90% Increase in USB-C® Cables Testing Throughput
Using Keysight Automated Interconnects Test Solution
Learn how a high-speed digital cables product manufacturer achieved fast and efficient test time at an affordable price to test their USB Type-C® cables.

**Organization**
- A leading high-speed digital cables product manufacturer

**Challenges**
- Increasing USB-C device test ports required multiport testing
- Increasing test times from manual setup and port re-connection
- The need to reduce test costs to meet operating profitability

**Solutions**
- Keysight S94USBCB automated interconnects compliance test solution to test USB-C cables with 20-ports switch matrix system

**Results**
- Achieved ~90% total test time reduction of USB-C (USB4 Gen3) cable from 5 hours to ~30 minutes
Introduction

USB Type-C is a breakthrough standard designed to meet the demand for technologies that support higher data rates and lower power in consumer electronics, IT, computing and peripherals. USB standards are maintained by the USB Implementers Forum (USB-IF) and widely adopted in most of the latest electronic devices and equipment. To achieve compliance to the standard, users need to perform a comprehensive range of transmitter, receiver, repeater and cable tests in accordance with the compliance test specification (CTS).

Challenges

The new USB Type-C cables and connectors CTS revision 2.1 released by USB-IF has extended more complex compliance test requirements to support a wide variety of cable types and USB generations. EG. Test-Group B8 high speed signal test for USB4 Gen3 to support 40 Gbps (20 Gbps/lane). It created several challenges for design and test engineers while they are conducting the test validation to ensure interoperability and compliance of their products.

1. Increasing number of device test ports

The increase of USB Type-C port count is driving the demands for an expanded test system. USB Type-C, DisplayPort (DP) and Thunderbolt connectors require a 20-port VNA system to avoid tedious cable port re-connections during the test. USB4 Gen3 high-speed signal testing requires 44 port connections using a 4-ports VNA. A true multiport PXI-VNA could be a good choice but also incurs a higher test cost.

2. Manual setup and lengthy test time

The conventional way of testing USB Type-C cables is manual following the test procedures in the Method of Implementation (MOI) document provided by Keysight.

Without software automation available to automate the compliance tests, calibration, measurement setup, and test execution are prone to unnecessary human errors making compliance tests inefficient and challenging.

3. Compliance test tools

USB-IF introduced new test requirements for USB4 Gen3 cables with Channel Operating Margin (COM) and integrated crosstalk analysis that required a Matlab-based compliance test tool (Get_iPar.exe) to compile the 44-sets of S-parameters for compliance verdict judgement. Users need to manually setup the tool’s configuration file to compile and verify pass/fail verdict. Other cable types on USB4 Gen2 and USB 3.2 Gen2, USB 3.2 Gen1 also required similar Matlab test tool (IntePar.exe) for compliance result compilation.

The number of USB Type-C test port counts and multiple manual test steps resulted in approximately 3 to 5 hours of testing time for one USB4 Gen3 cable.
Solutions

With the introduction and demo of the Keysight automated interconnects test solution, the customer was very impressed with the tremendous test efficiency that can complete one cable test in around 30 minutes.

The proposed Keysight USB Type-C automated interconnects test solution comes from a holistic approach that spans across both hardware and software. Besides the VNA as the main test instrument, a 4-to-20-ports switch matrix system (L8990M-0LZ) is used to enable full ports switching without manual port re-connection. The switch matrix system is a more affordable multiport test solution compared to the PXI-VNA and helps customers meet their high-volume production test cost budget.

The test efficiency is further strengthened by the S94USBCB compliance test software that provides comprehensive test coverage and in-depth test result analysis. The key features that are included as part of the USB Type-C software solution to overcome the addressed test challenges are highlighted in the next page.
1. Enables quick set up and calibration with the setup wizard

Calibration is one of the critical processes to make good VNA S-parameter measurements. Compliance tests involve time domain and frequency domain measurements that require different calibration steps on both domains. To ensure best measurement results, S94USBCB is taking care of these processes by the auto calibration wizard, including the calibration of a switch matrix system for each switching path.

2. Simplify test fixture de-embedding for highly accurate measurement

Conventional test fixture de-embedding process requires users to load fixture S2P files into VNA firmware for both time domain and frequency domain in different setup panels. The steps are easily skipped or prone to human errors that could lead to inaccurate measurement results. Leveraging from the powerful Automatic Fixture Removal (AFR) software, the solution includes single-ended AFR to measure and mathematically remove the effects of a 2-port test fixture. The fixture’s S2P files can be generated and loaded into the VNA firmware to enable the fixture de-embedding in a few simple operations.

Figure 2. Auto calibration and test fixture de-embedding panels in S94USBCB software
3. Delivers comprehensive test coverage in simple workflow

S94USBCB software delivers comprehensive test coverage to test a wide range of USB Type-C cables and connectors. It converted over 130 pages of test MOI and nearly 100 test procedures into software automation that significantly reduces the manual test procedures and avoid possible operator errors.

The compliance test setup panel has consolidated each cable/connector type and its supported USB generations into different test sets and test groups. Users just need to select their DUT type and the required test sets will be automatically loaded. The test sets are categorized based on the CTS with normative test parameters checked by default. This allows users to verify whether their DUT is fully compliant to the compliance standards while ensuring device’s interoperability. For details of covered test parameters in each test set, please refer to S94USBCB test MOI appendixes.

In addition, the “Optimize Number of Connections” feature will intelligently perform test optimization by removing redundant test ports with similar ports connections. This will further improve the test throughput and overall test time.

Figure 3. Compliance test setup panel for each cable and connector type
4. Automates USB-IF compliance test tools

Compliance test tools provided by USB-IF are Matlab-based program that need to run on a PC. It involves S-Parameters files exported from the VNA and configuration file setup to execute the Matlab tool. Result validation is based on self-checking through each output spreadsheet generated by the tool. With the integration of Get_iPar and IntePar compliance test tools into a single software platform, users just need to execute the test from the test plan panel. S4P measurements and test tool compilation will run automatically with test verdict and waveform diagrams consolidated in the test report. The automation of 4-to-20 ports L8990M switch matrix system has further improved test throughput by eliminating 44-times port re-connection (44 S4P files) for USB4 Gen3 high-speed signal test (using Get_iPar tool) and 30-times port re-connection (30 S4P files) for USB4 Gen2, USB 3.2 Gen2 and USB 3.2 Gen1 high-speed signal test (using IntePar tool).

Figure 4. Integration of USB-IF compliance test tools in test workflow and reporting
5. Provides deeper insight of measurement results with thorough test reports

Current test MOI methods rely on human operations to verify pass/fail results on the VNA and compliance test tools. With compliance software automation, users just need to execute the test flow and result verdict will be displayed on test plan panel. The solution includes HTML report that provides result table with test limits, margins, test descriptions and pass/fail status of each test parameters. It also captures waveform screenshots of the VNA measurements for reference and documentation. Raw test data (CSV, S4P files) will be saved in a test directory which can be used for production yield analysis and data analytics.

Figure 5. A typical USB2.0 D+/D- Intra-Pair skew test run using manual way (Left) and automated solution (Right).
Results

With Keysight automated compliance test solution, it helped the customer to achieve >90% of total test time saving on USB4 Gen3 cable’s high-speed signal test. Reducing typical test time of one cable from 3-5 hours to approximately 30 minutes.

<table>
<thead>
<tr>
<th>Test setup time</th>
<th>Manual mode</th>
<th>Automated mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calibration</td>
<td>20 min (4-Port VNA calibration)</td>
<td>16 min (VNA &amp; switch system calibration)</td>
</tr>
<tr>
<td>(Time-domain &amp; frequency-domain)</td>
<td>4 min (VNA &amp; switch connection to ECal)</td>
<td></td>
</tr>
<tr>
<td>Fixture de-embedding</td>
<td>10 min</td>
<td>1 min</td>
</tr>
<tr>
<td>(Time-domain &amp; frequency-domain)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Setup Time</td>
<td>30 min</td>
<td>27 min</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Test time (per DUT)</th>
<th>Manual mode</th>
<th>Automated mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>44-sets of S4P measurements with port re-connection</td>
<td>240 min (44 times port re-connection &amp; S4P)</td>
<td>4 min (44 times system switching &amp; S4P)</td>
</tr>
<tr>
<td>Compliance tool (Get_iPar) setup and compilation</td>
<td>20 min</td>
<td>2.5 min</td>
</tr>
<tr>
<td>Result validation and report</td>
<td>10 min</td>
<td>0 min</td>
</tr>
<tr>
<td>Total test time (Including setup time)</td>
<td>300 min</td>
<td>33.5 min</td>
</tr>
<tr>
<td>Test time for subsequent run (Using same calibrated setup)</td>
<td>270 min</td>
<td>6.5 min</td>
</tr>
</tbody>
</table>

Note 1:
- One-time switch matrix to test fixture port connection is needed for first setup (~10 min).
- Test time is based on optimized VNA sweep settings in S94USBCB software.
- Test time is ~17s faster for subsequent DUT run when switch de-embedded Cal sets were fully loaded.

Table 1. Typical test time for one USB4 Gen3 cable’s high-speed signal test
**Summary**

This case study illustrates how Keysight USB Type-C interconnects compliance test solution is used in high-speed digital cables and connectors manufacturing sectors and helped customer improve their productivity. The ability to perform compliance test sequencing and multiport test automation using PathWave TAP, in conjunction with Keysight’s in-depth technical expertise in signal integrity and VNA testing enable effortless compliance testing to ensure high performance interoperability of your products.

**Improve your HSD interconnects test efficiency today!**

Learn how to improve your test efficiency on USB Type-C or other HSD interconnects testing using the same setup configuration discussed in this case study. For more information about this solution and other support configurations, please visit the product page and data sheet.

---

**Try the software today!**

Experience S94USBCB compliance software’s powerful capabilities to improve your productivity and accelerate your USB Type-C compliance test workflow.

Download the 30-days free trial now!
## USB Type-C interconnects compliance test solution with E5080B

<table>
<thead>
<tr>
<th>Items</th>
<th>Description</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>E5080B</td>
<td>Vector network analyzer, 9 kHz to 20 GHz</td>
<td>1</td>
</tr>
<tr>
<td>S96011B</td>
<td>Enhanced time domain analysis with TDR software</td>
<td>1</td>
</tr>
<tr>
<td>S94USBCB</td>
<td>USB Type-C interconnects compliance test software</td>
<td>1</td>
</tr>
<tr>
<td>KS8400B</td>
<td>PathWave Test Automation, Developer System</td>
<td>1</td>
</tr>
<tr>
<td>KS8104B</td>
<td>HTML5 Result Listener Plugin</td>
<td>1</td>
</tr>
<tr>
<td>83059B</td>
<td>Coaxial Adapter, 3.5 mm (f) to 3.5 mm (f), DC to 26.5 GHz</td>
<td>4</td>
</tr>
<tr>
<td>L8990M-0LZ</td>
<td>Switch matrix, 20-ports, DC-26.5 GHz (Includes all cables)</td>
<td>1</td>
</tr>
<tr>
<td>N4433D</td>
<td>N4433D-010/0DC 4-Ports ECal Module</td>
<td>1</td>
</tr>
<tr>
<td>Others</td>
<td>USB Type-C High-Speed test fixtures from Luxshare-ICT</td>
<td>2</td>
</tr>
</tbody>
</table>

### Web Resources

- [www.keysight.com/find/S94USBCB](http://www.keysight.com/find/S94USBCB)
- [Product Video - Automated Cable Test Solution](http://www.keysight.com/find/ena-tdr_compliance)
- [www.keysight.com/find/usb-vna](http://www.keysight.com/find/usb-vna)
- [www.keysight.com/find/na](http://www.keysight.com/find/na)
- [www.keysight.com/find/vnasoftware](http://www.keysight.com/find/vnasoftware)
- [www.keysight.com/find/ecal](http://www.keysight.com/find/ecal)