Universal Serial Bus Implementers Forum Hub High-speed Electrical Test Procedure

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Dec 3, 2003

Revision History

Rev	Date	Filename	Comments
0.9	June-29-2003	Hub HS Tes for lecroyt.DOC	Initial draft revision
1.0	December-3-2003	Lecroy hs hub test rev 1.doc	Approved by USB-IF

Please send comments via electronic mail to techsupp©usb.org

USB-IF High-speed Electrical Test Procedure

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1 Introduction

The USB-IF High-speed Electrical Test Procedures are developed by the USB 2.0 Compliance Committee under the direction of USB-IF, Inc. There are three High-speed Electrical Test Procedures. The Host High-speed Electrical Test Procedure is for EHCI host controllers. The Hub High-speed Electrical Test Procedure is for high-speed capable hubs. The Device High-speed Electrical Test Procedure is for high-speed capable devices.

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 products must also complete and pass the applicable legacy compliance tests identified in these documents in order to be posted on the USB-IF Integrators List and use the USB-IF logo in conjunction with the said product (if the vendor has signed the USB-IF Trademark License Agreement). These legacy compliance tests are identified in the Legacy USB Compliance Test section in this document.

2 Purpose

This USB-IF High-speed Electrical Test Procedure documents a series of tests used to evaluate USB peripherals and systems operating at high-speed. These tests are also used to evaluate the high-speed operation of USB silicon that has been incorporated in ready-to-ship products, reference designs, proofs of concept and one of a kind prototypes of peripherals, add-in cards, motherboards, or systems.

This test procedure makes reference to the test assertions in the USB-IF USB2.0 Electrical Test Specification, Version 1.00.

This Hub High-speed Electrical Test Procedure is one of the three USB-IF High-speed Electrical Compliance Test Procedures. The other two are Host High-speed Electrical Test Procedure and Device High-speed Electrical Test Procedure. The adoption of the individual procedures based on the device class makes it easier to use.

3 Equipment Required

The commercial test equipment listed here are base on positive experience by the USB-IF members in executing the USB high-speed electrical tests. This test procedure is written with a set of specific models we use to develop this procedure. In time, there will be other equivalent or better test equipment suitable for use. Some minor adaptation of the procedure will be required in those cases.

- Digital Sampling Oscilloscope:
    - LeCroy Wavemaster 8300, 8500, 8600, SDA3000, 50000, 6000
        - LeCroy D300 or equivalent differential probe, qty = 2
        - LeCroy active probe HFP2500, qty = 2
- 3 1/2 Digital Multimeter – Fluke Model 77 or equivalent
    - Mini-clip DMM lead - one each of black and red color

- Digital Signal Generator (either instrument can be used)
    - Tektronix DG2040 Digital Signal Generator
        - 5x attenuator – for scaling the DSG output voltages needed for receiver sensitivity test, qty = 2
        - 50-ohm coaxial cable with female SMA connectors at both ends, qty = 4
    - 81130A Pulse/Pattern Generator (Agilent)
        - The DSG consists of an Agilent 81130A Pulse/Pattern Generator with 2 channels of Agilent 81132A (660MHz) option.
        - 6dB attenuator (Agilent 8493C opt 006) — for scaling the DSG output voltages needed for receiver sensitivity test, qty = 2
        - 50-ohm coaxial cable with male SMA connectors at both ends, qty = 2

- High-speed USB Electrical Test Fixtures
    - Host LeCroy USB test fixture part number TF-USB, qty = 1
- Miscellaneous Cables
    - 1M USB cable, qty = 1
    - 1.5M USB cable, qty = 1
    - 4-inch USB cable, qty = 1
    - Modular AC power cord, qty = 2

- High-speed USB Test Bed Computer

This is the computer that hosts a USB 2.0 compliance host controller for high-speed hub or device electrical test, or serves as a test bed host for a USB 2.0 host controller under test. This OS on this computer is Windows 2000 Professional. Please refer to the High-speed Electrical Test Setup Instruction for steps to configure this computer.

3.1 Equipment Setup

3.1.1 Digital Sampling Oscilloscope

Before turning on the oscilloscope, attach the differential probe to Channel 1. Make sure the 10x attenuator is attached at the tip of the differential probe. Attach the HFP2500 probes to channels 2 and 3. These probe assignments will be used through out the entire test procedure. Turn on the oscilloscope to allow for 10 minutes of warm up time prior to use.

Note: In certain test situations, there may not be a ground connection between the DSO and the device under test. This may lead to the signal seen by the differential probe to be modulated up and down due to mid frequency switching power supply. Connecting the DSO ground to the DUT ground will be require to establish a common ground reference.

3.1.2 Digital Signal Generator

The DSG is needed to perform the receiver sensitivity test that is structured toward the end of this test procedure. For energy conservation consideration, one may choose to turn on the DSG about 15 minutes prior to performing the measurement.

3.2 Operating Systems, Software, Drivers, and Setup Files

3.2.1 Operation Systems

Microsoft Windows 2000 Professional is required on the High-speed Electrical Test Bed Computer. Microsoft Windows 2000 Professional is required on the High-speed Signal Quality Analysis Computer. Please refer to the High-speed Electrical Test Setup Instruction for steps to configure these computers.

3.3 Special Purpose Software

The following special purpose software is required. Please refer to the High-speed Electrical Test Setup Instruction for steps to configure these computerS.

- High-speed Electrical Test Tool Software – To be used in the High-speed Electrical Test Bed Computer. The software USBHSET.exe can be downloaded from the UFB-IF web site at www.USB-IF.org and installed on the test bed computer. This same software must also be installed on the oscilloscope running the LeCroy USB2.0 test software.
- Matlab v6.5 release 13 installed on the oscilloscope running the LeCroy USB2.0 test software. This can be obtained from The Mathworks at www.mathworks.com.
- LeCroy USB2.0 (part number USB2)test software for the oscilloscope

4 Test Procedure

4.1 Test Record

Appendix A contains the test result entry form for this test procedure. Please make copies of the Appendix A for use as test record documentation for compliance test submission. All fields must be filled in. Fields not applicable for the device under test should be indicated as N/A, with appropriate note explaining the reason. The completed test result shall be retained for the compliance test submission.

In addition to the hardcopy test record, the electronic files from the signal quality, power delivery (inrush, drop and droop), and TDR shall be retained for compliance test submission.

4.2 Vendor and Product Information

Collect the following information and enter into a copy of the test record in Appendix A before performing any tests.

1. Test date
2. Vendor name

3. Vendor address and phone, and the contact name
4. Test submission ID number
5. Product name
6. Product model and revision
7. USB silicon vendor name
8. USB silicon model
9. USB silicon part marking
10. USB silicon stepping
11. Test conducted by

4.3 Legacy USB Compliance Tests

In addition to the high-speed electrical tests prescribed in this document, the hub under test must also pass the following legacy compliance tests applicable to the high-speed hub:

- Low speed signal quality – Downstream facing ports only
- Full speed signal quality – Upstream and downstream facing ports
- Inrush current – Upstream facing port only
- Drop/Droop – Downstream facing ports
- Interoperability

Perform all these tests and record the measurements and summarized Pass/Fail status in Appendix A.

4.4 Hub High-speed Signal Quality— Upstream Facing Port (EL_2, EL_46, EL_6, EL_7)

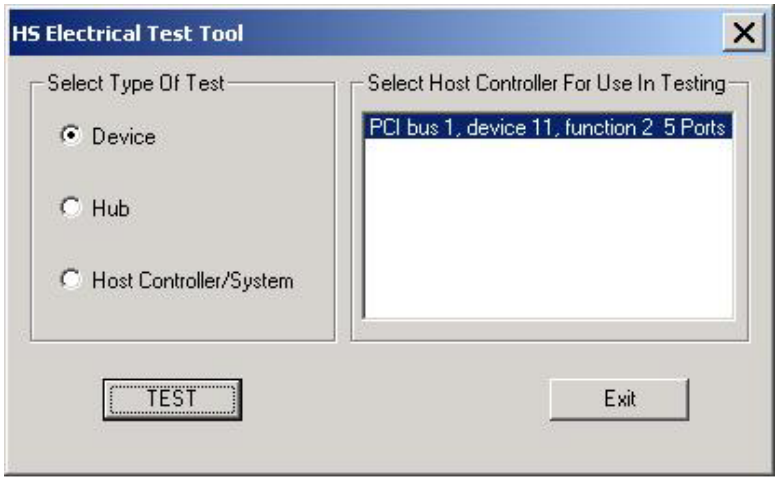
This test is applicable only for the upstream facing port of the hub.

1. Turn on the oscilloscope if not already have done so. Allow about 10 minutes for warm up.
2. Select “USB2” from the analysis menu of the oscilloscope. In the USB test wizard, select “Hub” for the mode and select “HS Upstream Signal Quality in the “Test” dialog box. Enter the path and file name for the intermediate result file in the “Result File Name” dialog box.
3. Attach the 5V power supply to J2 of the Device High-speed Signal Quality test fixture.
4. Verify yellow Power LED (D2) is lit, and the yellow Test LED (D8) is off.
5. Connect the Device port of the [SQ Device] section of the test fixture into the upstream facing port of the hub under test. Connect the [Init] port of the test fixture to a port of the Test Bed Computer. Apply power

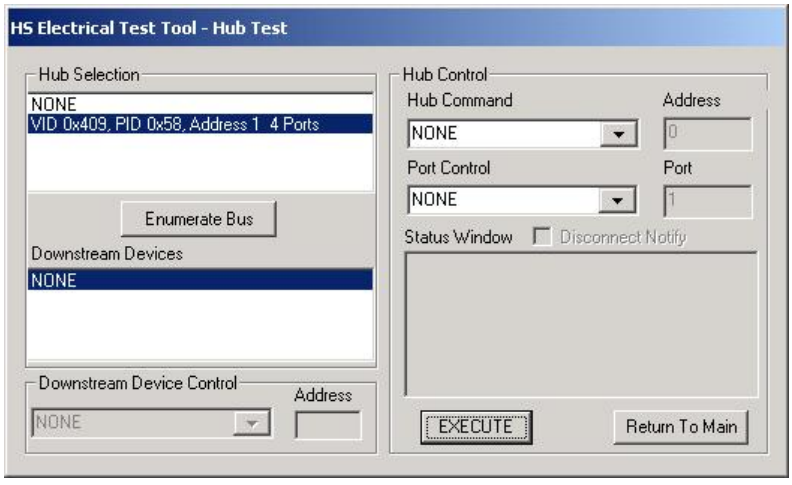
to the hub. Make sure that the INIT/TEST switch in the SQ Device section is in the INIT position.

6. Attach the differential probe to J19 of the test fixture. Ensure the + polarity on the probe lines up with D+ on the fixture.

7. Invoke the High-speed Electrical Test Tool software on the High-speed Electrical Test Bed computer. The main menu appears and shows the USB2.0 host controller.



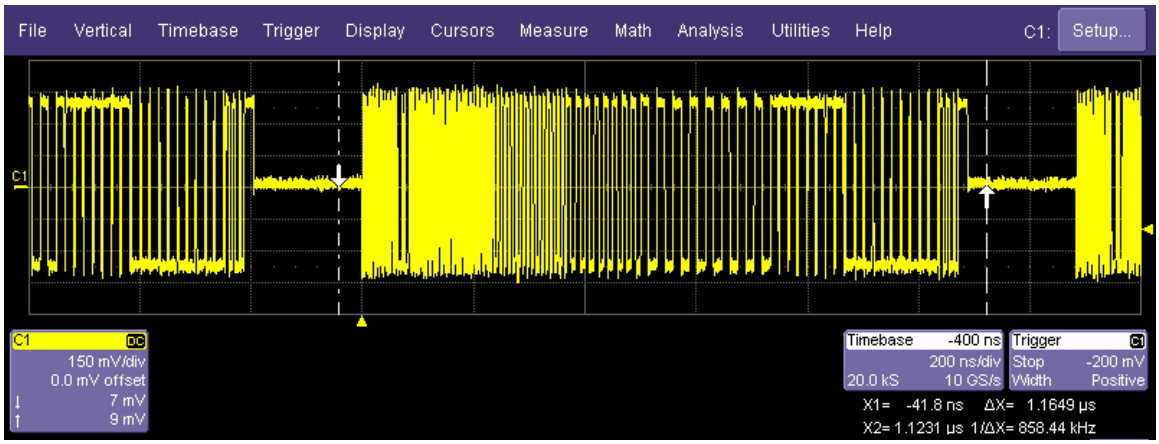
8. Select Hub and click the TEST button to enter the HS Electrical Test Tool - Hub Test menu. The hub under test should be enumerated with the hub's VID shown together with the USB address.
9. Press "next" in the USB test wizard.
10. Auto-zero the probe using the probe tab in the channel 1 menu. If the oscilloscope enters into the auto calibration mode, wait for this to complete. Press "next" in the USB test wizard.



11. Select TEST_PACKET from the Hub Command drop down menu and click EXECUTE. This forces the hub under test to continuously transmit test packets.

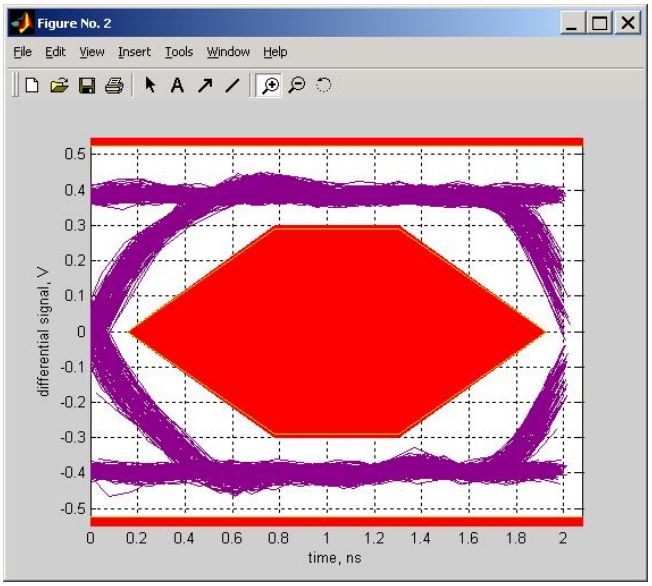
12. Place the INIT/TEST Switch in the TEST position and verify the yellow TEST LED is lit.

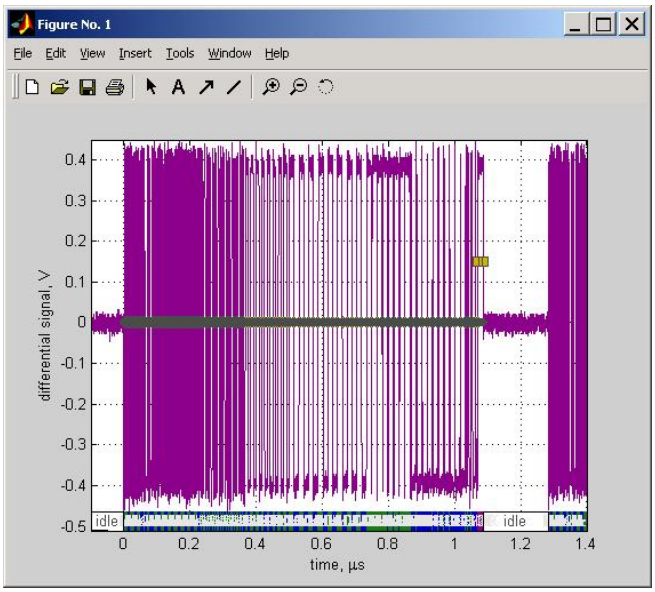
13. Using the oscilloscope, verify test packets are being transmitted from the port under test. Adjust the cursors so that they are on either side of the test packet on the screen if necessary.



Test packet from host showing cursor placement

14. Press the Next button in the test wizard to measure the signal quality. The following two images generated by the MatLab script will appear on the windows desktop on the oscilloscope. They can be viewed either by minimizing the oscilloscope window or using Alt-Tab is a keyboard is connected to the oscilloscope.





15. The results displayed are also recorded to an HTML report located in the directory specified in the "Data Path" control in the test wizard (D:\Applications\USB2\Results by default). Open this file and verify the Signal eye, EOP Width, and Signaling Rate all pass.

16. Note: if there are any irregularities in the captured waveform such as an incorrect EOP width, the Matlab plots shown above will not be displayed and the HML report will not be generated. Check the probe connections to make sure there are no problems.

17. Record the test result in EL_2, EL_3 or EL_4, EL_6 and EL_7.

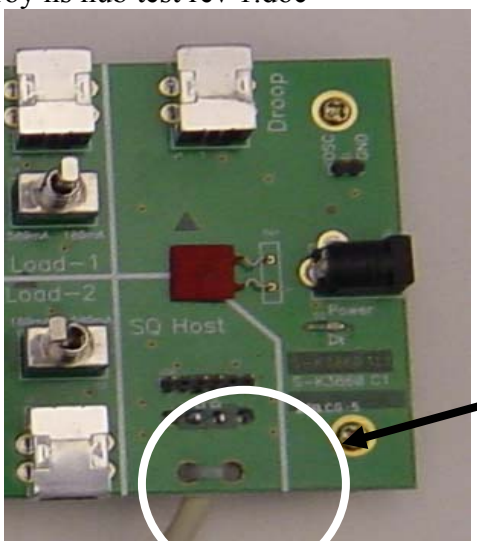
18. Return the Test switch of the test fixture back to the Normal position and verify the yellow TEST LED is not lit. Cycle power on the hub in preparation for subsequent tests.

4.5 Hub High-speed Signal Quality _Downstream Facing Ports (EL_2, EL_3, EL_6, EL_7)

This section applies only to the downstream facing ports of the hub under test.

1. In the USB test wizard, select Hub in the [mode] control and select HS Upstream Signal Quality in the [Test] control. Enter the path and file name for the intermediate result file in the "Result File Name" dialog box Attach the 5V power supply to the [power] jack of the USB test fixture. Enter a descriptive file name in the Result File Name control in the test wizard

2. Attach the host computer port to the upstream facing port of the hub under test. Attach the [INIT] port of the SQ Host section of the test fixture to a downstream port of the hub under test.



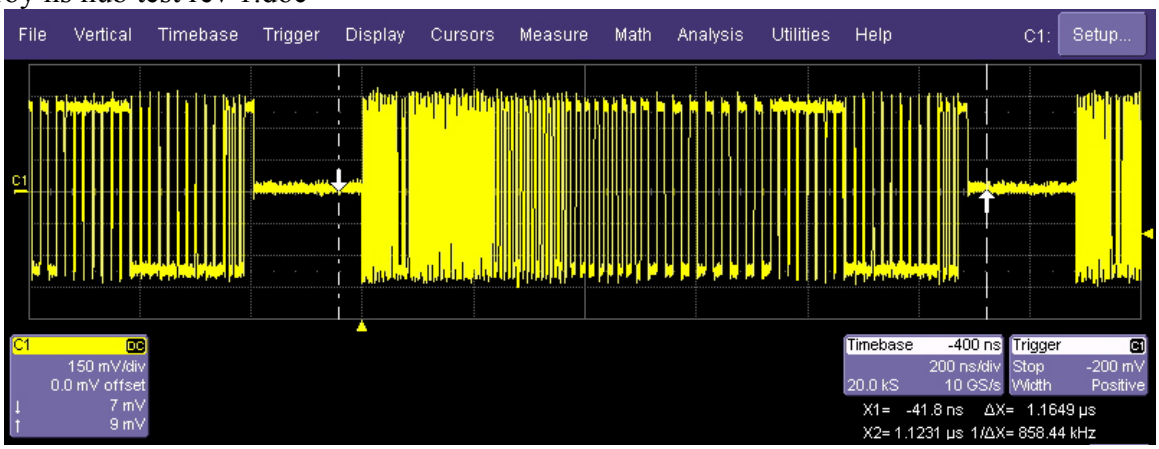
SQ Host test port

3. Start the HS test tool, select hub, push Test and then Enumerate bus. The host VID should appear. Press next in the USB test wizard.

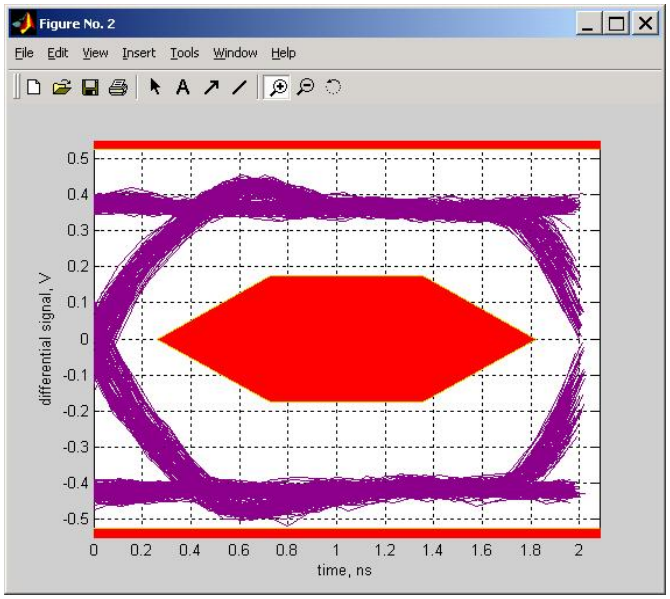
4. Connect the differential probe to D+ and D- of J30 of the test fixture. Be sure to match the polarity. If the oscilloscope enters into the calibration mode, wait until this completes. Press next in the test wizard.

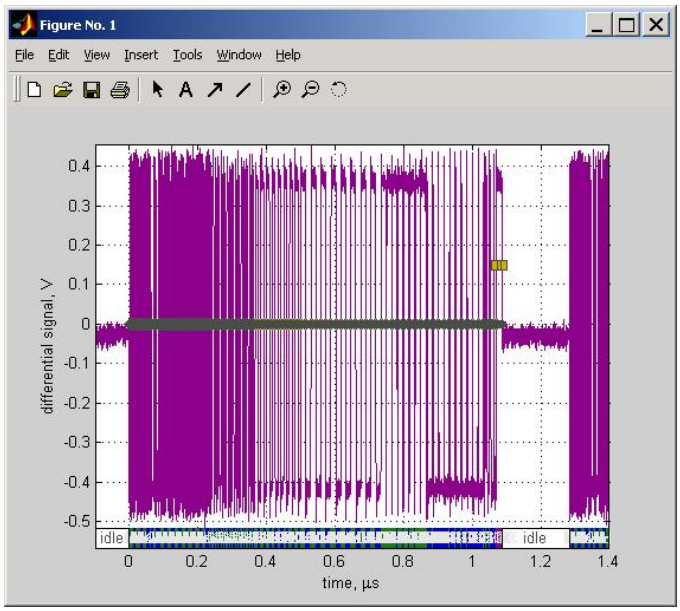
5. Select TEST_PACKET from the Port Control drop down menu. Enter the port number of the hub port being tested and click EXECUTE. This forces the hub port under test to continuously transmit test packets.

6. Using the oscilloscope, verify test packets are being transmitted from the port under test. Adjust the cursors so that they are on either side of the test packet on the screen if necessary.



7. Press the Next button in the test wizard to measure the signal quality. The following plots will be generaed:





8. The results displayed are also recorded to an HTML report located in the directory specified in the "Data Path" control in the test wizard (D:\Applications\USB2\Results by default). Open this file and verify the Signal eye, EOP Width, and Signaling Rate all pass. Record the test result in EL_2, EL_3, EL_6, and EL_7.

9. Disconnect the test fixture from downstream facing port just tested. Reconnect it to the next downstream facing port to be tested.

10. Repeat steps 5 through 9 for all remaining ports.

11. Save all files created during the tests by changing the file name in the Results File Name control on each iteration. Cycle power on the hub under in preparation for subsequent tests.

Note: A specific port fails to enter TEST_PACKET mode after TEST_PACKET command has been issued to the hub a number of times. Cycle power on the hub and click Enumerate Bus will alleviate this problem.

4.6 Hub Jitter-Downstream Facing Ports (EL_47)

Note: This test is currently not supported by the LeCroy the USB-IF test scripts. At this time, this is NOT a required test for high speed hubs.

4.7 Hub Disconnect Detect (EL_36, EL_37)

Please note that the Disconnect Detect tests in this section apply only to downstream facing ports of the hub.

This section uses the Disconnect section of the test fixture to verify the disconnect thresholds of the port under test by simulating the disconnect condition.

Test position

When the TEST switch on the test fixture is in the Test position, the port under test is subjected to a threshold <525mV. The port should not detect a disconnection.

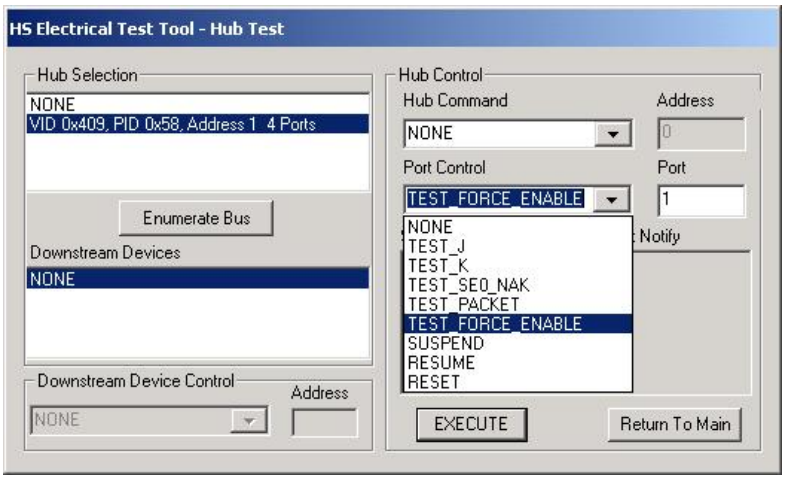
When the TEST switch is in the Normal position, the port under test is subjected to a threshold >625mV. The port should detect a disconnection.

1. Attach the differential probe to J5 of the Disconnect section of the test fixture. Ensure the + tip on probe lines up with D+ on the fixture.

2. Select “USB2” from the analysis menu of the oscilloscope. In the USB test wizard, select Hub for the [mode] and select HS Disconnect in the [Test] control.

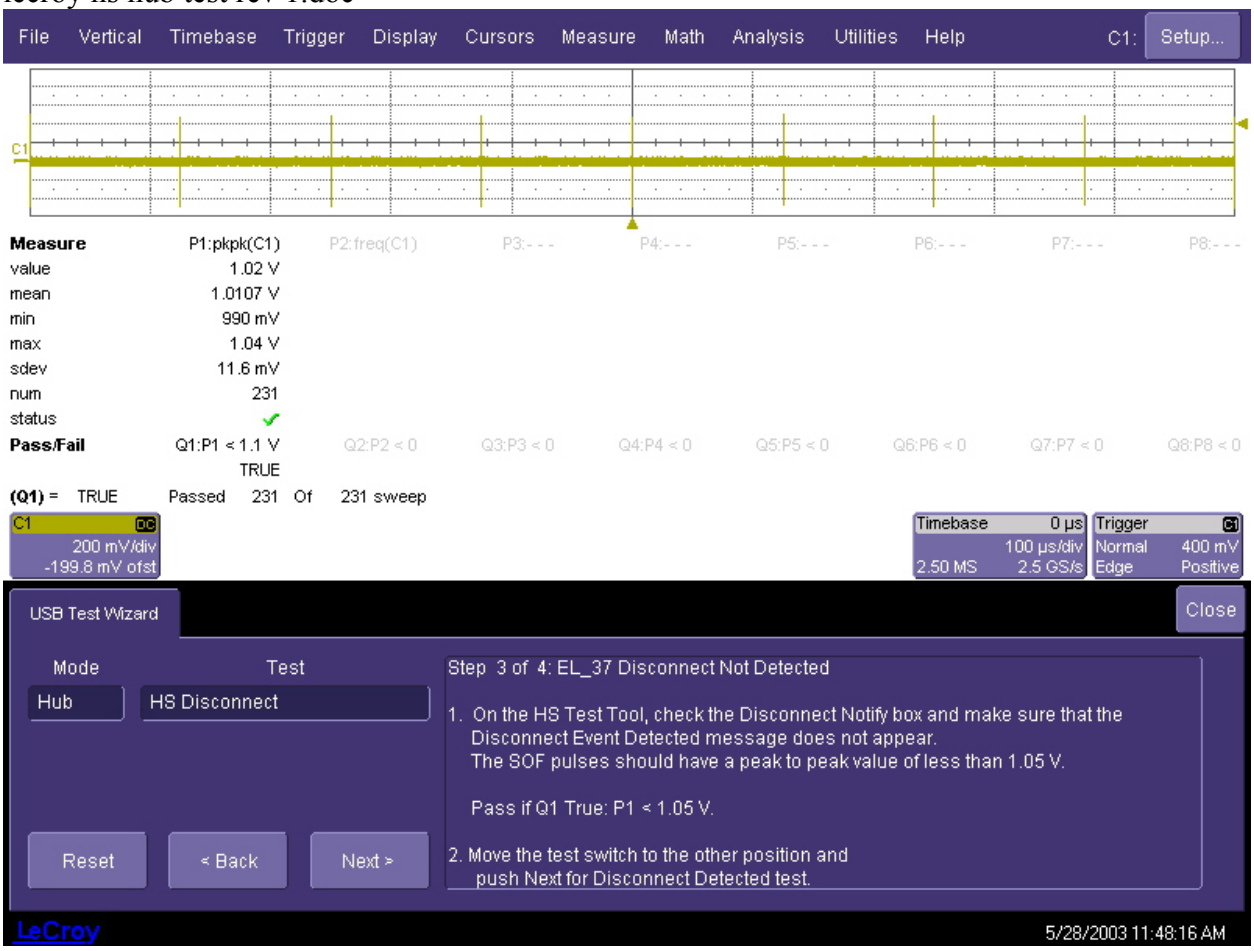
3. Set the TEST switch away from the Test position. This sets the test fixture to emulate a must-not-disconnect threshold. Press next in the USB test wizard.

4. Cycle power on the hub under test. Click Enumerate Bus once and verify the hub successfully enumerates. Attach the Test port of the test fixture to the port under test. In the HS Electrical Test Tool - Hub Test menu select TEST_FORCE_ENABLE from the Port Control window. Enter the port number and click Execute once and ensure the operation is successful in the Status Window.



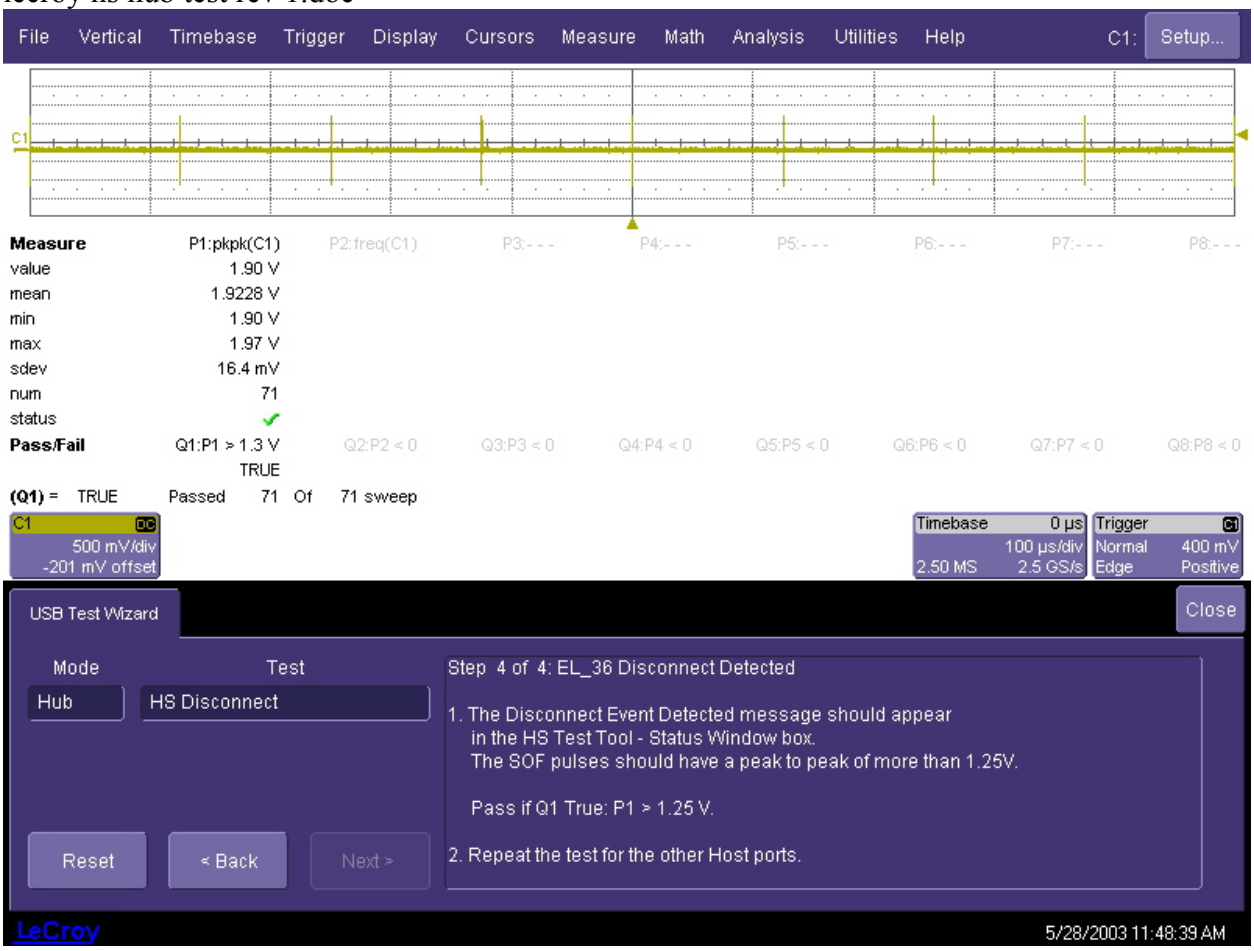
5. Click the Disconnect Notify check box to monitor the disconnect status in the Status Window.

6. Using the oscilloscope, verify the SOF packets are being transmitted from the port under test. The differential amplitude should be less than **+/-** 525mV. Verify that the Status Window does not display Disconnect Event Detected. Record the pass/fail result in EL_37. Press next in the USB test wizard.



7. Set the TEST switch of the Disconnect test fixture to the Test position. Press next in the USB test wizard.

8. Using the oscilloscope monitor the differential amplitude of the SOF. It should be greater than **+/-** 625mV. Verify that the Status Window now displays the Disconnect Event Detected. Record the pass/fail result in EL_36.



9. Return the TEST switch on the fixture away from the TEST.

10. Repeat step 4 through 9 for all the remaining ports.

11. Remove the Disconnect test fixture from the port under test before proceeding.

4.8 Hub Packet Parameters _Upstream Facing Port (EL_21, EL_22, EL_25)

1. Connect the INIT port of the SQ Device section of the test fixture into a high-speed capable port of the test bed computer.

2. Connect the SQ Device section test fixture (Device port) into B receptacle of the upstream facing port under test of the hub. Apply power to the hub.

Note: The use of the Device High-speed Signal Quality test fixture makes it possible to trigger on packets generated by the device because the differential probe is located closer to the device transmitter, hence the device packets are larger in amplitude.

3. Attach the channel 1 differential probe to J19 on the fixture near the device connector. Ensure the + polarity on the probe lines up with D+ on the fixture.

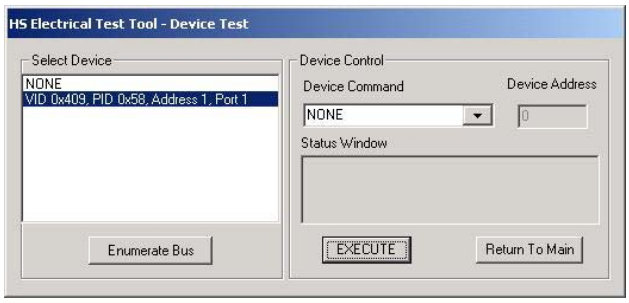
4. In the USB test wizard, select “Hub” for the mode and select “HS Packet Param” in the “Test” control.

5. Press next in the USB test wizard. If necessary, auto zero the differential probe attached to channel 1.

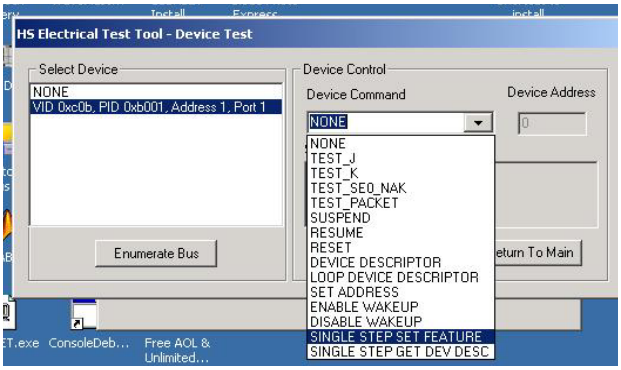
6. Exit the HS Electrical Test Tool - Hub Test menu by clicking the Return to Main button.

7. From the HS Electrical Test Tool main menu select Device and click TEST to enter the Device Test menu. Press next in the USB test wizard.

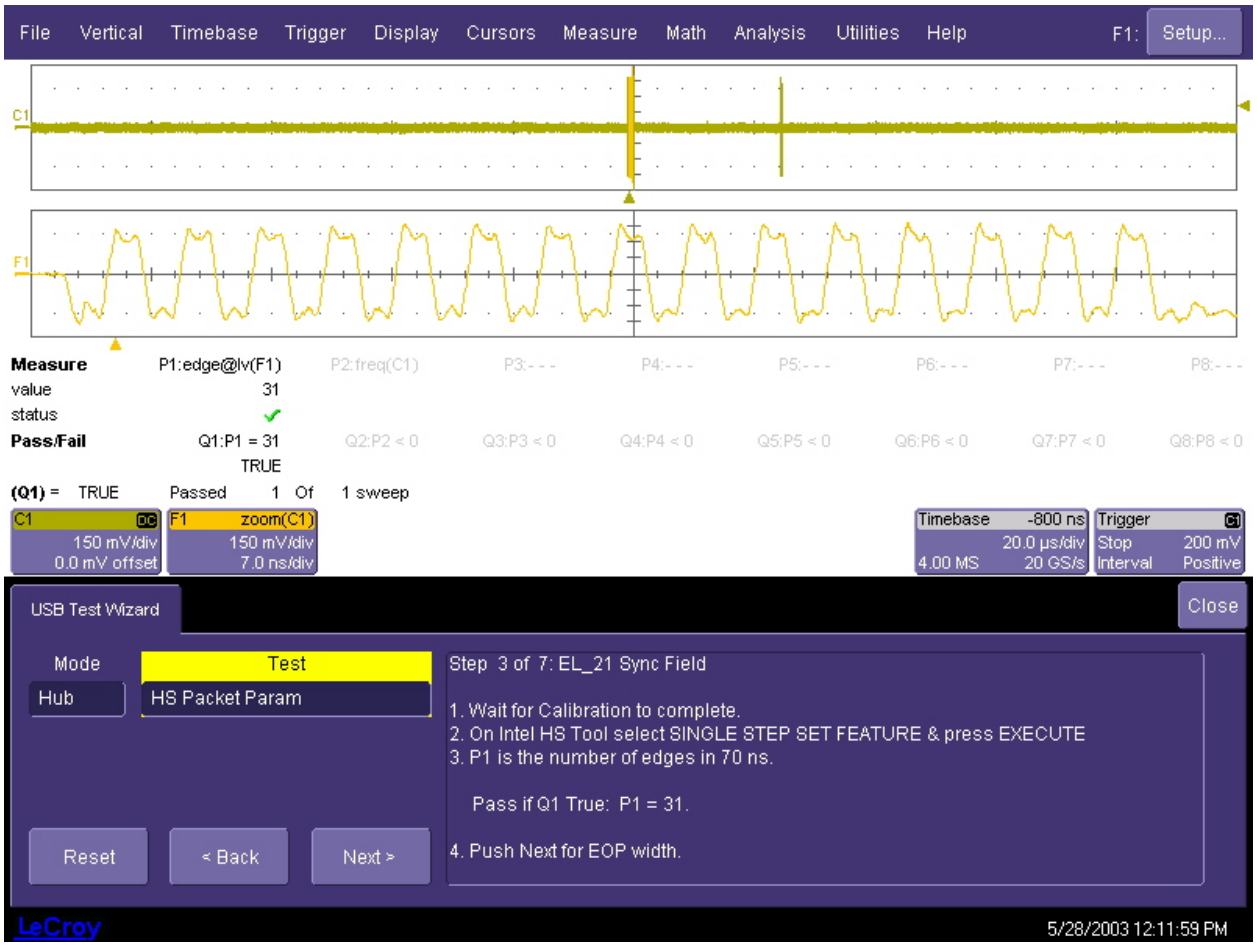
8. The HS Electrical Test Tool — Device Test menu should appear as in the figure:



9. In the HS Electrical Test Tool – Device Test ensure the hub under test is selected (highlighted). Select SINGLE STEP SET FEATURE from the Device Command window and press EXECUTE.



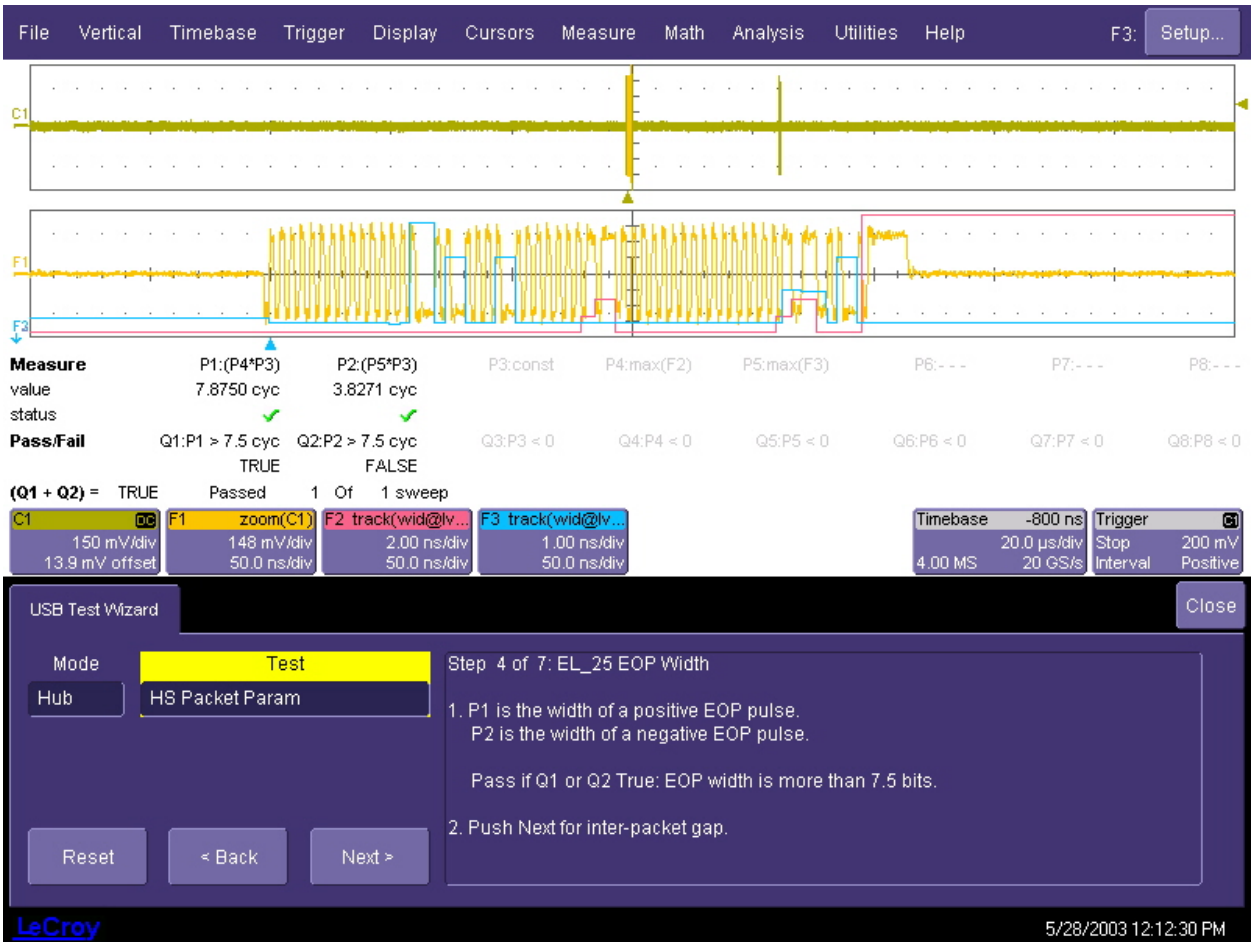
10. Click Next in the USB test wizard. The oscilloscope capture should appear as follows.



11. Parameter P1 is the sync field length (number of transitions) of the third (from the hub) packet on the oscilloscope and verify that it is 31 edges (32 bits per EL_21). Record the number in EL_21.

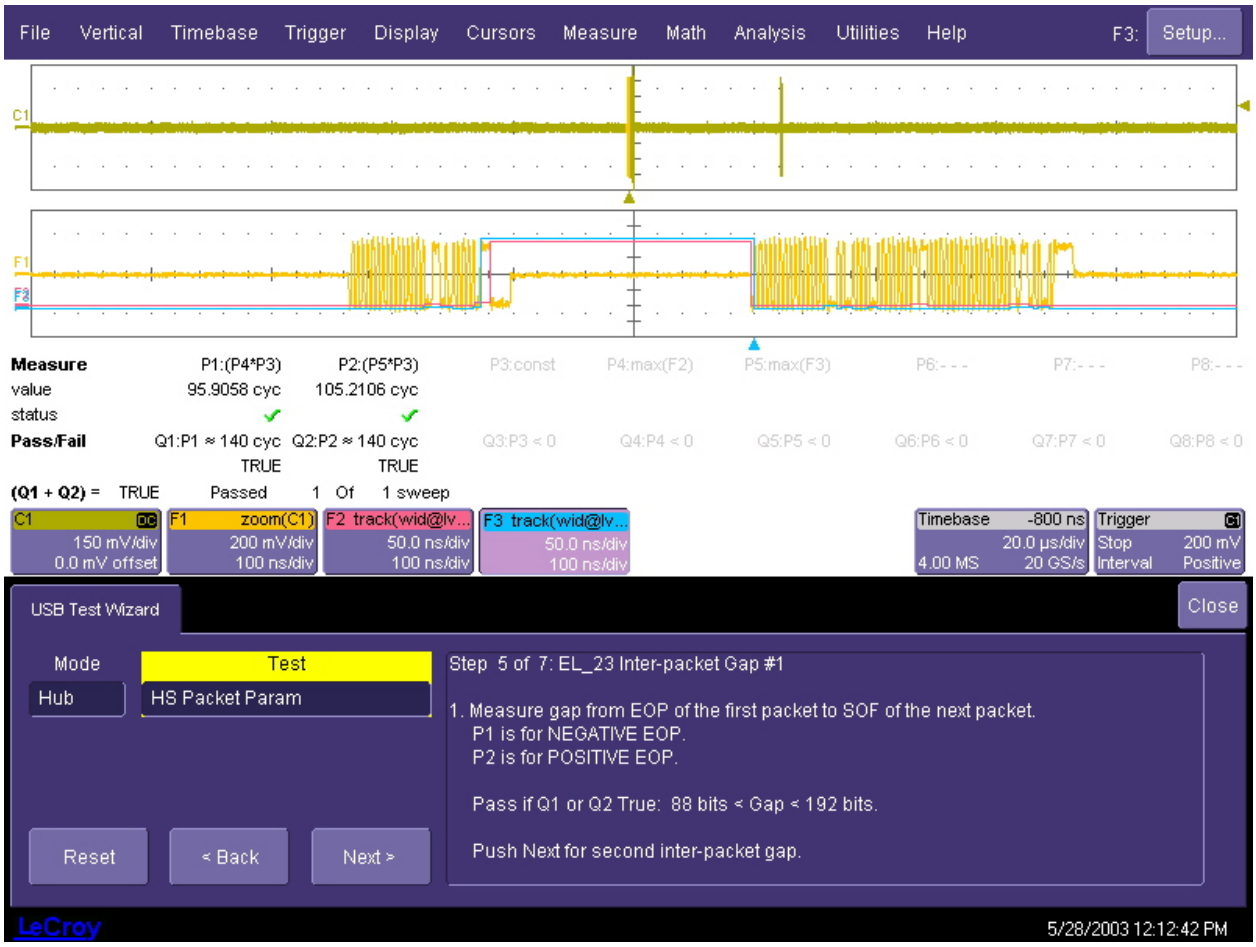
12. Press Next in the test wizard to measure the EOP length (number of bits) of the third packet on the oscilloscope This value is tested in P1 and P2 for the positive and negative going EOP. Record the result in

EL_25.



Note: EOP could appear as a negative going pulse, or a positive going pulse on differential measurement. The figure below illustrates the negative going pulse.

13. Push Next in the test wizard to measure the inter-packet gap between the second (from host) and the third (from the hub in respond to the host's) packets shown on the oscilloscope. This value is indicated in P1 for the positive going pulse and P2 for the negative going pulse. The requirement is it must be between 8 bits and 192 bits. (EL_22). Record this value in EL_22.



14. Push Next in the test wizard to measure the inter-packet gap between the first (from host) and the second (from the hub in respond to the host's) packets shown on the oscilloscope. This value is indicated in P1 for the positive going pulse and P2 for the negative going pulse. The requirement is it must be between 8 bits and 192 bits. (EL_22). Record the computed number of bits in EL_22.

15. On the HS test tool, press STEP twice and then Enumerate Bus. Press Next in the test wizard to measure the SOF EOP width.

16. The value of P1 is the positive pulse and P2 is the negative pulse. The requirement is that one of these is 83.2ns.

17. Exit the HS Electrical Test Tool – Device Test menu by clicking the Return to Main button.

18. From the HS Electrical Test Tool main menu select Hub and click TEST to enter the Hub Test menu.

4.9 Hub Receiver Sensitivity – Upstream Facing Port (EL_16, EL_I 7, EL_18)

This section tests the sensitivity of the receivers on a device under test. An Agilent 81130A Pulse/Pattern Generator or Tektronix DG2040 emulates the "IN" command from the hub port to device address 1.

1. Attach the 5V power supply to the test fixture (J2) and verify the yellow Power LED (D2) is lit. Leave the TEST switch at the INIT position. The yellow TEST LED (D8) should be off.

2. Connect the [INIT PORT] of the receiver sensitivity section of the fixture to a high-speed port on the Test Bed Computer. Connect the [TEST PORT] of the receiver sensitivity section of the fixture to the hub under test. Click the [Enumerate Bus] button once to force enumeration of the newly connected hub. The hub under test should be enumerated with the hub's VID shown together with the root port in which it is connected.

3. Two sets of SMA cables are required, each with a 6dB attenuators inserted. Connect the 6dB attenuators to OUTPUT1 and OUTPUT2 of Agilent 81130A Pulse/Pattern Generator. Connect OUTPUT 1 to SMA2, and OUTPUT 2 to SMA1 of the Device Receiver Sensitivity test fixture using the SMA cables.

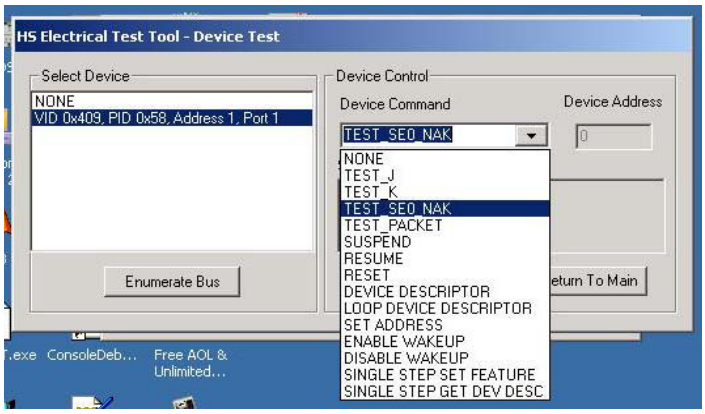
4. On the 81130A, select the [MEMCARD] softkey. If [MEMCARD] is not in the menu, press [MORE] key until [MEMCARD] comes up. The content of the memory will appear on the screen (For creating the setup files used in this section, please refer to Appendix B). Use the cursor and the rotary knob to select the [MIN_ADD1.STO] setup file. Move the cursor to [Perform Operation] and turn the knob to select [Recall]. Then press [ENTER] key to load it. This generates "IN" packets (of compliant amplitude) with a 12-bit SYNC field.

3a (alternate setup for Tektronix DG2040) Two sets of SMA cables are required, each with a 6dB attenuators inserted. Connect the 6dB attenuators to CH1 and CH0 of DG2040 Data Generator. Connect CH1 to SMA1, and CH2 to SMA2 of the Device Receiver Sensitivity test fixture using the SMA cables.

4a (alternate setup for Tektronix DG2040) On the DG2040, select the EDIT menu. Then press Load Data & Setup from the File function. The content of the floppy disk will appear on the screen. Use the jog dial to select the MIN-ADD1.PDA setup file. Press OK to load it. This generates IN packets (of compliant amplitude) with a 12-bit sync field. Start the data generator with the Start/Stop button.

5. Connect the differential probe from channel 1 of the oscilloscope to J12 of the signal quality section of the test fixture. Recall the HSRcvrSensitivity.lss panel file on the oscilloscope using the File-Recall Setup menu. Use the Browse button in the Recall Panel File dialog box to select the file from the D:\Applications\USB2\Setups directory. Press the Recall Now button to select this setup file.

6. On the HS Electrical Test Tool - Hub Test menu, select [TEST_SEO_NAK] from the Hub Command drop down menu. Click [EXECUTE] once to place the hub into TEST_SEO_NAK test mode.



7. Place the test fixture Test Switch (S1) into the TEST position. This switches in the data generator in place of the host controller. The data generator emulates the "IN" packets from the host controller.

8. Verify that all packets from the data generator are NAK'd by the port under test by viewing the signal on the oscilloscope screen. The NAK should appear as two bursts near each other on the oscilloscope screen that are slightly different in amplitude. Record the Pass/Fail in EL_18.

6. On the data generator select [MEMCARD] softkey. If [MEMCARD] is not in the menu, press [MORE] key until [MEMCARD] comes up. The content of the memory will appear on the screen (For creating the setup files used in this section, please refer to Appendix B.). Use the cursor and the rotary knob to select the IN_ADD1.STO setup file. Move the cursor to [Perform Operation] and turn the knob to select [Recall]. Then press [ENTER] key to load it.

9a (for Tektronix DG2040) On the data generator, select the Edit menu, then press Load Data & Setup from the File function. The content of the floppy disk will appear on the screen. Use the jog dial to select the

ADD1.PDA setup file. Press OK to load it.

10. Verify that all packets are NAK'd while signaling is at this amplitude.

11. Adjust the output level of each channel as follows:

12. Select the [LEVELS] softkey. If [LEVELS] is not in the menu, press [MORE] key until [LEVELS] comes up. Then move the cursor to the numeric value for [High] voltage value. Adjust the output level with the rotary knob or using the number keys while monitoring the actual level on the oscilloscope. Use the cursor arrow buttons to select the channel to change.

13. Reduce the amplitude of the data generator packets in 20mV steps (on the generator before the attenuator) while monitoring the NAK response from the hub on the oscilloscope. The adjustment should be made to both channels such that OUTPUT1 and OUTPUT2 are matched, as indicated by the data generator readout. Reduce the amplitude until the NAK packets begins to become intermittent. At this point, increase the amplitude such that the NAK packet is not intermittent. This is just above the minimum receiver sensitivity levels before squelch.

12a (Tektronix DG2040) select the Setup menu. Then press High from the Level Condition function. Adjustment of the output level is best done with the keypad in 50mV while monitoring the actual level on the oscilloscope. Use the Up and Down arrow buttons to select the channel to change.

13a (Tektronix DG2040) Reduct the signal amplitude in 50mV steps (before the attenuator) while monitoring the NAK response on the oscilloscope. The adjustment should be made on both channels such that CH0 and CH1 are matched, as indicated by the data generator readout. Reduce the amplitude until the NAK packets begin to become intermittent. At this point, increase the amplitude such that the NAK packet is not intermittent. This is just above the minimum receiver sensitivity level before squelch.

14. Measure the zero to positive peak of the packet from the data generator using the cursors in the lower (zoom) window of the oscilloscope display as shown in the figure below. Use the upper cursor position knob to position cursor 1 on the zero level of the waveform and the lower cursor control knob to position cursor 2 on the positive peak of the waveform. The cursor should be positioned on the plateaus of the wider pulses to avoid inflating the reading due to overshoots. The difference voltage is indicated in the "zoom(C1)" waveform box at the lower left corner of the oscilloscope screen. Record this value in EL_17.

15. Move cursor 2 to the negative peak of the waveform in the lower window of the oscilloscope screen using the lower cursor control knob again, positioning the cursor on the wider plateaus to avoid overshoots. Read the difference voltage in the wavefrom information box at the bottom left of the oscilloscope display. Record this value in EL_17. The receiver must continue to NAK packets above +/- 150mV to pass the test. Record Pass/Fail in EL_17.

16. Now further reduce the amplitude of the packet from the data generator in small steps. Still maintaining balance between the outputs until the receiver just ceases to respond with NAK. This is the squelch level of the receiver.

17. Measure the Zero to Positive Peak and Negative Peak of the packet from the data generator using the method described in step 14 and 15. Record the measurement in EL_16. As long as the receiver ceases to NAK the data generator packet below +/- 100mV, it is considered to pass the test. Record PASS/FAIL in EL_16.

Note: With certain hubs making an accurate zero-to-peak measurement of the In packet from the data generator may be difficult due to excessive reflection artifacts. Also, on hubs with captive cable, the measured zero-to-peak amplitudes of the IN packet at the test fixture could be considerably higher than that seen by the hub

receiver. In these situations, it is advisable to make the measurement near the hub receiver pins on the PCB.

4.10 Hub Repeater Test – Downstream Facing Ports (EL_42, EL_43, EL_44, EL_45, EL_48)

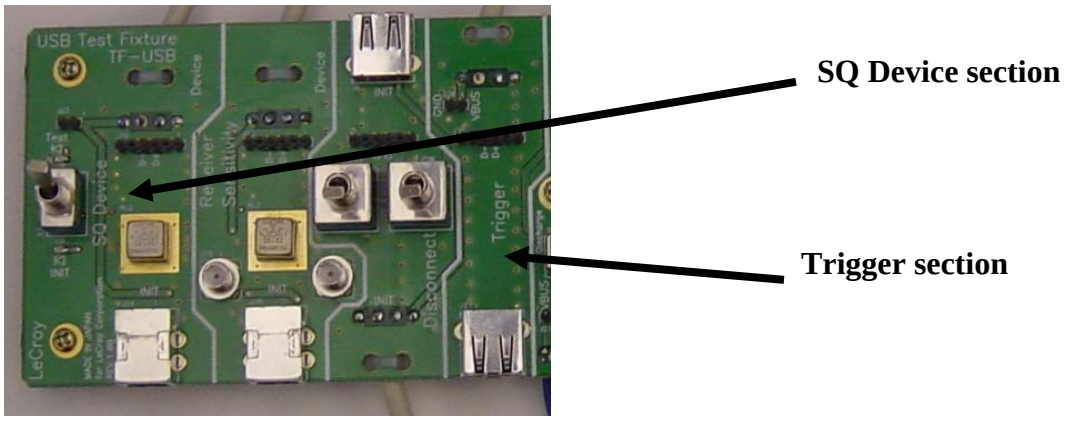
This section requires two sets of differential probes, one for monitoring packets at the upstream facing port, the other one for monitoring packets at a downstream facing port. One differential probe is connected to Channel 1 of the oscilloscope. A second differential probe is connected to Channel 4.

Note: Although most hubs have multiple downstream ports, it is acceptable to only test one port for the economy of test time.

1. select hub in the [mode] control and HS Downstream Repeater in the [Test] control of the USB test wizard.

2. Connect the SQ Device section of the test fixture between the upstream facing port of the hub and the host controller port. Attach the Channel 1 diff probe to J19 of the fixture. Ensure the +polarity on the probe lines up with D+ on the fixture. Ensure that the INIT/TEST switch is in the INIT position.

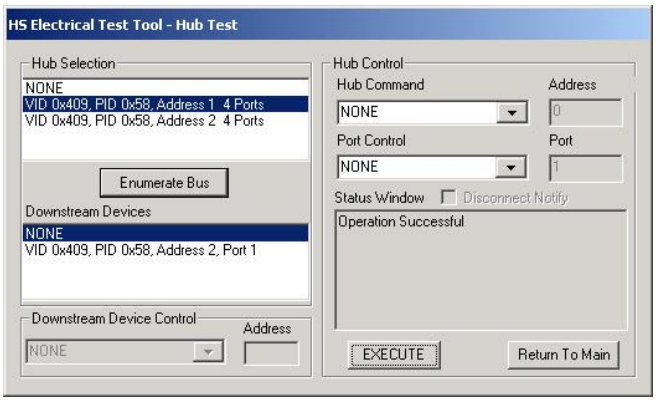
3. Connect the trigger section of the test fixture between the downstream port under test of the hub and a known-good high-speed device. Attach the Channel 4 diff probe to J26 in the trigger section of the fixture. Ensure the +polarity on the probe lines up with D+ on the fixture.



4. Start the HS test tool, select HUB, and press start. Press next in the USB test wizard.

5. If the oscilloscope enters into the auto calibration mode, wait until this completes. Perform an auto zero on the two differential probes using the probe tabs in the respective channel menus (ch1 and ch4).

6. Click the Enumerate Bus button once. The hub under test should be enumerated with the hub's VID shown together with the USB address. Likewise the known good device should be enumerated with it's VID shown together with the hub port in which it is connected.

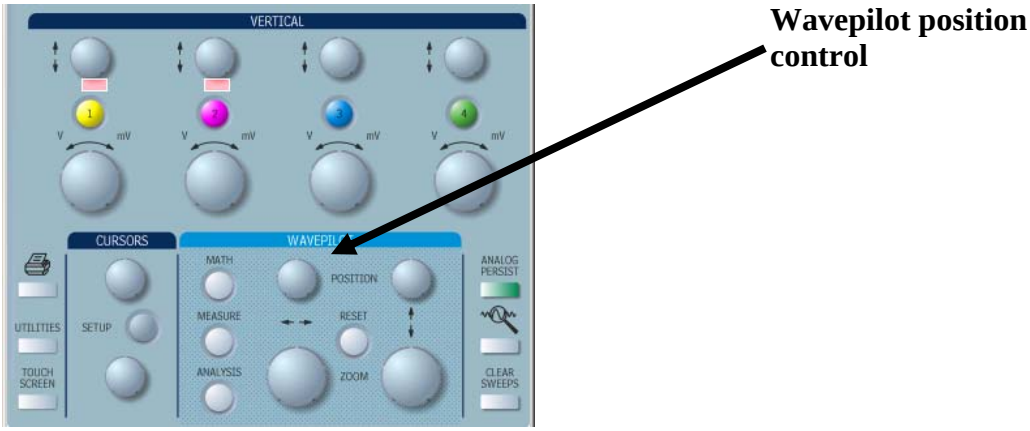


7. Click Next in the test wizard to recall the setup file and measurement. The image shown below will appear on the oscilloscope screen.

8. The delay between the start of packet between the hub's upstream facing port (Channel 1) and the hub's down stream facing port under test (Channel 4) is measured in P2 while P1 shows the equivalent number of bits corresponding to this time (P2) minus 4ps. This value should be no more than 36 bits. Record the result in EL_48.

9. Click 'Next' in the test wizard to display the number of bits in the sync fields on Channels 1 and 4. Each falling or rising edge counts as one bit (consecutive zeros in NRZI format), up to and including the first no transition (due to the first one that follows the consecutive zeros in NRZI format). The figure below shows the oscilloscope display for the sync field corruption test. The input to the hub is shown in the yellow trace

(F1) while the output from the hub is shown in purple (F2). Adjust the position of F1 by clicking or touching the waveform information box corresponding to F1 at the bottom left of the display. Use the horizontal position control in the Wavepilot control to move F1 so that the last sync field bit is positioned at the right of the screen. Repeat this procedure for F2.



10. P1 displays the number of sync field bits from the hub output port and P2 displays the number of sync field bits in the hub input. Determine the number of sync bits truncated by the hub. Record the result into EL_42.

11. Verify also that the sync field in Channel 4 is not corrupted, when compared to that in Channel 1 except the truncation of sync field bits. This can be done by comparing traces F1 and F2 on the oscilloscope screen.

Record the result in EL_43.

12. Press Next in the test wizard to measure the time of the EOP width of the packet in Channels 1 and 4. The number of bits of each is indicated in P2 and P3 respectively. P1 shows the difference in bits between channels 1 and 4. Channel 4 should have no more than 4 bits (EOP dribble) than that in Channel 1 (which should be 40 bits). Record the result shown in P1 in EL_44.

13. Verify also that the EOP in Channel 4 is not corrupted. Record the result in EL_45.

4.11 Hub Repeater Test – Upstream Facing Port (EL_42, EL_43, EL_44, EL_45)

This section also requires two sets of differential probes, one for monitor packets at the upstream facing port while the other one for monitor packets at a downstream facing port. In order to be able to trigger on a packet from the device, the diff probe on Channel 4 now needs to be placed nearer to the device than the hub port. This is accomplished by using a fixture that allows probing near the device. Please note that the two test fixtures in this section are interchanged with respect to the connections in section 4.10.

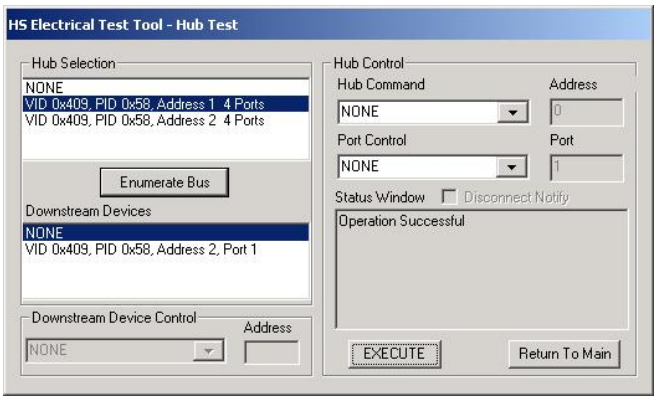
1. Select hub in the [mode] control and HS Upstream Repeater in the [Test] control of the USB test wizard.

2. Connect the SQ Device section of the test fixture between the upstream facing port of the hub and the host controller port. Attach the Channel 1 diff probe to J19 of the fixture. Ensure the + polarity on the probe lines up with D+ on the fixture. Ensure that the INIT/TEST switch is in the INIT position.

3. Connect the Receiver Sensitivity section of the test fixture between the downstream port under test of the hub and a known-good high-speed device. Attach the Channel 4 diff probe to J12 of the fixture. Ensure the + polarity on the probe lines up with D+ on the fixture. Apply power to the hub and the known good device.

4. If the oscilloscope enters into the auto calibration mode, wait until this completes. Perform an auto zero on the two differential probes using the probe tabs in the respective channel menus (ch1 and ch4).

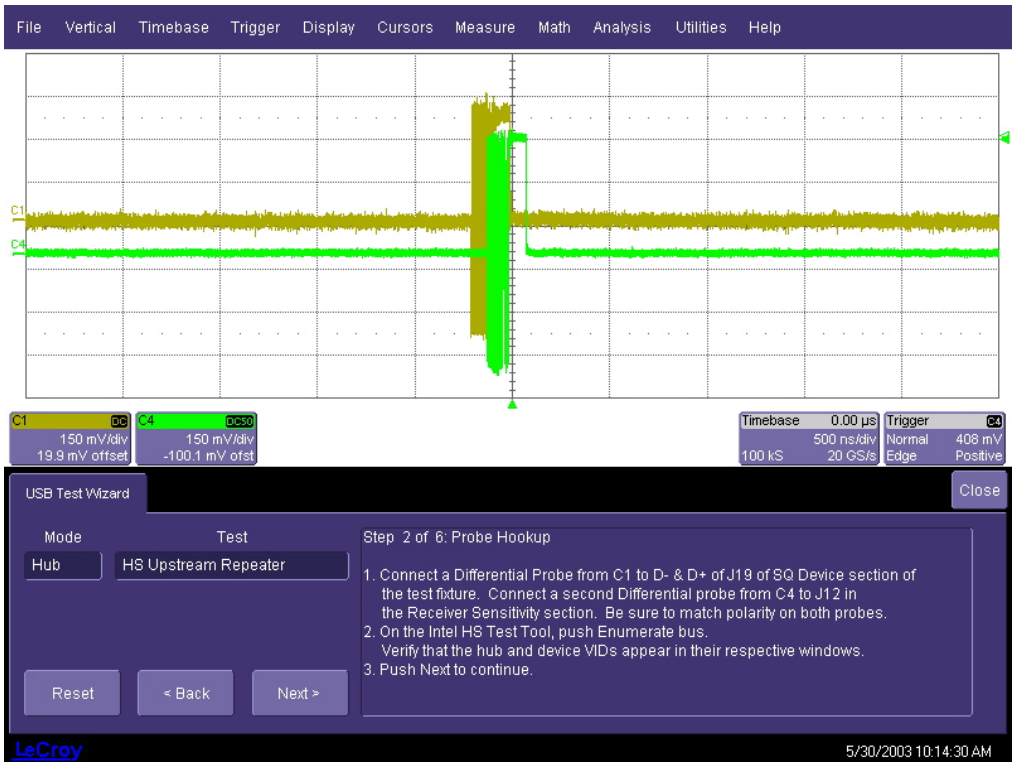
5. Click the Enumerate Bus button once. The hub under test should be enumerated with the hub's VID shown together with the USB address. Likewise the known good device should be enumerated with the it's VID shown together with the hub port in which it is connected.



6. In the USB test wizard, select "Hub" for the mode and select "HS Upstream Repeater" in the "Test" control.

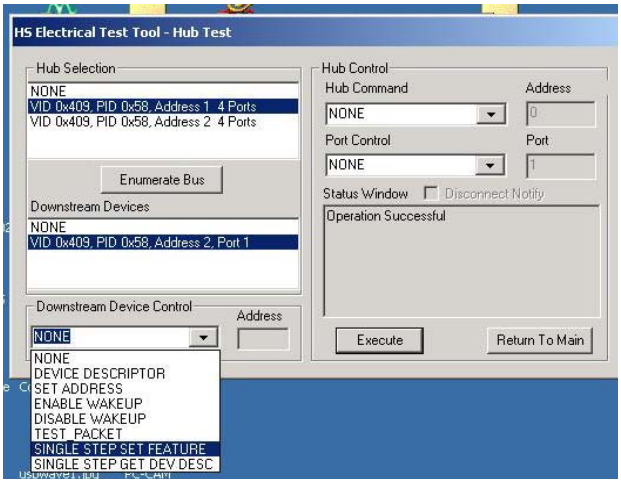
7. Using the oscilloscope, verify SOFs (Start Of Frame) packets are being transmitted on the downstream

facing port (on Channel 4). You may need to lower the trigger level to somewhat below 400mV.



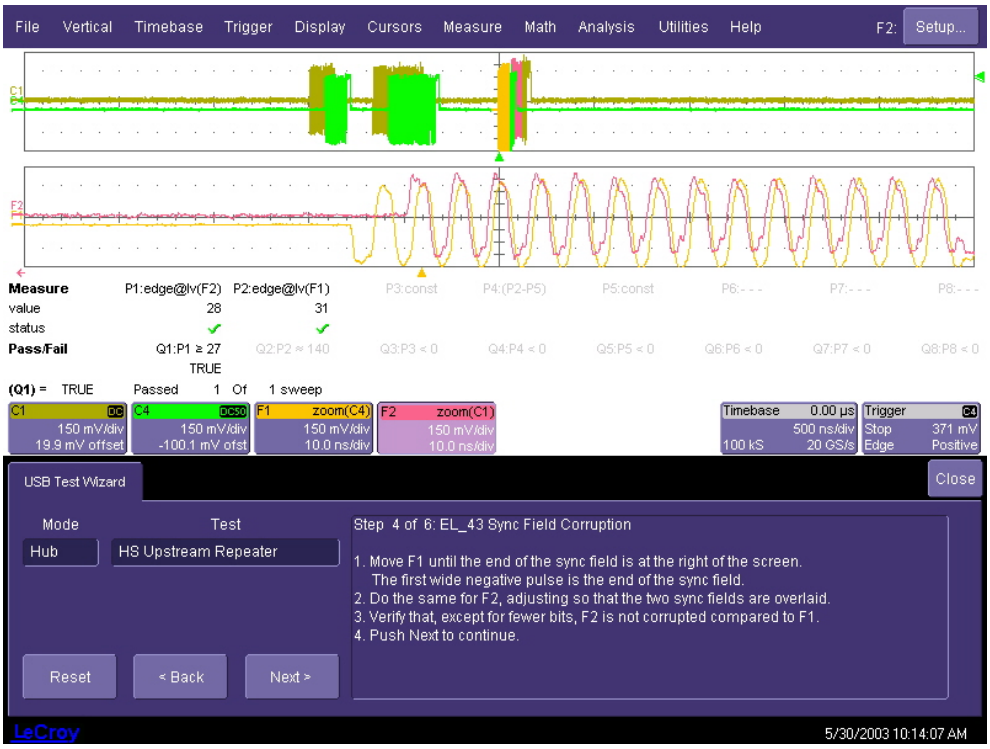
8. Now raise the oscilloscope trigger level slowly until it just stop being triggered on the SOFs (or any host traffic). Typically this is around or slightly below 400mV, depending on the hub and the length of cable used on the fixture. Ensure the RUN/STOP of the oscilloscope is set to RUN.

9. In the HS Electrical Test Tool - Hub Test menu select SINGLE STEP SET FEATURE from the Downstream Device Control drop down menu and click EXECUTE once.



10. The captured oscilloscope sample should appear as the figure below. If the oscilloscope doesn't trigger on the hub traffic the trigger level is set too high. Lower the trigger level slightly (but not so low that it triggers on host SOFs) and repeat from step 7. Press Next in the test wizard when the trigger is successful.

11. The oscilloscope display (below) will show the number of bits in the sync fields on Channels 1 and 4. Each falling or rising edge counts as one bit (consecutive zeros in NRZI format), up to and including the first no transition (due to the first one that follows the consecutive zeros in NRZI format). The figure below shows the oscilloscope display for the sync field corruption test. The input to the hub is shown in the yellow trace (F1) while the output from the hub is shown in purple (F2). Adjust the position of F1 by clicking or touching the waveform information box corresponding to F1 at the bottom left of the display. Use the horizontal position control in the Wavepilot control to move F1 so that the last sync field bit is positioned at the right of the screen. Repeat this procedure for F2.



12. P1 displays the number of sync field bits from the hub output port and P2 displays the number of sync field bits in the hub input. Determine the number of sync bits truncated by the hub. Verify the truncation of the sync field is no more than 4 bits (the number of sync bits in channel 1 should not be more than 4 bit less than that in channel 4. Record the result in EL_42.

13. Verify also that the sync field in Channel 1 is not corrupted, when compared to that in Channel 4 except the truncation of consecutive zeros. Record the result in EL_43.

14. Press Next in the test wizard to measure the time of the EOP width of the packet in Channels 1 and 4. The number of bits of each is indicated in P2 and P3 respectively. P1 shows the difference in bits between channels 1 and 4. Channel 4 should have no more than 4 bits (EOP dribble) than that in Channel 1 (which should be 80 bits). Record the result in EL_44.

15. Verify also that the EOP in Channel 4 is not corrupted. Record the result in EL_45.

16. Disconnect both differential probes. Disconnect the connection on the hub's downstream facing port.

4.12 Hub CHIRP Timing _Upstream Facing Port (EL_28, EL_29, EL_31)

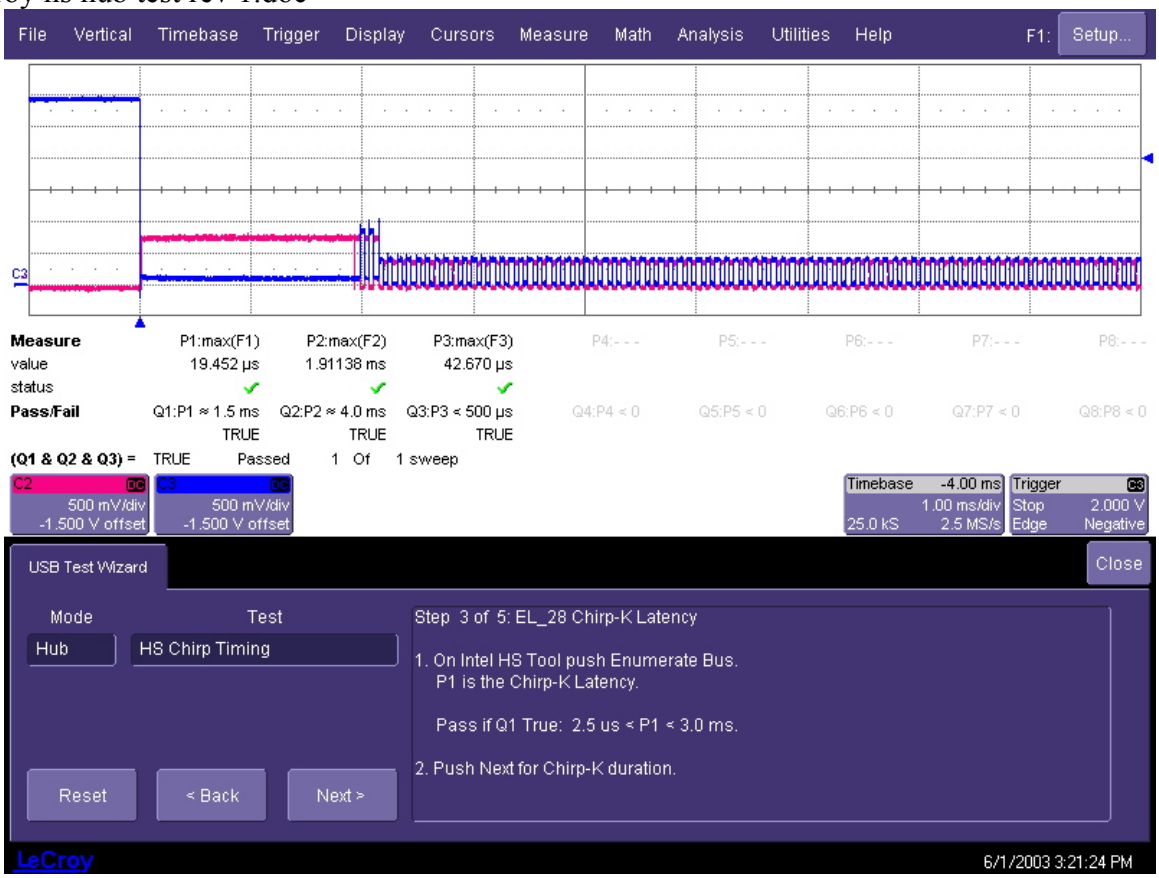
This test applies only to the upstream facing port of the hub under test.

1. Attach the Init port of the SQ Device section of the test fixture into a USB 2.0 compliant port of the HS host controller.

2. Connect Channel 2 and Channel 3 FET probes to the test fixture at J19. Connect Ch2 to D- and Ch3 to D+. Connect the probe grounds to the outside pins of J19.

3. In the USB test wizard, select Hub for the [mode] and select HS Chirp Timing in the [Test] control.

4. Attach the Device dongle of the fixture to the upstream port of the hub. Apply power to the hub. Click Enumerate Bus and capture the CHIRP handshake as in the figure below.



5. The hub's CHIRP-K latency in response to the reset from the upstream host port is shown in P1. Verify this timing is 2.5uS < $T_{WTRSTFS}$ < 3.0ms. Record the result in EL28.

6. The hub's CHIRP-K duration is shown in P2. Verify this assertion time is 1.0ms (T_{UCH}) < CHIRP-K duration < 7.0ms (T_{UCHEND}). Record the result in EL_29.

7. Following the host assertion of alternate sequence of Chirp-K and Chirp-J, the hub must respond by turning on its high-speed terminations. This is evident by a drop of amplitude of the alternate Chirp-K and Chirp-J sequence from the 800mV nominal to the 400mV nominal. The time from the beginning of the last J in the Chirp K-J-K-J-K-J (3 pairs of Chirp-KJ's) to the time when the hub turns on the high-speed terminations is shown in P3. Verify this is less than or equal to 500us. Record the measurement in EL_31.

4.13 Hub Suspend/Resume/Reset Timing _Upstream Facing Port (EL_27, EL_28, EL_38, EL_39, EL_40)

5. Plug the Init port of the SQ Device section of the fixture into a high-speed capable port of the test bed computer.

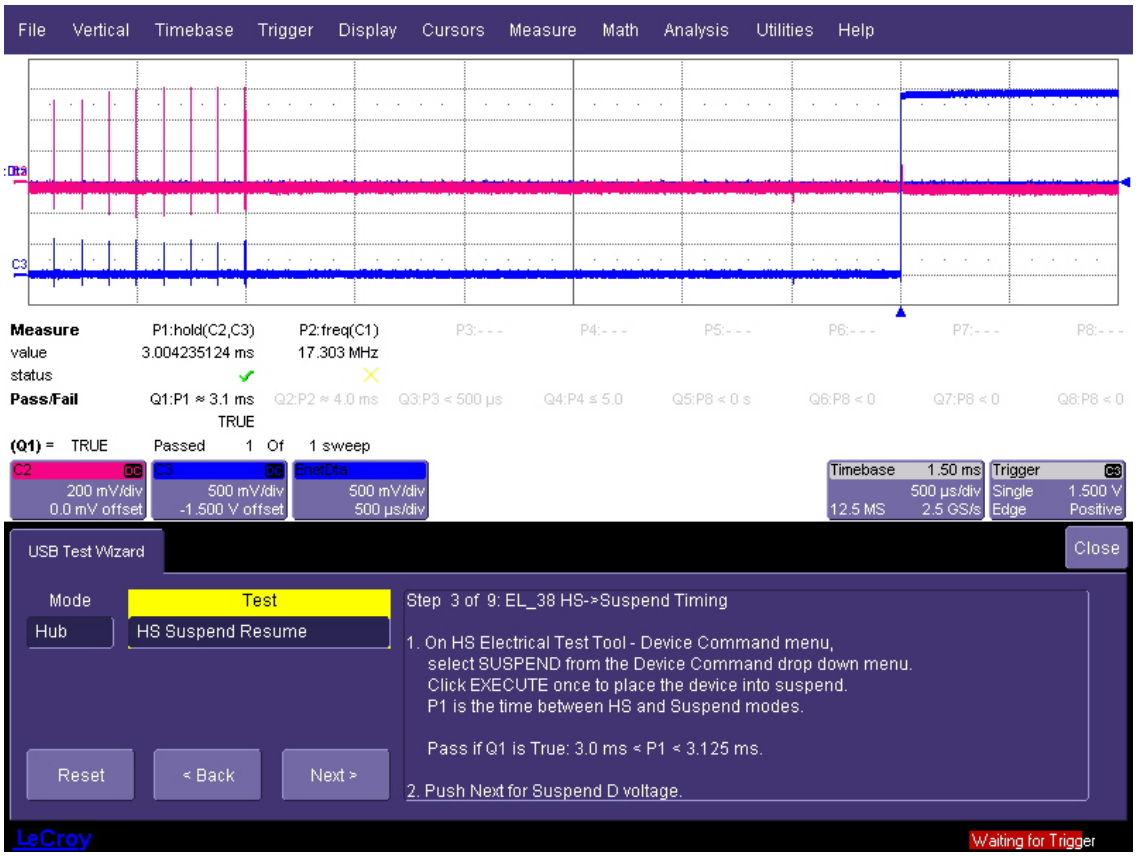
6. Connect Channel 2 and Channel 3 FET probes to the test fixture at J19. Connect Ch2 to D- and Ch3 to D+. Connect the probe grounds to J10 and J11.

7. Attach the DEVICE port of the fixture to the upstream port of the hub. Apply power to the hub. Click the Enumerate Bus button once. The hub under test should be enumerated with the hub's VID shown together

with the USB address.

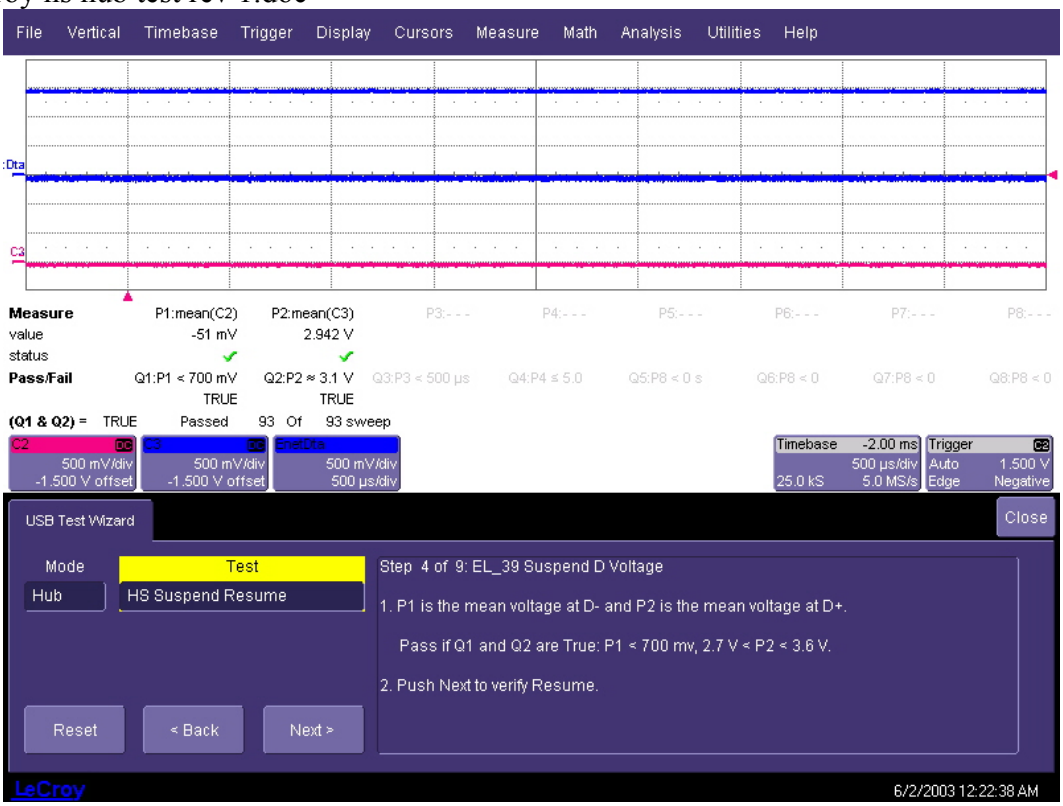
8. In the USB test wizard, select “Hub” for the mode and select “HS Suspend Resume” in the “Test” control.

9. On the HS Electrical Test Tool - Hub Test menu, select SUSPEND from the Hub Command drop down menu. Click EXECUTE once to place the hub into suspend. The captured suspend transition should appear as in the figure below.



10. The time interval from the end of last SOF packet issued by the hub to when the hub attached its full speed pull-up resistor on D+ is shown in P1. This is the time between the end of the last SOF packet and the rising edge transition to full speed J-state. Verify this time is between 3.000mS and 3.125mS. Record the result in EL_38.

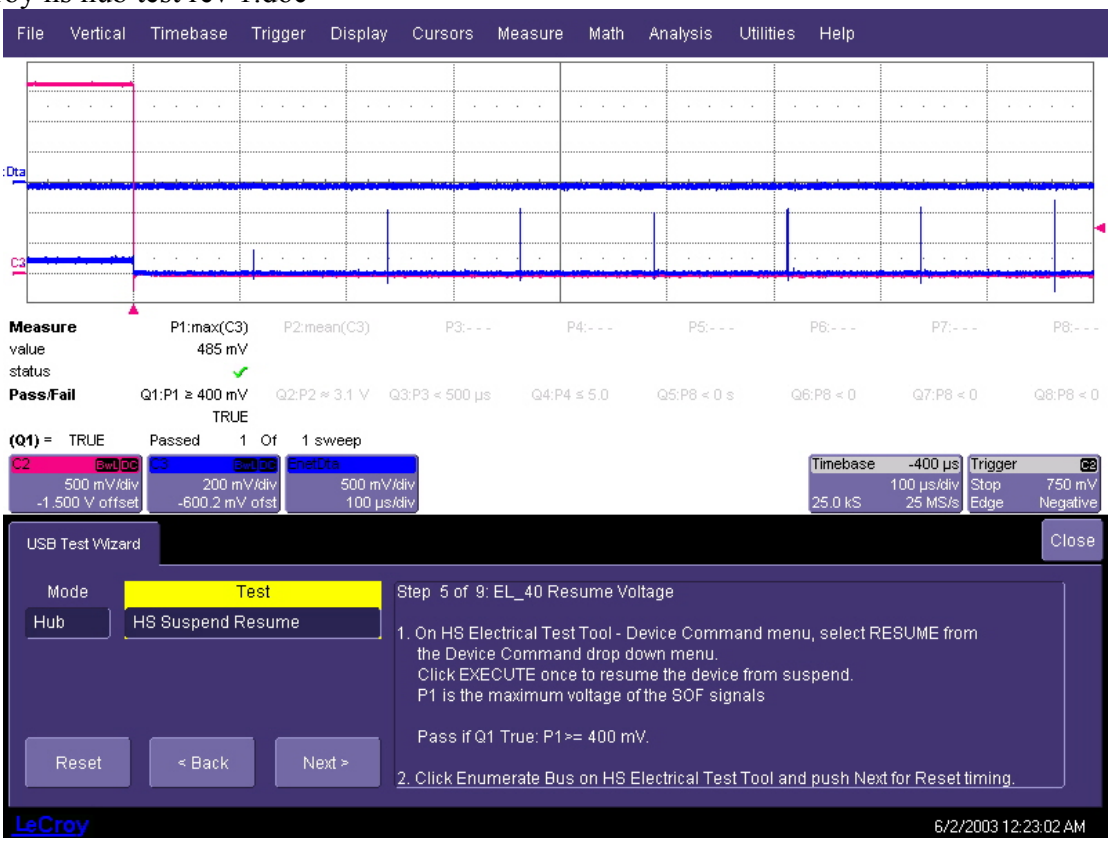
11. Press Next in the test wizard. The D+ should be at 3.3V nominal. The D- should be less than 0.7V. Record the Pass/Fail result in EL_39.



The following steps verify the Resume response of the hub under test.

12. Press Next in the test wizard.

13. On the HS Electrical Test Tool - Hub Test menu, select RESUME from the Hub Command drop down menu. Click EXECUTE once to resume the hub from suspend. The captured resume transition should appear as in the figure below.

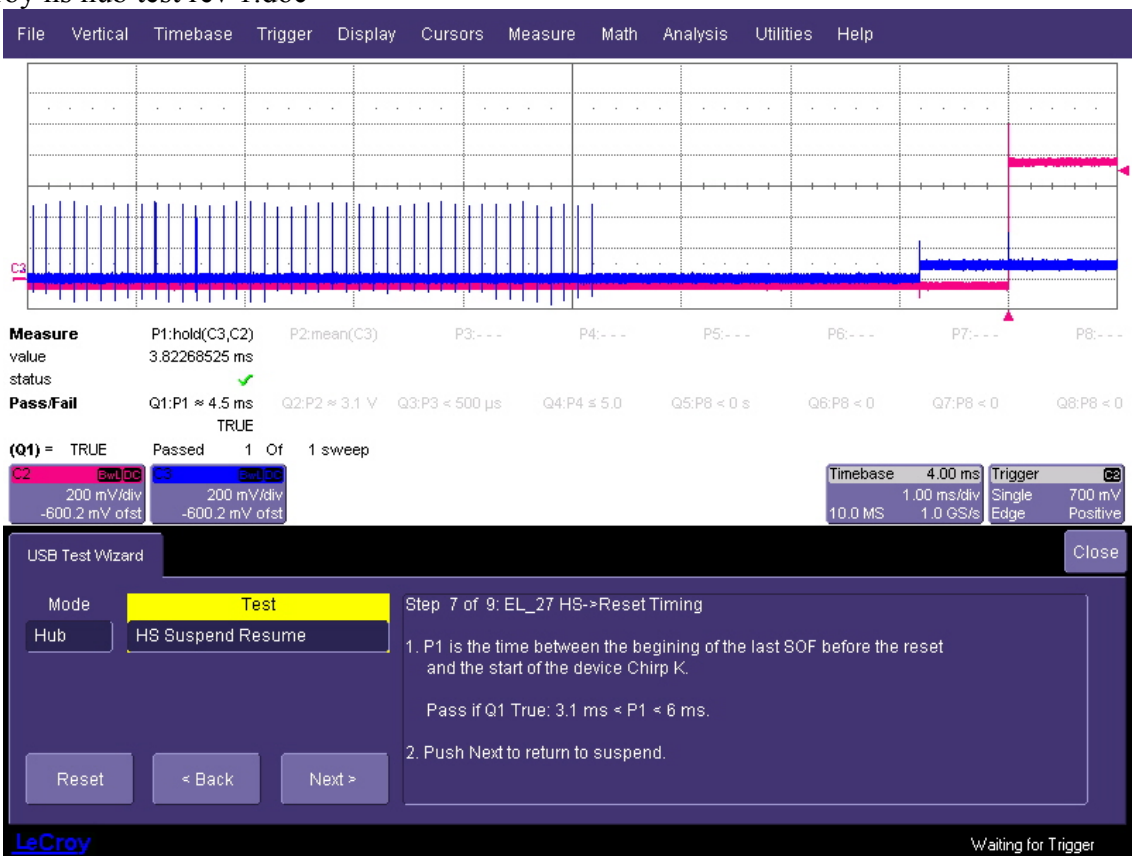


14. The hub should resume the high-speed operation, which is indicated by the presence of high-speed SOF packets (with 400mV nominal amplitudes) following the K State driven by the host controller. The presence of SOF at 400mV nominal amplitude indicates the hub resumes back to high-speed operation. Record the Pass/Fail result in EL_40.

The following steps verify the hub resumes back to high-speed operation after being reset from operating in high-speed.

15. Click Enumerate bus in the HS test tool and push Next in the test wizard.

16. On the HS Electrical Test Tool - Hub Test menu, select RESET from the Hub Command drop down menu. Click EXECUTE once to reset the hub operating in high-speed. The captured resume transition should appear as in the figure below.



17. The device should transmit a chirp handshake following the reset. P1 is the time between the beginning of the last SOF before the rest and the start of the device Chirp-K. Verify this is between 3.1mS and 6mS. Record the Pass/Fail result in EL_27.

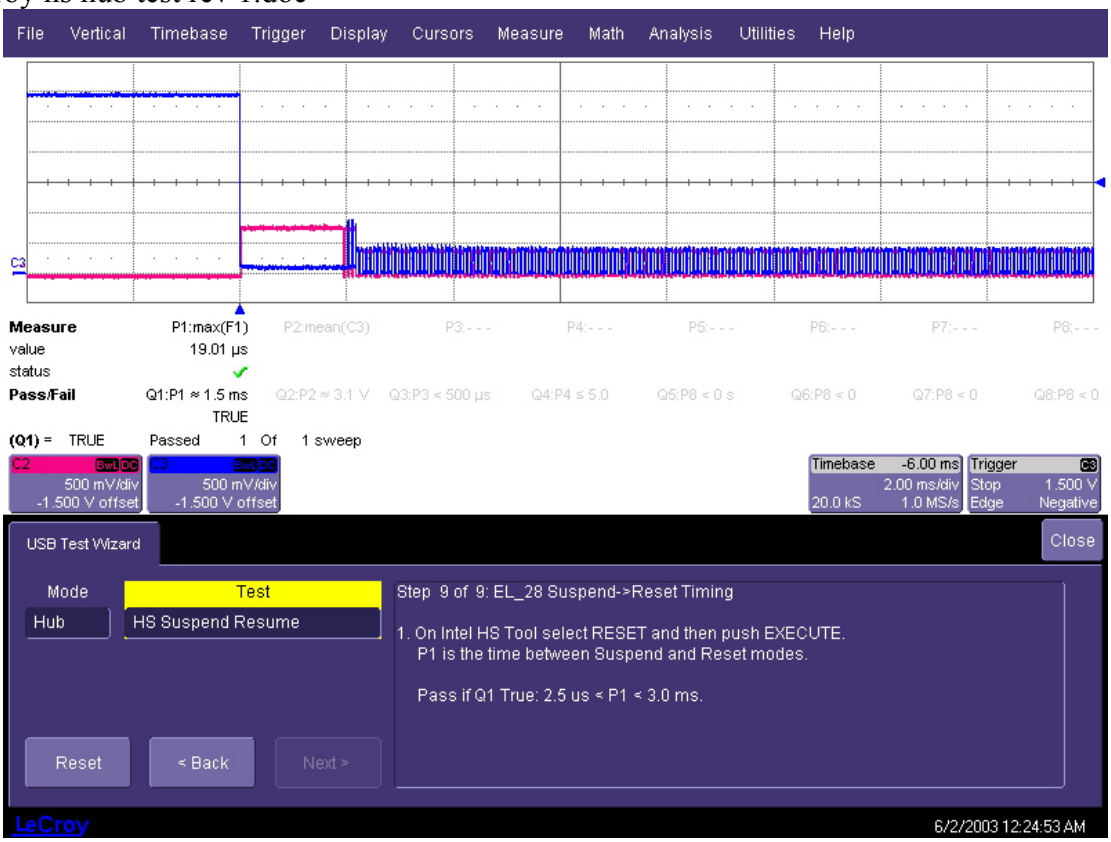
The following steps verify the hub's chirp response after being reset from suspend.

18. Press Next in the test wizard.

19. On the HS Electrical Test Tool - Hub Test menu, select SUSPEND from the Hub Command drop down menu. Click EXECUTE once to place the device into suspend.

20. The D+ should be at 3.3V nominal. The D- should be less than 0.7V.

21. On the HS Electrical Test Tool – Hub Test menu, select RESET from the Hub Command drop down menu. Click EXECUTE once to reset the device in suspend. The captured reset from suspend transition should appear as in the figure below.



22. The hub responds to the reset with the Chirp-K. P1 shows the time between the falling edge of the D+ and the start of the device chirp-K. Verify this is between 2.5us and 3ms. Record the Pass/Fail result in EL_28.

4.14 Hub Test J/K, SE0_NAK - Upstream Facing Port (EL_8, EL_9)

1. Attach the 5V power supply to J2 of the USB test fixture.

2. Verify the green Power LED (D1) is lit, and the yellow Test LED (D2) is off.

3. Connect the Test port of the Device High-speed Signal Quality section of the test fixture into the upstream facing port of the hub under test. Connect the INIT port of the test fixture to a port of the Test Bed Computer. Apply power to the hub. Click Enumerate Bus button once. Verify that it is enumerated in the HS Electrical Test Tool-Hub Test menu.

4. On the HS Electrical Test Tool - Hub Test menu select TEST_J from the Hub Command drop down menu. Click EXECUTE once to place the hub into TESTJ test mode.

5. Switch the test fixture into the TEST position. Using a DVM measure the DC voltage on the D+ line at J7 with respect to ground (pin J10 and J11 are ground pins). Record in section EL_8.

6. Using a DVM measure the DC voltage on the D- line at J7 with respect to ground. Record in section EL_8. Return the Test switch to the NORMAL position.

7. Cycle the hub power. This restores the hub to normal operation.

8. On the HS Electrical Test Tool - Hub Test menu click Enumerate Bus, select TEST_K from the Hub Command drop down menu. Click EXECUTE once to place the hub into TEST_K test mode.

9. Switch the test fixture into the TEST position. Using a DVM measure the DC voltage on the D+ line at J7 with respect to ground (pin J10 and J11 are ground pins). Record in section EL_8.

10. Using a DVM measure the DC voltage on the D- line at J7 with respect to ground. Record in section EL_8. Return the Test switch to the NORMAL position.

11. Cycle the hub power. This restores the hub to normal operation.

12. On the HS Electrical Test Tool — Hub Test menu click Enumerate Bus once. Select TEST_SE0_NAK from the Hub Command drop down menu. Click EXECUTE once to place the hub into TEST_SE0_NAK test mode.

13. Switch the test fixture into the TEST position. Using a DVM measure the DC voltage on the D+ line at J7 with respect to ground (pin J10 and J11 are ground pins). Record in section EL_9.

14. Using a DVM measure the DC voltage on the D- line at J7 with respect to ground (pin J10 and J11 are ground pins). Record in section EL_9. Return the Test switch to the NORMAL position.

15. Cycle the hub power to prepare the hub for the subsequent tests.

4.15 Hub Test J/K, SE0_NAK - Downstream Facing Ports (EL_8, EL_9)

1. Attach the 5V power supply to USB test fixture and verify the green Power LED (D1) is lit. Place the TEST/INIT Switch in the TEST position. Verify the yellow TEST LED is lit.

2. Attach the A cable in the device signal quality section of the test fixture to a downstream facing port of the hub under test. Apply power to the hub.

3. On the HS Electrical Test Tool-Hub Test menu click Enumerate Bus once. Select TEST_J from the Port Control drop down menu. Enter the port number and click EXECUTE once to place the port under test into TEST_J test mode.

4. Using a DVM measure the DC voltage on the D+ line at J19 with respect to ground (pin J10 and J11 are ground pins). Record in section EL_8.

5. Using a DVM measure the DC voltage on the D- line at J19 with respect to ground. Record in section EL_8.

6. On the HS Electrical Test Tool - Hub Test menu click Enumerate Bus once. Select TEST_K from the Port Control drop down menu. Enter the port number and click EXECUTE once to place the port under test into TEST_K test mode.

7. Using a DVM measure the DC voltage on the D+ line at J19 with respect to ground (pin J10 and J11 are ground pins). Record in section EL_8.

8. Using a DVM measure the DC voltage on the D- line at J19 with respect to ground. Record in section EL_8.

9. On the HS Electrical Test Tool – Hub Test menu click Enumerate Bus once. Select TEST_SE0_NAK from the Port Control drop down menu. Enter the port number and click EXECUTE once to place the port under

test into TEST_SEO_NAK test mode.

10. Using a DVM measure the DC voltage on the D+ line at J19 with respect to ground (pin J10 and J11 are ground pins). Record in section EL_9.

11. Using a DVM measure the DC voltage on the D- line at J19 with respect to ground (pin J10 and J11 are ground pins). Record in section EL_9.

12. Repeat step 2 through 11 for the remaining ports.

Note: A specific port fails to enter the specific test mode after test mode commands have been issued to the hub a number of times. Cycle power on the hub will alleviate this problem.

Appendix A

A.4 Hub High-speed Electrical Test Data

This section is for recording the actual test result. Please use a copy for each device to be tested.

A.4.2 Vendor and Product Information

Please fill in all fields. Please contact your silicon supplier if you are unsure of the silicon information.

Test Date	
Vendor Name	
Vendor Complete Address	
Vendor Phone Number	
Vendor Contact, Title	
Test ID Number	
Product Name	
Product Model and Revision	
USB Silicon Vendor Name	
USB Silicon Model	
USB Silicon Part Marking	
USB Silicon Stepping	
Tested By	

A.4.3 Legacy USB Compliance Tests

Legacy USB Compliance Checklist

Legacy Test	Pass/Fail	Comments
LS SQ (Downstream)		
FS SQ (Upstream and Downstream)		
Inrush (Upstream)		
Drop/Droop (Downstream)		
Interop		

P = PASS

F = FAIL

N/A = Not applicable

A.4.4 Hub High-speed Signal Quality— Upstream Facing Port (EL_2, EL_46, EL_6, EL_7)

EL_2 A USB 2.0 high-speed transmitter data rate must be 480 Mb/s ±0.05%.

Reference documents: *USB 2.0 Specification,* Section 7.1.11.

□Pass
□Fail
□N/A
Comments:

EL_46 A hub upstream repeater must meet Template 1 transform waveform requirements measured at TP3.

Reference documents: *USB 2.0 Specification,* Section 7.1.2.2.

□Pass
□Fail
□N/A
Comments:

EL6 A USB 2.0 HS driver must have 10% to 90% differential rise and fall times of greater than **500** p5.

Reference documents: *USB 2.0 Specification,* Section 7.1.2.2.

□Pass
□Fail
□N/A
Comments:

EL7 A USB 2.0 HS driver must have monotonic data transitions over the vertical openings specified in the appropriate eye pattern template.

Reference documents: *USB 2.0 Specification,* Section 7.1.2.2.

□Pass
□Fail
□N/A
Comments:

A.4.5 Hub High-speed Signal Quality –Downstream Facing Ports (EL_2, EL_3, EL_6, EL_7)

EL2 A USB 2.0 high-speed transmitter data rate must be 480 Mb/s ±0.05%.

Reference documents: *USB 2.0 Specification,* Section 7.1.2.2.

Port	**P1**	**P2**	**P3**	**P4**	**P5**
PASS					
FAIL					
NA					

Overall Results

□Pass
□Fail
□N/A
Comments:

EL_3 A USB 2.0 downstream facing port must meet Template 1 transform waveform requirements measured at TP2 (each hub downstream port).

Reference documents: *USB 2.0 Specification,* Section 7.1.2.2.

Port	**P1**	**P2**	**P3**	**P4**	**P5**
PASS					
FAIL					
NA					

Overall Result:

□Pass
□Fail
□N/A
Comments:

EL_6 A USB 2.0 HS driver must have 10% to 90% differential rise and fall times of greater than 500 ps.

Reference documents: *USB 2.0 Specification*, Section 7.1.2.2.

Port	**P1**	**P2**	**P3**	**P4**	**P5**
PASS					
FAIL					
NA					

Overall Result:

□Pass
□Fail
□N/A
Comments:

EL_7 A USB 2.0 HS driver must have monotonic data transitions over the vertical openings specified in the appropriate eye pattern template.

Reference documents: *USB 2.0 Specification*, Section 7.1.2.2.

Port	**P1**	**P2**	**P3**	**P4**	**P5**
PASS					
FAIL					
NA					

A.4.6 Hub Jitter – Downstream Facing Ports (EL_47)

EL_47 A hub downstream facing repeater must meet Template 1 transform waveform requirements measured at TP2 (each hub downstream port).

Reference documents: *USB 2.0 Specification*, Section 7.1.14.2.

Port	**P1**	**P2**	**P3**	**P4**	**P5**
PASS					
FAIL					

NA					

Overall Result:

□Pass
□Fail
□N/A
Comments:

A.4.7 Hub Disconnect Detect (EL_36, EL37)

EL_37 A USB 2.0 downstream facing port must not detect the high-speed disconnect state when the amplitude of the differential signal at the downstream facing driver's connector is < =525 mV.

Reference documents: *USB 2.0 Specification,* Section 7.1.7.3.

Port	**P1**	**P2**	**P3**	**P4**	**P5**
PASS					
FAIL					
NA					

Overall:

□Pass
□Fail
□N/A
Comments:

EL_36 A USB 2.0 downstream facing port must detect the high-speed disconnect state when the amplitude of the differential signal at the downstream facing driver's connector is ≥625 mV.

Reference documents: *USB 2.0 Specification,* Section 7.1.7.3.

Port	**P1**	**P2**	**P3**	**P4**	**P5**
PASS					
FAIL					
NA					

Overall Result:

□Pass
□Fail
□N/A
Comments:

A.4.8 Hub Packet Parameters – Upstream Facing Port (EL_21, EL_22, EL_25)

EL_21 The SYNC field for all transmitted packets (not repeated packets) must begin with a 32 bit SYNC field.

Reference documents: *USB 2.0 Specification,* Section 8.2.

Data Packet SYNC field

□Pass
□Fail
□N/A
Comments:

EL_25 The EOP for all transmitted packets (except SOFs) must be an 8-bit NRZ byte of 01111111 without bit stuffing. (Note, that a longer EOP is waiverable)

Reference documents: *USB 2.0 Specification,* Section 7.1.13.2

□Pass
□Fail
□N/A
Comments:

EL_22 When transmitting after receiving a packet, hosts and devices must provide an inter-packet gap of at least 8 bit times and not more than 192 bit times.

Reference documents: *USB 2.0 Specification,* Section 7.1.18.2.

□Pass
□Fail
□N/A
Comments:

A.4.9 Hub Receiver Sensitivity – Upstream Facing Port (EL_16, EL_17, EL_18)

EL_18 A high-speed capable device's Transmission Envelope Detector must be fast enough to allow the HS receiver to detect data transmission, achieve DLL lock, and detect the end of the SYNC field within 12 bit times.

Reference documents: *USB 2.0 Specification,* Section 7.1.

□Pass
□Fail
□N/A
Comments:

EL_17 A high-speed capable device must implement a transmission envelope detector that does not indicate squelch (i.e. reliably receives packets) when a receiver exceeds 150 mV differential amplitude.

Note: A waiver may be granted if the receiver does not indicate Squelch at +/-5OmV of 150mV differential amplitude. This is to compensate for the oscilloscope probe point away from the receiver pins.

Reference documents: *USB 2.0 Specification,* Section 7.1.

□Pass
□Fail
□N/A
Comments:

EL_16 A high-speed capable device must implement a transmission envelope detector that indicates squelch (i.e. never receives packets) when a receiver's input falls below 100 mV differential amplitude.

Note: A waiver may be granted if the receiver indicate Squelch at +/-50mV of 100mV differential amplitude. This is to compensate for the oscilloscope probe point away from the receiver pins.

Reference documents: *USB 2.0 Specification,* Section 7.1.

□Pass
□Fail
□N/A
Comments:

A.4.10 Hub Repeater Test – Downstream Facing Ports (EL_42, EL_43, EL_44, EL_45, EL_48)

EL_48 A hub repeater may not delay packets for more than 36 bit times plus 4ns.

Reference documents: *USB 2.0 Specification,* Section 7.1.14.2

□Pass
□Fail
□N/A
Comments:

EL_42 Hub repeaters must not truncate more than 4 bits from a repeated SYNC pattern.

Reference documents: *USB 2.0 Specification,* Section 7.1.10.

□Pass
□Fail
□N/A
Comments:

EL_43 Hubs must not corrupt any repeated bits of the SYNC field.

Reference documents: *USB 2.0 Specification,* Section 7.1.10.

□Pass
□Fail
□N/A
Comments:

EL_44 A hub may add at most 4 random bits to the end of the EOP field when repeating a packet.

Reference documents: *USB 2.0 Specification,* Section 7.1.13.2

□Pass
□Fail
□N/A
Comments:

EL45 A hub must not corrupt any of the valid EOP bits when repeating a packet.

Reference documents: *USB 2.0 Specification,* Section 7.1.13.2

□Pass
□Fail
□N/A
Comments:

A.4.11 Hub Repeater Test – Upstream Facing Port (EL_42, EL_43, EL_44, EL_45)

EL_42 Hub repeaters must not truncate more than 4 bits from a repeated SYNC pattern.

Reference documents: *USB 2.0 Specification,* Section 7.1.10.

□Pass
□Fail
□N/A
Comments:

EL_43 Hubs must not corrupt any repeated bits of the SYNC field.

Reference documents: *USB 2.0 Specification,* Section 7.1.10.

□Pass

EL_44 A hub may add at most 4 random bits to the end of the EOP field when repeating a packet.

Reference documents: *USB 2.0 Specification,* Section 7.1.13.2

□Pass
□Fail
□N/A
Comments:

EL45 A hub must not corrupt any of the valid EOP bits when repeating a packet.

Reference documents: *USB 2.0 Specification,* Section 7.1.13.2
□Pass
□Fail
□N/A
Comments:

A.4.12 Hub CHIRP Timing – Upstream Facing Port (EL_28, EL_29, EL_31)

EL_28 Devices must transmit a chirp handshake no sooner than 2.Sus and no later than 3ms when being reset from suspend or a full-speed state.

Reference documents: *USB 2.0 Specification,* Section *7.1.7.5.*
□Pass
□Fail
□N/A
Comments:

EL_29 The chirp handshake generated by a device must be at least 1ms and not more than 7ms in duration.

Reference documents: *USB 2.0 Specification,* Section *7.1.7.5.*

□Pass
□Fail
□N/A
Comments:

EL_31 During device speed detection, when a device detects a valid Chirp K-J-K-J-K-J sequence, the device must disconnect its 1.5K pull-up resistor and enable its high-speed terminations within 500us.

Reference documents: *USB 2.0 Specification,* Section *7.1.7.5.*
□Pass
□Fail
□N/A
Comments:

A.4.13 Hub Suspend/Resume/Reset Timing – Upstream Facing Port (EL_27, EL_28, EL_38, EL_39, EL_40)

EL_38 A device must revert to full-speed termination no later than 125us after there is a 3ms idle period on the bus.

Reference documents: *USB 2.0 Specification,* Section 7.1.7.6.

□Pass
□Fail
□N/A
Comments:

EL_39 A device must support the Suspend state.

Reference documents: *USB 2.0 Specification,* Section 7.1.7.6.

□Pass
□Fail
□N/A
Comments:

EL_40 If a device is in the suspend state, and was operating in high-speed before being suspended, then device must transition back to high-speed operation within two bit times from the end of resume signaling.

Note: It is not feasible to measure the hub transition back to high-speed operation within two bit time from the end of the resume signaling. The presence of SOF at nominal 400mV amplitude following the resume signaling is sufficient for this test.

Reference documents: USB 2.0 Specification, Section 7.1.7.7.

□Pass
□Fail
□N/A
Comments:

EL_27 Devices must transmit a chirp handshake no sooner than 3.lms and no later than 6ms when being reset from a non-suspended high-speed mode. The timing is measured from the beginning of the last uSOF transmitted before the reset begins.

Reference documents: *USB 2.0 Specification,* Section *7.1.7.5.*

□Pass
□Fail
□N/A

Comments:

EL_28 Devices must transmit a chirp handshake no sooner than 2.Sus and no later than 3ms when being reset from suspend or a full-speed state.

Reference documents: *USB 2.0 Specification,* Section *7.1.7.5.*

□Pass
□Fail
□N/A
Comments:

A.4.14 Hub Test J/K, SE0_NAK Upstream Facing Port (EL_8, EL_9)

EL_8 When either D+ or D- are driven high, the output voltage must be 400 mV ±10% when terminated with precision 45 Q resistors to ground.

Reference documents: *USB 2.0 Specification,* Section 7.1.1.3.

Test	D+ Voltage (mV)	D- Voltage (mV)
J		
K		

□Pass
□Fail
□N/A
Comments:

EL_9 When either D+ and D- are not being driven, the output voltage must be 0V ±10 mV when terminated with precision 45Ω resistors to ground.

Reference documents: *USB 2.0 Specification,* Section 7.1.1.3

	Voltage (mV)
D+	
D-	

□Pass
□Fail
□N/A
Comments:

A.4.15 Hub Test J/K, SEO_NAK Downstream Facing Ports (EL_8, EL_9)

EL_8 When either D+ or D- are driven high, the output voltage must be 400 mV ±10% when terminated with

precision 45Ω resistors to ground.

Reference documents: *USB 2.0 Specification,* Section 7.1.1.3.

Port	1		2		3		4		5	
Test	D+	D-	D+	D-	D+	D-	D+	D-	D+	D-
TEST_J										
TEST_K										

□Pass
□Fail
□N/A
Comments:

EL_9 When either D+ and D- are not being driven, the output voltage must be 0V ±10 mV when terminated with precision 45Ω resistors **to ground.**

Reference documents: *USB 2.0 Specification,* Section 7.1.1.3.

Port	**1**		**2**		3		4		*5*	
Signal	**D+**	**D-**	**D+**	**D-**	**D+**	**D-**	**D+**	**D-**	**D+**	**D-**
Measure WRT Ground (mV)										

□Pass
□Fail
□N/A
Comments: