USB2.0 Type-C™ & Regular USB Device Electrical Compliance test procedure

Version 0.87 – 6 August 2017

Contents

1. Reference

Standard	Description	Revision	Status
USB 2.0 Spec	USB 2.0 Specification with ECN	2.0	Released
USB 2.0 Electrical Test Specification		1.06	Released

2. Background

USB 2.0 Compliance Committee under the direction of USB-IF, Inc develops the USB-IF High-speed Electrical Test Procedures. This document covers the method of measuring the USB 2.0 electrical tests for devices. Hub, Host and Embedded Host are covered in another document.

The High-speed Electrical Compliance Test Procedures verify the electrical requirements of high-speed USB operation of these devices designed to the USB 2.0 specification. In addition to passing the high-speed test requirements, high-speed capable device must also complete and pass the applicable legacy compliance tests identified in this document.

The document covers only the USB 2.0 electrical tests but are applicable for all devices including USB 2.0 Full/Low/High Speed Device. But also, USB 3.1 Super Speed (5Gb or 10Gb) devices, since they need to be backward compatible with USB 2.0.

3. Required equipment and software

3.1 Oscilloscope, Software, and Accessories

Check with scope vendor.

3.2 High-Speed Electrical Test Bed Computer USBHSET

In order to perform USB 2.0 High Speed electrical tests a High Speed product must support test modes as defined in section 7.1.20 of the USB 2.0 specification.
To activate a test mode, the USB 2.0 Specification defines the *SetFeature()* command as the desired interface. The USB-IF offers for free a High Speed electrical Test Tool (USBHSET) which is Windows based, to activate the various test modes and operations.

The high-speed electrical test bed computer hosts a USB 2.0 compliance host controller for hi-speed hub or device electrical test, or serves as a test bed host for a USB 2.0 host controller under test. For instructions on configuring this computer, refer to the High-Speed Electrical Test Toolkit Setup Instruction document which comes with the High-Speed Electrical Test Tool Kit software. You can download the High-Speed Electrical Test Tool Kit software (USBHSET) from the developers tools page at the USB Implementers Forum web site, http://www.usb.org/developers/tools

The High-Speed Electrical Test Tool Kit software contains a proprietary EHCI or xHCI driver stack. The Hi-speed Electrical Test Tool software requires the use of a proprietary EHCI or xHCI driver stack. The use of this proprietary EHCI or xHCI driver stack facilitates the electrical testing that requires direct control of the command registers of the USB EHCI host controllers. The end result much more robust test bed environment. Since the proprietary EHCI or xHCI driver stack is designed for debug and test validation purposes, this driver stack does not support the normal functionality as found in the EHCI or xHCI drivers from Microsoft (or the device vendor). An automatic driver stack switching function has been implemented into the Hi-speed Electrical Test Tool for easy switching between the proprietary EHCI or xHCI driver stack and that from Microsoft. Upon invocation of the HS Electrical Test Tool software, the driver stack will automatically switch to the Intel proprietary EHCI or xHCI driver stack. Upon exit of the HS Electrical Test Tool software, the driver stack will automatically switch to the Microsoft EHCI or xHCI driver stack.

USBHSET XHCI
Is used for USB 3.1 host controllers

USBHSET EHCI
Is used for USB 2.0 host controllers

3.3 USB 2.0 Test fixtures

3.3.1 USB 2.0 Device with standard USB connector

Devices with Standard-B; Mini-B; Micro-B and A-plug with captive cable are considered being devices with standard USB connector.

The USB-IF High Speed fixture only require connecting SMA cables that are connected directly to the scope. Do note that the USB-IF fixture is only able in measuring the High Speed Eye diagram and therefore it is still required to use the TestUSB FS-HUCR for the remaining high speed electrical tests. The USB-IF fixtures can be purchased via the USB-IF eStore at:
http://www.usb.org/developers/estoreinfo/

Test fixture Description	Part number	High-Speed Device	Full/Low Speed Device
High Speed USB-IF Device Eye diagram fixture	USB-IF Device test Fixture	1	n/a
USB2.0 Type-C Signal Quality Test Fixture (Receptacle)	TestUSB.com FS-HUCR	1	1
Back-Voltage fixture	TestUSB.com FS-BV	1	1

This document covers the high speed signal quality measurement for devices with Type-C™ receptacles and plugs. It not cover the measurement for device with standard USB receptacles or plugs. Remaining high speed tests beside signal quality are however covered in this document and require the FS-HUCR fixture.

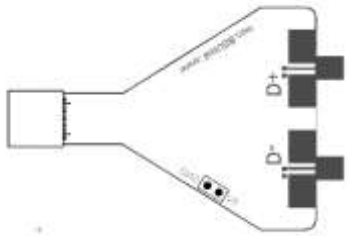
The FS-HUCR and FS-BV fixture can be purchase via:
http://testusb.com/TypeC20.html

3.3.2 USB 2.0 Device with Type-C™ connector

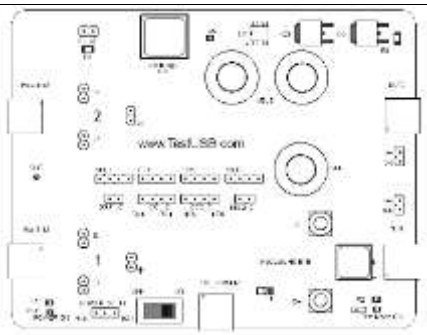
Test fixture Description	Part number	High-Speed Device	Full/Low Speed Device
USB2.0 Type-C Signal Quality Test Fixture (Receptacle)	TestUSB.com FS-HUCR	1	1
USB2.0 Type-C Signal Quality Test Fixture (Plug)	TestUSB.com FS-HUCP	1 (*)	n/a
Back-Voltage fixture	TestUSB.com FS-BV	1	1
USB2.0 Type-C Receiver fixture		1	n/a

(*) If high speed device is self-powered

FS-HUCP



FS-HUCR



The FS-HUCR, FS-HUCP and FS-BV fixture can be purchase via:
http://testusb.com/TypeC20.html

3.4 USB Cables

Cable Description	Required for device	Part number	Qty
USB 2.0 10cm Type-C™ Plug to Standard A-plug	All devices	FS-HC-CP-10-P	2
USB 3.1 10cm Type-C™ Plug to Standard A-receptacle	All devices	FS-SS+C-CP-10-AR-3A	2
USB 2.0 10cm Type-C™ Plug to Standard C-plug	All devices	FS-HC-CP-10-CP	1
USB 2.0 500cm Type-C™ Plug to Standard B-plug	with standard-B receptacle	FS-HC-CP-500-BP	1
USB 2.0 450cm Type-C™ Plug to Standard mini B-plug	with mini-B receptacle	FS-HC-CP-450-mBP	1
USB 2.0 200cm Type-C™ Plug to Standard micro B-plug	with micro-B receptacle	FS-HC-CP-200-uBP	1
USB 2.0 400cm Type-C™ Plug to Standard Type-C™ Plug	with Type-C™ receptacle	FS-HC-CP-400-CP	1
USB 2.0 or USB 3.1 Type-C™ Plug to Standard A-plug	Power FS-HUCR	Any listed on USB-IF web site	1
USB 2.0 or USB 3.1 Type-C™ Plug to Standard A-plug	From FS-HUCR to Host Test Bed	Any listed on USB-IF web site	1

3.5 Miscellaneous Cables and Devices

Description	Required for device	Part number	Qty
Digital multimeter	All devices	Keysight 33401A or equivalent	1
Matched SMA Cable Pair	High Speed devices	Keysight 15443A	1
Hi-Speed USB Hub		Any listed on USB-IF web site	1

4. Test procedure

4.1 Device High Speed Signal Quality

This document covers the high speed signal quality measurement for devices with Type-C™ receptacles and plugs. It not covers the measurement for device with standard USB receptacles or plugs.

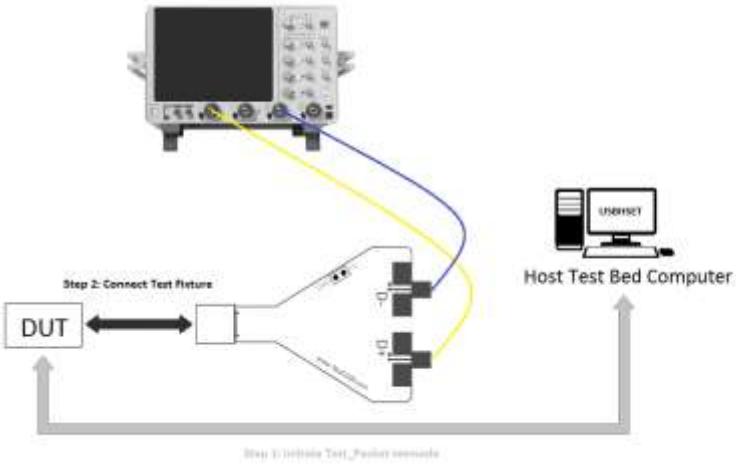
This test is measuring the high speed upstream Signal Quality (EYE diagram). For this test the device need to send out the Test_Packet as defined in section 7.1.20 of the USB 2.0 specification. The USB-IF tool USBET will make the required analyses.

4.1.1 Equipment Used

Quantity	Item	Description/ Model
1	Oscilloscope	
1	USB software	USBET
2	BNC - SMA	Keysight 54855-67604
2	SMA Cables	Matched SMA Cable Pair
1	Cable between Device under test and Device Hi-Speed Signal Quality Type-C™ test fixture	10cm Type-C™ plug to Type-C™ plug cable FS-HC-CP-10-CP
1	Host test bed computer	Any computer with hi-speed or super speed USB ports
1	Device Hi-Speed Signal Quality Type-C™ test fixture	For devices with Type-C™ plug or devices with Type-C™ receptacle and bus-powered use: • TestUSB.com FS-HUCR For device with Type-C™ receptacle and self-powered use: • TestUSB.com FS-HUCP
1	5V power supply	Any Type-C™ plug to A-plug cable that can take 5V from any USB host.
1	Cable between USBHSET PC and FS-HUCR Signal Quality Type-C™ test fixture	Any Type-C™ plug to A-plug cable
1	USBHSET for EHCI software application OR USBHSET for XHCI software application	http://www.usb.org/developers/tools/usb20_tools/#usbhset OR http://www.usb.org/developers/tools/

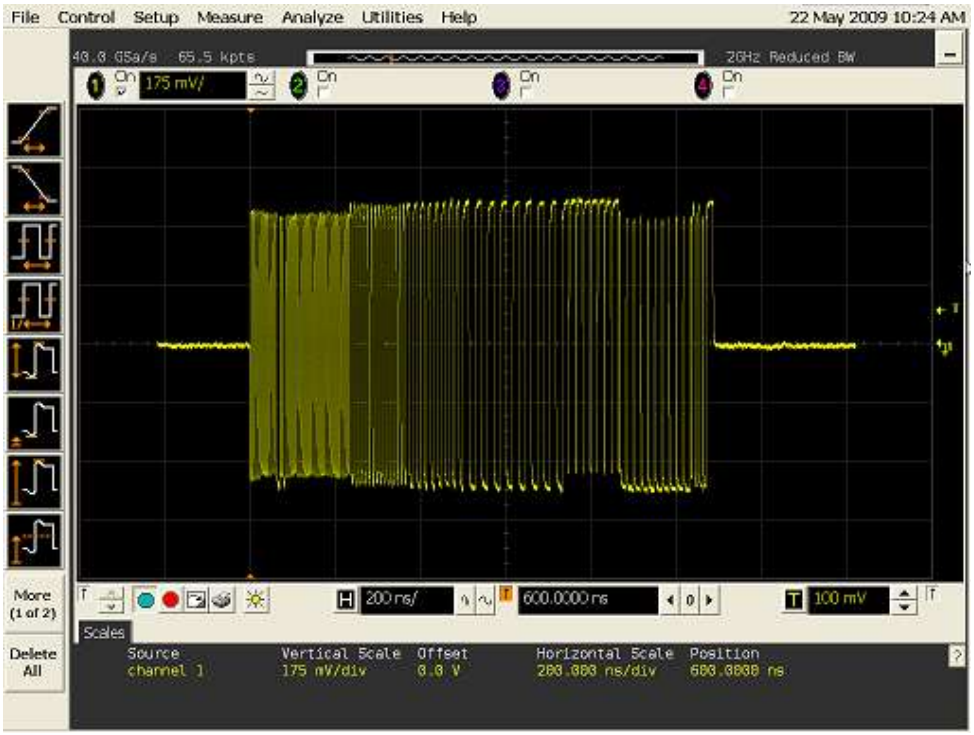
4.1.2 Setup Diagram if DUT has Type-C™ receptacle and is self-powered

If the DUT has a Type-C™ receptacle and is self-powered the setup is as followed:



Connecting the Equipment – DUT has Type-C™ receptacle and is self-powered (Test fixture FS-HUCP)

1. Connect the DUT to the Test Bed Computer running USBHSET, using a USB cable.
2. Follow Test Instructions below from step 5. to 8. in order to let the DUT send continuously TEST_PACKET.
3. Detach the DUT from Test Bed Computer running USBHSET. Since the device is self-powered the device keep sending TEST_PACKET till power cycle.
4. Attach the SMA cables to the SMA connectors D+ and D- on the USB2.0 Type-C™ plug test fixture FS-HUCP. In default D+ = Ch1 and D- = Ch3.
5. Connect the test fixture to the DUT and you should see the following.



6. Follow the oscilloscope vendor steps in acquiring the signal eye diagram and calculating the below signal quality compliance test items

   EL_6 Rise Time

   EL_6 Fall Time

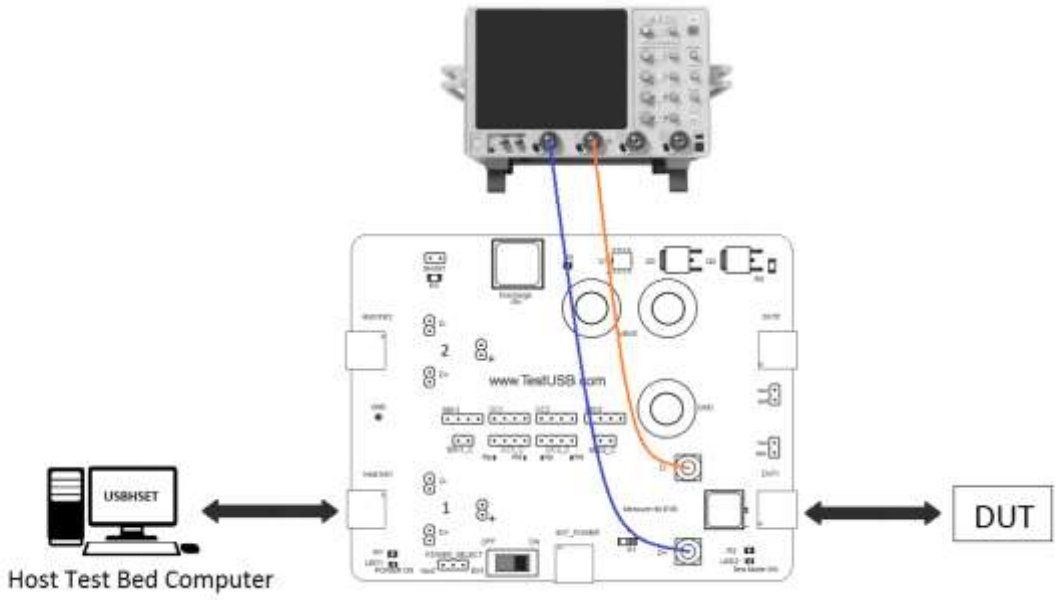
   EL_2 EL_4 EL_5 Data Eye and Mask Test

   EL_7 Non-Monotonic Edge Test

7. For Type-C™ products the measurement need to be done in both positions so flip the fixture and repeat the above step 5 and 6.

4.1.3 Setup Diagram for other Type-C™ devices

If the DUT not has a Type-C™ receptacle and is bus-powered the setup is as followed:



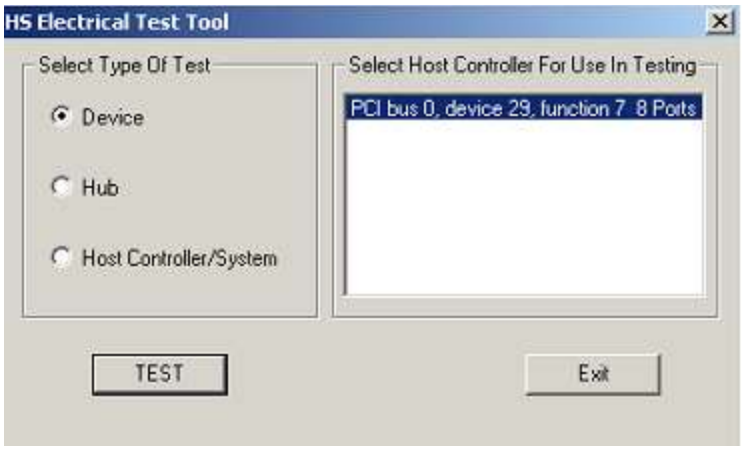
Connecting the Equipment

1. Attach the external power to EXT_POWER of the USB2.0 Type-C™ receptacle fixture. Leave the TEST switch 'S1' at the OFF position. Verify the red POWER ON LED is lit and the Test Mode ON LED is not lit.
2. Connect the DUT to DUT 1 side of the fixture.
   a. If device has captive Type-C™ plug directly connect DUT to DUT1 (*)
   b. If device has a Type-C™ receptacle and is bus-powered use the corresponding short cable to connect DUT to DUT1
3. Connect the Host Init 1 of the test fixture to a port of the Test Bed Computer running USBHSET, using a using the appropriated USB cable.
4. Attach the SMA cables to the SMA connectors D+ and D- on the test fixture. In default D+ = Ch1 and D- = Ch3

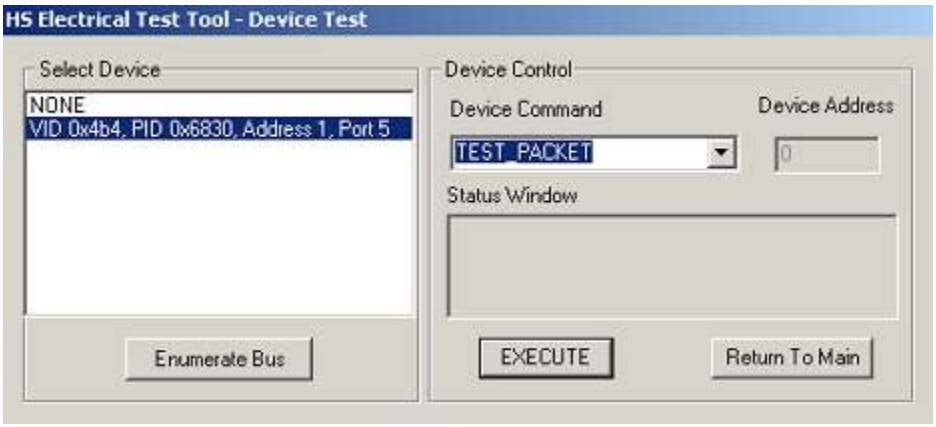
(*) Measurements to be performed using the far end eye template.

4.1.4 Test Instructions

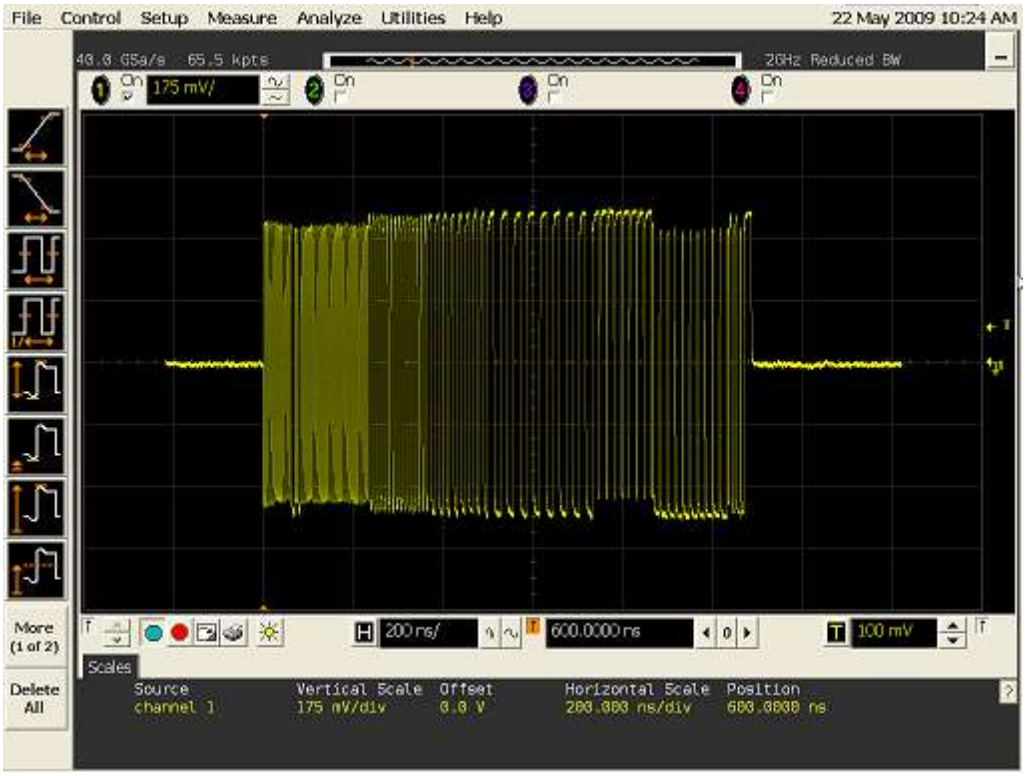
5. Invoke the HS Electrical Test Tool software on the Hi-Speed Electrical Test Bed computer.
6. Select Device and click the [TEST] button to enter the Device Test menu.



7. The device under test should be enumerated with the device's VID shown together with the root port in which it is connected.
8. Select **TEST_PACKET** from the Device Command drop down menu and click **[EXECUTE]**. This forces the device under test to continuously transmit test packets.



9. Place the Test Switch (S1) in the ON position. Verify the red Test Mode ON LED is lit. You should see the transmitted test packet on the oscilloscope as below.



10. Follow the oscilloscope vendor steps in acquiring the signal eye diagram and calculating the below signal quality compliance test items

    EL_6 Rise Time

    EL_6 Fall Time

    EL_2 EL_4 EL_5 Data Eye and Mask Test

    EL_7 Non-Monotonic Edge Test

8. For Type-C™ products the measurement need to be done in both positions so flip the cable at the DUT1 side of the fixture and repeat step 6 till 10.

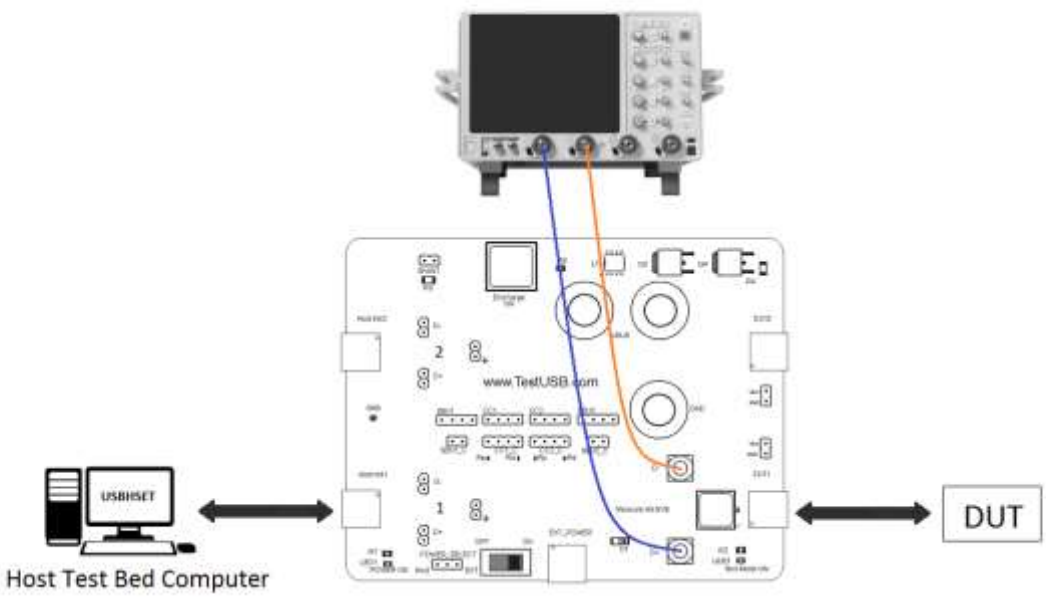
4.2 Device Test J/K, SE0NAK

All high speed devices must undergo this test. The following test can also be executed on devices with standard USB connectors.

4.2.1 Equipment Used

Quantity	Item	Description/ Model
1	Oscilloscope	
1	Oscilloscope USB software	
2	BNC – SMA	Keysight 54855-67604
2	SMA Cables	Matched SMA Cable Pair
1	Cable between Device under test and Device Hi-Speed Signal Quality Type-C™ test fixture	10cm Type-C™ plug to Type-C™ plug cable FS-HC-CP-10-CP
1	Host test bed computer	Any computer with hi-speed or super speed USB ports
1	Device Hi-Speed Signal Quality Type-C™ test fixture	TestUSB.com FS-HUCR
1	5V power supply	Any Type-C™ plug to A-plug cable that can take 5V from any USB host.
1	USBHSET for EHCI software application OR USBHSET for XHCI software application	http://www.usb.org/developers/tools/usb20_tools/#usbhset OR http://www.usb.org/developers/tools/

4.2.2 Setup Diagram



Connecting the Equipment

1. Attach the external power to EXT_POWER of the USB2.0 Type-C™ receptacle fixture. Leave the TEST switch 'S1' at the OFF position. Verify the red POWER ON LED is lit and the Test Mode ON LED is not lit.

2. Connect the DUT to DUT 1 side of the fixture.
    a. If device has captive Type-C™ plug directly connect DUT to DUT1
    b. If device has a receptacle use the corresponding short as possible cable to connect DUT to DUT1.
3. Connect the Host Init 1 of the test fixture to a port of the Test Bed Computer running USBHSET, using a using the appropriated USB cable.
4. Attach the SMA cables to the SMA connectors D+ and D- on the test fixture.

4.2.3 Test Instructions

Test Instructions EL_8 Test_J part

5. On the Device Test Menu of the HS Electrical Test Tool, click [Enumerate Bus] once.
6. Select TEST_J from the Device Command drop down menu. Click [EXECUTE] once to place the device into TEST_J test mode.

7. Switch the Test Switch (S1) in the ON position. Verify the red Test Mode ON LED is lit.
8. The captured transition should be as in the figure below.

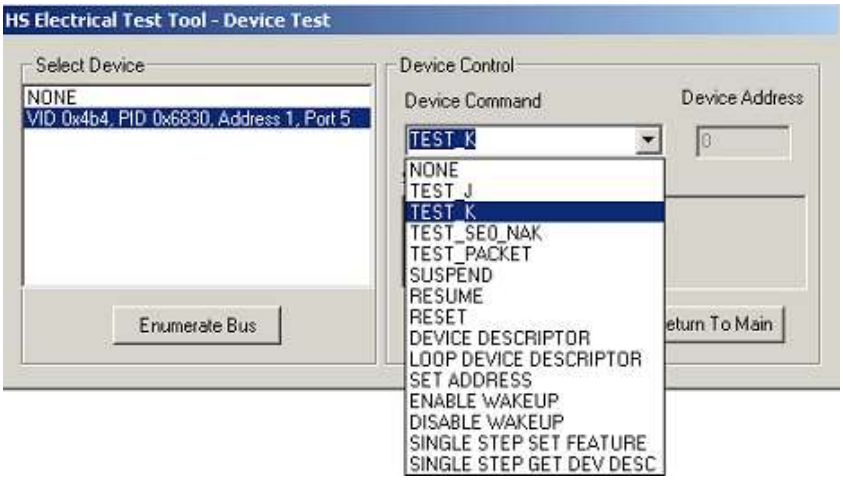
9. Follow the oscilloscope vendor steps in measuring the below compliance test items

EL_8 Test_J

10. Power Cycle USB Device Under Test and flip/ reverse attach USB Type-C™ connection
11. Repeat Test Instructions from step 5.
12. Power Cycle USB Device Under Test

Test Instructions EL_8 Test_K Part

13. On the Device Test Menu of the HS Electrical Test Tool, click [Enumerate Bus] once.
14. Select **TEST_K** from the Device Command drop down menu. Click **[EXECUTE]** once to place the device into TEST_K test mode.



15. Switch the Test Switch (S1) in the ON position. Verify the red Test Mode ON LED is lit.
16. The captured transition should be as in the figure below.

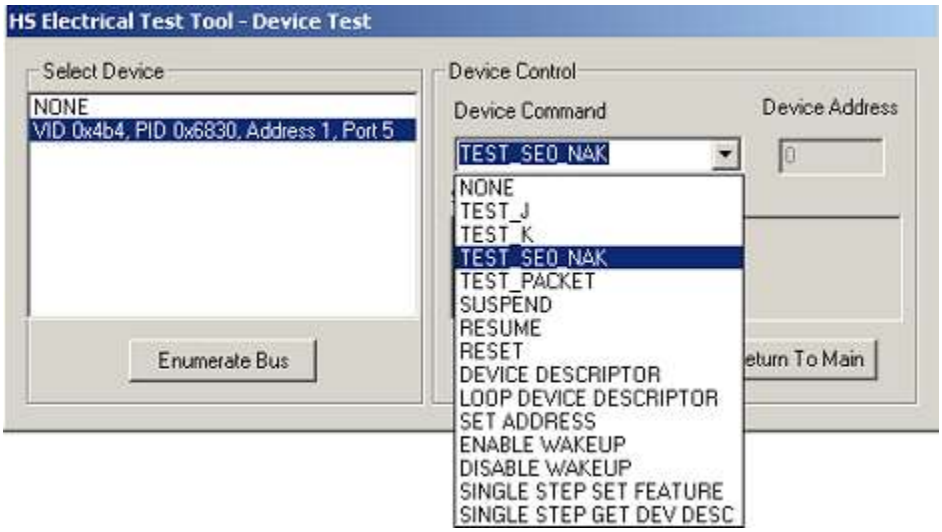
17. Follow the oscilloscope vendor steps in measuring the below compliance test items

    EL_8 Test_K

18. Power Cycle USB Device Under Test and flip/ reverse attach USB Type-C™ connection
19. Repeat Test Instructions from step 13.
20. Power Cycle USB Device Under Test

Test Instructions EL_8 Test_SE0 Part

21. On the Device Test Menu of the HS Electrical Test Tool, click [Enumerate Bus] once.
22. Select **SE0_NAK** from the Device Command drop down menu. Click **[EXECUTE]** once to place the device into SE0_NAK test mode.



23. Switch the Test Switch (S1) in the ON position. Verify the red Test Mode ON LED is lit.
24. The captured transition should be as in the figure below.

25. Follow the oscilloscope vendor steps in measuring the below compliance test items

EL_9 Test_SE0_NAK

26. Power Cycle USB Device Under Test and flip/ reverse attach USB Type-C™ connection
27. Repeat Test Instructions from step 21.
28. Power Cycle USB Device Under Test

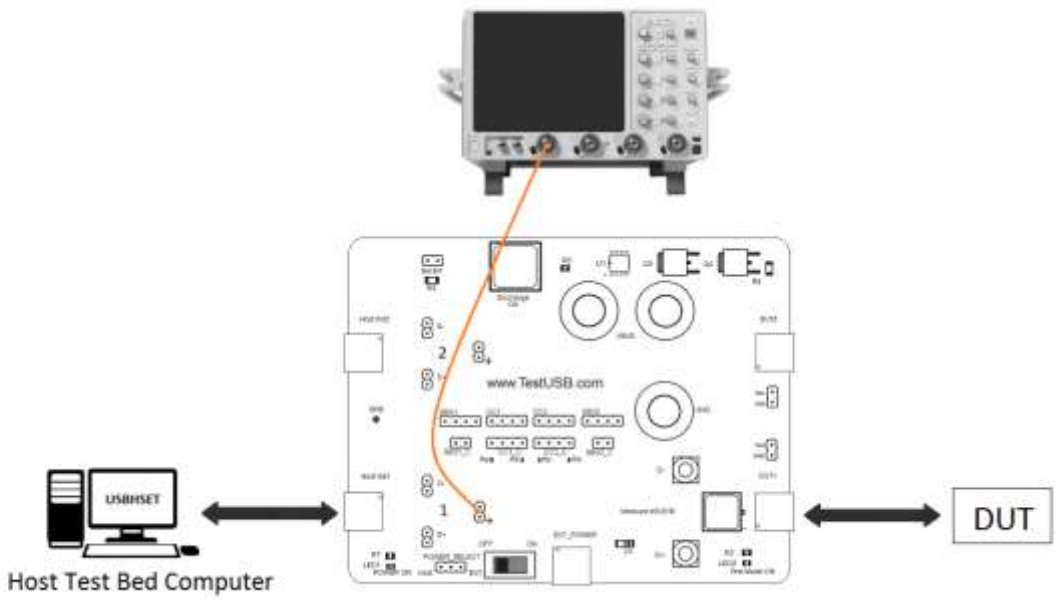
4.3 Device Packet Parameters

All high speed devices must undergo this test. The following test can also be executed on devices with standard USB connectors.

4.3.1 Equipment Used

Quantity	Item	Description/ Model
1	Oscilloscope	
1	Oscilloscope USB software	
1	Differential probe	
1	Cable between Device under test and Device Hi-Speed Signal Quality Type-C™ test fixture	10cm Type-C™ plug to Type-C™ plug cable FS-HC-CP-10-CP
1	Host test bed computer	Any computer with hi-speed or super speed USB ports
1	Device Hi-Speed Signal Quality Type-C™ test fixture	TestUSB.com FS-HUCR
1	5V power supply	Any Type-C™ plug to A-plug cable that can take 5V from any USB host.
1	USBHSET for EHCI software application OR USBHSET for XHCI software application	http://www.usb.org/developers/tools/usb20_tools/#usbhset OR http://www.usb.org/developers/tools/#sigHSETT

4.3.2 Setup Diagram



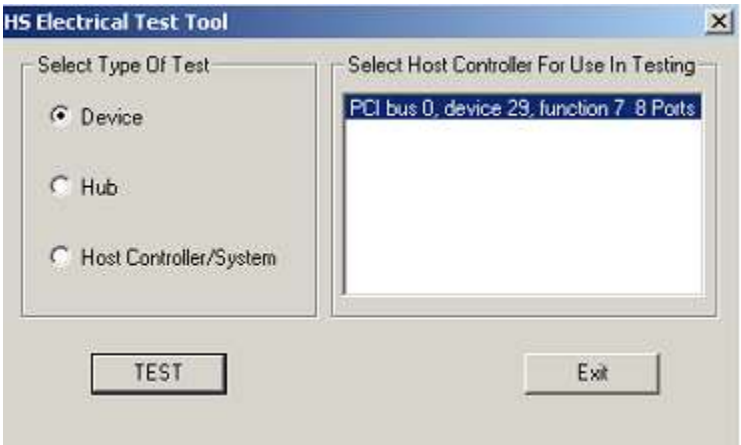
Connecting the Equipment

1. Attach the external power to EXT_POWER of the USB2.0 Type-C™ receptacle fixture. Leave the TEST switch 'S1' at the OFF position. Verify the red POWER ON LED is lit and the Test Mode ON LED is not lit.
2. Connect the DUT to DUT 1 side of the fixture.
    a. If device has captive Type-C™ plug directly connect DUT to DUT1
    b. If device has a receptacle use the corresponding short as possible cable to connect DUT to DUT1.
3. Connect the Host Init 1 of the test fixture to a port of the Test Bed Computer running USBHSET, using the appropriated USB cable.
4. If needed apply power to the device.
5. Attach the differential probe to D+/D- of "1" on the test fixture.

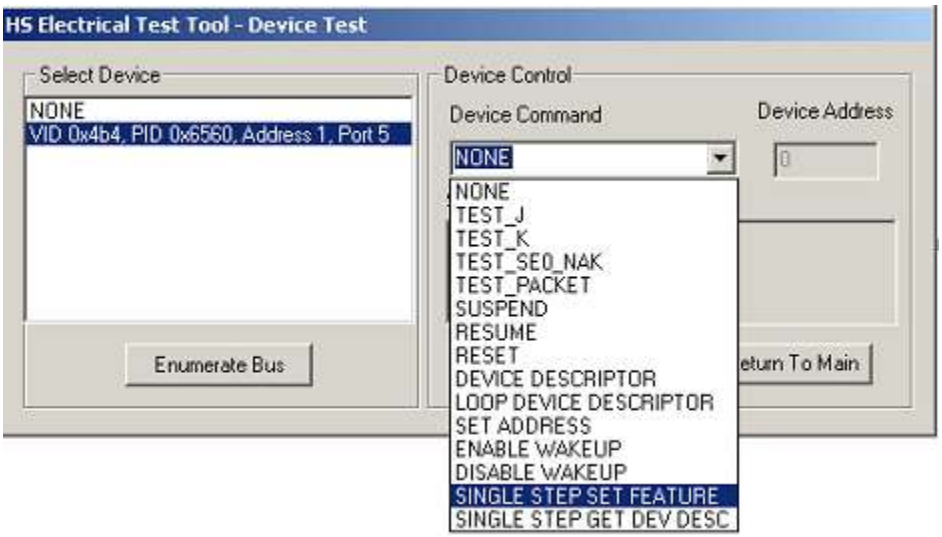
4.3.3 Test Instructions

Test Instructions part1

1. Invoke the HS Electrical Test Tool software on the Hi-Speed Electrical Test Bed computer.
2. Select Device and click the [TEST] button to enter the Device Test menu.



3. The device under test should be enumerated with the device's VID shown together with the root port in which it is connected.
4. Select **SINGLE STEP SET FEATURE** from the Device Command drop down menu and click **[EXECUTE]**.



5. You should see the transmitted test packet on the oscilloscope as below.

6. Follow the oscilloscope vendor steps in the below compliance test items

EL_21 Sync Field Length Test

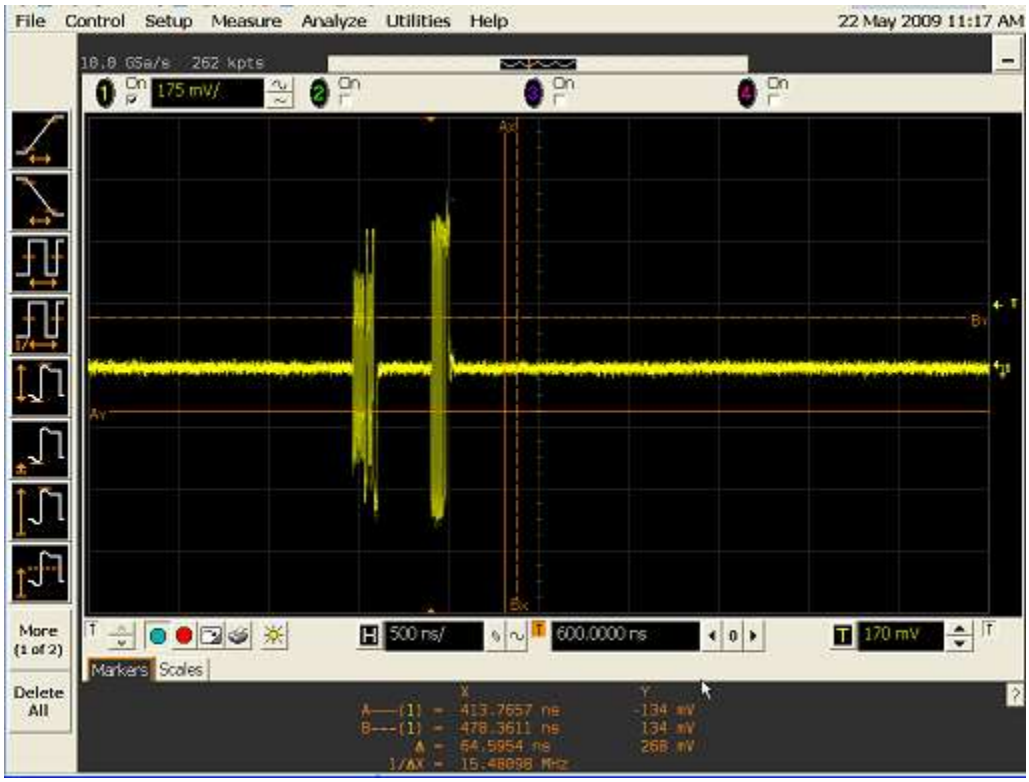
EL_25 EOP Length Test

EL_22 Measure Interpacket Gap Between Second and Third Packets

Test Instructions, Part 2

7. In the Device Test menu of the HS Electrical Test Tool, click **[STEP]** once again. This is the second step of the two-step Single Step Set Feature command.

8. You should see the transmitted test packet on the oscilloscope as below.



9. Follow the oscilloscope vendor steps in the below compliance test items

EL_22 Measure Interpacket Gap Between First and Second Packets

10. Power Cycle USB Device Under Test and flip/ reverse attach USB Type-C™ connection
11. Repeat Test Instructions Part 1; Part 2 and Part 3

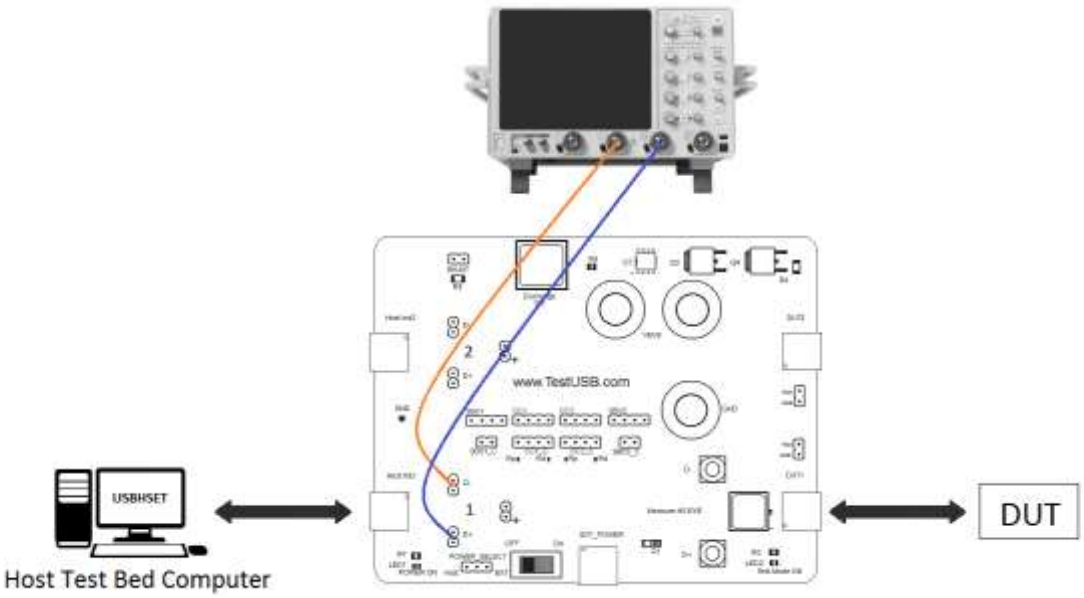
4.4 Device CHIRP Timing

All high speed devices must undergo this test. The following test can also be executed on devices with standard USB connectors.

4.4.1 Equipment Used

Quantity	Item	Description/ Model
1	Oscilloscope	
1	Oscilloscope USB software	
2	Active probes	
1	Cable between Device under test and Device Hi-Speed Signal Quality Type-C™ test fixture	
1	Host test bed computer	Any computer with hi-speed or super speed USB ports
1	Device Hi-Speed Signal Quality Type-C™ test fixture	TestUSB.com FS-HUCR
1	5V power supply	Any Type-C™ plug to A-plug cable that can take 5V from any USB host.
1	USBHSET for EHCI software application OR USBHSET for XHCI software application	http://www.usb.org/developers/tools/usb20_tools/#usbhset OR http://www.usb.org/developers/tools/#sigHSETT

4.4.2 Setup Diagram



Connecting the Equipment

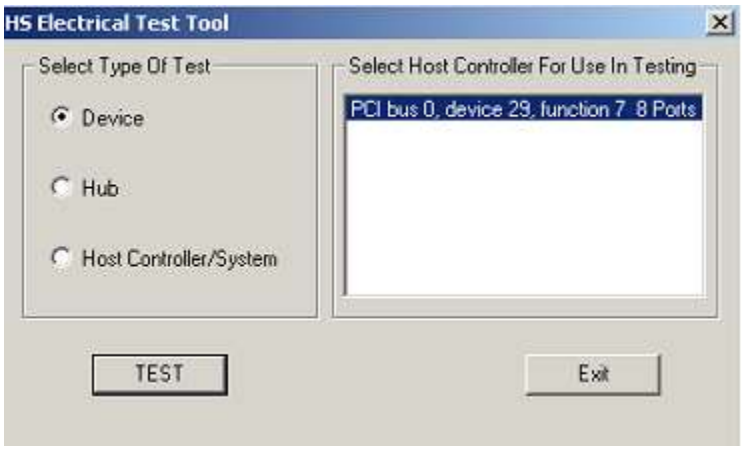
1. Attach the external power to EXT_POWER of the FS-HUCR. Leave the TEST switch at the OFF position. Verify the red Power LED is lit and the Test Mode LED is not lit.
2. Connect the DUT to DUT 1 side of the fixture.

a. If device has captive Type-C™ plug directly connect DUT to DUT1
b. If device has a receptacle use the corresponding short cable to connect DUT to DUT1.

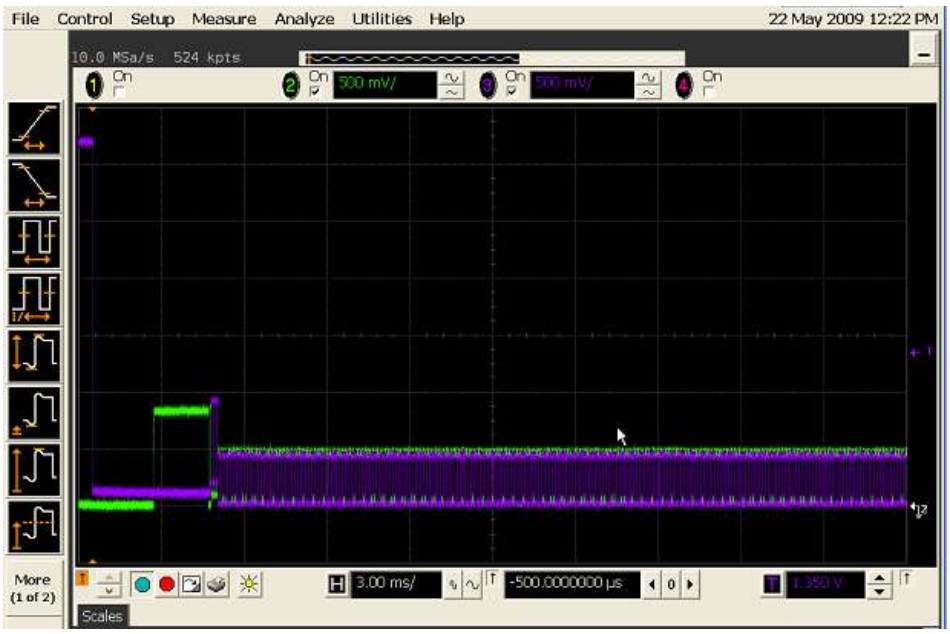
3. Connect the Host Init 1 of the FS-HUCR to a Hi-speed capable port of the Test Bed Computer, using a USB cable.
4. Connect the active probe on Channel 2 to the D- pin at “1” of the FS-HUCR. Make sure the probe position is set properly.
5. Connect the active probe on Channel 3 to the D+ pin at “1” of the FS-HUCR. Make sure the probe position is set properly.

4.4.3 Test Instructions

6. Invoke the HS Electrical Test Tool software on the Hi-Speed Electrical Test Bed computer.
7. Select Device and click the [TEST] button to enter the Device Test menu.



8. The device under test should be enumerated with the device's VID shown together with the root port in which it is connected.
9. On the HS Electrical Test Tool software, click [Enumerate Bus] once. You should capture the CHIRP handshake as in the below figure.



10. Follow the oscilloscope vendor steps in the below compliance test items

EL_28 Measure Device CHIRP-K Latency

EL_29 Measure Device CHIRP-K Duration

EL_31 Hi-Speed Terminations Enable and D+ Disconnect Time

11. Flip/reverse attach USB Type-C™ connection
12. Repeat Test Instructions 9. and 10.

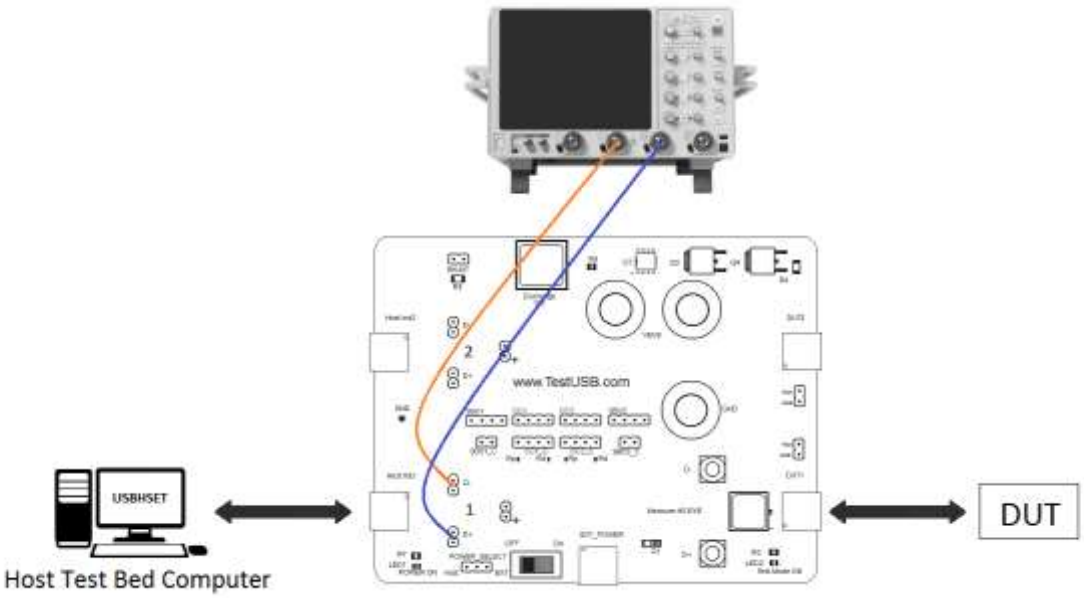
4.5 Device Suspend/Resume/Reset Timing

All high speed devices must undergo this test. The following test can also be executed on devices with standard USB connectors.

4.5.1 Equipment Used

Quantity	Item	Description/ Model
1	Oscilloscope	
2	Active probes	
1	Keysight Oscilloscope USB software	
1	Cable between Device under test and Device Hi-Speed Signal Quality Type-C™ test fixture	
1	Host test bed computer	Any computer with hi-speed or super speed USB ports
1	Device Hi-Speed Signal Quality Type-C™ test fixture	TestUSB.com FS-HUCR
1	5V power supply	Any Type-C™ plug to A-plug cable that can take 5V from any USB host.
1	USBHSET for EHCI software application OR USBHSET for XHCI software application	http://www.usb.org/developers/tools/usb20_tools/#usbhset OR http://www.usb.org/developers/tools/#sigHSETT

4.5.2 Setup Diagram



Connecting the Equipment

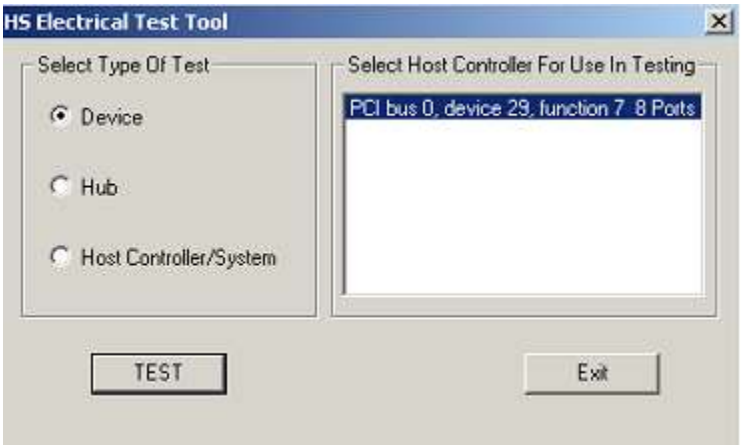
1. Attach the external power to EXT_POWER of the FS-HUCR. Leave the TEST switch at the OFF position. Verify the red Power LED is lit and the Test Mode LED is not lit.

2. Connect the DUT to DUT 1 side of the fixture.
    a. If device has captive Type-C™ plug directly connect DUT to DUT1
    b. If device has a receptacle use the corresponding short cable to connect DUT to DUT1.
3. Connect the Host Init 1 of the FS-HUCR to a Hi-speed capable port of the Test Bed Computer, using a USB cable.
4. Connect the active probe on Channel 2 to the D- pin at “1” of the FS-HUCR. Make sure the probe position is set properly.
5. Connect the active probe on Channel 3 to the D+ pin at “1” of the FS-HUCR. Make sure the probe position is set properly.

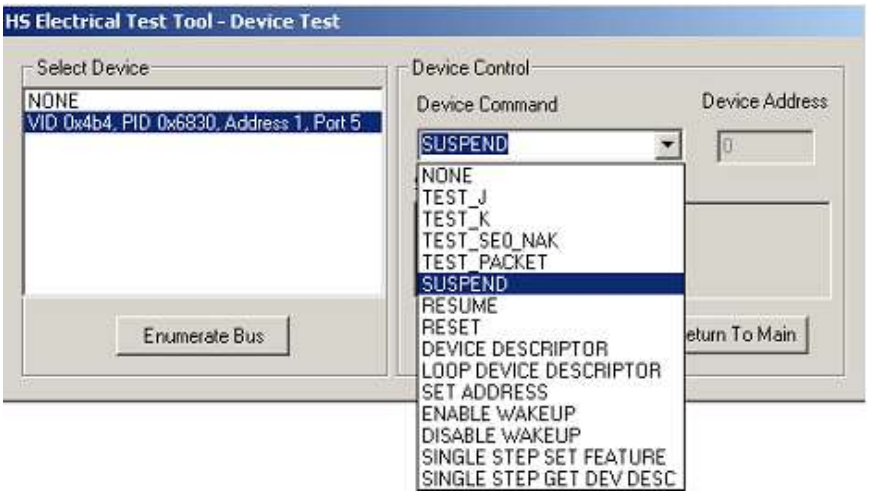
4.5.3 Test Instructions

Test Instructions part1

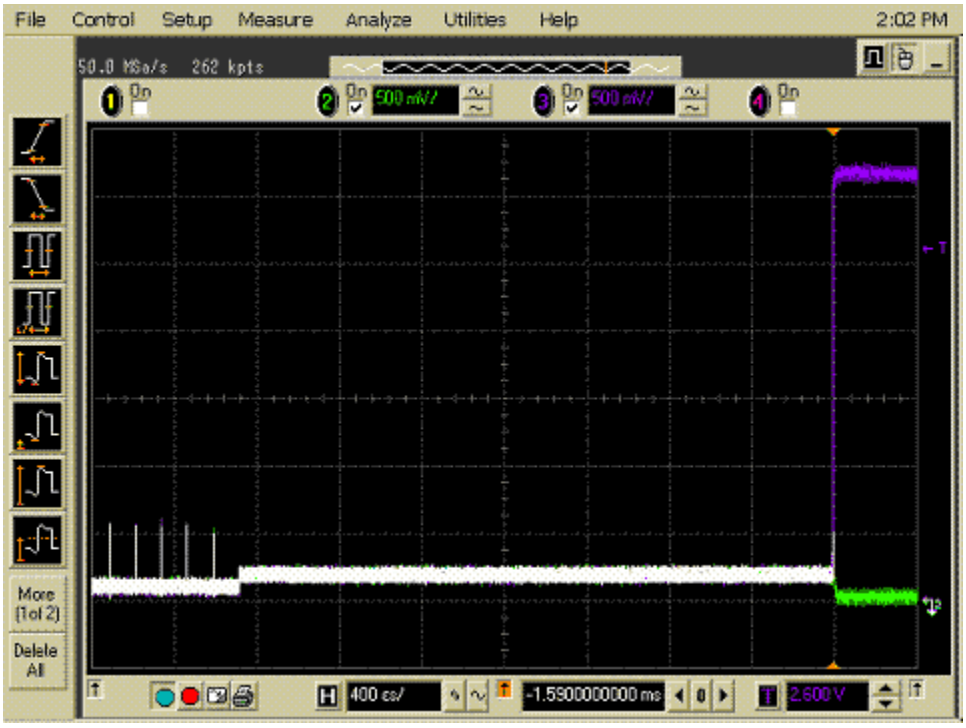
6. Invoke the HS Electrical Test Tool software on the Hi-Speed Electrical Test Bed computer.
7. Select Device and click the [TEST] button to enter the Device Test menu.



8. The device under test should be enumerated with the device's VID shown together with the root port in which it is connected.
9. Select **SUSPEND** from the Device Command drop down menu and click **[EXECUTE]**.



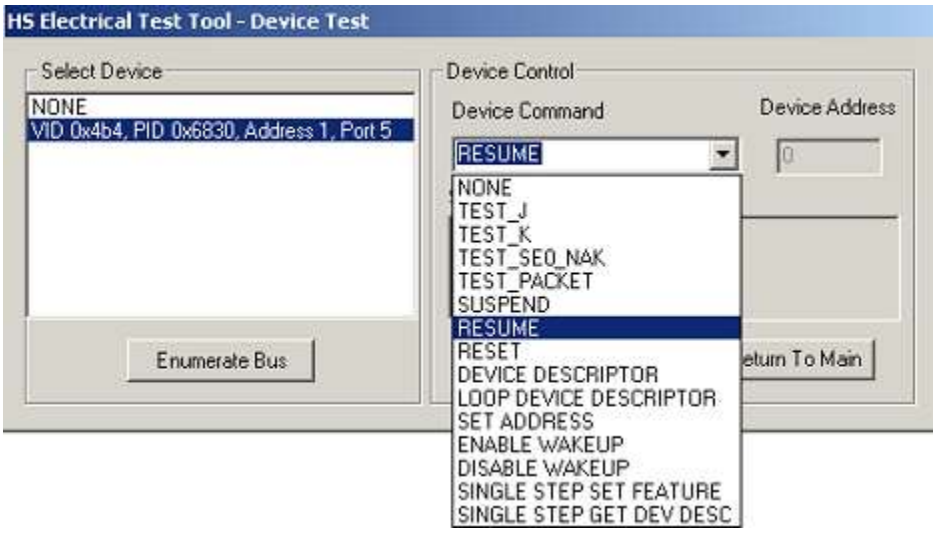
10. You should see the transmitted test packet on the oscilloscope as below.



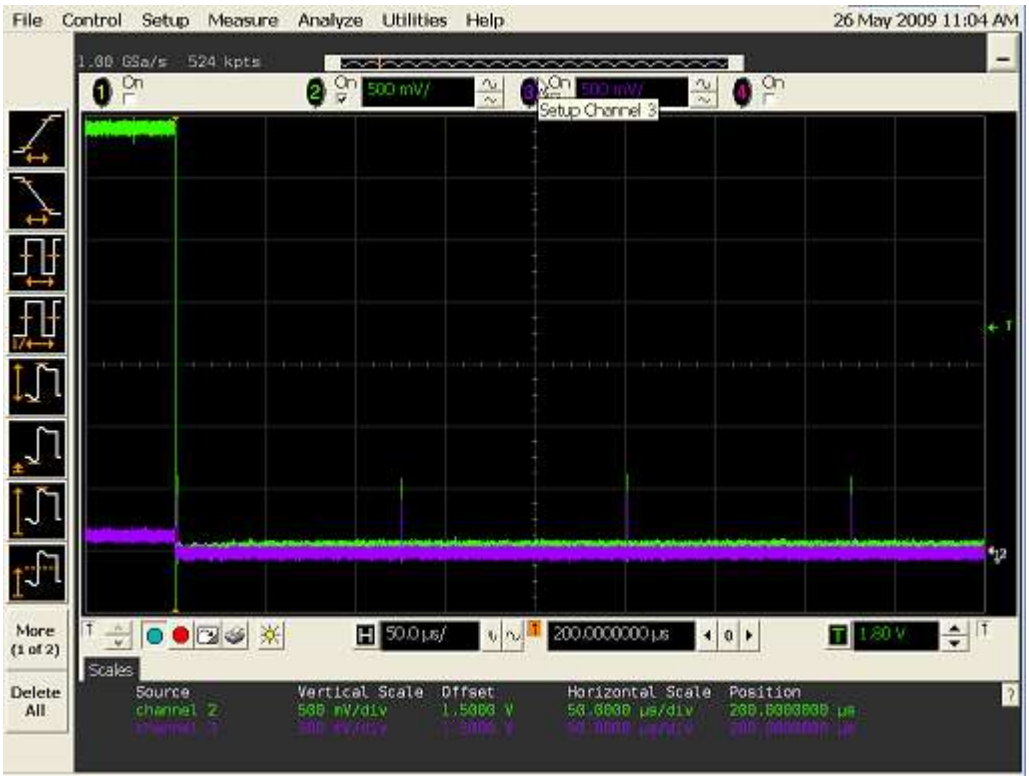
11. Follow the oscilloscope vendor steps in the below compliance test items

EL_38 Suspend Timing

12. On the Device Test Menu of the HS Electrical Test Tool, select **RESUME** from the Device Command drop down menu. Click **[EXECUTE]** once to resume the hub from suspend.

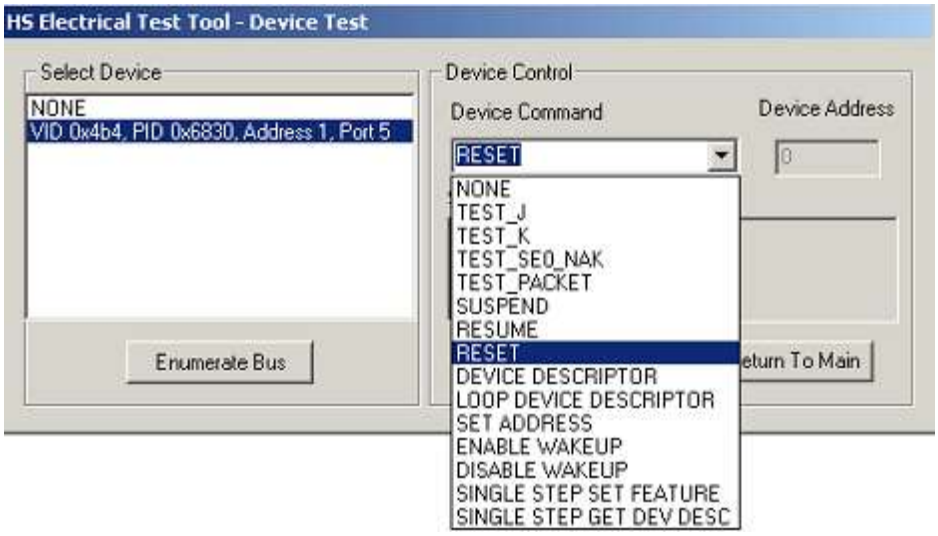


13. The captured transition should be as in the figure below.

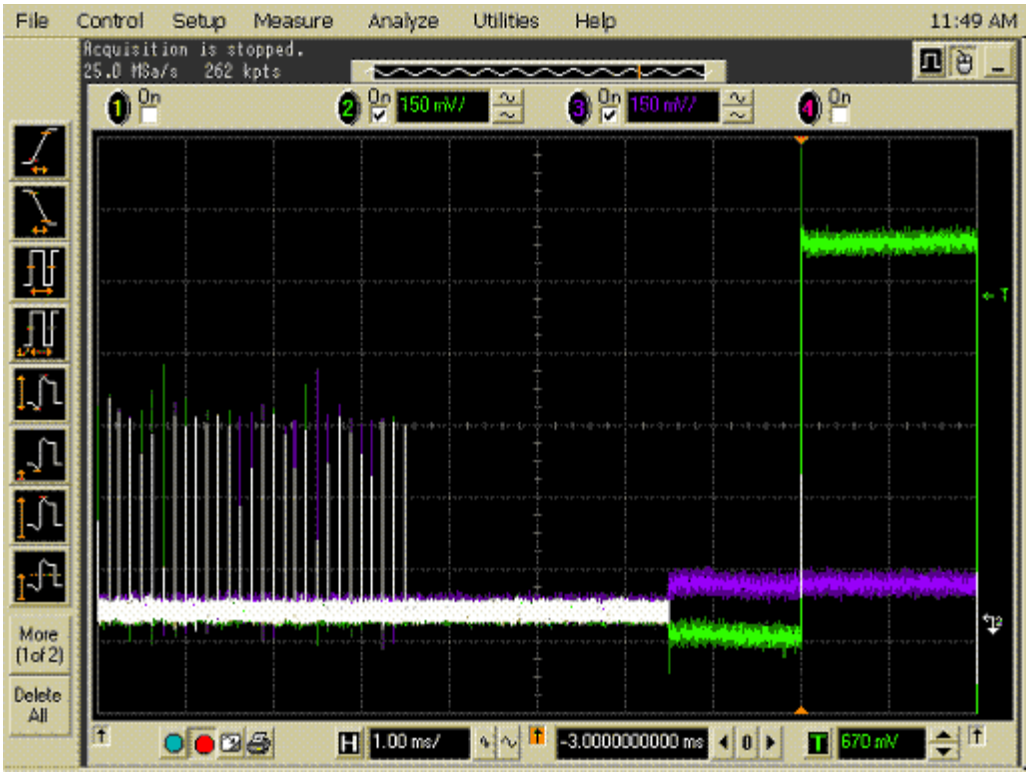


14. Follow the oscilloscope vendor steps in the below compliance test items **EL_40 Resume Timing Response**

15. On the Device Test Menu of the HS Electrical Test Tool, select **RESET** from the Device Command drop down menu. Click **[EXECUTE]** once to reset the device operating in high speed. The captured



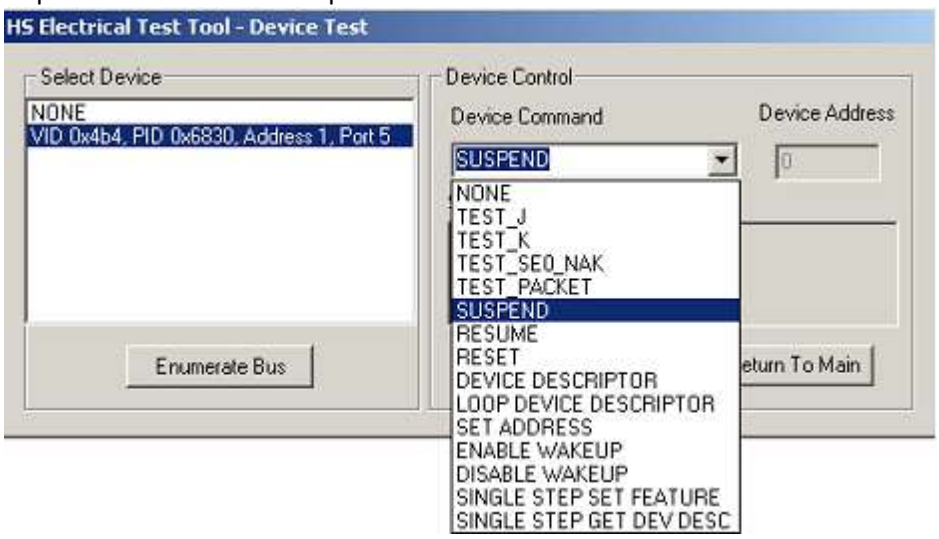
16. transition should be as in the figure below.



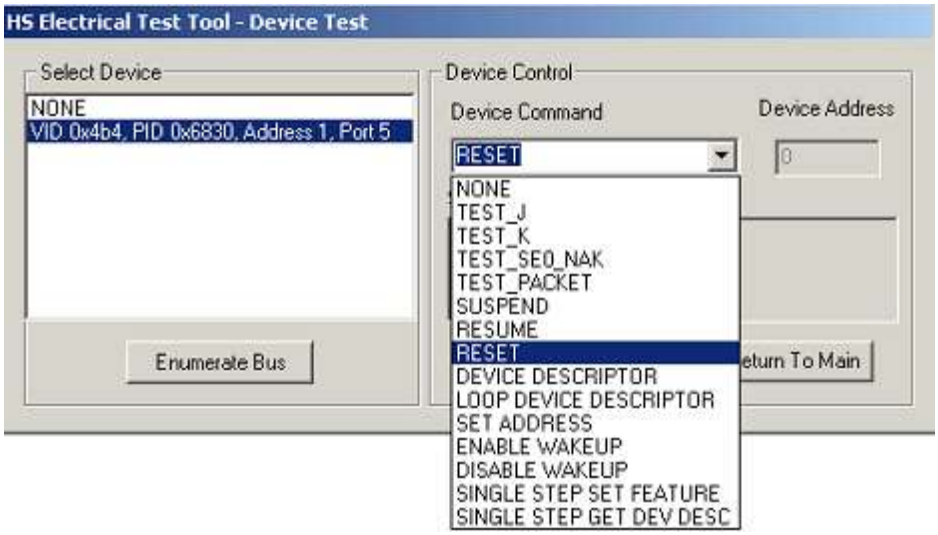
17. Follow the oscilloscope vendor steps in the below compliance test items

EL_27 Response time Reset

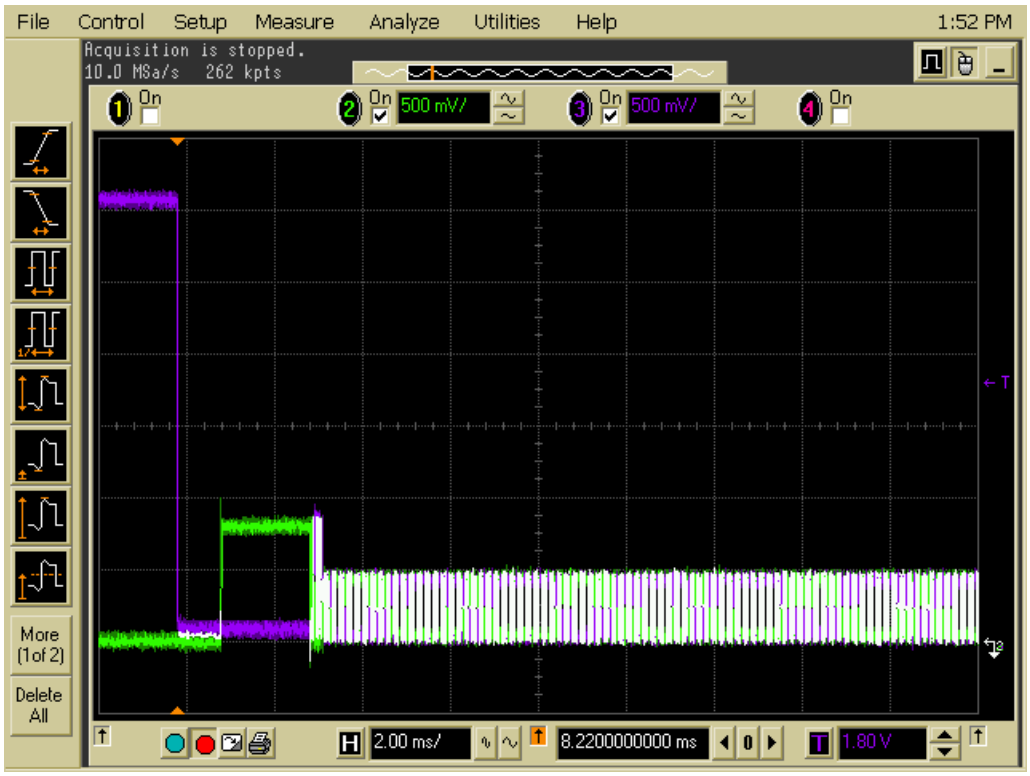
18. On the Device Test Menu of the HS Electrical Test Tool software, select **SUSPEND** from the Device Command drop down menu. Click **[EXECUTE]** once to place the device into suspend.



19. On the Device Test Menu of the HS Electrical Test Tool, select **RESET** from the Device Command drop down menu. Click **[EXECUTE]** once to reset the device operating in high speed.



20. The captured transition should be as in the figure below.



21. Follow the oscilloscope vendor steps in the below compliance test items

EL_28 Device CHIRP Response to Reset from Suspend

22. Repeat Test Instructions Part 1; Part 2

4.6 Device Receiver Sensitivity

4.6.1 Equipment Used

Quantity	Item	Description/ Model
1	Oscilloscope	
2	Active probes	
1	Keysight Oscilloscope USB software	
1	Cable between Device under test and Device Hi-Speed Signal Quality Type-C™ test fixture	
1	Host test bed computer	Any computer with hi-speed or super speed USB ports
1	Device Hi-Speed Receiver Sensitivity Type-C™ test fixture	TestUSB.com
1	5V power supply	Any Type-C™ plug to A-plug cable that can take 5V from any USB host.
1	USBHSET for EHCI software application OR USBHSET for XHCI software application	http://www.usb.org/developers/tools/usb20_tools/#usbhset OR http://www.usb.org/developers/tools/#sigHSETT

4.6.2 Setup Diagram

4.7 Upstream Full Speed Signal Quality Test

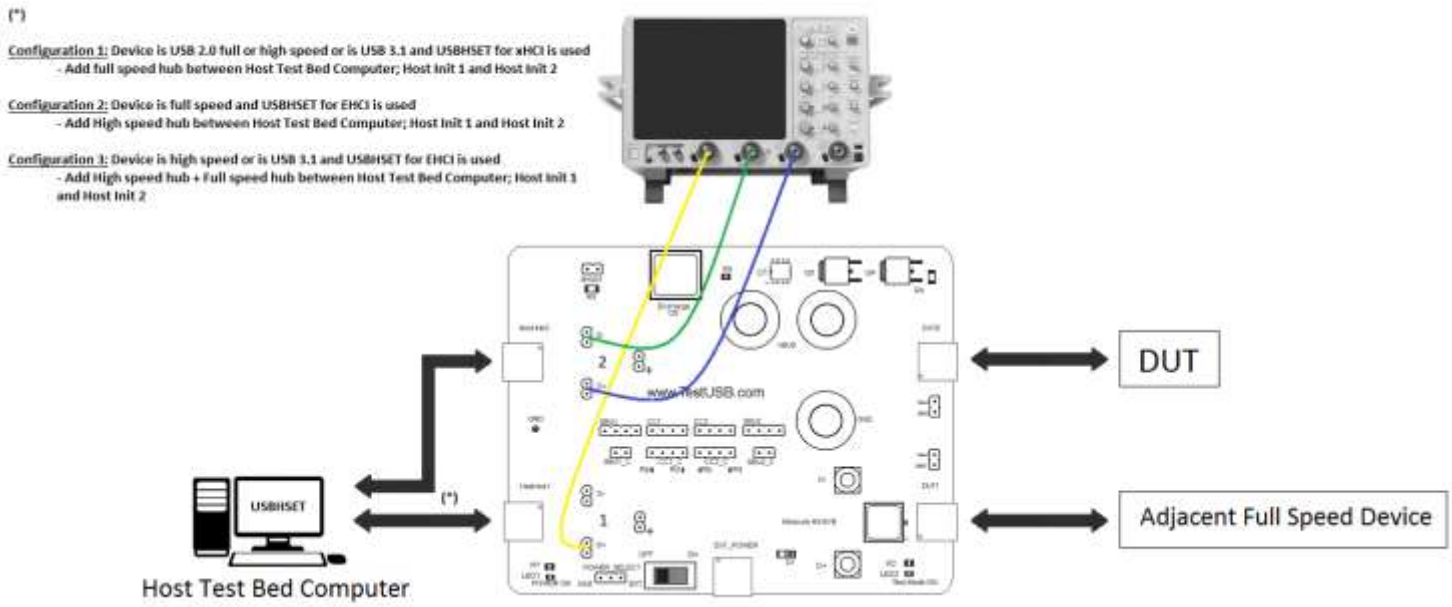
All USB 3.1 and USB 2.0 devices must go through this this. Note that the tier of 5 hubs is not required anymore. All high and full speed devices must undergo this test. The following test can also be executed on devices with standard USB connectors.

4.7.1 Equipment Used

Qty	Item	Description/ Model
1	Oscilloscope	
1	Oscilloscope USB software	USBET
3	Active probes	
1	Oscilloscope USB software	
1	Adjacent Device	Any certified USB2.0 Full Speed Device
1	Cable between Device under test and Device Hi-Speed Signal Quality Type-C™ test fixture	Cable to select depends on the device under test USB connector for: - Standard-B receptacle use 5m Type-C plug to B-plug cable (FS-HC-CP-500-BP) - Mini-B receptacle use 4.5m Type-C plug to Mini B-plug cable (FS-HC-CP-450-mBP) - Micro-B receptacle use 2m Type-C plug to Micro B-plug cable (FS-HC-CP-200-uBP) - Type-C 4m Type-C plug to Type-C plug cable (FS-HC-CP-400-CP-1A) - Product with captive cable use 10cm Type-C plug to A-receptacle (FS-SS+C-CP-10-AR-3A)
1	Host test bed computer	Any computer with hi-speed or super speed USB ports
1	Device Hi-Speed Signal Quality Type-C™ test fixture	TestUSB.com FS-HUCR
1	5V power supply	Any Type-C™ plug to A-plug cable that can take 5V from any USB host.
1	USBHSET for EHCI software application OR USBHSET for XHCI software application	http://www.usb.org/developers/tools/usb20_tools/#usbhset OR http://www.usb.org/developers/tools/#sigHSETT
(*)	USB Hub	(*) check configurations in setup diagram
2	Cable between HUB/Host and FS-HUCR	FS-HC-CP-10-AP

4.7.2 Setup Diagram

Note that the tier of 5 hubs is not required anymore.



Connecting the Equipment

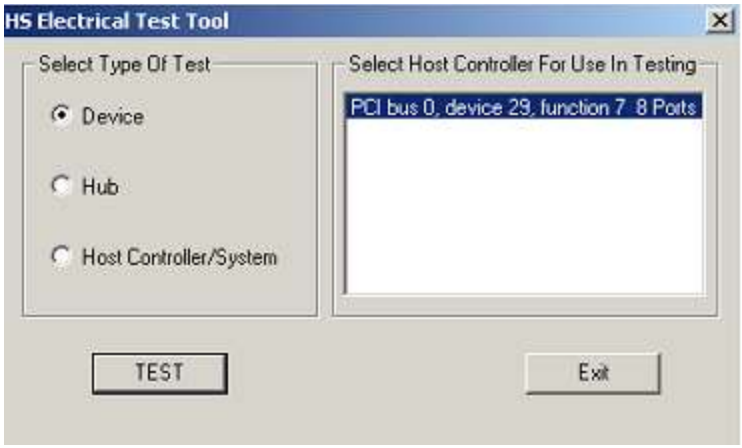
1. Attach the external power to EXT_POWER of the FS-HUCR. Leave the TEST switch at the OFF position. Verify the red Power LED is lit and the Test Mode LED is not lit.
2. Connect the Adjacent Device to DUT 1 side of the fixture
3. Connect the DUT to DUT 2 side of the fixture. Cable to select between DUT and the fixture depend on the USB connector on the DUT:
    a. Standard-B receptacle use
       5m Type-C plug to B-plug cable (FS-HC-CP-500-BP)
    b. Mini-B receptacle use
       4.5m Type-C plug to Mini B-plug cable (FS-HC-CP-450-mBP)
    c. Micro-B receptacle use
       2m Type-C plug to Micro B-plug cable (FS-HC-CP-200-uBP)
    d. Type-C
       4m Type-C plug to Type-C plug cable (FS-HC-CP-400-CP-1A)
    e. Product with captive cable use
       10cm Type-C plug to A-receptacle (FS-SS+C-CP-10-AR-3A)
4. Make the connection as defined in the above setup diagram (*) depending on DUT speed and USBHSET version.
5. Connect with the 10cm cable FS-HC-CP-10-AP to the fixture FS-HUCR at Host

Init 1 and Host Init 2

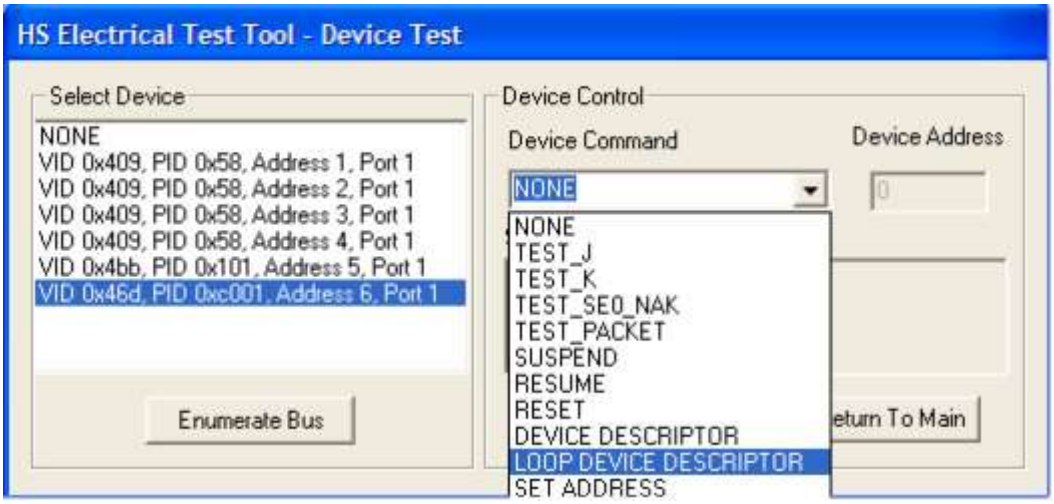
6. Connect the active probe on Channel 2 to the D- pin at “2” of the FS-HUCR. Make sure the probe position is set properly.
7. Connect the active probe on Channel 3 to the D+ pin at “2” of the FS-HUCR. Make sure the probe position is set properly.
8. Connect the active probe on Channel 1 to the D+ pin at “1 “of the FS-HUCR. Make sure the probe position is set properly.

4.7.3 Test Instructions

9. Invoke the HS Electrical Test Tool software on the Hi-Speed Electrical Test Bed computer.
10. Select Device and click the [TEST] button to enter the Device Test menu.



11. The device under test should be enumerated with the device's VID shown together with the root port in which it is connected.
12. Select **LOOP DEVICE DESCRIPTOR** from the Device Command drop down menu and click **[EXECUTE]**. This forces the device under test to continuously transmit test packets.



13. You should see the transmitted test packet on the oscilloscope as below.

14. Follow the oscilloscope vendor steps in acquiring the signal eye diagram and calculating the below signal quality compliance test items

    EL_6 Rise Time

    EL_6 Fall Time

    EL_2 EL_4 EL_5 Data Eye and Mask Test

    EL_7 Non-Monotonic Edge Test

15. If device has USB Type-C™ connection flip/ reverse attach
16. Repeat Test Instructions step 9. till 14.

4.8 Low Speed Signal Quality Test

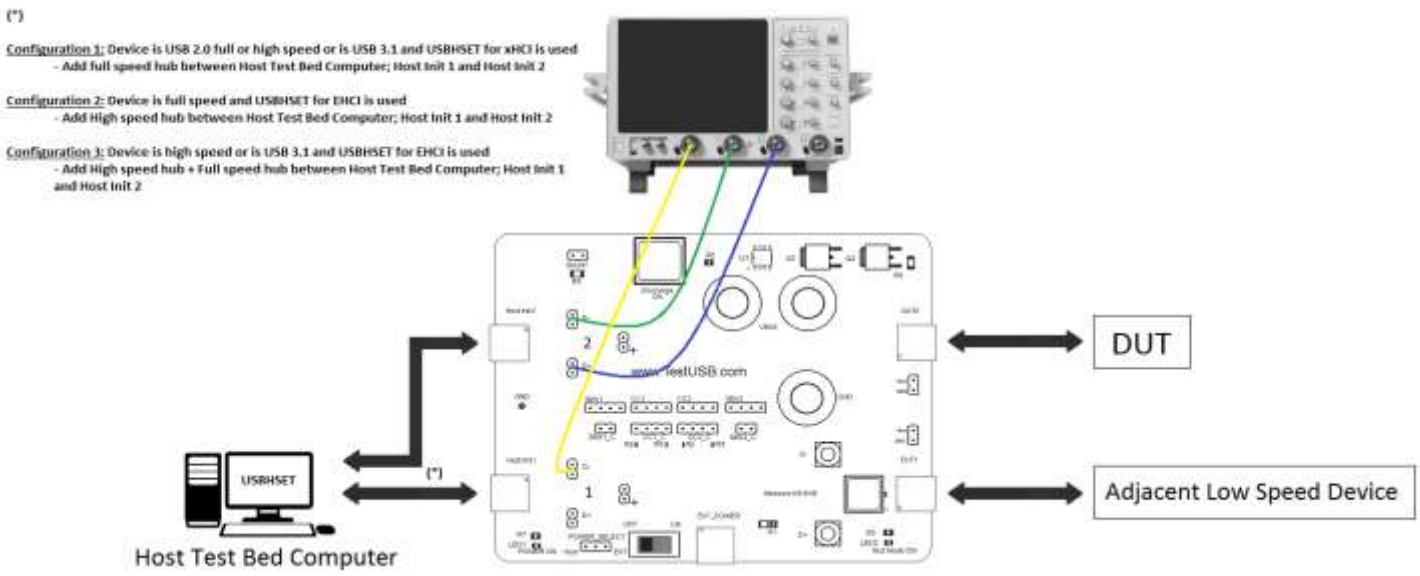
All low speed devices must undergo this test. The following test can also be executed on devices with standard USB connectors.

4.8.1 Equipment Used

Quantity	Item	Description/ Model
1	Oscilloscope Keysight	
1	Oscilloscope USB software	USBET
3	Probes	
1	Adjacent Device	Any certified USB2.0 Low Speed Device
1	Host test bed computer	Any computer with hi-speed or super speed USB ports
1	Device Hi-Speed Signal Quality Type-C™ test fixture	TestUSB.com FS-HUCR
1	5V power supply	Any Type-C™ plug to A-plug cable that can take 5V from any USB host.
1	USBHSET for EHCI software application OR USBHSET for XHCI software application	http://www.usb.org/developers/tools/usb20_tools/#usbhset OR http://www.usb.org/developers/tools/#sigHSETT
1		If the low speed device has a Type-C plug just directly connect to FS-HUCR. If the low speed device has a A-Plug put the 10cm Type-C plug to A-receptacle (FS-SS+C-CP-10-AR) in between
	HUB	
2	Cable between HUB and FS-HUCR	FS-HC-CP-10-AP-R1.0B1

4.8.2 Setup Diagram

Note that the tier of 5 hubs is not required anymore.



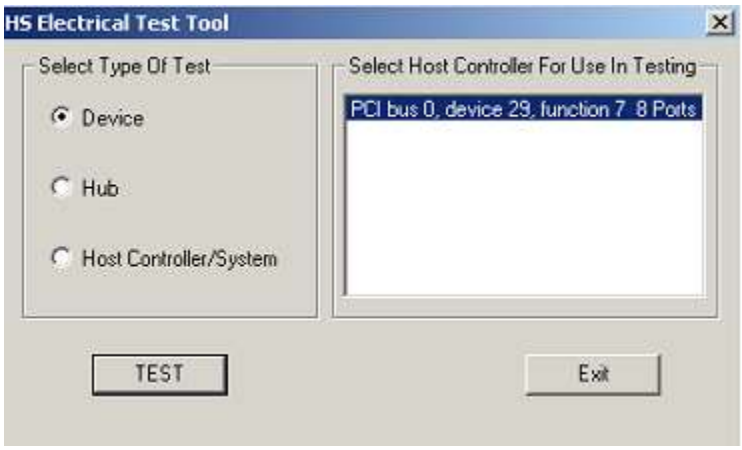
Connecting the Equipment

1. Attach the external power to EXT_POWER of the FS-HUCR. Leave the TEST switch at the OFF position. Verify the red Power LED is lit and the Test Mode LED is not lit.
2. Connect the Adjacent Device to DUT 1 side of the fixture
3. Connect the DUT to DUT 2 side of the fixture.
4. Make the connection as defined in the above setup diagram (*) depending on DUT speed and USBHSET version.
5. Connect with the 10cm cable FS-HC-CP-10-AP to the fixture FS-HUCR at Host Init 1 and Host Init 2
6. Connect the active probe on Channel 2 to the D- pin at “2” of the FS-HUCR. Make sure the probe position is set properly.
7. Connect the active probe on Channel 3 to the D+ pin at “2” of the FS-HUCR. Make sure the probe position is set properly.
8. Connect the active probe on Channel 1 to the D- pin at “1 “of the FS-HUCR.

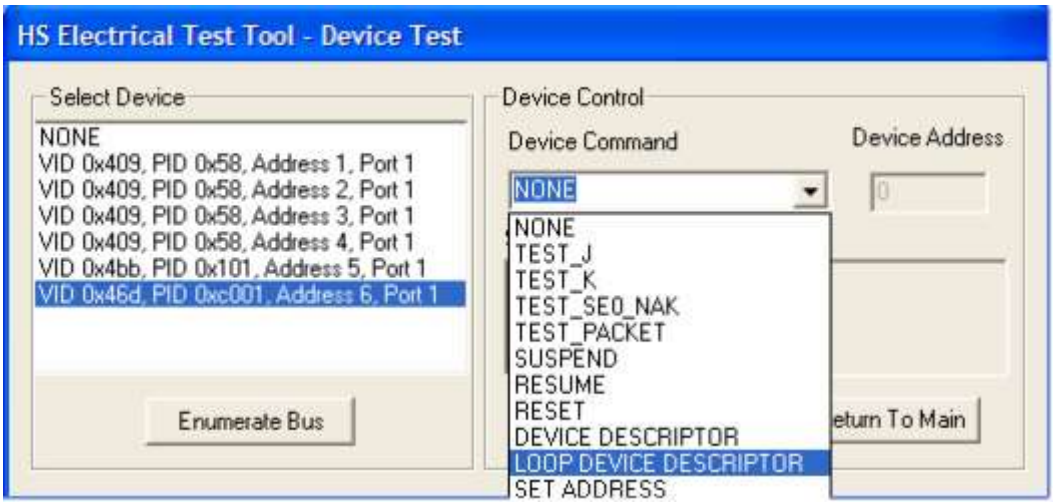
   Make sure the probe position is set properly.

4.8.3 Test Instructions

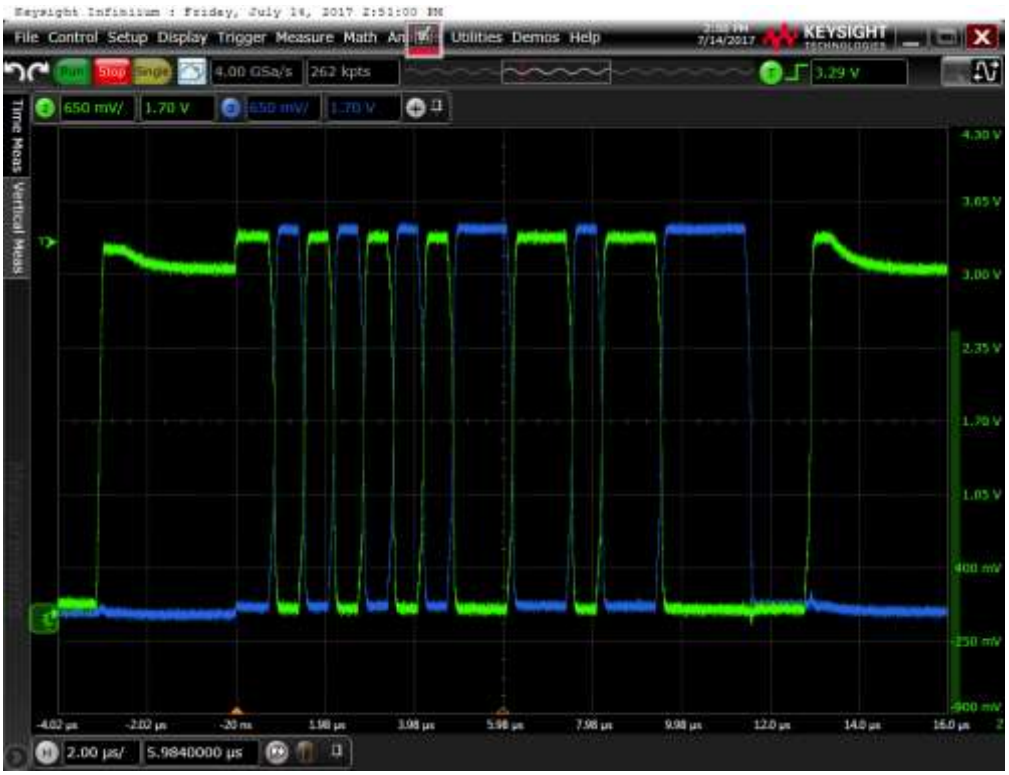
9. Invoke the HS Electrical Test Tool software on the Hi-Speed Electrical Test Bed computer.
10. Select Device and click the [TEST] button to enter the Device Test menu.



11. The device under test should be enumerated with the device's VID shown together with the root port in which it is connected.
12. Select **LOOP DEVICE DESCRIPTOR** from the Device Command drop down menu and click **[EXECUTE]**. This forces the device under test to continuously transmit test packets.



13. You should see the transmitted test packet on the oscilloscope as below.



14. Follow the oscilloscope vendor steps in acquiring the signal eye diagram and calculating the below signal quality compliance test items

    EL_6 Rise Time

    EL_6 Fall Time

    EL_2 EL_4 EL_5 Data Eye and Mask Test

    EL_7 Non-Monotonic Edge Test

15. If device has USB Type-C™ connection flip/ reverse attach
16. Repeat Test Instructions step 9. till 14.

4.9 Inrush Current

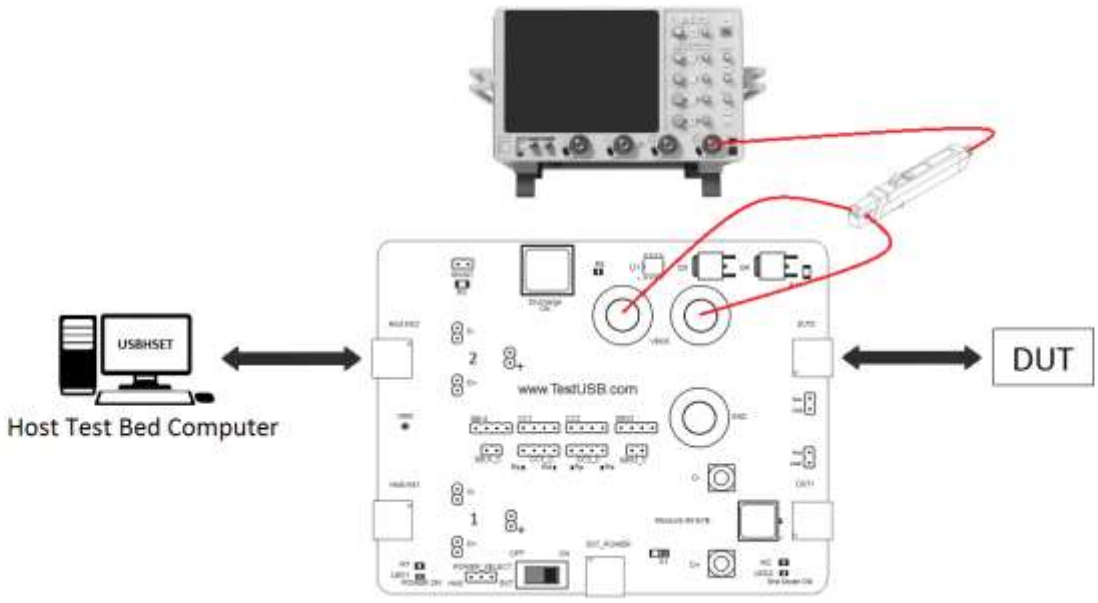
All devices must undergo this test. The following test can also be executed on devices with standard USB connectors.

The purpose of the test is to ensure that the current consumed due to bulk capacitance and peripheral startup does not cause a voltage drop below valid levels that causes other devices to drop out. For this measurement a current probe, scope and Inrush Current Test Fixture is needed. The scope should have a record time of 100ms at 1 Mega sample per second. The calculation of the Inrush can be made with USBET by saving the Inrush waveform as *.csv or *.tsv. Inrush current is measured for a minimum of 100 milliseconds after attach. Attach is defined as voltage rising to a valid level on the peripherals USB power line. Any current exceeding 100 mA during the 100ms interval is considered part of the inrush current event. The inrush current is divided into regions.
A region is an interval where the current exceeds 100 mA until the time the current falls below 100 mA for at least 100 us. There can be multiple inrush regions during the 100 ms period. Pass/Fail determination is done by the region having the highest charge value. The failures for Inrush mostly occur due to a too large capacity between Vbus and GND. The USB 2.0 Spec allows a maximum capacity of 10uF and therefore a maximum Inrush of 50uC.
Therefore, the total sum of capacity may not be higher that 10uF. Also, the device under test cannot consume more that 100mA during this 100ms of the start up. Common failures are that there is somewhere a to high capacitance on Vbus or that the device start consuming to much current in unconfigured state . Note that it is required to have at least a 1uF of capacity this in order to make ADP detection possible.
When doing the measurement make sure that you calibrate the current probe to 0mA before doing the measurement since a current probe will get quickly a DC offset that will result in a wrong measurement. It's also advisable to use the high resolution acquisition modes to reduce "the noise" on the signal

4.9.1 Equipment Used

Quantity	Item	Description/ Model
1	Oscilloscope Keysight	
1	Oscilloscope USB software	Keysight N5416A/N5416B USB
1	Current probe	Current clamp OR diff probe over the 10mOhm shunt
1	Host test bed computer	Any computer with hi-speed or super speed USB ports
1	Device Hi-Speed Signal Quality Type-C™ test fixture	TestUSB.com FS-HUCR
1	USB Cable	
1	5V power supply	Any Type-C™ plug to A-plug cable that can take 5V from any USB host.

4.9.2 Setup Diagram



Connecting the Equipment

1. Connect the DUT to DUT 2 side of the fixture.
2. Connect the Host Init 2 of the FS-HUCR to a Hi-speed capable port of the Test Bed Computer, using a USB cable.
3. Connect the current clamp on Channel 4 to the Vbus wire loop at VBUS of the FS-HUCR.

4.9.3 Test Instructions

4. Press and hold the Inrush Discharge switch of the FS-HUCR and hold for 10 seconds.
5. Release the Inrush Discharge switch of the FS-HUCR
6. You should see the Inrush current event on the oscilloscope as below (Please note that the inrush current peak may be larger or smaller)

7. Follow the oscilloscope vendor steps in acquiring Inrush current event and calculating the below compliance test item

Inrush Current

8. Flip/ reverse attach DUT USB Type-C™ connection on the DUT2 side of the FS-HUCR
9. Repeat Test Instructions from step 4.

4.10 Back Voltage

All devices must undergo this test. The following test can also be executed on devices with standard USB connectors.
No USB device shall supply current on VBUS at its upstream facing port at any time, a USB device may only draw current. The pull-up resistor D+ or D- may only become present when VBUS is High. This can be verified by measuring the Voltage over Vbus and GND, D+ and GND, D- and GND when the device is not connected with the Back Voltage fixture. This test must be performed twice, first before the device under test is enumerated and the second time after it has been enumerated. All values should remain below 400mV. A common failure is that self-powered devices put their pull-up resistor active even when Vbus is not detected. This will result in failure where the voltage is ~3V on the D+ for Full Speed and High Speed devices or on D- for a Low Speed device.
Another common mistake is that some device that are self powered or battery powered drive back voltage on Vbus.

4.10.1 Equipment Used

Quantity	Item	Description/ Model
1	Digital Multimeter	
1	Cable between Device under test and back voltage fixture	Any USB cable that fit the device and back voltage fixture
1	Host test bed computer	Any computer with hi-speed or super speed USB ports
1	Device Back-Voltage test fixture	TestUSB.com FS-BV

4.10.2 Test Instructions

Test Instructions part1

1. Apply power to the DUT
2. Connect the DUT to the Back Voltage fixture FS-BV with the corresponding USB Cable.
3. Using a DMM measure and record DC voltages between GND and Vbus, D+ and D-

Back Voltage before Enumeration – Type-C™ default position		
USB pin	**DC Voltage Before enumeration**	**Expected Value (VDC)**
Vbus		≤ 400mV
D+		≤ 400mV
D-		≤ 400mV

4. Flip/ reverse attach DUT USB Type-C™ connection on the Back Voltage fixture FS-BV if the device use USB Type-C™ connection.

5. Repeat Test Instructions Part 1 step 3 and record DC voltages between GND and Vbus, D+ and D-

Back Voltage before Enumeration – Type-C™ flip/ reverse attach position		
USB pin	**DC Voltage Before enumeration**	**Expected Value (VDC)**
Vbus		≤ 400mV
D+		≤ 400mV
D-		≤ 400mV

Test Instructions part 2

6. Connect the DUT into a known good host and verify proper enumeration.
7. Detach the DUT from the known good host and connect the DUT to the Back Voltage fixture FS-BV.
8. Using a DMM measure and record DC voltages between GND and Vbus, D+ and D-

Back Voltage after Enumeration – Type-C™ default position		
USB pin	**DC Voltage Before enumeration**	**Expected Value (VDC)**
Vbus		≤ 400mV
D+		≤ 400mV
D-		≤ 400mV

9. Flip/ reverse attach DUT USB Type-C™ connection on the Back Voltage fixture FS-BV
10. Repeat step 6. Till 8 .and record DC voltages between GND and Vbus, D+ and D-

Back Voltage after Enumeration – Type-C™ flip/ reverse attach position		
USB pin	**DC Voltage Before enumeration**	**Expected Value (VDC)**
Vbus		≤ 400mV
D+		≤ 400mV
D-		≤ 400mV