

USB Implementers Forum
xHCI Backwards Compatibility
Test Procedures For
Hosts and Hubs
Revision 1.7 – June 2016

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Revision:	Author:	Section:	Change:
1.0-1.3	Various	2.6.2:3	Rearranged operation of microphone. Added Device Speed verification.
		2.6.2:6	Rearranged operation of microphone.
		2.6.2:7	Rearranged operation of microphone.
		4	Added Device Speed Verification. Turn off/on external power during cold boot
		Appendix A	Added Driver Verifier Flag settings and list of Drivers for Windows 8
1.4	Martin Franke	All	Changed all topologies removing FS Keyboard Hub and adding Windows 8 Support
		4	Removed Active Detach/Attach
		4	Added Hybrid Shut Down for Windows 8
1.4	Sydney Fernandes	All	Reviewed and edited
1.5	Sydney Fernandes	3 (Section 2 and 3)	Clarified concurrent operation after resume from Hybrid Sleep and Hibernate
1.6	Sydney Fernandes	Appendix A	Updated the Driver Verifier list of files and flag
1.7	Sydney Fernandes	All	Updated document for Windows 10, removed Windows 7 and Windows 8 references. Reviewed and edited some older outdated content

1 xHCI Backwards Compatibility Testing

xHCI Backwards Compatibility testing covers several areas including device framework and the xHCI controller's ability to interoperate with numerous USB devices. It also provides insight into usability issues of the xHCI controller and the associated software.

xHCI Backwards Compatibility testing makes use of an arrangement of USB peripherals known as the xHCI Backwards Compatibility Tree. The xHCI Backwards Compatibility 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 23 meters from the xHCI 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 Backwards Compatibility test procedure is generic and should be applicable to the vast majority of xHCI controllers. This document cannot cover all possible types, configurations and combinations of peripherals, hubs and embedded devices. Thus, the application of the xHCI Backwards Compatibility test procedures may need to be modified in order to adequately test an xHCI controller for USB compliance. Test guidelines for unique xHCI controllers 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 BACKWARDS COMPATIBILITY 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 Backwards Compatibility test procedures.

Item	Description/Model	Qty
USB host system	1. A computer containing an available slot for the xHCI controller or a computer with the xHCI controller integrated into it. 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	1
HS hub (self-powered)	Any Certified USB self-powered, high-speed hub with at least 4 downstream ports	4
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
FS hub	Any Certified USB bus-powered, full-speed hub with at least 2 downstream ports	2
SS mass storage device	Any Certified SuperSpeed USB mass storage device compliant to the Mass Storage Class	1

FS drive	Any Certified USB low-power/self-powered, high-speed or full-speed mass storage device compliant to the Mass Storage Class	1
HS high power drive	Any Certified USB high-power, high-speed mass storage device compliant to the Mass Storage Class	1
HS video camera	Any Certified USB high-speed video camera compliant to the Video Class	1
FS video camera	Any Certified USB full-speed or high-speed video camera compliant to 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
Keypad	Any Certified USB keypad compliant to the Human Interface Device (HID) Class	1
Printer	Any Certified USB printer compliant to the Printer Class	1
Headset	Any Certified USB headset compliant to 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	1
Five meter HS USB cable	Any Certified USB 2.0 high-speed cable assembly	6

The xHCI Backwards Compatibility Tree consists of USB-IF certified, off-the-shelf, consumer devices. The Tree uses 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 xHCI Backwards Compatibility tree. Given the very short shelf-life of most consumer products, it is not practical to maintain a list of specific products for the xHCI Backwards Compatibility Tree. Thus, the choice of Certified USB products is yours to make.

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 you 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.

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

The following guidelines will help to select an appropriate product for the xHCI Backwards Compatibility Tree:

All Devices:

All devices in the xHCI Backwards Compatibility 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 xHCI Backwards Compatibility Tree.

USB Host System:

- The motherboard needs to have an available slot to add the xHCI controller or have the xHCI controller integrated.
- A multiple core processor is required.
- Memory and disk storage should be sufficiently large to reduce performance degradation.
- The machine must support S3 and S4 suspend.
- The machine must support Wake from PCI Express or Wake from ExpressCard when the xHCI controller is connected through PCI Express or ExpressCard.
- For host controllers that contain integrated HS hubs, the tree will need to be adjusted to ensure that there is one SuperSpeed 5-tier hubs branch and one HS/FS 5-tier hubs branch in the tree. These changes will be included in a future version of this document.

USB Hubs:

The xHCI Backwards Compatibility Tree exercises 5 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.

- Note: If the xHCI controller has an integrated hub, then the xHCI Backwards Compatibility Tree must add only 4 additional tiers of hubs to ensure turn-around time. To accommodate this, this xHCI controller with an integrated USB SS hub will substitute for both the xHCI controller and the USB SuperSpeed hub SS1 in the xHCI Backwards Compatibility Tree.

One high-speed hub must have multiple transaction translators (TT), and one high-speed hub must have only one 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 USB SuperSpeed hubs is required.

USB Mass Storage:

3 Certified USB mass storage devices must be used as xHCI Backwards Compatibility Tree devices.

- ✓ 1 SuperSpeed and 2 high-speed drives
- ✓ Bulk transport
- ✓ One high-speed device must be a high-power device, such as a flash drive or bus-powered hard drive
- ✓ One must be full-speed capable
- ✓ Compliance to the USB Mass Storage Class
 - The SuperSpeed device must be compliant to the USB Mass Storage UASP Class when such devices are prevalent in the ecosystem. Otherwise, it must be compliant to the USB Mass Storage Class.

USB Video Camera:

2 Certified USB video cameras must be used as xHCI Backwards Compatibility Tree devices.

- ✓ One must be high-speed
- ✓ One must be either full-speed or high-speed and must stream video at full-speed
 - To test the high-speed camera to see if it streams video at full speed, connect the device behind a full-speed hub on another system (not the xHCI Backwards Compatibility Tree system). Use the software provided with the device to see if the video camera will display any video, even if it is at a lower resolution. If it will not display, that video camera cannot work as an xHCI Backwards Compatibility 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 to the USB Video Class

USB Mouse:

1 Certified USB mouse must be used as a xHCI Backwards Compatibility Tree device.

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

USB Keypad:

1 Certified USB keypad must be used as a xHCI Backwards Compatibility Tree device.

- ✓ low-power device
- ✓ compliant to the USB HID Class

USB Printer:

1 Certified USB printer must be used as a xHCI Backwards Compatibility Tree device.

- ✓ bulk transport
- ✓ low-power or self-powered device
- ✓ compliant to the USB Printer Class

USB Headset:

1 Certified USB headset must be used as a XHCI Backwards Compatibility Tree device.

- ✓ isochronous transport
- ✓ compliant to 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:

To test worse 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 SS ports to the integrated xHCI controller. Also ensure that the BIOS settings are set to enable Spread Spectrum Clocking (SSC) for the USB SS ports with the correct modulation as specified in the USB 3.1 Specification.

1.2 Software Used

1.2.1 Install the Operating System

The host software required is Windows 10. Either restore the saved image of the previously prepared system or follow the steps given below.

Install Windows 10 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 (UAC). 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->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

For each S-State a batch file can be created on the desktop:

Hybrid Sleep:

- The Hybrid Sleep batch file, named HybridSleep.bat, should contain the following lines:

```
C:\Windows\system32\pwrtest.exe /sleep /c:1 /s:3 /h:y /p:90
echo You may now close this prompt
pause
```

Hibernate:

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

```
C:\Windows\system32\pwrtest.exe /sleep /c:1 /s:4 /h:n /p:60
echo You may now close this prompt
pause
```

Connected Standby:

- The Connected Standby batch file, named CS.bat, should contain the following lines:

```
C:\Windows\system32\pwrtest.exe /cs /c:1 /p:60
echo You may now close this prompt
pause
```

Shut-Down

- The Shut-Down batch file, named ColdBoot.bat, should contain the following lines:

```
Shutdown /s /f /t 0
echo You may now close this prompt
pause
```

Hybrid Shut-Down

- The Hybrid Shut-Down batch file, named HybridBoot.bat, should contain the following lines:

```
Shutdown /s /hybrid /f /t 0
echo You may now close this prompt
pause
```

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 xHCI Backwards Compatibility 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 (note: you may also use pre-defined list of drivers as specified in Chapter 4).
 - Connect the xHCI Backwards Compatibility Tree to another system running Windows 10 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 Backwards Compatibility 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 xHCI Backwards Compatibility Tree and enter safe mode on Windows. Then run 'Verifier /reset' to turn off the verifier.

1.2.2 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.

Three files are required for the data transfers in the xHCI Backwards Compatibility tests: A 25MB+ .zip file on the FS Drive and a 2GB+ .zip file on the SS Mass Storage Drive.

The USB host system must be ¹virus scanned before the test can begin. All mass storage devices must be virus scanned before beginning the tests.

1.3 xHCI Backwards Compatibility Logistical Overview

Effectively, xHCI Backwards Compatibility 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 Backwards Compatibility 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" capability, 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 will not work. In other words, a USB device is never to appear broken without justification and explanation to the consumer.

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.

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.

2 USB Backwards Compatibility Test Steps

Construct the xHCI Backwards Compatibility Tree of USB devices as outlined in Figure 1 or Figure 2 (for embedded hub controllers). Do not attach the xHCI Backwards Compatibility Tree to the xHCI controller.

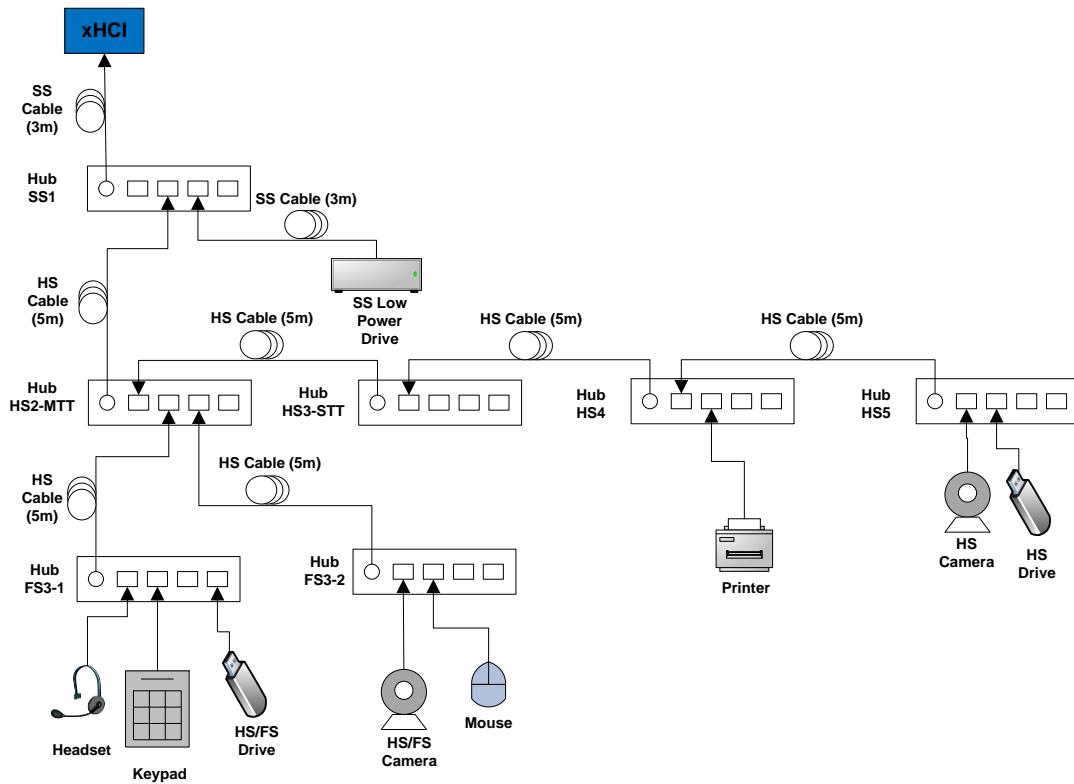


Figure 1: xHCI Backwards Compatibility Tree

Tier	Device
1	• Hub SS1 – Self-powered USB SS Hub attached to the Selected Port Under Test
2	• SS Mass Storage Device on port 3 of Hub SS1
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
4	• Hub HS4 - Self-powered high-speed Hub on port 1 of Hub HS3-STT
5	• Printer on port 2 of Hub HS4
5	• Hub HS5 - Self-powered high-speed Hub on port 1 of Hub HS4
6	• HS High Power Drive on port 2 of Hub HS5
6	• HS Video Camera on port 1 of Hub HS5
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	• Headset on port 1 of Hub FS3-1
4	• Keypad on port 2 of Hub FS3-1
3	• Hub FS3-2 – Full-Speed Hub on port 3 of Hub HS2-MTT
4	• Mouse on port 2 of Hub FS3-2
4	• FS Video Camera on port 1 of Hub FS3-2

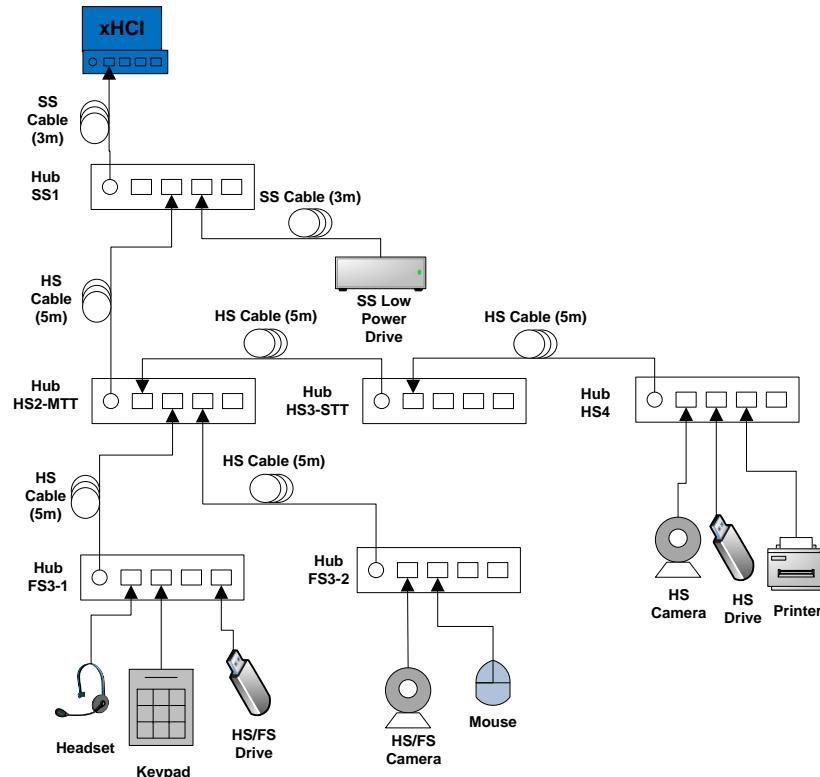


Figure 2: xHCI Backwards Compatibility Tree (Embedded Hub)

2.1 xHCI Backwards Compatibility Test Steps

2.1.1 xHCI Controller Inspection

Examine the xHCI controller and identify all USB connections.

- Each and every USB port on the xHCI controller must be tested and pass all required tests. The xHCI Backwards Compatibility Tests must be run separately for each USB port on the xHCI controller. If the xHCI controller has an integrated hub, then the tests must also be run for any exposed integrated hub ports.

Select a USB port of the xHCI controller or an integrated hub to run the xHCI Backwards Compatibility Tests on.

2.1.2 xHCI Backwards Compatibility 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 xHCI controller into the USB Host System if it is not already integrated.

- Ensure that the xHCI Backwards Compatibility Tree is not attached to the xHCI controller or integrated 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.

When testing all other additional ports:

No driver install procedure should be necessary, as you may 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 xHCI Backwards Compatibility Tree is not attached to the xHCI controller or integrated hub
- **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

When testing the first port:

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

Attach the xHCI Backwards Compatibility Tree by connecting Hub SS1 into the selected USB port under test.

- If the xHCI controller has an SS integrated hub and the selected USB port under test is an exposed integrated hub port:
 - plug Hub HS2-MTT directly into the USB port under test
 - plug the SS Mass Storage Device directly into another port on the same xHCI controller or integrated hub.

For each device in the xHCI Backwards Compatibility Tree follow the vendor-recommended install procedure. Ensure that all drivers listed for each device in the xHCI Backwards Compatibility 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 additional ports:

Attach the xHCI Backwards Compatibility Tree by connecting Hub SS1 into the selected USB port under test.

- If the xHCI controller has an integrated hub and the selected USB port under test is an exposed integrated hub port:
 - plug Hub HS2-MTT directly into the USB port under test
 - plug the SS Mass Storage Device directly into another port on the same xHCI controller or integrated hub.

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

- **Pass:**
 1. All xHCI Backwards Compatibility Tree devices enumerate
AND

2. All xHCI Backwards Compatibility Tree devices drivers are installed either automatically or through the vendor recommended install procedure
AND
 3. All xHCI Backwards Compatibility Tree devices do not require a reboot
AND
 4. All xHCI Backwards Compatibility 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. Backwards Compatibility

- Operate all of the devices in the xHCI Backwards Compatibility Tree.
 - Whenever this document states to operate all of the devices in the xHCI Backwards Compatibility 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 HS 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 you see poor quality, continue testing with the Driver Verifier enabled for all Backwards Compatibility steps. Repeat all Backwards Compatibility steps with Driver Verifier off. USB-IF will compare Backwards Compatibility results with Driver Verifier Enabled and Disabled to determine Pass/Fail for certification
 - Transfer a 25+ MB file from the SS Mass Storage Device to the Full-Speed Drive
 - Transfer a 1+ GB file from the High Power Drive to the SS Mass Storage Device
 - 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 keypad
 - Move the mouse
- Verify that all devices are operating concurrently.
- **Pass:**
 1. All xHCI Backwards Compatibility Tree devices operate correctly
- **Fail:**
 1. One or more xHCI Backwards Compatibility Tree devices fail to operate correctly

4. All Device Tests

- Run tests 1-6 located in Chapter 3

5. Active ExpressCard Detach & Reattach

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

6. Topology Change 1

- Stop all xHCI Backwards Compatibility Tree device operation! Close any software that is used for any xHCI Backwards Compatibility Tree device operation.
- Operate only the following devices concurrently:
 - Operate the microphone(s)
 - View streaming video from the HS Video Camera
 - Play a familiar song through the headset to ensure audio is working
 - Transfer a 25+ MB file from the SS Mass Storage Device to the Full-Speed Drive
 - Transfer a 1+ GB file from the High Power Drive to the SS Mass Storage Device

- Print a sample page from the printer
 - i. 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.
- While operating the devices, detach the Hub FS3-2 from port 3 on Hub HS2-MTT.
- While operating the devices, reattach Hub FS3-2 to port 3 on Hub HS3-STT as shown in Figure 3.

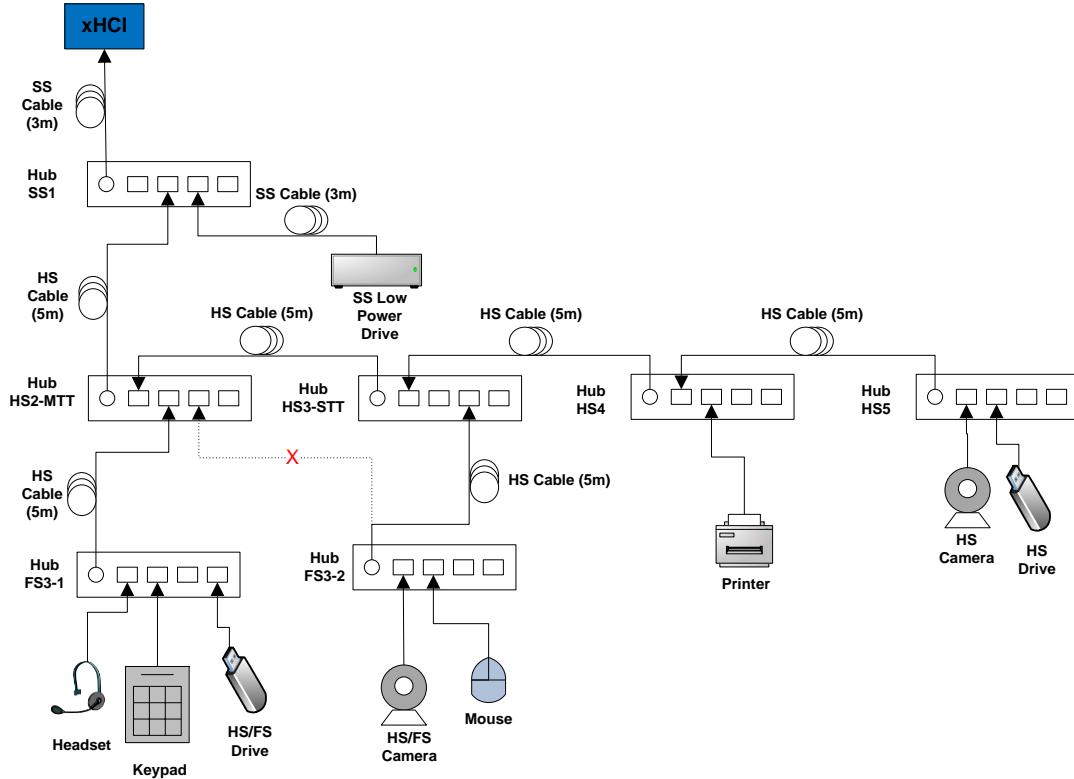


Figure 3: Topology Change 1

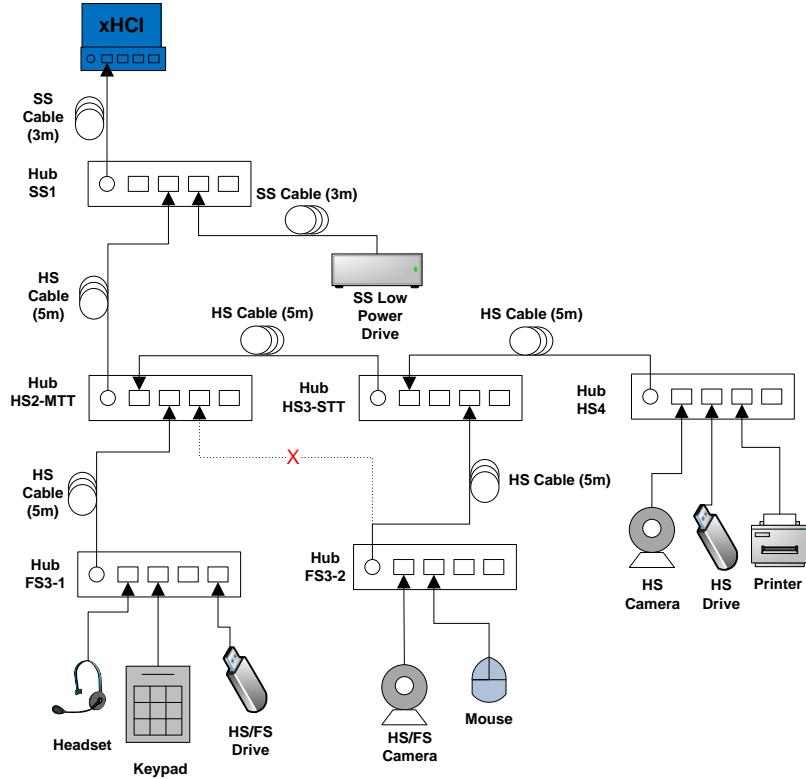


Figure 4: Topology Change 1 (Embedded Hub)

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

7. Topology Change 2

- Stop all xHCI Backwards Compatibility Tree device operation! Close any software that is used for any xHCI Backwards Compatibility Tree device operation and close the 'Recording' tab window.

- Operate only the following devices concurrently:
 - Operate the microphone(s)
 - View streaming video from the HS Video Camera
 - View streaming video from the FS Video Camera
 - Transfer a 1+ GB file from the High Power Drive to the SS Mass Storage Device
 - 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.
 - Move the mouse
- While operating the devices, detach Hub FS3-1 from port 2 on Hub HS2-MTT.
- While operating the devices, reattach Hub FS3-1 to port 2 on Hub HS3-STT as shown in Figure 5.

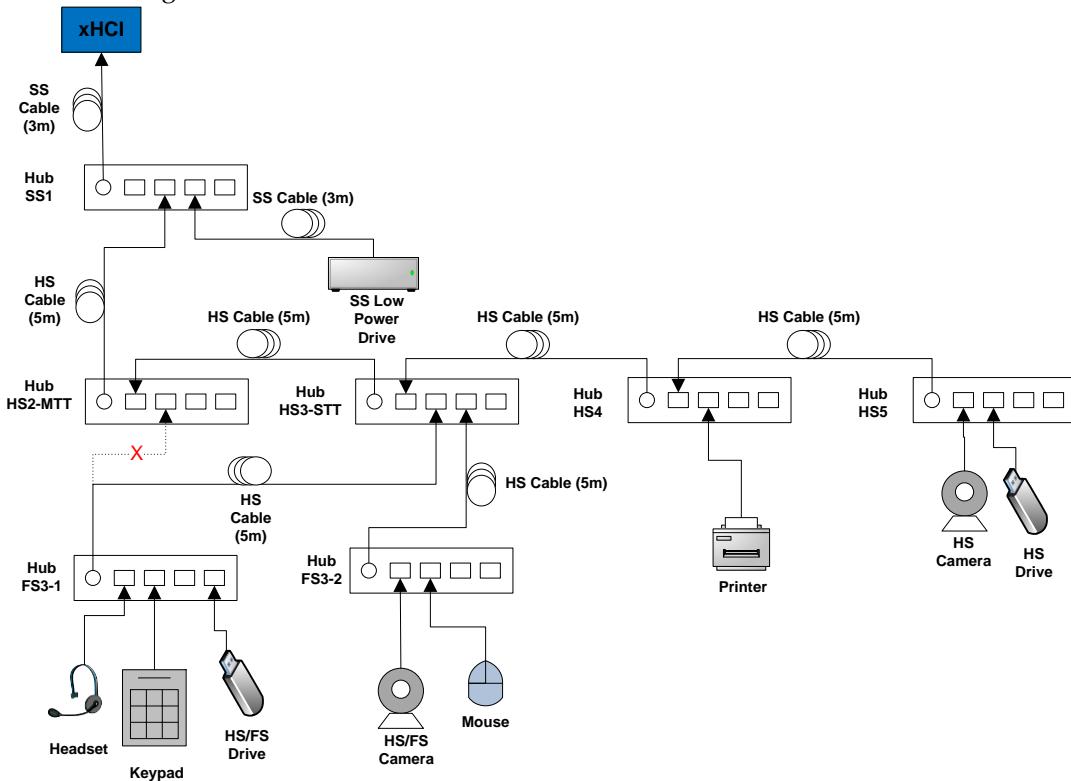


Figure 5: Topology Change 2

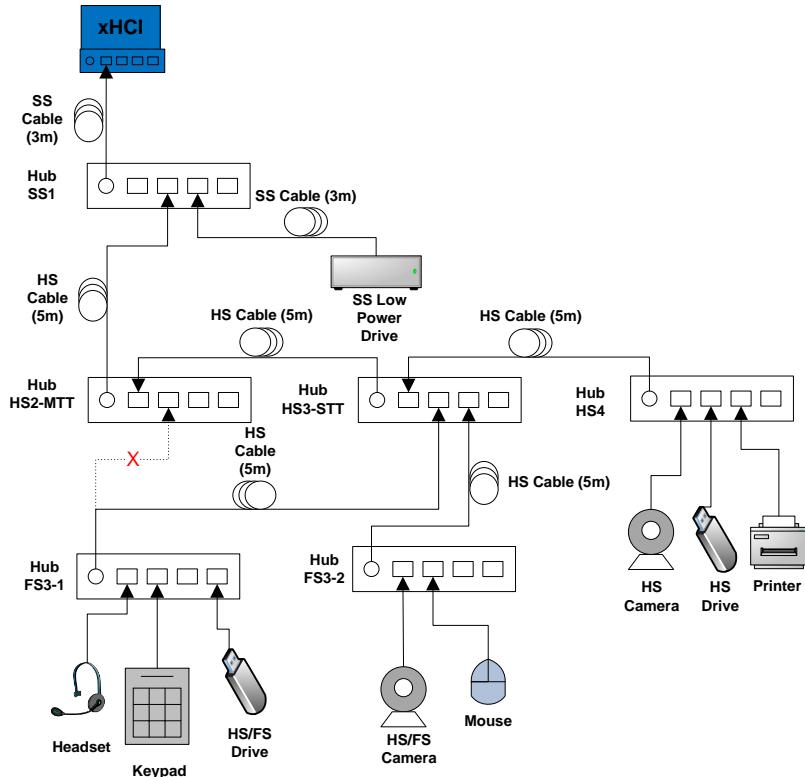


Figure 6: Topology Change 2 (Embedded Hub)

- Verify that the file transfer continues to take place.
- Verify that the HS Video Camera, FS 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 HS 3-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 2 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 4.
 - Operate all the devices in the xHCI Backwards Compatibility 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 HS Video Camera, FS Video Camera, and mouse continue to function
AND
 3. All xHCI Backwards Compatibility Tree devices operate correctly
- **Fail:**
 1. After the topology change the file transfer was cancelled
OR

2. After the topology change the HS Video Camera, FS Video Camera, or mouse stopped functioning
OR
3. One or more xHCI Backwards Compatibility Tree devices fail to operate correctly

8. Backwards Compatibility without Driver Verifier

- Run this test only if you saw poor video or audio quality when operating all of the devices in the xHCI Backwards Compatibility 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 xHCI Backwards Compatibility Tree. Verify that all devices are operating concurrently.
- **Pass:**
 1. All xHCI Backwards Compatibility Tree devices operate correctly
- **Fail:**
 1. One or more xHCI Backwards Compatibility Tree devices fail to operate correctly

3 All Device Tests – xHCI Backwards Compatibility Test Steps

1. Inactive Detach & Reattach

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

2. Active Sleep/Remote Wake

- Operate all the devices in the xHCI Backwards Compatibility Tree except for the Printer.
- While operating the devices, use the Hybrid Sleep batch file to put the system into sleep.
- Wait 60 seconds then wake the system with the mouse on the xHCI Backwards Compatibility 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 the devices in the xHCI Backwards Compatibility 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. 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

3. Active S4 Hibernation/Resume

- Operate all the devices in the xHCI Backwards Compatibility Tree except for the Printer.
 - While operating the devices, use the Hibernate batch file to 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 the devices in the xHCI Backwards Compatibility 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. 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

4. 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 xHCI Backwards Compatibility Tree. Verify that all devices are operating concurrently. Verify the Device Speed using the USB View utility.
- **Pass:**
 1. All xHCI Backwards Compatibility Tree devices operate correctly
 - **Fail:**
 1. One or more xHCI Backwards Compatibility Tree devices fail to operate correctly

5. Cold boot

- If there are file copying processes, close all of them.
- Turn off system by double-clicking on the ShutDown.bat batch file. 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 xHCI Backwards Compatibility Tree. Verify that all devices are operating concurrently. Verify the Device Speed using the USB View utility.
- **Pass:**
 - 1. All xHCI Backwards Compatibility Tree devices operate correctly
- **Fail:**
 - 1. One or more xHCI Backwards Compatibility Tree devices fail to operate correctly

6. Hybrid boot (Windows 10 Only)

- If there are file copying processes, close all of them.
- Turn off system by double-clicking on the HybridShutDown.bat file. 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 xHCI Backwards Compatibility Tree. Verify that all devices are operating concurrently. Verify the Device Speed using the USB View utility.
- **Pass:**
 - 1. All xHCI Backwards Compatibility Tree devices operate correctly
- **Fail:**
 - 1. One or more xHCI Backwards Compatibility Tree devices fail to operate correctly

xHCI Backwards Compatibility Test Results

Overall Backwards Compatibility Result	PASS/FAIL
xHCI Backward Compatibility Tests	
1. xHCI Controller Driver Installation:	PASS/FAIL
2. Peripheral Enumeration and Driver Installation:	PASS/FAIL
3. Backwards Compatibility:	PASS/FAIL
4. All Device Tests:	PASS/FAIL
1. Inactive Detach & Reattach:	PASS/FAIL
2. Active Sleep/Remote Wake:	PASS/FAIL
3. Active S4 Hibernation/Resume:	PASS/FAIL
4. Warm boot:	PASS/FAIL
5. Cold boot:	PASS/FAIL
6. Hybrid boot (Win10 Only):	PASS/FAIL
5. Active ExpressCard Detach & Reattach:	PASS/FAIL
6. Topology Change 1:	PASS/FAIL
7. Topology Change 2:	PASS/FAIL
8. Backwards Compatibility without Driver Verifier:	PASS/FAIL/NA

4 Appendix A

xHCI Backwards Compatibility 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 10. Please choose the correct drivers to verify based on your operating system and then put these drivers into Driver Verifier as described in section **Error! Reference source not found.**.

List of Drivers for Windows 10:

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