

# **Getting Started with USB technology and compliance testing**

**This is a short introduction on USB technology and compliance testing intended for the novice USB engineer. The summary slides given on the next page highlight the topics.**



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# Summary Slide

- **Getting Started with USB technology and compliance testing**
- **Data Rates**
- **Devices, hosts, and hubs**
- **Cables and Connectors**
- **USB A connector**
- **USB B connector**
- **Packets and Protocols**
- **Power, Voltage, and Current**
- **Device Test Methodology**
- **Device Signal Quality Test Schematic using the 501 fixture**

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## **Summary Slide (cont.)**

- **Host Signal Quality Test Methodology**
- **Host Signal Quality Test Schematic using the 502 board**
- **Hub Test Methodology**
- **Switching Voltages**
- **USBHSET Tool**
- **The Agilent N5416A test software**

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## Data Rates

- **USB 1.0 is 1.5 Mbits/s and is called the low speed mode.**
- **USB 1.1 is 12 Mbits/s and is called the full speed mode.**
- **USB 2.0 is 480 Mbits/s and is called the high speed mode.**
- **A high speed device must also be capable of operating in the full speed mode. The compliance tests for a high speed device also test the device at full speed but not low speed.**
- **Pullup resistors on D+ and D- on the device enable a host to identify a full or low speed device.**

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## **devices, hosts, and hubs**

- **A host is a controller. A prime example is your PC.**
- **A device (or peripheral) is controlled by a host. A prime example is a flash drive.**
- **A hub is an expander. A single USB port can be expanded to 127 ports.**
- **Most hubs have less than six expansion ports.**
- **Hubs can be self powered or bus powered.**
- **A bus powered hub receives its power from a host or another hub.**
- **Note that the word device is sometimes loosely used to refer to any of the three groups: hosts, hubs, or peripheral devices. One can tell from the context what is meant.**

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# Cables and Connectors

- The maximum cable length is five meters or approximately 15 feet.
- The cables contain four wires. Power, Ground, Data Plus (D+) and Data Minus (D-). D+ and D- form a differential pair.
- The power line is +5VDC.
- The connectors are called A connectors and B connectors.
- Pictures of the A and B connectors are given on the next two slides.
- The A connector is rectangular and the B connector has a more rounded type mechanical structure.
- There are also mini A, mini B, and mini AB connectors which are smaller special versions of the A and B connectors.

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# USB A connector



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# USB B connector



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# Packets and Protocols

- **The USB data bits are transmitted in packets with idle states between the packets.**
- **A special test packet mode is used for constructing the eye diagrams measured as part of the set of tests defined by the USBIF and designated as the compliance tests. The test packet is a uniquely designed set of PRBS data patterns selected to provide a maximum stress test on the USB circuitry.**
- **The USBIF is the USB standards body tasked with maintaining the USB compliance program. The USBIF acronym is derived from Universal Serial Bus Interoperability Forum.**

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# Power, Voltage, and Current

- **The power line is called Vbus and is +5 VDC.**
- **The current drawn by a device cannot exceed 500 mA.**
- **There are also surge specifications listed as part of the battery of full and low speed compliance tests:**
  - **Inrush current must be less than xx microamps.**
  - **Drop voltage must be less than xxx mV DC. Drop is the DC voltage drop measured on Vbus when all the ports are loaded.**
  - **Droop voltage cannot exceed xxx mV AC. Droop is the instantaneous AC drop in voltage on Vbus seen on neighboring devices.**
  - **Where xxx is specified by the specific test procedure.**

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# Device Test Methodology

- **The general procedure is to place the device in a test mode that sends out the PRBS test packet.**
- **A test bed computer is used as the test bed computer or host. The host uses a special software supplied by the USBIF. The software is called USBHSET. This software is downloaded from the USBIF website at [www.usb.org](http://www.usb.org)**
- **After the device is placed in the packet test mode, the switch on the connection fixture is flipped to disengage the test bed computer and engage the termination resistors on the fixture.**
- **The oscilloscope is used to measure the eye diagrams from the test packet using its own software application program.**

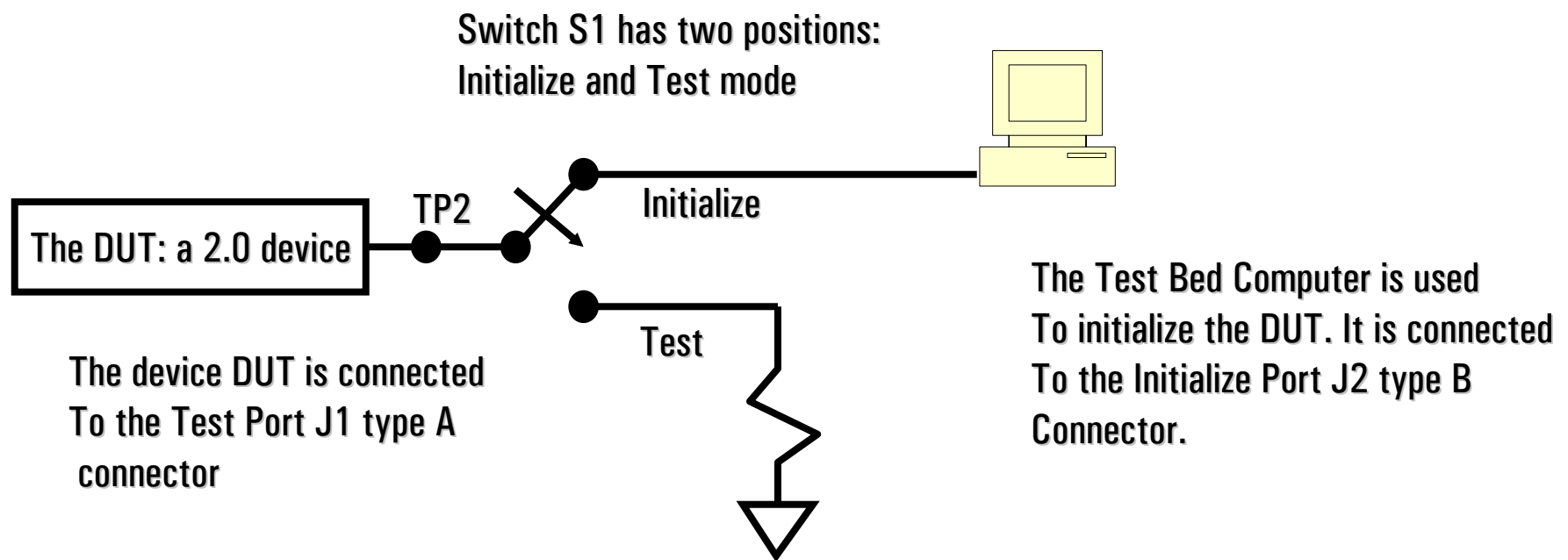
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# Device Signal Quality Test Schematic using the 501 fixture



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# Host Signal Quality Test Methodology

- For this test, the S1 switch starts in the test mode and remains there.
- In this mode the termination resistors are always engaged.
- This enables consistent measurement of the eye diagrams.
- The host places itself in the test packet mode.
- The oscilloscope captures the test packet and constructs the eye diagram.

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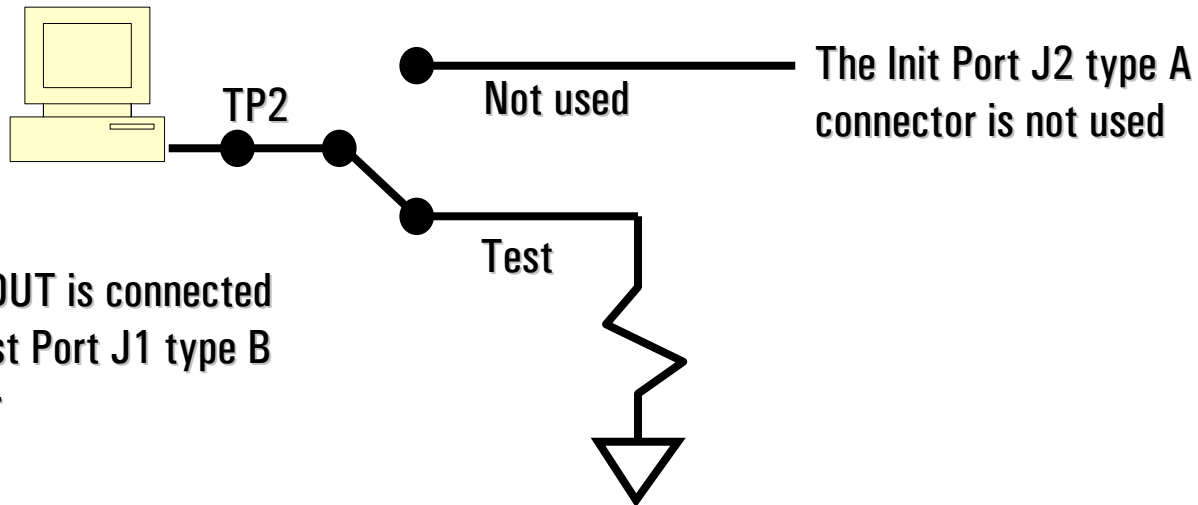
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# Host Signal Quality Test Schematic using the 502 board

Switch S1 is placed in the Test mode and does not change positions



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# Hub Test Methodology

- **A hub is an expander.**
- **The upstream port on a hub interfaces to a host. Therefore, to the host the hub looks like a device.**
- **The downstream ports on a hub interface to devices or other hubs. Therefore, these ports look like hosts.**
- **So testing of a hub requires testing the upstream port as a device and the downstream ports as hosts.**
- **We already know how to test devices and hosts from the previous slides so we now should have a good conceptual picture of how the high speed tests will be performed for hosts, hubs, and devices.**

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# Switching Voltages

- **The high speed data voltages are  $\pm 400$  mV pp nominal.**
- **The full speed data voltages are 3.5 Volts pp nominal.**
- **The low speed data voltages are 3.5 Volts pp nominal.**
- **A high speed device must also be capable of operating in the full speed mode. The compliance tests for a high speed device also test the device at full speed but not low speed.**
- **Pullup resistors on D+ and D- on the device enable a host to identify a full or low speed device.**

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## USBHSET Tool

- **This software is used to configure hosts, devices, and hubs in the proper test mode.**
- **The software is provided free of charge by the USBIF at their website at [www.usb.org](http://www.usb.org). Select developers and scroll down.**
- **There is one precaution! If you place a device in the test packet mode or J mode or K mode then the device must be reset before trying to transmit another command from the USBHSET tool! If this is not done then the software is stuck in an endless loop trying to engage the device that is already in a permanent test mode. The software will appear to hang when it is actually waiting for a response from the device which of course cannot respond. So the device must be reset or its power must be cycled.**
- **Also, in some tests a hub is required. Note that only high speed self powered hubs will talk to the USBHSET tool.**

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## The Agilent N5416A test software

- **This is the new USB compliance test software that runs on the Agilent Infiniium oscilloscope.**
- **It is fully automated and contains all of the instructions, hookups, and setups embedded right in the software itself.**
- **When the software begins it takes you to its desktop.**
- **The general procedure is to select the desired tests, configure the software, hookup the test equipment, and run the tests. This is done by selecting the test buttons on the left or the index tabs at the top of the desktop.**
- **There is a datasheet and video at [www.agilent.com](http://www.agilent.com). Search on N5416A. Scroll down to find the data sheet and video.**

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