USB On-The-Go Compliance Plan for the USB 2.0 Specification

Revision 1.2

Revision History

Revision	Issue Date	Comment
0.7	6/28/02	
0.71	7/15/02	
0.80a RC1	8/2/02	Release Candidate 1
0.81rc4eo	10/10/2002	Updates from compliance review – partial Add protocol checklist items. Add tests for sections 7, 8.
0.81rc5	11/05/02	Rewrite of protocol section based on set of proposed errata to bound DRD behavior for a specified test device.
.89 RC 1	12/19/02	Updates based on feedback from 11/07/02 OTG FTF review and subsequent review comments. Started adding pointers from checklist assertions to the tests that cover them.
.90	1/28/03	Minor review updates. Dual role device terminology changed to OTG Device. Sections added to test descriptions for assertions covered. Protocol assertions updated to reflect proposed errata to the OTG supplement version 1.0.
1.0 RC	3/21/03	Updates to compliance plan to use variable load on OET. Minor corrections of typographical errors. Checklist material moved to separate checklist documents.
1.0 RC2	4/16/03	Updates from RC feedback and first Compliance Workshop trial.
1.0 RC3	5/21/03	Updates from detailed review of electrical tests and procedures. Updates from OTG supplement errata introduced in the last month.
1.0 RC4	6/5/03	Updates to resolve disagreement over amount of time VBUS needs to remain valid without a connect. Updates to messaging tests.
1.0 RC5	6/19/03	Updates to reflect recent supplement change to make TA_WAIT_BCON consistent at 1 second. Changes to message tests to reflect consistent use of a device not responding type error message in Messaging error cases.
1.0	6/25/03	Updates on messaging test min and max times based on technical discussion and vote for 1.0 compliance plan at the 6/24/03 OTG FTF.
1.0 (final)	8/12/03	Remove “Review and discussion“ disclaimer, correct typographical errors, and correct test description 5.9 under section 6.4.2.2 to require an error message at any time prior to 30 seconds.
2.0 v1	September 2003	Update $T_{B\_SVLD\_BCON}$ to 1 second in Section: 5.5.6.3 Add HS test section to OPT
2.0 RC2	October 2004	Edit HS test section per results of HS OPT acceptance tests Define optional HS host test mode Product IDs (PIDs) General clean-up
2.0 RC3	November 2004	Correct TD.6.16 procedure Add TD.6.17
2.0 RC4	December 2004	Correct TD.6.13 and TD.6.16 per OTG F2F Meeting
2.0 RC5	June 2005	Updated Battery Charging 9.1.4.6 Added HS EH electrical test support requirements 9.2.6.2.1

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1 Introduction

1.1 General

USB has become a popular interface for exchanging data between a host PC and its peripherals. Due to its low cost, high speed, and widespread use, an increasing number of portable devices have a USB peripheral port. Although communication directly between portable devices would sometimes be useful, the USB specification only enables communication between a host port and a peripheral port. It does not enable communication directly between peripheral ports.

For this reason, the On-The-Go (OTG) supplement to the USB 2.0 specification was developed. The OTG Supplement enables USB connectivity between portable devices by specifying:

- smaller connectors
- new cables and adapters
- limited host capability for portable devices
- low power features
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To ensure compliance with the added requirements of OTG, an OTG compliance program is required.

1.2 Objective of the OTG Compliance Program

The purpose of the OTG compliance program is to mirror the effectiveness of the USB-IF compliance program. The benefits of a compliance program have been proven by the USB initiative: the proliferation of knowledge, more stringent testing, and a higher standard of quality.

1.3 Scope of the Document

This document tests and/or checks for compliance with OTG requirements specified in the OTG Supplement.

1.4 Intended Audience

This specification is intended for developers of devices that support OTG.

1.5 Reference Document(s)

- On-The-Go Supplement to the USB 2.0 Specification (www.usb.org/developers/onthego)
- USB 2.0 Specification (www.usb.org/developers/docs.html)
- ECN_27%_ Resistor (www.usb.org/developers/docs.html)

2 Acronyms and Terms

This chapter lists and defines terms and abbreviations used throughout this specification. The On-The-Go terms and abbreviations are provided in the On-The-Go Supplement to the USB 2.0 Specification.

OTG	USB On-The-Go
DUT	Device Under Test, same as UUT
OET	OTG Electrical Tester
OPT	OTG Protocol Tester
UUT	Unit Under Test, same as DUT
HNP	Host negotiation protocol as defined on the On-The-Go Supplement.
SRP	Session request protocol as defined in the On-The-Go Supplement.
On-The-Go Device	Device with a mini-AB connector supporting the HNP protocol.
A-UUT	Unit Under Test with a mini-A plug attached.
B-UUT	Unit Under Test with a mini-B plug attached
A-OPT	OTG Protocol Tester with a mini-A plug attached
B-OPT	OTG Protocol Tester with a mini-B plug attached

3 Executive Summary

The “USB On-The-Go Compliance Plan” does not overlap the USB 2.0 peripheral compliance plan. Any parameter/feature specified in the USB 2.0 Specification will not be tested here. The “USB On-The-Go Compliance Plan” will test only “New” parameters/features that are specified in the “On-The-Go Supplement to the USB 2.0 Specification.”

The Significant features are:

- A limited Host capability
- Session Request Protocols
- Host Negotiation Protocols
- The ability to source at least 8 mA on VBUS
- A means of communicating with the user
- No Silent failures – *i.e.* there must be a method of alerting the user that an unsupported device has been attached, or that the attached device violates one of the conditions required to interface to the OTG Device, *e.g.* it requires more current than the OTG Device can provide.
- Interoperability with devices on the Targeted Peripheral List defined for the device under test.
- The details of these and other compliance tests are covered in subsequent sections of this document.

4 Submission Materials

The manufacturer of an OTG Device or SRP capable peripheral must provide completed checklists, Targeted Peripheral List, device specific procedures and information before submitting the device for OTG testing.

4.1 Non-OTG Checklists

The USB-IF peripheral checklists (product and/or silicon) are required for an OTG Device which must also pass all standard USB-IF peripheral testing. The OTG checklist is also required. The OTG checklist is available separately from the USB-IF.

4.2 Device Specific Procedures

The manufacturer must provide the following written procedures to be used during testing:

1. If supported, a procedure to make the A-Device under test turn on V_{BUS}
2. If supported, a procedure to make the B-Device under test initiate an SRP
3. If supported, a procedure to make the A-device enter a state where it is responsive to SRP.

4.3 Device Specific Information

The manufacturer must provide a written document with the maximum-rated output current information for the A-Device under test.

The OET electrical test fixtures contain a variable resistance load that can be used to characterize the current output of an OTG device. This option is provided to allow consistent output current characterization between OTG devices. It may have compliance uses in the future.

5 Electrical

5.1 Introduction

The electrical tests in this section test only a partial list of all the possible electrical parameters. The tests should not be considered as a full validation test plan. It is the responsibility of the manufacturer of a device to verify compliance of all the electrical parameters specified in the OTG Supplement.

5.2 Electrical Test Tables

An OTG device must pass all relevant USB 2.0 compliance tests as well as the tests indicated in the electrical test tables. The tables are divided into tests for the device types: OTG devices and SRP capable peripherals.

The tests for OTG Devices are listed in Table 5-1.

Table 5-1 OTG Device Electrical Tests

OTG Test Section Number	Test Name	OTG Supplement Section Number	Parameter Name
5.5.1.1	A-UUT Output Voltage ($V_{A\_VBUS\_OUT}$)	5.1.1	$V_{A\_VBUS\_OUT}$
5.5.1.2	A-UUT V_{BUS} Rise Time ($T_{A\_VBUS\_RISE}$)	5.1.3	$T_{A\_VBUS\_RISE}$
5.5.1.4	B-UUT (SRP capable) to OTG Device Output Voltage ($V_{B\_DRD\_OUT}$)	5.3.4	$V_{B\_DRD\_OUT}$
5.5.1.5	B-UUT (SRP capable) to Host Output voltage ($V_{B\_HST\_OUT}$)	5.3.4	$V_{B\_HST\_OUT}$
5.5.2.1	A-UUT Output Current ($I_{A\_VBUS\_OUT}$)	5.1.1	$I_{A\_VBUS\_OUT}$
5.5.2.2	B-UUT (OTG Device) Unconfigured Average Current ($I_{B\_DRD\_UNCFG}$)	5.2.1	$I_{B\_DRD\_UNCFG}$
5.5.6.1	A-UUT V_{BUS} Valid ($V_{A\_VBUS\_VLD}$)	5.1.1	$V_{A\_VBUS\_VLD}$
5.5.6.2	A-UUT Session Valid ($V_{A\_SESS\_VLD}$)	5.3.6	$V_{A\_SESS\_VLD}$
5.5.6.3	B-UUT V_{BUS} Valid ($V_{B\_SESS\_VLD}$)	5.3.7	$V_{B\_SESS\_VLD}$
5.5.7.1	OTG Device V_{BUS} Bypass Capacitance (C_{DRD_VBUS})	5.1.4	C_{DRD_VBUS}
5.5.8.1	Data-Line Pulsing Test ($T_{B\_DATA\_PLS}$)	5.3.3	$T_{B\_DATA\_PLS}$

The tests for SRP Capable Peripherals are listed in Table 5-2.

Table 5-2 OTG Peripheral (SRP Capable) Electrical Tests

OTG Test Section Number	Test Name	OTG Supplement Section Number	Parameter Name
5.5.1.4	B-UUT (SRP capable) to OTG Device Output Voltage ($V_{B\_DRD\_OUT}$)	5.3.4	$V_{B\_DRD\_OUT}$
5.5.1.5	B-UUT (SRP capable) to Host Output voltage ($V_{B\_HST\_OUT}$)	5.3.4	$V_{B\_HST\_OUT}$
5.5.6.3	B-UUT V_{BUS} Valid ($V_{B\_SESS\_VLD}$)	5.3.7	$V_{B\_SESS\_VLD}$
5.5.8.1	Data-Line Pulsing Test ($T_{B\_DATA\_PLS}$)	5.3.3	$T_{B\_DATA\_PLS}$

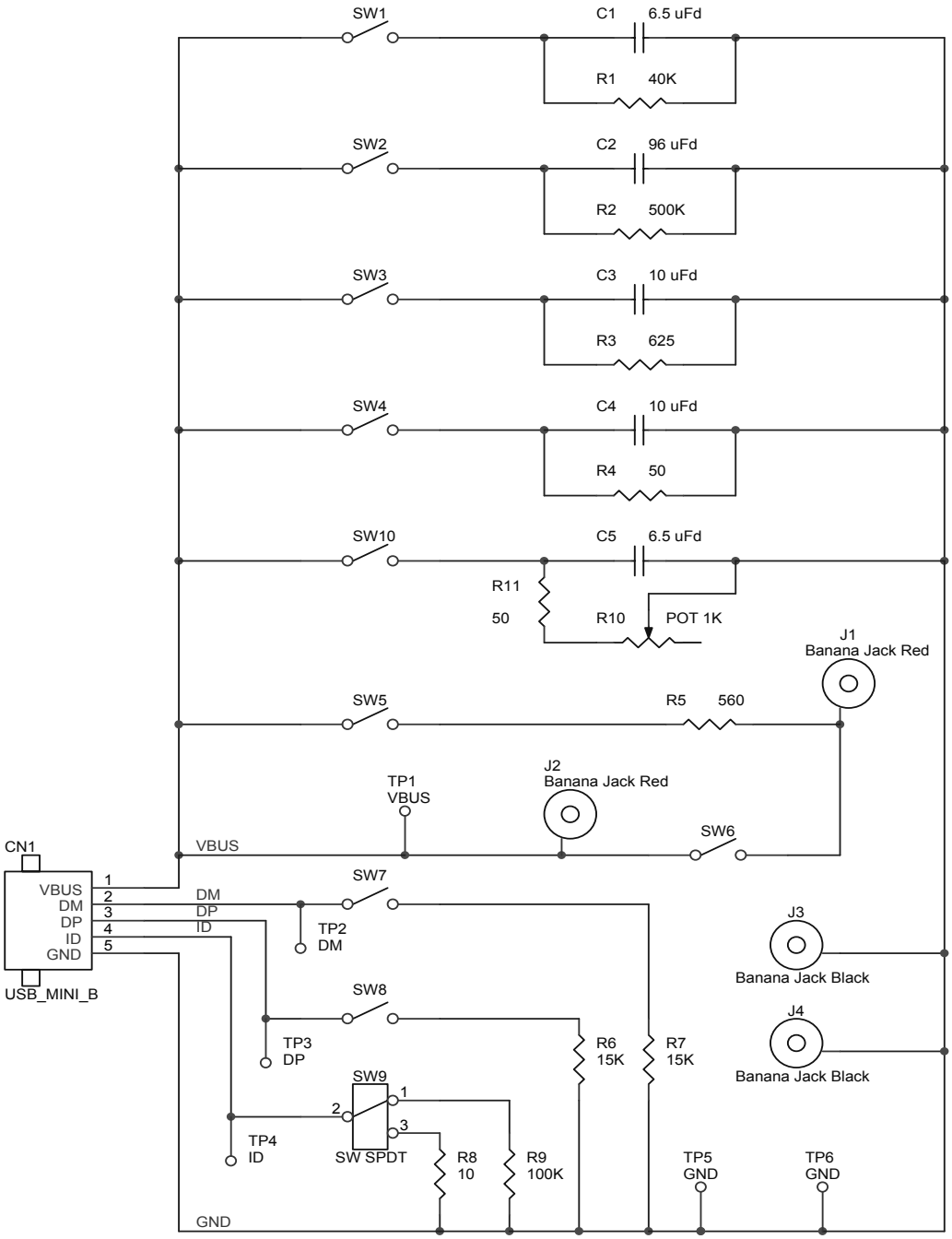
5.3 OTG Electrical Test Device (OET)

5.3.1 Mode Switch Settings

Table 5-3 OTG Electrical Test Device Mode Switch Settings

Mode	SW1	SW2	SW3	SW4	SW5	SW6	SW7	SW8	SW9	SW10
Passive OTG Device Duplicator	**ON**	OFF	OFF	OFF	OFF	OFF	**ON**	**ON**	B-Device	OFF
Passive "PC" Duplicator	OFF	**ON**	OFF	OFF	OFF	OFF	**ON**	**ON**	B-Device	OFF
8 mA Load	OFF	OFF	**ON**	OFF	OFF	OFF	OFF	OFF	A-Device	OFF
100 mA Load	OFF	OFF	OFF	**ON**	OFF	OFF	OFF	OFF	A-Device	OFF
A-Device VBUS Level	OFF	OFF	OFF	OFF	**ON**	OFF	OFF	OFF	A-Device	OFF
B-Device VBUS Level	OFF	OFF	OFF	OFF	**ON**	OFF	**ON**	**ON**	B-Device	OFF
VBUS Current Bypass	OFF	OFF	OFF	OFF	OFF	**ON**	**ON**	**ON**	B-Device	OFF
Variable Load	OFF	OFF	OFF	OFF	OFF	**OFF**	**OFF**	**OFF**	A-Device	On

5.3.2 OTG Electrical Test Device Schematic



SW1 - PASSIVE DUAL-ROLE DEVICE DUPLICATOR

SW2 - PASSIVE "PC" DUPLICATOR

SW3 - 8 mA LOAD

SW4 - 100 mA LOAD

SW5 - VBUS LEVEL

SW6 - VBUS CURRENT BYPASS

SW7 - DM PULL DOWN

SW8 - DP PULL DOWN

SW9 - ID RESISTANCE

SW10 - VARIABLE VBUS LOAD

NOTE: RESISTOR TOLERANCES ARE +/- 1%
CAPACITOR TOLERANCES ARE +/- 10%

Figure 5-1 OTG Electrical Test Device Schematic

Note: The switches can be replaced with relays and additional circuitry to allow external control through an interface (e.g. USB, GPIB, etc.). An OET that can be controlled remotely could be used to automate testing.

5.4 OTG Electrical Test Setup

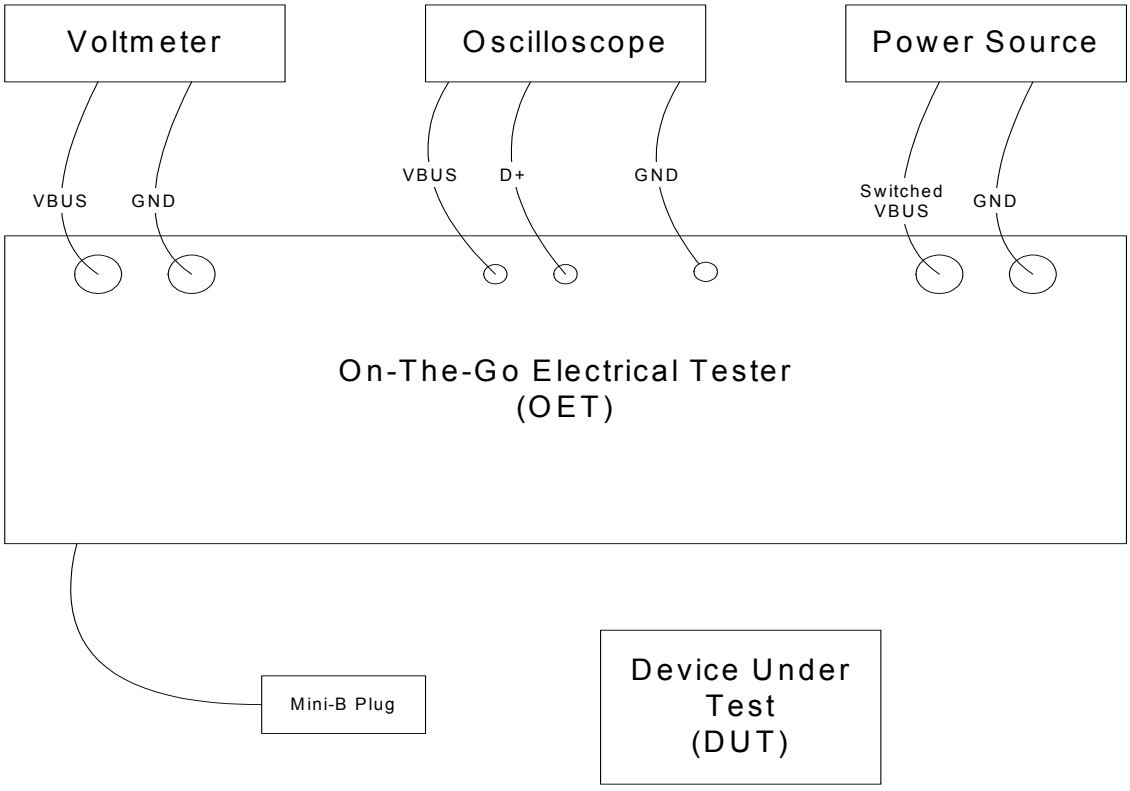


Figure 5-2 OTG Electrical Test Setup

Note: The OET Electrical Test Setup could be automated if the test equipment supports external communications, such as GPIB, and there is the addition of a PC to control the test equipment and the OET.

5.4.1 Description of OTG Electrical Test Setup components:

Table 5-4 lists the OTG Electrical Test Setup equipment. The OTG Electrical Test Setup equipment was chosen to match the equipment listed in the USB-IF Full and Low Speed Compliance Test Procedure to minimize testing costs wherever possible.

Table 5-4 OTG Electrical Test Setup Equipment

Item	Description/Model	Qty
Oscilloscope	Tektronix TDS 684C, 784C or equivalent	1
TDS Probes	P6243 voltage probes	2
Multimeter (Voltmeter)	Keithley 2000 Multimeter or equivalent	1
Power Source	Agilent E3631A or equivalent	1
OET Test Board	OTG Electrical Tester	1

5.5 Electrical Tests

The electrical tests in this section are shown in the same order as the parameters in Table 5-1 DC Electrical Characteristics of the OTG Supplement to the USB 2.0 Specification where possible.

5.5.1 VBUS Voltage Tests

5.5.1.1 A-UUT Output Voltage ($V_{A\_VBUS\_OUT}$)

Test Setup	OTG Electrical Test Setup
Purpose	To verify that the A-UUT can maintain voltage $V_{A\_VBUS\_OUT}$ while supplying the minimum required and maximum supported output current.
Description	This test measures the voltage at the minimum required output current and determines the maximum supported output current.
Checklist Items	E1, E8
Procedure	1. Set OET to **8 mA Load** mode 2. Connect A-UUT to mini-B plug. 3. Use the manufacturer documented procedure to raise V_{BUS} 4. Recommended oscilloscope settings: Trigger oscilloscope when V_{BUS} voltage reaches 4.4 Volts (minimum $V_{A\_VBUS\_OUT}$ value). If oscilloscope does not trigger, device may not be able to provide 8 mA and fails this test. 5. Check that VBUS remains above 4.4 (VA_VBUS_VLD) volts for at least one second after first reaching 4.4 volts. It can not drop below 4.4 volts during this time. 6. Set OET to variable resistance mode. 7. Determine the resistance where VA_VBUS_OUT fails to stay in the valid range. Note: This is the maximum rated load for the device. If the device never fails its maximum rated load is 100 mA. 8. If the load has not exceeded the product rating the test fails.
Pass Criteria	Voltage ($V_{A\_VBUS\_OUT}$) stays in valid range of 4.4 to 5.25 Volts The maximum rated load is greater than or equal to the manufacturer's rating.

5.5.1.2 A-UUT VBUS Rise Time (TA_VBUS_RISE)

Test Setup	OTG Electrical Test Setup
Purpose	To verify the VBUS Rise Time (TA_VBUS_RISE).
Description	This test measures the rise time VBUS (TA_VBUS_RISE).
Checklist Items	E3
Procedure	1. Set OET to **8 mA Load** mode 2. Connect device to mini-B plug 3. Use the manufacturer documented procedure to raise VBUS 4. Recommended oscilloscope settings: Trigger the oscilloscope when the VBUS voltage rises above 300mV. Set oscilloscope to 1V/div and 10ms/div 5. Measure the time it takes the VBUS voltage to rise from 200mV to 4.4 V and record the results. 6. Repeat the test using the manufacturer's rated load for the device.
Pass Criteria	VBUS rise time (TA_VBUS_RISE), measured from 200mV to 4.4V, is under 100 ms

5.5.1.3 A-UUT Leakage Voltage (VA_VBUS_LKG)

- Not tested at this time.

Note: The USB-IF backdrive test partially covers this requirement.

5.5.1.4 B-UUT (SRP capable) to OTG Device Output Voltage ($V_{B\_DRD\_OUT}$)

Test Setup	OTG Electrical Test Setup
Purpose	To verify the minimum OTG Device Output Voltage ($V_{B\_DRD\_OUT}$) is achieved and that the maximum output voltage is not exceeded.
Description	This test measures the peak voltage when a B-UUT initiates V_{BUS} Pulsing to the OTG Device Duplicator.
Checklist Items	E5
Procedure	1. Set OET to **Passive OTG Device Duplicator** mode 2. Connect B-UUT to mini-B plug 3. Use manufacturer documented procedure to initiate SRP. 4. Recommended oscilloscope settings: Trigger the oscilloscope when the V_{BUS} voltage rises above 850mV. (Set oscilloscope to 1V/div and 4ms/div) 5. Record peak V_{BUS} voltage 6. Repeat the test with the following capacitance and load settings: 1uF, 100 kOhms Note: The OET may not support step 6.
Pass Criteria	Measured peak voltage is greater than or equal to the minimum OTG device Output Voltage ($V_{B\_DRD\_OUT}$) of 2.1Volts. Measured peak voltage does not exceed 5.25 volts.

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5.5.1.5 B-UUT (SRP capable) to Host Output voltage ($V_{B\_HST\_OUT}$)

Test Setup	OTG Electrical Test Setup
Purpose	To verify the maximum Host Output Voltage ($V_{B\_HST\_OUT}$) is not achieved.
Description	This test measures the peak voltage when a B-UUT initiates V_{BUS} Pulsing to the Passive PC Duplicator (non-OTG Host).
Checklist Items	E6
Procedure	1. Set OET to **Passive "PC" Duplicator** mode 2. Connect B-UUT to mini-B plug 3. Use manufacturer documented procedure to initiate SRP. 4. Recommended oscilloscope settings: Trigger the oscilloscope when the V_{BUS} voltage rises above 300mV. (Set oscilloscope to 1V/div and 4ms/div) 5. Record V_{BUS} peak voltage
Pass Criteria	Measured peak voltage is less than or equal to the maximum Host Output Voltage ($V_{B\_HST\_OUT}$) of 2.0 Volts.

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5.5.1.6 B-UUT (SRP capable) Induced Transient ($V_{B\_DELTA\_PK}$)

- Not tested at this time.

5.5.2 VBUS Current Tests

5.5.2.1 A-UUT Output Current ($I_{A\_VBUS\_OUT}$)

- Test indirectly handled by the A-UUT Output Voltage ($V_{A\_VBUS\_OUT}$) test

5.5.2.2 B-UUT (OTG Device) Unconfigured Average Current ($I_{B\_DRD\_UNCFG}$)

Test Setup	USB-IF Current Measurement Test Setup
Purpose	To verify that the OTG device consumes less than or equal to the maximum allowed current in the On-The-Go supplement when unconfigured.
Description	This test can be performed during the USB-IF current measurement test using a more stringent current measurement.
Checklist Items	E9
Procedure	1. Obtain the USB-IF Current Measurement Test results 2. Evaluate results with a lower limit of 150 uA.
Pass Criteria	Current measured at less than or equal to maximum ($I_{B\_DRD\_UNCFG}$) of 150 uA.

5.5.3 Data-Line Voltage Tests

5.5.3.1 OTG Device Leakage ($V_{DRD\_DATA\_LKG}$)

- Not tested at this time.

5.5.4 ID Resistance (Detection) Tests

5.5.4.1 Resistance to ground on Mini-B plug ($R_{B\_PLUG\_ID}$)

- Not directly tested at this time.

5.5.4.2 Resistance to ground on Mini-A plug ($R_{A\_PLUG\_ID}$)

- Not directly tested at this time.

5.5.5 Termination Tests

5.5.5.1 A-UUT Data Line Pull-down (R_{PD})

- Not tested at this time.

5.5.5.2 B-UUT Data Line Pull-down (R_{PD})

- Not tested at this time.

5.5.5.3 A-UUT V_{BUS} Input Impedance to GND ($R_{A\_BUS\_IN}$)

- Not tested at this time.

5.5.5.4 B-UUT V_{BUS} SRP pull-up ($R_{B\_SRP\_UP}$)

- Not tested at this time.

5.5.5.5 B-UUT V_{BUS} SRP pull-down ($R_{B\_SRP\_DWN}$)

- Not tested at this time.

5.5.6 Input Levels Tests

5.5.6.1 A-UUT V_{BUS} Valid ($V_{A\_VBUS\_VLD}$)

Test Setup	OTG Electrical Test Setup
Purpose	Verify the detection of a low voltage condition on V_{BUS}.
Description	The test applies a 100mA load to V_{BUS} to verify the A-UUT indicates a low voltage condition or properly supports the load.
Checklist Items	E1
Procedure	1. Set OET to **100 mA Load** mode 2. Connect A-UUT to mini-B plug 3. Use the manufacturer documented procedure to raise V_{BUS} 4. Watch for an indication from the A-UUT of a low voltage condition. 5. For devices that do not provide a low voltage indication, verify that the V_{BUS} voltage did not fall below V_{BUS} Valid ($V_{A\_VBUS\_VLD}$). Check that VBUS remains above 4.4 (VA_VBUS_VLD) volts for at least one second after first reaching 4.4 volts. It can not drop below 4.4 volts during this time.
Pass Criteria	The low voltage indication occurs when the voltage falls below the minimum V_{BUS} Valid ($V_{A\_VBUS\_VLD}$) voltage of 4.4 Volts. If the rated current is 500 mA the voltage must not fall below 4.75 volts.

5.5.6.2 A-UUT Session Valid ($V_{A\_SESS\_VLD}$)

Test Setup	OTG Electrical Test Setup
Purpose	Verify the A-UUT SRP detection level ($V_{A\_SESS\_VLD}$) is in the valid range. Note: This test is only valid for A-UUTs that support V_{BUS} pulsing.
Description	The V_{BUS} voltage is set below the minimum and above the maximum $V_{A\_SESS\_VLD}$ voltage range to verify that the A-UUT starts a session.
Checklist Items	E19
Procedure	1. Set OET to **A-Device VBUS Level** mode 2. Recommended oscilloscope settings: Set the oscilloscope to trigger when the V_{BUS} voltage rises above 4.4 Volts ($V_{A\_VBUS\_VLD}$) 3. Set the Power Supply voltage to 0 Volts 4. Connect A-UUT to mini-B plug 5. Raise the Power Supply voltage until the V_{BUS} voltage is 750mV 6. Verify that a session does not start (V_{BUS} does NOT increase and the oscilloscope does not trigger). 7. Increase the Power Supply voltage to 2.05 Volts 8. Verify that V_{BUS} increased to $V_{A\_VBUS\_VLD}$ as the A-Device started a session. 9. Check that VBUS remains above 4.4 (VA_VBUS_VLD) volts for at least 1 second (TA_WAIT_BCON) after first reaching 4.4 volts. It can not drop below 4.4 volts during this time.
Pass Criteria	A session started when the V_{BUS} voltage level ($V_{A\_SESS\_VLD}$) was between 0.8 and 2 Volts. VBUS remains above 4.4 volts (VA_SESS_VLD) during the required window of time (TA_WAIT_BCON).

5.5.6.3 B-UUT VBUS Valid (VB_SESS_VLD)

Test Setup	OTG Electrical Test Setup
Purpose	Verify the level of the B-UUT VBUS Valid (VB_SESS_VLD) is in the valid range and the appropriate data-line pull-up is raised within 1 second (TB_SVLD_BCON)
Description	The VBUS voltage is set below the minimum and above the maximum VB_SESS_VLD voltage range to verify that the B-UUT enables the appropriate data-line pull-up within 1 second (TB_SVLD_BCON).
Checklist Items	E20
Procedure	1. Set OET to **B-Device VBUS Level** mode 2. Recommended oscilloscope settings: Set the oscilloscope to trigger when the appropriate data-line voltage rises above 600mV 3. Set the VBUS voltage to 750mV 4. Connect B-UUT to mini-B plug 5. Verify that the B-UUT does not turn on a data-line pullup (Oscilloscope does not trigger). 6. Raise the VBUS voltage to 4.05V 7. Verify that the B-UUT raises a data-line pull-up. The oscilloscope should trigger and show a voltage rise on the appropriate data-line 8. Record the time difference between when the VBUS voltage reached 4 Volts and the B-UUT pull-up was enabled. Note: this may be a negative number.
Pass Criteria	B-UUT raises data-line pull-up less than 1 second (TB_SVLD_BCON) after the VBUS (VB_SESS_VLD) voltage level is 4.0 Volts.

5.5.6.4 B-UUT Session End (VB_SESS_END)

- Not tested at this time.

5.5.7 Decoupling Capacitance Test

5.5.7.1 OTG Device V_{BUS} Bypass Capacitance (C_{DRD_VBUS})

Test Setup	USB-IF In-rush Current Measurement Setup
Purpose	Verify the capacitance (C_{DRD_VBUS}) of OTG Device by using the USB-IF in-rush current test.
Description	This test can be performed during the USB-IF current measurement test but with a more stringent current measurement.
Checklist Items	E21
Procedure	1. Obtain the USB-IF in-rush current test results 2. Evaluate results with a lower limit of 33uC (instead of 50uC).
Pass Criteria	The in-rush current stays below 33uC.

5.5.8 Data-Line Pulsing Test

5.5.8.1 Data-Line Pulsing Test ($T_{B\_DATA\_PLS}$)

Test Setup	OTG Electrical Test Setup
Purpose	Verify the duration of a Data-Line pulse ($T_{B\_DATA\_PLS}$) of a B-UUT when performing SRP.
Description	This test verifies that an SRP pulse on the appropriate data line is in the range of 5 to 10 ms.
Checklist Items	E22
Procedure	1. Set OET to **Passive OTG Device Duplicator** mode 2. Connect B-UUT to mini-B plug 3. Use the manufacturer documented procedure to initiate an SRP 4. Recommended oscilloscope settings: Trigger the oscilloscope when the appropriate data line voltage rises above 1 Volt 5. Measure duration of Data-Line pulse
Pass Criteria	The duration of the Data-Line pulse is in the range of 5 to 10 ms.

6 Protocol

6.1 Introduction

The Protocol testing area is divided into 2 sections. A-UUT and B-UUT.

The test descriptions and pass/fail criteria are written in terms of observable bus states and stimulus. Reference is made to the example state diagrams found in the OTG supplement as an aid to developers who followed these examples.

6.2 Equipment

6.2.1 Test Equipment

- PC
- OPT (can be a PCI card or the stand alone embedded that has the USB or RS232 serial interface to the PC)
- OTG protocol test software.
- mini-A to mini-B cable

6.2.2 OTG Protocol Tester (OPT)

The OTG Protocol Tester (OPT) is an OTG device that can perform testing of HNP/SRP protocols of the UUT. When in host role, it supports low speed and full speed. When in peripheral role, it supports full speed only. High-speed support will be in a future version of OPT.

6.2.3 Test Setup 1

In this setup, the mini-B plug is connected to the OPT. The mini-A plug is connected to UUT. The UUT is the default host.

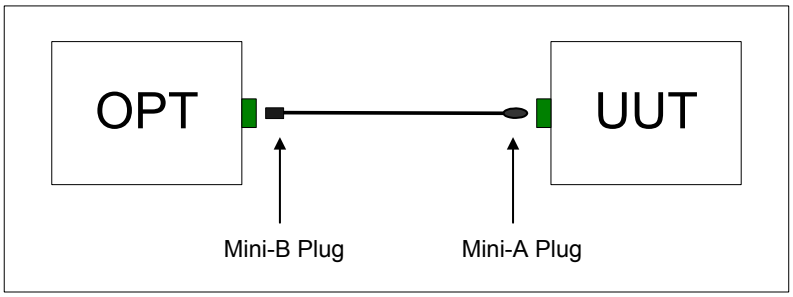


Figure 6-1 Protocol Test Setup 1

6.2.4 Test Setup 2

In this setup, the mini-A plug is connected to the OPT. The mini-B plug is connected to UUT. The UUT is the default peripheral.

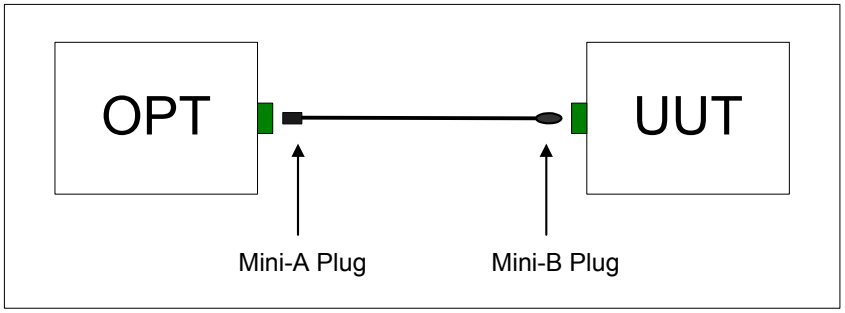


Figure 6-2 Protocol Test Setup 1

6.3 Unit Under Test Requirements

In order to validate the Protocol Compliance all OTG Units Under Test are expected to have the following implementation:

UUT must support a means of external initiation of SRP by the operator. This can be a button, a software setting etc…

For a usage based (VBUS off until SRP occurs) OTG-A device, if a OTG-B device starts a session by means of SRP, the OTG-A is expected to set the feature b_hnp_enable on OTG-B and go into suspend.

For an insertion based (VBUS on with connection) OTG-A device, if a OTG-B device is physically connected, the OTG-A is expected to set the feature b_hnp_enable on OTG-B and go into suspend.

The unit under test is expected to comply with all errata to the OTG supplement. In particular there are errata related to testability that specify UUT behavior with THE unsupported test device.

6.4 Tests

6.4.1 A-UUT

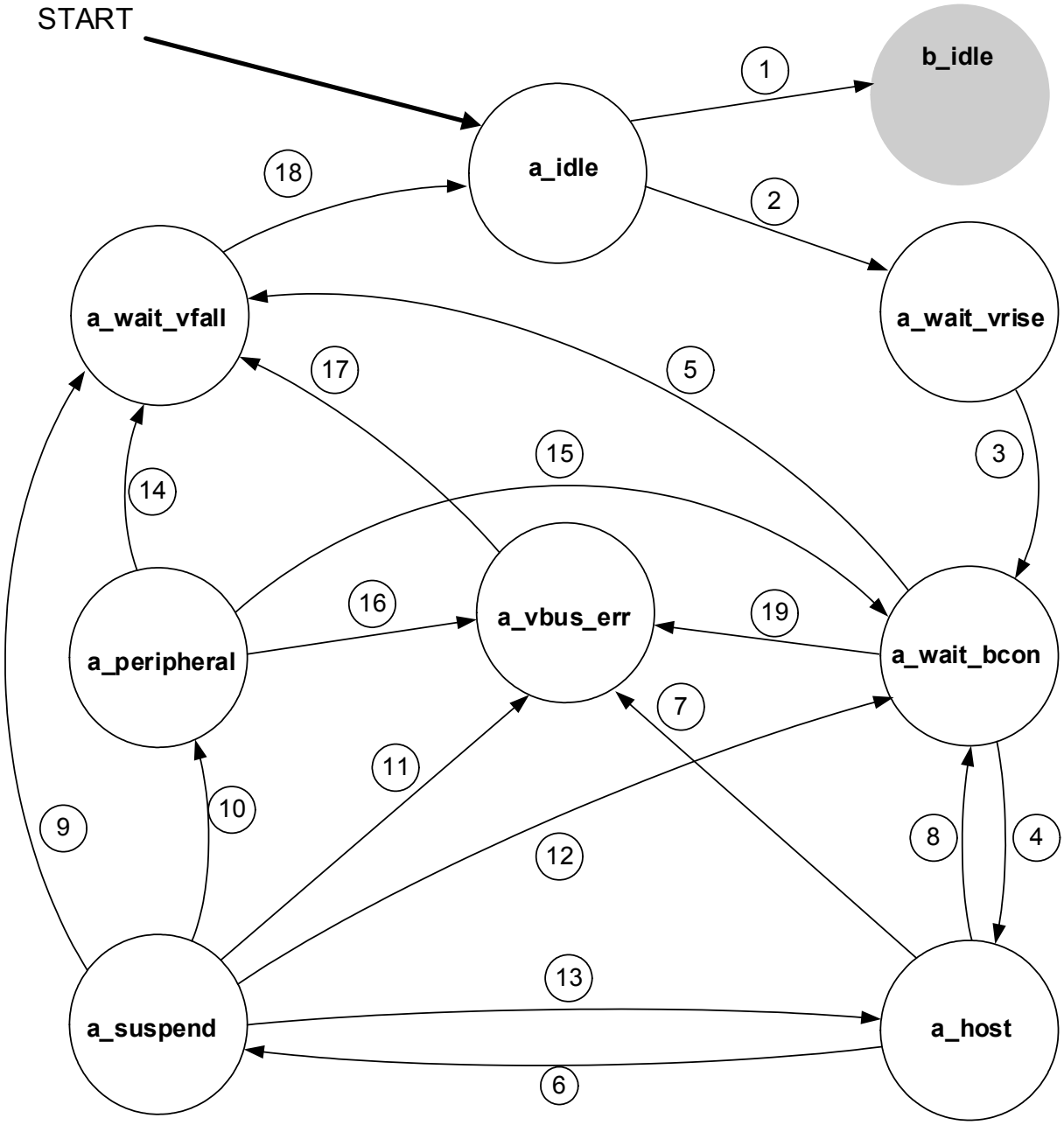


Figure 6-3 State Diagram A-UUT

Test Matrix A-UUT Tests

6.4.1.1 Test-flow A-UUT 1: SRP & HNP test

Test Setup

Use Test Setup 1.

Remark: After having established the cable connection between the 2 devices, both parties (A-UUT and B-OPT) will cycle through the test without the need for operator initiation if the A-UUT is an OTG device that turns on VBUS by means of ID detection. (Insertion Based OTG device)

If the A-UUT turns on VBUS after an SRP, the operator shall have to initiate the test (B-OPT performs SRP).

6.4.1.1.1 Test Initialization

Each of the protocol tests is written so that they can be run individually. Whenever a test tests a condition that happens several steps into the SRP/HNP process a standard initialization procedure is followed to get the device under test into the necessary starting state. This common procedure is documented here and referred to by each of the tests that use it for initialization. The procedure is as follows:

1. B-OPT disconnects by removing its pull-up.
2. B-OPT monitors VBUS until it is removed. If its not removed after 5 seconds software skips to step 4 and continues.
3. B-OPT issues an SRP with the following parameters.

   D+ pull-up applied for 7.5 milliseconds.
   VBUS driven to at least 2.1 volts.

   NOTE: If the UUT is an insertion based device that never drops VBUS this step is skipped.
4. B-OPT connects D+ pull-up when VBUS reaches session valid for a B device.
5. B-OPT enumerates normally and indicates HNP support when queried by the A-UUT.
6. B-OPT successfully acknowledges a Set Feature HNP_ENABLE when received.
7. When the B-OPT sees a suspend condition on the bus it waits for around 75 milliseconds and then disconnects.
8. When the A-UUT connects the B-OPT waits for .5 milliseconds and then drives a bus reset for 50 milliseconds.
9. The B-OPT attempts to enumerate the A-UUT as follows after the bus reset:
   a. Get device descriptor using a maximum packet size of 64. (This will cause a short packet for devices with maxpacketsize0 < 64)
   b. Issue a Set Address command with the next available USB address.
   c. Get the device descriptor again with the right maximum packet size.

d. Get configuration descriptor asking for a number of bytes equal to configuration descriptor size only.

e. Issue a Set Configuration command for the first configuration supported by the device.

f. Get the configuration descriptor again asking for a number of bytes equal to the configuration descriptor size.

g. Get the configuration descriptor using the total length of the entire descriptor.

10. The B-OPT suspends the bus.

11. After the A-UUT disconnects as a peripheral the B-OPT connects in 100 milliseconds (if VBUS still present).

6.4.1.1.2 Test descriptions

TD.4.1 **A-UUT Response to SRP**

This test verifies that an A-UUT that supports SRP responds by starting a session after a valid SRP is issued by a connected device.

NOTE: If the UUT is an insertion based device that never drops VBUS this test is skipped.

Checklist Items: P26, P27

Starting Condition

A-UUT is not supplying VBUS. (A-IDLE). For some A-UUTs that supply VBUS when a cable is connected, device dependent steps may need to be followed to put the A-UUT into a state where VBUS is not provided with the B-OPT test device connected. If the device always supplies VBUS with the cable connected this test does not apply.

Overview of Test Steps

1. Connect the B-OPT tester to the A-UUT.
2. B-OPT verifies that VBUS is not present.
   Note: Some A-UUTs may require device dependent procedures once the B-OPT is connected to drop VBUS.
3. B-OPT issues an SRP with the following parameters:
   D+ Dataline pulsed for 5 milliseconds.
   VBUS driven until reaching 2.1 volts. (Over as little as possible).
4. B-OPT starts a timer as soon as it stops driving VBUS.
5. B-OPT monitors VBUS levels. If VBUS never falls below session valid the test is successful. If VBUS falls below session valid – the B-OPT stops the timer when it again reach B session valid.
6. B-OPT monitors VBUS for 1 second to make sure that it remains supplied.
7. The test is repeated with the following SRP parameters.
   D- Dataline Pulsed for 5 milliseconds.
   VBUS driven until reaching 2.1 volts (Over as little as possible).

Results Interpretation

The test transcribes all results to a text based log file.

The test *fails* if:

- VBUS is not supplied within 30 seconds by the A-UUT.
- VBUS is supplied for less than 1 second by the A-UUT.
- Low speed devices are supported and VBUS is not supplied within 30 seconds by the A-UUT.
- An unsupported error message is not produced in response to the D- pulse case by an A-UUT that does not support LS devices.

TD.4.2 A-UUT Reset on B Connect

This test verifies that an A-UUT providing VBUS after an SRP request properly resets the bus when a device connects.

Checklist Items: P7, P28

Starting Condition

A-UUT is supplying VBUS in response to an SRP. The B-OPT has not yet connected its pull-up resistor to signal connect. (A_WAIT_BCON)

Overview of Test Steps

1. The first three steps of the A-UUT standard initialization procedure described in section **6.4.1.1.1** are followed.

2. The B-OPT connects its D+ pull-up resistor 100 milliseconds after VBUS reaches VB_SESS_VLD.

NOTE: In some cases VBUS may never fall below VB_SESS_VLD after the B-OPT SRP pulse. In this case B-OPT connects 100 milliseconds after it stops driving VBUS as part of the SRP pulse.

3. The B-OPT starts a timer as soon as it connects its D+ pull-up.

4. The B-OPT records the time until a bus reset occurs.

Results Interpretation

The test transcribes all results to a text based log file.

The test *fails* if:

- The A-UUT does not perform a bus reset within 30 seconds of B-OPT connect.
- The reset starts less than 100 milliseconds (debounce) from the B-OPT connect.
- Reset is not driven for at a total of 50ms
- If not continuous, reset is driven less than 10ms
- If not continuous, interval between reset is less than 3ms

TD.4.3 A-UUT Sends Set Feature HNP_Enable and Suspends

This test verifies that an A-UUT providing VBUS after an SRP request properly starts an HNP transition when an unsupported device connects to the bus. (A_HOST to A_SUSPEND)

Checklist Items: P29, P30

Starting Condition

A-UUT has reset the bus following a device connect after SRP.

Overview of Test Steps

1. The first four steps of the A-UUT standard initialization procedure described in section **6.4.1.1.1** are followed.
2. The B-OPT starts a timer.
3. The B-OPT reports HNP support if its descriptors are queried.
4. B-OPT acknowledges the Set Feature HNP_Enable command.
5. The B-OPT monitors for the suspend condition.

Results Interpretation

The test transcribes all results to a text based log file.

The test *fails* if:

- The A-UUT does not send a set feature b_hnp_enable to the B-OPT within 30 seconds of bus reset.
- The A-UUT sends a set feature b_hnp_enable after configuring the B-OPT without sending a set feature a_hnp_support before configuring the B-OPT.
- The A-UUT sends a get descriptor (OTG) at any point.
- The A-UUT sends a set feature A_ALT_HNP_SUPPORT at any time.
- The A-UUT does not suspend the bus (following a successful set feature hnp_enable) within 30 seconds of bus reset.
- User interaction is required for the HNP sequence to occur. (ie – acknowledging an unsupported device message).

TD.4.4 A-UUT Transitions From Suspend to Peripheral In HNP Process.

This test verifies that an A-UUT transitions from host to peripheral when the B-OPT disconnects during a suspend in the HNP process. (A_HOST to A_SUSPEND)

Checklist Items: P31, P20

Starting Condition

A-UUT has suspended the bus in the middle of an HNP sequence.

Overview of Test Steps

1. The first six steps of the A-UUT standard initialization procedure described in section **6.4.1.1.1** are followed.
2. The B-OPT detects 3 missing SOFs, waits for 1 ms and then disconnects.
3. The B-OPT starts a timer when it disconnects.
4. The B-OPT monitors for a connect from A-UUT and stops its timer when this occurs.

Note if D+ is already high and stays that way for TA_BDIS_ACON the test is successful.

5. The Test is repeated with the B-OPT waiting slightly less than 199 milliseconds to disconnect in step 2.

The test *fails* if:

- The A-UUT does not connect within TA_BDIS_ACON.
- The A-UUT exits suspend before the B-OPT disconnects.

TD.4.5 A-UUT is Reset/Enumerated as Peripheral After HNP

This test verifies that an A device enumerates correctly as a peripheral after an HNP handshake.(A_PERIPHERAL)

Checklist Items: P32

Starting Condition

B-OPT has disconnected from the bus in the middle of an HNP sequence.

Overview of Test Steps

1. The first seven steps of the A-UUT standard initialization procedure described in section **6.4.1.1.1** are followed.
2. The B-OPT starts a timer when the A-UUT connects.
3. The B-OPT drives reset for 10 milliseconds immediately after the connection.
4. The B-OPT ensures the A-UUT can be successfully enumerated following the procedure in section **6.4.1.1.1**
5. The test is repeated with the following sets of parameters:

Delay For Reset Start:	0 ms	Reset Duration:	50 ms
Delay For Reset Start:	2.9 ms	Reset Duration:	10 ms
Delay For Reset Start:	2.9 ms	Reset Duration:	50 ms
Delay for Reset Start:	0 ms	Reset Duration:	100 ms
Delay for Reset Start:	2.9 ms	Reset Duration:	100 ms

The test *fails* if:

- The A-UUT does not enumerate properly as a peripheral under any conditions.

TD.4.6 After HNP B-OPT Performs Only Bus Reset Before Suspending

This test verifies that an A-UUT successfully transitions back to waiting for a connect from the B device even when the B-OPT abruptly ends its role as host.

Checklist Items: P21

Starting Condition

B-OPT has performed a bus reset following the connection of the A-UUT as a peripheral.

Overview of Test Steps

1. The first eight steps of the A-UUT standard initialization procedure described in section **6.4.1.1.1** are followed.
2. After finishing driving bus reset the B-OPT performs no traffic and starts a timer.
3. The B-OPT monitors for VBUS dropping below VB_SESS_VLD and D+ disconnecting.
4. If VBUS is removed the B-OPT follows the standard A-UUT initialization procedure to ensure correct functionality (Steps 3-11).
5. If VBUS is not removed after 5 seconds the B-OPT connects and responds normally to a device enumeration sequence.

Note: The B-OPT must attempt to verify that VBUS is not decaying when it connects or the test result could be invalid.

The test *fails* if:

- The A-UUT drops D+ in less than 3 milliseconds (TA_BIDL_ADIS(min)) or more than 200ms (TA_BIDL_ADIS(max)).
- The A-UUT removes VBUS but does not properly respond to a legal SRP/HNP sequence.
- The-AUUT does not remove VBUS but does not respond normally to the B-OPT connecting after the HNP sequence.

TD.4.7 A-UUT Reset on B Connect After HNP Cycle

This test verifies that an A device providing VBUS after an HNP cycle properly resets the bus when a device connects. (A_WAIT_B_CON to A_HOST).

Note: If the A-UUT drops VBUS after the HNP cycle the B-OPT must initiate SRP to start a session and this test is no different than TD.4.2. The A-UUT is allowed to do this at any point in this test – even after the B-OPT has reconnected.

Checklist Items: P28

Starting Condition

A-UUT is supplying VBUS after an HNP transition. The B-OPT has not yet connected its pull-up resistor to signal connect again. (A_WAIT_BCON)

Overview of Test Steps

1. The first 11 steps of the A-UUT standard initialization procedure described in section **6.4.1.1.1** are followed.
2. The B-OPT connects its D+ pull-up resistor 100 milliseconds after A disconnects.
3. The B-OPT starts a timer as soon as it connects its D+ pull-up.
4. The B-OPT records the time until a bus reset occurs.
5. The test is repeated with the B-OPT connecting as close to 1 second (but not over) after the A-UUT drives VBUS to VB_SESSN_VLD.

Results Interpretation

The test transcribes all results to a text based log file.

The test *fails* if:

- The A-UUT does not perform a bus reset within 30 seconds of B connect.

TD.4.7a A-UUT Provides VBUS and Recognizes a Device Connect For the Minimum Required Time.

This test verifies that an A-UUT handles a device connect that happens just before 1 second after VBUS reaches session valid.

NOTE: If the UUT is an insertion based device that never drops VBUS this test is skipped.

Checklist Items:

Starting Condition

A-UUT is not supplying VBUS. (A-IDLE). For some A-UUTs that supply VBUS when a cable is connected, device dependent steps may need to be followed to put the A-UUT into a state where VBUS is not provided.

Overview of Test Steps

1. Connect the B-OPT tester to the A-UUT.
2. Follow the necessary procedure (device specific) to cause VBUS to be supplied.
3. The B-OPT starts a timer when VBUS reaches session valid (4.4 volts).
4. Slightly less than 1 second ($T_{B\_SVLD\_BCON}$) after VBUS reached 4.4 volts the B-OPT connects as a peripheral.
5. The B-OPT monitors for a bus reset and proper enumeration.

The test *fails* if:

- VBUS is dropped by the A-UUT before a successful enumeration has taken place.
- The B-OPT is not successfully enumerated within 30 seconds of connecting.

6.4.1.2 Test-flow A-UUT 2: Resume test

Test Setup

Use Test Setup 1.

Remark: After having established the cable connection between the 2 devices, both parties (A-UUT and B-OPT) will cycle through the test without the need for operator initiation if the A-UUT is a OTG that turns on VBUS by means of ID detection. (Insertion Based OTG)

If the A-UUT turns on VBUS after an SRP, the operator shall have to initiate the test (B-OPT performs SRP).

Test description

Note: There is an errata to the OTG supplement requiring that an A-UUT respond properly to resume signaling if it supports remote wakeup. This is required even if the A-UUT has not enabled the downstream device for remote wakeup.

TD.4.8 **A-UUT Response To Remote Wakeup Before HNP Handoff**

This test verifies that an A-device responds to a remote wakeup when it has suspended the bus as part of the HNP process.

Checklist Items: P33

Starting Condition

A-UUT is has suspended the bus and is waiting for the B-OPT to disconnect. (A_SUSPEND)

Overview of Test Steps

1. The first six steps of the A-UUT standard initialization procedure described in section **6.4.1.1.1** are followed.
2. After the B-OPT sees 5 ms of suspend it drives resume for 1 millisecond.
3. B-OPT monitors to see that resume continues from the A-UUT.
4. The B-OPT starts a timer once resume finishes and records when the first subsequent command occurs and when SOFs begin
5. The test is repeated for the following parameters.

Suspend Time 5 ms	Resume Time 15 ms
Suspend Time 5 ms	Resume Time 1 ms
Suspend Time 150 ms	Resume Time 15 ms
Suspend Time 150 ms	Resume Time 1 ms

The test *fails* if:

- The A-UUT does not respond to remote wakeup by driving at least 20 ms of resume on the bus.
- The A-UUT drives resume for more than 30 seconds.
- The A-UUT does not start sending SOFs within 3 mS of the end of resume.
- The A-UUT attempts to access the B-OPT before 10 ms after the resume ends.

6.4.1.3 Test-flow A_UUT 3: Message Tests

Test Setup

Use Test Setup 1. The cable is initially unconnected for this test.

Test descriptions

TD.4.9 **A-UUT Produces A "Device No Response" Error Message**

This test verifies that an A-UUT produces a device not connected or not responding error message when an A-UUT bus request occurs and it is connected to an OPT programmed to act like a non-responsive device.

Note: This test does not apply to A-UUT devices that supply VBUS based on the insertion of the mini-A plug.

Checklist Items:

Starting Condition

The A-UUT and the B-OPT are not connected or are connected with the A-UUT not providing VBUS.

Overview of Test Steps

1. The B-OPT is programmed to not connect after VBUS becomes valid..
2. The first three steps of the A-UUT standard initialization procedure described in section **6.4.1.1.1** are followed.
3. The B-OPT does not connect after VBUS becomes valid.
4. The B-OPT displays a message 5 seconds after VBUS becomes valid.
5. The B-OPT displays a message 30 seconds after VBUS becomes valid.

The test *fails* if:

- The A-UUT does not produce a device not connected/not responding type error message after the 5 second message is displayed by the test software and before the 30 second message is displayed by the test software.

TD.4.10 A-UUT Produces An "Unsupported Device" Message When The B Device Is Unsupported And Does Not Support HNP.

This test verifies that an A-UUT produces a device not supported error message when a device it doesn't recognize uses SRP to start a session and does not support HNP.

Checklist Items:

Starting Condition

A-UUT is not supplying VBUS. (A-IDLE). For some A-UUTs that supply VBUS when a cable is connected, device dependent steps may need to be followed to put the A-UUT into a state where VBUS is not provided with the B-OPT test device connected.

Overview of Test Steps

1. The B-OPT is programmed to use a VID/PID that is not The Unsupported Device and is not on the A-UUT's targeted peripheral list. The B-OPT is also programmed to indicate that it does not support HNP.
2. The first four steps of the A-UUT standard initialization procedure described in section **6.4.1.1.1** are followed.
3. The B-OPT starts a timer after the A-UUT reads its device descriptor.
4. The B-OPT displays a message 30 seconds after the timer is started.

The test *fails* if:

The A-UUT does not produce an unsupported device message before the 30 seconds elapsed message is displayed by the test software.

TD.4.11 A-UUT Produces A "Device No Response" Error Message When The B Device Stalls Set_Feature B_HNP_ENABLE

This test verifies that an A-UUT produces a device not responding error message when a device it doesn't recognize uses SRP to start a session, indicates HNP support, but STALLs the Set Feature B_HNP_ENABLE request.

Checklist Items:

Starting Condition

A-UUT is not supplying VBUS. (A-IDLE). For some A-UUTs that supply VBUS when a cable is connected, device dependent steps may need to be followed to put the A-UUT into a state where VBUS is not provided with the B-OPT test device connected.

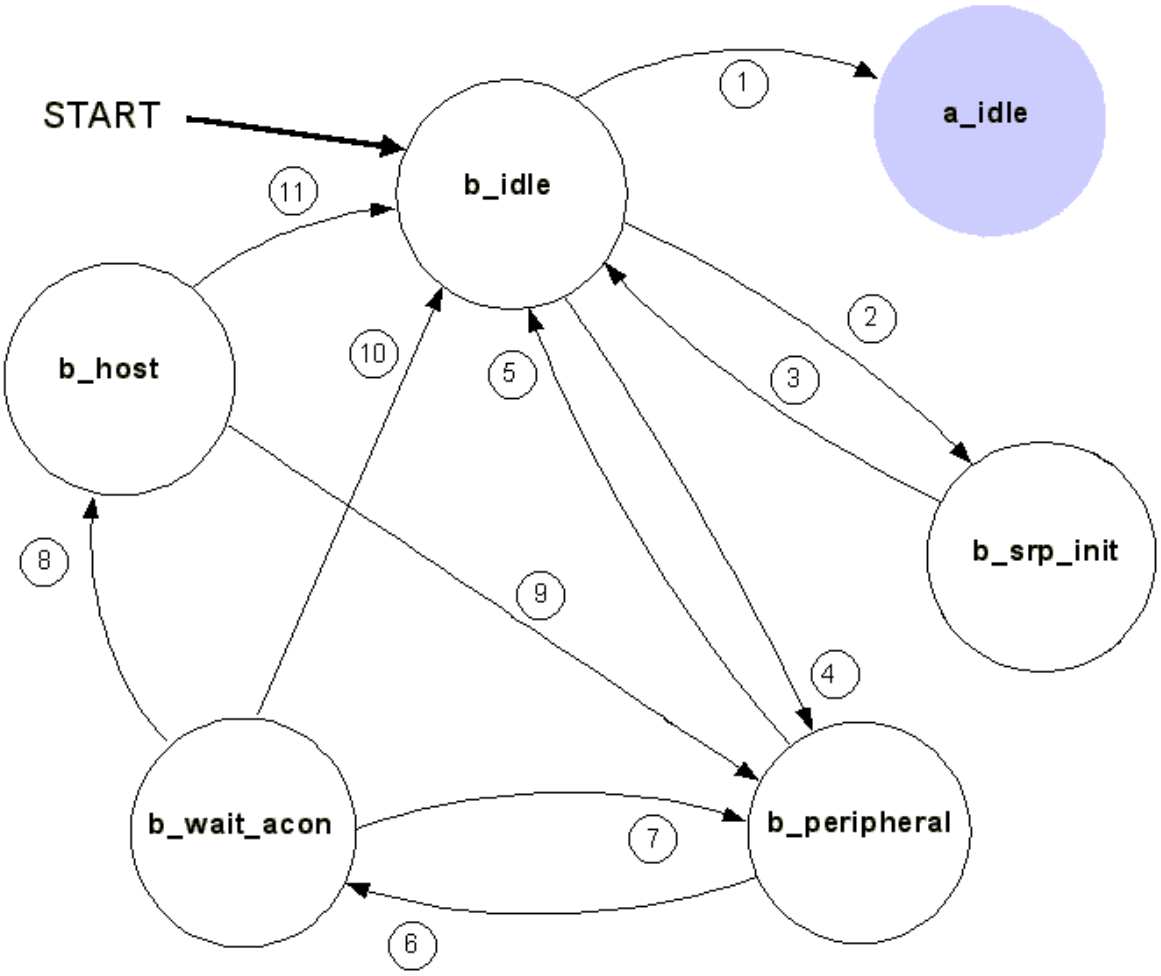
Overview of Test Steps

1. The B-OPT is programmed to use a VID/PID that is not The Unsupported Device and is not on the A-UUT's targeted peripheral list. The B-OPT is also programmed to indicate that it does support HNP. It is programmed to STALL a Set Feature B_HNP_ENABLE request when it occurs.
2. The first four steps of the A-UUT standard initialization procedure described in section **6.4.1.1.1** are followed.
3. The B-OPT starts a timer after it returns STALL on a Set Feature B_HNP_ENABLE request.
4. The B-OPT displays a message 30 seconds after the timer is started.

The test *fails* if:

The A-UUT does not produce a device not connected/not responding message before the 30 seconds elapsed message is displayed by the test software.

6.4.2 B-UUT



State Diagram

Figure 6-4 State diagram B-UUT

6.4.2.1 Test-flow B-UUT 1: SRP, HNP test

Test Setup

Use Test Setup 2.

6.4.2.1.1 Test Initialization: Standard Initialization For B-UUT Protocol Tests.

Each test is written to be run individually. Whenever a test tests a condition that occurs several steps into the SRP/HNP process a standard initialization procedure is followed to get the device under test into the necessary starting state. This common procedure is documented here and referred to by each of the tests that use it for initialization. The procedure is as follows:

1. The B-UUT issues an SRP to start a session with the A-OPT.
2. 100 milliseconds after VBUS begins to decay the A-OPT powers VBUS.
3. 100 milliseconds after the B-UUT connects the A-OPT drives reset for 50 milliseconds.
4. The A-OPT waits for 10 milliseconds.
5. The A-OPT enumerates the B-UUT as follows:
    a. Get device descriptor using a maximum packet size of 64. (This will cause a short packet for devices with maxpacketsize0 < 64)
    b. The A-OPT sends a Set Feature b_hnp_enable
    c. Issue a Set Address command with the next available USB address.
    d. Get the device descriptor again with the right maximum packet size.
    e. Get configuration descriptor asking for a number of bytes equal to configuration descriptor size only.
    f. Issue a Set Configuration command for the first configuration supported by the device.
    g. Get the configuration descriptor again asking for a number of bytes equal to the configuration descriptor size.
    h. Get the configuration descriptor using the total length of the entire descriptor.
6. The A-OPT immediately suspends the bus after receiving the acknowledge for the handshake phase of the Get configuration descriptor command. The A-OPT waits for the B disconnect.
7. The A-OPT waits for 1.5 milliseconds and connects.
8. The A-OPT responds normally to configuration activity as a peripheral.
9. If the bus is suspended by the UUT (Host) the A-OPT disconnects as peripheral after detecting at least 3 milliseconds of suspend.

6.4.2.1.2 Test descriptions

TD.5.1 **B-UUT Connects Properly After Initiating SRP**

This test verifies that a B-UUT that has requested a session through the SRP protocol connects as a device within the required timing.

Checklist Items: E20

Starting Condition

A-OPT is not supplying VBUS. (A-IDLE). B-UUT is unconnected.

Overview of Test Steps

1. Connect the B-UUT to the A-OPT.
2. The test software prompts the user to generate an SRP. (If necessary)
3. The A-OPT starts providing VBUS immediately after 5 milliseconds of the SRP dataline pulse.
4. The A-OPT starts a timer when VBUS reaches VA_SESS_VLD.
5. A-OPT monitors for the B-UUT connect.
6. The test is repeated with the A-OPT providing VBUS slightly less than 5 seconds from the end of SRP. (VBUS starts to decay).

Results Interpretation

The test transcribes all results to a text based log file.

The test *fails* if:

- A valid SRP is not generated. (No sufficient length D+ data line pulse).
- The B-UUT does not connect within 1 second ($T_{B\_SVLD\_BCON}$) of VBUS reaching VB_SESS_VLD.

TD.5.2 **B-UUT Receives Set_Feature HNP Related Commands Correctly At Different Stages of the Enumeration Sequence**

This test verifies that the B-UUT responds successfully to Set Feature B_HNP_Enable command when it is sent in various locations throughout the enumeration sequence..

Checklist Items: P16

Starting Condition

B-UUT has connected to the bus after issuing an SRP to request a session from the A-OPT.

Overview of Test Steps

1. The first two steps of the Standard Initialization For B-UUT Protocol Tests described in section **6.4.2.1.1** are followed.

2. The A-OPT drives reset for 50 milliseconds starting 100 milliseconds after the B-UUT connects.

3. The A-OPT waits for 10 milliseconds.

4. The A-OPT performs the standard enumeration sequence defined in section **6.4.2.1.1**

5. Steps 1-4 are repeated with the Set Feature B_HNP_Enable sent when the device is addressed (but not configured).

6. Steps 1-4 are repeated with Set Feature A_HNP_Support sent when the device is in the default state and Set Feature B_HNP_ENABLE sent after it is configured.

7. Steps 1-5 (the entire test with Set Feature B_HNP_ENABLE sent with the device in different states) is repeated with the following sets of timing parameters:

Time After Connect To Reset	100 milliseconds
Reset Length	30 milliseconds
Time After Reset To First Command	10 milliseconds
Time After Connect To Reset	1 second
Reset Length	30 milliseconds
Time After Reset To First Command	10 milliseconds
Time After Connect To Reset	1 second
Reset Length	50 milliseconds
Time After Reset To First Command	10 milliseconds
Time After Connect To Reset	100 milliseconds
Reset Length	1 second
Time After Reset To First Command	10 milliseconds
Time After Connect To Reset	100 milliseconds
Reset Length	50 milliseconds
Time After Reset To First Command	1 second

The test *fails* if:

- The B-UUT fails to enumerate in any scenario.
- The B-UUT does not accept a Set Feature B_HNP_Enable command in any device state.

TD.5.3 B-UUT Disconnects Within the Allowed Window After Accepting a Set Feature B_HNP_Enable Command.

This test verifies that the B-UUT disconnects within the appropriate timeframe after the A-OPT has suspended the bus for an HNP transition.

Checklist Items: P10, P34

Starting Condition

B-UUT has successfully acknowledged a Set Feature B_HNP_Enable command and is waiting for the A_OPT to suspend the bus.

Overview of Test Steps

1. The first five steps of the Standard Initialization For B-UUT Protocol Tests described in section **6.4.2.1.1** are followed.

2. The A_OPT directly suspends the bus after the Set Feature B_HNP_Enable command is accepted.

3. The A_OPT starts a timer after 3 milliseconds of suspend.

4. The A_OPT records when the B-UUT disconnects.

5. The test is repeated with the A_OPT waiting slightly less than 30 seconds before suspending the bus.

6. The test is again repeated with the A_OPT waiting 2 minutes after the Set Feature B_HNP_Enable to suspend the bus (and finishing the standard sequence through step 5).

The test *fails* if:

- The B-UUT disconnects less than 4 milliseconds ($T_{B\_AIDL\_BDIS}$ min.) after the start of suspend.
- The B-UUT does not disconnect within 150 milliseconds ($T_{B\_AIDL\_BDIS}$ max.) of the start of suspend.

TD.5.4 B-UUT Becomes Host and Drives Reset To Complete HNP Transition.

This test verifies that the B-UUT assumes the role of host and drives a reset after the A-OPT has connected as a peripheral after an HNP sequence.

Checklist Items: P14, P15

Starting Condition

B-UUT has disconnected from the bus following a suspend as part of the HNP sequence.

Overview of Test Steps

1. The first six steps of the Standard Initialization For B-UUT Protocol Tests described in section **6.4.2.1.1** are followed.
2. The A-OPT connects immediately.
3. The A-OPT monitors for SE0 on the bus.
4. The A-OPT monitor for reset start time reset duration.
5. The test is repeated with the A-OPT connecting slightly before 3 milliseconds from the B-UUT disconnect.

The test *fails* if:

- The B-UUT does not drive a reset.
- The B-UUT reset length is less than 10 milliseconds.
- The B-UUT drives a reset starting more than 1 millisecond from the A-OPT connect.

TD.5.5 **B-UUT Ends Session For The Unsupported Device After Becoming Host.**

This test verifies that the B-UUT ends its session after becoming host for the unsupported device.

Checklist Items: P35

Starting Condition

B-UUT has become host after an HNP transition.

Overview of Test Steps

1. The first 7 steps of the Standard Initialization For B-UUT Protocol Tests described in section **6.4.2.1.1** are followed.
2. The A-OPT waits for a reset.
3. The A-OPT starts a timer..
4. The A-OPT responds normally to standard peripheral requests from the B-UUT as host..
5. The A-OPT monitors for a suspend state on the bus.

The test *fails* if:

- The A-OPT does not receive a get device descriptor request after the B-UUT has become host.
- The A-OPT receives a Get Descriptor (OTG) command from the UUT after it becomes peripheral.
- The A-OPT receives a Set Feature A_ALT_HNP_SUPPORT after it becomes peripheral.
- The A-OPT does not receive a reset after the B-UUT has become host.
- The B-UUT does not suspend the bus within 30 seconds of assuming the role of host.

TD.5.6 **After Ending Session for The Unsupported Device B-UUT Transitions Back to Peripheral**

This test verifies that the B-UUT transitions back to the peripheral state after ending a session to the unsupported device.

Checklist Items:

Starting Condition

B-UUT has suspended the bus to end the session after becoming host.

Overview of Test Steps

1. The first 9 steps of the Standard Initialization For B-UUT Protocol Tests described in section **6.4.2.1.1** are followed.
2. The A-OPT monitors for the B connect.
3. The A-OPT performs steps 3-5 of the standard initialization sequence in section 6.4.2.1.1

The test *fails* if:

- The B-UUT does not reconnect as a peripheral within 200 milliseconds of the A disconnecting.
- The B-UUT does not respond normally to any part of the standard enumeration sequence after connecting.

6.4.2.2 Test-flow B-UUT2: Message Tests

Test Setup

Use Test Setup 2.

Test descriptions

TD.5.7 **B-UUT Displays A "Device No Response" Error Message When An Attempt To Start A Session Fails.**

This test verifies that the B-UUT displays an error message when it is unable to start a session. The B-UUT is connected to a non-responsive A-OPT for this test.

Checklist Items:

Starting Condition

A-OPT is not supplying VBUS. (A-IDLE). B-UUT is unconnected or connected.

Overview of Test Steps

1. Connect the B-UUT to the A-OPT (if necessary).
2. The test software prompts the user to generate an SRP. (If necessary)
3. The A-OPT starts a timer after detecting SRP. It does not supply VBUS.
4. 5 seconds after starting the timer the A-OPT displays a message indicating that 5 seconds has elapsed.
5. 6 seconds after starting the timer the A-OPT displays a message indicating that 6 seconds have elapsed.

The test *fails* if:

- The B-UUT does not display a device not connected or not responding type error message between the 5 and 6 second messages.

TD.5.8 B-UUT Displays "Unsupported Device" Error Message

This test verifies that the B-UUT displays an unsupported device error message when it becomes host and enumerates the A-OPT which is programmed to have an unsupported Vendor and Device ID.

Checklist Items:

Starting Condition

B-UUT has become host after an HNP transition.

Overview of Test Steps

1. The A-OPT is programmed to use a VID/PID that is not The Unsupported Device and is not on the B-UUTs targeted peripheral list.

2. The first 8 steps of the Standard Initialization For B-UUT Protocol Tests described in section **6.4.2.1.1** are followed.

3. The A-OPT starts a timer after its device descriptor is read by the B-UUT.

4. The A-OPT responds normally to all configuration requests.

5. The A-OPT displays a message that 30 seconds have elapsed when the timer started in step 3 reaches 30 seconds.

The test *fails* if:

- The B-UUT does not display an unsupported device error message before 30 seconds.

TD.5.9 B-UUT Displays A "Device No Response" Error Message When HNP Fails

This test verifies that the B-UUT displays an error message when it starts a session and HNP fails.

Checklist Items:

Starting Condition

A-OPT is not supplying VBUS. (A-IDLE). B-UUT is unconnected or connected.

Overview of Test Steps

1. A-OPT enumerates as an unsupported device (Product ID = 0x1234) which is not on the B-UUTs targeted peripheral list.

2. The first 6 steps of the Standard Initialization For B-UUT Protocol Tests described in section **6.4.2.1.1** are followed.

3. The A-OPT starts a timer after it suspends the bus as part of HNP. It performs no further actions.

4. The A-OPT displays a message that 30 seconds have elapsed when the timer started in step 3 reaches 30 seconds.

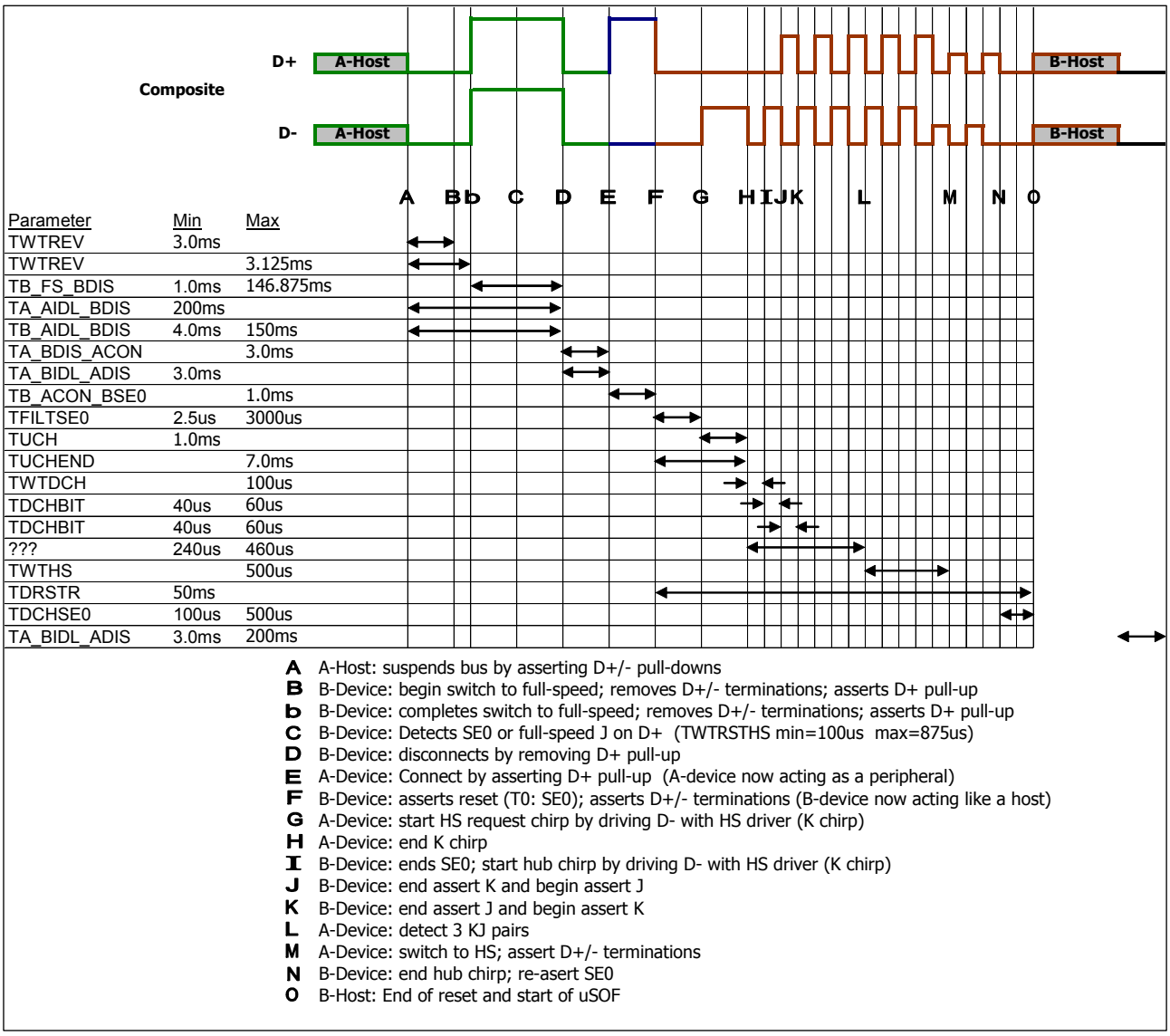
5. The test is repeated with the A-OPT dropping VBUS after suspending the bus.

The test *fails* if:

- The B-UUT does not display a device not responding or not connected type error message before 30 seconds.

6.4.3 High-Speed Test Cases

The following diagram (Figure 7 High-Speed HNP Signaling) shows the high speed host negotiation protocol with the A-device relinquishing host control to the B-device.



Parameter	Min	Max
TWTREV	3.0ms	
TWTREV		3.125ms
TB_FS_BDIS	1.0ms	146.875ms
TA_AIDL_BDIS	200ms	
TB_AIDL_BDIS	4.0ms	150ms
TA_BDIS_ACON		3.0ms
TA_BIDL_ADIS	3.0ms	
TB_ACON_BSE0		1.0ms
TFILTSE0	2.5us	3000us
TUCH	1.0ms	
TUCHEND		7.0ms
TWTDCH		100us
TDCHBIT	40us	60us
TDCHBIT	40us	60us
???	240us	460us
TWTHS		500us
TDRSTR	50ms	
TDCHSE0	100us	500us
TA_BIDL_ADIS	3.0ms	200ms

A A-Host: suspends bus by asserting D+/- pull-downs
B B-Device: begin switch to full-speed; removes D+/- terminations; asserts D+ pull-up
b B-Device: completes switch to full-speed; removes D+/- terminations; asserts D+ pull-up
C B-Device: Detects SE0 or full-speed J on D+ (TWTRSTHS min=100us max=875us)
D B-Device: disconnects by removing D+ pull-up
E A-Device: Connect by asserting D+ pull-up (A-device now acting as a peripheral)
F B-Device: asserts reset (T0: SE0); asserts D+/- terminations (B-device now acting like a host)
G A-Device: start HS request chirp by driving D- with HS driver (K chirp)
H A-Device: end K chirp
I B-Device: ends SE0; start hub chirp by driving D- with HS driver (K chirp)
J B-Device: end assert K and begin assert J
K B-Device: end assert J and begin assert K
L A-Device: detect 3 KJ pairs
M A-Device: switch to HS; assert D+/- terminations
N B-Device: end hub chirp; re-asert SE0
O B-Host: End of reset and start of uSOF

Figure 7 High-Speed HNP Signaling

6.4.3.1 High-Speed A-UUT: HNP with HS A-UUT and HS B-OPT.

Test Setup

Use Test Setup 1 as described in Section 6.2.3.

Remark: After having established the cable connection between the 2 devices, both parties (A-UUT and B-OPT) will cycle through the test without the need for operator intervention if the A-UUT is an OTG device that turns on VBUS by means of ID detection. (Insertion Based OTG device)

If the A-UUT turns on VBUS after an SRP, the operator shall have to initiate the test (B-OPT performs SRP).

6.4.3.1.1 A-UUT Test Initializations

Each of the protocol tests is written so that they can be run individually. Whenever a test examines a condition occurring several steps into the HNP process, a standard initialization procedure is followed to get the device under test into the necessary starting state. This common procedure is documented here and referred to by each of the tests that use it for initialization. The procedure is as follows:

A-UUT Initialization

1. B-OPT disconnects by removing its pull-up.
2. B-OPT monitors VBUS until it is removed. If it's not removed after 5 seconds, OPT skips to step 4 and continues.
3. B-OPT issues an SRP with the following parameters.

   D+ pull-up applied for 7.5 milliseconds.
   VBUS driven to at least 2.1 volts.
4. B-OPT connects D+ pull-up when VBUS reaches session valid for a B device.
5. B-OPT starts driving a "chirp K" 1 millisecond after it detects reset (TFILTSE0).
6. B-OPT stops driving "chirp K" 4 milliseconds after starting the chirp (TUCH).
7. B-OPT applies HS terminations 250 microseconds after seeing 3 chirp KJ pairs from the A-UUT (TWTHS).
8. B-OPT successfully acknowledges a Set Feature HNP_ENABLE if received.

A-Host → A-Peripheral Initialization

9. After the B-OPT sees a 3 millisecond suspend condition on the bus, it waits for 100 microseconds and then switches to full-speed, removes D+/- terminations, and applies its D+ pull-up (TWTREV).
10. The B-OPT samples the state of D+ 500 microseconds after applying its pullup in step 9 (TWTRSTHS).
    a. If the sampling determines a reset (SE0) then
       i. Skip to step 5 if test is a HS reset
       ii. Error out if test is a HS HNP

b. If the sampling determines a bus suspend, then

i. Continue to step 11 if test is HS HNP and b_hnp_enable = true

ii. B-OPT suspends if b_hnp_enable = false

11. The B-OPT disconnects 75 milliseconds after the start of suspend (TB_AIDL_BDIS).
12. When the A-UUT connects, the B-OPT waits for 0.5 milliseconds, starts timer T0 and then begins to drive a bus reset (TB_ACON_BSE0)
13. If the B-OPT detects a “Chirp K” during reset, it ends reset and begins driving high-speed Chirp KJ pairs 50 microseconds (TWTDCH) after the end of the A-UUT “Chirp K”. The B-OPT KJ pairs are each 50 microseconds in duration (TDCHBIT).

    If the B-OPT does not detect a “chirp K,” then reset continues until timer T0 reaches 60 milliseconds and jumps to step 16.
14. The B-OPT ends chirp KJ pairs when timer T0 reaches 60 milliseconds
15. The B-OPT asserts reset (SE0) for 250 microseconds.
16. The B-OPT begins sending SOFs.
17. The B-OPT attempts to enumerate the A-UUT as follows:

    a. Get device descriptor using a maximum packet size of 64. (This will cause a short packet for devices with maxpacketsize0 < 64)

    b. Issue a Set Address command with the next available USB address.

    c. Get the device descriptor again with the right maximum packet size.

    d. Get configuration descriptor asking for a number of bytes equal to configuration descriptor size only.

    e. Issue a Set Configuration command for the first configuration supported by the device.

    f. Get the configuration descriptor again asking for a number of bytes equal to the configuration descriptor size.

    g. Get the configuration descriptor using the total length of the entire descriptor.

A-Peripheral → A-Host Initialization

18. B-OPT suspends the bus and switches to full-speed terminations
19. A-UUT detects 3 milliseconds of bus suspend (TA_BIDL_ADIS). It may do either:

    a. switches to full-speed, removes D+/- terminations, and remove its D+ pull-up; OR

    b. turns-off VBus and ends session
20. The B-OPT connects by applying its D+ pull-up 1.5 milliseconds.after A-UUT disconnects.
21. When the B-OPT connects, the A-UUT begins to drive a bus reset (SE0) within 1.0 milliseconds
22. The B-OPT drives a 3.0 millisecond high-speed “Chirp K” 1.0 millisecond after the A-UUT drives reset.
23. Upon completion of the chirp K, the A-UUT ends reset and begins driving Chirp KJ pairs within 100 microseconds.
24. The B-OPT monitors the KJ chirps.
25. 100 microseconds after detecting 3 valid KJ chirps, the B-OPT switches to high-speed and asserts D+/- terminations.

26. At least 50 milliseconds from the time A-UUT asserts reset in step 26, it begins sending SOFs.

TD.6.1. **A-UUT Enumerates High-Speed B-OPT**

This test verifies that an A-UUT that supports high speed peripherals successfully resets and enumerates a high-speed B-OPT.

Checklist Items:

Starting Condition

A-UUT is not supplying VBUS. (A-IDLE). For some A-UUTs that supply VBUS when a cable is connected, device dependent steps may need to be followed to put the A-UUT into a state where VBUS is not provided with the B-OPT test device connected.

Overview of Test Steps

1. Connect the B-OPT tester to the A-UUT.
2. Follow the first 4 steps of section 6.4.3.1.1 A-UUT Test Initializations.
3. B-OPT starts driving a “chirp K” 1.0 millicsecond after it detects reset (TFILTSE0).
4. B-OPT stops driving a “chirp K” 3.0 millisecond after starting the chirp (TUCH).
5. B-OPT measures when A-UUT begins first high-speed chirp K (TWTDCH < 100us)
6. B-OPT monitors for at least 3 chirp KJ pairs from the A-UUT. The A-OPT checks the duration of each K or J pulse. It also counts the number of K and J pulses.
7. B-OPT monitors when A-UUT asserts SE0 and begins SOFs
8. The B-OPT is enumerated and receives a SetFeature HNP_ENABLE
9. The test is repeated with the following peripheral “chirp K” parameters.
   a. TFILTSE0 = 2.5 microseconds. TUCH = 6.9975 ms
   b. TFILTSE0 = 2.5 microseconds. TUCH = 1.0 ms
   c. TFILTSE0 = 3.0 milliseconds. TUCH = 1.0 ms
   d. TFILTSE0 = 3.0 milliseconds. TUCH = 4.0 ms

Results Interpretation

The test transcribes all results to a text based log file.

The test fails if:

- The A-UUT begins chirp KJ sequence more than 100us after end of chirp K. (TWTDCH)
- The A-UUT does not respond to the “Chirp K” with at least 3 chirp KJ pairs where each pulse width is between 40 and 60 microseconds (TDCHBIT).
- The A-UUT asserts SE0 less than 100us or greater than 500us before sending SOFs (TDCHSE0)
- The A-UUT fails to assert SE0 before issuing SOFs
- The A-UUT begins to send SOFs less than 50ms from initial reset (TDRSTR).
- The A-UUT fails to enumerate the B-OPT and send the SetFeature HNP_ENABLE.

TD.6.2. **A-UUT Sends Set Feature HNP_Enable and Initiates HNP**

This test verifies that an A-UUT providing VBUS after an SRP request properly starts an HNP transition when an unsupported device connects to the bus. (A_HOST to A_SUSPEND)

Checklist Items: P29, P30

Starting Condition

A-UUT has reset the bus following a device connect after SRP. (a-host)

Overview of Test Steps

1. Follow the first 4 steps of section 6.4.3.1.1 A-UUT Test Initializations.
2. The B-OPT starts a timer when a reset is detected
3. B-OPT starts driving a “chirp K” 1.0 millisecond after it detects reset (TFILTSE0).
4. B-OPT stops driving “chirp K” 3.0 millisecond after starting the chirp (TUCH).
5. B-OPT measures when B-UUT begins first high-speed chirp K (TWTDCH < 100us)
6. B-OPT monitors for at least 3 chirp KJ pairs from the A-UUT. The A-OPT checks the duration of each K or J pulse. It also counts the number of K and J pulses.
7. B-OPT monitors when A-UUT asserts SE0 and begins SOFs
8. The B-OPT reports HNP support when queried and starts a timer.
9. The B-OPT acknowledges the Set Feature HNP_Enable command.

Results Interpretation

The test transcribes all results to a text based log file.

The test *fails* if:

- The A-UUT does not send a set feature b_hnp_enable to the B-OPT within 30 seconds of bus reset.
- The A-UUT sends a set feature b_hnp_enable after configuring the B-OPT without sending a set feature a_hnp_support before configuring the B-OPT.
- The A-UUT sends a get descriptor (OTG) at any point.
- The A-UUT sends a set feature A_ALT_HNP_SUPPORT at any time.
- The A-UUT does not suspend the bus (following a successful set feature hnp_enable) within 30 seconds of bus reset.
- User interaction is required for the HNP sequence to occur. (*e.g.* – acknowledging an unsupported device message).

TD.6.3. **A-UUT Host Response to B-OPT Disconnect During HNP**

This test verifies that a high-speed A-UUT successfully recognizes the B-OPT disconnect to initiate HNP. The A-UUT must connect as a full-speed peripheral after the B-OPT disconnects.

Checklist Items:

Starting Condition

A-UUT has suspended the bus to initiate an HNP sequence. (a_suspend)

Overview of Test Steps

1. Follow the first 8 steps of the A-UUT initialization procedure described in section 6.4.3.1.1.
2. When the B-OPT detects a suspend condition on the bus it waits for 3 milliseconds (TWTREV) and then applies its D+ pull-up.
3. The B-OPT samples the state of D+ 100 microseconds (TWTRSTHS) after applying its pull-up in step 2.
4. The B-OPT disconnects 70.0 milliseconds (TB_FS_BDIS) after D+ pull-up.
5. The B-OPT monitors for the A-UUT connecting as a peripheral. NOTE: The D+ may already be high as long as it stays that way for TA_BDIS_ACON.
6. The B-OPT monitors how long the A-UUT signals connect (TA_BIDL_ADIS min)
7. The test repeats with the following combinations of parameters.

Suspend to D+ pull-up	TWTREV = 3 milliseconds
D+ pull-up to D+ state sample	TWTRSTHS = 875 microseconds
D+ pull-up to disconnect	TB_FS_BDIS = 1.0 milliseconds
Suspend to D+ pull-up	TWTREV = 3 milliseconds
D+ pull-up to D+ state sample	TWTRSTHS = 100 microseconds
D+ pull-up to disconnect	TB_FS_BDIS = 146.875 milliseconds
Suspend to D+ pull-up	TWTREV = 3 milliseconds
D+ pull-up to D+ state sample	TWTRSTHS = 875 microseconds
D+ pull-up to disconnect	TB_FS_BDIS = 146.875 milliseconds
Suspend to D+ pull-up	TWTREV = 3.125 milliseconds
D+ pull-up to D+ state sample	TWTRSTHS = 100 microseconds
D+ pull-up to disconnect	TB_FS_BDIS = 1.0 milliseconds
Suspend to D+ pull-up	TWTREV = 3.125 milliseconds
D+ pull-up to D+ state sample	TWTRSTHS = 875 microseconds
D+ pull-up to disconnect	TB_FS_BDIS = 1.0 millisecond
Suspend to D+ pull-up	TWTREV = 3.125 milliseconds
D+ pull-up to D+ state sample	TWTRSTHS = 100 microseconds
D+ pull-up to disconnect	TB_FS_BDIS = 146.875 milliseconds
Suspend to D+ pull-up	TWTREV = 3.125 milliseconds
D+ pull-up to D+ state sample	TWTRSTHS = 875 microseconds
D+ pull-up to disconnect	TB_FS_BDIS = 146.875 milliseconds

Results Interpretation

The test *fails* if:

- The A-UUT does not connect as a full speed peripheral within 3 milliseconds (TA_BDIS_ACON) in any scenario.
- The B-OPT is unable to sample D+ line TWTRSTHS in any scenario.
- The A-UUT fails to assert connect for at least 3 milliseconds (TA_BIDL_ADIS min)

TD.6.4. A-UUT Response to B-OPT Host Reset During HNP

This test verifies that the A-UUT produces a valid HS request “chirp K” to the B-OPT’s reset

Checklist Items:

Starting Condition

The A-UUT has connected as a peripheral (a_peripheral)

Overview of Test Steps

1. Follow the first 11 steps of the A-UUT Initialization procedure described in section 6.4.3.1.1.
2. The B-OPT detects the A-UUT connecting
3. The B-OPT waits 0.5 milliseconds (TB_ACON_BSE0), then drives an SE0 and starts timer T0
4. B-OPT records when the A-UUT starts HS request “chirp K” (TFILTSE0)
5. B-OPT records when the A-UUT ends HS request “chirp K” (TUCH and TUCHEND)
6. The test repeats with the following parameters:
   a. TB_ACON_BSE0 = 0.0 ms
   b. TB_ACON_BSE0 = 1.0 ms

Results Interpretation

The test *fails* if:

- The A-UUT fails to produce a HS request “chirp K”
- The A-UUT starts its chirp K before timer T0 reaches 2.5 microseconds (TFILTSE0)
- The A-UUT starts its chirp K after timer T0 reaches 3.0 milliseconds (TFILTSE0)
- The width of the A-UUT chirp K is less than 1.0 milliseconds (TUCH)
- The A-UUT ends the chirp K after timer T0 reaches 7.0 milliseconds (TUCHEND)

TD.6.5. A-UUT Recognizes High-Speed B-OPT Host During HNP

This test verifies that the A-UUT identifies 3 consecutive chirp KJ pairs and enumerates at high speed

Checklist Items:

Starting Condition

The A-UUT has completed its high-speed request “chirp K.”(a_peripheral)

Overview of Test Steps

1. Follow the first 12 steps of the A-UUT Initialization procedure described in section 6.4.3.1.1.
2. The B-OPT detects the end of the A-UUT’s HS request “chirp K”
3. The B-OPT waits 50.0 microseconds after the A-UUT HS request chirp K to begin the chirp KJ pairs (TWTDCH)
4. The B-OPT issues chirp K of 50 microseconds (TDCHBIT-K1)
5. The B-OPT issues chirp J of 50 microseconds (TDCHBIT-J1)
6. The B-OPT repeats steps 4 and 5 until timer T0 reaches 60 milliseconds (TDRSTR)
7. The B-OPT asserts SE0 for 300 microseconds (TDCHSE0)
8. The B-OPT begins sending SOFs
9. The B-OPT enumerates the A-UUT
10. The test repeats with the following parameters:

a.	TWTDCH = 0us	TDCHBIT-K1 = 40us	TDCHBIT-J1 = 40us
b.	TWTDCH = 0us	TDCHBIT-K1 = 60us	TDCHBIT-J1 = 60us
c.	TWTDCH = 100.0us	TDCHBIT-K1 = 40us	TDCHBIT-J1 = 40us
d.	TWTDCH = 100.0us	TDCHBIT-K1 = 60us	TDCHBIT-J1 = 60us
e.	TWTDCH = 0us	TDCHBIT-K1 = 40us	TDCHBIT-J1 = 60us
f.	TWTDCH = 0us	TDCHBIT-K1 = 60us	TDCHBIT-J1 = 40us

Results Interpretation

The test *fails* if:

- The A-UUT fails to enumerate at high-speed

TD.6.6. A-UUT Enumerates at High-Speed

This test verifies that the A-UUT enumerates at high speed with various reset periods

Checklist Items:

Starting Condition

The B-OPT is sending high-speed “chirp KJ” pairs (a_peripheral)

Overview of Test Steps

1. Follow the first 13 steps of the A-UUT Initialization procedure described in section 6.4.3.1.1.
2. The B-OPT stops sending chirp KJ pairs when timer T0 reaches 60 milliseconds (TDRSTR)
3. The B-OPT asserts SE0 for 300 microseconds (TDCHSE0)
4. The B-OPT begins sending SOFs
5. The B-OPT enumerates the A-UUT
6. The test repeats with the following parameters:
   a. TDRSTR = 49.5ms TDCHSE0 = 500us
   b. TDRSTR = 49.9ms TDCHSE0 = 100us
   c. TDRSTR = 200ms TDCHSE0 = 100us

Results Interpretation

The test *fails* if:

- The A-UUT fails to enumerate at high-speed

TD.6.7. B-OPT Host Resets A-UUT with Successful High-Speed Detection

This test verifies that an A-UUT that supports high speed as a peripheral is successfully reset by the B-OPT to high speed operation following an HNP transition.

Checklist Items:

Starting Condition

The A-UUT has connected as a peripheral following an HNP transition. (a_peripheral)

Overview of Test Steps

1. Follow the first 17 steps of the A-UUT Initialization procedure described in section 6.4.3.1.1.
2. After the B-OPT enumerates the A-UUT, it immediately begins driving reset.
3. A-UUT drives D+ within 3.0ms and 3.125ms
4. The B-OPT monitors for a “Chirp K” from the A-UUT as peripheral.
5. 50 microseconds after the end of the A-UUT “Chirp K” (TWTDCH), the B-OPT drives Chirp KJ pairs of 50 microsecond width (TDCHBIT).
6. The B-OPT continues driving Chirp KJ pairs for 52 milliseconds from the start of reset (TDRSTR).
7. The B-OPT asserts reset for 200 milliseconds (TDCHSE0)
8. The B-OPT begins sending SOFs
9. The B-OPT verifies that the A-UUT enumerates normally as a peripheral.
10. The test is repeated with the following combinations of parameters.

    a. TWTDCH = 0 ms, TDRSTR = 50 ms, TDCHBIT = 40 microseconds, TDCHSE0 = 100 us

    b. TWTDCH = 0 ms, TDRSTR = 50 ms, TDCHBIT = 60 microseconds, TDCHSE0 = 500 us

    c. TWTDCH = 0 ms, TDRSTR = 100 ms, TDCHBIT = 40 microseconds, TDCHSE0 = 100 us

Results Interpretation

The test *fails* if:

- The A-UUT is high speed capable and does not enumerate successfully at high speed in any scenario.
- The A-UUT does not assert D+ within 3.0ms and 3.125ms of detecting bus reset
- The A-UUT “Chirp K” is not at least 1 millisecond in width.
- The A-UUT “Chirp K” starts less than 2.5 microseconds from the beginning of reset.
- The A-UUT “Chirp K” starts more than 3 milliseconds from the start of reset.
- The A-UUT “Chirp K” does not end before 7 milliseconds from the start of reset.

TD.6.8. **A-UUT's Remote Wake-up Support**

This test verifies that an A-UUT responds to remote wake-up when it has suspended the bus as part of the HNP process.

Checklist Items: P33

Starting Condition

A-UUT is has suspended the bus to initiate HNP and is waiting for the B-OPT to disconnect. (a_suspend)

Overview of Test Steps

1. Follow the first 8 steps of the A-UUT Initialization procedure described in section 6.4.3.1.1.
2. After the B-OPT sees 15 ms of suspend it drives resume for 1 millisecond.
3. B-OPT monitors to see that resume continues from the A-UUT.
4. The B-OPT starts a timer once resume finishes and records when the first subsequent command occurs and when SOFs begin
5. The test repeats for the following parameters.
   a. Suspend Time: 199 ms Resume Time: 15 ms
   b. Suspend Time: 5 ms Resume Time: 1 ms
   c. Suspend Time: 190 ms Resume Time: 15 ms
   d. Suspend Time: 190 ms Resume Time: 1 ms
   e. Suspend Time: 5 seconds Resume Time: 1ms (NOTE: If the A-UUT drops VBUS after 200ms (TA_AIDL_BDIS) for this test, the A-UUT passes this test.)

Results Interpretation

The test *fails* if:

- The A-UUT does not respond to remote wakeup by driving at least 20 ms of resume on the bus.
- The A-UUT drives resume for more than 30 seconds.
- The A-UUT does not start sending SOFs within 3 ms of the end of resume.
- The A-UUT attempts to access the B-OPT before 10 ms after the resume ends.
- The A-UUT Drops Vbus before 200ms (TA_AIDL_BDIS)

6.4.3.2 A-UUT: HNP with HS A-UUT and a Hybrid B-OPT Full-Speed Host.

TD.6.9. **A-UUT High-Speed Host to A-UUT Full-Speed Peripheral**

This test verifies that the A-UUT, when operating as a high-speed host, properly enumerates as a full-speed peripheral during HNP. The test verifies that the A-UUT operates correctly when attached to a mixed speed OTG device. In this case the B-OPT is a full-speed host with a high-speed peripheral.

Checklist Items:

Starting Condition

The A-UUT has the B-OPT enumerated at high-speed and has begun the HNP process (a_peripheral)

Overview of Test Steps

1. Connect the B-OPT tester to the A-UUT.
2. Follow the first 12 steps of section 6.4.3.1.1 A-UUT Test Initializations.
3. The B-OPT ignores the high-speed request “chirp K “ from the A-UUT
4. The B-OPT drives reset until timer T0 reaches 60 milliseconds and begins sending SOFs
5. The B-OPT attempts to enumerate the A-UUT as follows:
   a. Get device descriptor using a maximum packet size of 64. (This will cause a short packet for devices with maxpacketsize0 < 64)
   b. Issue a Set Address command with the next available USB address.
   c. Get the device descriptor again with the right maximum packet size.
   d. Get configuration descriptor asking for a number of bytes equal to configuration descriptor size only.
   e. Issue a Set Configuration command for the first configuration supported by the device.
   f. Get the configuration descriptor again asking for a number of bytes equal to the configuration descriptor size.
   g. Get the configuration descriptor using the total length of the entire descriptor.

Results Interpretation

The test *fails* if:

- The A-UUT fails to enumerate at full-speed

6.4.3.3 B-UUT: HNP with HS capable B-UUT and A-OPT.

Test Setup

Use Test Setup 2 as described in Section 6.2.4.

6.4.3.3.1 B-UUT Test Initializations

Each of the protocol tests is written so that they can be run individually. Whenever a test examines a condition occurring several steps into the HNP process, a standard initialization procedure is followed to get the device under test into the necessary starting state. This common procedure is documented here and referred to by each of the tests that use it for initialization. The procedure is as follows:

B-UUT Initialization

1. A-OPT removes VBUS.
2. B-UUT issues an SRP to initiate test.
3. B-UUT connects D+ pull-up when VBUS reaches session valid for a B device.
4. One millisecond after the B-UUT connects, the A-OPT starts timer T0 and drives SE0 (reset)
5. A-OPT responds 50 microseconds after detecting “a chirp K” from the B-UUT with a continuous stream of alternating chirp K and chirp J of 50 microseconds each.

   NOTE: If the B-UUT fails to provide a high-speed K chirp, the test fails with an error message asking for a high-speed OTG UUT.
6. The A-OPT stops sending chirp KJ pairs until time T0 reaches 60 milliseconds and re-asserts SE0.
7. A-OPT begins sending SOFs 300 microseconds after re-asserting SE0.
8. A-OPT enumerates the B-UUT and sends SetFeature HNP_ENABLE to the B-UUT
9. B-UUT acknowledges a Set Feature HNP_ENABLE

B-Peripheral → B-Host Initialization

10. (A) A-OPT suspends the bus and switches to full-speed
11. (B) B-UUT detects 3 milliseconds of bus suspend and switches to full-speed, removes D+/- terminations, and connects by applying its D+ pull-up.
12. (D) Up to 150 milliseconds may pass before the B-UUT disconnects.
13. (E) The A-OPT connects 1.5 milliseconds.after B-UUT disconnects.
14. (F) The A-OPT starts timer T0 when the B-UUT begins to drive a bus reset (SE0).
15. (G) The A-OPT drives a 3.0 millisecond high-speed “Chirp K” 1.0 millisecond after the B-UUT drives reset.
16. (I) Upon completion of the chirp K, the B-UUT ends reset and begins driving Chirp KJ pairs within 100 microseconds.
17. The A-OPT monitors the KJ chirps.
18. (M) 250 microseconds after detecting 3 valid KJ chirps, the A-OPT switches to high-speed and asserts D+/- terminations.

19. (N) The B-UUT ends chirp KJ pairs and immediately drives SE0 within 100us to 500us of sending SOFs
20. (O) After timer T0 reaches 50 milliseconds, the B-UUT begins sending SOFs.

B-Host → B-Peripheral Initialization

21. The B-UUT suspends the bus and switches to full speed terminations
22. After the A-OPT sees a 3 millisecond suspend condition on the bus, it waits for 100 microseconds and turns off VBUS

6.4.1.1.2 High-Speed A-UUT Host Test descriptions

TD.6.10. **B-UUT Enumerated by an A-OPT**

This test verifies that the B-UUT enumerates as a B-Device under various timing conditions.

Checklist Items:

Starting Condition

The B-UUT and A-OPT are not connected.

Overview of Test Steps

1. Connect the B-UUT to the A-OPT.
2. Follow the first 4 steps of the B-UUT Test Initialization described in section 6.4.3.3.1
3. Some time after T0 reaches 3.0 mjilliseconds (TWTRSTFS), the B-UUT initiates a high-speed “chirp K”
4. The A-OPT measures the pulse width of the chirp K (TUCH)
5. The A-OPT records T0 when the HS request chirp K ends (TUCHEND)
6. 50 microseconds after the end of the B-UUT “Chirp K” (TWTDCH), the A-OPT drives Chirp KJ pairs of 50 microsecond width (TDCHBIT).
7. The A-OPT continues driving Chirp KJ pairs for 52 milliseconds from the start of reset (TDRSTR).
8. The A-OPT asserts reset for 200 microseconds (TDCHSE0)
9. The A-OPT begins sending SOFs
10. The A-OPT verifies that the B-UUT enumerates normally as a peripheral.
11. The A-OPT sends an SetFeature HNP_ENABLE to the B-UUT
12. The B-UUT acknowledges the SetFeature HNP_ENABLE
13. The test repeats with the following combinations of parameters.

    a. TWTDCH = 0 ms, TDRSTR = 50 ms
       TDCHBIT = 40 microseconds, TDCHSE0 = 100 us

    b. TWTDCH = 100 ms, TDRSTR = 50 ms
       TDCHBIT = 60 microseconds, TDCHSE0 = 500 us

    c. TWTDCH = 0 ms, TDRSTR = 100 ms
       TDCHBIT = 40 microseconds, TDCHSE0 = 100 us

Results Interpretation

The test *fails* if:

- The B-UUT is high speed capable and does not enumerate successfully at high speed in any scenario.
- The B-UUT “Chirp K” starts less than 2.5 microseconds from the beginning of reset (TFILTSE0).
- The B-UUT “Chirp K” starts more than 3 milliseconds from the start of reset (TFILTSE0).
- The B-UUT “Chirp K” is not at least 1 millisecond in width (TUCH).
- The B-UUT “Chirp K” does not end before 7 milliseconds from the start of reset (TUCHEND).

TD.6.11. **B-UUT Asserts D+ Pull-Up within the Allowed Window after Accepting a Set Feature B_HNP_Enable Command.**

This test verifies that the B-UUT switches to full-speed and asserts D+ pull-up within the appropriate timeframe after the A-OPT has suspended the bus for an HNP transition.

Checklist Items:

Starting Condition

B-UUT has successfully acknowledged a Set Feature B_HNP_Enable command and is waiting for the A_OPT to suspend the bus. (b_peripheral)

Overview of Test Steps

1. Follow the first 9 steps of the B-UUT Initialization described in section 6.4.3.3.1.
2. The A_OPT directly suspends the bus and starts a timer after the Set Feature B_HNP_Enable command is accepted.
3. The A_OPT records when the B-UUT asserts D+ pull-up (TWTREV)
4. The A-OPT records when the B-UUT disconnects to signal it wants host control (TB_AIDL_BDIS)
5. The test repeats with the A_OPT waiting slightly less than 30 seconds before suspending the bus.
6. The test is again repeated with the A_OPT waiting 2 minutes after the Set Feature B_HNP_Enable to suspend the bus

The test *fails* if:

- The B-UUT asserts its D+ pull-up outside the 3.0 – 3.125 millisecond window (TWTREV)
- The B-UUT disconnects outside the 4 - 150 milliseconds window after the start of suspend (TB_AIDL_BDIS).

TD.6.12. **B-UUT Response to A-OPT Connect during HNP**

This test verifies that a B-UUT recognizes the A-OPT connect during HNP

Checklist Items:

Starting Condition

The B-UUT has just disconnected during bus suspend indicating its desire to become host. (b_wait_acon)

Overview of Test Steps

1. Connect the A-OPT tester to the B-UUT.
2. Follow the first 12 steps of the B-UUT Test Initialization described in section 6.4.3.3.1
3. The A-OPT connects 1.5 milliseconds after detecting the B-UUT disconnecting (TA_BDIS_ACON)
4. The B-UUT responds by asserting SE0 within 1.0 millisecond (TB_ACON_BSE0)
5. The test is repeated with the following parameters:
   a. TA_BDIS_ACON = 0ms
   b. TA_BDIS_ACON = 3.0ms

Results Interpretation

The test transcribes all results to a text based log file.

The test *fails* if:

- B-UUT does not respond by asserting a reset within 1.0 ms (TB_ACON_BSE0)
- B-UUT exceeds TWTDCH (100us) to start chirp KJ pairs
- The B-UUT does not respond to all of the “Chirp K” values with at least 3 consecutive chirp KJ pairs where each pulse is between 40 and 60 microseconds.

TD.6.13. **B-UUT Returns to B_PERIPHERAL State from B_WAIT_ACON During HNP**

This test verifies that the B-UUT returns to b_peripheral when the A-OPT signals a K state on the bus.

Checklist Items:

Starting Condition

The B-UUT is waiting for the A-OPT to connect as a peripheral (b_wait_acon)

Overview of Test Steps

1. Follow the first 13 steps of the B-UUT Test Initialization described in section 6.4.3.3.1
2. 4.9ms after the A-OPT suspended the bus, a ResumeK is issued for 25 milliseconds and returns to the high-speed idle state (TDRSMDN).
3. The A-OPT begins sending SOFs 2.0 milliseconds after starting high-speed idle.
4. The A-OPT waits 12 milliseconds (TRSMRCY) and queries the B-UUT descriptors

Results Interpretation

The test transcribes all results to a text based log file.

The test *fails* if:

- B-UUT fails to return to high-speed
- The B-UUT is unresponsive to the A-OPT queries.

TD.6.14. B-UUT Host Response to "Chirp K" during HNP

This test verifies that a B-UUT, after transitioning to host from peripheral, responds with Chirp KJ pairs to a legal "Chirp K" pulse from the A-OPT.

Checklist Items:

Starting Condition

The B-UUT is waiting for the A-OPT to connect as a peripheral (b_wait_acon)

Overview of Test Steps

1. Connect the A-OPT tester to the B-UUT.
2. Follow the first 14 steps of the B-UUT Test Initialization described in section 6.4.3.3.1
3. A-OPT starts driving a "chirp K" 1 millisecond after it detects reset (TFILTSE0).
4. A-OPT stops driving a "chirp K" 3 millisecond after starting the chirp (TUCH).
5. A-OPT measures when B-UUT begins first high-speed chirp K (TWTDCH < 100us)
6. A-OPT monitors for 3 legal consecutive chirp KJ pairs from the B-UUT. The A-OPT checks the duration of each K or J pulse (TDCHBIT). It also counts the number of K and J pulses.
7. The A-OPT switches to high-speed and asserts D+/- terminations after detecting 3 legal chirp KJ pairs
8. The A-OPT records when the B-UUT stops sending chirp KJ pairs and begins driving SE0 (TDCHSE0)
9. The A-OPT records when the B-UUT begins sending SOFs (TDRSTR)
10. The test is repeated with the following peripheral "chirp K" parameters.

TFILTSE0 = 2.5 microseconds	TUCH = 6.9975 ms
TFILTSE0 = 2.5 microseconds	TUCH = 1.0 ms
TFILTSE0 = 3 milliseconds	TUCH = 1.0 ms
TFILTSE0 = 3 milliseconds	TUCH = 4.0 ms

Results Interpretation

The test transcribes all results to a text based log file.

The test *fails* if:

- B-UUT exceeds TWTDCH (100us) to start chirp KJ pairs
- The B-UUT does not respond to all of the high-speed request "Chirp K" values with at least 3 consecutive chirp KJ pairs where each pulse is between 40 and 60 microseconds.
- The B-UUT ends chirp KJ pairs before timer T0 reaches 49.5 ms
- The B-UUT fails to immediately drive SE0 after ending chirp KJ pairs
- The B-UUT fails to drive SE0 for 100us to 500us before issuing SOFs
- The B-UUT starts sending SOFs when timer T0 is less than 50ms

TD.6.15. B-UUT Host Enumerates A-OPT Peripheral

This test verifies that the B-UUT drives reset after performing chirp KJs and can enumerate the A-OPT after HNP.

Checklist Items:

Starting Condition

The B-UUT has completed HNP and has started issuing SOFs

Overview of Test Steps

1. Connect the A-OPT tester to the B-UUT.
2. Follow the first 20 steps of the B-UUT Test Initialization described in section 6.4.3.3.1
3. The B-UUT queries the A-OPT descriptors
4. The B-UUT suspends the bus after enumerating the A-OPT

Results Interpretation

The test transcribes all results to a text based log file.

The test *fails* if:

- B-UUT fails to query the A-OPT descriptors

TD.6.16. A-OPT resets the B-UUT with HNP Enabled

This test verifies that the B-UUT does not continue with HNP without seeing the A-OPT connect. .

Checklist Items:

Starting Condition

The A-OPT has finished enumerating the B-UUT and has issued the SetFeature HNP_ENABLE

Overview of Test Steps

1. Connect the A-OPT tester to the B-UUT.
2. Follow the first 9 steps of the B-UUT Test Initialization described in section 6.4.3.3.1
3. The A-OPT asserts 50ms of SE0 (reset) on the bus and starts a timer.
4. The A-OPT monitors that at least 3.1 milliseconds (T_{RVTFS} min + $T_{WTRSTHS}$ min) pass before the B-UUT begins a high-speed request chirpK.
5. The A-OPT monitors that the B-UUT issues a high-speed request chirpK within 6 milliseconds of the start of SE0.
6. The A-OPT negotiates the high-speed handshake and begins sending SOFs.
7. The A-OPT reads the B-UUT descriptors 10ms after the start of SOFs

Results Interpretation

The test transcribes all results to a text based log file.

The test *fails* if:

- The B-UUT fails to return to a high-speed b_peripheral state
- The B-UUT begins its high-speed chirp within 3.1 milliseconds of asserting SE0.
- The B-UUT fails to begin its high-speed chirp within 6 milliseconds of asserting SE0.
- A-OPT is unable to query the B-UUT descriptors

TD.6.17. A-OPT suspends the B-UUT with HNP Enabled

This test verifies that the B-UUT does not continue with HNP without seeing the A-OPT connect. This test emulates a user initiated suspend on the host.

Checklist Items:

Starting Condition

The A-OPT has finished enumerating the B-UUT, has issued the SetFeature HNP_ENABLE, and has suspended the bus

Overview of Test Steps

1. Connect the A-OPT tester to the B-UUT.
2. Follow the first 12 steps of the B-UUT Test Initialization described in section 6.4.3.3.1 where the bus is suspended and the B-UUT had disconnected to initiate HNP.
3. A-OPT does not connect
4. The B-UUT has its timer $T_{B\_ASEO\_BRST}$ time out
5. The A-OPT monitors that 3.125 milliseconds pass before the B-UUT reconnects. ($T_{B\_ASEO\_BRST}$ min)
6. The A-OPT does not issue a reset
7. The A-OPT verifies that the B-UUT pull-up is asserted continuously for 1 second (has entered suspend).

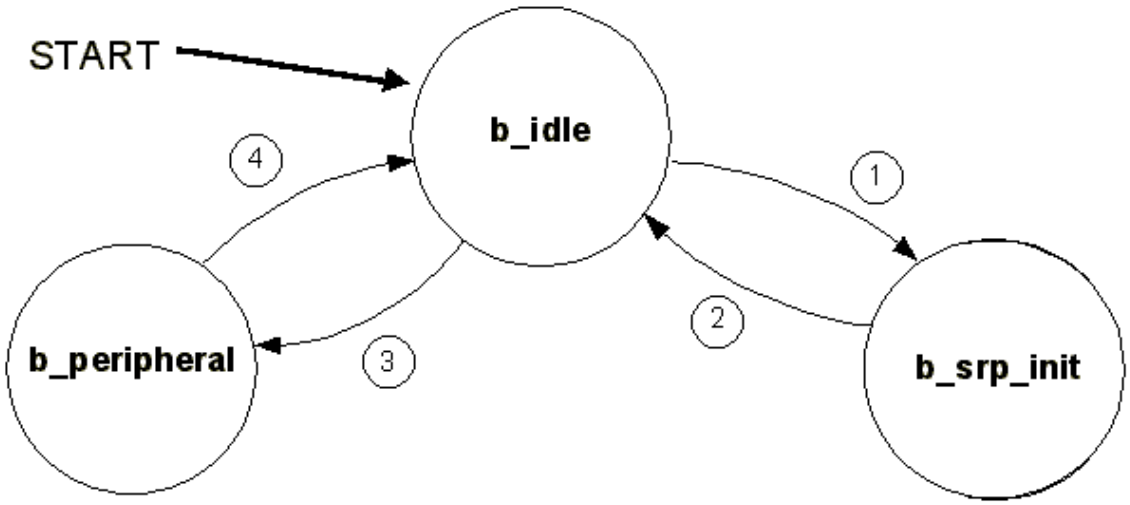
Results Interpretation

The test transcribes all results to a text based log file.

The test *fails* if:

- The B-UUT does not enter suspend (continues to attempt HNP)

6.4.4 Peripheral Only



A peripheral that supports SRP must pass the section 5 SRP related electrical testing.

7 Messaging

7.1 Overview

Section 3.4 "No Silent Failures" of the On-The-Go Supplement to the USB 2.0 Specification version 1.0 states:

"Whenever the cabling allows USB devices to be connected, and the devices do not support the type of communication being requested by the user, then the devices shall provide messages to the user that allow him or her to understand the problem, and correct it if possible. Insofar as is possible, the messages shall be self explanatory, and shall not require the user to reference a manual or other additional material."

The On-The-Go Supplement to the USB 2.0 Specification does not define messages so it is beyond the scope of the OTG Compliance Document to do so. However, suggested messages for particular events are provided as a guideline.

Some messaging options may not be acceptable. Take the example of an OTG device with one LED. A device like this may not be able to provide multiple messages that are self-explanatory. It is the responsibility of the manufacturer to verify that the content of the messages supplied comply with the intent of the specification.

The message checklist defined in this document can be used to verify that messages are provided under specific events or conditions. There are several cases where messages MUST be provided. However, the content of the messages will NOT be verified, since the language of the messages can be subjective to each user.

7.2 Minimum Required Messages

Two error messages are required at a minimum for devices that do not support hubs. The first message indicates when a device is not connected or is not responding correctly. The second message indicates that a device is unsupported because it is not on the Targeted Peripheral list, draws too much current, and/or etc. A third message is required for devices that support hubs. Suggested text for the messages might be:

- "Device Not Connected/Responding"
- "Attached Device Not Supported"
- "Unsupported Hub Topology" (If A-Device supports Hubs)

The following table lists the events that require error messages in the OTG Supplement. Suggested message text is supplied as a guideline to help manufacturers be consistent.

Event Description	Suggested Message Text	OTG Supplement Section
B-Device draws more current than A-Device supports	A-Device Message: "Attached device Not Supported"	5.1.3
B-Device (not HNP capable) not on A-Device Targeted Peripheral List	A-Device Message: "Attached device not supported"	6.8.1.4
A-Device not on B-Device Targeted Peripheral List	B-Device Message: "Attached device not supported"	6.8.2.5

A-Device timed out to B-Device SRP	B-device message: “Device not connected/responding “	6.8.2.2
An nth-tier Hub attached to an A-Device with (n-1) tier Hub support.	A-Device message: “Unsupported Hub Topology”	3.4
Unsupported Hub Topology attached to an A-Device with Hub support.	A-Device message: “Unsupported Hub Topology”	3.4

A simple OTG device without hub support might be implemented with two LEDs that are clearly labeled with the required error messages.

7.3 Additional Messages

Manufacturers are allowed to provide additional messages as appropriate to help a user understand possible failures.

7.4 Compliance tests

Most of the compliance tests for messaging are performed with the OPT. These tests are defined in Section 6 of this specification. The hub messages are tested during interoperability testing.

MA3	**A-device Invalid Hub topology**
Start State	A-UUT attached to an unsupported hub topology (too many levels or too many devices – what this requires will depend on the manufacturer)
Stimulus	Perform procedure to cause a bus request on the A-UUT
Observation	Observe messaging behavior on A-device
Pass/Fail	Pass if A-device displays ‘Invalid Hub Topology message Fail if no message is shown

This test is only required if the A-device supports hubs and the A-device supports limited hub topologies.

8 Interoperability

8.1 Introduction

Devices, acting as a host, are only tested for interoperability with peripherals from the device's own Targeted Peripheral List.

8.2 Targeted Peripheral List

Any OTG device, acting as a host, must work with all the peripherals listed on the device's Targeted Peripheral List.

The manufacturer of an OTG device is expected to provide a subset of the peripheral(s) from the device's Targeted Peripheral List for testing. It is required that the OTG device, acting as a host, demonstrates appropriate functionality with the peripheral(s) supplied from the device's Targeted Peripheral List.

The manufacturer is responsible for verifying that the OTG device supports all the peripherals listed on the device's Target Peripheral List. If an OTG device is found NOT to work with a peripheral on the device's Targeted Peripheral List, all of the OTG devices on the shelves could be recalled.

8.3 OTG Peripheral Types

OTG Peripheral Types may be defined by the DWG and each type will have its own type specification.

Any OTG device, acting as a host, that claims to support an OTG Peripheral Type shall be tested with a peripheral of that type.

The manufacturer is expected to provide a peripheral of each supported OTG Peripheral Type for testing. It is only necessary to test with one peripheral of each supported OTG Peripheral Type.

As OTG Peripheral Type devices become available, a "golden" peripheral of each type shall be used instead of the manufacturer provided test peripheral devices.

Any host or OTG device that claims to support an OTG Peripheral Type must also support the Peripheral Type when it is implemented in a composite peripheral.

8.4 Compliance Tests

I1	**Targeted Peripheral List Interoperability**
Start State	A-UUT attached to a device on the targeted peripheral list for that device (provided by manufacturer).
Stimulus	Perform procedure to cause a bus request on the A-UUT
Observation	Observe messaging behavior on A-device
Pass/Fail	Pass if A-device does not display 'Unsupported Device' or 'Device not attached' messages and device can demonstrate normal operation. Fail if any error message is shown

9 USB-IF Required Tests

Devices supporting features of the On-The-Go supplement to the USB 2.0 specification must undergo additional testing beyond the tests described in this document. This additional testing is a subset of existing tests for USB peripherals and USB host controllers. This section of the document describes exactly what tests are required for full USB-IF certification and provides pointers to the locations where these tests are documented. Devices are split into multiple categories in this section as follows:

SRP Capable Peripheral: Device that is capable of generating SRP to attempt to start a session when VBUS is not present.

FS Capable OTG Device: OTG device capable of full speed signaling as a host but not capable of HS signaling as a host.

HS Capable OTG Device: OTG Device capable of high speed signaling as a host.

SRP Capable Host: The OTG supplement specifies that any host controller can respond to and support SRP. The compliance plan does not currently specify what tests apply to this type of host controller or how this type of host controller gets identified.

Note: These types are not mutually exclusive. An HS Capable OTG device can also support SRP generation as a device, etc. A single device could fit into multiple categories.

9.1 USB-IF Peripheral Testing

All USB-IF standard peripheral tests are required for SRP Capable Peripherals, FS Capable OTG devices, and HS Capable OTG devices. References to documentation for the standard USB-IF peripheral compliance tests as well as any necessary modifications to the procedures are described below.

Note: As with all peripherals, devices that are high speed capable as a peripheral must function at full speed and pass all HS and FS tests.

The complete set of USB-IF tests for peripherals are documented as follows:

9.1.1 Interoperability

USB-IF Full and Low Speed Electrical and Interoperability Compliance Test Procedure

http://www.usb.org/developers/docs.html#legacy_test_procedures

9.1.2 Full Speed/Low Speed Electricals

USB-IF Full and Low Speed Electrical and Interoperability Compliance Test Procedure

http://www.usb.org/developers/docs.html#legacy_test_procedures

9.1.3 High Speed Electricals

High-Speed Electrical Test Specification (Version 1.00)

http://www.usb.org/developers/docs.html#legacy_test_procedures

9.1.3.1 Procedures for specific test equipment

High-Speed Electrical Test Procedures for Tektronix Test Equipment (Version 1.0)

- Device High-speed Electrical Test Procedure (pdf, 623k) - for Tektronix Test Equipment

High-Speed Electrical Test Procedures for Agilent Test Equipment (Version 1.0)

- Device High-speed Electrical Test Procedure (pdf, 549k) - for Agilent Test Equipment

http://www.usb.org/developers/docs.html#legacy_test_procedures

9.1.4 OTG Required Peripheral Test Modifications

Note: Dealing with new cable options. Since peripherals following the On-The-Go Supplement have new cable options, there are some new cases to be handled by/with test fixtures used for peripheral electrical tests and for interoperability testing.

9.1.4.1 Interoperability

For all interoperability testing a Mini-A receptacle to Standard-A plug will be used with all captive cables. The particular Mini-A receptacle to Standard-A plug to be used by the official interoperability procedures will be specified in the future. For cases where the peripheral under test has a mini-B or mini-AB receptacle a 4.5 meter USB-IF certified mini-B to standard – A cable will be used.

9.1.4.2 Electrical

The standard peripheral electrical test fixtures will be used with devices with mini-AB or mini-B receptacles by using a Mini-B plug to Standard B receptacle adaptor. Note – this is not a legal adaptor and will be used only for electrical testing purposes. For captive cable devices with a mini-A plug – a standard Mini-A receptacle to Standard-A plug will be used. Using the adaptor, the tests will be performed in the standard fashion for captive cable peripherals.

9.1.4.3 Current Measurements Modifications

Current consumption measurements of peripherals in the unconfigured, configured, suspended, and addressed states are made as normal. However, the passing values are different as noted below:

OTG Device as Peripheral: Unconfigured Current < 150 uA.

SRP capable peripherals, FS capable OTG Devices, and HS capable OTG Devices must perform all peripheral tests described in the documents above.

9.1.4.4 Additional tests for devices capable of initiating SRP

Additional tests for SRP capable devices are described in this document. The list of required tests is listed in table 5-2.

9.1.4.5 OTG Device as Peripheral with Dead Battery

There are no clear requirements in the On-The-Go supplement to the USB 2.0 specification with regards to how a OTG should behave as a peripheral if its battery has become depleted. This section attempts to specify a baseline for common behavior. The OTG supplement says that an OTG device without a battery (or with a dead battery) is allowed to function as a standard USB peripheral. It is also allowed to do absolutely nothing. These are the only options. These requirements are tested by performing the following tests for an OTG device when it has a dead battery (or the battery is removed).

1. Run the Chapter 9 USBCV test with the OTG device connected to a standard host.

2. Record the reported current consumption of the device. If the device does not enumerate, the allowed current consumption for the unconfigured device is zero.

3. Run the standard USB-IF current consumption tests. If the device passed USBCV the standard current rules apply. If the device failed USBCV – the unconfigured current must be zero.

9.1.4.6 OTG Devices that Charge their Battery from USB

Although not sanctioned by the USB 2.0 Specification, charging batteries from is not prohibited. Thus, devices that charge their batteries from USB may be certified provided they pass average current and transient current tests as defined below. These tests are in addition to the compliance tests required for all devices.

1. All battery powered devices must test with a dead battery. A dead battery is defined by a device that is unable to power on when not attached to an external power supply (such as USB or an AC adapter).
2. Once the device has asserted its pull-up, it must fully comply with the USB 2.0 Specification.
3. When unconfigured, the upstream port must never consume more than ICCINIT (100mA)
4. When configured, the upstream port must never consume more current than its active bMaxPower value. If current draw exceeds 100mA, the device must report itself as bus-powered during enumeration.
5. If a peripheral is unable to connect (assert its pull-up) due to a dead battery, it must never consume more than ICCINIT (100mA) including when attached to a suspended downstream port.
6. If a peripheral is able to connect (assert its pull-up) with a dead battery, it must fully abide by the USB 2.0 Specification and the USB-IF Compliance Program in regards to power draw.
7. The peripheral must pass Inrush tests with a dead battery.
8. If the peripheral is not able to charge its batteries from USB with a dead battery, then the battery is permitted to be charged to the point where it is able to power on using its battery. The peripheral is permitted to be tested from a low battery state, but with the peripheral turned off.
9. If the peripheral is not able to charge its batteries from USB with a low battery while in an off state, then the peripheral is permitted to be tested with a low battery while turned on.
10. A device that uses USB to charge its batteries must enumerate correctly on the host system.

9.2 USB-IF Host Testing

All standard USB-IF host testing as documented in the following references is required for OTG devices. Any exceptions or changes from the documented tests are explained in the following sections.

9.2.1 Interoperability

USB-IF Full and Low Speed Electrical and Interoperability Compliance Test Procedure

http://www.usb.org/developers/docs.html#legacy_test_procedures

9.2.2 Full Speed/Low Speed Electricals

USB-IF Full and Low Speed Electrical and Interoperability Compliance Test Procedure

http://www.usb.org/developers/docs.html#legacy_test_procedures

9.2.3 High Speed Electricals

High-Speed Electrical Test Specification (Version 1.00)

http://www.usb.org/developers/docs.html#legacy_test_procedures

9.2.4 Procedures for specific test equipment

High-Speed Electrical Test Procedures for Tektronix Test Equipment (Version 1.0)

- Host High-speed Electrical Test Procedure (pdf, 1,026k) - for Tektronix Test Equipment

High-Speed Electrical Test Procedures for Agilent Test Equipment (Version 1.0)

- Host High-speed Electrical Test Procedure (pdf, 734k) - for Agilent Test Equipment

9.2.5 OTG Required Host Interoperability Testing Modifications

Current USB-IF host interoperability procedures are defined for Windows 2000 and Windows XP and require peripheral drivers for a number of peripherals defined in a standard interoperability gold tree. Host logo testing is currently not supported for any hosts that do not fit into one of these defined interoperability procedures. As hosts, OTG devices are not required to support hubs, low speed peripherals, or to provide support for HID or any other standard USB device class. These allowances are specified in the On-The-Go Supplement to the USB 2.0 Specification. The only peripherals that are required to work with the OTG as a host are the items on the OTG's targeted peripheral list. There are two different versions of the basic OTG as host interoperability procedure. The procedure is differentiated by whether any hubs appear on the targeted peripheral list of the OTG.

9.2.5.1 Interoperability Procedure – No Hubs

One peripheral from the targeted peripheral list must be provided along with instructions on how to operate the peripheral. If any peripherals on the targeted peripheral list do not have a captive cable – the peripheral provided must not have a captive cable. The peripheral will be plugged into the OTG device using a 4.5 meter Mini-A plug to Mini-B cable or Mini-A plug to

standard B cable as appropriate. The procedure to operate the device will be followed and the result must be successful.

9.2.5.2 Interoperabilty Procedure – Hubs

If any hubs appear on the OTG devices targeted peripheral list the OTG device must still supply a peripheral following the criteria listed above in the No-Hubs interoperability procedure. The difference is that the peripheral from the target list will be tested by plugging it in at the end of the full USB-IF gold tree as defined in the USB-IF Full and Low Speed Electrical and Interoperability Compliance Test Procedure. The targeted peripheral must still demonstrate functionality at the end of the defined gold tree. Other peripherals in the gold tree are not required to function unless they appear on the OTG device's targeted peripheral list.

Note: The OTG device is not required to support 5 levels of hub. If plugging a targeted peripheral into the end of the USB-IF gold tree produces a hub topology error message levels, of hub must be removed one at a time until the targeted peripheral operates correctly.

Sections 7 and 8 provide more details on the messaging and interoperability tests for OTG devices.

9.2.6 OTG Required Host Electrical Test Modifications

9.2.6.1 Host Full and Low Speed Electrical Testing

Host full and low speed electrical testing is performed for an OTG device acting as host in the exact same fashion as described in the USB-IF Full and Low Speed Electrical and Interoperability Compliance Test Procedure. To obtain full and low speed signaling for measurements the OTG device must provide peripherals that will enumerate at full speed. A low speed peripheral must be provided if the OTG device supports low speed devices as a host. The full and low speed electrical tests described in the USB-IF procedure are performed by capturing the traffic when the devices undergo enumeration. A mini-A plug to standard-A receptacle adapter is used for all the tests so that existing USB-IF test fixtures can be used.

Drop testing is the only significant case where the test procedure for a OTG acting as a host differs significantly from the existing USB-IF FS/LS capable host test procedures. Drop testing for a OTG acting as a host is described separately below:

9.2.6.1.1 Drop Testing

Drop testing for host controllers in the USB-IF full and low speed electrical test procedures places either 100 mA (low powered) or 500 mA (high powered) loads on all host ports and verify the V_{BUS} has not dropped below required levels on any of the ports. If an OTG supplies somewhere between 8 mA and 100 mA on its port the currently defined USB-IF drop test is not sufficient to check V_{BUS} under worst case loading conditions. Furthermore, there is no hardware based reporting mechanism for the amount of current the host can supply while meeting the minimum voltage. This test uses a variable resistance to slowly increase the current consumption of the test fixture from 8 mA. After each increase in current draw the voltage supplied on V_{BUS} is measured and must be above 4.4 volts (or 4.75 volts for current above 100mA). The point at which the voltage drops below 4.4 volts is measured and recorded. If the current draw when V_{BUS} drops below 4.4 volts is below the manufacturer's reported current support the test fails. This test/procedure is intended to provide a consistent means for reporting power provisions for non-standard power providers. The OET provides a variable load resistance for this testing.

9.2.6.1.2 Droop Testing

Droop testing is required for OTG devices that have multiple downstream ports. OTG devices must have one miniAB receptacle and optionally may have a second downstream port that is a mini-A receptacle. Droop testing verifies that high current transients on one downstream port do not negatively affect devices attached to adjacent downstream ports. A load equal to the host's maximum rated current output is attached to one downstream port causing an inrush event while voltage is measured on the adjacent downstream port. The droop in voltage must not exceed 330mV.

9.2.6.2 HS Electrical Host Testing

All USB-IF HS electrical host tests must be performed by OTG devices that are capable of supporting HS devices when acting as hosts. An HS Capable OTG device must either be able to run the existing USB-IF High Speed Electrical Test Tool (Win2k and WinXP support) or provide its own application during test that provides equivalent functionality. The most likely case will be that the OTG device needs to provide its own software application. This section gives an overview of the requirements for the software application that must be provided for electrical testing of OTG devices that are capable of supporting HS devices.

Step 1. Provide means to put all downstream HS capable ports into any of the USB 2.0 test modes. The test modes are described in Section 7.1.20 of the USB 2.0 specification. The test modes must meet the USB 2.0 specification requirements. The test modes are:

- TEST_J:
- TEST_K:
- TEST_SEO_NAK:
- TEST_PACKET:
- TEST_FORCE_ENABLE:

Step 2. Provide the ability to perform any of the following operations on an indicated downstream port.

- HS_HOST_PORT_SUSPEND
- HS_HOST_PORT_RESUME
- HS_HOST_PORT_RESET

Step 3. Provide an option to enumerate everything downstream of the host.

Step 4. Provide the means to select a downstream device and issue any of the following commands to the device:

- SINGLE_STEP_GET_DEVICE_DESCRIPTOR: The host performs only the setup phase of a GET_DESCRIPTOR command to the device indicated.
- EXECUTE: The host issues an IN token. The EXECUTE command normally follows after a SINGLE_STEP_GET_DEVICE_DESCRIPTOR command.

Example Software**: A sample screenshot of a piece of software providing the functionality described in this section is shown in the figure below.**

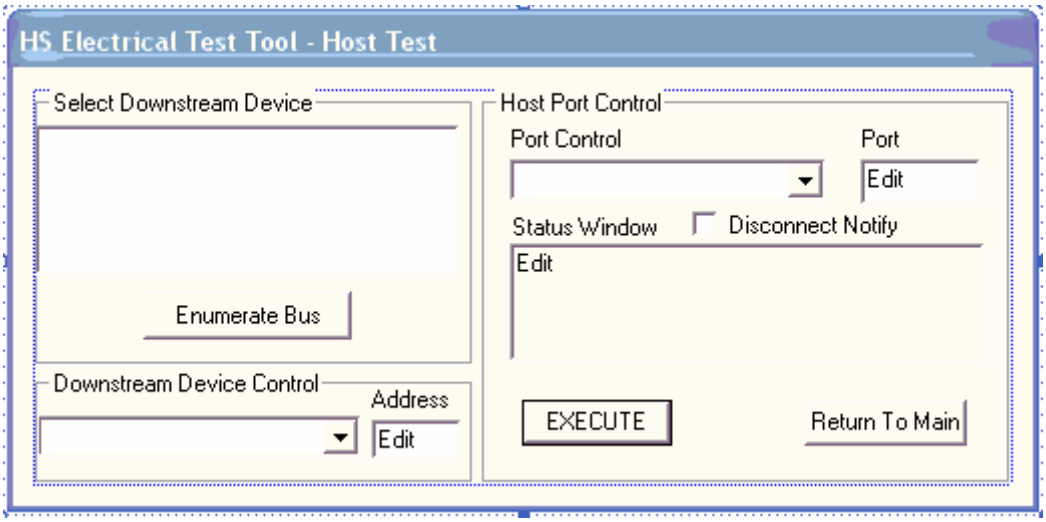


Figure 9-1 HS Electrical Test Tool

This software is provided by the USB-IF as part of the High Speed Electrical Test Package (HSET) distributed on the following USB-IF website:

http://www.usb.org/developers/tools.html.

HSET can be downloaded and run on an EHCI (HS capable) host controller as an example of the functionality that needs to be supplied by an application on the OTG device being tested as an HS capable host.

9.2.6.2.1 Alternative Test Mode Support

All USB-IF high-speed host electrical compliance tests must be performed on high-speed hosts. These high-speed tests utilize the test modes defined in Section 7.1.20 of the USB 2.0 Specification and associated errata. The USB 2.0 specification assumes that the test modes must be controlled via software running on the host and provides an interface via the SetFeature() command as described in the previous section. Thus, a high-speed capable host must either run the existing Windows based HSET utility; or run an equivalent application, supplied by the vendor, that will run on the host's operating system. The most likely case for OTG devices is that the vendor will need to provide their own equivalent High-speed Electrical Test Tool that can run on the specific operating system of their device.

An alternative is to have the embedded host support a test fixture that initiates the test modes. Upon enumeration by the host, the test fixture presents a VID/PID pair that defines a test mode or operation to execute. The Vendor ID is specified in Section 6.6.6 of the OTG Supplement as the Test Device. Its value is 0x1A0A. Upon enumerating a device with VID of 0x1A0A, the embedded host must perform the following operations based on the PID presented. The test mode or operation must occur on the port where the test fixture is attached.

9.3 Test Modes PID Definitions

The PIDs presented by the test fixture correspond to the following test modes. The VID is 0x1A0A.

PID	Test Mode
0x0101	TEST_SEO_NAK
0x0102	TEST_J
0x0103	TEST_K
0x0104	TEST_PACKET
0x105	Reserved.
0x0106	HS_HOST_PORT_SUSPEND_RESUME
0x0107	SINGLE_STEP_GET_DEV_DESC
0x0108	SINGLE_STEP_SET_FEATURE

9.4 Test Modes

The Test Modes described below are related to Section 7.1.20 of the USB 2.0 Specification and associated errata.

TEST_SE0

Upon enumerating VID 0x1A0A/PID 0x0101, the host's downstream port must enter a high-speed receive mode as described in Section 7.1.20 of the USB 2.0 Specification and drives an SE0 until the controller is reset.

TEST_J

Upon enumerating VID 0x1A0A/PID 0x0102, the host's downstream port must enter a high-speed J state as described in Section 7.1.20 of the USB 2.0 Specification until the host controller is reset.

TEST_K

Upon enumerating VID 0x1A0A/PID 0x0103, the host's downstream port must enter a high-speed K state as described in Section 7.1.20 of the USB 2.0 Specification until the host controller is reset.

TEST_PACKET

Upon enumerating VID 0x1A0A/PID 0x0104, the host must begin sending test packets as described in Section 7.1.20 of the USB 2.0 Specification until the host controller is reset.

HS_HOST_PORT_SUSPEND_RESUME

Upon enumerating VID:0x1A0A/PID 0x0106, the host must continue sending SOFs for 15 seconds, then suspend the downstream port under test per Section 7.1.7.6.1 of the USB 2.0

specification. After 15 seconds has elapsed, the host must issue a ResumeK state on the bus, then 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 GetDescriptor(Device)
4. The device ACKs the request, triggering the scope. (Note: SOFs may follow the IN transaction).

SINGLE_STEP_SET_FEATURE
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 another GetDescriptor()
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).