Embedded Host

High Speed Electrical Test Procedure

Revision 0.99

January 2014

Table of content

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.

Beside the High Speed electrical test an embedded host also must pass other tests as defined at:

http://testusb.com/Ehost_test.htm

This document only describe the High Speed electrical tests.

3. Test Mode Support

3.1 Setup

3.1.1 Agilent setup


"old" PID/VID and Agilent E2649-26402   "new" PID/VID

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

3.1.2 USB-IF setup

The USB-IF logo compliance require to use the USB-IF fixture for the High Speed EYE diagram. Reason for only using this fixture is that that there are differences reported between all fixtures available on the market.
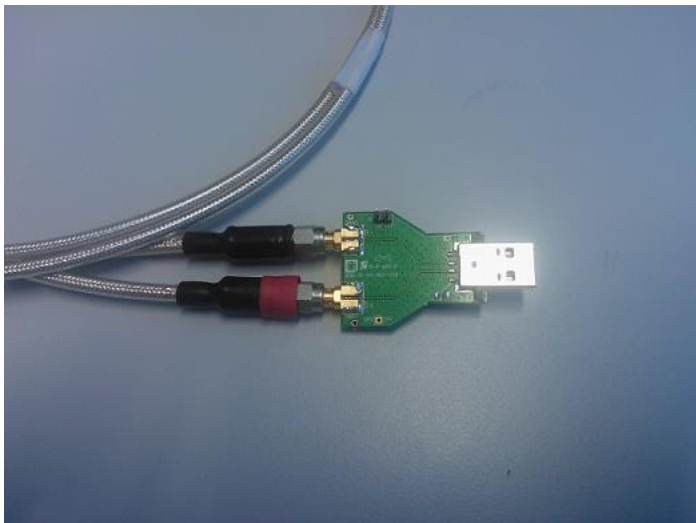
The USB-IF High Speed host fixture only require to connect SMA cables that are connected directly to the scope. Do note that the USB-IF fixture is only able in measuring the High Speed Eye diagram and therefore it is still required to use the Agilent E2649-26402 for the remaining high speed electrical tests.

The USB-IF fixtures can be purchased via the USB-IF eStore at :
http://www.usb.org/developers/estoreinfo/

3.1.3 Micro AB setup

OTG products and some Embedded Hosts 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
0x0200	TTST_CONFIG
0x0201	Unknown Device Not Supporting HNP
0x0202	Unknown Device Supporting HNP

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).

Unknown Device Not Supporting HNP (not an electrical test)

A device with VID=0x1A0A, PID=0x0201 is reserved as a test device, which shall not be on the TPL of any Targeted Host. It may be used by the compliance tester to represent a device which is not supported and which does not support HNP. Vendors should note that the compliance tester may use this, or any other VID/PID combination which is not on the TPL, for the purposes of tests which require compliant behavior when encountering such a device.

Unknown Device Supporting HNP (not an electrical test)

A device with VID=0x1A0A, PID=0x0202 is reserved as a test device, which shall not be on the TPL of any Targeted Host. It may be used by the compliance tester to represent a device which is not supported and which supports HNP. Vendors should note that the compliance PET may use this, or any other VID/PID combination which is not on the TPL, for the purposes of tests which require compliant behavior when encountering such a device.

Test 0x0200

TBD

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
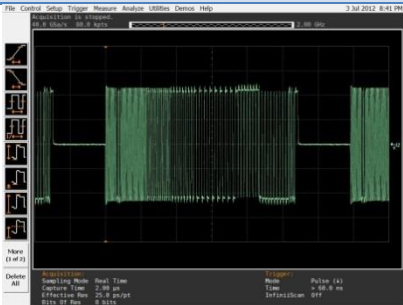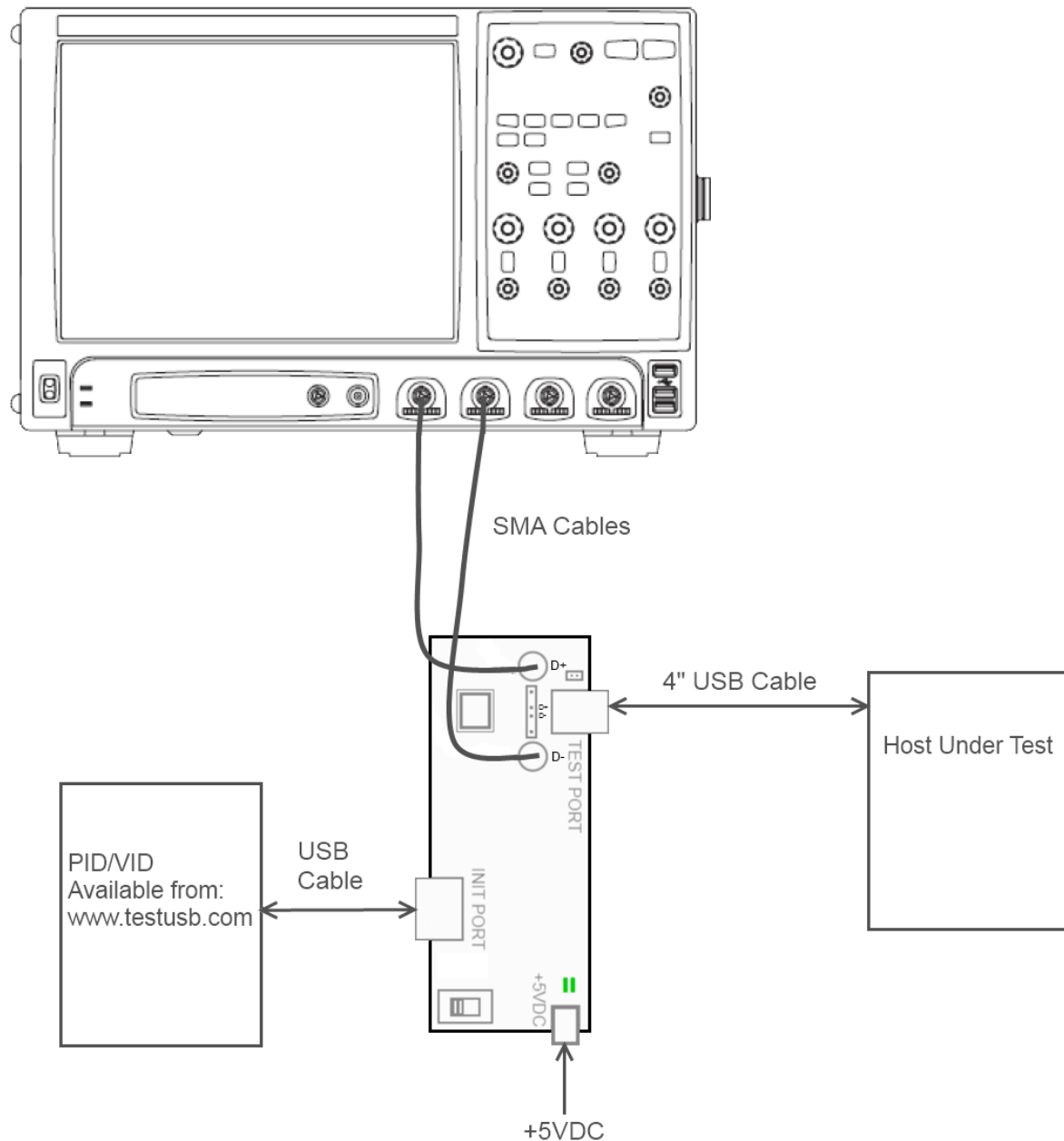
>

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.
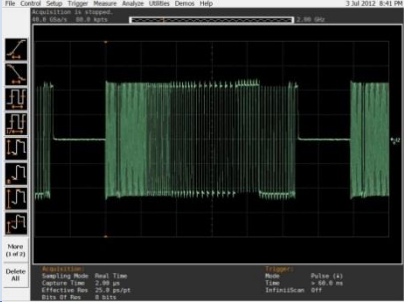
Test Setup:

Test Procedure Agilent fixture:

	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 3 of the Scope and make the scope settings accordingly. For the differential signal subtract Channel 1 with Channel 3.	
3	Connect a short USB cable from the Test port of the fixture to the Embedded Host under test.	
4	Connect PID/VID and select with UP or DOWN *Test_Packet* and press Enter.	
5		Host enumerates the PID/VID and responds to send continuously Test_Packet
6	Flip the switch of the test fixture that switches the termination on. LED power and Test mode illuminate (Orange LED lit).	
7	Scope will capture the packet.	
8	Scope will analyze and calculate the parameters with USBET. (EL_2, EL_3, EL_6, EL_7)	
9	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.

Test Procedure USB-IF fixture:

	Test Fixture & PID/VID	EHost
1	Attach the two SMA cables to the fixture with the D+ to Channel 1 and D- to Channel 3 of the Scope and make the scope settings accordingly. For the differential signal subtract Channel 1 with Channel 3.	
2	Connect PID/VID and select with UP or DOWN *Test_Packet* and press Enter.	
3		Host enumerates the PID/VID and responds to send continuously Test_Packet
4	Remove PID/VID	
5	Connect fixture to embedded host	
6	Scope will capture the packet.	
7	Scope will analyze and calculate the parameters with USBET. (EL_2, EL_3, EL_6, EL_7)	
8	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.

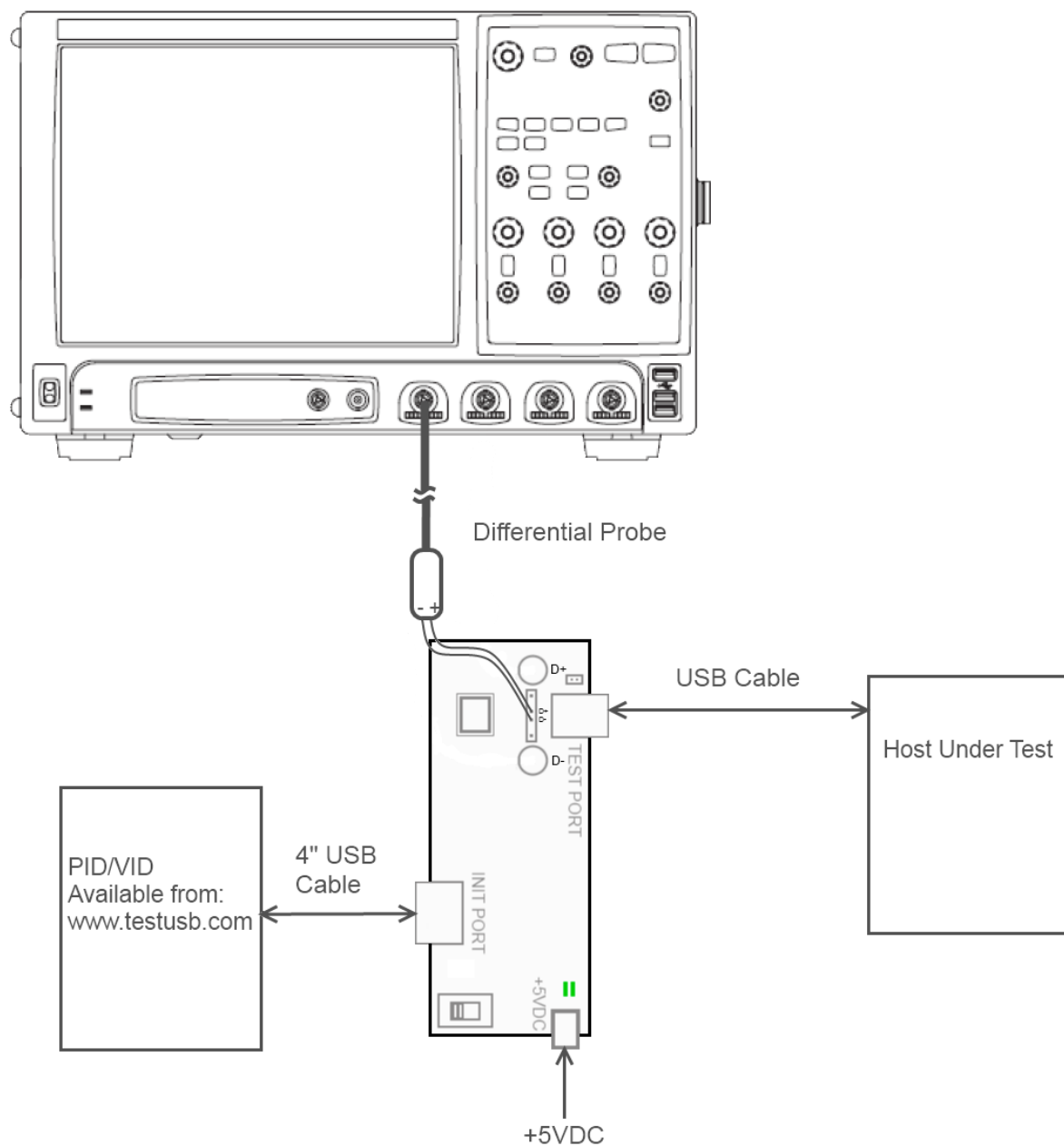## 4.2 Host Controller Packet Parameters (EL_21, EL_22, EL_23, EL_25, EL_55)

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)
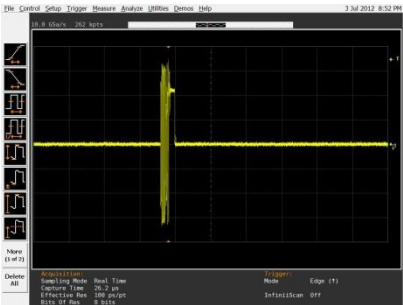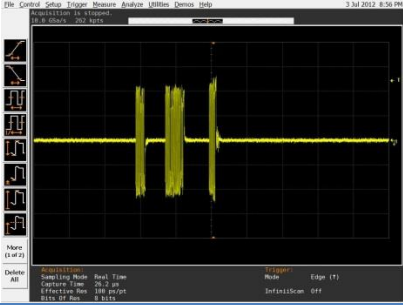
Test Procedure:

This test is split up into two sub-tests.

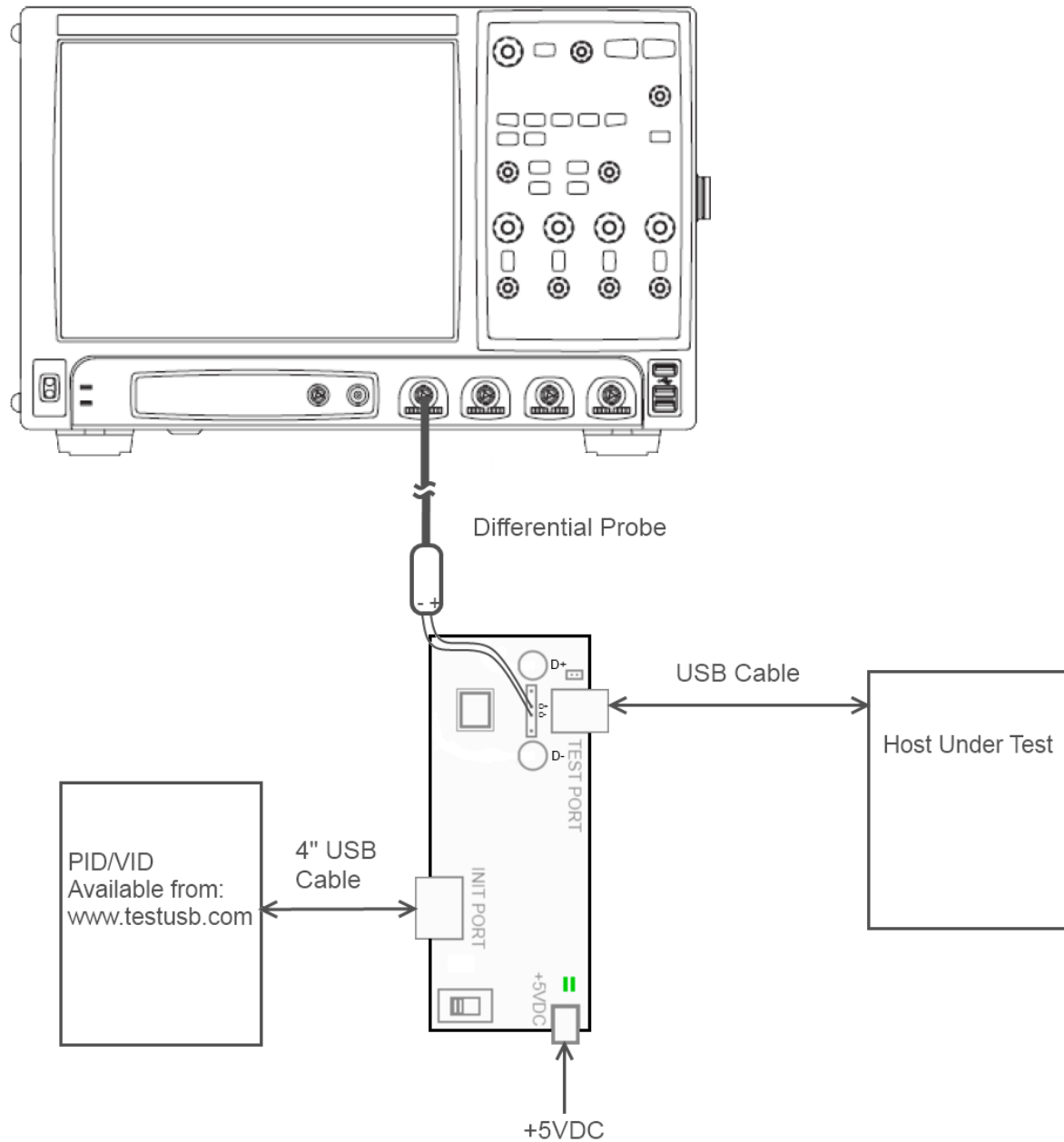### 4.2.1. SINGLE_STEP_DEV_DESC (EL_21, EL_25, EL_23)
Test Setup:

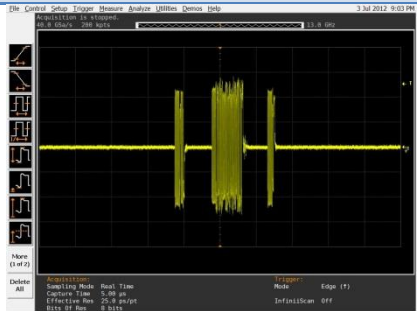|	Test Fixture & PID/VID	EHost
1	Apply power to the test fixture and put test fixture switch test mode off. LED power illuminate (Green LED), Test mode not (Orange LED)	
2	Terminate the SMA probing points with 50Ohm.	
3	Connect the differential probe to TP2. With the + of the probe to D+.	
4	Connect a long USB cable (*) from the Test port of the fixture to the Embedded Host under test.	
5	Connect PID/VID and select with UP or DOWN *SINGLE_STEP_GET_DEVICE_DESCRIPTOR* and press Enter.	
6		Host enumerates the PID/VID and responds to send SOFs for 15 seconds.
7	Verify SOFs are send and increase the scope amplitude trigger level until SOFs are no longer triggered. (*)	
8		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)
9	The PID/VID sends an ACK as response. The scope triggers on this ACK.	
10	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	Connect PID/VID and select with UP or DOWN *SINGLE_STEP_GET_DEVICE_DESCRIPTOR* and press Enter.	
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.	

Comments:

EL_22 can be difficult to measure there the test mode is often wrongly implemented by the embedded host vendor. Therefore if it not work you may want to try to capture the packets on real life communication between a TPL devices and embedded host by inserting the device. Make sure that the cable between the TPL device and test fixture is short while the cable between the fixture

and embedded host is long (preferred 5m). The difference in cable length is to distinguish the difference between host and device packets.

It may be required to disconnect and re-connect more than once in order to trigger properly. If the scope used is have infiniiScan software you can download the trigger setting from www.testusb.com
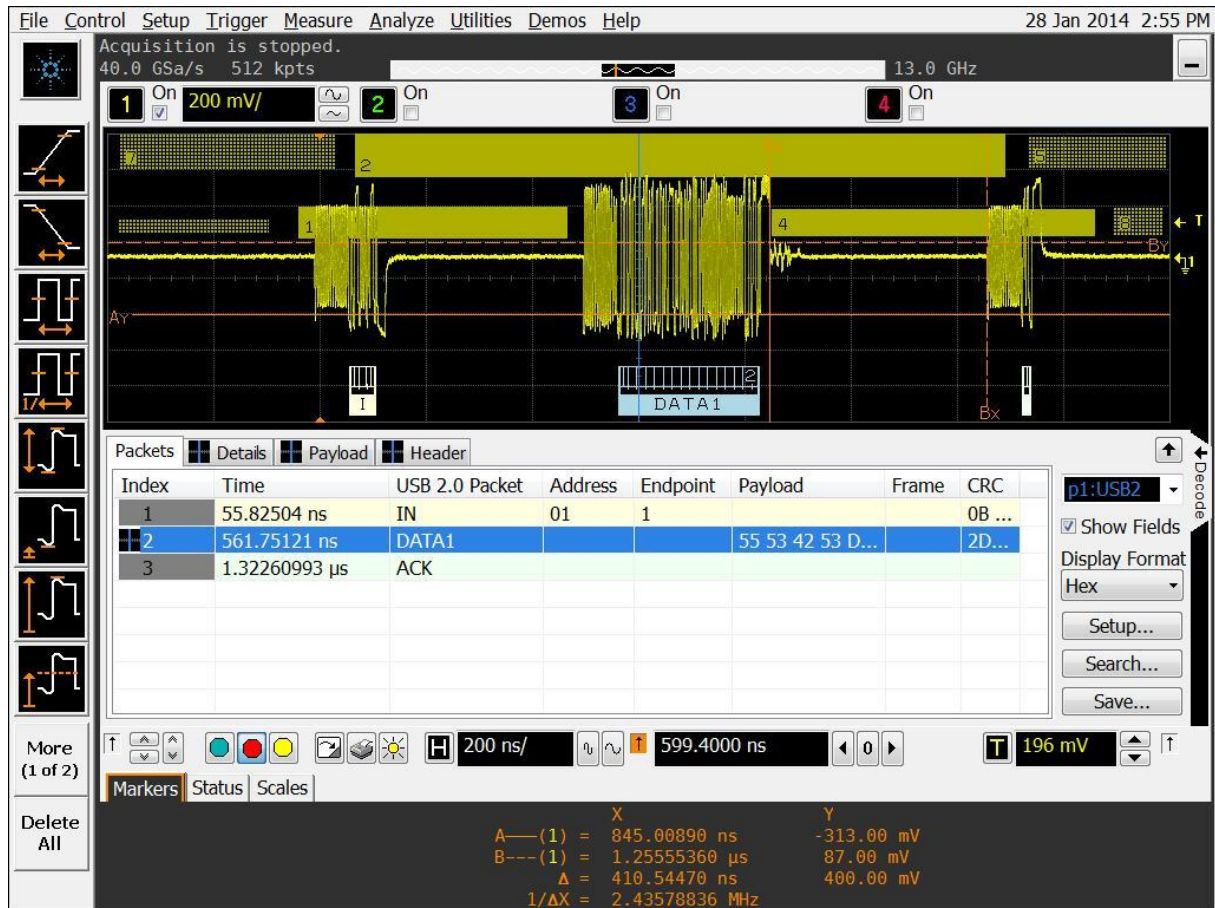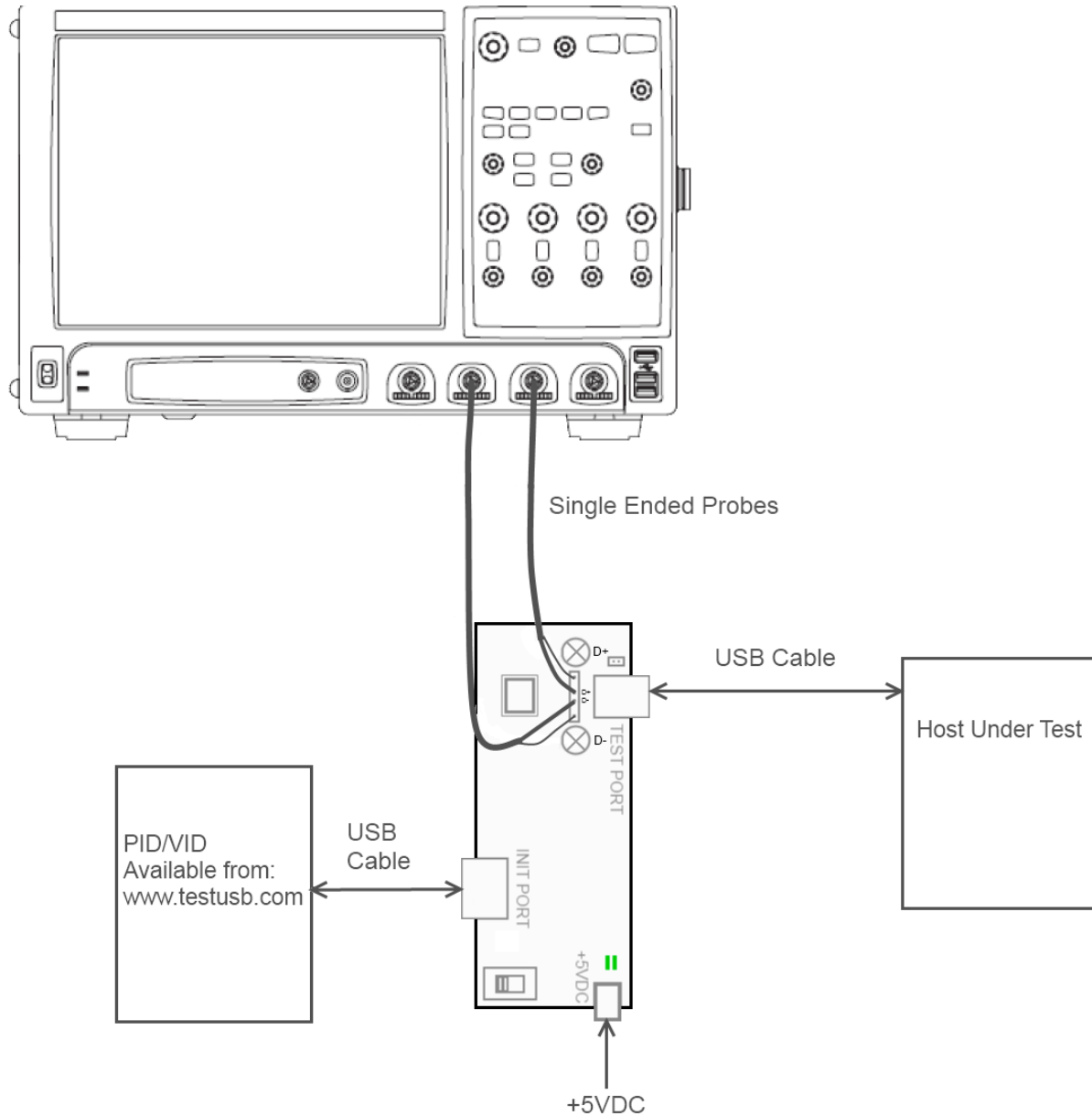

Do note that you should take an additional delay of 60ns for 5m cable.

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.
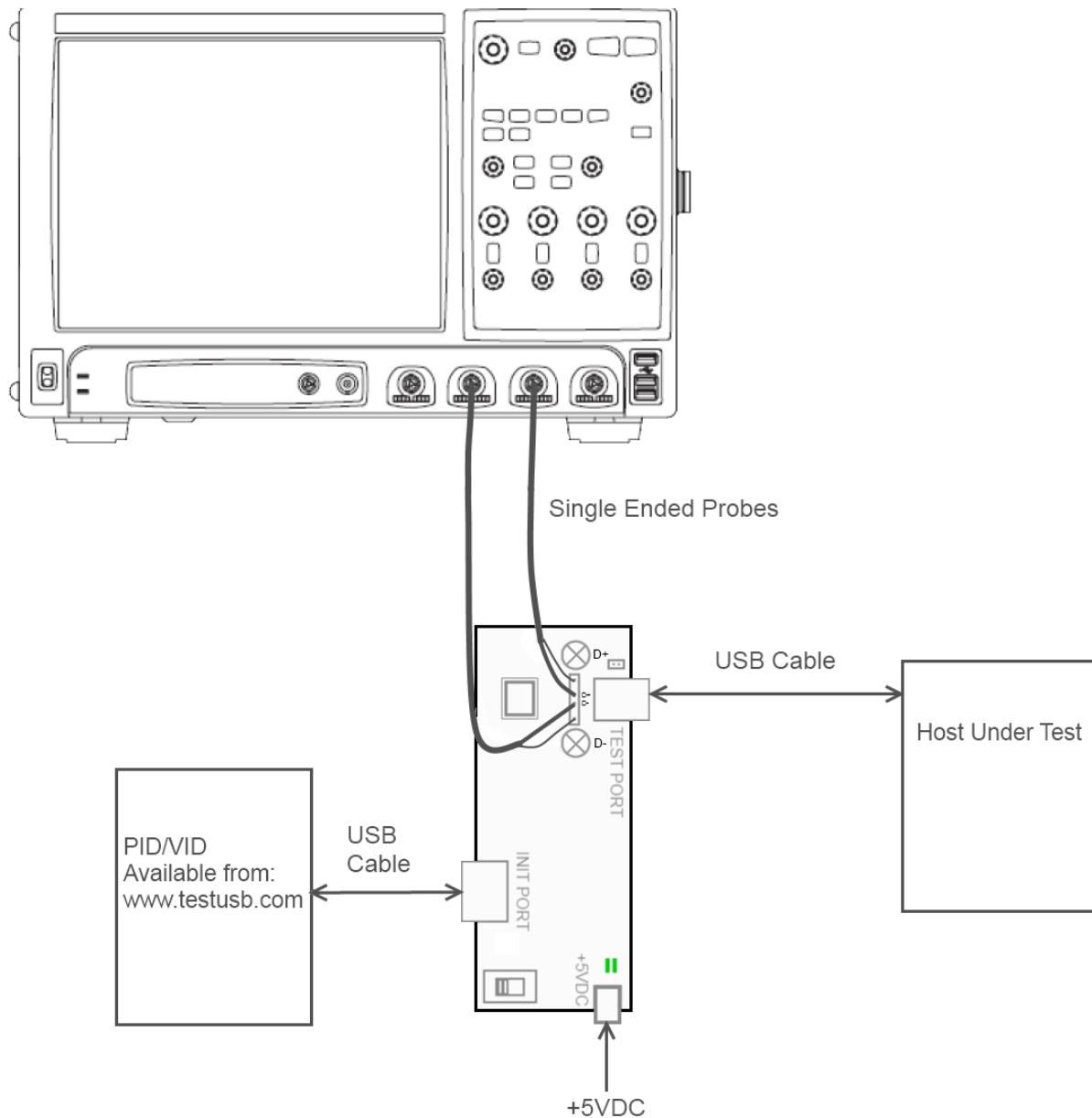
Test Setup:

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	

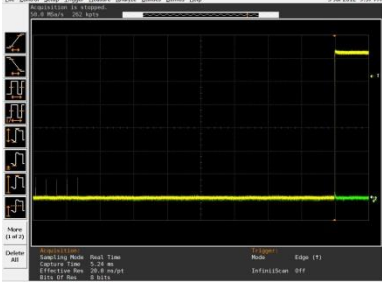## 4.4 Host Suspend/Resume (EL_39, EL_41)

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.
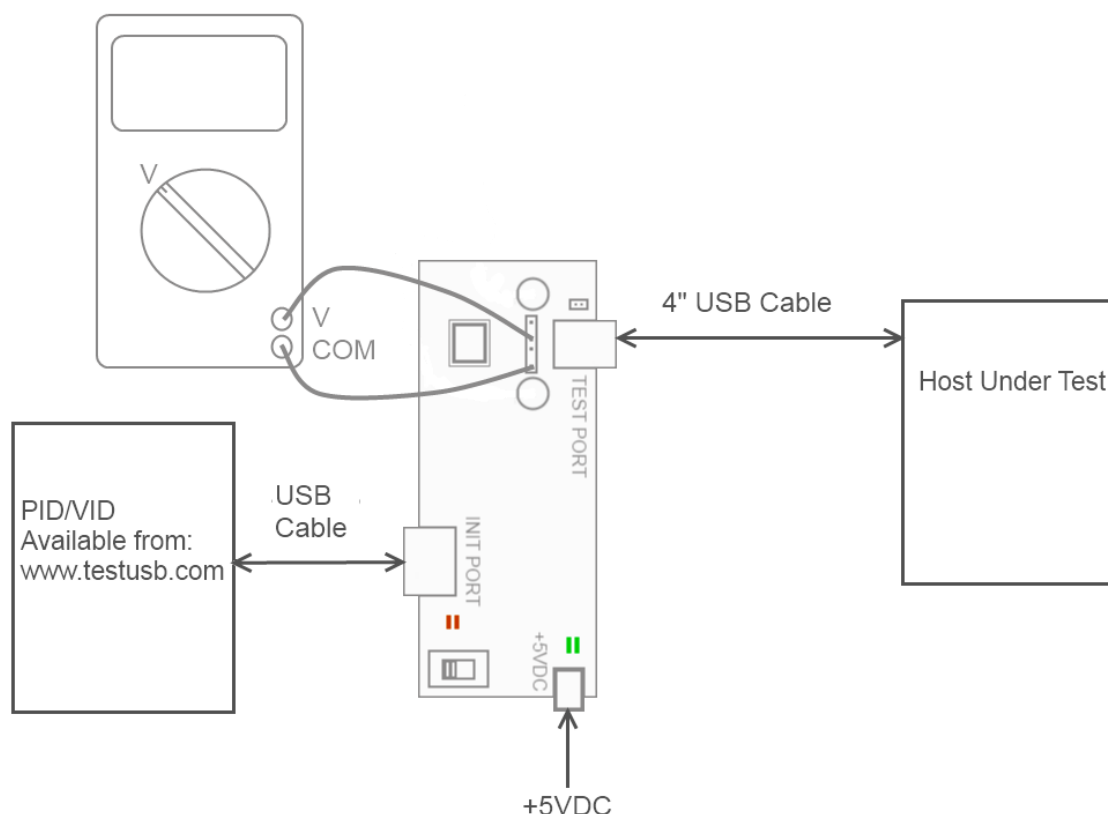
Test Setup:

Test Procedure:

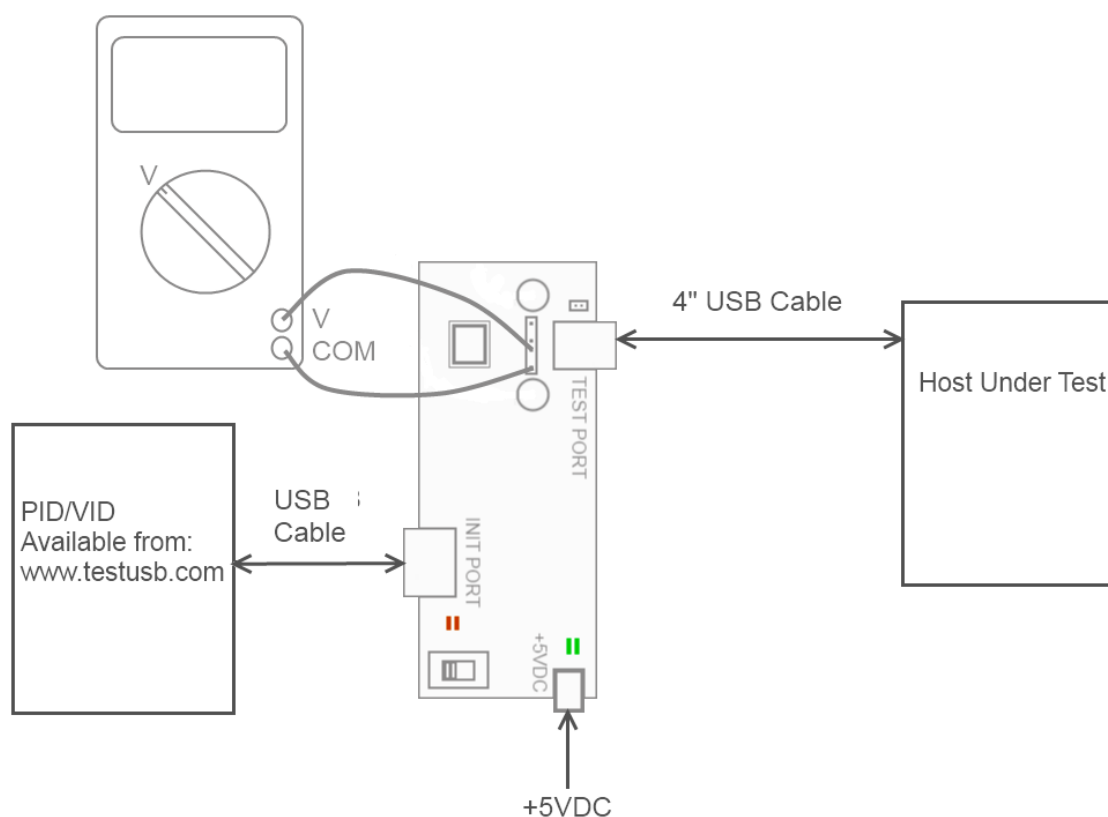|	Test Fixture & PID/VID	EHost
1	Apply power to the test fixture and put test fixture switch test mode off. LED power illuminate (Green LED), Test mode not (Orange LED)	
2	Terminate the SMA probing points with 50Ohm.	
3	Connect the single-ended probe of channel 1 to D+ of TP2.	
4	Connect the single-ended 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	Connect PID/VID and select with UP or DOWN *HS_HOST_PORT_SUSPEND_RESUME* and press Enter.	
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	Connect PID/VID and select with UP or DOWN *Test_J* and press Enter.	
5		Host enumerates the PID/VID and shall enter a high-speed J state. (D+ high ; D- low)
6	Flip the switch of the test fixture that switches the termination on. LED power and Test mode illuminate (Orange LED lit).	
7	Measure with a DC Voltmeter the voltage between D+ and GND.	
8	Measure with a DC Voltmeter the voltage between D- and GND	

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

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		Connect PID/VID and select with UP or DOWN *Test_K* and press Enter.	
5			Host enumerates the PID/VID and shall enter a high-speed K state. (D+ low ; D- high)
6		Flip the switch of the test fixture that switches the termination on. LED power and Test mode illuminate (Orange LED lit).	
7		Measure with a DC Voltmeter the voltage between D+ and GND	
8		Measure with a DC Voltmeter the voltage between D- and GND	

A power cycle of the host is required in order to proceed.
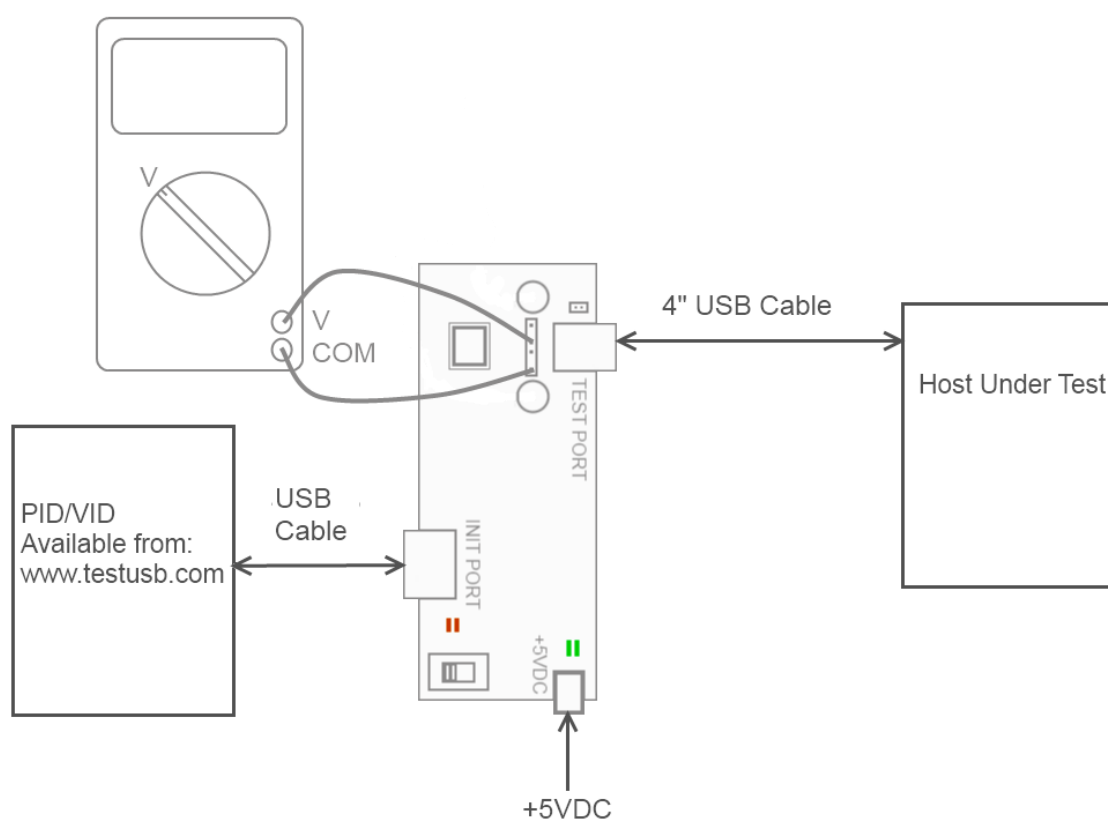
4.7 Host Test_SE0_NAK (EL_8, EL_9)

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	Connect PID/VID and select with UP or DOWN *Test_SE0_NAK* and press Enter.	
5		Host enumerates the PID/VID and shall drive an SE0 state. (D+ low; D- low)
6	Flip the switch of the test fixture that switches the termination on. LED power and Test mode illuminate (Orange LED lit).	
7	Measure with a DC Voltmeter the voltage between D+ and GND	
8	Measure with a DC Voltmeter the voltage between D- and GND	

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

5. Fill out form

ID	Test	Requirement	Measured Value	Status
EL_2	High-Speed transmitter data rate	480 Mb/s +-0.05%	Mb/s	Pass/Fail
EL_3	Data Eye and Mask Test	Not touch near end EYE	Number EYE hits	Pass/Fail
EL_6	Rise and fall times	> 500 ps (*)	ps	Pass/Fail
EL_7	Monotonic edge	Data transition is monotonic		Pass/Fail
EL_21	Sync Field Length Test	(**)	ns	Pass/Fail/NA
EL_25	EOP Length Test	(**)	ns	Pass/Fail/NA
EL_23	Inter-packet Gap Between First 2 host Packets (Host – Host)	(**)	ns	Pass/Fail/NA
EL_22	Inter-packet Gap of a host to a device packet (Device – Host)	(**)	ns	Pass/Fail
EL_55	SOF EOP Width Test	(**)	ns	Pass/Fail
EL_33	CHIRP Timing Response	1ns to 100µs	µs	Pass/Fail
EL_34	CHIRP J K Width	40µs to 60µs	µs	Pass/Fail
EL_35	SOF Timing Response	100µs to 500µs	µs	Pass/Fail
EL_39	Suspend	Enter suspend		Pass/Fail/NA
EL_41	Resume	< 3ms		Pass/Fail/NA
EL_8	Host J Test	Driven data line 400mV +-10% (***) Non driven data lines max 10mV	D+: mV D-: mV	Pass/Fail
EL_8	Host K Test	Driven data line 400mV +-10% (***) Non data driven lines max 10mV	D+: mV D-: mV	Pass/Fail
EL_9	Host SE0_NAK Test	Non data driven lines max 10mV	D+: mV D-: mV	Pass/Fail

(*) EL_6 waiver low as 100ps:
http://compliance.usb.org/index.asp?UpdateFile=Electrical&Format=Standard#87

(**) EL_22 for products with an internal hub to the embedded host may have an additional delay:
http://compliance.usb.org/index.asp?UpdateFile=Electrical&Format=Standard#43
One HS Hub may truncate up to 4 bits of the sync field and add up to 4 bits to the EOP.

(***) EL_8 only the non-driven lines are pass / fail criteria
http://compliance.usb.org/index.asp?UpdateFile=Electrical&Format=Standard#67

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.>

The linux patch you can find at: http://www.testusb.com/EHHS.html

Here the steps to take to apply this patch and is based on Ubuntu 12.10 x86_32:
Download on www.ubuntu.com and install
 After it's installed:
· Open 'terminal'
· sudo su -
· apt-get update && apt-get upgrade
· apt-get install build-essential linux-source
· cd /usr/src
· tar xvf linux-source-3.5.0.tar.bz2
· cd linux-source-3.5.0
· cp /home/user/patch_file .
· patch –p1 < pach_file
· make oldconfig (enter 'm' when asked what to do for "USB OTG & EH Test Mode Support Driver")
· make deb-pkg (this takes some time)
After build completes:
· cd ..
· rm –v *firmware*.deb
· dpkg –I *.deb
· reboot

Now the patch is applied and the PID VID detection should work.