# Embedded Host & OTG

# High Speed Electrical Test Procedure

Revision 0.97

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## 1. Reference

| Standard | Description | Revision | Status |
|---|---|---|---|
| USB 2.0 Spec | USB 2.0 Specification with ECN | 2.0 | Released |
| OTG & EH Supplement 2.0 | | | |
| OTG & EH Compliance Plan | | | |
| | | | |
| | | | |

## 2. Background

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 active 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 (HSET) which is Windows based, to activate the various test modes and operations.

Problem is that HSET only runs on Windows based PC systems and cannot be used for High Speed USB hosts that not run Windows PC systems.

The solution for this problem is that the “On-The-Go and Embedded Host Supplement to the USB Revision 2.0 Specification” defines a method in entering the required high speed electrical test modes.

USB 3.0 Super Speed Embedded host that support USB 2.0 High Speed should follow the same guidelines as described in this document.

It’s important that non-windows based host vendors implement these test modes.

# 3. Test Mode Support

## 3.1 Setup

PID/VID and Agilent E2649-26402

The Agilent E2649-26402 has the option to directly probe via SMA (for HS EYE) and with differential probe (for packet parameter). Keep the cable between the fixture and host under test as short as possible.

### 3.1.1 Micro AB setup

OTG product and some Embedded Host have a micro AB receptacle. For those product a short adapter with mirco-A plug to standard A-receptacle is required.

If the product is an OTG product the micro-A plug will force it to host mode there it has the ID-pin to GND.

## 3.2 USB High Speed PID definitions

The VID is 0x1A0A. The PIDs presented by the PID/VID corresponds with the following test modes.

| PID | Test Mode |
|---|---|
| **0x0101** | TEST_SE0_NAK |
| **0x0102** | TEST_J |
| **0x0103** | TEST_K |
| **0x0104** | TEST_PACKET |
| **0x0105** | RESERVED |
| **0x0106** | HS_HOST_PORT_SUSPEND_RESUME |
| **0x0107** | SINGLE_STEP_GET_DEV_DESC |
| **0x0108** | SINGLE_STEP_SET_FEATURE |

## 3.3 Test mode details

*High-speed Electrical Test Mode Support*

All USB-IF high-speed host electrical compliance tests shall be performed on high-speed hosts. These high-speed tests utilize the test modes defined in Section 7.1.20 of [USB2.0]. An OTG device or EH shall support the test device that initiates these test modes. Upon enumeration by the host, the test device presents a VID/PID pair that defines a test mode or operation to execute. Upon enumerating the test device with VID of 0x1A0A, the Targeted Host shall perform the following operations based on the PID presented. The test mode or operation shall occur on the port where the test fixture is attached. The test devices shall continue to be recognized by retail examples of the devices, to permit subsequent audit.

**Test_SE0_NAK**

Upon enumerating VID 0x1A0A/PID 0x0101, the hosts downstream port shall enter a high-speed receive mode as described in Section 7.1.20 [USB2.0] and drives an SE0 until the controller is reset.

**Test_J**

Upon enumerating VID 0x1A0A/PID 0x0102, the host's downstream port shall enter a high-speed J state as described in Section 7.1.20 of [USB2.0] until the host controller is reset.

**Test_K**

Upon enumerating VID 0x1A0A/PID 0x0103, the host's downstream port shall enter a high-speed K state as described in Section 7.1.20 of [USB2.0] until the host controller is reset.

**Test_Packet**

Upon enumerating VID 0x1A0A/PID 0x0104, the host shall begin sending test packets as described in Section 7.1.20 of [USB2.0] until the host controller is reset.

**HS_HOST_PORT_SUSPEND_RESUME**

Upon enumerating VID:0x1A0A/PID 0x0106, the host shall continue sending SOFs for 15 seconds, then suspend the downstream port under test per Section 7.1.7.6.1 of [USB2.0]. After 15 seconds has elapsed, the host shall issue a ResumeK state on the bus, then it will continue sending SOFs.

**SINGLE_STEP_GET_DEVICE_DESCRIPTOR**

When the host discovers a device with VID 0x1A0A/PID 0x0107, the following steps are executed by the host and the device.

1. The host enumerates the test device, reads VID 0x1A0A/PID 0x0107, then completes its enumeration procedure.

2. The host issues SOFs for 15 seconds allowing the test engineer to raise the scope trigger just above the SOF voltage level.

3. The host sends a complete GetDescriptor(Device) transfer

4. The device ACKs the request, triggering the scope. (Note: SOFs continue.)

**SINGLE_STEP_GET_DEVICE_DESCRIPTOR_DATA**

When the host discovers a device with VID 0x1A0A/PID 0x0108, the following steps are executed by the host and the device.

1. The host enumerates the test device and reads VID 0x1A0A/PID 0x0108, then completes its enumeration procedure

2. After enumerating the device, the host sends GetDescriptor(Device)

3. The device ACKs the request

4. The host issues SOFs for 15 seconds allowing the test engineer to raise the scope trigger just above the SOF voltage level

5. The host sends an IN packet

6. The device sends data in response to the IN packet, triggering the scope

7. The host sends an ACK in response to the data. (Note: SOFs may follow the IN transaction).

## 3.4 Test mode implementation

Windows PC systems can use the USB.ORG tool USBHSET for the High Speed electrical tests but USB hosts that run another OS's will require to implement a VID, PID detection. Upon detecting the VID PID as in the above chapter 4.3 the host will have to behave accordingly.

Appendix A give some details how this should be implemented for Linux variants.

For updates and more details please check www.testusb.com

## 3.5 High Speed Embedded Host Tester (PID/VID)

In order to send the required VID and PID the High Speed Embedded Host Tester (PID/VID) of www.testusb.com can be used. With this small bus powered device you select the required test mode with the selection switch and plug it into the High Speed embedded Host. Between the EHost and PID/VID the high speed host test fixture is connected in order to make it possible to probe the signals.

## 3.6 High Speed Embedded Host with internal Hub

TO BE DONE

*<When a Hub is*
*A Hub may add EOP width*
*Remove SYNC bits*
*Increase packet delay*

*http://compliance.usb.org/index.asp?UpdateFile=Electrical&Format=Standard#43*

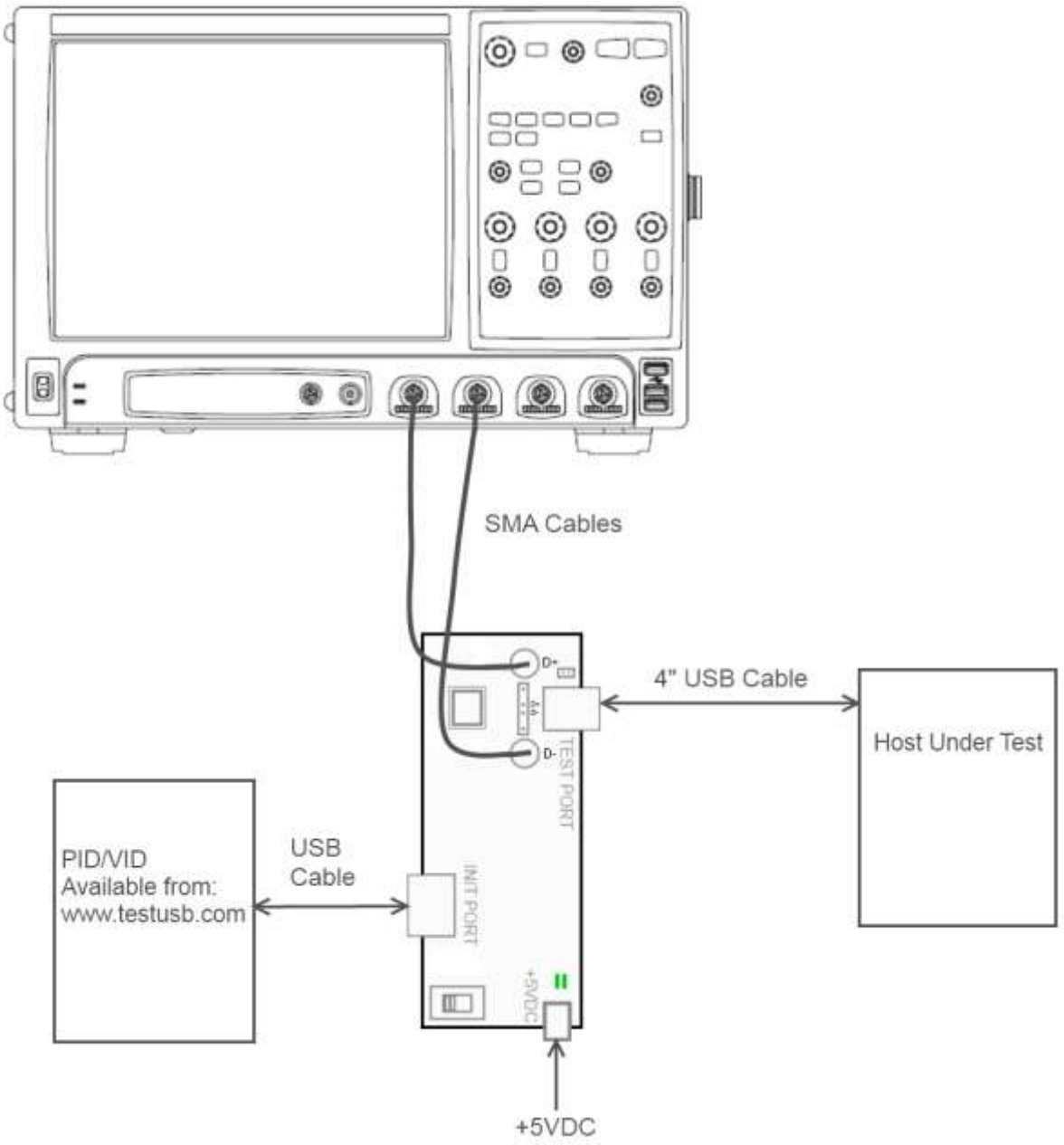
*>*

# 4. Test Procedure

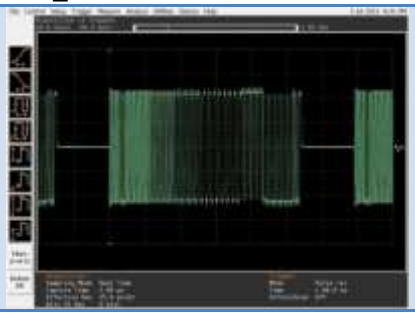
## 4.1 High Speed Signal Quality (EL_2, EL_3, EL_6, EL_7)

This test is measuring the downstream near end Signal Quality (EYE diagram). For this test the host 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.

**Test Setup:**



**Test Procedure:**

| | Test Fixture & PID/VID | EHost |
|---|---|---|
| **1** | Apply power to the test fixture and put test fixture switch test mode off. LED power illuminate (Green LED), Test mode not (Orange LED) | |
| **2** | Attach the two SMA cables to the fixture with the D+ to Channel 1 and D- to Channel 2 of the Scope and make the scope settings accordingly. For the differential signal subtract Channel 1 with Channel 2. | |
| **3** | Connect a short USB cable from the Test port of the fixture to the Embedded Host under test. | |
| **4** | Before connecting the PID/VID put it in the correct position by selecting *Test_Packet.* | |
| **5** | Connect the PID/VID to the Initialize host port | |
| **6** | | Host enumerates the PID/VID and responds to send continuously Test_Packet |
| **7** | Flip the switch of the test fixture that switches the termination on. LED power and Test mode illuminate (Orange LED lit). |  |
| **8** | Scope will capture the packet. | |
| **9** | Scope will analyze and calculate the parameters with USBET. (EL_2, EL_3, EL_6, EL_7) | |
| **10** | If there are more ports available repeat the test for the remaining downstream ports. | |

A power cycle of the host is required in order to proceed.

## 4.2 Host Controller Packet Parameters (EL_21, EL_22, EL_23, EL_25, EL_55)

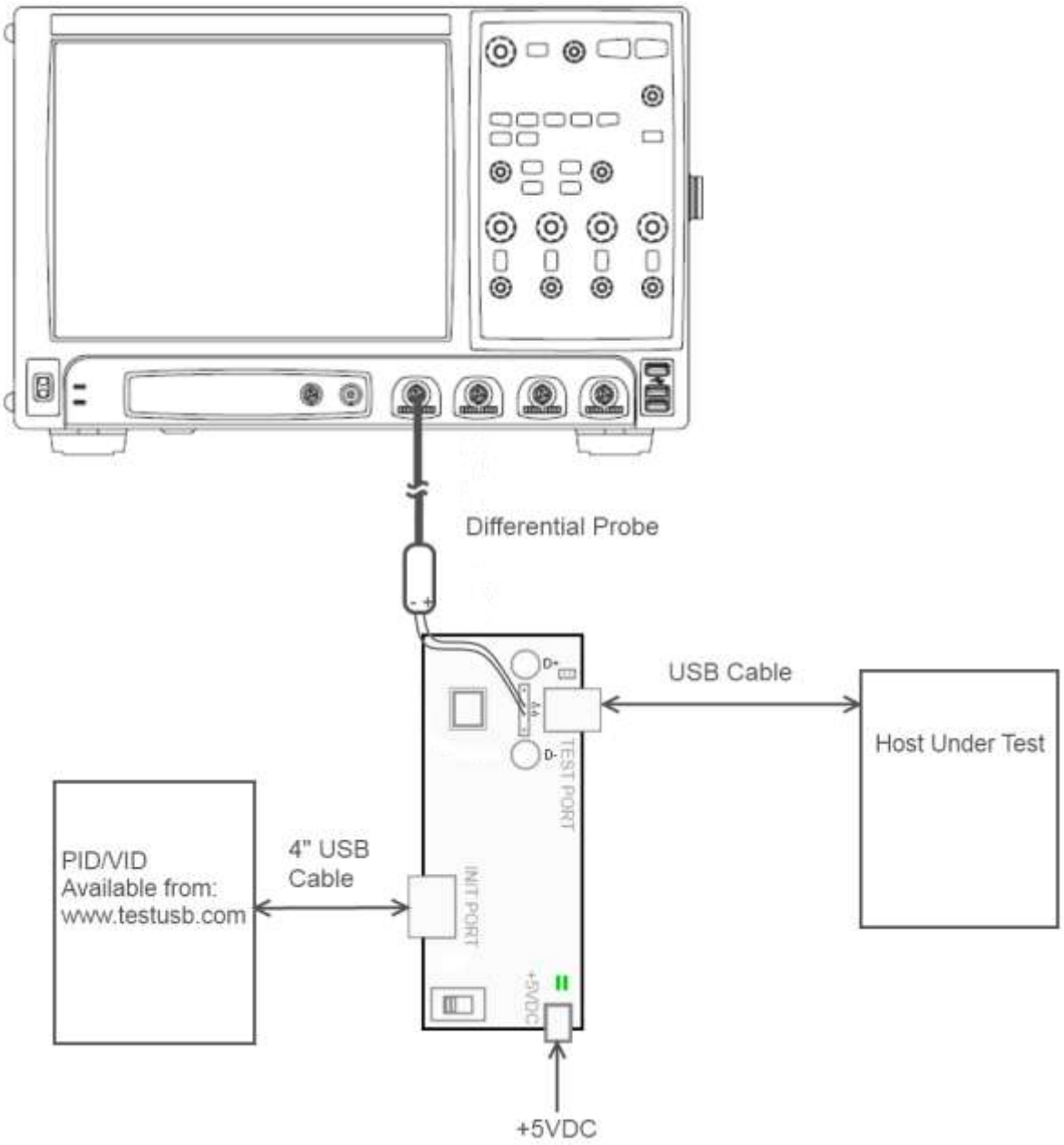
The test will measure the sync field (EL_21) EOP field (EL_25), EOP field of SOF (EL_55), the delay between two host packets (EL_23) and the response time of a host to a device packet (EL_22)

**Test Procedure:**

This test is split up into two sub-tests.

### 4.2.1. SINGLE_STEP_DEV_DESC (EL_21, EL_25, EL_23)

**Test Setup:**

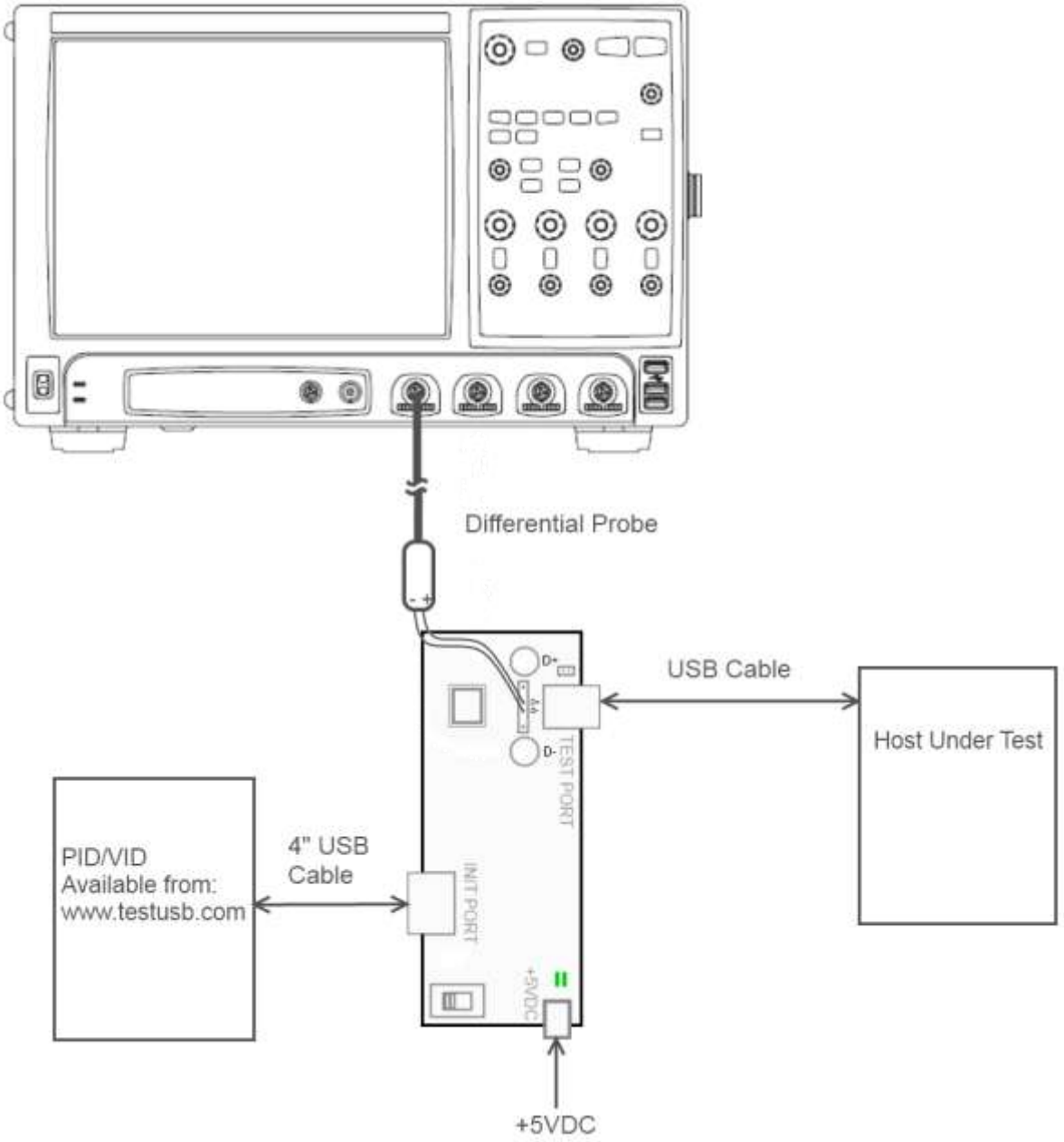


| | Test Fixture & PID/VID | EHost |
|---|---|---|
| **1** | Apply power to the test fixture and put test fixture switch test mode off. LED power illuminate (Green LED), Test mode not (Orange LED) | |
| **2** | Terminate the SMA probing points with 50Ohm. | |
| **3** | Connect the differential probe to TP2. With the + of the probe to D+. | |
| **4** | Connect a long USB cable (*) from the Test port of the fixture to the Embedded Host under test. | |
| **5** | Before connecting the PID/VID put it in the correct position by selecting SINGLE_STEP_GET_DEVICE_DESCRIPTOR. | |
| **6** | Connect with a short USB cable the PID/VID to the Initialize port | |
| **7** | | Host enumerates the PID/VID and responds to send SOFs for 15 seconds.  |
| **8** | Verify SOFs are send and increase the scope amplitude trigger level until SOFs are no longer triggered. (*) | |
| **9** | | After 15 seconds of SOFs the host initiates the setup phase of the GetDescriptor() command. The host sends SETUP and DATA. (first and second packet)  |
| **10** | The PID/VID sends an ACK as response. The scope triggers on this ACK. | |
| **11** | The host packets are the first two packets. Measure the sync field (EL_21) EOP field (EL_25) on the first two packets and measure the time between those two (EL_23) packets. | |

(*) In order to differentiate host and device packets we use the voltage drop of the cable. The longer the cable between the test fixture and embedded host the lower the amplitude of the embedded host packet. Between the PID/VID and fixture we use a short cable since we want to trigger on device packet with higher amplitude. It's also possible to make another trigger method and not trigger on voltage amplitude different. In that case ignore step 8 (EL_23) and step 10 (EL_22).

### 4.2.2. SINGLE_STEP_SET_FEATURE (EL_22, EL_55)

**Test Setup:**

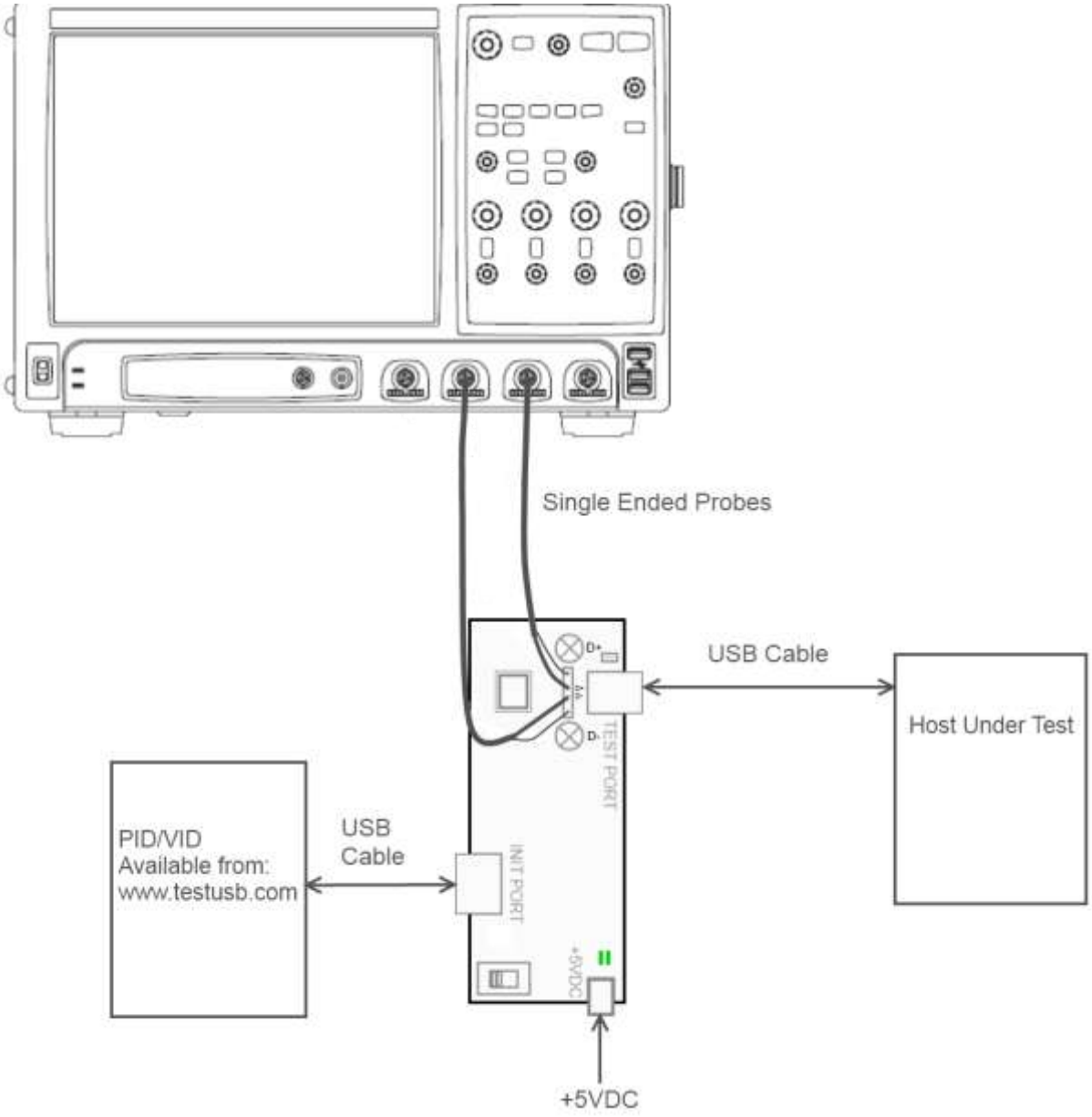


| | Test Fixture & PID/VID | EHost |
|---|---|---|
| **1** | Apply power to the test fixture and put test fixture switch test mode off. LED power illuminate (Green LED), Test mode not (Orange LED) | |
| **2** | Terminate the SMA probing points with 50Ohm. | |
| **3** | Connect the differential probe to TP2. With the + of the probe to D+. | |
| **4** | Connect a long USB cable from the Test port of the fixture to the Embedded Host under test. (*) | |
| **5** | Before connecting the PID/VID put it in the correct position by selecting SINGLE_STEP_GET_DEVICE_DESCRIPTOR_DATA | |
| **6** | Connect with a short USB cable the PID/VID to the Initialize port. | |
| **7** | | The host enumerates the PID/VID and request GetDescriptor() |
| **8** | PID/VID send ACK | |
| **9** | | The host sends for 15 seconds SOFs |
| **10** | Verify SOFs are send and increase the scope amplitude trigger level until SOFs are no longer triggered. | |
| **11** | | Host issues an IN |
| **12** | PID/VID send DATA (second packet) that trigger the scope. | |
| **13** | | Host send an ACK (third packet) |
| **14** | EL_22 Measure the time between DATA (second) and ACK (third) |  |
| **15** | Lower the trigger level of the scope so it triggers on SOFs. | |
| **16** | EL_55 Measure the EOP of the SOF packet. |  |

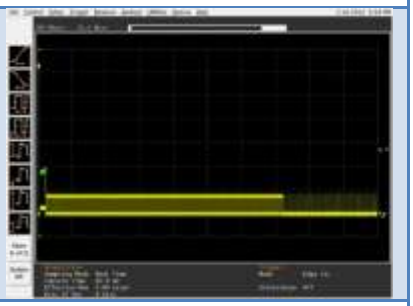
## 4.3 Host Chirp Timing (EL_33, EL_34, EL_35)

Any known good high speed device can be used for this test. When using the Embedded Host tester it's advisable to not select a Test_Mode there it requires to power cycle the host.

**Test Setup:**



**Test Procedure:**

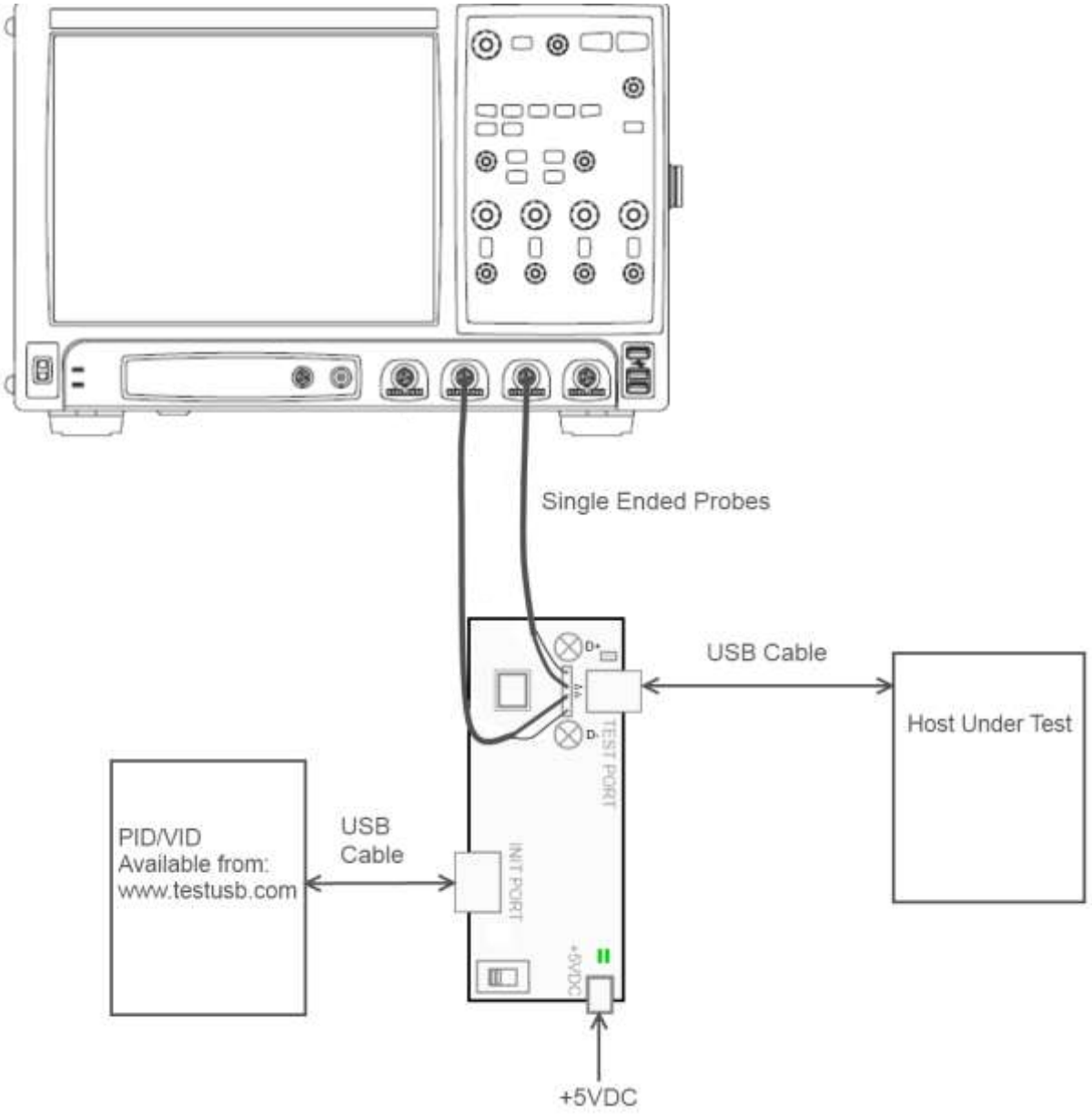
| | Test Fixture & PID/VID | EHost |
|---|---|---|
| **1** | Apply power to the test fixture and put test fixture switch test mode off. LED power illuminate (Green LED), Test mode not (Orange LED) | |
| **2** | Terminate the SMA probing points with 50Ohm. | |
| **3** | Connect the single-ended probe of channel 1 to D+ of TP2. | |
| **4** | Connect the single-ended probe of channel 2 to D- of TP2. | |
| **5** | Connect a USB cable from the Test port of the fixture to the Embedded Host under test. | |
| **6** | Connect any known good high speed device to the Initialize port. | |
| | The Host and device do the Chirp negotiation |  |
| **7** | Scope will measure the EL_33, EL_34, EL_35 | |

## 4.4 Host Suspend/Resume (EL_39, EL_41)

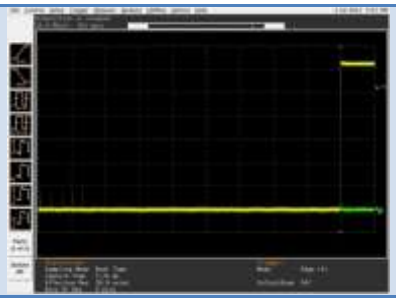
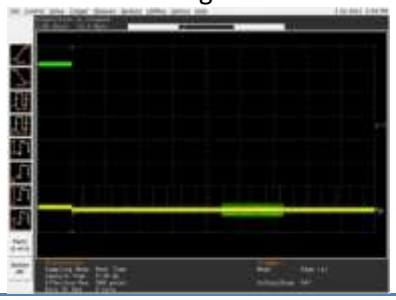
It's not mandatory for an embedded host to support suspend, if the embedded host not support suspend, suspend and resume test should not be performed.

This test verifies if the embedded host enters the suspend state and resumes.

**Test Setup:**

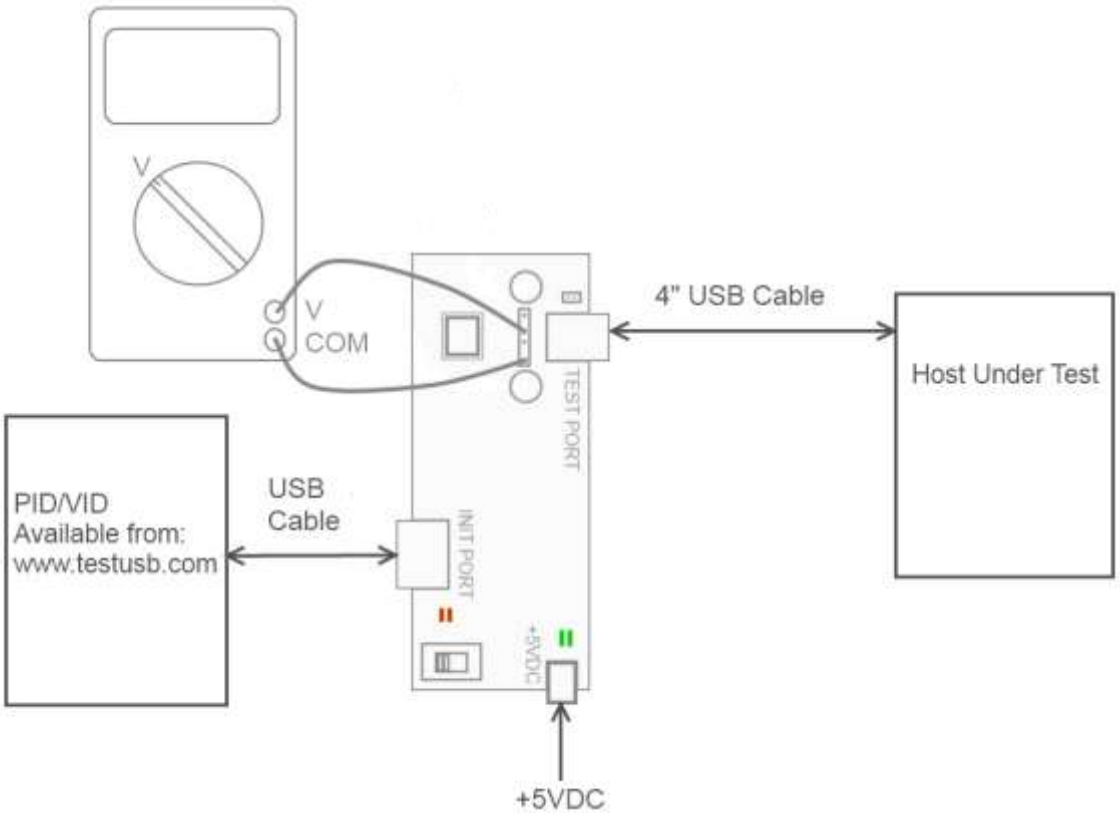


**Test Procedure:**

| | Test Fixture & PID/VID | EHost |
|---|---|---|
| **1** | Apply power to the test fixture and put test fixture switch test mode off. LED power illuminate (Green LED), Test mode not (Orange LED) | |
| **2** | Terminate the SMA probing points with 50Ohm. | |
| **3** | Connect the single-ended probe of channel 1 to D+ of TP2. | |
| **4** | Connect the single-ended probe of channel 2 to D- of TP2. | |
| **5** | Connect a USB cable from the Test port of the fixture to the Embedded Host under test. | |
| **6** | Before connecting the PID/VID put it in the correct position by selecting HS_HOST_PORT_SUSPEND_RESUME | |
| **6** | Connect with a short USB cable the PID/VID to the Initialize port | |
| **7** | | Host enumerates the PID/VID and responds to send SOFs for 15 seconds. |
| **8** | After 15 seconds the host port will enter suspend state |  |
| **9** | | After 15 seconds of suspend state the host shall issue a ResumeK state on the bus, then continue sending SOFs.  |

## 4.5 Host Test_J (EL_8, EL_9)

**Test Setup:**

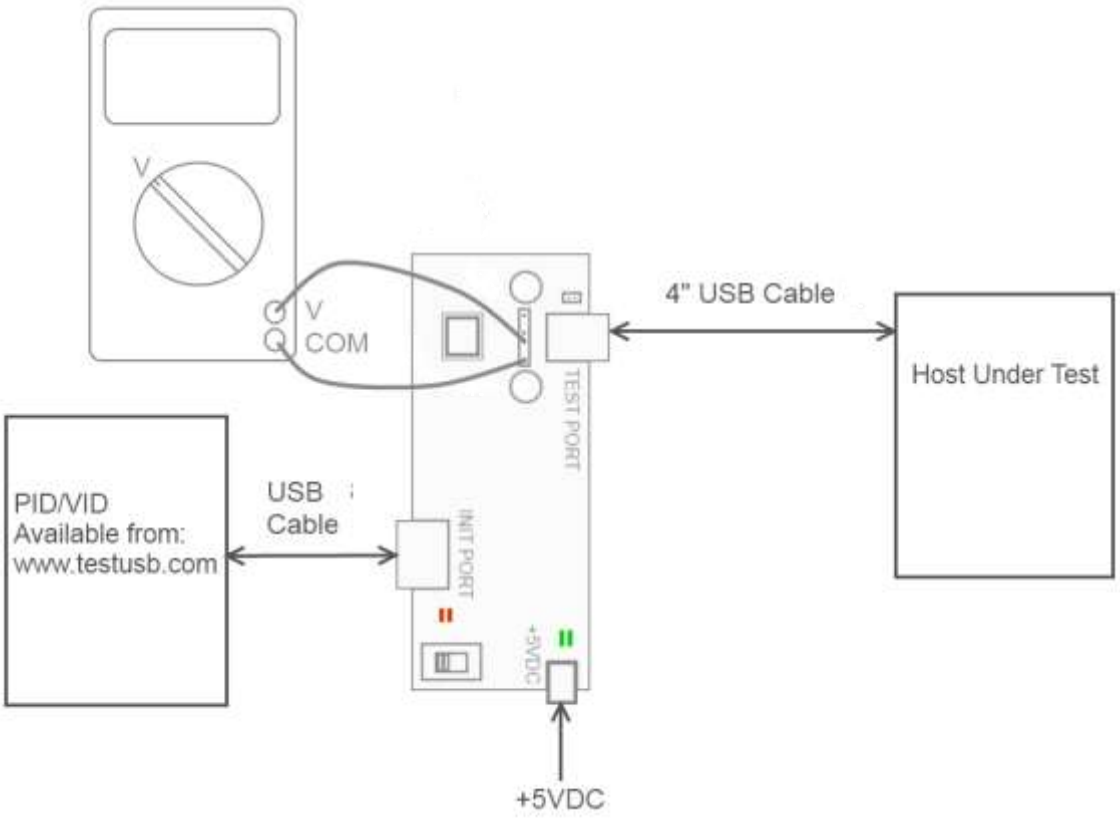



**Test Procedure:**

| | Test Fixture & PID/VID | EHost |
|---|---|---|
| **1** | Apply power to the test fixture and put test fixture switch test mode off. LED power illuminate (Green LED), Test mode not (Orange LED) | |
| **2** | Terminate the SMA probing points with 50Ohm. | |
| **3** | Connect a short USB cable from the Test port of the fixture to the Embedded Host under test. | |
| **4** | Before connecting the PID/VID put it in the correct position by selecting *Test_J* | |
| **5** | Connect the PID/VID to the Initialize port | |
| **6** | | Host enumerates the PID/VID and shall enter a high-speed J state. (D+ high ; D- low) |
| **7** | Flip the switch of the test fixture that switches the termination on. LED power and Test mode illuminate (Orange LED lit). | |
| **8** | Measure with a DC Voltmeter the voltage between D+ and GND. | |
| **9** | Measure with a DC Voltmeter the voltage between D- and GND | |

## 4.6 Host Test_K (EL_8, EL_9)

**Test Setup:**

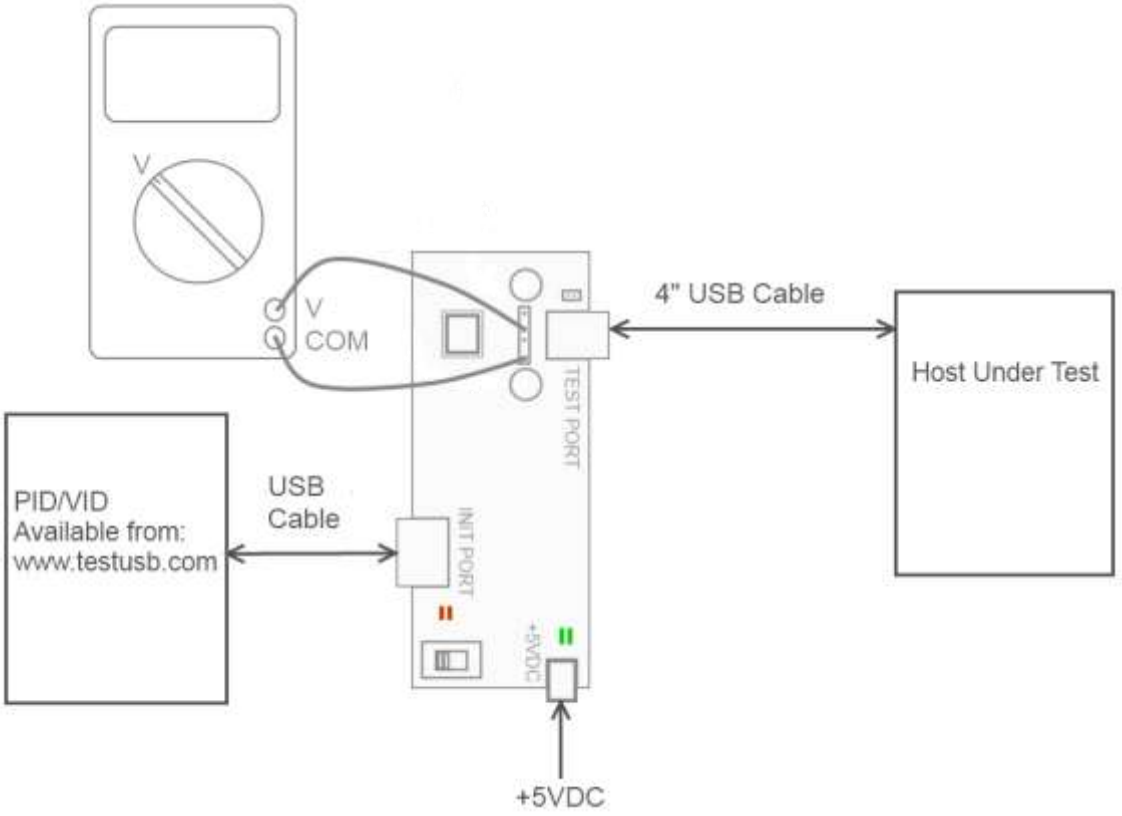



**Test Procedure:**

| | Test Fixture & PID/VID | EHost |
|---|---|---|
| **1** | Apply power to the test fixture and put test fixture switch test mode off. LED power illuminate (Green LED), Test mode not (Orange LED) | |
| **2** | Terminate the SMA probing points with 50Ohm. | |
| **3** | Connect a short USB cable from the Test port of the fixture to the Embedded Host under test. | |
| **4** | Before connecting the PID/VID put it in the correct position by selecting *Test_K* | |
| **5** | Connect the PID/VID to the Initialize port | |
| **6** | | Host enumerates the PID/VID and shall enter a high-speed K state. (D+ low ; D- high) |
| **7** | Flip the switch of the test fixture that switches the termination on. LED power and Test mode illuminate (Orange LED lit). | |
| **8** | Measure with a DC Voltmeter the voltage between D+ and GND | |
| **9** | Measure with a DC Voltmeter the voltage between D- and GND | |

## 4.7 Host Test_SE0_NAK (EL_8, EL_9)

**Test Setup:**




**Test Procedure:**

| | Test Fixture & PID/VID | EHost |
|---|---|---|
| **1** | Apply power to the test fixture and put test fixture switch test mode off. LED power illuminate (Green LED), Test mode not (Orange LED) | |
| **2** | Terminate the SMA probing points with 50Ohm. | |
| **3** | Connect a short USB cable from the Test port of the fixture to the Embedded Host under test. | |
| **4** | Before connecting the PID/VID put it in the correct position by selecting *Test_SE0_NAK* | |
| **5** | Connect the PID/VID to the Initialize port | |
| **6** | | Host enumerates the PID/VID and shall drive an SE0 state. (D+ low; D- low) |
| **7** | Flip the switch of the test fixture that switches the termination on. LED power and Test mode illuminate (Orange LED lit). | |
| **8** | Measure with a DC Voltmeter the voltage between D+ and GND | |
| **9** | Measure with a DC Voltmeter the voltage between D- and GND | |

# Appendix A

<To be done>

*<A popular Embedded Host OS is Linux that comes in many different flavors including Ubuntu, Red Hat, Android and many more.*

*Starting from Linux Kernel v3.6 the PID VID detection that force the embedded hosts in test modes are implemented in the kernel and no special patches should be required.*

*If the product is using an earlier Linux Kernel version the USB driver requires a patch.*

*For more details please check www.kernel.org>*

For updates please check www.testusb.com