How to Test and Troubleshoot USB4

What Is USB4?

USB4 is a hardware interface that supports several protocols through the USB Type-C connector. Based on the Thunderbolt protocol specification, the USB4 architecture doubles the bandwidth of USB and enables multiple simultaneous data and display protocols.

It enables users to connect a diverse collection of external devices to a computer. These external devices can be anything from high-resolution displays to external memory drives to docking stations — and they all can connect with the same USB Type-C connector. This connector is small and reversible, removing the frustration of having to figure out the correct way to plug it into a device.

Recommended test equipment:

- Keysight's Infiniium UXR-Series (25 GHz and above)
- Keysight's D9040USBC USB4 compliance test software

Figure 1. USB Type-C connector

USB4 supports high-speed data transfer, video bandwidth, and power delivery on a single cable. It has two independent 20 Gbps links bonded into one logical 40 Gbps link.

USB4 connects two 60 Hz 4K displays and provides 100 watts of power. It supports more protocols than the previous generation of Thunderbolt, including DisplayPort, USB, and PCIe. Creating a USB4 network involves daisy-chaining multiple devices. USB4 supports connecting devices with passive cables at full speed. New uses, such as 4K video, single-cable charging docks, external graphics, and built-in 10 Gigabit Ethernet networking, plus smaller-form-factor devices, are drivers of USB4 technology. USB4 chipsets are in servers, workstations, laptops, gaming PCs, industrial cameras, high-speed PCIe storage, displays, and adapters.

USB4 Test Recommendations

The original Thunderbolt and Thunderbolt 2 were simple to test because they had active cables and open eyes at the transmitter and receiver. USB4 incorporates a passive cable, which makes testing significantly more complicated. At 20 Gbps, signals are significantly impaired when conducted electrically, even over short distances with passive cables.

The following steps can help you verify that you are properly sending and receiving signals.

Step 1.

You'll need to use transmitter equalization to compensate for the lossy channel. The USB4 standard defines the transmitter equalization presets required to characterize and ensure the correct preshoot and de-emphasis are set for each preset. You'll also need to perform calibration for each preset you apply to your transmitter.

Keysight's D9040USBC USB4 transmitter test software provides a simple-to-use setup wizard for quick setup, configuration, and test selection, covering legacy and rounded, Gen 2 and Gen 3 rates (10 Gb/s, 10.3125 Gb/s, 20 Gb/s, 20.625 Gb/s).
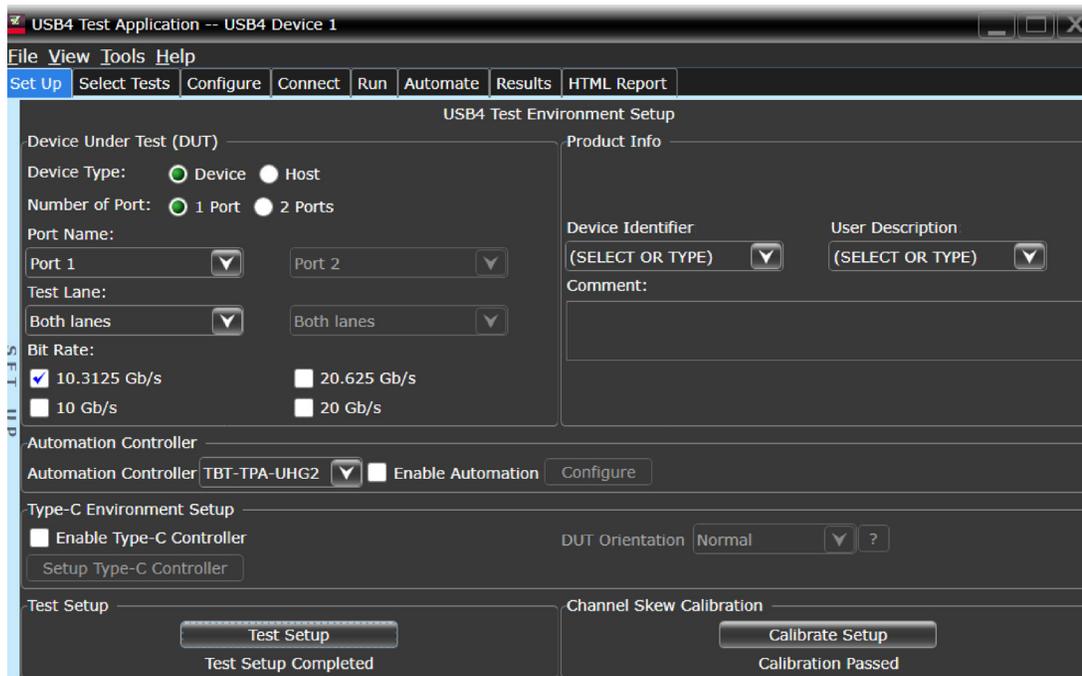

Figure 2. USB4 application test setup screen

Keysight's N7019A USB4 Type-C active link test fixture provides embedding and de-embedding to enable more accurate margin estimates.

Figure 3. N7019A USB4 Type-C active link test fixture

Step 2.

Implement receiver equalization to account for the effects of the passive cable.

Step 3.

Test to confirm how everything runs over the Type-C connector. Since the Type-C connector is reversible — hooked up to your computer right side up or right side down — you need to test four differential pairs (TX1 / RX1 and TX2 / RX2 pairs).

How to Test Transmission

Analyzing your signals is critical when characterizing silicon for a USB4 chipset, debugging for system integration, validation, or compliance. You need to follow the USB Type-C Thunderbolt Alternate Mode Electrical Host / Device Compliance Test Specification to ensure that you transmit your signal correctly.

You can use an oscilloscope to test your transmission. Oscilloscope requirements for standard compliant tests are as follows:

- DC to 21 ± 1 GHz, -3 dB bandwidth or greater
- 50 GSa/s sampling rate or greater; sampling two channels simultaneously
- sample memory: two channels at 50 M samples per channel or greater
- first- and second-order clock and data recovery capability
- equalization for USB3.1 model capability

Compliance software is also a helpful tool. It provides a fast and easy method to verify and debug your USB4 designs for silicon or end-product validation. Choose compliance software that matches the standard's test requirements and parameters of certification testing to replicate how the design will perform during official certification.

Compliance software can automate the test process and provide reports of test results, including margin analysis, to show by how much you passed or failed each test. It can do the following:

- automatically set up and control a cross-talk generator source, a required condition for electrical testing during the official certification test
- guide you through test selection, configuration, connection, execution, and results reporting with a test setup wizard
- display measurement connection setups
- run tests with live or saved waveforms for easy regression testing if specification requirements change
- create and fully integrate custom tests, configuration variables, and connection instructions
- insert external application calls into the run sequence, such as MATLAB scripts or your device controller
- configure additional external instruments used in your test suite
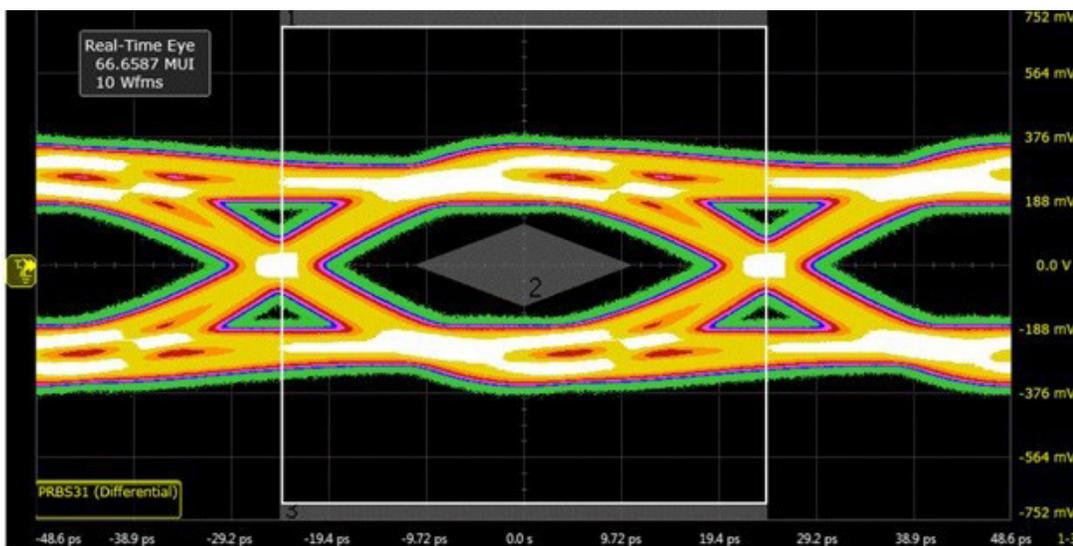
Summary

USB4 is a hardware interface that supports several protocols through the USB-Type-C connector. USB4 incorporates a passive cable and signals at 20 Gb/s, which makes testing significantly more complicated than Thunderbolt and Thunderbolt 2. To make sure you are transmitting and receiving signals correctly, use transmitter equalization to compensate for the lossy channel, perform calibration for each preset you apply to your transmitter, implement receiver equalization to account for the effects of the passive cable, and test the four differential pairs to confirm how everything runs over the reversible Type-C connector. Oscilloscope compliance software can aid in this testing by providing automation and results that will match official compliance test lab results.

Resources

Here is a list of recommended Keysight equipment and software to test USB4:

- D9040USBC USB4 Transmitter Test Software
- N5991U40A USB4 Receiver Compliance Test Software
- N7019A USB Type-C Active Link Fixture
- D9010USBP USB4 Protocol Decode / Trigger Software
- E5080B and S96011A, to measure interconnect test return loss
- Infiniium UXR-Series Real-Time Oscilloscopes
- Infiniium UXR-Series Oscilloscopes, 5992-3132EN — Data Sheet

Learn more at: www.keysight.com

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