Tektronix

# High-Speed Electrical Testing - Host

*Universal Serial Bus Measurement Package*

www.tektronix.com

2015-05-05

REVISION RECORD SHEET

| Versio n | Completion Date | Initiator | Page s | Nature of Change |
|---|---|---|---|---|
| 1.0 | 7-16-2014 | S. Harrison | 35 | First Draft |
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# DISCLAIMER OF WARRANTIES

# Table of Contents

# Signal Quality Tests for High Speed Host
**(EL_2, EL_3, EL_6, EL_7)**

### Specifying the Equipment-Signal Quality Tests for High Speed Host/Hub for Downstream Testing

- Tektronix digital oscilloscope
- USB2SIGQUAL compliance test fixture
- Two SMA cables (phase matched)
- Host PC
- 1 meter USB2.0 cable

### Typical Equipment Setup-Signal Quality Tests for High Speed Host (Downstream Testing)

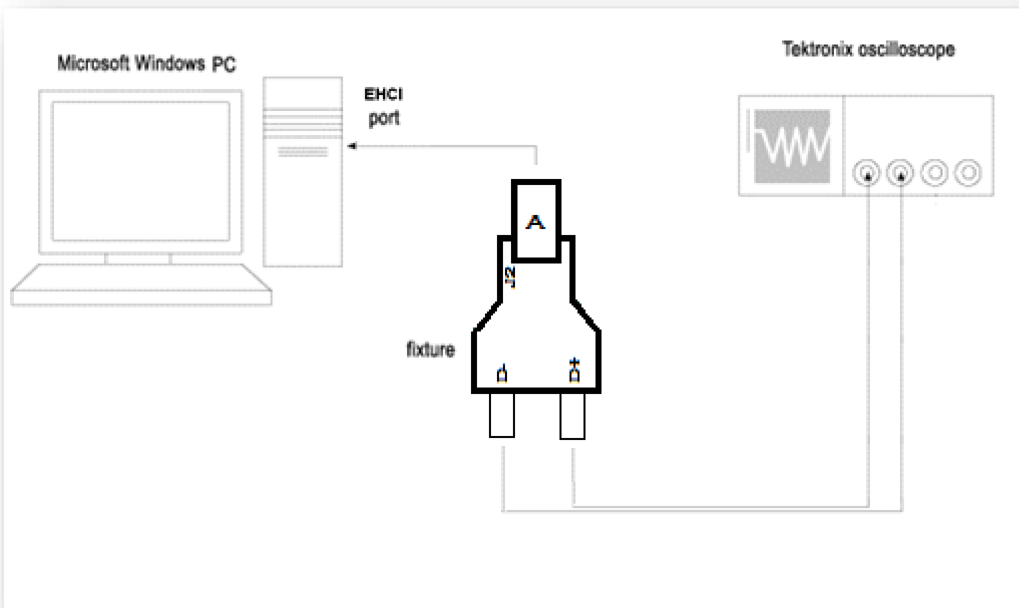



**Figure 1: Equipment Setup for Signal Quality Measurement**

To set up the equipment for the High Speed Signal Quality test, follow these steps:

1. Connect the USB2SIGQUAL compliance test fixture to the Host port.
2. Connect the two SMA cables from CH1 and CH2 of the oscilloscope to the D+ and D- SMA connections on the fixture.

3. Run the High-Speed Electrical Test Tool software on the host PC. EHCI_HSETT main menu shown in figure below.

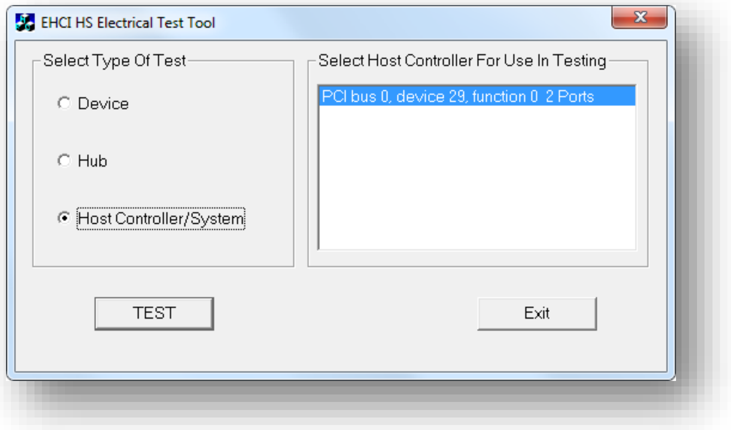



**Figure 2: High-Speed Electrical Test Tool - Main Menu**

4. Configure the device into the test mode from the host PC controller. Select TEST_PACKET from the Device Command dropdown menu; enter the port number of the port being tested and click EXECUTE.

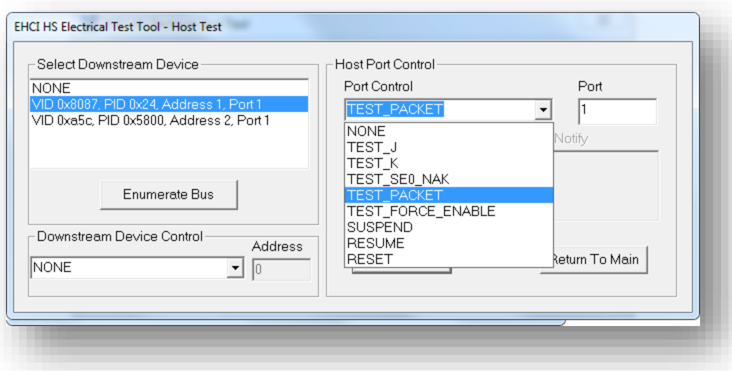



**Figure 3: Test Host Packet**

### Selecting and Configuring Measurements-Signal Quality Tests for High Speed Host (DownStream Testing)

5. On the Tektronix scope, set your Math channel to **Ch1 - Ch2**

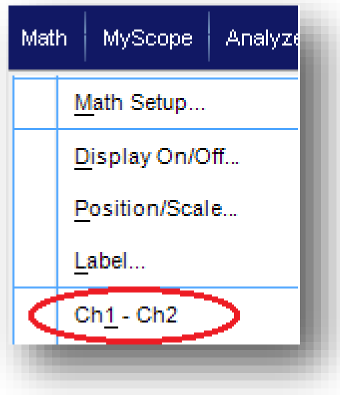



Figure 4: Math Setup

6. Adjust the scope Horizontal scale so that one complete packet is displayed

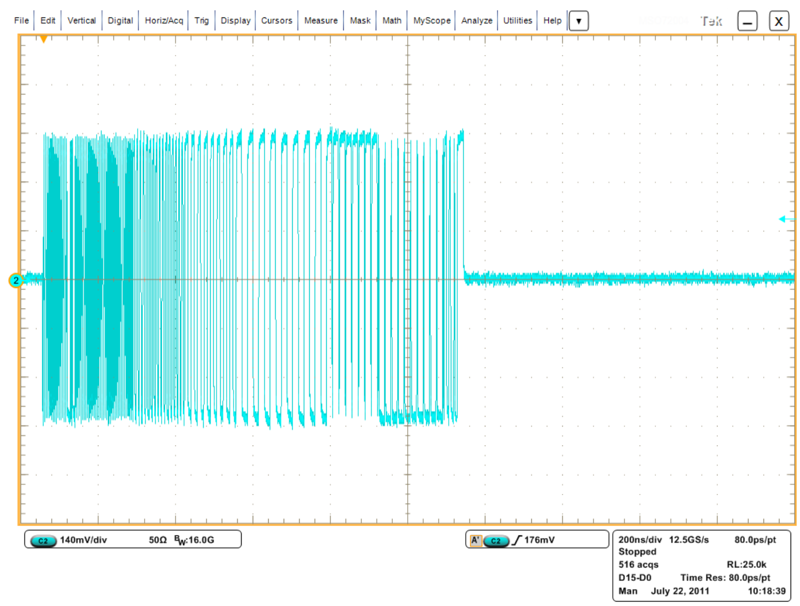



Figure 5: Test Packets

7. Save Math waveform as a CSV (*.csv) or Tek Waveform (*.wfm) for later processing.

### Selecting and Configuring Measurements-Signal Quality Tests for High Speed Host (DownStream Testing)

Launch USB Electrical Analysis Tool 2.0 (Download from www.USB.org)

8. From the application menu, select **Device/Host SQ (tab)**.

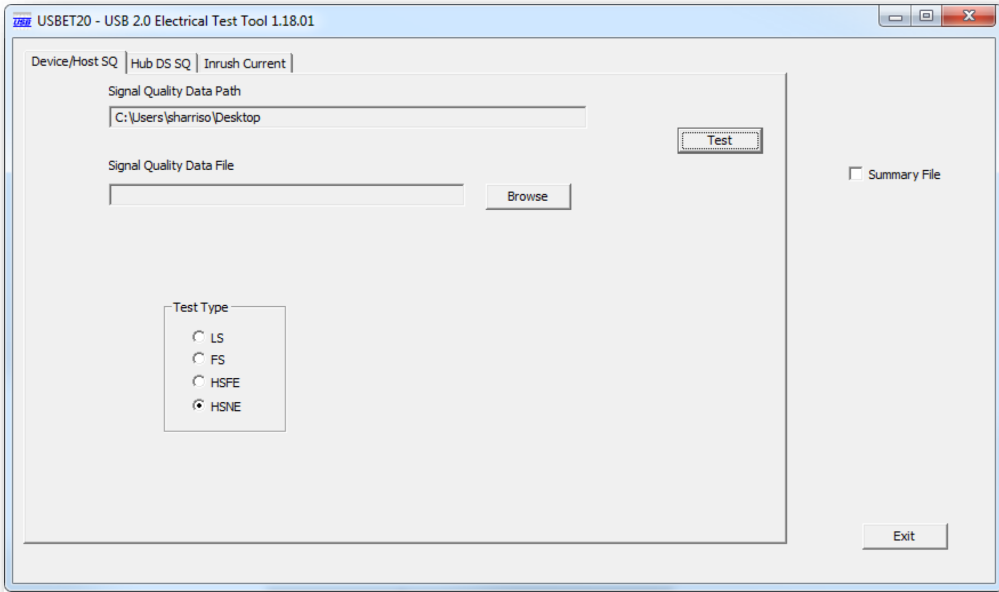



Figure 6: USBET20 Analysis Tool

9. Select the Test Type:
   - HSNE (High Speed Near End)

10. Browse to the Math waveform saved from the scope.

11. Press **Test.**

***REPEAT FOR EACH PORT**

## Packet Parameter Measurement

**(EL_21, EL_22, EL_23, EL_25, EL_55)**

### Specifying the Equipment-Packet Parameter Measurement

- Tektronix digital oscilloscope
- One differential probe
- Host PC
- 1 meter USB2.0 cable

### Typical Equipment Setup-Packet Parameter Measurement

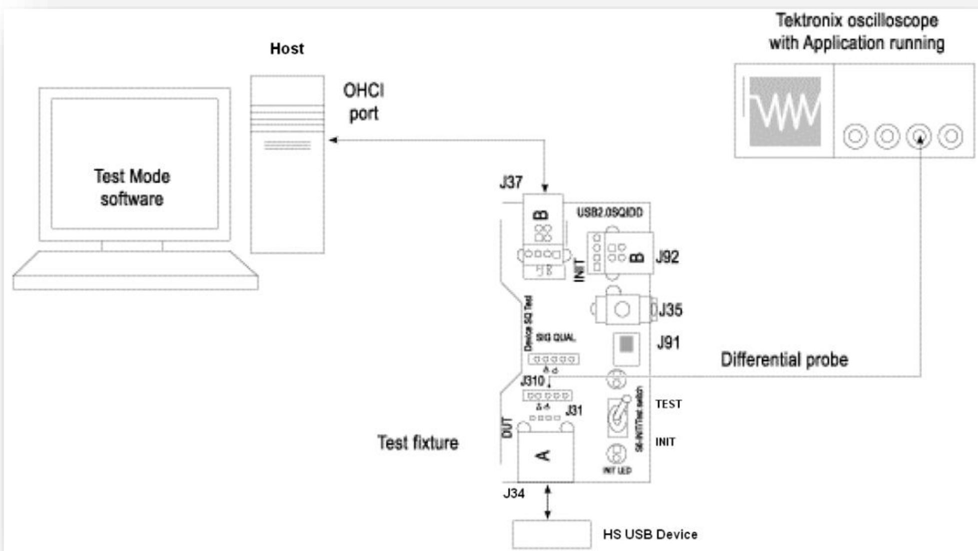



Figure 7: Equipment Setup for Packet Parameter Measurement

**Test Fixture Setup**

To set up the test fixture, follow these steps:

1. Set the **S6** switch to the **INIT** position.
2. Connect the standard USB cable between the Device SQ Init port **(J37)** and the host PC port.
3. Connect the A receptacle (marked DUT) from the Device SQ test port **(J34)** to a known good high speed device (i.e. thumb drive, memory stick… etc.)
4. Apply the power to the test fixture.
5. Attach the differential probe near the device connector on the test fixture **(J31)**.

### Selecting and Configuring Measurement-Packet Parameter Measurement

**Oscilloscope Setup**

**6.** Verify that SOFs (Start Of Frame packets) are being transmitted.

**7.** Set the vertical scale to 200mV/div and the horizontal scale to 400ns/div.

**8.** Go to scope trigger menu to trigger on:

   a. Width: The EOP is required to be NRZ 01111111 without bit stuffing. Since the only other traffic is SOF's, we can trigger on the EOP; 7 x 2.08ns = 14.56ns

   b. Edge: Since we are measuring at the device, its amplitude should be higher than from the host. Set the Edge trigger just below the nominal voltage of 400mV

**9.** In the HS Electrical Test Tool application- select SINGLE STEP GET DEV DESC from the Downstream Device Command dropdown menu and click EXECUTE once.

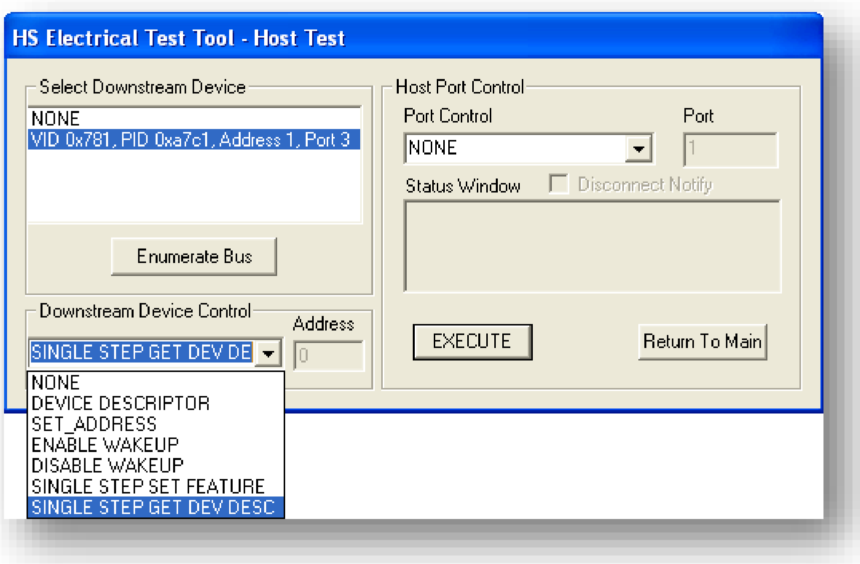



**Figure 8: Device Single Step Set Feature**

- The oscilloscope capture should appear as follows:

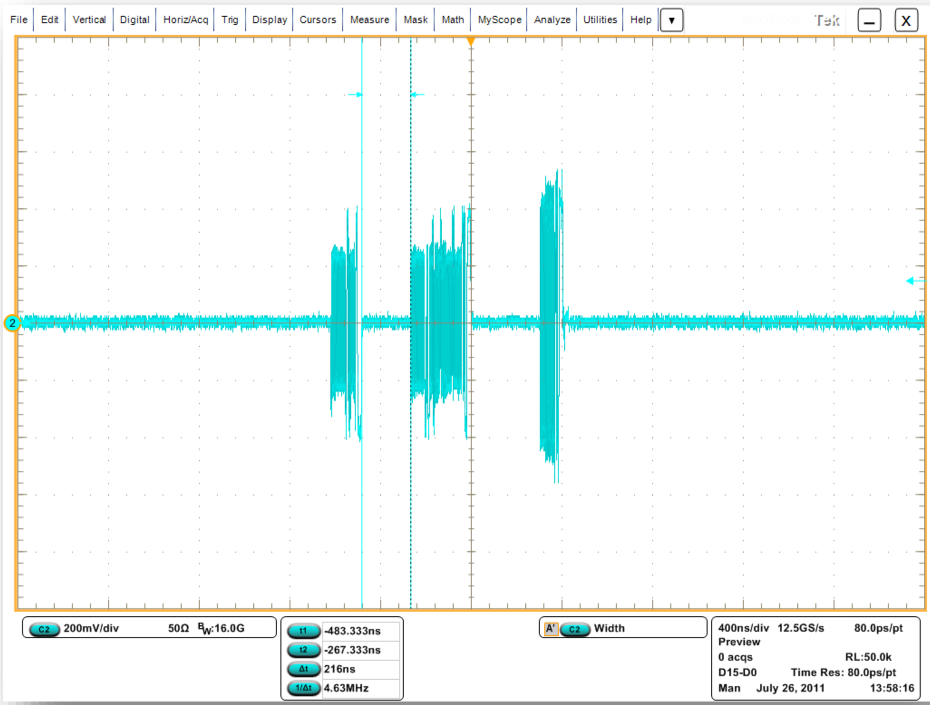



**Figure 9: Device Packets**

- The synchronous bits (32) from the second packet is EL_21: The SYNC field for all transmitted packets (not repeated packets) must begin with a 32 bit SYNC field.

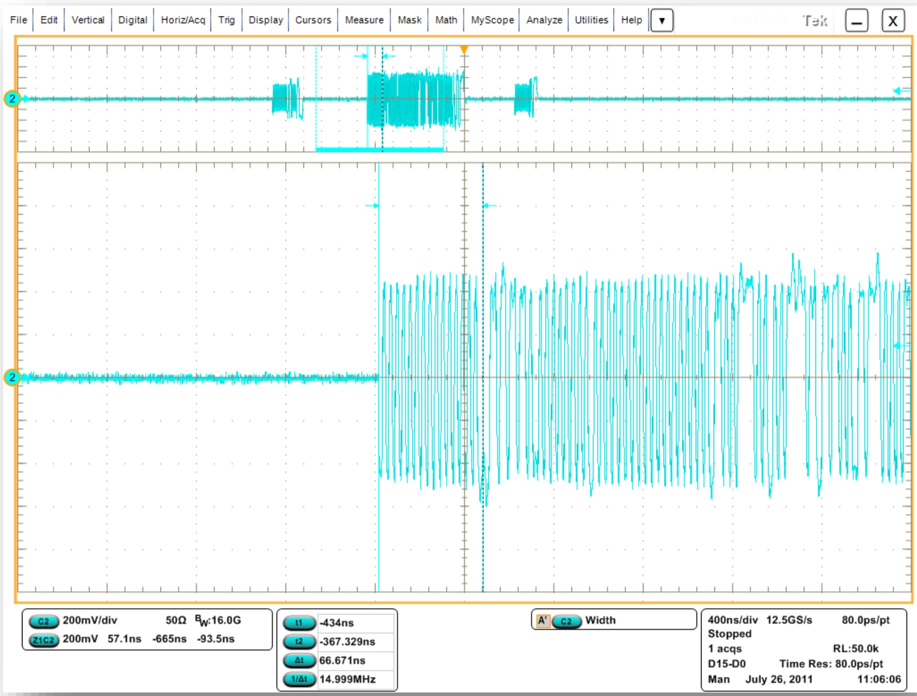



Figure 10: Sync Field - Device Packet

- The inter-packet gap (EL_23) between the first two packets shown on the oscilloscope are back-to-back packets from the host (Setup packet and data packet). The requirement is that it must be between 88 bits and 192 bits (183ns & 400ns).

- The results consist of EL_25 EOP (End of Packet) width (number of bits) for all transmitted packets (except SOFs) must be an 8 bit NRZ byte of 01111111 without bit stuffing.  Second packet on oscilloscope

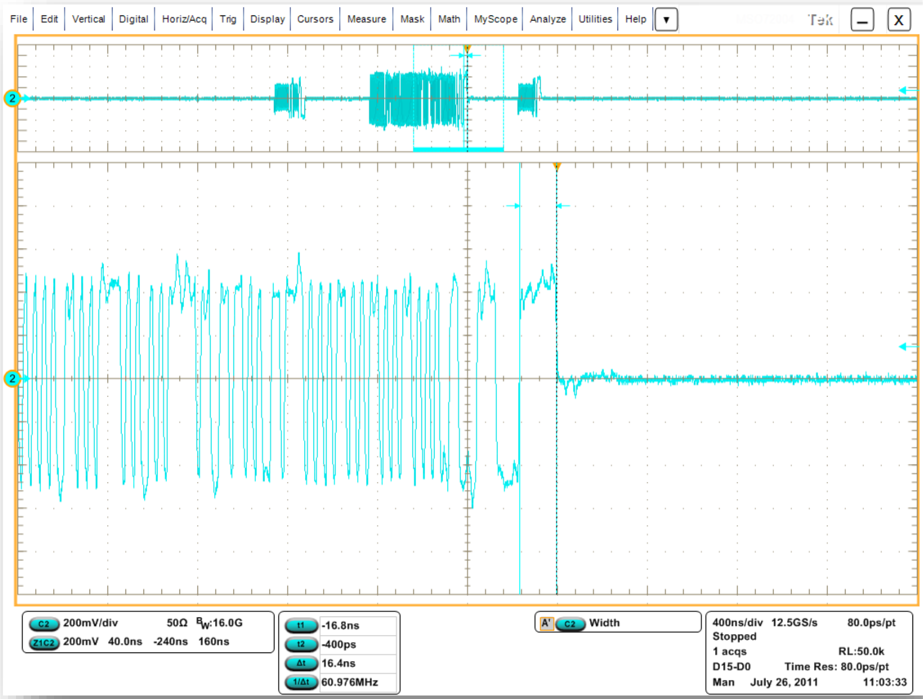



Figure 11: EOP in Device's Packet

### Selecting and Configuring Measurement-Packet Parameter Measurement

1. The Scope should still be setup from previous measurement. Press ‘Step’ from EHCI HS Electrical Test Tool
2. In the HS Electrical Test Tool application- click STEP once.
3. The oscilloscope capture should appear as followed.

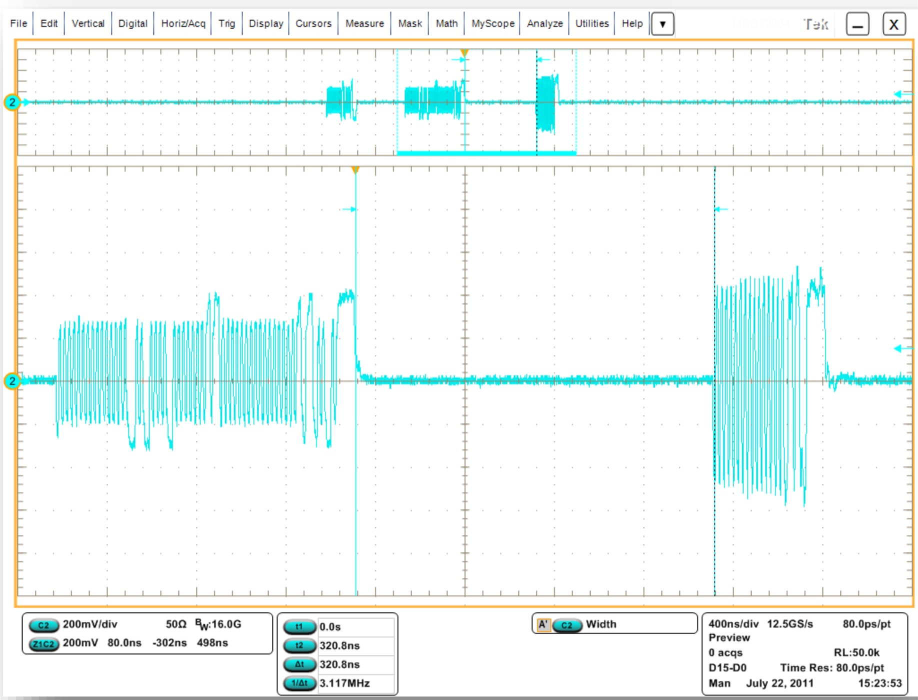



Figure 12: Inter Packet Gap - Host Respond to Device

- The results consist of the inter-packet gap (EL_22) between the second and the third packets shown on the oscilloscope. The second (of higher amplitude) is a device packet and the third is the host response. The requiremtns is it must be between 16.64ns (8 bits) and 399.4ns (192 bits).

### Selecting and Configuring Measurement-Packet Parameter Measurement

1. Adjust the scope trigger to trigger on edge trigger and lower till Start of Frames (SOF’s) appear.
2. The EOP should be 83.2ns (40 bits) EL_55

# Chirp Timing

**(EL_33, EL_34, EL_35)**

### Specifying the Equipment-Chirp

The following equipment is needed to test Chirp measurement:

- Tektronix digital oscilloscope
- TDSUSBF compliance test fixture
- Two single-ended probes
- Host PC
- 1 meter USB cable

### Typical Equipment Setup-Chirp

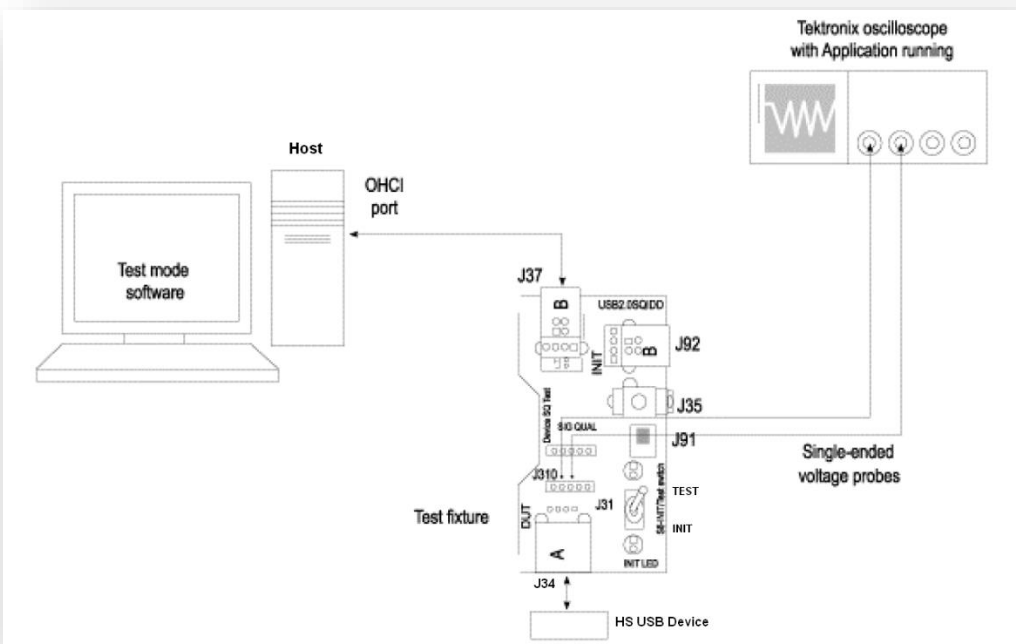



Figure 13: Equipment Setup for Chirp Measurement

To set up the equipment for the Chirp test, follow these steps:

1. Set the **S6** switch to the **INIT** position.
2. Connect a short USB cable between the Device SQ Init port **(J37)** and the host port.
3. Connect the A receptacle (marked DUT) from the Device SQ test port **(J34)** to a known good device.

4. Connect the single-ended probes to D- and D+ on the test fixture pins **J31**.

### Selecting and Configuring Measurement-Chirp

5. Set the scope to trigger at **2.0 volts** on the **Falling** edge of **D+**.
6. Set the vertical scale to 500mV/div and the Horizontal Scale to 1.0ms/div.
7. In the HS Electrical Test Tool, click **Enumerate** and observe the chirp signal on the oscilloscope. This will resume the device from suspend state.

*Note*: Instead of enumerating the device, an alternative method to generate the chirp signal, is to disconnect and reconnect the Device to the port.

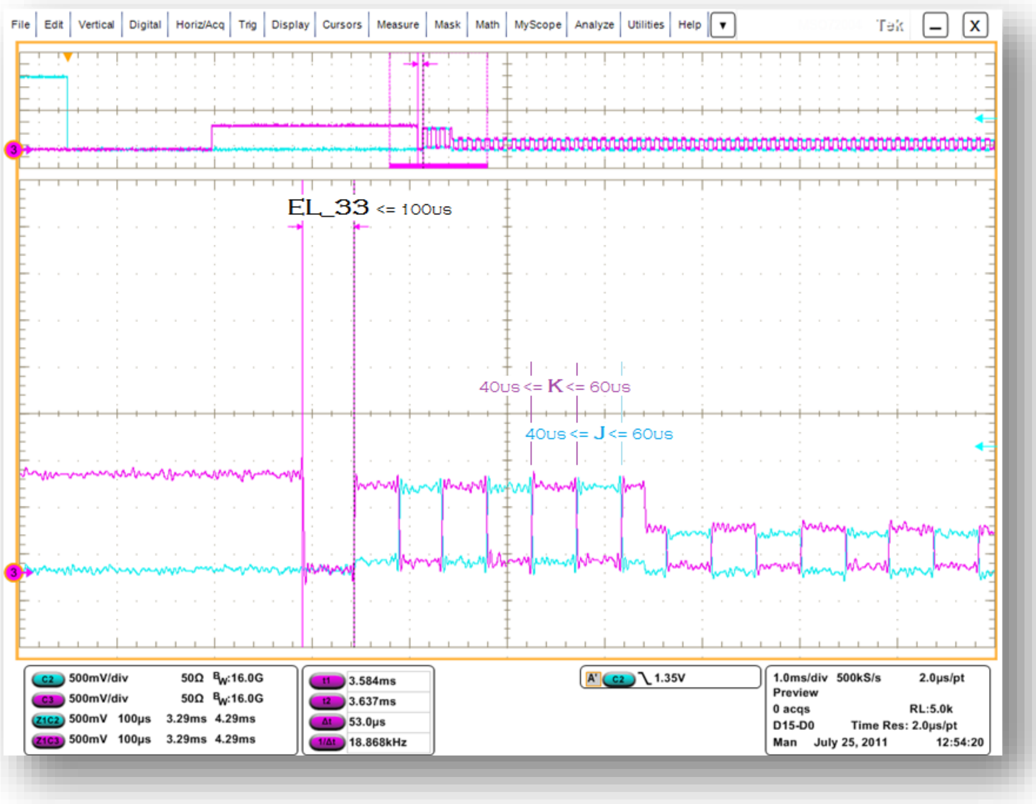



**Figure 14: Host Chirp-K Latency (EL_33, EL_34)**

- EL_33: This is the time between the Chirp-K stops and the downstream port start sending and alternating sequence of Chirp-K and Chirp-J. The timing should be ≤ 100us.

- EL_34: The durations of the individual Chirp-K and Chirp-J states and verifies that both are between 40us ≤ 60us.

- EL_35: The time from the last of host Chirp (J or K) to the first SOF sent out by the host. The result (EL_35) should be between 100us ≤ 500us.

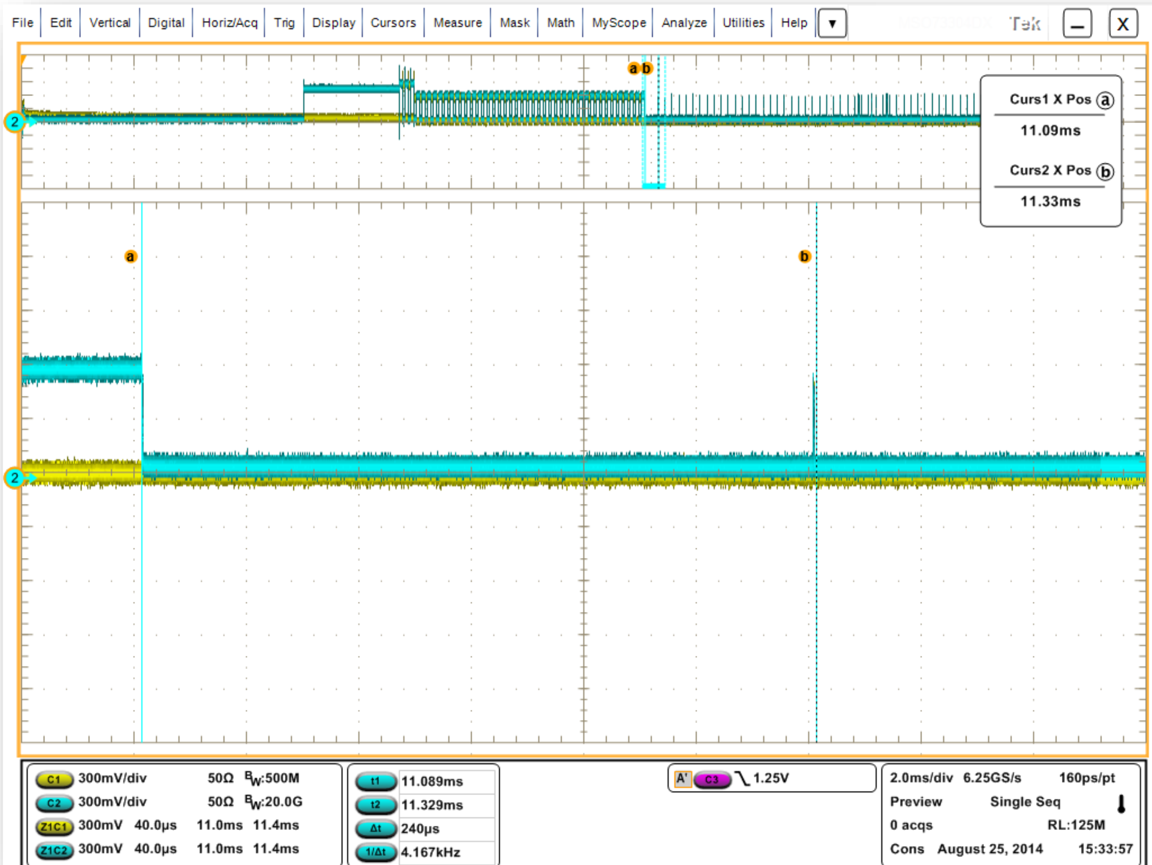



**Figure 15: Host Chirp (EL_35)**

## Suspend/Resume Timing Measurement
**(EL_39, EL_41)**

**Specifying the Equipment-Suspend Measurement**

The following equipment is needed for Suspend measurement:

- Tektronix digital oscilloscope
- TDSUSBF compliance test fixture
- Two single-ended probes
- Host PC
- 1 meter USB cable

**Typical Equipment Setup-Suspend Measurement**

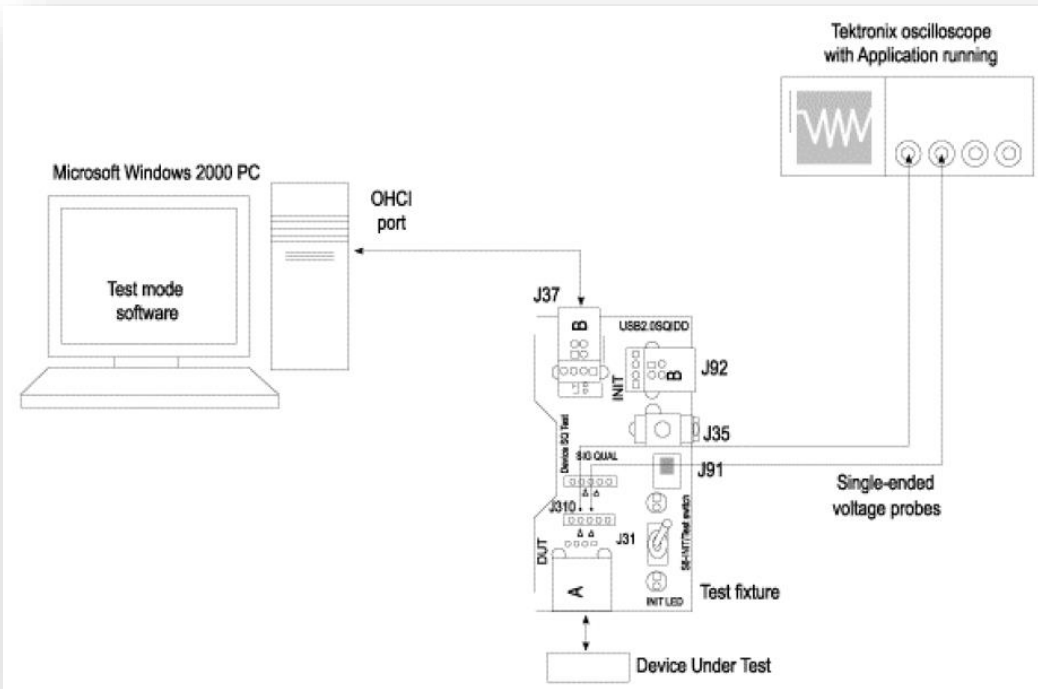



Figure 16: Equipment Setup for Suspend Measurement

To set up for the Suspend test, follow these steps:

1. Set the **S6** switch to the **INIT** position.
2. Connect a short USB cable between the Device SQ Init port **(J37)** and the host port.
3. Connect the A receptacle from the Device SQ test port **(J34)** of the test fixture to a known good Device. (i.e. certified USB thumb drive)

4. Connect the single-ended probes of the oscilloscope to the D+ and D– pins **(J31)**.

### Selecting and Configuring Measurement-Suspend Measurement

5. Set the scope to trigger on the **Rising** edge at 2.5V of the D+ line. When suspended, the D+ pull-up resistor will bring the voltage to between 3.0 – 3.6 volts.
6. Set the vertical scale to 500mV/div and the horizontal scale to 400us/div
7. In the HS Electrical Test Tool application- select SUSPEND from the Device Command dropdown menu and click EXECUTE once.

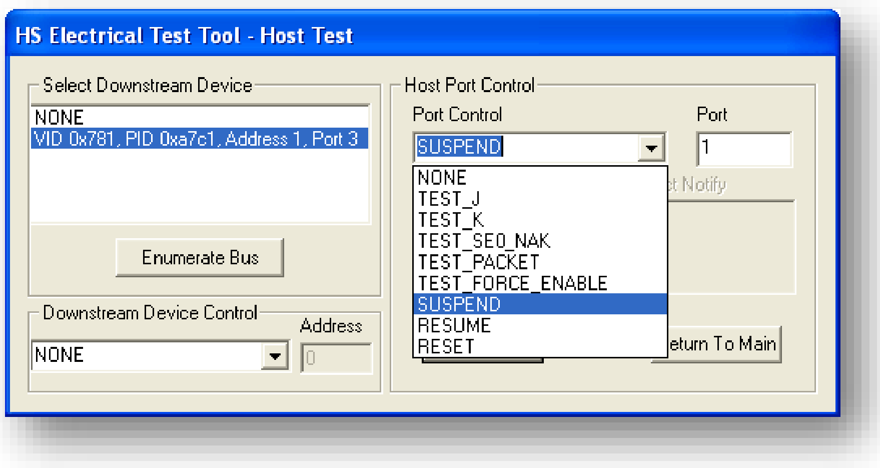



Figure 17: Device Suspend

8. The captured suspend transition should appear as in the following figure.

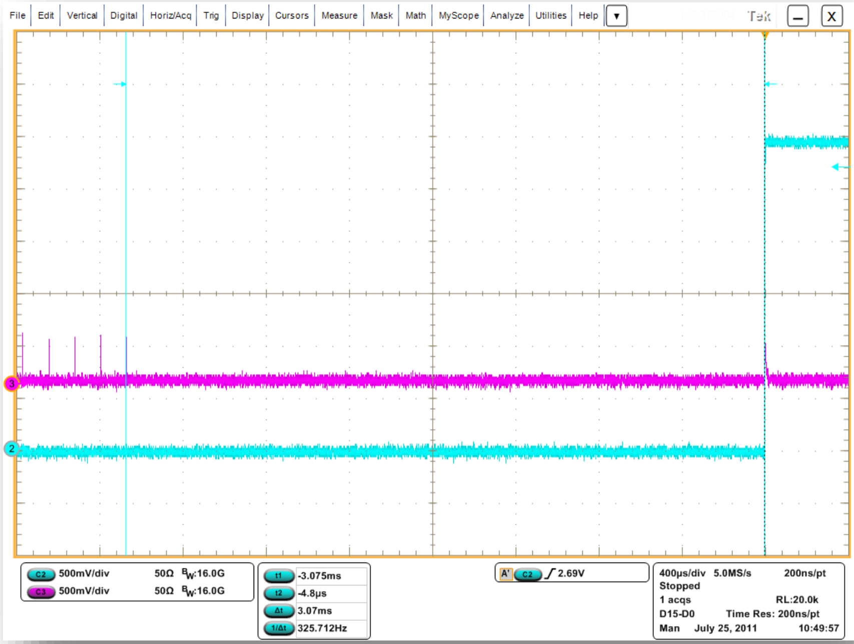



Figure 18: Device Respond to Suspend from High-Speed

- EL_39: Is the time interval from the end of last SOF packet issued by the host to when the device attached its full speed pull-up resistor on D+. This is the time between the last SOF packet and the rising edge transition to full speed J-state. Time should be between 3.000 ms and 3.125 ms.

**Continue To Resume Test**

**9.** Setup the scope trigger to trigger on the **Falling** edge of D+.

**10.** On the Host Test menu, select RESUME from the Port Control dropdown menu and enter the port number. Click EXECUTE once to resume the port.

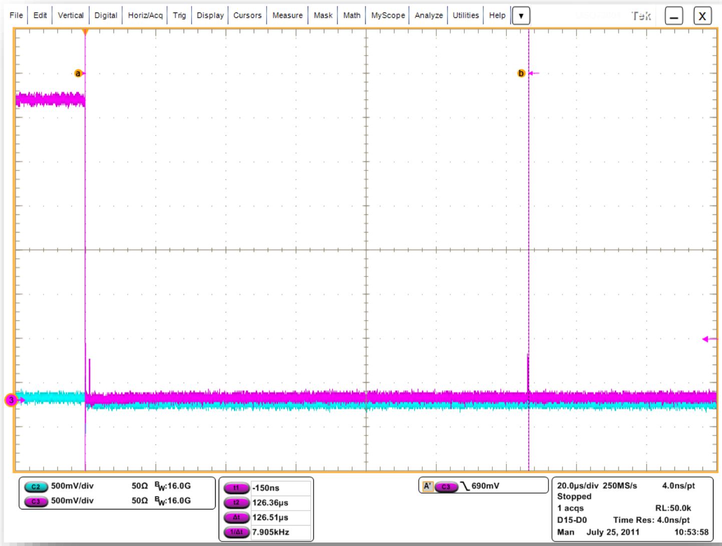



Figure 19: Resume (EL_41)

- EL_41: The time from the falling edge of D+ to the first SOF issued by the host as shown in the figure above. From the falling edge of D+ to the first SOF issued by the host never exceeds 3ms.

## *REPEAT FOR EACH PORT

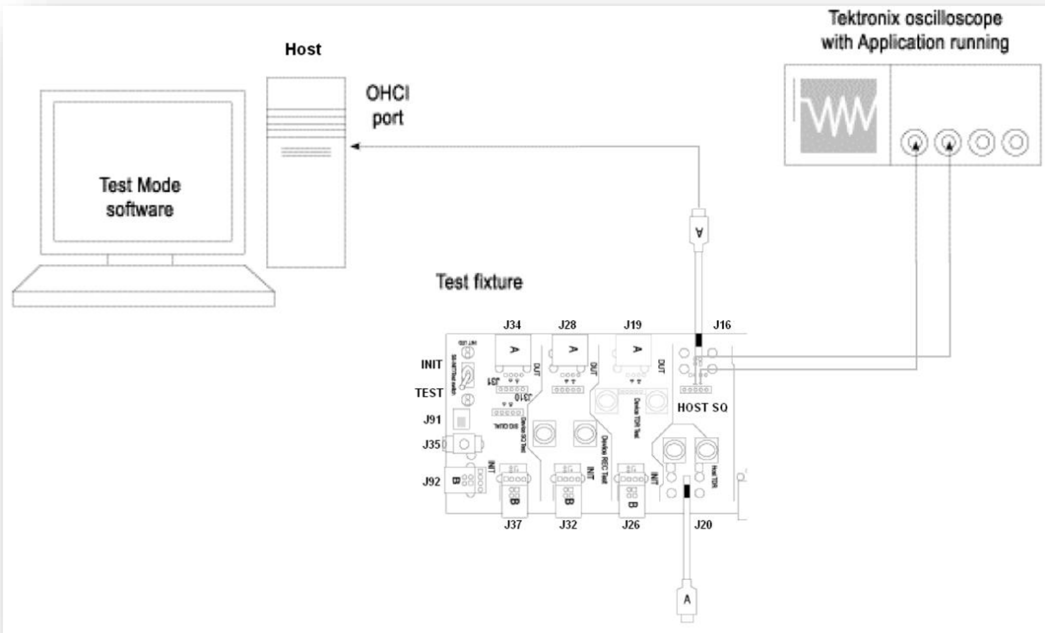
## Host Test J/K, SE0_NAK

**(EL_8, EL_9)**

### Specifying the Equipment-J/K & SE0_NAK

- Digital Volt Meter
- TDSUSBF compliance test fixture

### Typical Equipment Setup-J/K, SE0_NAK Measurement




### Typical Equipment Setup-J/K and SE0_NAK

The section used for this host test is Host SQ on the test fixture. To set up the equipment for J/K & SE0_NAK, follow these steps:

1. On the HS Electrical Test Tool application - Device Test menu, select TEST_J from the Device Command dropdown menu. Click EXECUTE once to place the device into TEST_J test mode.

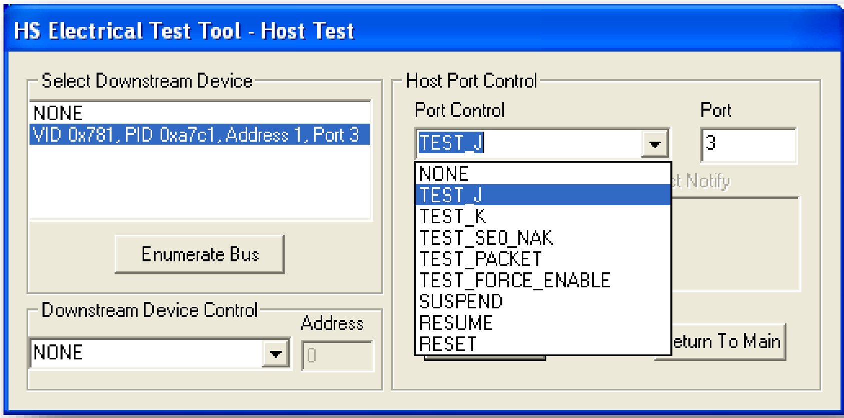



Figure 20: Device TEST_J

1. D+ output voltage must be 400mV +/-10%. D- output voltage must be 0V
2. Cycle the device power. Click Enumerate Bus once to force enumerate the device. This restores the device to normal operation.
3. On the HS Electrical Test Tool application - Device Test menu, select TEST_K from the Device Command dropdown menu. Click EXECUTE once to place the device into TEST_K test mode.
4. D- output voltage must be 400mV +/-10%.  D+ output voltage must be 0V.
5. Return the Test switch to the NORMAL position. Cycle the device power. Click Enumerate Bus once to force enumeration of the device. This restores the device to normal operation.
6. On the HS Electrical Test Tool application - Device Test menu, select TEST_SE0_NAK from the Device Command dropdown menu. Click EXECUTE once to place the device into TEST_SE0_NAK test mode.
7. D+ and D- output voltage must be 0V +/- 10mV.

## Legacy USB Compliance Tests

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

- Host Full Speed Signal Quality
- Droop Test

## Host Signal Quality Tests for Full Speed Host

**Specifying the Equipment-Full Speed Signal Quality Tests for Downstream Testing**

- Tektronix digital oscilloscope
- TDSUSBF compliance test fixture
- 5 x USB Hubs (One of them Full-Speed)
- 6 x Five Meter USB Cables
- 1 Full Speed USB Certified Device
- Two single-ended voltage probes

**Typical Equipment Setup-Full Speed Signal Quality Tests for Downstream Testing**

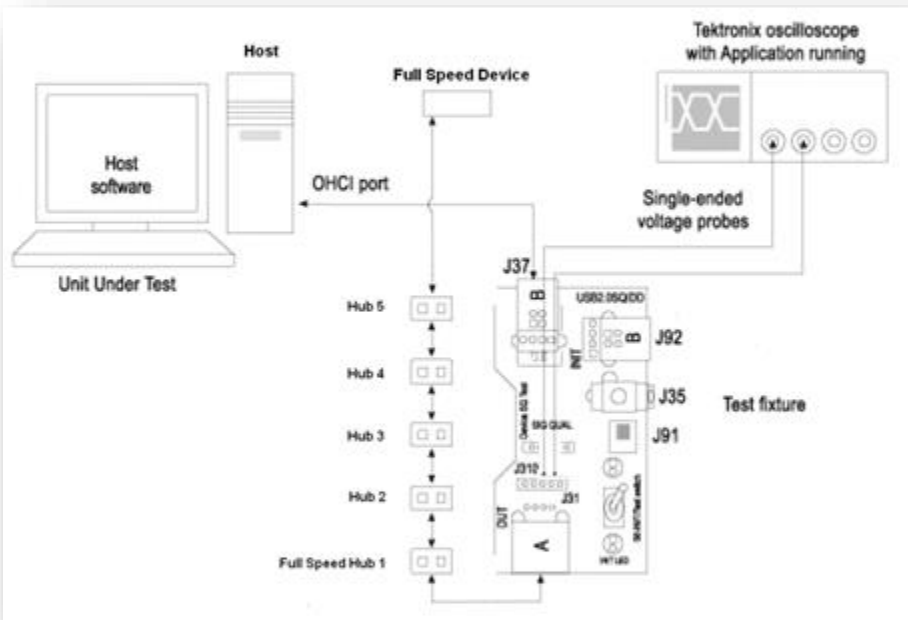



Figure 21: Equipment Setup for Full Speed Signal Quality Measurement

To set up the equipment for Full Speed Signal Quality, follow these steps:

1. Connect the Host USB port (HUT) to the B type USB receptacle of the Device SQ section on the test fixture.
2. Connect the Full Speed Qualifier device to the fifth Hub.
3. Connect Ch1 probe to the D+ pins **J31**.
4. Connect Ch2 probe to the D– pins **J31**.

5. Hub #1 is required to be a Full Speed Hub. All Hubs should be self-powered.

### Selecting and Configuring Measurements-Full Speed Signal Quality Tests for Downstream Testing

6. Set the trigger to trigger on D+ **Rising** edge at 500mV

7. On the Tektronix scope, set your Math channel to **Ch1 - Ch2**

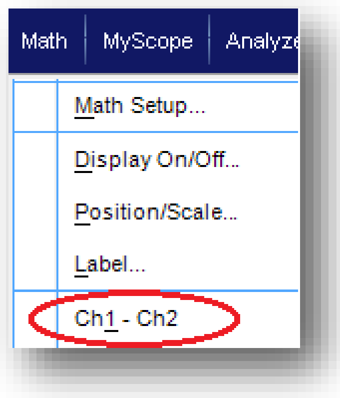



Figure 22: Math Setup

8. Adjust the scope Horizontal scale so that one complete packet is displayed

9. Save Math waveform as a CSV (*.csv) or Tek Waveform (*.wfm) for later processing.

10. Launch USB Electrical Analysis Tool 2.0 (Download from USB.org)

11. From the application menu, select **Device/Host SQ (tab)**.

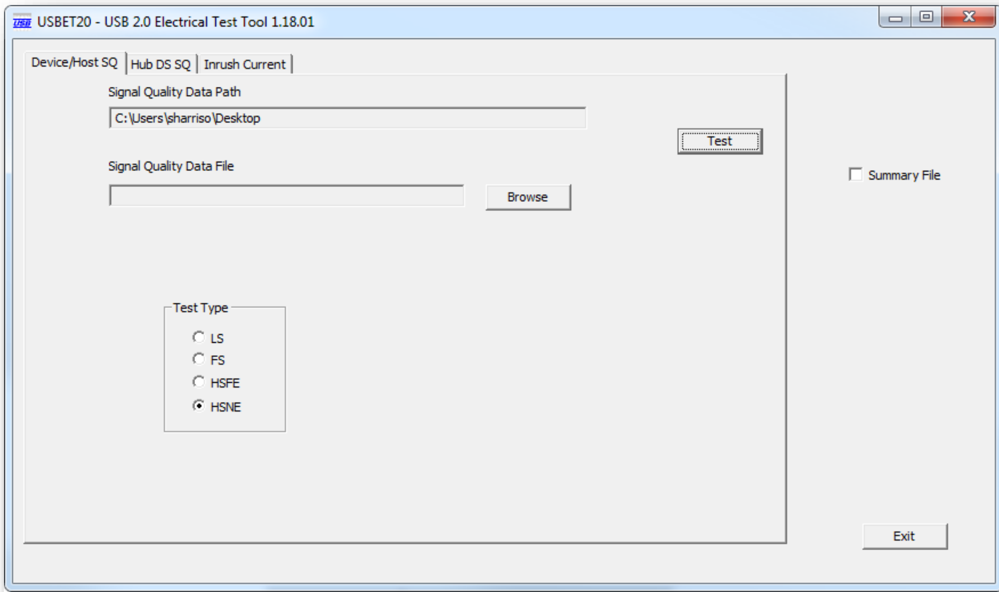



Figure 23: USBET20 Analysis Tool

**12.** Select the Test Type:

- FS

**13.** Browse to the Math waveform saved from the scope.

**14.** Press **Test.**

# Droop Test for Host

### Specifying the Equipment-Droop Test for Downstream Testing

- Tektronix digital oscilloscope
- TDSUSBF compliance test fixture
- Enough one Meter USB Cables for every Host Port
- Two single-ended voltage probes

### Typical Equipment Setup-Full Speed Signal Quality Tests for Upstream Testing

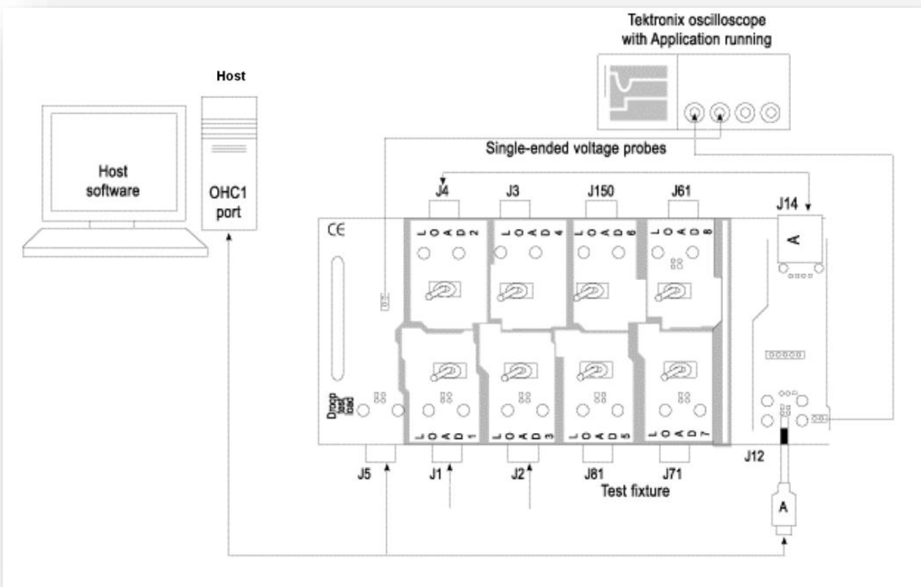



Figure 24: Equipment Setup for Full Speed Signal Quality Measurement

To set up the equipment for Droop test for Downstream, follow these steps:

1. Use the Droop and Adjacent Trigger section for the Droop test. Load the remaining ports on the Host with standard USB cables.
2. Connect Channel 1 to the VBUS on the Adjacent Trigger and Droop Test section of the test fixture; connect Channel 2 to the Droop Load Trigger Timer that is on the Droop test load section.
3. Place the loads on 500mA for self-powered Host's and 100mA for battery powered Host's (ie laptops).
4. Set the scope to trigger on the Rising edge of Channel 2.

5. Measuring Channel1 Peak-to-Peak voltage (Highest voltage – Lowest voltage) will indicate the Droop.

- The Droop voltage is the difference in the VBUS voltage when you apply a no load condition and a 100mA load to the port under test and all other ports are fully loaded. The droop must not exceed 330mV