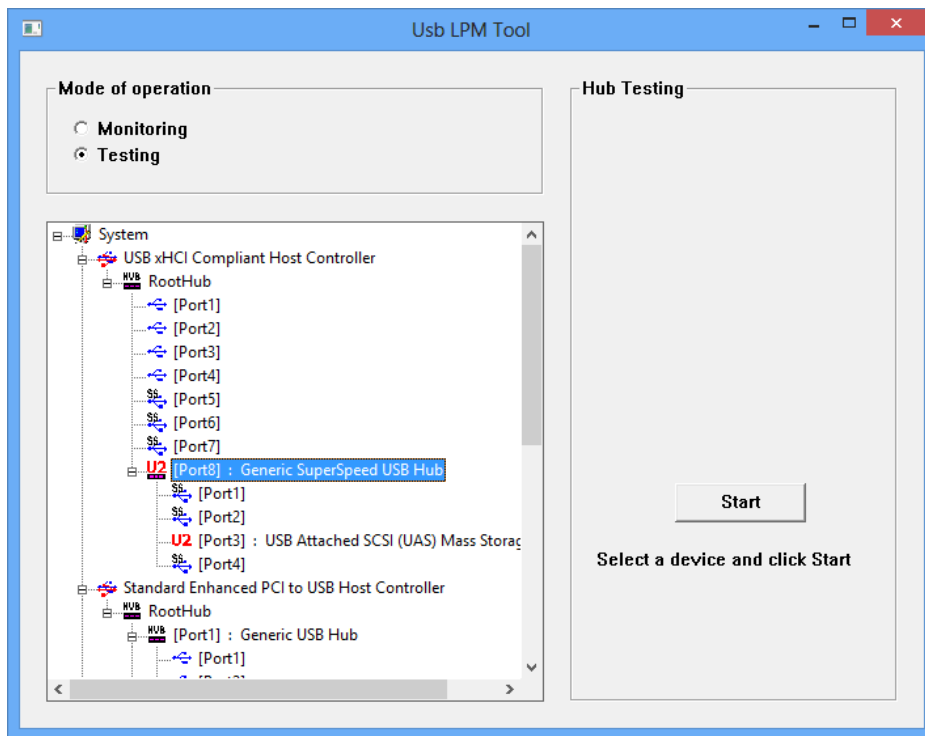


Figure 6-25: USB LPM Tool Interface

7 All Devices – Interoperability Test Steps

1. Inactive Detach & Reattach

- Stop all Interoperability Tree device operation! Close any software that is used for any Interoperability Tree device operation and close the “Recording” tab window.
 - Detach the entire Interoperability Tree from the selected port(s).
 - Reattach the entire Interoperability Tree to the same selected port(s) that it was detached from.
 - For Hub under Test, Detach and Reattach SSP KGD connected to the downstream port as an additional test. This test is in addition to the upstream port inactive detach/reattach.
 - Operate all the devices in the Interoperability Tree. Verify that all devices are operating concurrently. Verify the Device Speed using the USBView utility (USBView runs on Windows OS).
- **Pass:**
All Interoperability Tree devices operate correctly
 - **Fail:**
One or more Interoperability Tree devices fail to operate correctly

2. Inactive Detach & Flip/Reverse Attach - USB Type-C Connectors Only

- Stop all Interoperability Tree device operation! Close any software that is used for any Interoperability Tree device operation and close the “Recording” tab window.
- Detach the entire Interoperability Tree from the selected port(s).
- **Rotate the USB Type-C Plug 180 degrees and reinsert the plug into the host.** Operate all the devices in the Interoperability Tree. Verify that all devices are operating concurrently. Verify the Device Speed using the USBView utility (USBView runs on Windows OS).
- **Detach the plug from the UFP port. Rotate the USB Type-C Plug 180 degrees and reinsert the plug into the UFP of the peripheral.** Operate all the devices in the Interoperability Tree. Verify that all devices are operating concurrently. Verify the Device Speed using the USBView utility (USBView runs on Windows OS).
- **Detach the plug from the host port. Rotate the USB Type-C Plug 180 degrees and reinsert the plug into the host.** Operate all the devices in the Interoperability Tree. Verify that all devices are operating concurrently. Verify the Device Speed using the USBView utility (USBView runs on Windows OS).

Note: Make sure all combinations of the Flip/Reverse attach is tested for a UFP (Peripheral) connected to a DFP (Host)

- **Pass:**
All Interoperability Tree devices operate correctly
- **Fail:**
One or more Interoperability Tree devices fail to operate correctly

3. Active Sleep/Remote Wake – S3 Capable Systems Only

Note: Hub and Peripheral Test Systems are required to support this state

- Operate all the devices in the Interoperability Tree.
 - While operating the devices, put the system into sleep.
 - Wait 60 seconds then wake the system with the mouse on the Interoperability Tree.
 - Upon resuming verify file transfers resume without error and that no application crashes. Note: if necessary it is acceptable to close and reopen the audio/video application after resuming.
 - Operate all devices in the Interoperability Tree. Verify that all devices are operating concurrently. Verify the Device Speed using the USBView utility (USBView runs on Windows OS).
- **Pass:**
 1. System sleeps
AND
 2. System resumes
AND
 3. Active operation continues without error
 - **Fail:**
 1. System does not sleep
OR
 2. System does not resume
OR
 3. System blue screens / locks up
OR
 4. Any device is not functional or does not continue operation
OR
 5. Any application freeze or crash

4. Active S4 Hibernation/Resume – S4 Capable Systems Only

Note: Hub and Peripheral Test Systems are required to support this state

- Operate all the devices in the Interoperability Tree.

- While operating the devices, put the system into hibernation. This will hibernate the system for 60 seconds and automatically resume the system.
 - Upon resuming verify file transfers resume without error and that no application crashes. Note: if necessary it is acceptable to close and reopen the audio/video application after resuming.
 - Operate all devices in the Interoperability Tree. Verify that all devices are operating concurrently. Verify the Device Speed using the USBView utility (USBView runs on Windows OS).
- **Pass:**
 1. System hibernates
AND
 2. System resumes
AND
 3. Active operation initiated in previous step continues without error
 - **Fail:**
 1. System does not hibernate
OR
 2. System does not resume
OR
 3. System blue screens / locks up
OR
 4. Any device is not functional or does not continue operation
OR
 5. Any application freeze or crash

5. Active Modern Standby/Remote Wake - Modern Standby Capable Systems Only (applies to Windows OS)

- Operate all the devices in the Interoperability Tree.
 - While operating the devices, put the system into Modern Standby. Wait 60 seconds and wake the system with the mouse on the Interoperability Tree.
 - Verify that file transfers resume without error and that no application crashes.
 - Operate all devices in the Interoperability Tree. Verify that all devices are operating concurrently. Verify the Device Speed using the USBView utility (USBView runs on Windows OS).
- **Pass:**
 1. System enters Modern Standby
AND
 2. System Resumes
AND
 3. Active operation initiated in previous step continues without error
 - **Fail:**
 1. System does not enter Modern Standby
OR

2. System does not resume
OR
3. System blue screens / locks up
OR
4. Any device is not functional or does not continue operation
OR
5. Any application freeze or crash

6. Warm boot/Restart

- If there are file copying processes, let them finish and then close all of them.
- Restart system.
- After system reboots operate all the devices in the Interoperability Tree. Verify that all devices are operating concurrently. Verify the Device Speed using the USBView utility (USBView runs on Windows OS).
- **Pass:**
All Interoperability Tree devices operate correctly
- **Fail:**
One or more Interoperability Tree devices fail to operate correctly

7. Cold boot/Shutdown

- If there are file copying processes, let them finish and then close all of them.
- Turn off system with the ColdBoot.bat batch file. Turn off the External Power Supply for the Host Controller (if applicable). In case of non-Windows OS do a Shutdown and turn off the External Power Supply for the Host Controller (if applicable).
- Turn PC and External Power Supply for the Host Controller back on.
- After system boots operate all the devices in the SSP Interoperability Tree. Verify that all devices are operating concurrently. Verify the Device Speed using the USBView utility (USBView runs on Windows OS).
- **Pass:**
All Interoperability Tree devices operate correctly
- **Fail:**
One or more Interoperability Tree devices fail to operate correctly

8. Hybrid boot/Shutdown (applicable mainly to Windows 11 OS)

- If there are file copying processes, let them finish and then close all of them.
- Turn off PC system by double-clicking on the HybridBoot.bat file.
- Turn PC system back on.

- After system boots operate all the devices in the Interoperability Tree. Verify that all devices are operating concurrently. Verify the Device Speed using the USBView utility.
- **Pass:**
All Interoperability Tree devices operate correctly
- **Fail:**
One or more Interoperability Tree devices fail to operate correctly

8 USB Type-C Interoperability

Perform USB power delivery and USB Type-C Functional testing using the PD/USB Type-C tester as defined by USB PD/USB Type-C Compliance. Confirm all PD and USB Type-C Functional tests run on the PD and USB Type-C tester are passing before proceeding to Interop Testing.

This chapter contains guidelines for testing with USB Type-C connector, in addition to tests from Chapters 1-7 and Appendices. It assumes reader is familiar with testing procedures from Chapters 1 to 7, and Appendices. **The purpose of the USB Type-C Interoperability is to ensure all devices connected via USB Type-C connector to the system work correctly (this includes USB, Alternate Mode and Charging). Note that the USB Type-C is a reversible connector and must be tested for detach and flip/reverse attach (at both Upstream and Downstream Facing Port locations in all possible combinations).**

The Interoperability test document is generic and should be applicable to the vast majority of devices. This document cannot cover all possible types, configurations and combinations of peripherals, hubs, hosts and embedded devices. Thus, the application of the xHCI Interoperability test procedures may need to be modified in order to adequately test a device for USB compliance. Test guidelines for unique devices that do not fall into categories outlined in this document should be brought to the attention of TechAdmin@usb.org for assistance.

It is highly recommended that vendors expand in-house interoperability testing to include many more devices, hubs and hosts from the ecosystem, than the minimum required for the USB Type-C Interop Tree. Effectively, **Interoperability is a consumer experience test of the product.** It examines the product's ability to function correctly in normal system configurations. **Consumer experience is the most important factor when assessing a Pass or Fail result. If the test result yields any kind of negative consumer experience, the test must be recorded as a fail.**

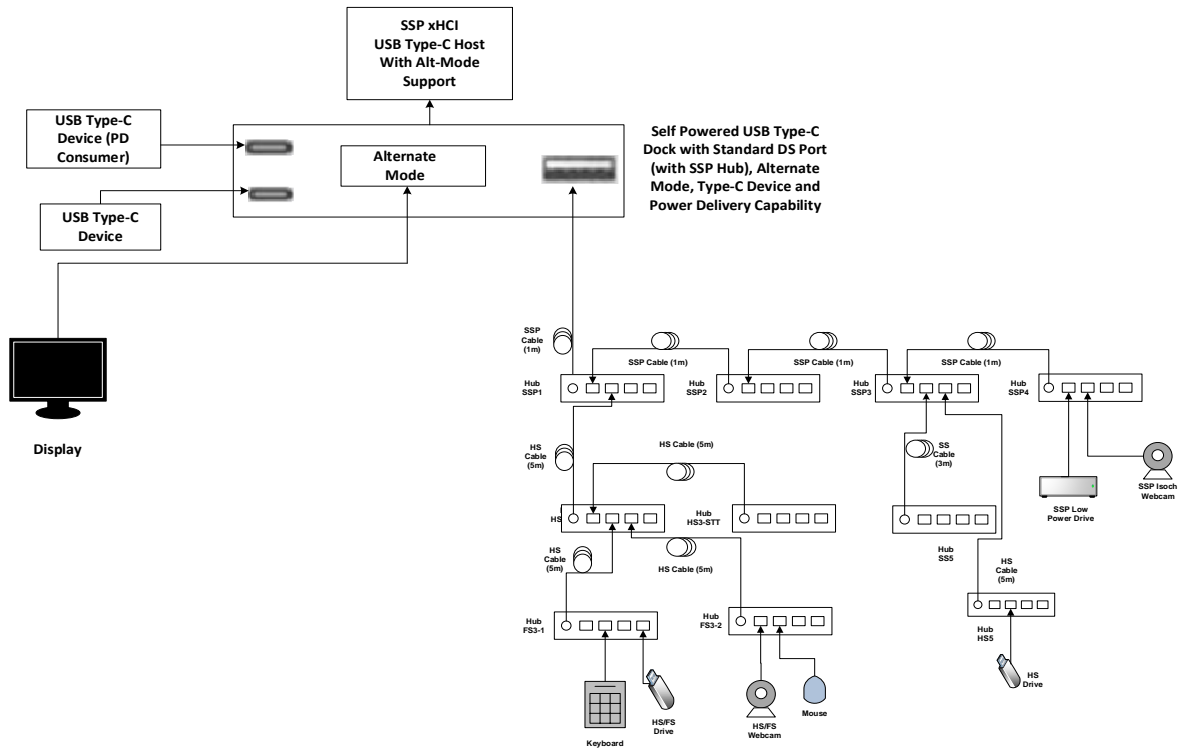


Figure 8-1: USB-Type C Interoperability Tree

Tier	Device
1	<ul style="list-style-type: none"> • USB Type-C Dock with Alternate Mode, Standard A Receptacle, PD Capability, USB Type-C ports
2	<ul style="list-style-type: none"> • Hub SSP1 - Externally-powered SuperSpeedPlus Hub on hub port on the USB Type-C Dock
3	<ul style="list-style-type: none"> • Hub SSP2 - Externally-powered SuperSpeedPlus Hub on port 1 of Hub SSP2
4	<ul style="list-style-type: none"> • Hub SSP3 - Externally-powered SuperSpeedPlus Hub on port 1 of Hub SSP2
5	<ul style="list-style-type: none"> • Hub SSP4 - Externally-powered SuperSpeedPlus Hub Under Test on port 1 of Hub SSP3
	<ul style="list-style-type: none"> • SuperSpeedPlus Low Power Drive on port 1 of HUT SSP5
	<ul style="list-style-type: none"> • SuperSpeedPlus Webcam on port 2 of HUT SSP5
	<ul style="list-style-type: none"> • Hub HS5 - Externally-powered high-speed Hub on port 3 of Hub SSP3
	<ul style="list-style-type: none"> • HS Drive on port 2 of Hub HS5
5	<ul style="list-style-type: none"> • Hub SS5 - Externally-powered SuperSpeed Hub on port 2 of Hub SSP3
2	<ul style="list-style-type: none"> • Hub HS2-MTT - Externally-powered high-speed Hub with multiple transaction translators on port 2 of Hub SSP1
3	<ul style="list-style-type: none"> • Hub HS3-STT - Externally-powered high-speed Hub with a single transaction translator on port 1 of Hub HS2-MTT
3	<ul style="list-style-type: none"> • Hub FS3-1 – Full-Speed Hub on port 2 of Hub HS2-MTT
4	<ul style="list-style-type: none"> • FS Drive on port 4 of Hub FS3-1
4	<ul style="list-style-type: none"> • Keyboard on port 2 of FS3-1
3	<ul style="list-style-type: none"> • Hub FS3-2 - Full-Speed Hub on port 3 of Hub HS2-MTT
4	<ul style="list-style-type: none"> • HS/FS Webcam on port 1 of Hub FS3-2
4	<ul style="list-style-type: none"> • Mouse on port 2 of Hub FS3-2
Alt Mode	4K Display Monitor
PD Consumer	Power Consumer with USB Type-C Connector

8.1 USB Type-C Host, Hub and Device Inspection

Examine the Host, Hub and Peripheral under test and identify all USB Type-C connections.

- Each and every USB Type-C port on the Host/System, Hub and Peripheral must be tested and pass all required tests. The Interoperability Tests must be run separately for each USB Type-C port. **On a USB Type-C hub make sure that the Upstream Facing Port (UFP) is clearly labeled or marked.**

8.2 Interoperability Tests

Connect the tree as shown in Figure 8-1

- Operate all devices on the Interop Tree.
- Whenever the **Interoperability Test Steps** state to operate all of the devices in the Interop Tree, this involves operating the following steps concurrently:

- Operate the microphone in the Video Cameras by speaking into the microphone and viewing its input level
 - This can be found under Control Panel -> Hardware and Sound -> Sound under the "Recording" tab.
- View streaming video from the SSP Video Camera
- View streaming video from the FS Video Camera

Poor video quality may be seen when Driver Verifier is enabled. If there was poor quality, continue testing with the Driver Verifier enabled for all Interoperability steps. Repeat all Interoperability steps with Driver Verifier off. USB-IF will compare Interoperability results with Driver Verifier Enabled and Disabled to determine Pass/Fail for certification.

- Transfer a 30+ MB file from the SSP Low Power Drive to the FS Drive
- Transfer a 1+ GB file from the HS Drive to the SS Low Power Drive
- Watch video and listen to audio from display monitor attached to the dock (**Alternate Mode**)
- Strike keys on the keypad
- Move the mouse
- Confirm the USB Type-C PD Consumer device is operational and is receiving power (this can be verified by monitoring both Voltage and Current using a power meter)
- Verify that all devices are operating concurrently. Verify the Device Speed using the

USBView utility (USBView runs on Windows OS). If the xHCI host is on a laptop with PD, verify the laptop is being charged.

- **Pass:**
All Interop Tree devices operate correctly
- **Fail:**
One or more Interop Tree devices fail to operate correctly

1. All Devices Tests

Run tests 1-8 as specified in Chapter 7.

2. Root Port Testing with USB Type-C Device Only

- Connect USB Type-C device to one of the root ports of USB Type-C host system. Run tests 1-8 as specified in Chapter 7
- **Pass:**
All the tests 1-8 of Chapter 7 PASS
- **Fail:**
If any of the tests 1-8 of Chapter 7 FAIL

3. Root Port Testing with USB Type-C Device and Interop Tree

If a Host system has more than one USB Type-C receptacles:

- Connect USB Type-C device to one of the root ports of USB Type-C host system
- Connect the USB Type-C Interoperability Tree from Figure 8-1 to a second USB Type-C Port
- Run tests 1-8 as specified in Chapter 7
- **Pass:**
All the tests 1-8 of Chapter 7 PASS
- **Fail:**
If any of the tests 1-8 of Chapter 7 FAIL

8.3 Alternate Mode Testing Methodology

- Connect an Alternate Mode-enabled USB Type-C device to an Alternate Mode-enabled USB Type-C port on the system; ensure both the device and the system share at least one Alternate Mode in common
 - For Type-C dongles/adapters, ensure that an appropriate peripheral is powered on and connected to the non-Type-C end of the dongle/adaptor.
- Confirm that the Alternate Mode device is added in **Device Manager**. In some cases, the Alternate Mode device may show up as a monitor or other bus
- Run tests 1-8 as specified in Chapter 7 with intended function of the Alternate Mode Device

Pass:

All the tests 1-8 of Chapter 7 PASS

Fail:

If any of the tests 1-8 of Chapter 7 FAIL

*Note: For this section, a USB Type-C to non USB Type-C (e.g. HDMI, DP, VGA, etc.) cable adapter or dongle can be considered an Alternate Mode “device”.

- Repeat tests 1-8 as specified in Chapter 7 with for all configurations of the Alt-Mode Unit Under Test: e.g. for DisplayPort Alt-Mode, make sure both configurations are tested (USB2.0 + DP Alt-Mode (4 Lanes for DP operation)) and Multi-Function DisplayPort Alt-Mode (Enhanced SuperSpeed (2 Lanes for Enhanced SuperSpeed operation) + DP Alt-Mode (2 Lanes for DP operation))

- **When testing a USB Enhanced SuperSpeed Type-C Hub confirm the Downstream Facing Ports do not support Alternate or Accessory modes (Note: For USB4 Hub/Dock Unit Under Test, when connected to an Enhanced SuperSpeed USB Host Controller that supports Alternate-Mode, Alternate-Mode is allowed on Downstream Facing Ports of the USB4 Unit Under Test)**
 - **Connect an alternate mode device/dock to the downstream port of the USB Type-C hub (that is connected to USB Type-C Host that supports alternate mode)**
- **Pass:**
USB Type-C Hub DS Port does not support Alternate mode and displays Billboard device if it does not have and equivalent USB functionality
- **Fail:**
USB Type-C Hub DS port supports Alternate mode
- Connect an Alternate Mode-enabled USB Type-C device to an USB Type-C Host (that does not have PD/Alternate Mode) port on the system
 - For USB Type-C dongles/adapters, ensure that an appropriate peripheral is powered on and connected to the non USB Type-C end of the dongle/adapter.
- Confirm that Billboard device is displayed in the OS and is added in **Device Manager** if there is no equivalent USB functionality

Run tests 1-8 as specified in Chapter 7

Pass:

All the tests 1-8 of Chapter 7 PASS

Fail:

If any of the tests 1-8 of Chapter 7 FAIL

*Note: For this section, a USB Type-C to non USB Type-C (e.g. HDMI, DP, VGA, etc.) cable adapter or dongle can be considered an Alternate Mode “device”.

8.4 Charging and power delivery (PD)

- **Perform USB power delivery testing and USB Type-C Functional tests using the PD/USB Type-C tester as defined by USB PD Compliance. Confirm all PD and USB Type-C Functional tests run on the PD and USB Type-C tester are passing before proceeding to Interop Testing.**
- If testing a system perform the following:
 - Connect two systems together with a USB Type-C cable. Confirm that only one system is receiving current (this can be verified by monitoring both Voltage and Current using a power meter).
 - Run all tests 1-8 as specified in Chapter 7

Pass:

Only one system receives current. All the tests 1-8 of Chapter 7 PASS

Fail:

System does not receive current. If any of the tests 1-8 of Chapter 7 FAIL

- If systems contains more than one USB Type-C port, connect two USB Type-C ports on the same system with a USB Type-C cable. Confirm the system is not charging (itself).

Pass:

System does not charge itself

Fail:

System charges itself

- Connect the bundled USB Type-C charger (if bundled) to the USB Type-C port of the system. Confirm the system is charging (this can be verified by monitoring both Voltage and Current using a power meter). Repeat step with USB Type-C chargers from other sources.
- Run all tests 1-8 as specified in Chapter 7

Pass:

The system is charging and the charger is performing to its intended functionality.
All the tests 1-8 of Chapter 7 PASS

Fail:

The system is not charging and the charger is performing to its intended functionality.
If any of the tests 1-8 of Chapter 7 FAIL

- Connect USB Type-C device to the systems exposed USB Type-C port. Confirm the device is receiving current (this can be verified by monitoring both Voltage and Current using a power meter).
- If testing a dock perform the following:
 - Connect dock to USB Type-C enabled system with USB Type-C cable. Confirm the dock is charging the system connected (this can be verified by monitoring both Voltage and Current using a power meter).
 - Run all tests 1-8 as specified in Chapter 7

Pass:

The dock is charging the system and the dock is performing to its functionality.
All the tests 1-8 of Chapter 7 PASS

Fail:

The dock is not charging the system and the dock is not performing to its functionality.
If any of the tests 1-8 of Chapter 7 FAIL

- If testing a device perform the following:
 - Connect device to a USB Type-C enabled system. Confirm the device receives power from the system (this can be verified by monitoring both Voltage and Current using a power meter).
 - Run all tests 1-8 as specified in Chapter 7

Pass:

The device is receiving power from the system and the device is performing to its functionality.
All the tests 1-8 of Chapter 7 PASS

Fail:

The device is not receiving power from the system and the device not is performing to its functionality.
If any of the tests 1-8 of Chapter 7 FAIL

- If a device is capable of charging a system, connect device to a USB Type-C enabled system. Confirm the device will charge the system (this can be verified by monitoring both Voltage and Current using a power meter).
- Run all tests 1-8 as specified in Chapter 7

Pass:

The device is charging the system and the dock is performing to its functionality.
All the tests 1-8 of Chapter 7 PASS

Fail:

The device is charging the system and the dock is performing to its functionality.
If any of the tests 1-8 of Chapter 7 FAIL

8.5 USB Type-C Chargers

- **Perform USB power delivery testing using the PD/USB Type-C tester as defined by USB PD Compliance. Run all USB Type-C Functional tests using the PD/USB Type-C tester as defined by USB Type-C Compliance. Confirm all PD and USB Type-C Functional tests run on the PD and USB Type-C tester are passing before proceeding to Interop Testing.**
 - **For testing a system with USB Type-C charger perform the following:**
 - 1) Connect USB Type-C charger to USB Type-C port of the system. Confirm the system is charging (this can be verified by monitoring both Voltage and Current using a power meter). Examples of systems include Laptops, Tablets and Cell Phones

- 2) Run tests 1-8 as specified in Chapter 7. After each test listed in Chapter 7, confirm the system is charging and the charger is performing to its intended functionality.

Pass:

The system is charging and the charger is performing to its intended functionality.
All the tests 1-8 of Chapter 7 PASS

Fail:

The system is not charging and the charger is performing to its intended functionality.
If any of the tests 1-8 of Chapter 7 FAIL

8.6 Fast Role Swap (FRS) Interop Test

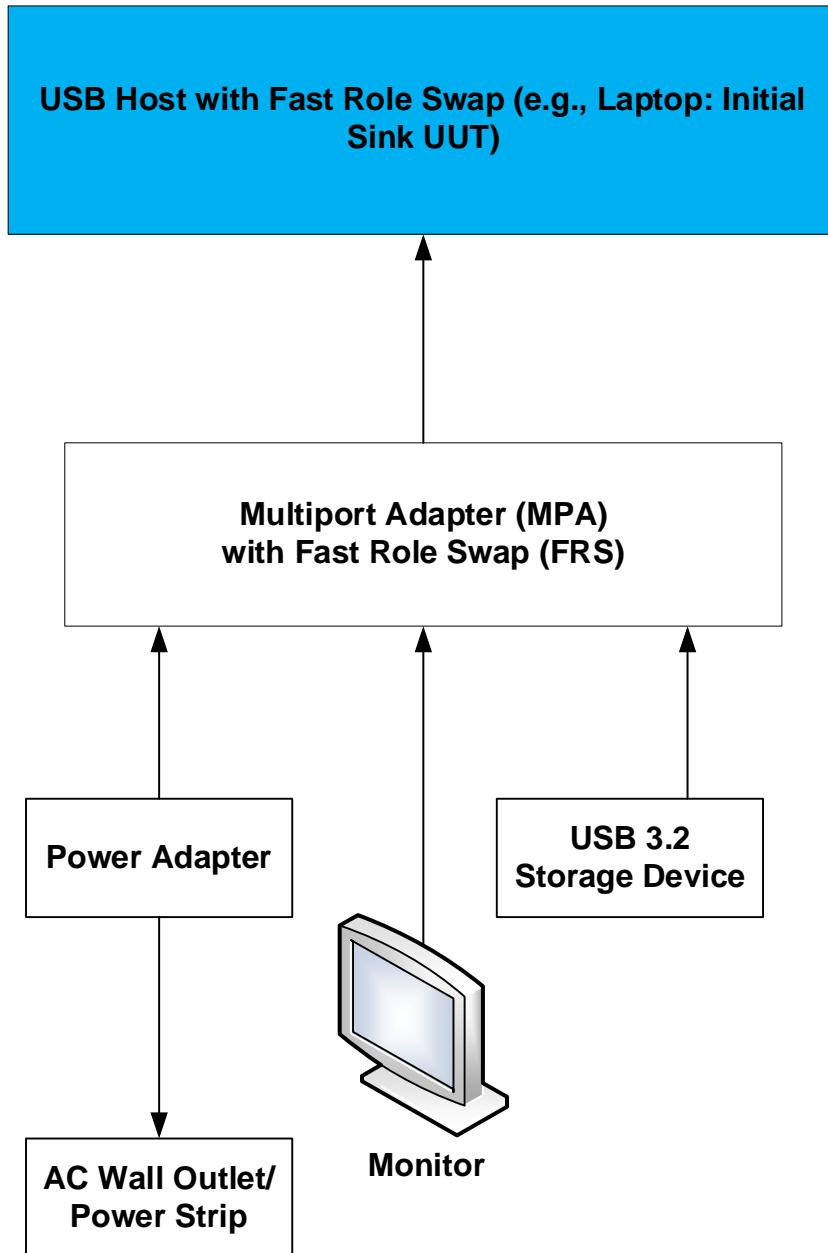


Figure 8-2: Fast Role Swap (FRS) Topology Setup

Connect the tree as shown in Figure 8-2

- Operate all devices connected to the Multiport Adapter (MPA)
 - Watch a video on the Display Monitor
 - Transfer a file 2+ GB File to and from the Storage Device
 - Make sure the MPA (Source) is charging the Host Laptop (UUT Initial Sink) via the Power Adapter connected to the MPA

1) **Detach/Reattach the Power Adapter at Multiport Adapter Port (MPA):**

- a) Operate all devices connected to the MPA.
- b) While operating the devices, Detach the Power Adapter **from the MPA port**. Verify File Transfer continues and that the Monitor is still displaying/playing video. There should be no re-enumeration of devices connected to MPA.
- c) While operating the devices, Reattach the Power Adapter **to the MPA port**. Verify File Transfer continues, the Monitor is still displaying/playing video, and MPA charges the UUT. There should be no re-enumeration of devices connected to MPA.
- d) **Repeat a) to c) step 10 times.**

- **Pass:**

All Interoperability Tree devices operate correctly without any re-enumeration

- **Fail:**

All devices attached to the MPA do not operate correctly

or

Device/s re-enumerate on detach or reattach

or

Device/s attached to the MPA drop

or

MPA does not charge the UUT (Initial Sink) when the Power Adapter is connected to the MPA

2) **Detach/Reattach the Power Adapter at the AC wall outlet/Power Strip or Switch Off/On the Power Adapter at the AC wall outlet/Power Strip:**

- a) Operate all devices connected to the MPA.
- b) While operating the devices, Detach the Power Adapter (connected to the MPA) **at the AC wall outlet/Power Strip** or Switch Off the Power Adapter **at the AC wall outlet/Power Strip**. Verify File Transfer continues and that the Monitor is still displaying/playing video. There should be no re-enumeration of devices connected to MPA.
- c) While operating the devices, Reattach the Power Adapter (connected to the MPA) **at the AC wall outlet/Power Strip** or Switch On the Power Adapter **at the AC wall outlet/Power Strip**. Verify File Transfer continues, the Monitor is still displaying/playing video, and MPA charges the UUT. There should be no re-enumeration of devices connected to MPA.
- d) **Repeat a) to c) step 10 times.**

- **Pass:**

All Interoperability Tree devices operate correctly without any re-enumeration

- **Fail:**
 - All devices attached to the MPA do not operate correctly
 - or
 - Device/s re-enumerate on detach or reattach
 - or
 - Device/s attached to the MPA drop
 - or
 - MPA does not charge the UUT (Initial Sink) when the Power Adapter is connected or the Switch is On

USB Peripheral Interoperability

Peripheral Overall

PASS/FAIL

Peripheral Interoperability Tests

1. **SSP xHCI Controller Driver Installation:** PASS/FAIL
2. **Peripheral Enumeration and Driver Installation:** PASS/FAIL
3. **Interoperability:** PASS/FAIL
4. **All Device Tests:** PASS/FAIL
 - 1) Inactive Detach & Reattach: PASS/FAIL
 - 2) Inactive Detach & Flip/Reverse attach (USB Type-C) PASS/FAIL
 - 3) Active Sleep/Remote Wake: PASS/FAIL
 - 4) Active S4 Hibernation/Resume: PASS/FAIL
 - 5) Active Modern Standby/Remote Wake PASS/FAIL
 - 6) Warm boot: PASS/FAIL
 - 7) Cold boot: PASS/FAIL
 - 8) Hybrid boot (Win8 Only) PASS/FAIL
5. **Topology Change 1:** PASS/FAIL
6. **All Device Tests:** PASS/FAIL
 - 9) Inactive Detach & Reattach: PASS/FAIL
 - 10) Inactive Detach & Flip/Reverse attach (USB Type-C) PASS/FAIL
 - 11) Active Sleep/Remote Wake: PASS/FAIL
 - 12) Active S4 Hibernation/Resume: PASS/FAIL
 - 13) Warm boot: PASS/FAIL
 - 14) Cold boot: PASS/FAIL
 - 15) Hybrid boot (Win8 Only) PASS/FAIL
7. **Topology Change 2:** PASS/FAIL/NA

8. All Device Tests:	PASS/FAIL/NA
16) Inactive Detach & Reattach:	PASS/FAIL
17) Inactive Detach & Flip/Reverse attach (USB Type-C)	PASS/FAIL
18) Active Sleep/Remote Wake:	PASS/FAIL
19) Active S4 Hibernation/Resume:	PASS/FAIL
20) Warm boot:	PASS/FAIL
21) Cold boot:	PASS/FAIL
22) Hybrid boot (Win8.1 Only)	PASS/FAIL
9. Interoperability without Driver Verifier:	PASS/FAIL/NA
10. Current Measurement:	PASS/FAIL
11. Function Wake:	PASS/FAIL
12. Root Port Testing	PASS/FAIL
13. U1/U2 Test Steps	PASS/FAIL
14. LPM Tests	PASS/FAIL

USB Externally-Powered Hub Interoperability

Externally-Powered Hub Overall **PASS/FAIL**

Externally-Powered Hub Interoperability Tests

- 1. SSP xHCI Controller Driver Installation:** **PASS/FAIL**
- 2. Peripheral Enumeration and Driver Installation:** **PASS/FAIL**
- 3. Interoperability:** **PASS/FAIL**
- 4. All Device Tests:** **PASS/FAIL**
 - 1) Inactive Detach & Reattach: **PASS/FAIL**
 - 2) Inactive Detach & Flip/Reverse attach (USB Type-C) **PASS/FAIL**
 - 3) Active Sleep/Remote Wake: **PASS/FAIL**
 - 4) Active S4 Hibernation/Resume: **PASS/FAIL**
 - 5) Warm boot: **PASS/FAIL**
 - 6) Cold boot: **PASS/FAIL**
 - 7) Hybrid boot (Win8.1 Only): **PASS/FAIL**
- 5. Topology Change 1:** **PASS/FAIL**
- 6. All Device Tests:** **PASS/FAIL**
 - 1) Inactive Detach & Reattach: **PASS/FAIL**
 - 2) Inactive Detach & Flip/Reverse attach (USB Type-C) **PASS/FAIL**
 - 3) Active Sleep/Remote Wake: **PASS/FAIL**
 - 4) Active S4 Hibernation/Resume: **PASS/FAIL**
 - 5) Warm boot: **PASS/FAIL**
 - 6) Cold boot: **PASS/FAIL**
 - 7) Hybrid boot (Win8 Only): **PASS/FAIL**
- 7. Topology Change 2:** **PASS/FAIL**
- 8. All Device Tests:** **PASS/FAIL**

1) Inactive Detach & Reattach:	PASS/FAIL
2) Active Sleep/Remote Wake:	PASS/FAIL
3) Inactive Detach & Flip/Reverse attach (USB Type-C)	PASS/FAIL
4) Active S4 Hibernation/Resume:	PASS/FAIL
5) Warm boot:	PASS/FAIL
6) Cold boot:	PASS/FAIL
7) Hybrid boot (Win8.1 Only):	PASS/FAIL
9. Interoperability without Driver Verifier:	PASS/FAIL/NA
10. Function Wake:	PASS/FAIL
11. Current Measurement Tests:	PASS/FAIL
12. U1/U2 Tests:	PASS/FAIL
13. LPM Tests:	PASS/FAIL

SSP xHCI Interoperability Test Results

SSP xHCI Overall	PASS/FAIL
SSP xHCI Interoperability Tests	
1. SSP xHCI Controller Driver Installation:	PASS/FAIL
2. Peripheral Enumeration and Driver Installation:	PASS/FAIL
3. Interoperability:	PASS/FAIL
4. All Device Tests (If Applicable):	PASS/FAIL
1. Inactive Detach & Reattach:	PASS/FAIL
2. Inactive Detach & Flip/Reverse attach (USB Type-C)	PASS/FAIL
3. Active Sleep/Remote Wake:	PASS/FAIL
4. Active S4 Hibernation/Resume:	PASS/FAIL
5. Warm boot:	PASS/FAIL
6. Cold boot:	PASS/FAIL
7. Hybrid boot (Win8 Only):	PASS/FAIL
5. Topology Change 1:	PASS/FAIL
6. All Device Tests:	PASS/FAIL
7. Topology Change 2:	PASS/FAIL
8. All Device Tests:	PASS/FAIL
9. Active Express Card Detach (Express Card SSP xHCI):	PASS/FAIL/NA
10. Interoperability without Driver Verifier:	PASS/FAIL/NA
11. Function Wake:	PASS/FAIL
12. Tree Enumeration on Each Exposed Port:	PASS/FAIL
13. Each Host Testing:	PASS/FAIL
14. Exposed Port Testing:	PASS/FAIL
15. Host U1/U2 Modes:	PASS/FAIL

16. LPM Tests

PASS/FAIL

9 Appendix A – Driver Verifier

Interoperability testing should be tested with driver verifier enabled in order to help catch problems that may arise during testing. A pre-defined list of drivers has been developed by the USB-IF for Windows 11. Please choose the correct drivers to verify based on your operating system and then put these drivers into Driver Verifier as described in section 1.2.1.

9.1 List of Drivers for Windows 11:

Flag Setting: Verifier /flags 0x2099B /driver

bthusb.sys
hidclass.sys
hidparse.sys
hidusb.sys
kbdclass.sys
kbdhid.sys
mouclass.sys
mouhid.sys
uaspstor.sys
ucx01000.sys
usbaudio.sys
usbccgp.sys
usbd.sys
usbehci.sys
usbhub.sys
usbhub3.sys
usbohci.sys
usbport.sys
usbprint.sys
usbscan.sys
usbstor.sys
usbuhci.sys
usbvideo.sys
usbxhci.sys
winusb.sys
wmbclass.sys

Add Display Adapter Driver's

Any class or device-specific drivers used by a Device Under Test

10 Appendix B – Modified Interop Trees for SuperSpeed Testing

This appendix details temporary changes to this document. Unless noted here, all steps must be followed as described earlier in this document. All steps to verify interoperability, including driver verifier usage, function remote wake operation, current measurement, etc., must be followed as described in the main document. This appendix is only intended as a brief summary of testing changes required by lack of approved devices for the final interoperability tree.

USB Peripheral Interoperability Test Steps

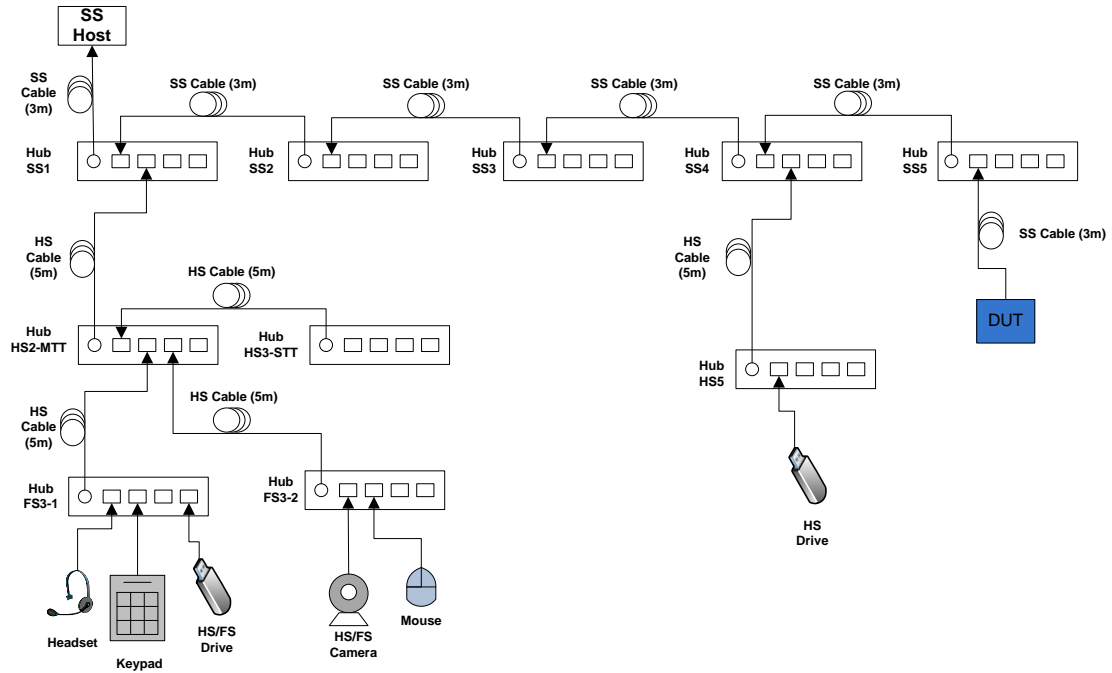


Figure 10-1: Modified Device (SuperSpeed Interoperability) Interim Tree

Modified tree:

Tier	Device
1	• Hub SS1 – Externally-powered USB SuperSpeed Hub at Root Port
2	• Hub SS2 - Externally-powered USB SuperSpeed Hub on port 1 of Hub SS1
3	• Hub SS3 - Externally-powered USB SuperSpeed Hub on port 1 of Hub SS2
4	• Hub SS4 - Externally-powered USB SuperSpeed Hub on port 1 of Hub SS3
5	• Hub SS5 – Externally-powered USB SuperSpeed Hub on port 1 of Hub SS4
6	• DUT on port 1 of Hub SS5
5	• Hub HS5 - Externally-powered high-speed Hub on port 2 of Hub SS4
6	• HS Drive on port 1 of Hub HS5
2	• Hub HS2-MTT - Externally-powered high-speed Hub with multiple transaction translators on port 2 of Hub SS1
3	• Hub HS3-STT - Externally-powered high-speed Hub with a single transaction translator on port 1 of Hub HS2-MTT
3	• Hub FS3-1 – Full-Speed Hub on port 2 of Hub HS2-MTT
4	• Headset on port 1 of Hub FS3-1
4	• FS Drive on port 4 of Hub FS3-1
4	• Keypad on port 2 of FS3-1
3	• Hub FS3-2 - Full-Speed Hub on port 3 of Hub HS2-MTT
4	• FS Video Camera on port 1 of Hub FS3-2
4	• Mouse on port 2 of Hub FS3-2

Chapter 2

a. Testing of DUT at Root Port

- Connect DUT to a port of xHCI controller
- Operate all devices at root port
- Run tests 1-8 as specified in Chapter 7
- Use same pass/fail criteria as used in main document

b. Test of DUT behind SS hub

- Disconnect all devices from xHCI controller
- Attach DUT to port 1 of Hub SS5 in the modified tree
- Attach modified tree to xHCI controller
- Operate all devices in tree as described in main document
- Run tests 1-8 as specified in Chapter 7
- Use same pass/fail criteria as used in main document

c. Test of DUT behind HS hub

- Unplug DUT from SS5
- Plug DUT into port 4 of HS Hub of HS5
- Operate all devices in tree as described in main document
- Run tests 1-8 as specified in Chapter 7
- Use same pass/fail criteria as used in main document

d. Test of DUT behind FS hub

- Unplug DUT from HS5
- Plug DUT into port 3 of FS3-1
- Operate all devices in tree as described in main document
- Use same pass/fail criteria as used in main document

DUT testing behind a USB 2.0 Hub (Host--USB2.0 Hub--DUT Topology)

- Connect DUT to the Downstream Facing Port of a USB2.0 Hub connected to the Host. Run tests 1-8 as specified in Chapter 7
- **Pass:**
All the tests 1-8 of Chapter 7 PASS
- **Fail:**
If any of the tests 1-8 of Chapter 7 FAIL

Repeat test by replacing the USB 2.0 Hub with a different USB 2.0 Hub. Repeat this test with various USB 2.0 Hubs available (the goal here is to test with various USB 2.0 Hubs that drop upto 4, 3, 2 or 1 sync bits).

USB Externally-Powered Hub Interoperability Test Steps

Chapter 3

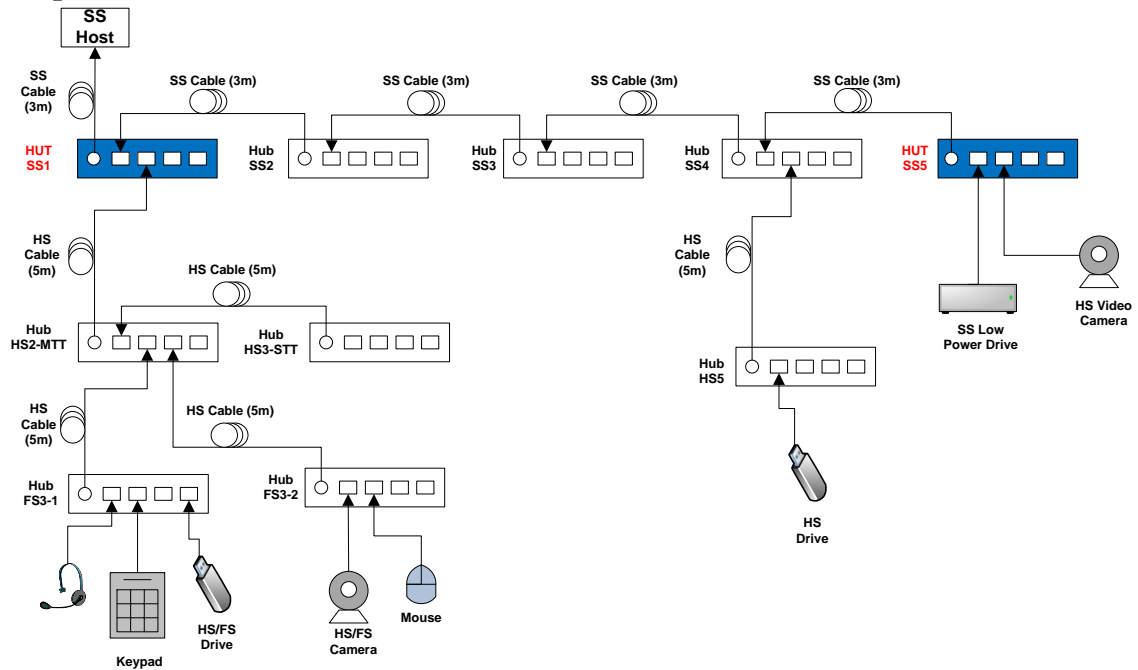


Figure 10-2: Modified Hub (SuperSpeed Interoperability) Interim Tree

Tier	Device
1	• Hub SS1 – Externally-powered USB SuperSpeed Hub Under Test (HUT) at Root Port
2	• Hub SS2 - Externally-powered USB SuperSpeed KGH on port 1 of Hub SS1
3	• Hub SS3 - Externally-powered USB SuperSpeed KGH on port 1 of Hub SS2
4	• Hub SS4 - Externally-powered USB SuperSpeed KGH on port 1 of Hub SS3
5	• Hub SS5 – Externally-powered USB SuperSpeed Hub Under Test (HUT) on port 1 of Hub SS4
6	• SS Low Power Drive on port 1 of Hub SS5
6	• HS Video Camera on port 2 of Hub SS5
5	• Hub HS5 - Externally-powered high-speed Hub on port 2 of Hub SS4
6	• HS Drive on port 1 of Hub HS5
2	• Hub HS2-MTT - Externally-powered high-speed Hub with multiple transaction translators on port 2 of Hub SS1
3	• Hub HS3-STT - Externally-powered high-speed Hub with a single transaction translator on port 1 of Hub HS2-MTT
3	• Hub FS3-1 – Full-Speed Hub on port 2 of Hub HS2-MTT
4	• Headset on port 1 of Hub FS3-1
4	• FS Drive on port 4 of Hub FS3-1
4	• Keypad on port 2 of FS3-1
3	• Hub FS3-2 - Full-Speed Hub on port 3 of Hub HS2-MTT
4	• FS Video Camera on port 1 of Hub FS3-2
4	• Mouse on port 2 of Hub FS3-2

a. DS port test

- Connect 2 KGD's to DS port's of 1 HUT. Connect upstream port of HUT to the XHCI Host
- Run tests 1-8 as specified in Chapter 7
- Use same pass/fail criteria as used in main document

b. Interop tree test

- Connect HUTs as shown in Figure 10-2 (Note use of 5 hubs)
- Run tests 1-8 as specified in Chapter 7
- Use same pass/fail criteria as used in main document
- Do topology changes as specified in Chapter 3
- Do 5 HUT Interop, by replacing Hub SS2 with HUT SS2, Hub SS3 with HUT SS3, and Hub SS4 with HUT SS4. Run tests 1-8 as specified in Chapter 7. Do topology changes as specified in Chapter 3.

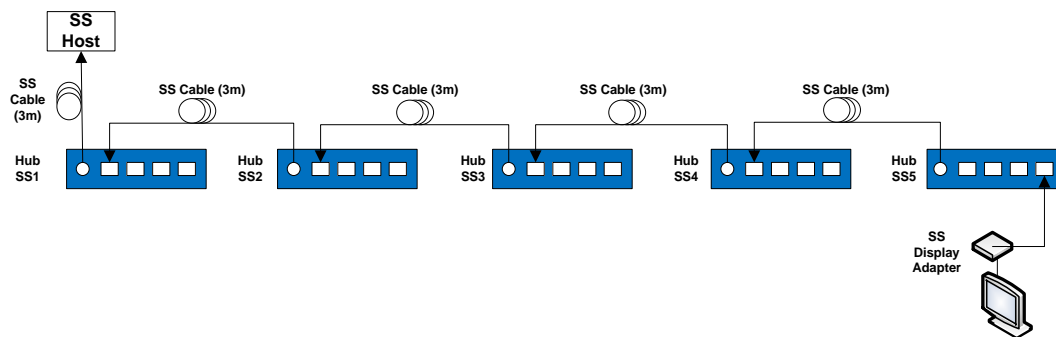


Figure 10-3: Modified Hub (SS Interoperability) Interim Tree - Display Device

Tier	Device
1	<ul style="list-style-type: none"> • Hub SS1– Externally-powered USB SuperSpeed Hub Under Test (HUT) at Root Port
2	<ul style="list-style-type: none"> • Hub SS2 - Externally-powered USB SuperSpeed Hub Under Test (HUT) on port 1 of Hub SS1
3	<ul style="list-style-type: none"> • Hub SS3 - Externally-powered USB SuperSpeed Hub Under Test (HUT) on port 1 of Hub SS2
4	<ul style="list-style-type: none"> • Hub SS4 - Externally-powered USB SuperSpeed Hub Under Test (HUT) on port 1 of Hub SS3
5	<ul style="list-style-type: none"> • Hub SS5– Externally-powered USB SuperSpeed Hub Under Test (HUT) on port 1 of Hub SS4
5	<ul style="list-style-type: none"> • SS Display Adapter– USB Video Display Adapter on port 4 of SS5

Interop 5 Deep HUT plus SS Isoch device test

- Connect HUTs as shown in Figure 10-3 (Note use of 5 hubs)
- Run tests 1-8 as specified in Chapter 7
- Use same pass/fail criteria as used in main document

USB Host Interoperability Test Steps

Chapter 5

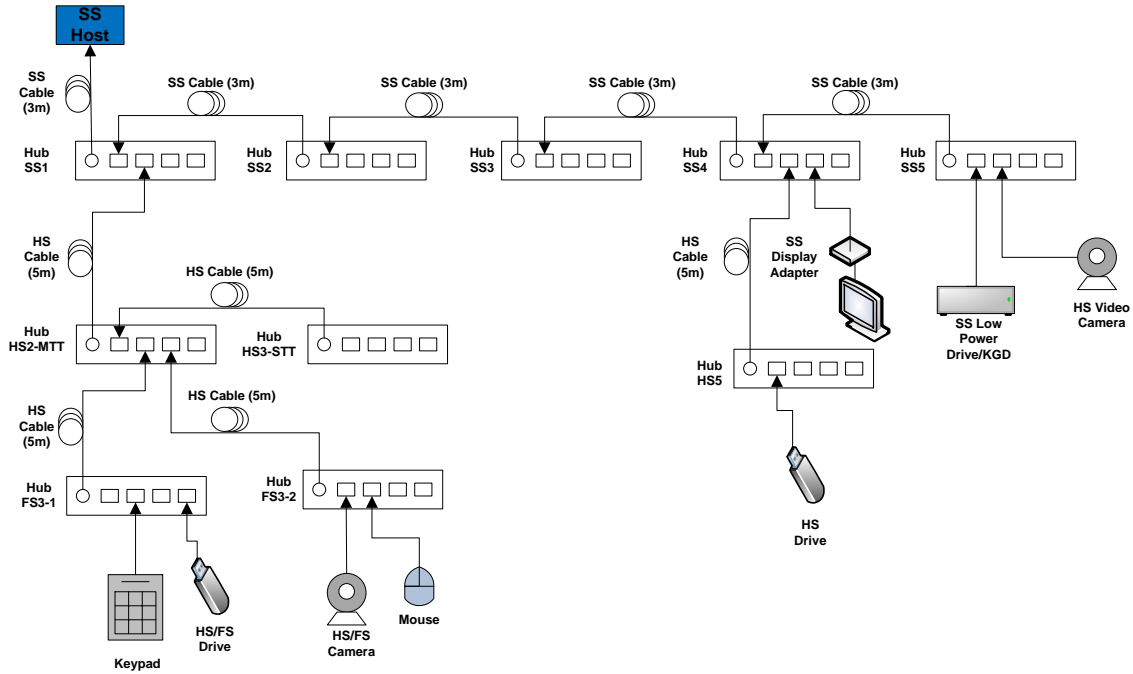


Figure 10-4: Modified Host (SuperSpeed Interoperability) Interim Tree

Tier	Device
1	• Hub SS1 – Externally-powered USB SuperSpeed Hub attached to the xHCI controller under test
2	• Hub SS2 - Externally-powered USB SuperSpeed Hub on port 1 of Hub SS1
3	• Hub SS3 - Externally-powered USB SuperSpeed Hub on port 1 of Hub SS2
4	• Hub SS4 - Externally-powered USB SuperSpeed Hub on port 1 of Hub SS3
5	• Hub SS5 - Externally-powered USB SuperSpeed Hub on port 1 of Hub SS4
6	• SS Low Power Drive/KGD on port 1 of Hub SS5
6	• HS Video Camera on port 2 of Hub SS5
5	• Hub HS5 - Externally-powered high-speed Hub on port 2 of Hub SS4
6	• HS Drive on port 1 of Hub HS5
5	• Display Adapter on Port 3 of SS4
2	• Hub HS2-MTT - Externally-powered high-speed Hub with multiple transaction translators on port 2 of Hub SS1
3	• Hub HS3-STT - Externally-powered high-speed Hub with a single transaction translator on port 1 of Hub HS2-MTT
3	• Hub FS3-1 – Full-Speed Hub on port 2 of Hub HS2-MTT
4	• FS Drive on port 4 of Hub FS3-1
4	• Keypad on port 2 of FS3-1
3	• Hub FS3-2 - Full-Speed Hub on port 3 of Hub HS2-MTT
4	• FS Video Camera on port 1 of Hub FS3-2
4	• Mouse on port 2 of Hub FS3-2

c. Root port test.

- Operate one KGD at root port
- Run tests 1-8 as specified in Chapter 7
- Repeat the test with each KGD
- Use same pass/fail criteria as used in main document

d. Interoperability with Modified Tree

- Remove all devices from xHCI controller
- Attach one KGD to hub SS5 of Modified Tree. Refer to Figure 10-4
- Attach Modified Tree to one xHCI controller port
- Operate all devices in tree as described in main document
- Run tests 1-8 as specified in Chapter 7
- Do Topology Changes 1 and 2 as described in the main document
- Use same pass/fail criteria as used in main document

e. Root port enumeration with Modified Tree

- Attach the tree to the other root ports
- Check all devices are enumerated correctly

11 Appendix C – Modified Interop Trees for SuperSpeedPlus Testing

This appendix details temporary changes to this document. Unless noted here, all steps must be followed as described earlier in this document. All steps to verify interoperability, including driver verifier usage, function remote wake operation, current measurement, etc., must be followed as described in the main document. This appendix is only intended as a brief summary of testing changes required by lack of approved devices for the final interoperability tree.

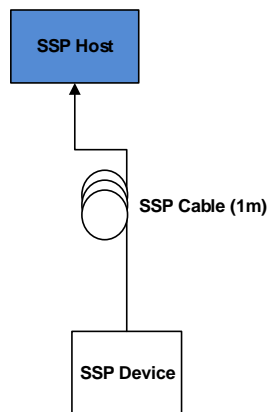


Figure 11-1: Modified Host/Device SSP Interoperability Interim Tree (with SSP Device)

a Root port test (with SSP Device)

- Operate one SSP Device at root port of the SSP Host (see Figure 11-1)
- Run tests 1-8 as specified in Chapter 7
- Repeat the test with each SSP DUT/KGD
- Use same pass/fail criteria as used in main document

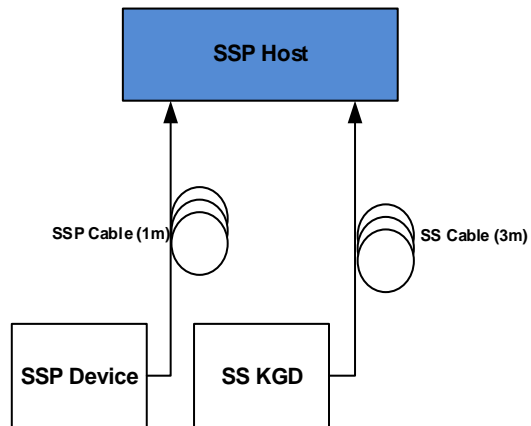


Figure 11-2: Modified Host/Device 3.1 Interoperability Interim Tree (with SSP device and 3.0 KGD)

c Root port test (with SSP Device and SS KGD)

- Connect one SSP Device at root port and a SS Asmedia KGD to another port of the SSP host (see Figure 11-2)
- Run tests 1-8 as specified in Chapter 7
- Repeat the test with SSP DUT/KGD and SS TI KGD
- Use same pass/fail criteria as used in main document

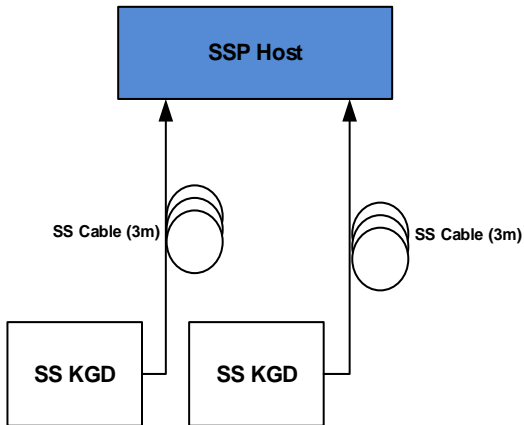


Figure 11-3: Modified Host Interoperability Interim Tree (with two 3.0 KGD's)

d Root port test (with two SS KGD's)

- Connect a SS Asmedia KGD and TI KGD at root port (see Figure 11-3)
- Run tests 1-8 as specified in Chapter 7
- Use same pass/fail criteria as used in main document

e DUT testing behind a USB 2.0 Hub (Host--USB2.0 Hub--DUT Topology)

Connect DUT to the Downstream Facing Port of a USB 2.0 Hub connected to the Host. Run tests 1-8 as specified in Chapter 7

- **Pass:**
All the tests 1-8 of Chapter 7 PASS
- **Fail:**
If any of the tests 1-8 of Chapter 7 FAIL

Repeat test by replacing the USB 2.0 Hub with a different USB 2.0 Hub. Repeat this test with various USB 2.0 Hubs available (the goal here is to test with various USB 2.0 Hubs that drop upto 4, 3, 2 or 1 sync bits).

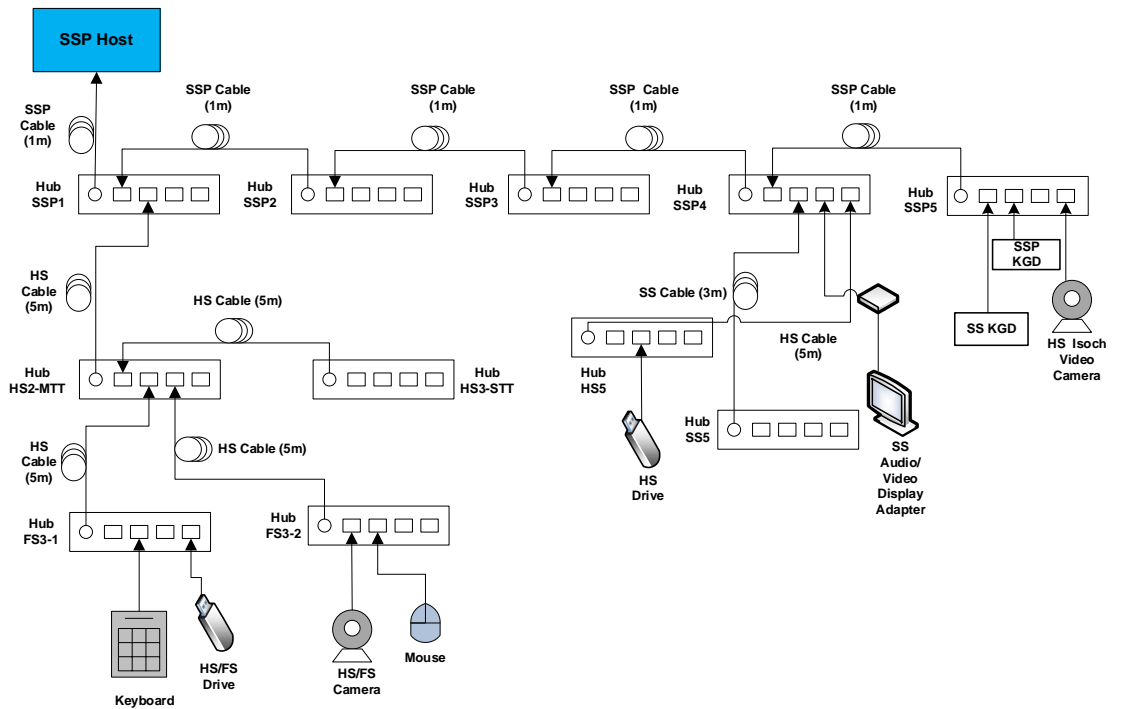


Figure 11-4: Modified SSP Host Interoperability Interop Tree (with SSP device and SSP Hubs Interop Tree)

f Root port test

- Connect the SSP tree as shown in Figure 11-4
- Run tests 1-8 as specified in Chapter 7
- Use same pass/fail criteria as used in main document

g Topology Change 1

- Stop all Interop Tree device operation! Close any software that is used for any Interop Tree device operation and close the “Recording” tab window.
- Operate the following devices concurrently:
 - Operate the microphone(s)
 - View streaming video from the Video Camera
 - Transfer a 30+ MB file from the SSP KGD to the FS Drive
 - Transfer a 1+ GB file from the HS Drive to the SS KGD
 - Transfer a 1+ GB file from the SS KGD to the SSP KGD
 - Watch video from monitor and listen to audio attached to USB Display Adapter
 - Strike keys on the keypad
- While operating the devices, detach the Hub FS3-2 from port 3 on Hub HS2-MTT.
- Reattach Hub FS3-2 to port 2 on Hub HS3-STT.
- Verify that all file transfers continue to take place.
- Verify that the Video Camera and Display Adapter continue to function.

- Operate all the devices in the SSP Interop Tree. Verify that all devices are operating concurrently.
- **Pass:**
 1. After the topology change the file transfers continued to take place
AND
 2. After the topology change the Video Camera continues to function
AND
 3. All Interop Tree devices operate correctly
- **Fail:**
 4. After the topology change any file transfer was cancelled
OR
 5. After the topology change the Video Camera stopped functioning
OR
 6. One or more Interop Tree devices fail to operate correctly

h Topology Change 2

- Stop all Interop Tree device operation! Close any software that is used for any Interop Tree device operation and close the “Recording” tab window.
- Operate the following devices concurrently:
 - View streaming video from the HS Video Camera
 - View streaming video from the FS Video Camera
 - Transfer a 1+ GB file from the HS Drive to the SS KGD
 - Transfer a 1+ GB file from the SS Drive to the SSP KGD
 - Watch video and listen to audio from monitor attached to USB Display Adapter
 - Move the mouse
 -
- While operating the devices, detach the Hub FS3-1 from port 2 on Hub HS2-MTT.
- Reattach Hub FS3-1 to port 1 on Hub HS3-STT
- Verify that both file transfers continue to take place.
- Verify that the FS Video Camera, HS Video Camera, and mouse continue to function.
- Operate the microphone(s).
- If the microphones do not work, this is acceptable. The current configuration may require more bandwidth than Hub HS3-STT can provide. The test setup must be restored to a configuration that has enough bandwidth by following the steps below:
 - Detach Hub FS3-1 from port 1 on Hub HS3-STT and reattach the Hub FS3-1 back to port 2 on Hub HS2-MTT. This should set the configuration back to what is displayed in Figure 5 3 and Figure 5 4.
- Operate all the devices in the SSP Interop Tree. Verify that all devices are operating concurrently.
- **Pass:**
 1. After the topology change the file transfers continued to take place

- AND
- 2. After the topology change the FS Video Camera, HS Video Camera, and mouse continue to function
- AND
- 3. All Interop Tree devices operate correctly
- **Fail:**
 - 4. After the topology change any file transfer was cancelled
 - OR
 - 5. After the topology change the SSP Video Camera, HS Video Camera, or mouse stopped functioning
 - OR
 - 6. One or more Interop Tree devices fail to operate correctly
 - **Please note all SSP hosts should pass Host, Device and Hub Interop Tree tests**

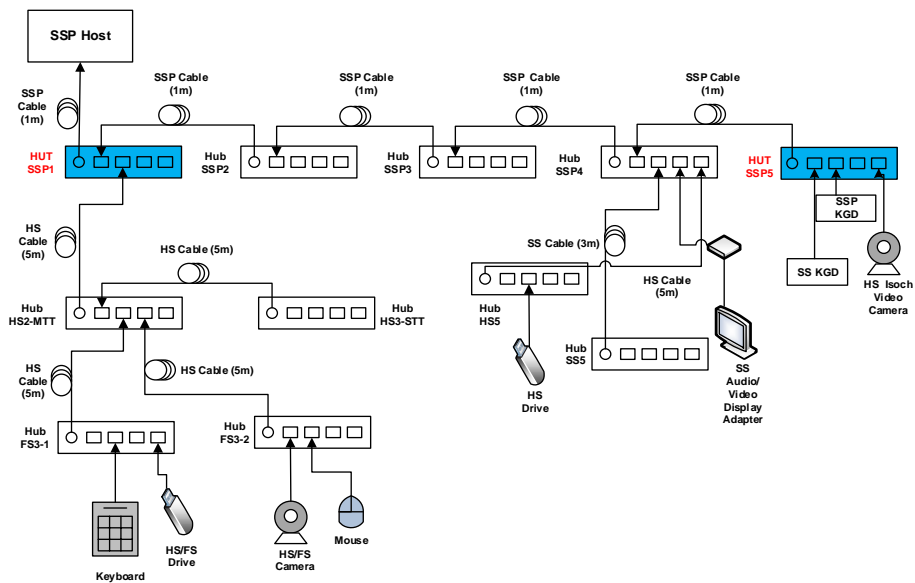


Figure 11-5: Modified Hub SSP Interoperability Interim Tree (with SSP device and SSP Hubs Interop Tree)

Interop Tree with SSP Hubs

- Connect HUT's as shown in Figure 11-5
- Run tests 1-8 as specified in Chapter 7
- Use same pass/fail criteria as used in main document (Chapter 3)
- Do Topology Change 1 and 2 as mentioned in the main document (Chapter 3)

Topology Change 1

- Stop all SSP Interop Tree device operation!
- Detach the Hub Under Test SSP1 from the SSP xHCI controller and detach all attached devices from the Hub Under Test SSP1.

Reattach the Hub Under Test SSP1 to port 3 of Hub SSP2. Then attach Hub HS2-MTT to port 2 of Hub SSP2 and Hub HS3-STT to port 3 of the Hub Under Test SSP1. Then attach Hub FS3-1 to port 1 of the Hub Under Test SSP1. Then attach Hub FS3-2 to port 2 of the Hub Under Test SSP1

- Run tests 1-8 as specified in Chapter 7
- Use same pass/fail criteria as used in main document (Chapter 3)

Topology Change 2

Stop all SSP Interop Tree device operation!

Operate the following devices concurrently:
View streaming video from the HS Video Camera
Transfer a 1+ GB file from the HS Drive to the SSP KGD
Watch video and listen to audio from monitor attached to USB Display Adapter
While operating the devices, detach the Hub Under Test from SSP2 and detach all attached devices from the Hub Under Test.

Detach Hub FS3-1 from Port 1 on Hub SSP1. Attach Hub FS3-1 to Port 1 on HS2-MTT

Detach HS3-STT from Hub SSP1 and attach Hub HS3-STT to Port 2 of Hub HS2-MTT

Detach Hub FS3-2 from Hub SSP1 and remove all devices from Hub FS3-2.
Attach Hub FS3-2 to port 2 of HS3-STT

Attach Hub SSP1 to Port 3 of Hub HS3-STT. Attach Mouse and Camera to Ports 1 and 2 of Hub SSP1

- Run tests 1-8 as specified in Chapter 7
- Use same pass/fail criteria as used in main document (Chapter 3)

DS port test (of SSP Hubs)

- Connect 2 SSP Devices/KGD's to DS port's of 1 SSP HUT. Connect upstream port of HUT to the SSP XHCI Host
- Run tests 1-8 as specified in Chapter 7
- Use same pass/fail criteria as used in main document

- Connect 1 SSP Devices/KGD's and 1 SS KGD to DS port's of 1 SSP HUT. Connect upstream port of HUT to the SSP XHCI Host
- Run tests 1-8 as specified in Chapter 7
- Use same pass/fail criteria as used in main document

- **Please note all SSP hubs should pass Host, Device and Hub Interop Tree tests**

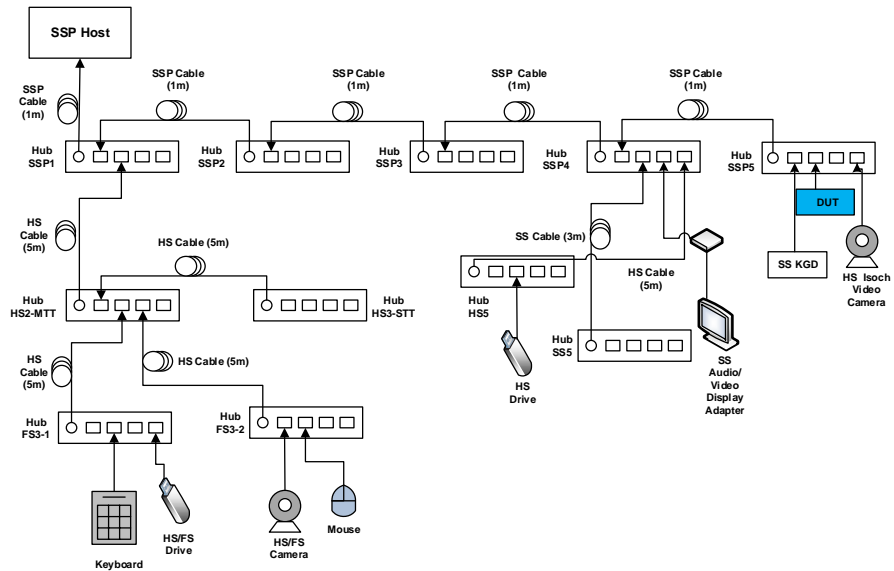


Figure 11-6: Modified Device SSP Interoperability Interim Tree (with SSP Hubs Interop Tree)

Root port test (with SSP Device and SSP Interop Tree)

- Connect one SSP DUT at root port.
- Run tests 1-8 as specified in Chapter 7
- Use same pass/fail criteria as used in main document

SSP Device Topology Change Tests (with SSP Device and SSP Interop Tree)

- Disconnect the SSP device from root port and connect it behind SSP5 (refer to Figure 11-6)
- Run tests 1-8 as specified in Chapter 7
- Use same pass/fail criteria as used in main document
- Disconnect the SSP device from SSP5 and connect it behind SS5 (refer to Figure 11-6)
- Run tests 1-8 as specified in Chapter 7
- Use same pass/fail criteria as used in main document
- Disconnect the SSP device from SS5 and connect it behind HS5 (refer to Figure 11-6)
- Run tests 1-8 as specified in Chapter 7
- Use same pass/fail criteria as used in main document
- Disconnect the SSP device from HS5 and connect it behind FS3-1 (refer to Figure 11-6)

11-6)

- Verify all devices can operate concurrently
- Use same pass/fail criteria as used in main document

12 Appendix D – Modified Interop Tree for USB Type-C Interoperability

This appendix details temporary changes to this document. Unless noted here, all steps must be followed as described earlier in this document (Chapter 8). All steps to verify interoperability, including driver verifier usage, function remote wake operation, current measurement, etc., must be followed as described in the main document. This appendix is only intended as a brief summary of testing changes required by lack of approved devices for the final interoperability tree.

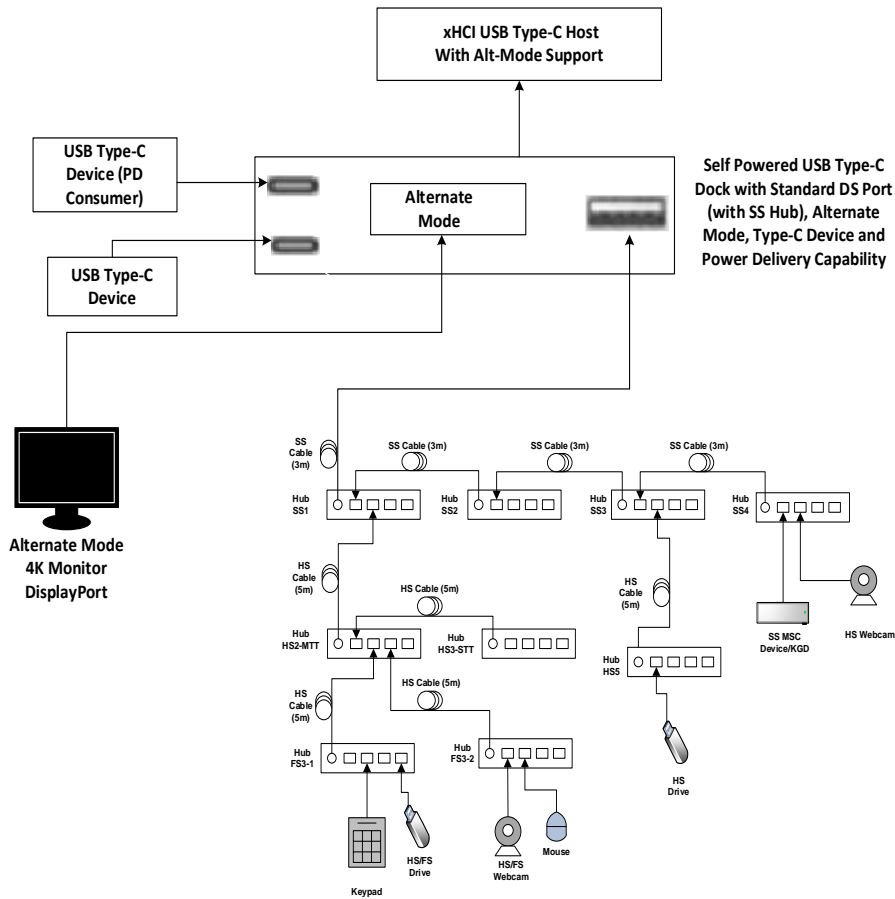


Figure 12-1: Modified USB Type-C Interoperability Interim Tree with SS Hubs and Devices (Example: For USB Type-C Dock, USB Type-C Devices connected to a USB Type-C Port on the dock, and Host)

Tier	Interoperability Tree Devices
USB Type-C Dock	USB Type-C Dock with Alternate Mode Display, Standard A receptacle, USB Type-C Ports
2	<ul style="list-style-type: none"> • Hub SS1– Externally-powered SuperSpeed Hub attached to the USB Type-C AV Adapter
3	<ul style="list-style-type: none"> • Hub SS2 - Externally-powered SuperSpeed Hub on port 1 of Hub SS1
4	<ul style="list-style-type: none"> • Hub SS3 - Externally-powered SuperSpeed Hub on port 1 of Hub SS2
5	<ul style="list-style-type: none"> • Hub SS4 - Externally-powered SuperSpeed Hub on port 1 of Hub SS3
	<ul style="list-style-type: none"> • SS MSC Device (eg. ASMedia KGD) on port 1 of Hub SS4
	<ul style="list-style-type: none"> • HS Webcam on port 2 of Hub SS4
5	<ul style="list-style-type: none"> • Hub HS5 - Externally-powered high-speed Hub on port 2 of Hub SS3
	<ul style="list-style-type: none"> • HS Drive on port 1 of Hub HS5
2	<ul style="list-style-type: none"> • Hub HS2-MTT - Externally-powered high-speed Hub with multiple transaction translators on port 2 of Hub SS1
3	<ul style="list-style-type: none"> • Hub HS3-STT - Externally-powered high-speed Hub with a single transaction translator on port 1 of Hub HS2-MTT
3	<ul style="list-style-type: none"> • Hub FS3-1 – Full-Speed Hub on port 2 of Hub HS2-MTT
4	<ul style="list-style-type: none"> • FS Drive on port 4 of Hub FS3-1
4	<ul style="list-style-type: none"> • Keypad on port 2 of FS3-1
3	<ul style="list-style-type: none"> • Hub FS3-2 - Full-Speed Hub on port 3 of Hub HS2-MTT
4	<ul style="list-style-type: none"> • FS Video Camera on port 1 of Hub FS3-2
4	<ul style="list-style-type: none"> • Mouse on port 2 of Hub FS3-2

USB Type-C Interop Tree Testing

a. Root port test

- Operate USB Type-C device/dock at root port
- Run tests 1-8 as specified in Chapter 7
- Repeat the test with each USB Type-C Device
- Use same pass/fail criteria as used in main document

b. Interoperability with Modified Tree

- Setup tree as illustrated in **Error! Reference source not found.**
- Operate all devices in tree as described in main document
- Run tests 1-8 as specified in Chapter 7
- Use same pass/fail criteria as used in main document

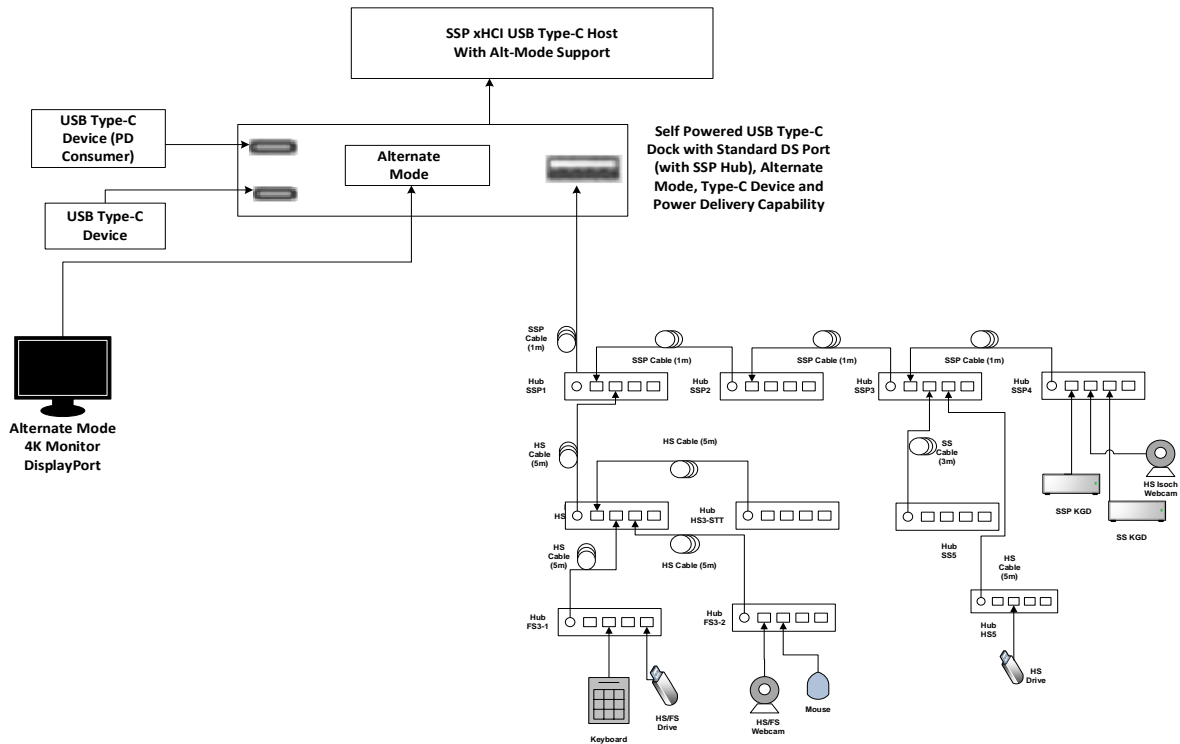


Figure 12-2: Modified USB Type-C Interoperability Interim Tree with SSP Host, SSP Hub and SSP Device (Example: For USB Type-C Dock, USB Type-C Devices connected to a USB Type-C Port on the dock, and Host)

Tier	Device
1	<ul style="list-style-type: none"> • USB Type-C Dock with Alternate Mode, Standard A Receptacle, PD Capability, USB Type-C ports
2	<ul style="list-style-type: none"> • Hub SSP1 - Externally-powered SuperSpeedPlus Hub on hub port on the USB Type-C Dock
3	<ul style="list-style-type: none"> • Hub SSP2 - Externally-powered SuperSpeedPlus Hub on port 1 of Hub SSP2
4	<ul style="list-style-type: none"> • Hub SSP3 - Externally-powered SuperSpeedPlus Hub Under Test on port 1 of Hub SSP2
5	<ul style="list-style-type: none"> • Hub HS5 - Externally-powered high-speed Hub on port 3 of Hub SSP3
	<ul style="list-style-type: none"> • HS Drive on port 2 of Hub HS5
5	<ul style="list-style-type: none"> • Hub SS5 - Externally-powered SuperSpeed Hub on port 2 of Hub SSP3
5	<ul style="list-style-type: none"> • Hub SSP4 - Externally-powered SuperSpeedPlus Hub Under Test on port 1 of Hub SSP3
	<ul style="list-style-type: none"> • SuperSpeedPlus KGD on port 1 of HUT SSP4
	<ul style="list-style-type: none"> • High Speed Webcam on port 2 of HUT SSP4
	<ul style="list-style-type: none"> • SuperSpeed KGD on port 3 of HUT SSP4
2	<ul style="list-style-type: none"> • Hub HS2-MTT - Externally-powered high-speed Hub with multiple transaction translators on port 2 of Hub SSP1
3	<ul style="list-style-type: none"> • Hub HS3-STT - Externally-powered high-speed Hub with a single transaction translator on port 1 of Hub HS2-MTT
3	<ul style="list-style-type: none"> • Hub FS3-1 – Full-Speed Hub on port 2 of Hub HS2-MTT
4	<ul style="list-style-type: none"> • FS Drive on port 4 of Hub FS3-1
4	<ul style="list-style-type: none"> • Keyboard on port 2 of FS3-1
3	<ul style="list-style-type: none"> • Hub FS3-2 - Full-Speed Hub on port 3 of Hub HS2-MTT
4	<ul style="list-style-type: none"> • HS/FS Webcam on port 1 of Hub FS3-2
4	<ul style="list-style-type: none"> • Mouse on port 2 of Hub FS3-2
Alt Mode	4K Display Monitor
PD Consumer	Power Consumer with USB Type-C Connector

USB Type-C Interop Tree Testing (with SSP Host, SSP Hub and SSP Device)

c. Root port test

- Operate USB Type-C device/dock at root port
- Run tests 1-8 as specified in Chapter 7
- Repeat the test with each USB Type-C Device
- Use same pass/fail criteria as used in main document

d. Interoperability with Modified Tree

- Setup tree as illustrated in Figure 12-2
- Operate all devices in tree as described in main document
- Run tests 1-8 as specified in Chapter 7
- Use same pass/fail criteria as used in main document

Please note: To test xHCI Host Systems that support DisplayPort-Alt Mode, the recommended 4K monitor with a hub that has a USB Type-C Upstream port and 2 Downstream A ports (listed in the Equipment for USB Type-C/PD Testing Doc.) can be used to construct the tree shown in Figure 12-2. This interop testing is in addition to the Interop testing required for all xHCI Hosts as mentioned in Chapter 5. Please note this is subject to change due to the limited life cycle of end products off the shelf.

13 Appendix E – Interop Tree for USB 3.2 Gen 2x2

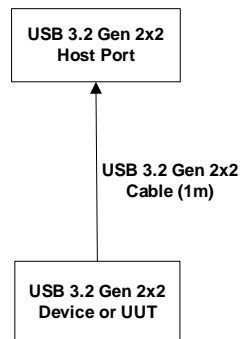


Figure 13-1: Host/Device USB 3.2 Gen 2x2 Interoperability at Root Port

a Root port test (with USB 3.2 Gen 2x2 Device)

- Connect one Device (USB 3.2 Gen 2x2 Device or DUT) at root port of the USB 3.2 Gen 2x2 Host Port (see Figure 13-1)
- Run tests 1-8 as specified in Chapter 7
- For USB 3.2 Gen 2x2 Host testing repeat with various USB 3.2 Gen 2x2 Devices at the Root Port
- Use same pass/fail criteria as used in main document

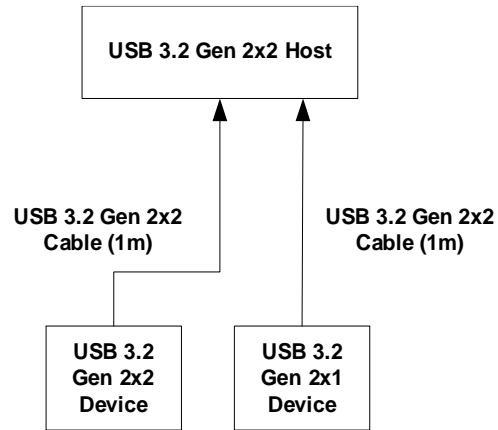


Figure 13-2: Host Root Port Testing with Multiple USB Devices (with USB3.2 Gen 2x2 device and USB3.2 Gen 2x1 KGD)

b Root port test (with USB 3.2 Gen 2x2 Device and USB 3.2 Gen 2x1 KGD)

Connect one USB 3.2 Gen 2x2 Device at root port and a USB 3.2 Gen 2x1 KGD to another port of the USB 3.2 Gen 2x2 host (see

- Figure 13-2)
- Run tests 1-8 as specified in Chapter 7
- Use same pass/fail criteria as used in main document

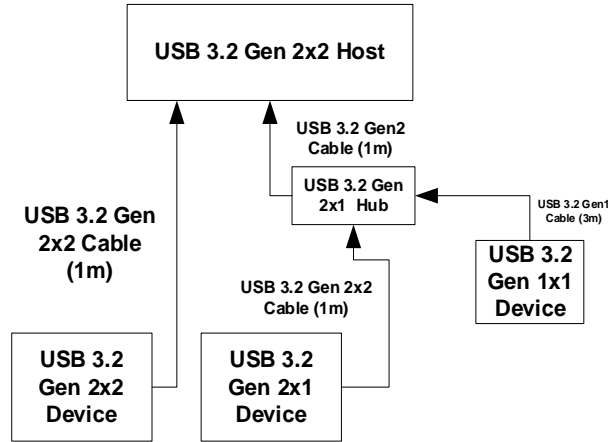


Figure 13-3: Host Root Port Testing with Multiple Devices (of various speeds) and Hub

c Root port test

- Connect one USB 3.2 Gen 2x2 Device at root port, and a USB3.2 Gen 2x1 Hub (with devices connected to the downstream facing ports of the Hub) to another port of the USB 3.2 Gen 2x2 host (see Figure 13-3)
- Run tests 1-8 as specified in Chapter 7
- Use same pass/fail criteria as used in main document

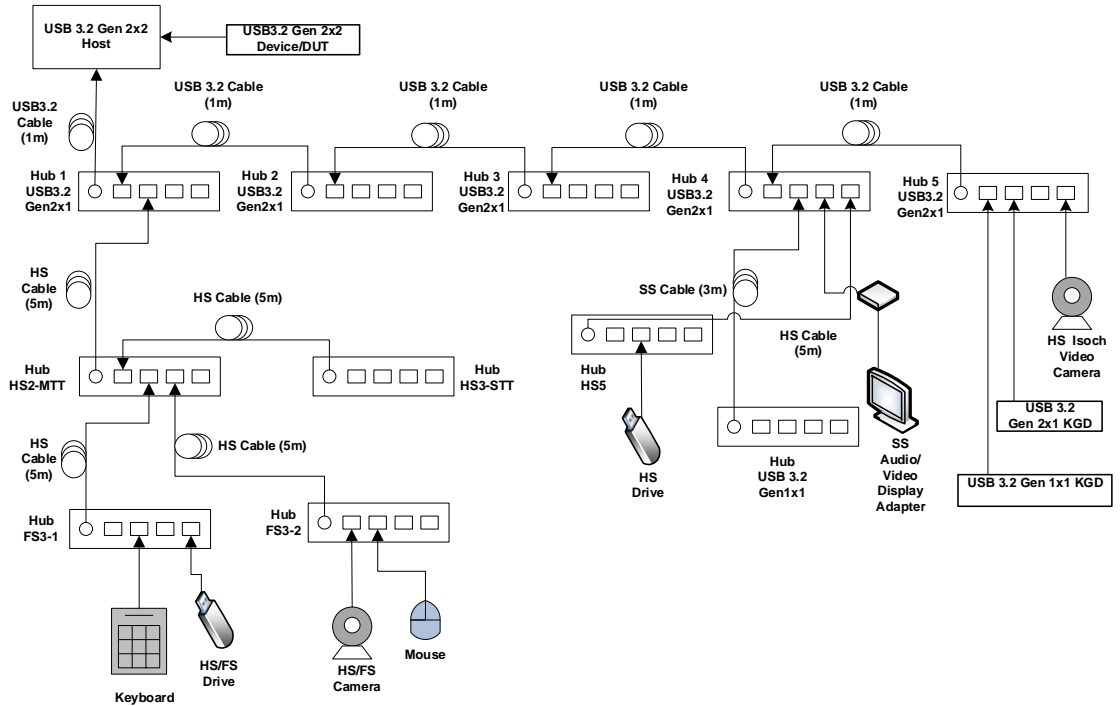


Figure 13-4: Modified USB 3.2 Gen 2x2 Host/Device Interoperability Interim Tree

d Root port test (with USB 3.2 Gen 2x2 Device and Interop Tree)

- Connect the USB 3.2 Gen 2x2 tree as shown in Figure 13-4
- Run tests 1-8 as specified in Chapter 7
- Use same pass/fail criteria as used in main document

e Device Topology Change Tests

- Disconnect the USB 3.2 Gen 2x2 DUT device from root port (refer to Figure 13-4) and connect it behind Hub 5 USB 3.2 Gen 2x1
- Run tests 1-8 as specified in Chapter 7
- Use same pass/fail criteria as used in main document

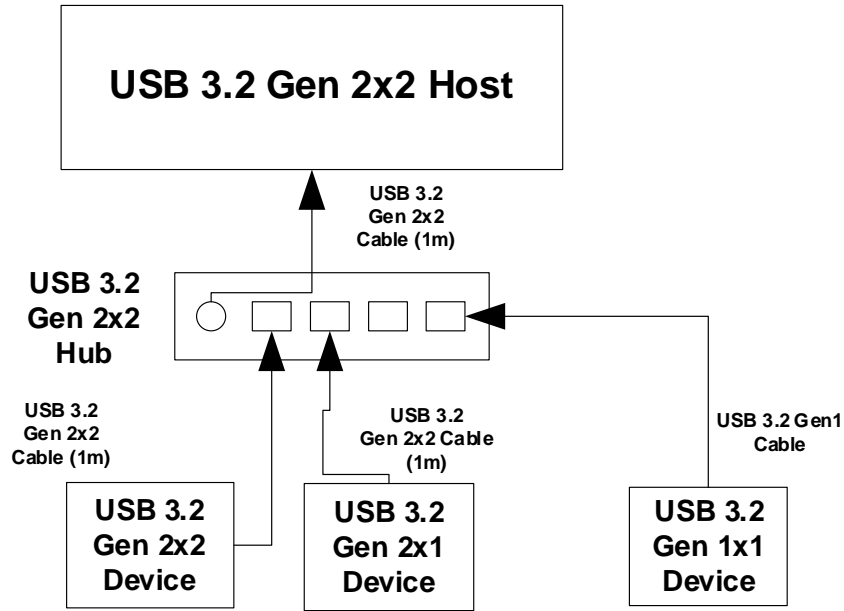


Figure 13-5: USB 3.2 Gen 2x2 Hub/Host/Device Interop Test Topology with USB 3.2 Gen 2x2 Hub

- g USB 3.2 Gen 2x2 Interop Topology with USB 3.2 Gen 2x2 Hub**
 - o Connect the USB 3.2 Gen 2x2 tree as shown in Figure 13-6Figure 13-5
 - o Run tests 1-8 as specified in Chapter 7
 - o Use same pass/fail criteria as used in main document

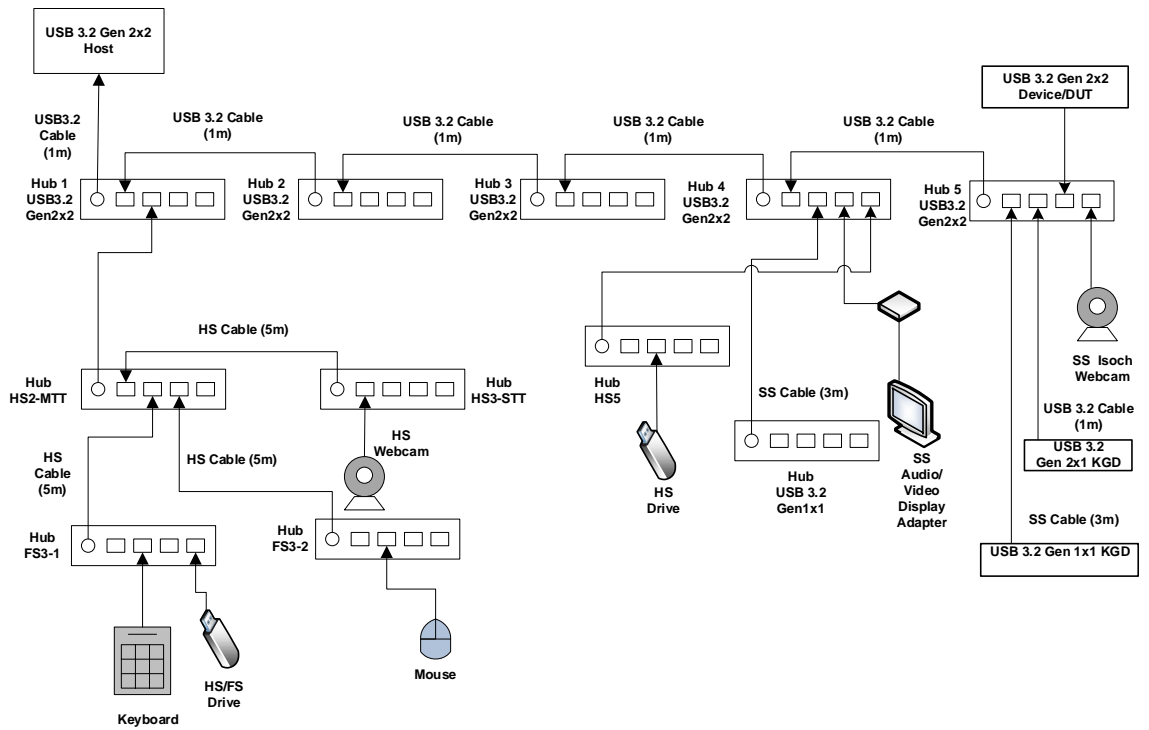


Figure 13-6: Modified USB 3.2 Gen 2x2 Hub/Host/Device Interoperability Interim Tree with USB 3.2 Gen 2x2 Hubs

h USB 3.2 Gen 2x2 Interop Tree with USB 3.2 Gen 2x2 Hubs

- Connect the USB 3.2 Gen 2x2 tree as shown in Figure 13-6
- Run tests 1-8 as specified in Chapter 7
- Use same pass/fail criteria as used in main document