

USB Implementers Forum
xHCI Interoperability Test Procedures For
Peripherals,
Hubs,
Hosts
Revision 1.3 – October 2011

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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 SuperSpeed Interop Tree. The SuperSpeed Interop 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 SuperSpeed, high-speed and full-speed
- Contains devices that operate at SuperSpeed, high-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.

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

1.1 Equipment Used

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 SuperSpeed hubs in this document are actually USB 3.0 hubs with USB 2.0 and SuperSpeed functionality.

Item	Description/Model	Qty
USB host system	1. A computer containing an available slot for a Certified USB xHCI controller or an integrated Certified USB xHCI controller. 2. A multiple core processor is required	1
SS hub(self-powered)	Any Certified SuperSpeed USB 3.0 self-powered hub with at least 4 downstream ports	5
HS hub w/STT (self-powered)	Any Certified USB self-powered, high-speed hub with a single TT and at least 4 downstream ports	1
HS hub w/MTT (self-powered)	Any Certified USB self-powered, high-speed hub with multiple TTs and at least 4 downstream ports	1
HS hub(self-powered)	Any Certified USB self-powered, high-speed hub with at least 4 downstream ports	3
FS hub (bus-powered) with integrated keyboard	Any Certified USB bus-powered, full-speed hub with at least 2 downstream ports and an integrated keyboard	2
SS low power UASP drive	Any Certified SuperSpeed USB low-power/self-powered mass storage device compliant with the Mass Storage UASP Class	1
SS high power UASP drive	Any Certified SuperSpeed USB high-power mass storage device compliant with the Mass Storage UASP Class	1
SS video camera	Any Certified SuperSpeed USB video camera compliant with the Video Class	1
FS low power drive	Any Certified USB low-power/self-powered, 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
Printer	Any Certified USB printer compliant with the Printer Class	1
Headset	Any Certified USB headset compliant with the Audio Class that can operate at full-speed and has both headphones and a microphone	1
three meter SS USB cable	Any Certified SuperSpeed USB 3.0 cable assembly	5
five meter HS USB cable	Any Certified USB 2.0 high-speed cable assembly	5

The SuperSpeed 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

SuperSpeed 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 SuperSpeed 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 SuperSpeed USB 3.0 hubs or Certified SuperSpeed USB peripherals for some device classes. Any Certified SuperSpeed USB 3.0 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 USB 3.0 hub or SuperSpeed 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
SS high power UASP drive	SS low power UASP drive	Any Certified SuperSpeed USB low-power/self-powered mass storage device compliant with the Mass Storage UASP Class
SS high power UASP drive	SS high power drive	Any Certified SuperSpeed USB high-power mass storage device compliant with the Mass Storage Class
SS high power UASP drive	SS low power drive	Any Certified SuperSpeed USB low-power/self-powered mass storage device compliant with the Mass Storage Class
SS low power UASP drive	SS low power drive	Any Certified SuperSpeed USB low-power/self-powered mass storage device compliant with the Mass Storage Class
SS video camera	HS video camera	Any Certified USB high-speed video camera compliant with the Video Class
SS Optical Device	HS CD ROM Device	Any Certified USB high-speed Optical Device compliant with the Mass Storage Class
SS USB cable	SS USB cable	Any available SuperSpeed USB 3.0 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 SuperSpeed Interop Tree.

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

All Devices:

All devices in the SuperSpeed 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 SuperSpeed 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.
- 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 SuperSpeed Interop Tree exercises five tiers of 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 as well as high-speed and USB3.0 hubs is required since all high-speed peripherals must support full-speed signaling. Finding a certified full-speed hub is extremely difficult because the USB-IF has not certified full-speed hubs for many years. However, the USB-IF allows compound devices to expose full-speed downstream ports and be certified. Thus, two certified full-speed compound USB keyboards are required and must each offer two full-speed downstream ports.

The USB 3.0 and high-speed hubs are required to be self-powered, while the compound keyboards are required to be bus-powered. This is to ensure the SuperSpeed Interop Tree exercises both self-powered and bus-powered hubs.

USB Mass Storage:

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

- ✓ Two SuperSpeed, one high-speed, and one high-speed or full-speed
- ✓ bulk transport
- ✓ one SuperSpeed USB device must be a high-power device, such as a flash drive or bus-powered hard drive
- ✓ one SuperSpeed USB device must be a low-power or self-powered device, such as an external hard drive
 - To determine if a device is high-power, low-power, or self-powered, connect the device to another system (not the SuperSpeed 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 3.0 devices and more than 100mA for USB 2.0 devices.
- ✓ the full-speed or high-speed device operating at full-speed must be a low-power or self-powered device, such as an external hard drive
- ✓ compliant with the USB Mass Storage Class
 - The SuperSpeed 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 SuperSpeed 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 a SuperSpeed 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 USB View.
- ✓ compliant with the USB Video Class

USB Mouse:

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

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

USB Printer:

1 Certified USB printer must be used as a SuperSpeed Interop Tree device.

- ✓ bulk transport
- ✓ compliant with the USB Printer Class

USB Headset:

One Certified USB headset must be used as a SuperSpeed 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 3.0 specification are 3 meters in length. To test the worst case propagation delays, the use of Certified USB five meter high-speed cables and Certified SuperSpeed USB three meter cables is mandatory.

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.

If the xHCI controller is integrated into the motherboard, ensure that the BIOS settings are set to give full control of the integrated USB 3.0 ports to the integrated xHCI. Also ensure that the BIOS settings are set to enable Spread Spectrum Clocking (SSC) (if the host controller uses the motherboard clock to generate the USB clock) for the USB 3.0 ports with the correct modulation as specified in the USB 3.0 Specification.

1.2 Software Used

Item	Description / Model
Operating system	Microsoft Windows 7 (any edition)
Disk imaging utility	Microsoft Windows 7 Backup and Restore Center <i>or</i> Norton Ghost™ from Symantec <i>or</i> Backup & Recovery™ from Acronis®
Data File Verification	Winzip® from WinZip Computing, S.L. <i>or</i> jZip from Discordia Limited

1.2.1 Install the Operating System

The host software required is Windows 7. Either restore the saved image of the previously prepared system or follow the steps given below.

Install Windows 7 using the default installation options. If you decide to choose custom installation options, verify that USB Selective Suspend is enabled.

Turn off User Account Control. This can be found under Control Panel -> User Accounts and Family Safety -> 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->Edit Plan Settings, click "Change advanced power settings", then "Sleep" -> "Allow Hybrid Sleep" and make sure it's set to "On".

Install the Windows Driver Kit (WDK) for Windows 7. This is freely available on Microsoft.com. This will be used to set specific sleep states. At the time of this writing, the WDK 7600.16385.1 was used and installed in the default location, making the scripts reference to the location C:\WinDDK\7600.16385.1\. Please update this location in the scripts if the WDK has a newer version or is installed in a different directory.

For setting hibernate sleep state, a short batch file must be created on the desktop.

- The Hibernate batch file, named Hibernate.bat, should contain the following lines:

```
C:\WinDDK\7600.16385.1\tools\PowerManagement\i386\pwrtest.exe /sleep /s:4 /h:n /p:60
echo You may now close this prompt
pause
```

Note: If you are using a 64bit version of Windows 7, the shortcuts above need to point to 'amd64' instead of 'i386'. Test out these shortcuts to ensure that they suspend the machine correctly before continuing.

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 service packs and recommended updates for the operating system.

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

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

- Connect the xHCI Backwards Compatibility Tree to another system running Windows 7 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 Backwards Compatibility 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. If you hit a recurring crash on boot, disconnect the Interop Tree and enter safe mode on Windows. Then run 'Verifier /reset' to turn off the verifier.

1.2.2 Software Logistical Overview

Certification is permitted using Windows 7. Testing other operating systems is encouraged, but not required.

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 25MB+ .zip file on the HS Low Power Drive, a 1GB+ .zip file on the HS Drive, and a 4GB+ .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.

1.3 xHCI Interoperability Test Verification

Before running the xHCI Interoperability tests with a newly created Interop Tree, run the tests without the DUT first and with a similar Certified USB device instead. Ensure that all tests pass. If a test does not pass, investigate what software, driver, or device could be causing the failure. The xHCI Interoperability tests were designed to pass when run on any Certified USB device, so any issues that arise from testing with the Certified USB device should be resolved before testing the device under test.

1.4 xHCI Interoperability Logistical Overview

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

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

1.5 USB Peripheral Interoperability Test Steps

Construct the SuperSpeed Interop Tree as outlined in Figure 1.5.1. Do not attach the SuperSpeed Interop Tree to the xHCI controller.

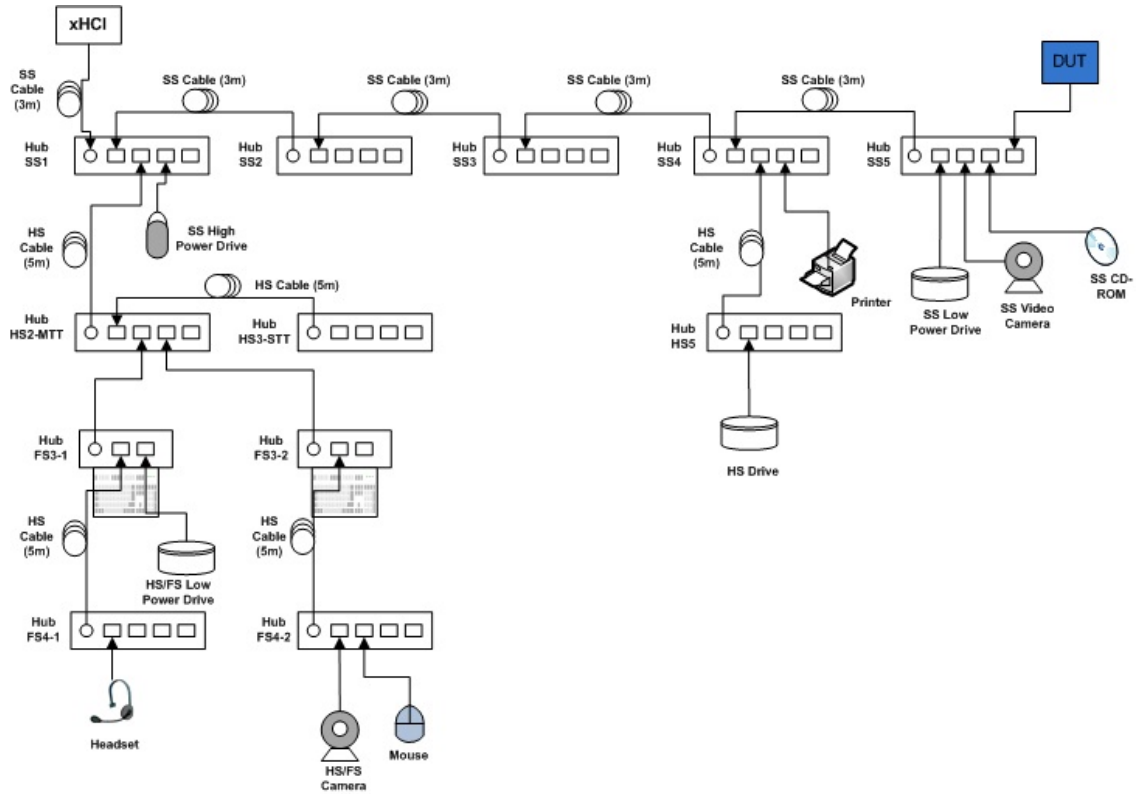


Figure 1.5.1: SuperSpeed Interop Tree with Device Under Test

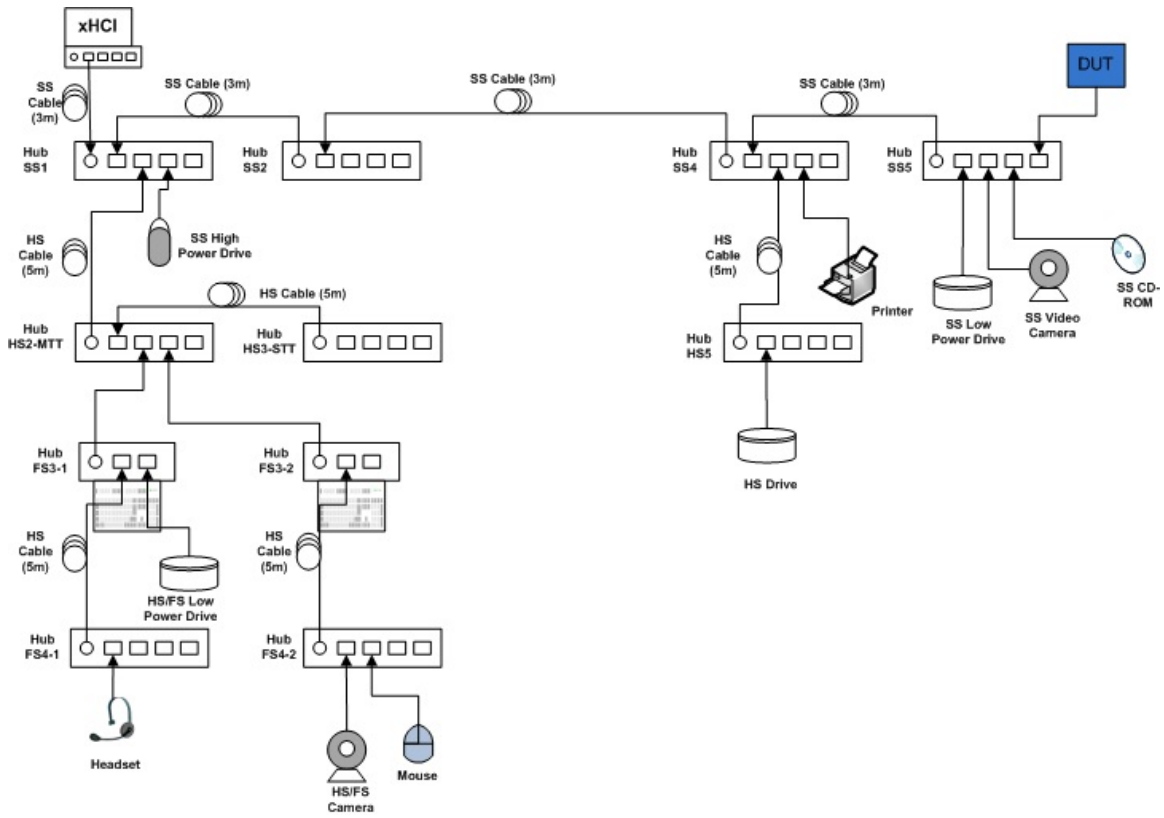


Figure 1.5.1 (embedded hub): SuperSpeed Interop Tree with Device Under Test

Tier	Device
1	• Hub SS1 – Self-powered USB3.0 Hub attached to the xHCI controller
2	• Hub SS2 - Self-powered USB3.0 Hub on port 1 of Hub SS1
3	• Hub SS3 - Self-powered USB3.0 Hub on port 1 of Hub SS2
4	• Hub SS4 - Self-powered USB3.0 Hub on port 1 of Hub SS3-STT
5	• Hub SS5 - Self-powered USB3.0 Hub on port 1 of Hub SS4
6	• SS Low Power Drive on port 1 of Hub SS5
6	• SS Video Camera on port 2 of Hub SS5
6	• SS CD-ROM on port 3 of Hub SS5
6	• Device Under Test on port 4 of Hub SS5
5	• Hub HS5 - Self-powered high-speed Hub on port 2 of Hub SS4
6	• HS Drive on port 1 of Hub HS5
5	• Printer on port 3 of Hub SS4
2	• Hub HS2-MTT - Self-powered high-speed Hub with multiple transaction translators on port 2 of Hub SS1
3	• Hub HS3-STT - Self-powered high-speed Hub with a single transaction translator on port 1 of Hub HS2-MTT
3	• Hub FS3-1 - Bus-powered full-speed Keyboard Hub on port 2 of Hub HS2-MTT
4	• Hub FS4-1 - Self-powered high-speed Hub on port 1 of Hub FS3-1
5	• Headset on port 1 of Hub FS4-1
4	• FS Low Power Drive on port 2 of Hub FS3-1
3	• Hub FS3-2 - Bus-powered full-speed Keyboard Hub on port 3 of Hub HS2-MTT
4	• Hub FS4-2 - Self-powered high-speed Hub on port 1 of Hub FS3-2
5	• FS Video Camera on port 1 of Hub FS4-2
5	• Mouse on port 2 of Hub FS4-2
2	• SS High Power Drive on port 3 of Hub SS1

1.5.1 USB Peripheral Interoperability Tests

1. 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 xHCI controller into the USB Host System if it is not already integrated.

- Ensure that the SuperSpeed Interop Tree is not attached to the 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 xHCI controller driver.

- The OS displays that it cannot find the driver for the xHCI controller. Follow the vendor-recommended install procedure to complete the driver install.
- If the xHCI controller is already integrated into the USB Host System, then the OS displays nothing, as it has already attempted install for the 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 xHCI controller driver
OR
 2. The vendor-recommended install procedure installs the xHCI controller driver)
AND
 3. The xHCI controller driver is installed correctly and operates (no yellow exclamation point is displayed in device manager)
- **Fail:**
 1. The xHCI controller driver does not install
OR
 2. The 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 SuperSpeed Interop Tree prior to attaching the SuperSpeed Interop Tree to the xHCI controller.

Attach the SuperSpeed Interop Tree by connecting SS1 into any port on the xHCI controller.

- If the xHCI controller has an embedded hub, then unplug Hub SS3 and Hub SS4; re-plug Hub SS4 directly into port one of Hub SS2.

For each device in the SuperSpeed Interop Tree (including the DUT) follow the vendor-recommended install procedure. Ensure that all drivers listed for each device in the SuperSpeed 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 SuperSpeed Interop Tree devices enumerate
AND
 2. All SuperSpeed Interop Tree devices drivers are installed either automatically or through the vendor recommended install procedure
AND
 3. All SuperSpeed Interop Tree devices do not require a reboot
AND
 4. All SuperSpeed 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 SuperSpeed Interop Tree.
- Whenever the **Peripheral 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 Headset (and the microphones in the Video Cameras if applicable) by speaking into the microphone and viewing the microphone's status
 - This can be found under 'Control Panel' -> 'Hardware and Sound' -> 'Sound' under the 'Recording' tab
 - View streaming video from the SS Video Camera
 - View streaming video from the FS Video Camera
 - Play a familiar song through the headset to ensure audio is working

Poor video or audio quality may be seen when Driver Verifier is enabled. If there was poor quality, then the xHCI Backwards Compatibility without Driver Verifier Test will be required for this host. Otherwise, it is an option to run xHCI Backwards Compatibility without Driver Verifier Test.
 - Transfer a 1+ GB file from the SS High Power Drive to the SS Low Power Drive
 - Transfer a 25+ MB file from the FS Low Power Drive to the SS High Power Drive
 - Transfer a 1+ GB file from the HS Drive to the SS High Power Drive
 - Operate the Device Under Test
 - If the DUT is a SS Mass Storage Device, then transfer a 4GB+file from the SS 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.

- Print a sample page from the printer
 - The printing should be long enough to overlap with other operations. The sample page can be a picture or a text file that lasts long enough in print to meet the test requirements.
- Strike keys on both of the keyboards
- Move the mouse
- Verify that all devices are operating concurrently. Verify the Device Speed using the USB View utility.
- - **Pass:**
All SuperSpeed Interop Tree devices operate correctly
 - **Fail:**
One or more SuperSpeed Interop Tree devices fail to operate correctly

4. All Devices Tests

- Run tests 1-6 located in Section 1.9

5. Topology Change 1

- Operate all the devices in the SuperSpeed Interop Tree except the Device Under Test.
- While operating the devices, detach the Device Under Test from port 4 on Hub SS5
- While operating the devices, reattach the Device Under Test to port 2 on Hub HS5 as shown in Figure 1.5.2.

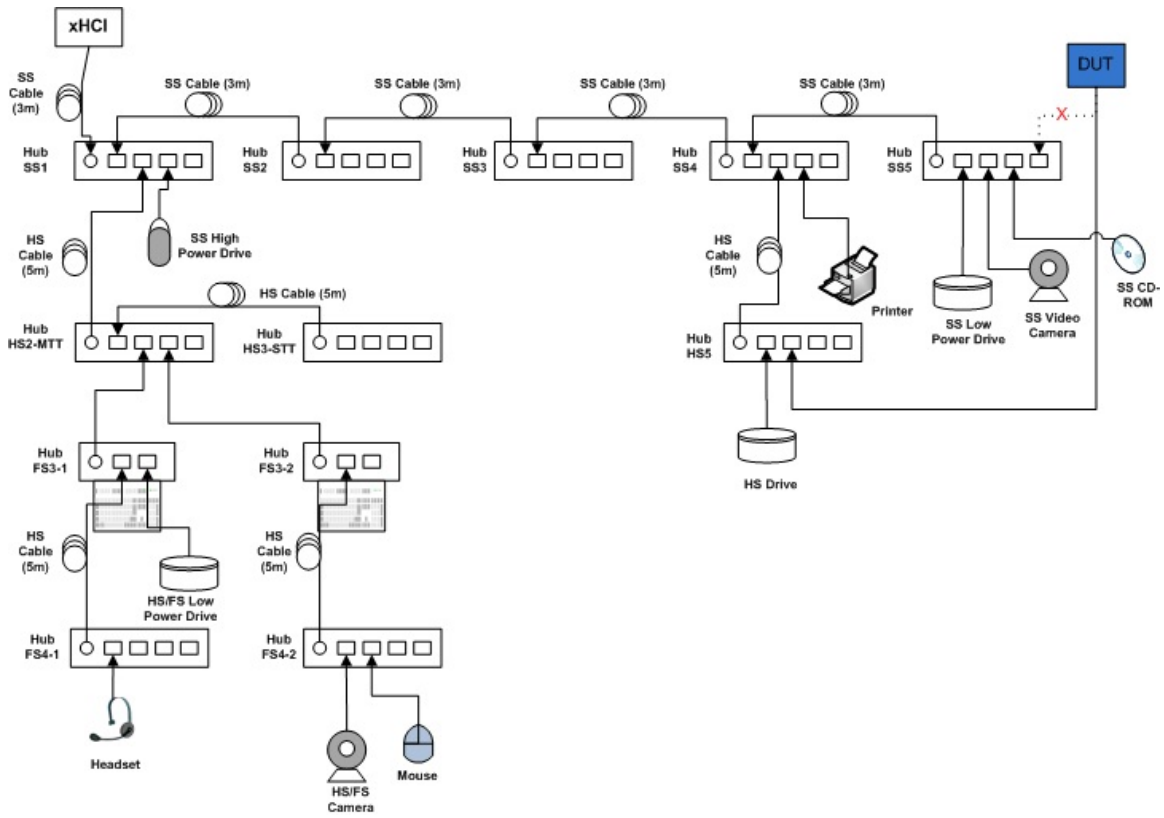


Figure 1.5.2: Topology Change 1

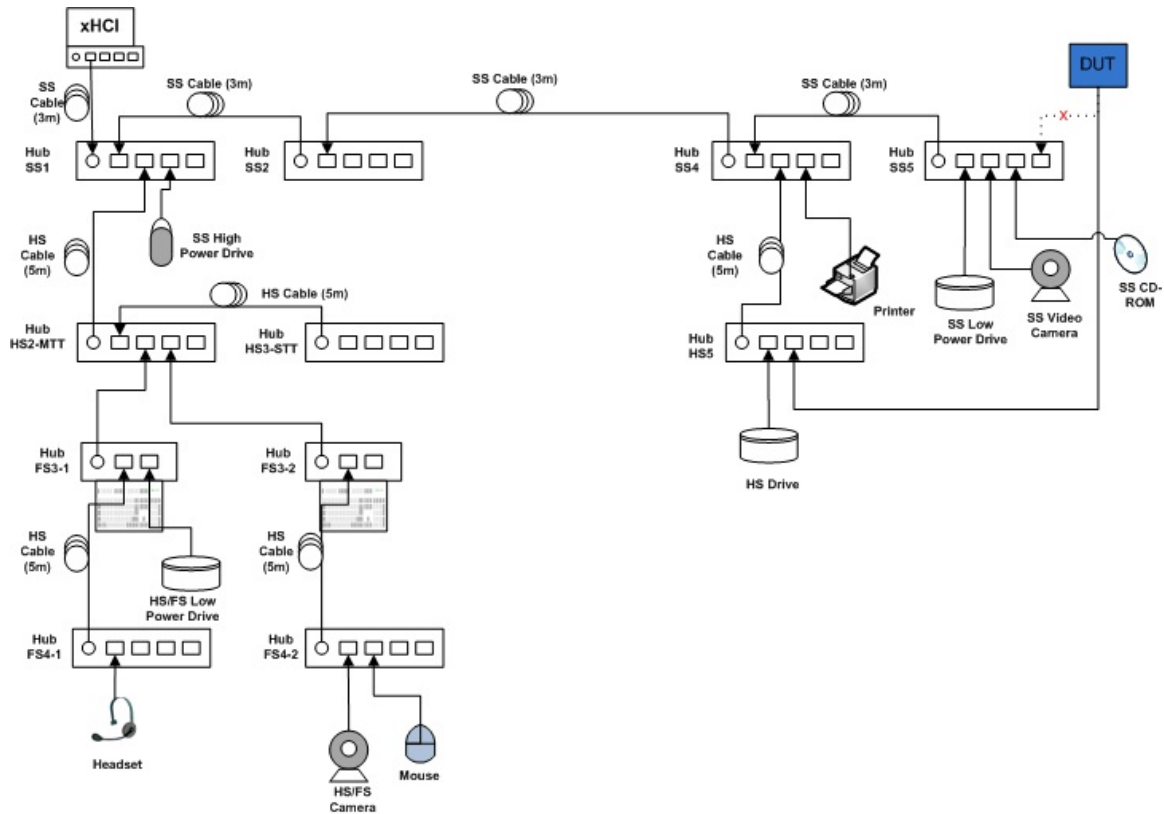


Figure 1.5.2 (embedded hub): Topology Change 1

- Verify that all devices except for the Device Under Test continue to operate concurrently.
- Operate the Device Under Test.
 - If the Device Under Test has Isochronous or Interrupt endpoints, then it may not have enough bandwidth to function properly. If the Device Under Test cannot function properly in this configuration, disable the headset speakers and the headset microphone for this test and leave it disabled for the All Device Tests.
- **Pass:**
All SuperSpeed Interop Tree devices operate correctly
- **Fail:**
One or more SuperSpeed Interop Tree devices fail to operate correctly

6. All Devices Tests

- Run tests 1-6 located in Section 1.9

7. Topology Change 2(For Low/Full-speed capable USB Devices only)

- Operate all the devices in the SuperSpeed Interop Tree except the Device Under Test.
- While operating the devices, detach the Device Under Test from port 2 on Hub HS5.
- While operating the devices, attach the Device Under Test to port 2 on Hub FS4-1 as shown below in Figure 1.5.3.

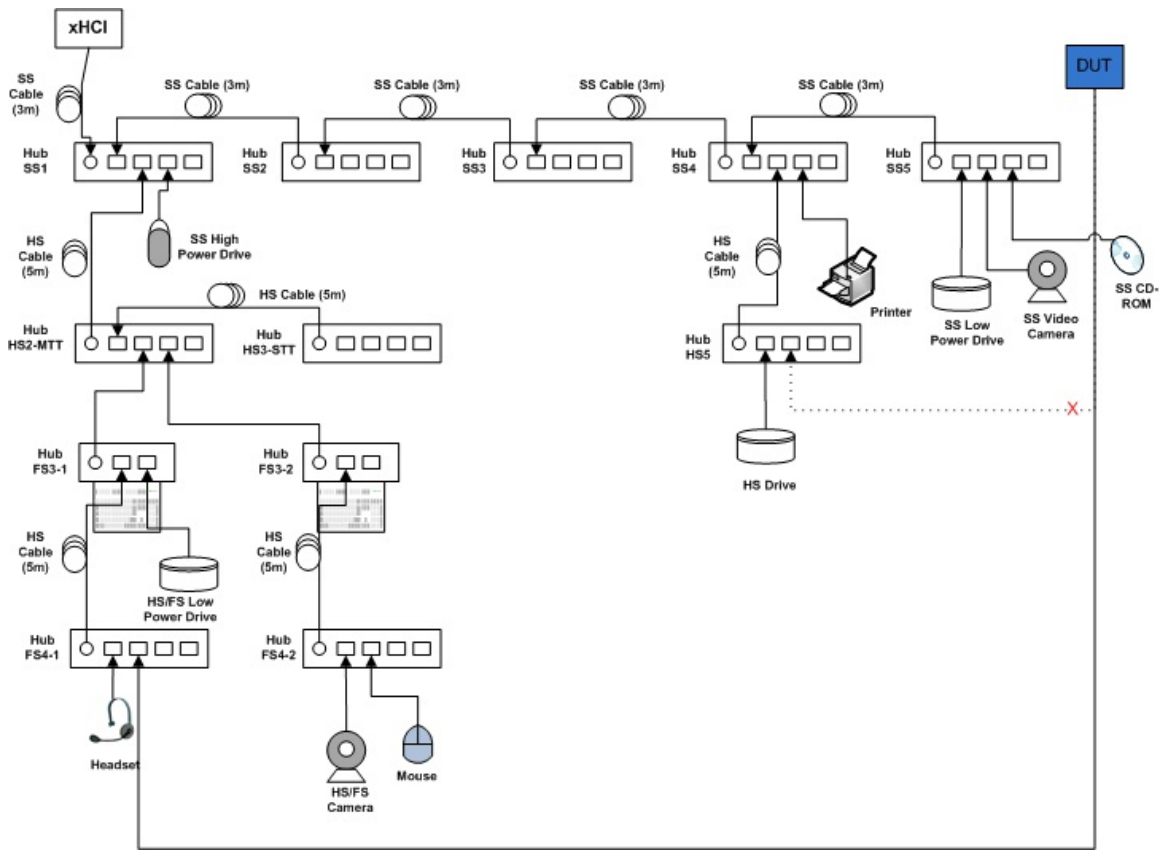


Figure 1.5.3: Topology Change 2 (For Low/Full-speed capable USB Devices only)

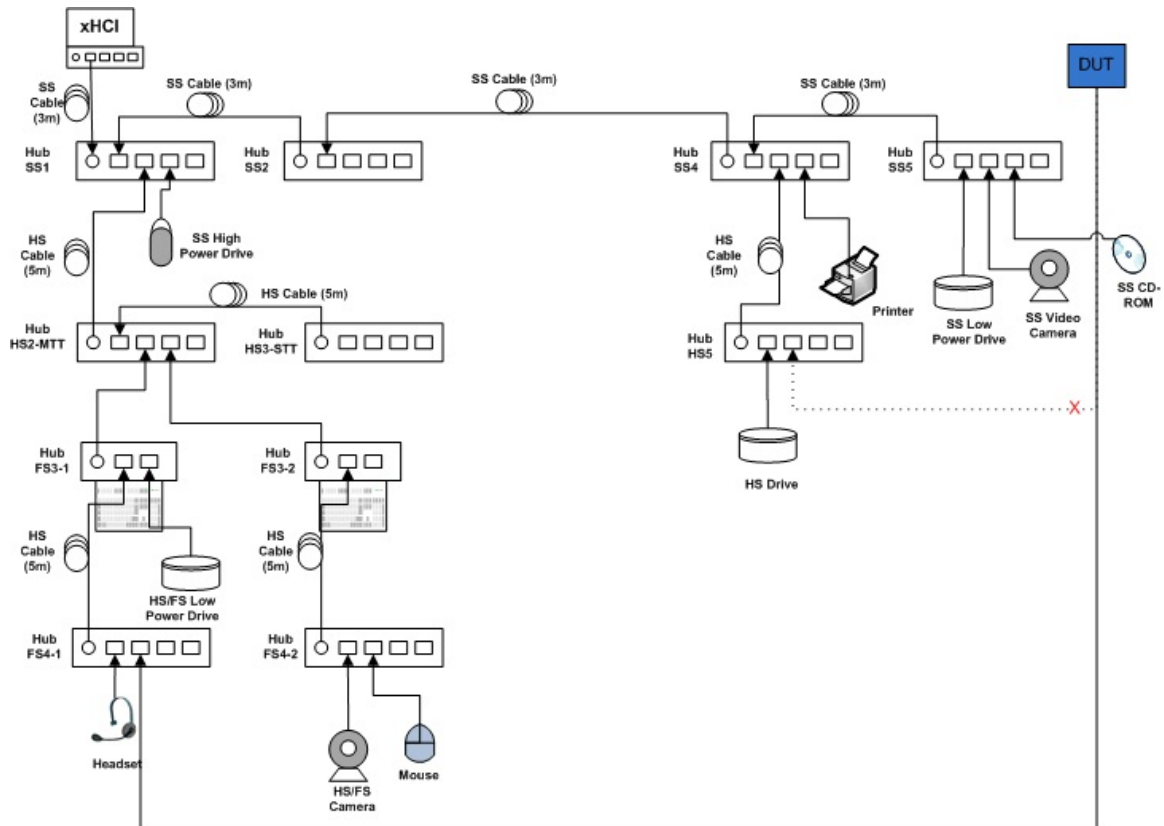


Figure 1.5.3 (embedded hub): Topology Change 2 (For Low/Full-speed capable USB Devices only)

- Verify that all devices except for the Device Under Test are continuing to operate concurrently.
- Operate the Device Under Test.
 - If the Device Under Test has Isochronous or Interrupt endpoints, then it may not have enough bandwidth to function properly. If the Device Under Test cannot function properly in this configuration, disable the headset speakers and the headset microphone for this test and leave it disabled for the All Device Tests.
- Operate all the devices in the SuperSpeed Interop Tree. Verify that all devices are operating concurrently.
 - **Pass:**
All SuperSpeed Interop Tree devices operate correctly
 - **Fail:**
One or more SuperSpeed Interop Tree devices fail to operate correctly

8. All Devices Tests (For Low/Full-speed capable USB Devices only)

- Run tests 1-6 located in Section 1.9

9. Interoperability without Driver Verifier

- Run this test only if there was poor video or audio quality when operating all of the devices in the SuperSpeed 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 SuperSpeed Interop Tree. Verify that all devices are operating concurrently.
 - **Pass:**
All SuperSpeed Interop Tree devices operate correctly
 - **Fail:**
One or more SuperSpeed Interop Tree devices fail to operate correctly

10. Current Measurement

- Connect a SuperSpeed cable fixture between DUT and xHCI host.
- Set up a Multimeter to measure the current.
- Install Command Verifier driver (xHCI compliance driver which is downloadable with Command Verifier test suite software USB30_CV)
- Run "Current Measurement" test of 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:
 - is DUT bus-powered 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
 - Repeat the test in USB2.0 mode (HS/FS).
- Reload the xHCI controller driver being used for Interop..
- Perform the function the device is designed for and measure the current (operating current) during device operation.
 - **Pass:**
Self-Powered Device
 1. The log shows 'self-powered'.
 2. Maximum current should be '0' at all stages.
 3. Operating Current is less than the Max Power defined in the Device Descriptor.
Bus-Powered Device

1. The log shows 'bus-powered'.
2. The maximum current in the trace should be less than 'Max Power Consumption' defined in the BOS descriptor
3. The current in U3 should be less than 2.5mA.
4. The current in un-configured mode should be less than 150mA
5. Operating Current is less than the Max Power defined in the Device Descriptor

- **Fail:**

Any value that is out of the scope is a failure.

11. Function Wake

- If the DUT has function wake ability, it should have an interface for users to initiate function wake. To run this test, operate all the devices in the SuperSpeed Interop Tree except for the Printer.
- 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 SuperSpeed Interop Tree device operation and close the 'Recording' tab window.
- Operate all the devices in the SuperSpeed Interop Tree. Verify that all devices are operating concurrently.
- Repeat test #11 for all functions that support wake. (The 'Device Summary' test of Command Verifier 3.0 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 xHCI host. Run 1-6 test located in section 1.9.
 - **Pass:**
All the tests 1-6 of section 1.9 PASS
 - **Fail:**
If any of the tests 1-6 FAIL

1.5.2 Peripherhal U1/U2 Test Steps

- Connect a USB 3.0 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:**
Link successfully enters U1 or U2.
Link returns to U0 and the original packet that was sent during U1/U2 is successfully completed.
- **Fail:**
Link remains in U0.
Re-sent packet does not complete correctly.

1.6 USB Self-Powered Hub Interoperability Test Steps

For Self-Powered Hub testing, two Hubs Under Test are required.

Construct the SuperSpeed Interop Tree as outlined in Figure 1.6.1. Do not attach the SuperSpeed Interop Tree to the xHCI controller.

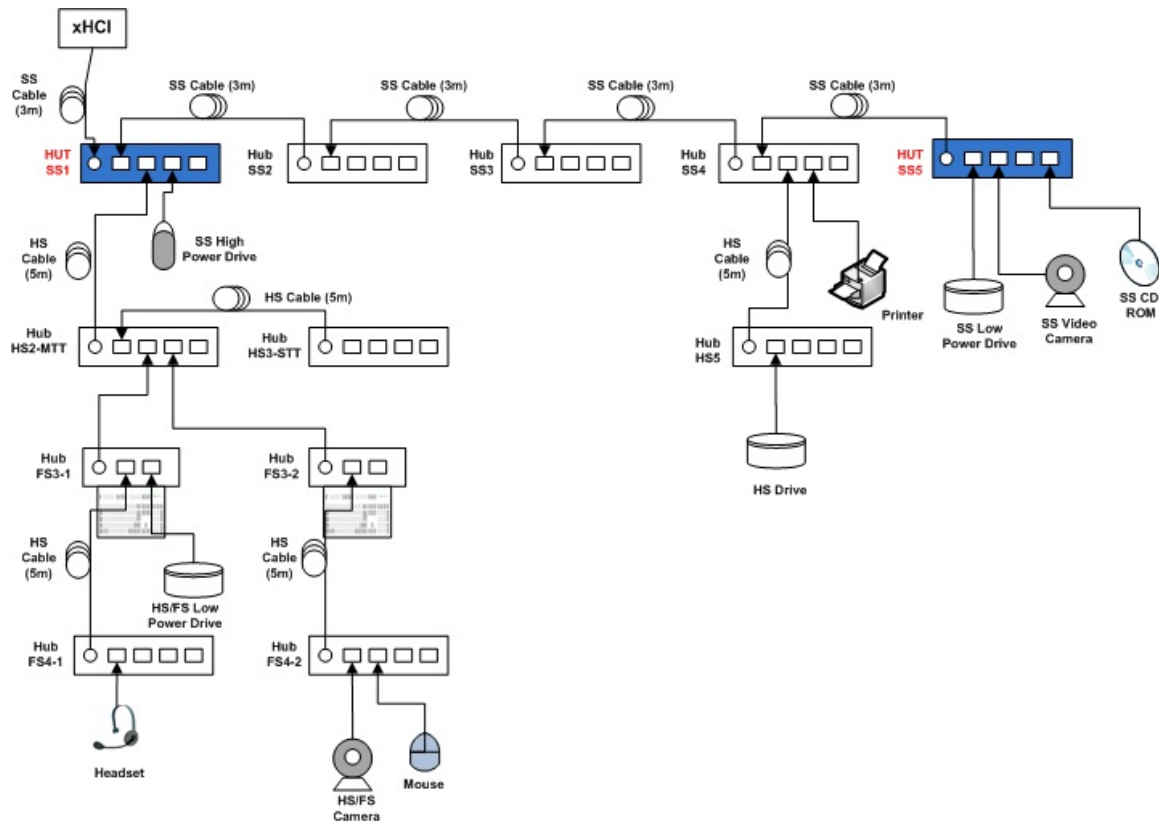


Figure 1.6.1: SuperSpeed Interop Tree with Self-Powered Hubs Under Test

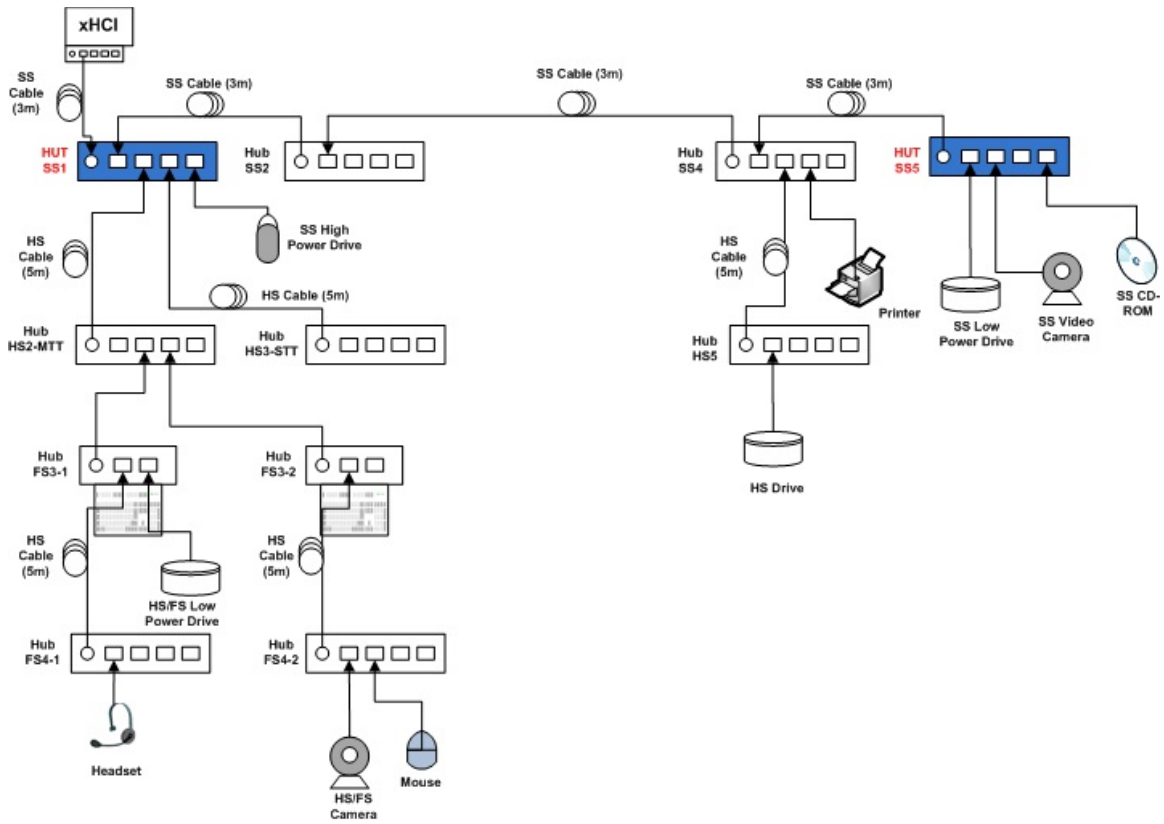


Figure 1.6.1 (embedded hub): SuperSpeed Interop Tree with Self-Powered Hubs Under Test

Tier	Device
1	<ul style="list-style-type: none"> • HUT SS1– Self-powered USB3.0 Hub attached to the xHCI controller or an embedded SS hub in the xHCI controller
2	<ul style="list-style-type: none"> • Hub SS2 - Self-powered USB3.0 Hub on a port 1 of Hub Under Test 1
3	<ul style="list-style-type: none"> • Hub SS3 - Self-powered USB3.0 Hub on port 1 of Hub SS2
4	<ul style="list-style-type: none"> • Hub SS4 - Self-powered USB3.0 Hub on port 1 of Hub SS3-STT
5	<ul style="list-style-type: none"> • HUT SS5 - Self-powered USB3.0 Hub on port 1 of Hub SS4
6	<ul style="list-style-type: none"> • SS Low Power Drive on the first selected port of Hub Under Test 2
6	<ul style="list-style-type: none"> • SS Video Camera on the second selected port of Hub Under Test 2
6	<ul style="list-style-type: none"> • SS CD-ROM on the second selected port of Hub Under Test 4
5	<ul style="list-style-type: none"> • Hub HS5 - Self-powered high-speed Hub on port 2 of Hub SS4
6	<ul style="list-style-type: none"> • HS Drive on port 1 of Hub HS5
5	<ul style="list-style-type: none"> • Printer on port 3 of Hub SS4
2	<ul style="list-style-type: none"> • Hub HS2-MTT - Self-powered high-speed Hub with multiple transaction translators on port 2 of Hub Under Test 1
3	<ul style="list-style-type: none"> • Hub HS3-STT - Self-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 - Bus-powered full-speed Keyboard Hub on port 2 of Hub HS2-MTT
4	<ul style="list-style-type: none"> • Hub FS4-1 - Self-powered high-speed Hub on port 1 of Hub FS3-1
5	<ul style="list-style-type: none"> • Headset on port 1 of Hub FS4-1
4	<ul style="list-style-type: none"> • FS Low Power Drive on port 2 of Hub FS3-1
3	<ul style="list-style-type: none"> • Hub FS3-2 - Bus-powered full-speed Keyboard Hub on port 3 of Hub HS2-MTT
4	<ul style="list-style-type: none"> • Hub FS4-2 - Self-powered high-speed Hub on port 1 of Hub FS3-2
5	<ul style="list-style-type: none"> • FS Video Camera on port 1 of Hub FS4-2
5	<ul style="list-style-type: none"> • Mouse on port 2 of Hub FS4-2
2	<ul style="list-style-type: none"> • SS High Power Drive on port 3 of Hub Under Test 1

1.6.1 USB Self-Powered Hub Inspection

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 xHCI Interoperability Tests operate three ports of the Hub Under Test at a time. For each topology, all ports must be tested in at least one topology.

1.6.2 USB Self-Powered Hub Interoperability Tests

1. 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 xHCI controller into the USB Host System if it is not already integrated.

- Ensure that the SuperSpeed Interop Tree is not attached to the 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 xHCI controller driver.
 - The OS displays that it cannot find the driver for the xHCI controller. Follow the vendor-recommended install procedure to complete the driver install.
 - If the xHCI controller is already integrated into the USB Host System, then the OS displays nothing, as it has already attempted install for the 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 xHCI controller driver
OR
 2. The vendor-recommended install procedure installs the xHCI controller driver)
AND
 3. The xHCI controller driver is installed correctly and operates (no yellow exclamation point is displayed in device manager)
 - **Fail:**
 1. The xHCI controller driver does not install
OR
 2. The 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 SuperSpeed Interop Tree prior to attaching the SuperSpeed Interop Tree to the xHCI controller.

Attach the SuperSpeed Interop Tree by connecting the Hub Under Test SS1 into any port on the xHCI controller.

- If the xHCI controller has an embedded hub, replace Hub SS2 with the Hub Under Test #1. Then plug the Hub Under Test SS1 into an embedded hub port, and plug HS2-MTT into another embedded hub port.

For each device in the SuperSpeed Interop Tree follow the vendor-recommended install. Ensure that all drivers listed for each device in the SuperSpeed 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 SuperSpeed Interop Tree devices enumerate
AND
 2. All SuperSpeed Interop Tree devices drivers are installed either automatically or through the vendor recommended install procedure
AND
 3. All SuperSpeed Interop Tree devices do not require a reboot
AND
 4. All SuperSpeed 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 SuperSpeed Interop Tree.
 - Whenever the Self-Powered Hub 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 Headset (and the microphones in the Video Cameras if applicable) by speaking into the microphone and viewing the microphone's status
 - This can be found under 'Control Panel' -> 'Hardware and Sound' -> 'Sound' under the 'Recording' tab.
 - View streaming video from the SS Video Camera
 - View streaming video from the FS Video Camera
 - Play a familiar song through the headset to ensure audio is working
 - Poor video or audio quality may be seen when Driver Verifier is enabled. If there was poor quality, then the xHCI Interoperability without Driver Verifier Test will be required for this host.
 - Transfer a 1+ GB file from the SS High Power Drive to the SS Low Power Drive
 - Transfer a 25+ MB file from the FS Low Power Drive to the SS High Power Drive
 - Transfer a 1+ GB file from the HS Drive to the SS Low Power Drive
 - Print a sample page from the printer
 - The printing should be long enough to overlap with other operations. The sample page can be a picture or a text file that lasts long enough in print to meet the test requirements.
 - Strike keys on both of the keyboards
 - Move the mouse
 - Verify that all devices are operating concurrently. Verify the Device Speed using the USB View utility.
 - - **Pass:**
All SuperSpeed Interop Tree devices operate correctly
 - **Fail:**
One or more SuperSpeed Interop Tree devices fail to operate correctly

4. All Devices Tests

- Run tests 1-6 located in Section 1.9

5. Topology Change 1

- Stop all SuperSpeed Interop Tree device operation!
- Detach the Hub Under Test SS1 from the xHCI controller and detach all attached devices from the Hub Under Test SS1.
- Reattach the Hub Under Test SS1 to port 2 of Hub SS2. Then attach Hub HS3-MTT to port 3 of SS2 and Hub HS3-STT to port 3 of the Hub Under Test SS1. Then attach Hub FS3-1 to port 1 of the Hub Under Test SS1. Then attach Hub FS3-2 into a port 2 of the Hub Under Test SS1 as shown in Figure 1.6.2.

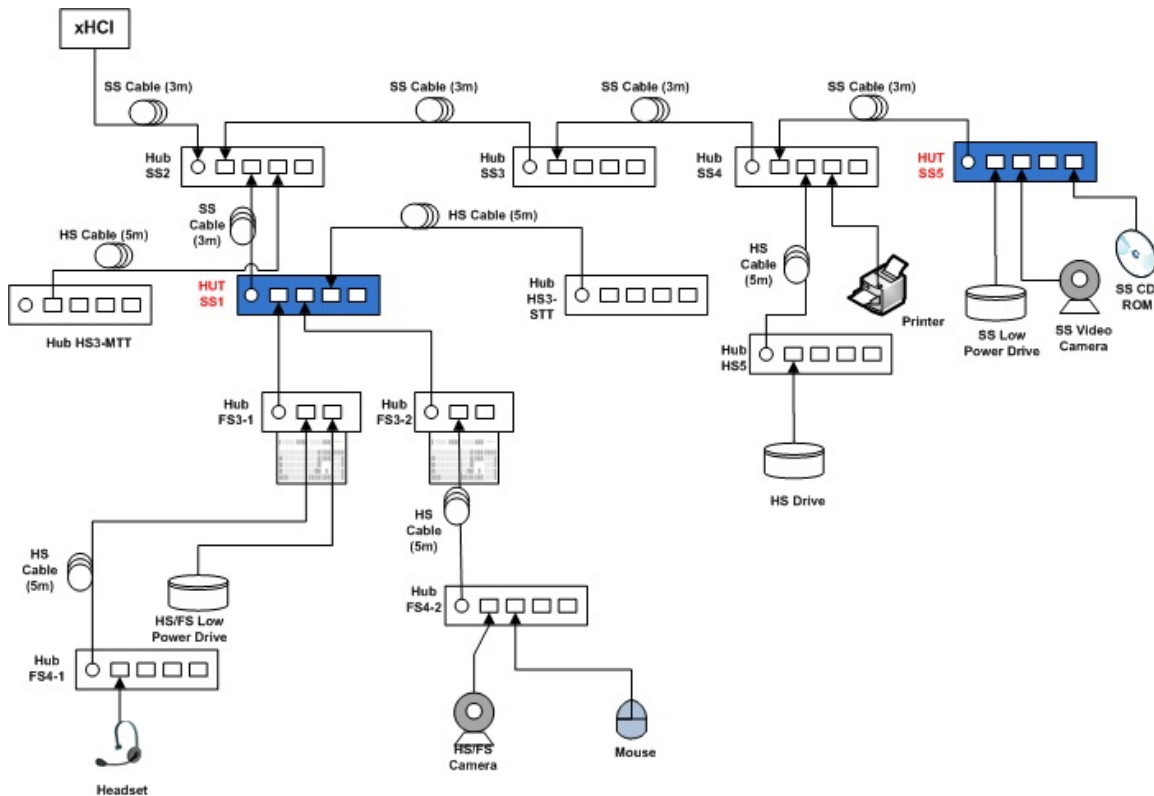


Figure 1.6.2: Topology Change 1

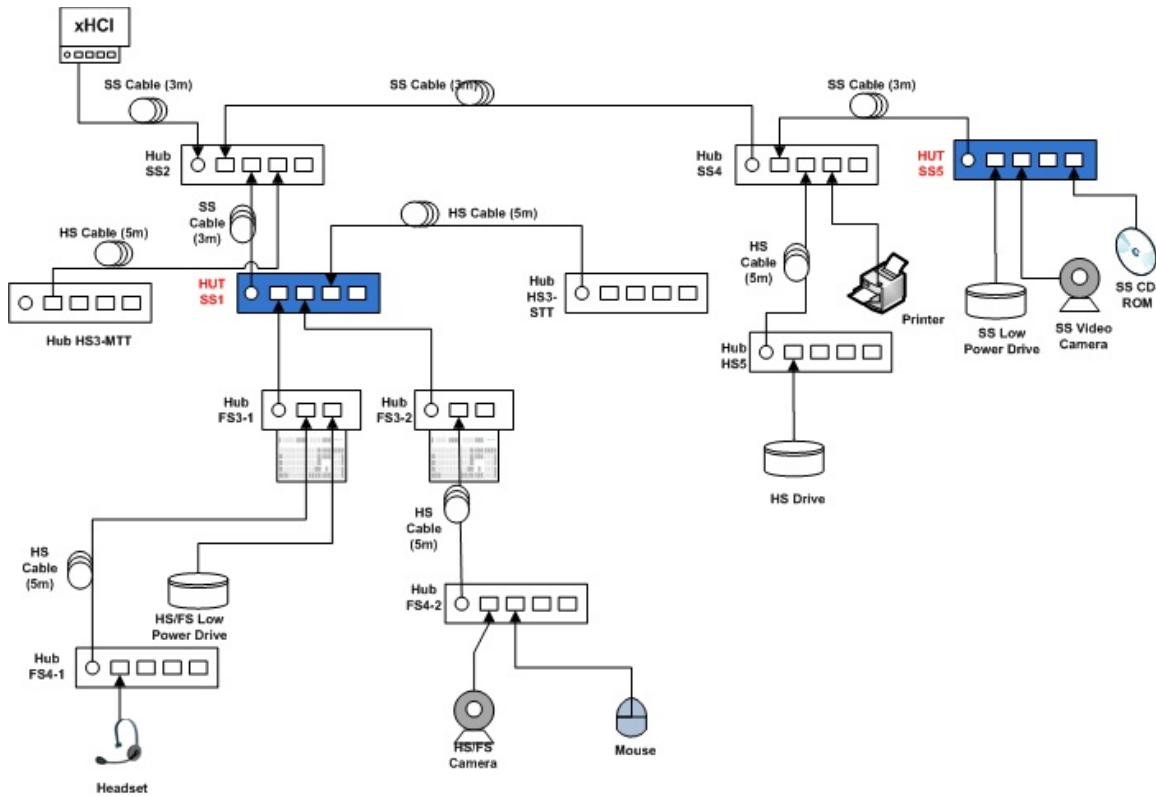


Figure 1.6.2 (embedded hub): Topology Change 1

- Operate the Headset, microphones, and FS Video Camera. Also operate all SS devices down in the tree.
- 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.
 - i. detach Keyboard Hub FS3-2 from port 2 on the Hub Under Test and attach the Keyboard Hub FS3-2 to port 1 on Hub HS3-STT. This should set the configuration to what is displayed in Figure 1.6.3

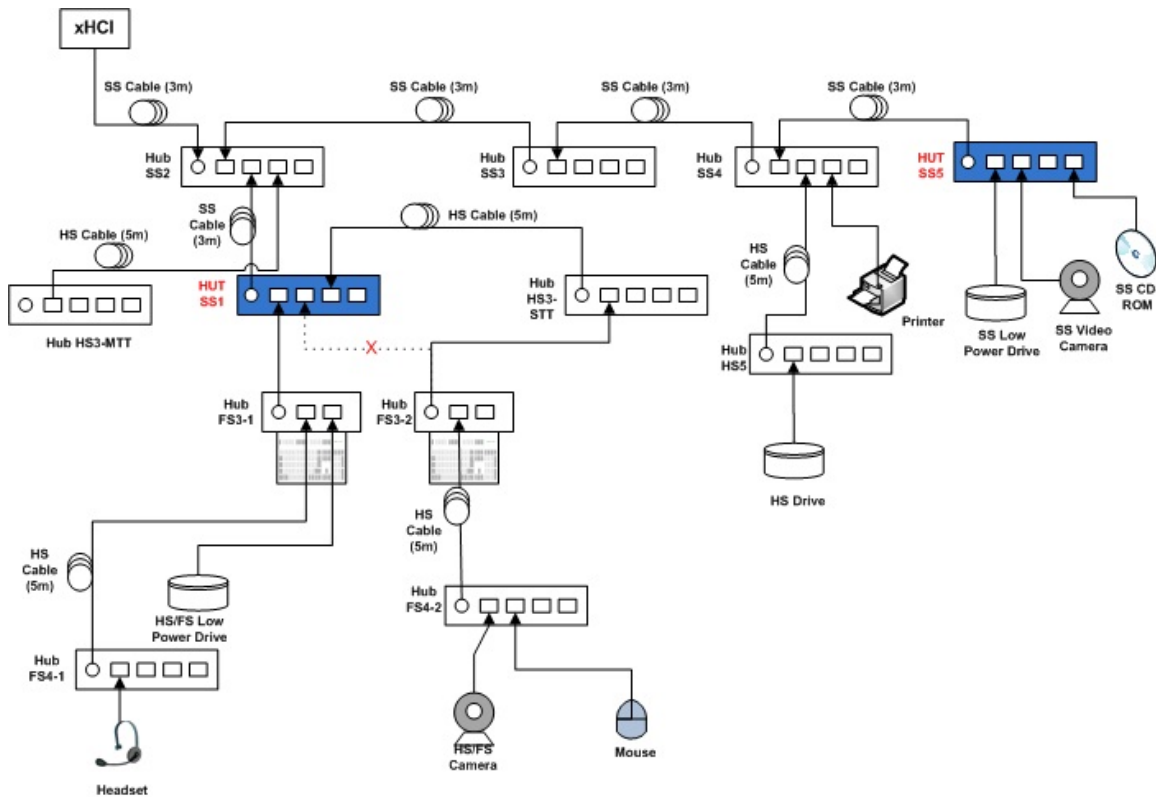


Figure 1.6.3 Topology Change 1 - For Single-TT Hubs Only

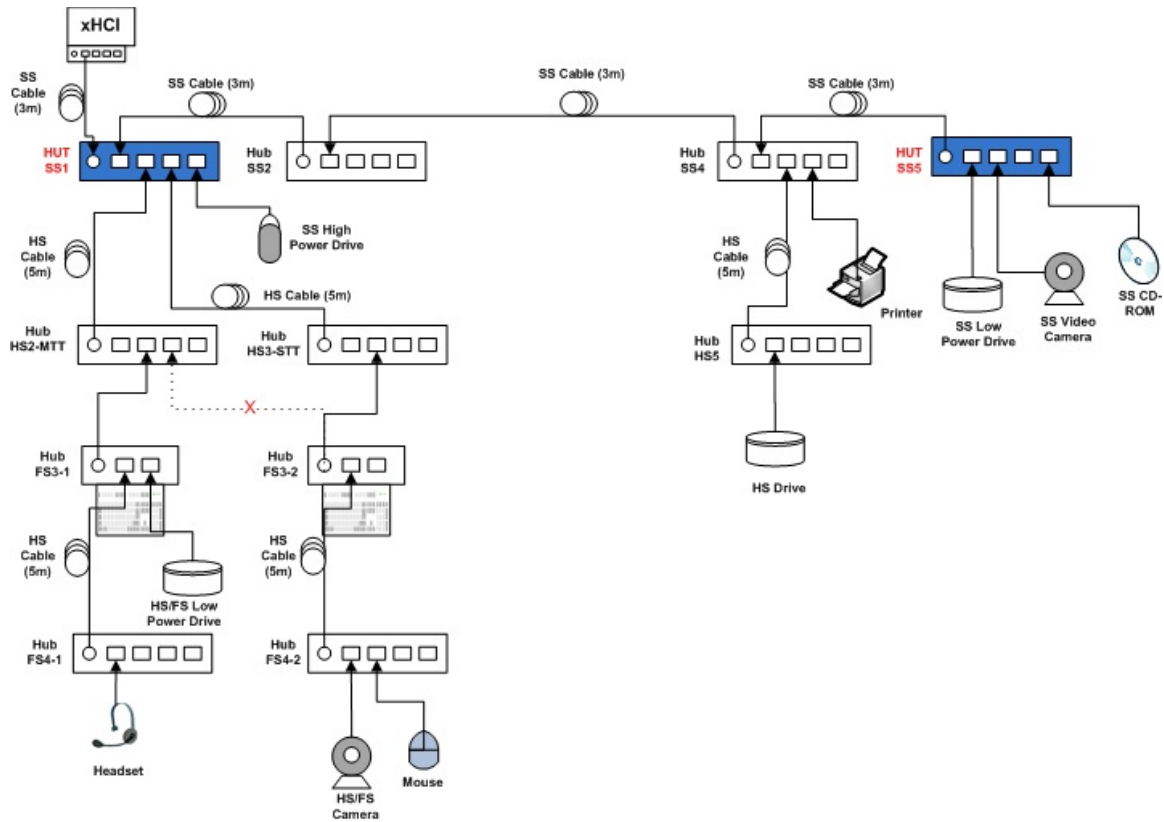


Figure 1.6.3 (embedded hub) Topology Change 1 - For Single-TT Hubs Only

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

6. All Devices Tests

- Run tests 1-6 located in Section 1.9

7. Topology Change 2

- Stop all SuperSpeed Interop Tree device operation!
- Operate the following devices concurrently:
 - View streaming video from the SS Video Camera
 - Transfer a 1+ GB file from the SS High Power Drive to the SS Low Power Drive
 - Transfer a 25+ MB file from the HS Low Power Drive to the SS High Power Drive

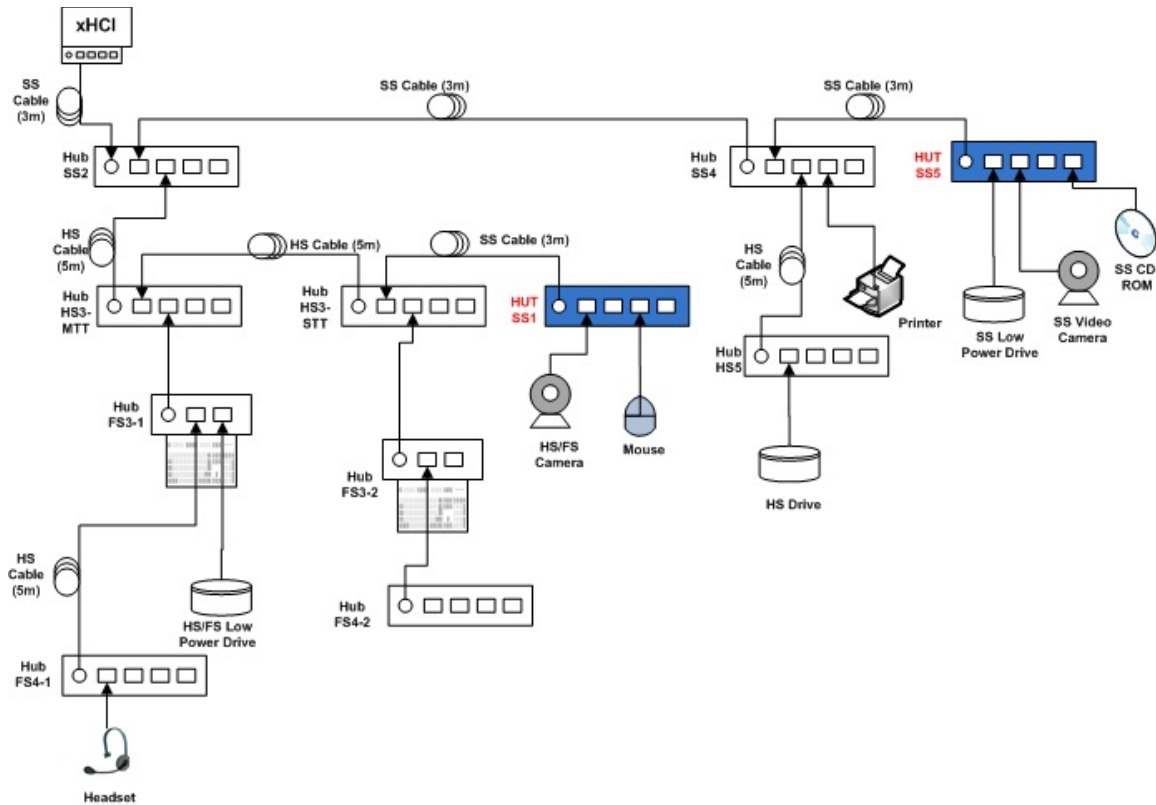


Figure 1.6.4 (embedded hub): Topology Change 2

- Verify that the file transfers continue to take place.
- Verify that the SS Video Camera continues to function.
- Operate all the devices in the SuperSpeed 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 SS Video Camera continues to function
AND
 3. All SuperSpeed Interop Tree devices operate correctly
- **Fail:**
 1. After the topology change the file transfer was cancelled
OR
 2. After the topology change the SS Video Camera stopped functioning
OR
 3. One or more SuperSpeed Interop Tree devices fail to operate correctly

8. All Devices Tests

- Run tests 1-6 located in Section 1.9

9. Interoperability without Driver Verifier

- Run this test only if there was poor video or audio quality when operating all of the devices in the SuperSpeed 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 SuperSpeed Interop Tree. Verify that all devices are operating concurrently.
 - **Pass:**
All SuperSpeed Interop Tree devices operate correctly
 - **Fail:**
One or more SuperSpeed Interop Tree devices fail to operate correctly

10. Function Wake

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

1.6.3 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:**
Link successfully enters U1 or U2.
Link returns to U0 and the original packet that was sent during U1/U2 is successfully completed.
 - **Fail:**

Link remains in U0.
Re-sent packet does not complete correctly.

1.7 USB Bus-Powered Hub Interoperability Test Steps

Currently Not Available

1.8 USB Host Interoperability Test Steps

Construct the SuperSpeed Interop Tree as outlined in Figure 1.8.1. Do not attach the SuperSpeed Interop Tree to the Host Under Test.

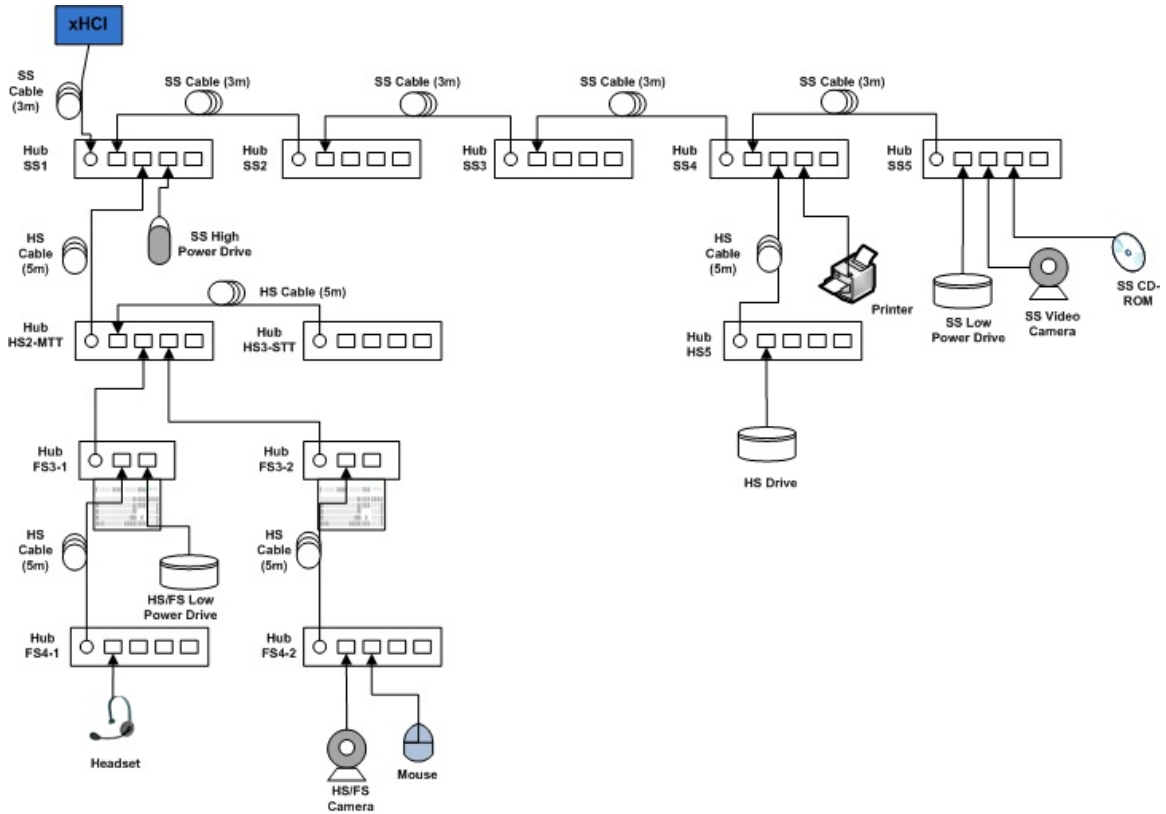


Figure 1.8.1: SuperSpeed Interop Tree with Host Under Test

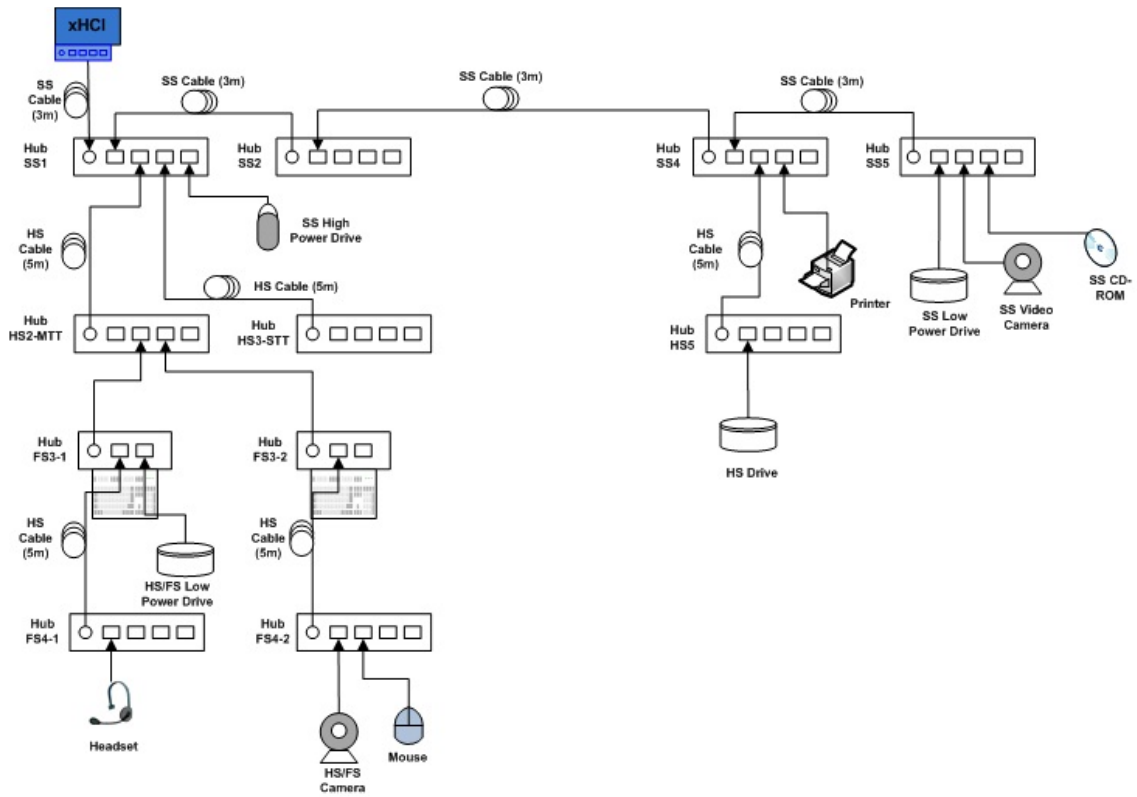


Figure 1.8.1 (embedded hub): SuperSpeed Interop Tree with Host Under Test

Tier	Device
1	• Hub SS1 – Self-powered USB3.0 Hub attached to the Host Under Test
2	• Hub SS2 - Self-powered USB3.0 Hub on port 1 of Hub SS1
3	• Hub SS3 - Self-powered USB3.0 Hub on port 1 of Hub SS2
4	• Hub SS4 - Self-powered USB3.0 Hub on port 1 of Hub SS3
5	• Hub SS5 - Self-powered USB3.0 Hub on port 1 of Hub SS4
6	• SS Low Power Drive on port 1 of Hub SS5
6	• SS Video Camera on port 2 of Hub SS5
6	• SS CD-ROM on port 3 of Hub SS5
5	• Hub HS5 - Self-powered high-speed Hub on port 2 of Hub SS4
6	• HS Drive on port 1 of Hub HS5
5	• Printer on port 3 of Hub SS4
2	• Hub HS2-MTT - Self-powered high-speed Hub with multiple transaction translators on port 2 of Hub SS1
3	• Hub HS3-STT - Self-powered high-speed Hub with a single transaction translator on port 1 of Hub HS2-MTT
3	• Hub FS3-1 - Bus-powered full-speed Keyboard Hub on port 2 of Hub HS2-MTT
4	• Hub FS4-1 - Self-powered high-speed Hub on port 1 of Hub FS3-1
5	• Headset on port 1 of Hub FS4-1
4	• FS Low Power Drive on port 2 of Hub FS3-1
3	• Hub FS3-2 - Bus-powered full-speed Keyboard Hub on port 3 of Hub HS2-MTT
4	• Hub FS4-2 - Self-powered high-speed Hub on port 1 of Hub FS3-2
5	• HS or FS Video Camera on port 1 of Hub FS4-2
5	• Mouse on port 2 of Hub FS4-2
2	• SS High Power Drive on port 3 of Hub SS1

1.8.1 USB 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 xHCI 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 xHCI Interoperability Tests on.

1.8.2 USB Host Interoperability Tests

1. 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 1.2.1. 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 SuperSpeed Interop Tree is not attached to the Host Under Test or embedded hub.

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

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

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 has been configured as described in Section 1.2.1.

- Ensure that the SuperSpeed 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 SuperSpeed Interop Tree prior to attaching the SuperSpeed Interop Tree to the selected USB port under test.

Attach the SuperSpeed Interop Tree by connecting Hub SS1 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 SS3 and Hub SS4; re-plug Hub SS4 directly into port one of Hub SS2.

For each device in the SuperSpeed Interop Tree follow the vendor-recommended install. Ensure that all drivers listed for each device in the SuperSpeed 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'

When testing all other additional ports:

Attach the SuperSpeed Interop Tree by connecting Hub SS1 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 SS3 and Hub SS4; re-plug Hub SS4 directly into port one of Hub SS2.

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

- **Pass:**
 1. All SuperSpeed Interop Tree devices enumerate
AND
 2. All SuperSpeed Interop Tree devices drivers are installed either automatically or through the vendor recommended install procedure
AND
 3. All SuperSpeed Interop Tree devices do not require a reboot
AND
 4. All SuperSpeed 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 SuperSpeed Interop Tree.
- Whenever the **Host 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 Headset (and the microphones in the Video Cameras if applicable) by speaking into the microphone and viewing the microphone's status
 - This can be found under 'Control Panel' -> 'Hardware and Sound' -> 'Sound' under the 'Recording' tab.
 - View streaming video from the SS Video Camera
 - View streaming video from the FS Video Camera
 - Operate the microphone in the Headset (and the microphones in the Video Cameras if applicable) by speaking into the microphone and viewing the microphone's status
 - This can be found under 'Control Panel' -> 'Hardware and Sound' -> 'Sound' under the 'Recording' tab.
 - Play a familiar song through the headset to ensure audio is working
 - Poor video or audio quality may be seen when Driver Verifier is enabled. If there was poor quality, then the xHCI Interoperability without Driver Verifier Test will be required for this host.
 - Transfer a 1+ GB file from the SS High Power Drive to the SS Low Power Drive
 - Transfer a 25+ MB file from the FS Low Power Drive to the SS High Power Drive
 - Transfer a 1+ GB file from the HS Drive to the SS Low Power Drive
 - Print a sample page from the printer
 - The printing should be long enough to overlap with other operations. The sample page can be a picture or a text file that lasts long enough in print to meet the test requirements.
 - Strike keys on both of the keyboards
 - Move the mouse
- Verify that all devices are operating concurrently. Verify the Device Speed using the USB View utility.

- **Pass:**

All SuperSpeed Interop Tree devices operate correctly

- **Fail:**

One or more SuperSpeed Interop Tree devices fail to operate correctly

4. All Devices Tests

- Run tests 1-6 located in Section 1.9

5. Topology Change 1

- Stop all SuperSpeed Interop Tree device operation! Close any software that is used for any SuperSpeed Interop Tree device operation and close the 'Recording' tab window.
- Operate the following devices concurrently:
 - Operate the microphone(s)
 - View streaming video from the SS Video Camera
 - Play a familiar song through the headset to ensure audio is working
 - Transfer a 1+ GB file from the SS High Power Drive to the SS Low Power Drive
 - Transfer a 25+ MB file from the FS Low Power Drive to the SS High Power Drive
 - Transfer a 1+ GB file from the HS Drive to the SS Low Power Drive
 - Print a sample page from the printer
 - The printing should be long enough to overlap with other operations. The sample page can be a picture or a text file that lasts long enough in print to meet the test requirements.
 - Strike keys on both of the keyboards
- While operating the devices, detach the Keyboard Hub FS3-2 from port 3 on Hub HS2-MTT.
- Reattach Keyboard Hub FS3-2 to port 2 on Hub HS3-STTas shown in Figure 1.8.2.

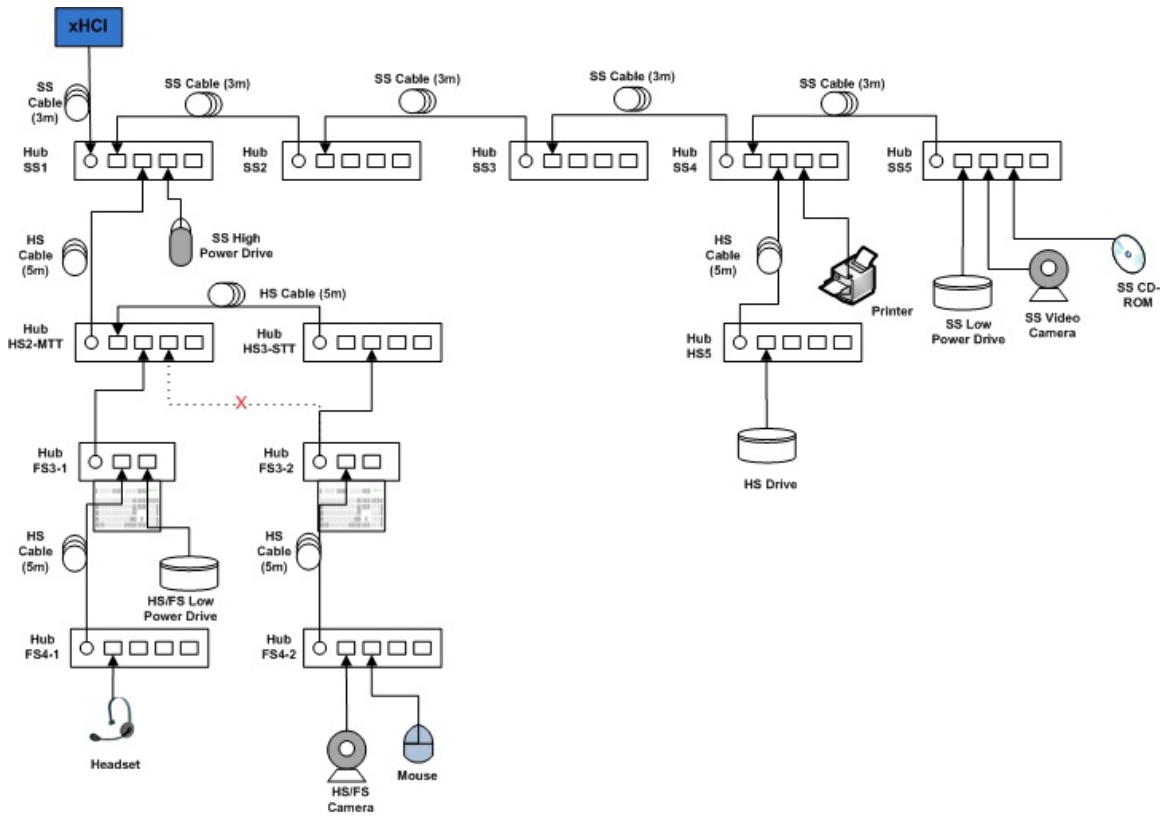


Figure 1.8.2: Topology Change 1

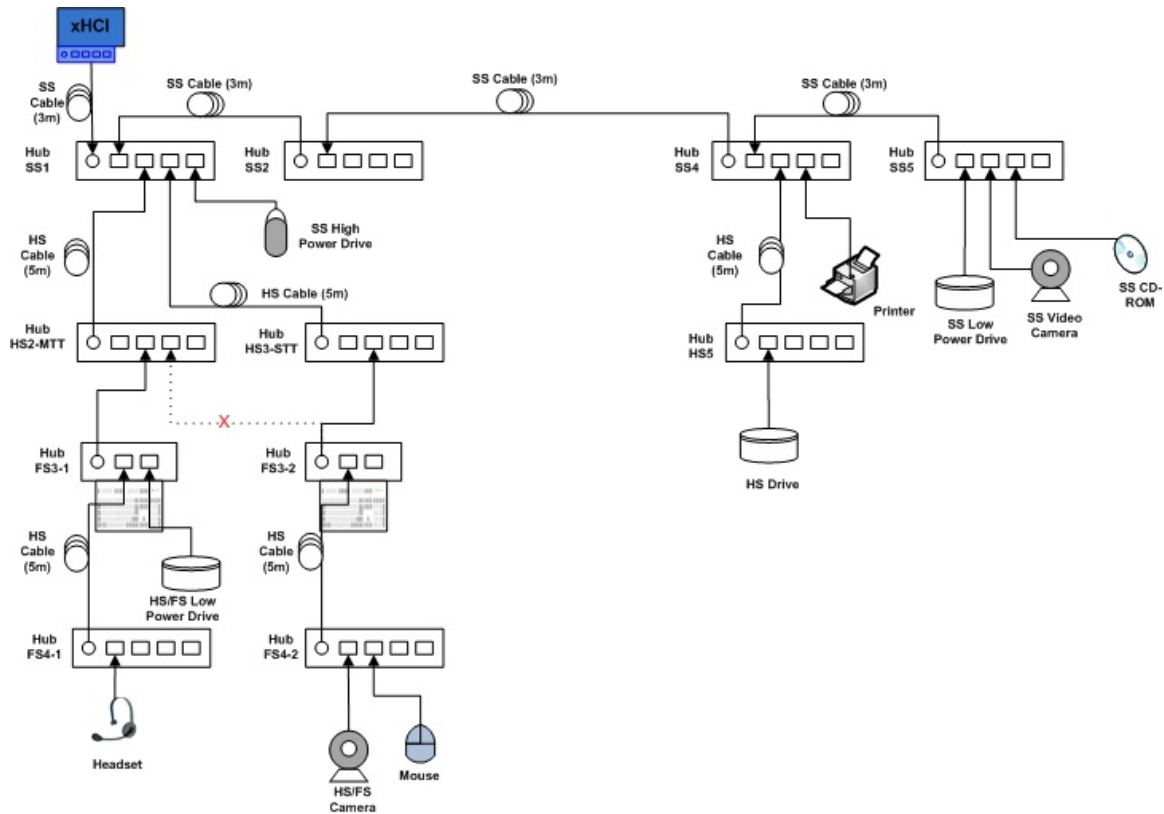


Figure 1.8.2 (embedded hub): Topology Change 1

- Verify that all three file transfers continue to take place.
- Verify that the SS Video Camera and Headset continues to function.
- Operate all the devices in the SuperSpeed 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 SS Video Camera and Headset continue to function
AND
 3. All SuperSpeed Interop Tree devices operate correctly
- **Fail:**
 1. After the topology change any file transfer was cancelled
OR
 2. After the topology change the SS Video Camera or Headset stopped functioning
OR
 3. One or more SuperSpeed Interop Tree devices fail to operate correctly

6. All Devices Tests (N/A)

- Not necessary for this test procedure.

7. Topology Change 2

- Stop all SuperSpeed Interop Tree device operation! Close any software that is used for

any SuperSpeed Interop Tree device operation and close the 'Recording' tab window.

- Operate the following devices concurrently:
 - View streaming video from the SS Video Camera
 - View streaming video from the HS Video Camera
 - Transfer a 1+ GB file from the SS High Power Drive to the SS Low Power Drive
 - Transfer a 1+ GB file from the HS Drive to the SS Low Power Drive
 - Move the mouse
- While operating the devices, detach the Keyboard Hub FS3-1 from port 2 on Hub HS2-MTT.
- Reattach Keyboard Hub FS3-1 to port 1 on Hub HS3-STT as shown in Figure 1.8.

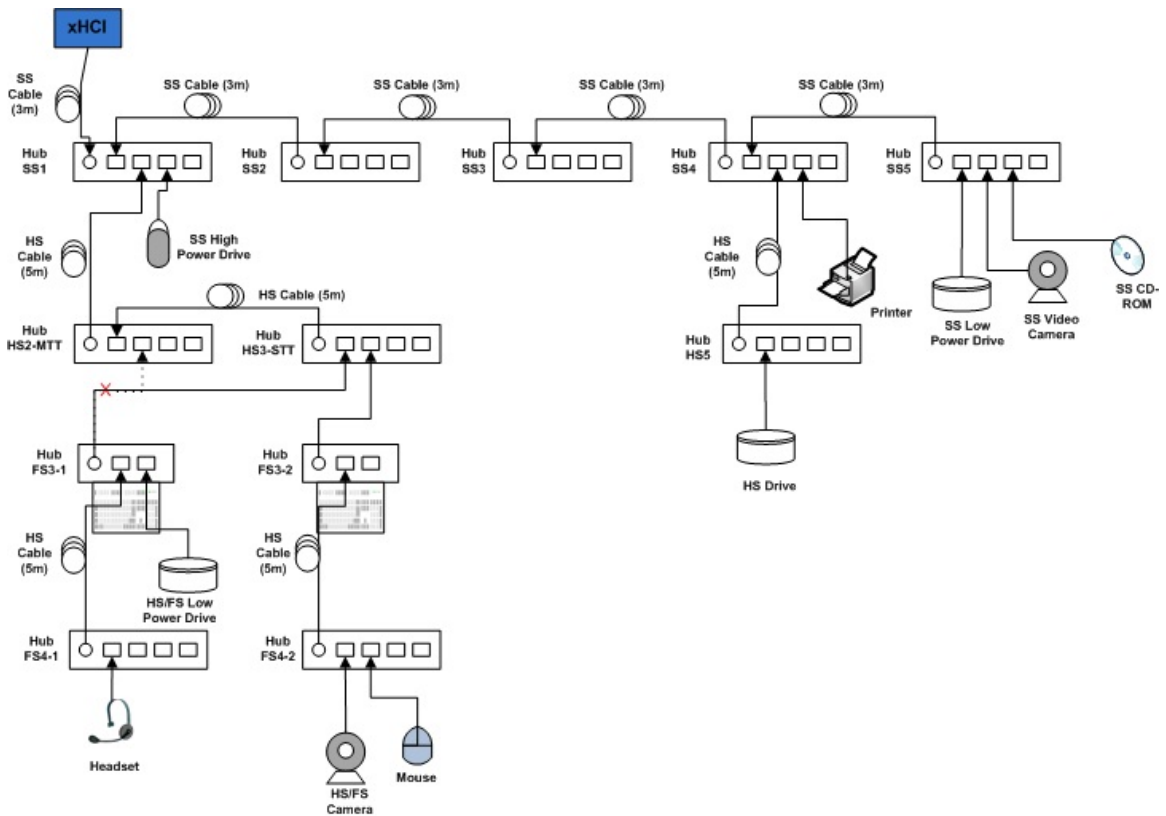


Figure 1.8.3: Topology Change 2

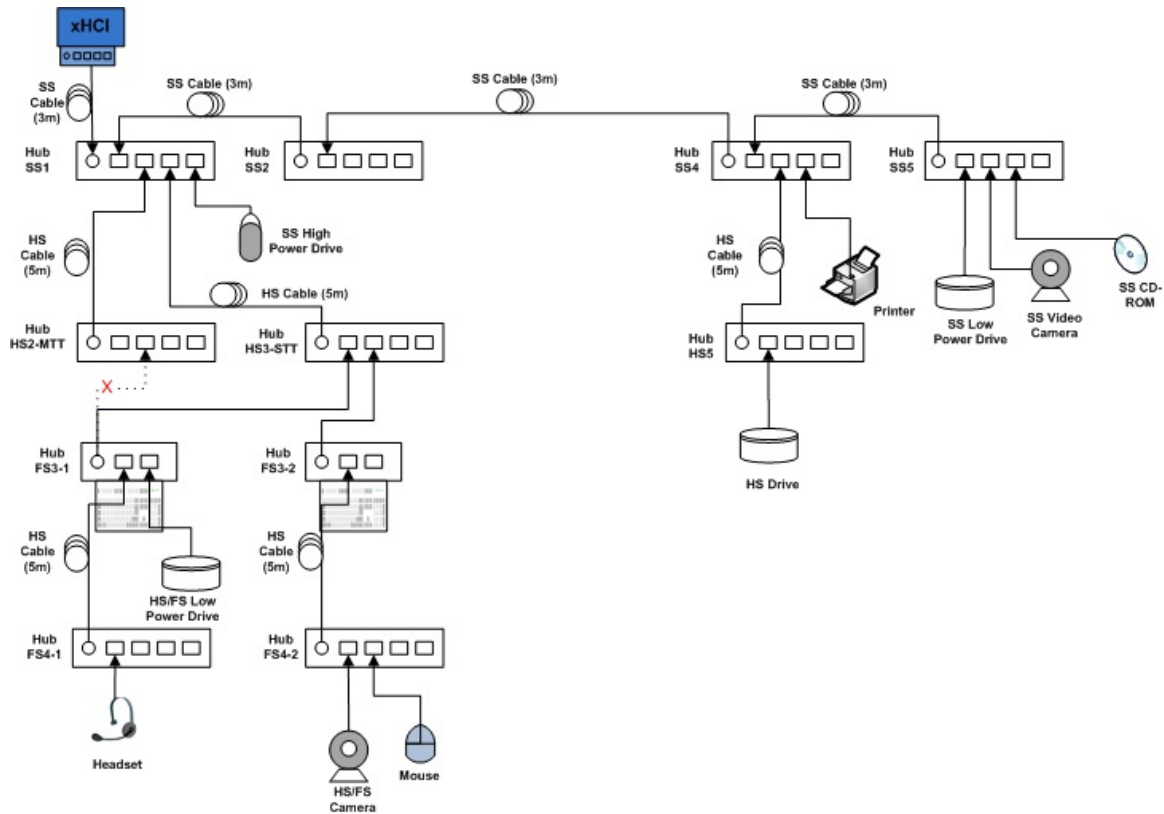


Figure 1.8.3 (embedded hub): Topology Change 2

- Verify that both file transfers continue to take place.
- Verify that the SS Video Camera, HS Video Camera, and mouse continue to function.
- Play a familiar song through the headset and operate the microphone(s).
 - If the headset or 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 Keyboard Hub FS3-1 from port 1 on Hub HS3-STT and reattach the Keyboard Hub FS3-1 back to port 2 on Hub HS2-MTT. This should set the configuration back to what is displayed in Figure 1.8.2.

- Operate all the devices in the SuperSpeed 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 SS Video Camera, HS Video Camera, and mouse continue to function
AND
 3. All SuperSpeed Interop Tree devices operate correctly
- **Fail:**
 1. After the topology change any file transfer was cancelled

- OR
- 2. After the topology change the SS Video Camera, HS Video Camera, or mouse stopped functioning
- OR
- 3. One or more SuperSpeed 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 SuperSpeed Interop Tree except for the Printer. 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 SuperSpeed Interop Tree device operation and close the 'Recording' tab window.
- Operate all the devices in the SuperSpeed Interop Tree. Verify that all devices are operating concurrently.

- **Pass:**

All SuperSpeed Interop Tree devices operate correctly

- **Fail:**

1. One or more SuperSpeed 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 SuperSpeed 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 SuperSpeed Interop Tree. Verify that all devices are operating concurrently.

- **Pass:**

All SuperSpeed Interop Tree devices operate correctly

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

11. Function Remote Wake

- Connect a function-remote-wake capable SuperSpeed device to one of the root ports.
- Put the system into sleep
- Wake up the system by the function-remote-wake interface on the SuperSpeed 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 SuperSpeed device other than a Hub to one of exposed ports of xHCI host under test. Run 1-6 test located in section 1.9. Repeat this test for each root port of the host.
- **Pass:**
All the tests 1-6 of section 1.9 PASS
- **Fail:**
If any of the tests 1-6 FAIL

1.8.3 Host U1/U2 Test Steps

- Connect a USB 3.0 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:**
 - Link successfully enters U1 or U2.
 - Link returns to U0 and the original packet that was sent during U1/U2 is successfully completed.
- **Fail:**
 - Link remains in U0.
 - Re-sent packet does not complete correctly.

1.9 All Devices – xHCI Interoperability Test Steps

1. Inactive Detach & Reattach

- Stop all SuperSpeed Interop Tree device operation! Close any software that is used for the SuperSpeed Interop Tree device operation and close the 'Recording' tab window.
 - Detach the entire SuperSpeed Interop Tree from the xHCI controller.
 - Reattach the entire SuperSpeed Interop Tree to the same selected port(s) that it was detached from.
 - Operate all the devices in the SuperSpeed Interop Tree. Verify that all devices are operating concurrently. Verify the Device Speed using the USB View utility.
- **Pass:**
All SuperSpeed Interop Tree devices operate correctly
 - **Fail:**
One or more SuperSpeed Interop Tree devices fail to operate correctly

2. Active Detach & Reattach

- Operate all the devices in the SuperSpeed Interop Tree except for the Printer.
 - While operating the devices, detach the entire SuperSpeed Interop Tree from the selected port(s).
 - Reattach the entire SuperSpeed Interop Tree to the same selected port(s) that it was detached from.
 - Close any software that is used for any SuperSpeed Interop Tree device operation and close the 'Recording' tab window.
 - Operate all the devices in the SuperSpeed Interop Tree. Verify that all devices are operating concurrently. Verify the Device Speed using the USB View utility.
- **Pass:**
All SuperSpeed Interop Tree devices operate correctly
 - **Fail:**
 1. One or more SuperSpeed Interop Tree devices fail to operate correctly
OR
 2. System blue screens / locks up

3. Active Sleep and Remote Wake

- Operate all the devices in the SuperSpeed Interop Tree except for the Printer.
- While operating the devices, use the 'Sleep' function in the 'Start' menu of OS to put the system into sleep.
- Wait 60 seconds then wake the system with the DUT.

- If the DUT is a peripheral that does not support remote wakeup or function remote wakeup, then wake the system with the Mouse.
- Upon resuming, verify that the file transfers continue without error.
- Close any software that is used for any SuperSpeed Interop Tree device operation and close the 'Recording' tab window.
- Operate all the devices in the SuperSpeed Interop Tree. Verify that all devices are operating concurrently. Verify the Device Speed using the USB View utility.
- **Pass:**
 1. System sleeps
AND
 2. System resumes
AND
 3. File transfers continue without error
AND
 4. All devices can function after resuming
- **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

4. Active S4 Hibernation/Resume

- Operate all the devices in the SuperSpeed Interop Tree except for the Printer.
- While operating the devices, use the Hibernate batch file to put the system into hibernation. This will sleep the system for 60 seconds and automatically resume the system.
- Upon resuming, verify that the file transfers continue without error.
- Close any software that is used for any SuperSpeed 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. Verify the Device Speed using the USB View utility.
- **Pass:**
 1. System hibernates
AND
 2. System resumes
AND
 3. File transfers continue without error
AND
 4. All devices can function after resuming

- **Fail:**
 1. System does not hibernate
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 does not continue after resuming

5. Warm boot

- If there are file copying processes, close all of them.
- Restart system through the start menu (Start -> Shutdown -> Restart).
- After system reboots operate all the devices in the SuperSpeed Interop Tree. Verify that all devices are operating concurrently. Verify the Device Speed using the USB View utility.
- **Pass:**
All SuperSpeed Interop Tree devices operate correctly
- **Fail:**
One or more SuperSpeed Interop Tree devices fail to operate correctly

6. Cold boot

- If there are file copying processes, close all of them.
- Turn off system through the start menu (Start -> Shutdown -> Shutdown). Turn off the External Power Supply for the Host Controller.
- Turn PC and External Power Supply for the Host Controller back on.
- After system boots operate all the devices in the SuperSpeed Interop Tree. Verify that all devices are operating concurrently.
- **Pass:**
All SuperSpeed Interop Tree devices operate correctly
- **Fail:**
One or more SuperSpeed Interop Tree devices fail to operate correctly

Driver Verifier should be enabled for these drivers:

Cdrom.sys
Disk.sys
Drmk.sys
Hidclass.sys
Hidparse.sys
Hidusb.sys
Kbdclass.sys
Kbdhid.sys
Ks.sys
Mouclass.sys
Mouhid.sys
Usbccgp.sys
Usbd.sys
Usbehci.sys
Usbhub.sys
Usbohci.sys
Usbport.sys
Usbprint.sys
Usbstor.sys
Usbuhci.sys
Usbvideo.sys

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

Renesas Host Drivers:

Nusb3hub.sys
Nusb3xhc.sys

Fresco Logic Host Drivers:

Flxhcic.sys
Flxhcih.sys

Please ensure that the host driver names are correct for the host that is being used in the SuperSpeed Interop Tree.

USB Peripheral Interoperability

Peripheral Overall	PASS/FAIL
Peripheral Interoperability Tests	
1. 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) Active Detach & Reattach:	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
5. Topology Change 1:	PASS/FAIL
6. All Device Tests:	PASS/FAIL
1) Inactive Detach & Reattach:	PASS/FAIL
2) Active Detach & Reattach:	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. Topology Change 2:	PASS/FAIL/NA
8. All Device Tests:	PASS/FAIL/NA
1) Inactive Detach & Reattach:	PASS/FAIL
2) Active Detach & Reattach:	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
9. Interoperability without Driver Verifier:	PASS/FAIL/NA
10. Current Measurement:	PASS/FAIL
11. Function Wake:	PASS/FAIL
12. Root Port Testing:	PASS/FAIL

USB Self-Powered Hub Interoperability

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

Self-Powered Hub Interoperability Tests

- 1. 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) Active Detach & Reattach: **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**
- 5. Topology Change 1:** **PASS/FAIL**
- 6. All Device Tests:** **PASS/FAIL**
 - 1) Inactive Detach & Reattach: **PASS/FAIL**
 - 2) Active Detach & Reattach: **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. Topology Change 2:** **PASS/FAIL**
- 8. All Device Tests:** **PASS/FAIL**
 - 1) Inactive Detach & Reattach: **PASS/FAIL**
 - 2) Active Detach & Reattach: **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 |
|
 | |
| 9. Interoperability without Driver Verifier: | PASS/FAIL/NA |
|
 | |
| 10. Function Wake: | PASS/FAIL |

xHCI Interoperability Test Results

xHCI Overall	PASS/FAIL
xHCI Interoperability Tests	
1. 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. Active Detach & Reattach:	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
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 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

2 Appendix A

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.

Modified tree:

Tier	Device
1	• Hub SS1 – Self-powered USB3.0 Hub attached to the xHCI controller
2	• Hub HS2-MTT - Self-powered high-speed Hub with multiple transaction translators on port 2 of Hub SS1
3	• Hub FS3-1 - Bus-powered full-speed Keyboard Hub on port 2 of Hub HS2-MTT
4	• Hub FS4-1 - Self-powered high-speed Hub on port 1 of Hub FS3-1
5	• Headset on port 1 of Hub FS4-1
4	• FS Low Power Drive on port 2 of Hub FS3-1
3	• Hub FS3-2 - Bus-powered full-speed Keyboard Hub on port 3 of Hub HS2-MTT
4	• Hub FS4-2 - Self-powered high-speed Hub on port 1 of Hub FS3-2
5	• FS Video Camera on port 1 of Hub FS4-2
5	• Mouse on port 2 of Hub FS4-2

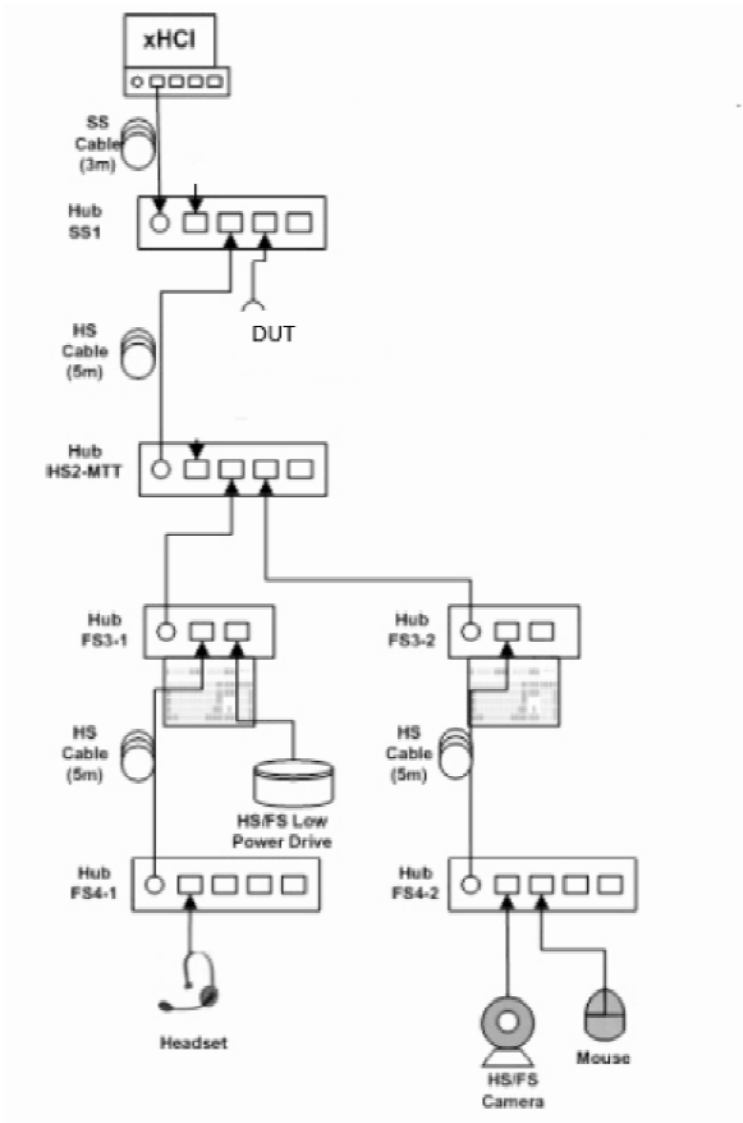


Figure A: Modified Interoperability Tree

USB Peripheral Interoperability Test Steps

Section (1.5)

- a. Testing of DUT at Root Port
 - Connect DUT to a port of xHCI controller. .
 - Operate all devices at root port.
 - Run tests 1-6 located in section 1.9
 - 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 SS1 in the modified tree

- Attach modified tree to xHCI controller
 - Operate all devices in tree as described in main document
 - Run tests 1-6 located in section 1.9
 - Use same pass/fail criteria as used in main document
- c. Test of DUT behind HS hub
- Unplug DUT from SS1
 - Plug DUT into port 4 of HS2-MMT
 - Operate all devices in tree as described in main document
 - Run tests 1-6 located in section 1.9
 - Use same pass/fail criteria as used in main document
- d. Test of DUT behind FS hub
- Unplug DUT from HS2-MMT
 - Plug DUT into port 2 of FS4-1
 - Operate all devices in tree as described in main document
 - Use same pass/fail criteria as used in main document

USB Self-Powered Hub Interoperability Test Steps

No changes to this section

USB Host Interoperability Test Steps

Section 1.8

- a. Root port test.
- Operate one KGD at root port.
 - Run tests 1-6 located in section 1.9
 - Repeat the test with each KGD..
 - Use same pass/fail criteria as used in main document.
- b. Interoperability with Modified Tree
- Remove all devices from xHCI controller
 - Attach one KGD to hub SS1 of Modified Tree.
 - Attach Modified Tree to one xHCI controller port.
 - Operate all devices in tree as described in main document
 - Operate the KGD.
 - Run tests 1-6 located in section 1.9
 - Use same pass/fail criteria as used in main document
- c. Root port enumeration with Modified Tree
- Attach the tree to the other root ports.
 - Check all devices are enumerated correctly.

APPENDIX B: SUMMARY OF CHANGES FROM REVISION 1.2 TO 1.3

Section	Change
1.5.1: 3. Interoperability	Rearranged operation of microphone. Added Device Speed verification.
1.5.2: Peripheral U1/U2 Test Steps	Please read entire section
1.6.2: 3. Interoperability	Rearranged operation of microphone. Added Device Speed verification.
1.6.3: Hub U1/U2 Test Steps	Please read entire section
1.8.2: 3. Interoperability	Rearranged operation of microphone. Added Device Speed verification.
1.8.3: Host U1/U2 Test Steps	Please read entire section
1.9: All Devices –xHCI Interoperability Test Steps	Added Device Speed Verification. Turn off/on external power during cold boot
Appendix A	Please read entire section