

N5991 USB 3.2

Receiver Compliance Test Automation Software

N5991U32A & N5991U32E

The screenshot displays the USB3.2 N5991 ValiFrame software interface. The main window is titled "USB3.2 N5991 ValiFrame" and features a menu bar with options: NEW, LOAD, SAVE, EXPORT, RESET, START, PAUSE, and ABORT. The interface is divided into several sections:

- Left Panel:** A tree view showing the test configuration for a "3.2 Device with Type-C Connector". It includes sections for Calibration (5 Gb/s and 10 Gb/s for Lane 1 and Lane 2, and Long Channel), Receiver (5 Gb/s (Gen1x1), 10 Gb/s (Gen1x2), and 20 Gb/s (Gen2x1) for Long Channel Tests, Short Channel Tests, and LFPS Tests), and 20 Gb/s (Gen2x2) for Long Channel Tests and Short Channel Tests.
- Right Panel:** A configuration table for the 20 Gb/s (Gen2x2) test.

Section	Parameter	Value
20 Gb/s (Gen2x2)	Repetitions	0
	Loopback Training	
Loopback Training	CDR during Loopback Training	False
	CDR Idle	M8020A Idle
	Dual Lane Loopback Training Method	WarmReset
	Warm Reset Link Training Suite Settings File	C:\ProgramData\BtiffEye\ValiFrameK1\USB3\Settings\M8020A\M8020A
	Non Config Warm Reset Link Training Suite Settings File	C:\ProgramData\BtiffEye\ValiFrameK1\USB3\Settings\M8020A\NonCon
	Use Instrument Scrambler	False
	Error Detector	
Error Detector	CDR Loopbandwidth	15 MHz
	CDR Transition Density	50 %
	CDR Peaking	1 dB
	Analyzer CTLE	USB 10Gb/s 0dB
	Input Sensitivity	High
	Auto-align Timeout	60 s
	Error Detector Operation Mode	Differential
	Input Polarity inverted	False
- Bottom Panel:** A log window showing the following messages:

Severity	Message	Date
Progress	Instrument Connections	4/10/2020 1:34:49 PM
Progress	Opening offline connection to Keysight M8020A J-BERT at TCP/IP0::127.0.0.1:hislip0::INSTR	4/10/2020 1:34:49 PM
Progress	Opening offline connection to DSO Infinium Series at TCP/IP0::192.168.0.103:hislip0::INSTR	4/10/2020 1:34:49 PM
Progress	Opening offline connection to NETIO at 192.168.0.105:username.password	4/10/2020 1:34:49 PM
Progress	Opening offline connection to Type-C Controller N7018A at 127.0.0.1	4/10/2020 1:34:49 PM
Info	USB3.2 N5991 ValiFrame startup complete!	4/10/2020 1:34:50 PM

The status bar at the bottom indicates "Ready" and "Not Running USB3 Station".

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At a Glance

High-speed digital standards are quickly evolving to keep pace with emerging technologies such as 5G, Internet of Things (IoT), artificial intelligence (AI), virtual reality (VR), and autonomous vehicles.

Each generational change introduces new test challenges for your digital designs. You are required to test your high-speed digital designs across all product development stages, with design and simulation, analysis, debug, and compliance test. Followed by system implementation, the latest N5991 software solution anticipates test challenges, optimizes performance, and accelerates time-to-market of your high-speed computing interfaces, data center connections, and consumer electronics.

The Keysight N5991 software solution comprises the following features:

- Support for High-Speed digital standards such as USB, PCIe, CCIX, SAS and HDMI. Other standards will be continuously added with the requirements for higher data speed testing
- Guided setup with automated fast stress signal calibrations and compliance measurement functions
- Modern interface with enhanced functionalities
- System modularity that lets you enable just the required functionality
- Test reports generated in HTML / Excel formats
- Link training suites that include the feature for debugging of DUTs
- Node-locked and transportable licenses, which includes 12 months of service, support and updates
- Characterization mode for in-depth testing
- Support for real-time parameter changes of amplitude levels, etc.
- Optional user programming for legacy code integration (such as LabVIEW, VEE, C++) and custom test procedures

Transform Your Instruments into a Solution

An efficient test strategy is a proven competitive advantage. The Keysight N5991 test automation software platform is the successor to the well-known industry standard N5990A test automation software platform. While it follows the same concept of combining the performance of your instruments with the convenience of your PC, the latest N5991 test automation software platform provides unprecedented test integration, high-throughput, and ease-of-use for a wide range of stimulus and response systems. This approach provides a level of control that transforms a collection of instruments into a universal, user-friendly and highly productive test solution.

Fast and Reliable Testing

The comprehensive N5991 software platform increases test speed, reduces test costs, and ensures greater thoroughness than manual electrical testing. If, for example, the USB standard is tested using the N5991 software, you can test a wide range of products – devices, hosts or retimers – whether they are production-ready prototypes, development boards, or chipsets.

Standardize Your Tests

The N5991 receiver-test options provide dedicated receiver compliance tests for popular and emerging digital buses. You can choose compliance mode for fast certification testing, or characterization mode for in-depth analysis. The Receiver Test Automation Platform’s compliance testing capabilities have been repeatedly proven at interoperability workshops or “plug-fests”.

The N5991 platform has been built upon the success of previous generations to deliver significant gains in productivity. Like its predecessor (the N5990A software), the interface for the new system has been designed using a common framework, which makes it easy to test multiple buses, such as USB, PCI Express, CCIX, SAS and more. It delivers additional gains by using HTML or Excel formats for reporting results. The N5991 software architecture is based on C# code and Microsoft .NET, which, in conjunction with on-the-fly amplitude and jitter control supported by many Keysight instruments, ensures fast interaction, calibration, and test execution for the highest possible throughput.

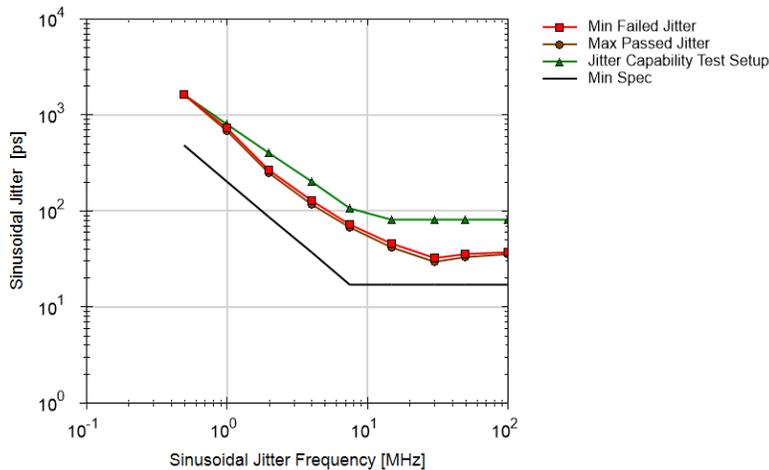
Test Selection and Test Results

The test automation software platform lets you select tests from an intuitive tree structure with multiple levels of detail. Select the tests you want to run, as well as the number of their repetitions. Test results are provided in HTML or Microsoft Excel format. Measuring results are reported in parameter tables and graphically in curves (see Figure 1).

Product Number: USB USB Station Unknown User 12/11/2019 10:24:19

Rx1_10Gx2_JToI

for USB3.2 Device with Type-C Connector



Result	Sinusoidal Jitter Frequency [MHz]	Min Failed Jitter [ps]	Max Passed Jitter [ps]	Jitter Capability Test Setup [ps]	Min Spec [ps]	Margin [%]
pass	0.500	1600.0	1600.0	1600.0	476.0	236.1
pass	1.000	723.0	688.0	800.0	202.9	236.7
pass	2.000	267.0	247.0	400.0	86.5	185.7
pass	4.000	127.0	117.0	200.0	36.8	217.6
pass	7.500	72.0	67.0	106.7	17.0	294.1
pass	15.000	45.0	41.0	80.0	17.0	141.2
pass	30.000	32.0	29.0	80.0	17.0	70.6
pass	50.000	35.0	33.0	80.0	17.0	94.1
pass	100.000	37.0	35.0	80.0	17.0	108.9

Figure 1: 10 Gb/s dual lane jitter tolerance test result

N5991U32A USB 3.2 Receiver Tests

The N5991U32A application is designed to help verify and debug USB products, providing great value on top of the test instruments by offering an intuitive user interface, which hides the complexity of the receiver calibration and test procedures, automating the whole process and minimizing the sources of errors.

Calibrations

N5991U32A fully automates the complex calibration procedure described in the *Enhanced SuperSpeed USB Electrical Compliance Test Specification* to generate the stress signal by finely adjusting the pattern generator differential voltage, transmitter equalization, random jitter and periodic jitter at different frequencies to obtain a certain eye opening. In addition, the application gives you a clear guidance through the steps needed for the 10 Gb/s calibration procedure to adjust the total channel loss by selecting the appropriate Compliance Load Board fixture.

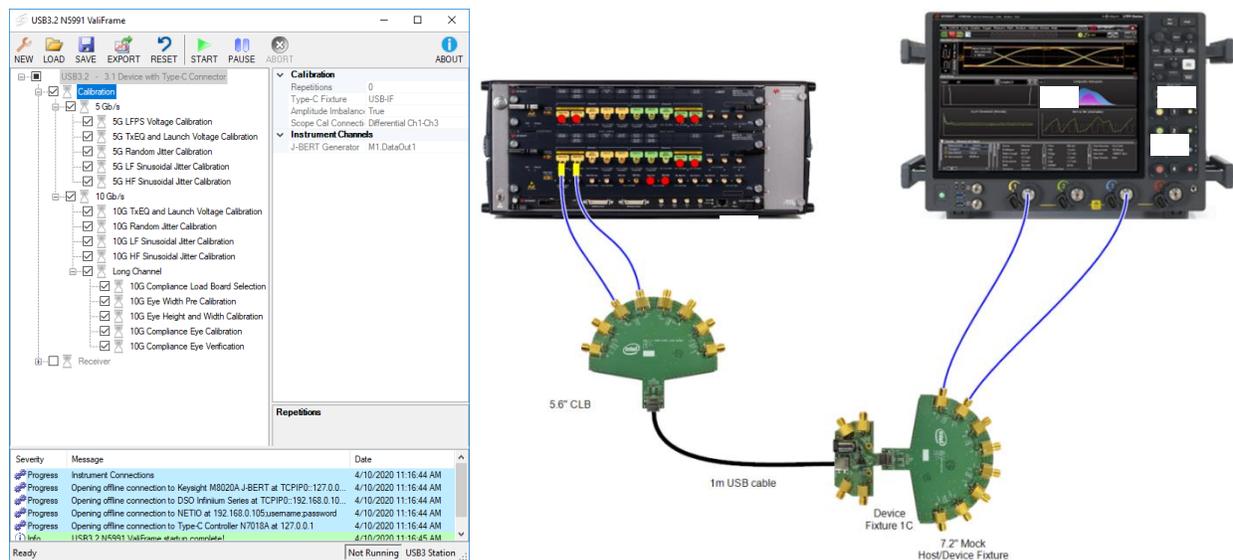


Figure 2: Receiver Calibrations and 10 Gb/s long channel calibration setup

Some of the calibration steps described earlier require the use of the waveform post-processing tool SIGTEST, which is fully integrated into the application and its execution has been optimized for faster, more accurate results.

Receiver Tests

According to the *Enhanced SuperSpeed USB Electrical Compliance Test Specification*, receiver testing must be performed while the DUT operates in loopback, which is an LTSSM (Link Training Status and State Machine) state where the DUT sends back the received data without performing error correction.

The receiver compliance test consists of two phases. First, the DUT must be trained into loopback, following the strict requirements of the LTSSM. Then, while the DUT is in loopback, the test instrument pattern generator sends the test pattern to the DUT and compares it with the data that the DUT sends back to the error detector. The pattern generator is configured to generate the stress signal resulting from the calibration process in order to evaluate the receiver performance under the worst conditions.

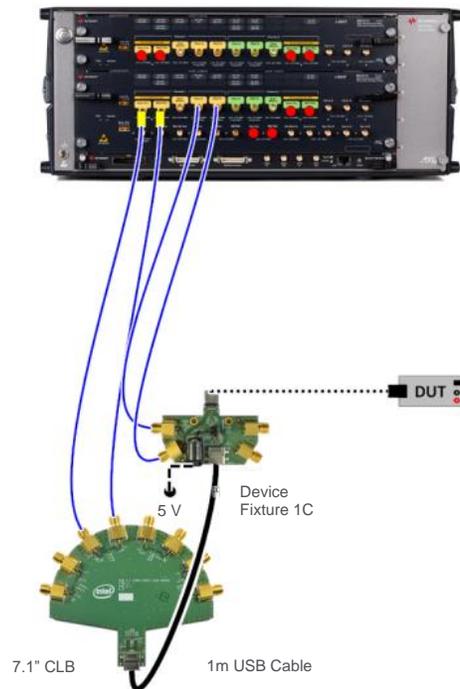
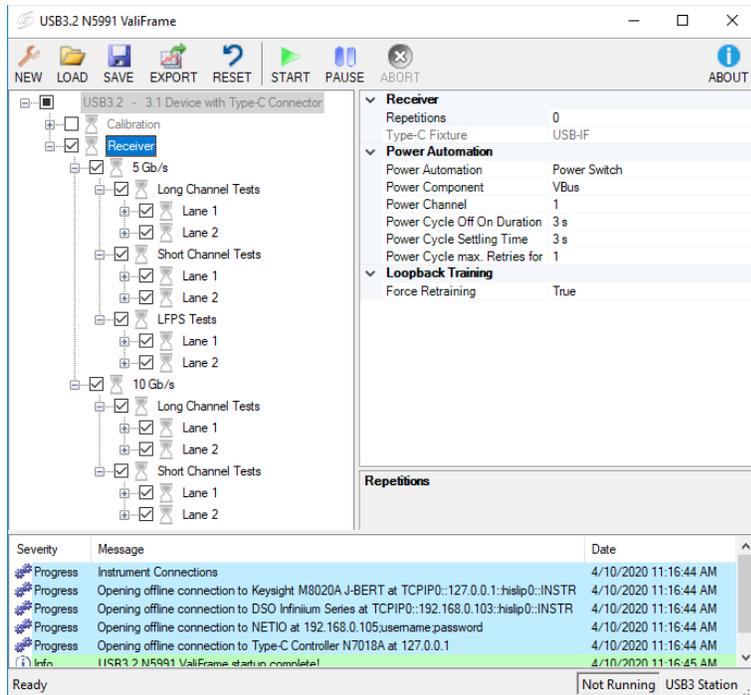


Figure 3: Receiver Tests and long channel receiver test setup

Dual Lane Mode

The USB 3.2 specification comprehends the 5 Gb/s and 10 Gb/s PHY rates on single lane mode, and the same rates on dual lane mode for the USB Type-C® interface, producing aggregate rates of 10 Gb/s and 20 Gb/s, respectively.

The performance of a USB 3.2 product operating in dual lane mode compared to single lane mode is significantly degraded by the crosstalk generated by all transmitter and receiver differential pairs being active at the same time. Therefore, in order to ensure the product's interoperability, it is crucial to characterize it as close as possible to its operating conditions.

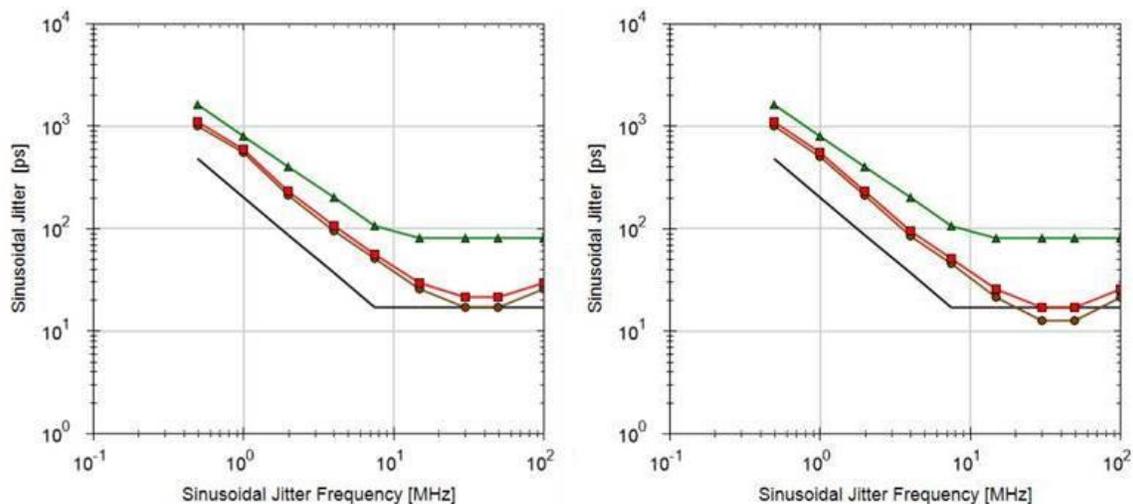


Figure 4: Jitter tolerance test result of a USB 3.2 product operating in single lane mode (left) vs dual lane mode (right)

N5991U32A does so by utilizing two pattern generators and two error detectors. First, the two data paths from the pattern generator to the DUT receivers are calibrated independently as described in the *Enhanced SuperSpeed USB Compliance Test Specification*. Then, the software trains the two receivers simultaneously into loopback and runs concurrent jitter tolerance tests, evaluating the performance of both lanes. Following this methodology, the DUT is under the same stress conditions as when it interoperates with other USB 3.2 products.

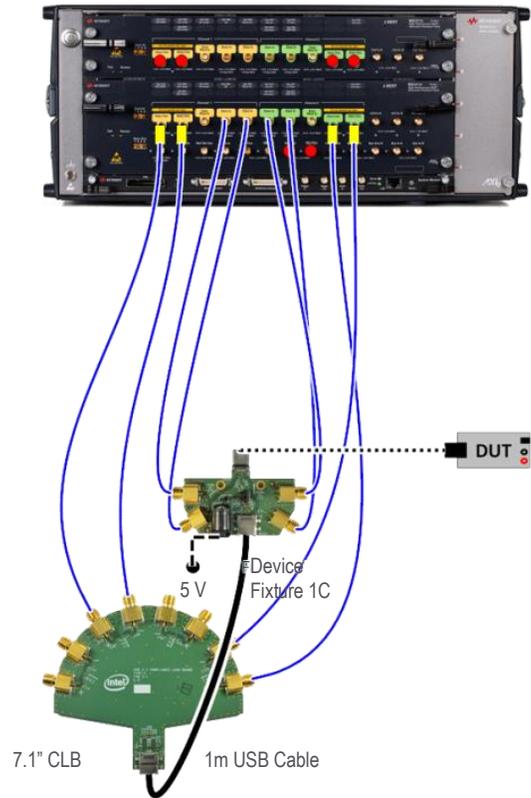
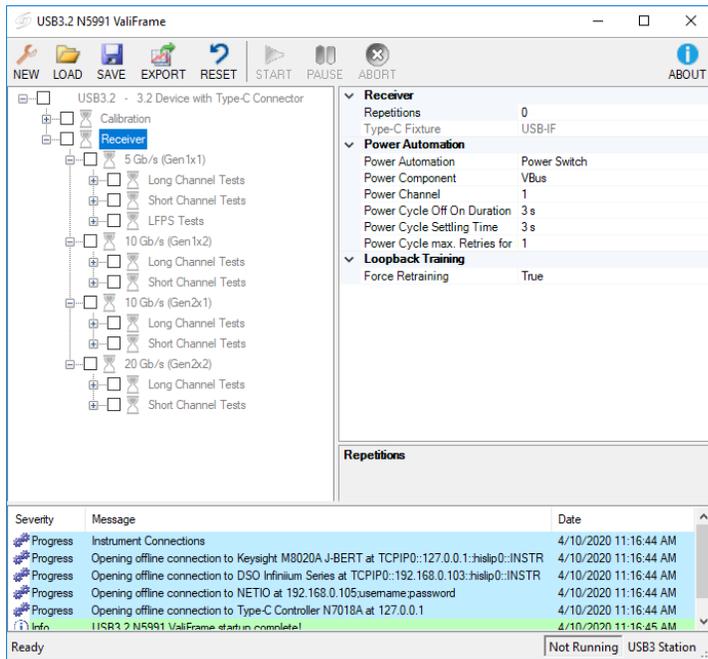


Figure 5: Dual lane receiver tests and long channel test setup

Add-ons

Integrated BER Reader Support

In USB 3.2, Integrated BER Reader is designed to allow a custom way to read the bit error rate (BER) from the DUT. With product option “N5991U3IY-ADD USB 3.x Integrated BER Reader Support Add-on”, you may implement your own code to configure and reset the DUT and access bit and error information during a receiver test to compute the bit error rate (BER).

Type-C PDO Support

The USB Type-C® interface supports the USB PD (Power Delivery) protocol, which allows two USB products to negotiate the power contract besides the high-speed data link. Traditionally, USB hosts were always the providers of power for USB devices, and USB devices were the consumers. Now, USB PD allows to swap the power provider/consumer roles, thus enabling a flexible usage and a wide range of applications. In addition, USB PD supports numerous provider/consumer and voltage/current schemes – or power contracts – that allow a maximum power transfer of 100W (20V/5A).

With such diverse power contracts, it is crucial to ensure that your product meets the PHY layer electrical compliance while operating under all of them. The “N5991U3PY-ADD USB 3.x Type-C PDO Support Add-on” leverages the Keysight N7015A Type-C High Speed Test Fixture and the N7018A Type-C Test Controller to communicate with your product to identify and establish the different power contracts that it supports, allowing compliance testing and debugging under different power transfer conditions.

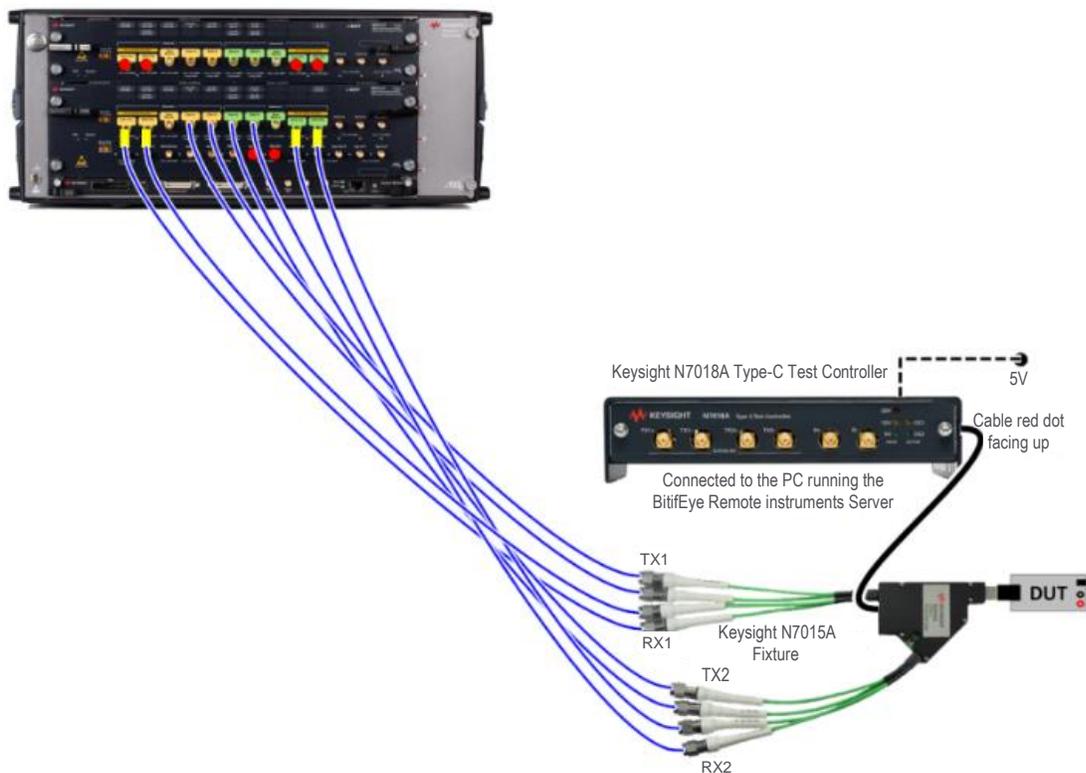


Figure 6: Receiver test setup with N7015A and N7018A

Component Retimer Support

Some USB applications require longer link distances, where the signal integrity is severely compromised if using a passive channel. In order to overcome such technical obstacles, the USB 3.2 specification contemplates the usage of repeaters between two link partners, improving the signal quality and enabling longer communication channels. Repeaters can be classified in two categories: redrivers and retimers. A redriver compensates the channel loss by equalizing and amplifying the received signal. A retimer is a more complex product which establishes two USB links – one at each of its sides – by implementing its own RTSM (Retimer Training State Machine). This functionality must be tested to ensure the retimer's interoperability in a USB link.

N5991U32A makes it possible to test and characterize a retimer by training both of its ports simultaneously, verifying that both receivers meet the specification and that the data transmitted from port A to port B and vice versa is correct.

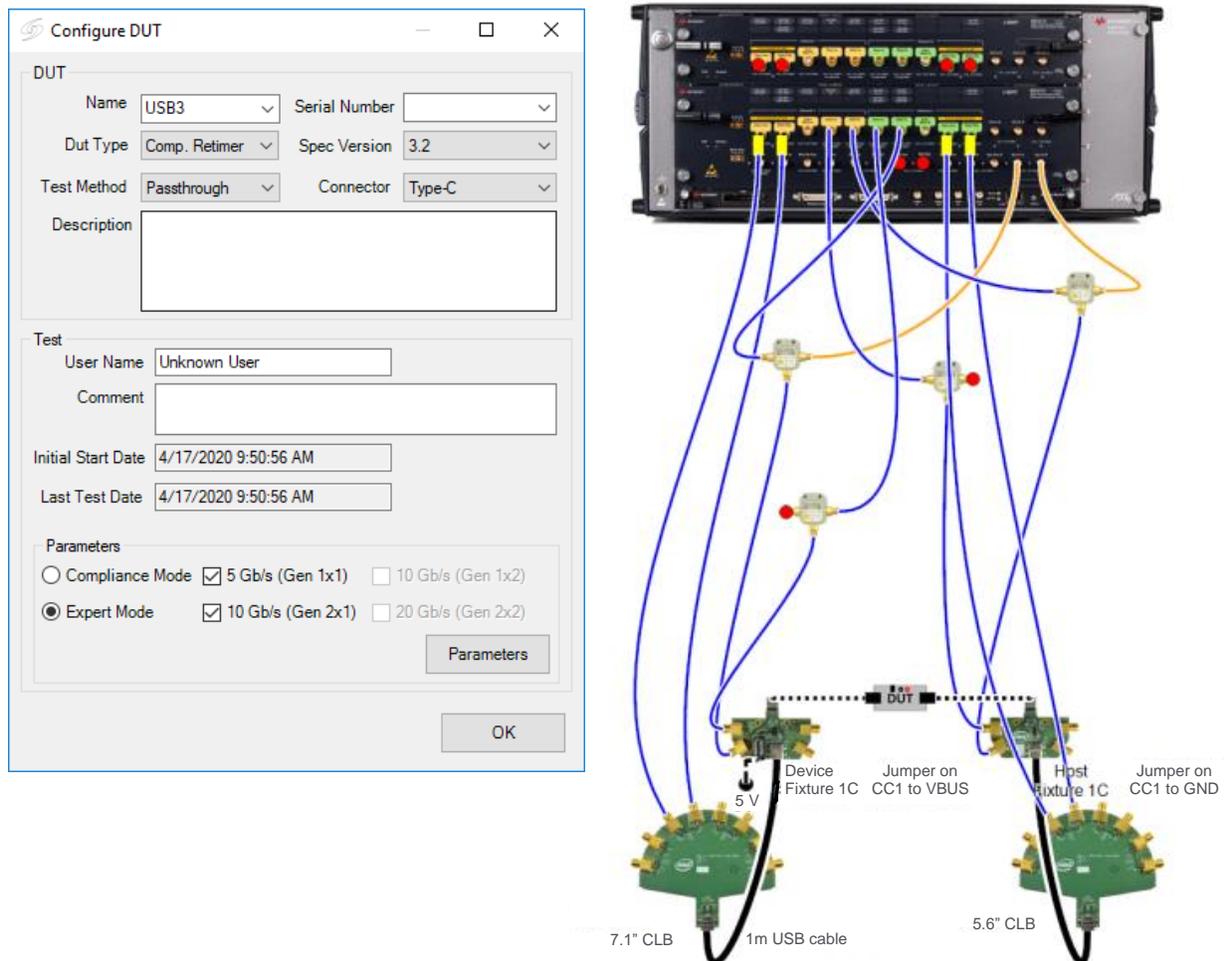


Figure 7: Component retimer configuration and receiver test setup in passthrough mode

N5991U32E USB 3.2 Debug Tool Link Training Suite

N5991U32A offers fully automated calibrations and receiver tests. However, DUTs often require a fine adjustment of the link training process to bring them into the loopback state. The N5991U32E Debug Tool offers full control of the LTSSM (Link Training Status and State Machine), allowing you to create the optimal settings for your DUT.

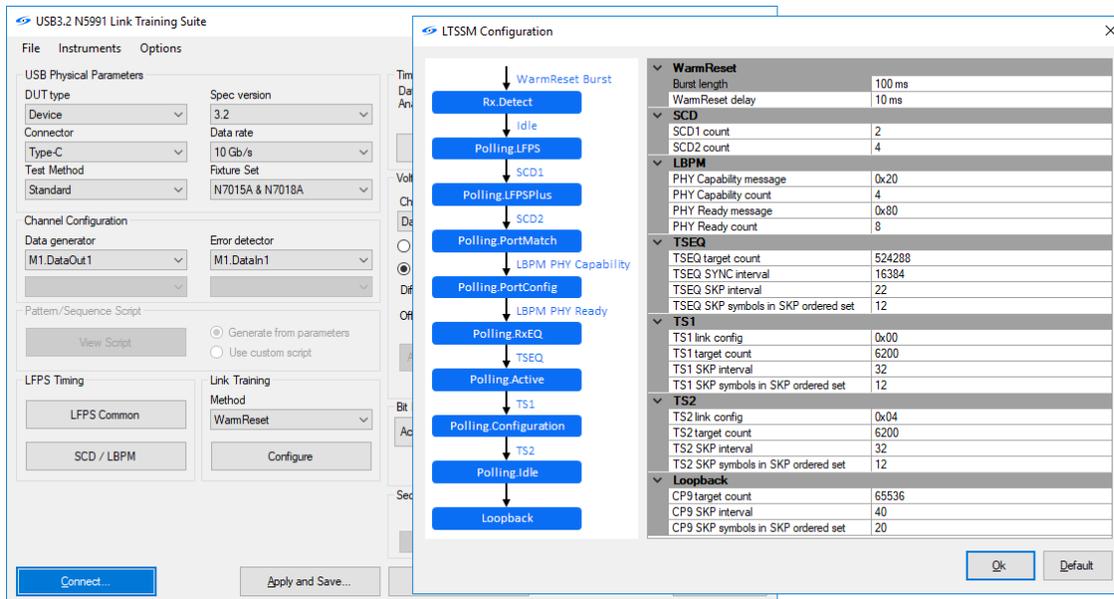


Figure 8: USB 3.2 Link Training Suite

Thanks to an intuitive user interface, N5991U32E makes it very easy to fine-tune the LTSSM: time definitions of low-speed signals such as LFPS (Low-Frequency Periodic Signaling), SCD (SuperSpeed Capability Declaration) or LBPM (LFPS-Based PWM Message), message content of LBPM signals, Link Configuration field of TS1 and TS2 ordered sets and duration of each LTSSM state or test pattern.

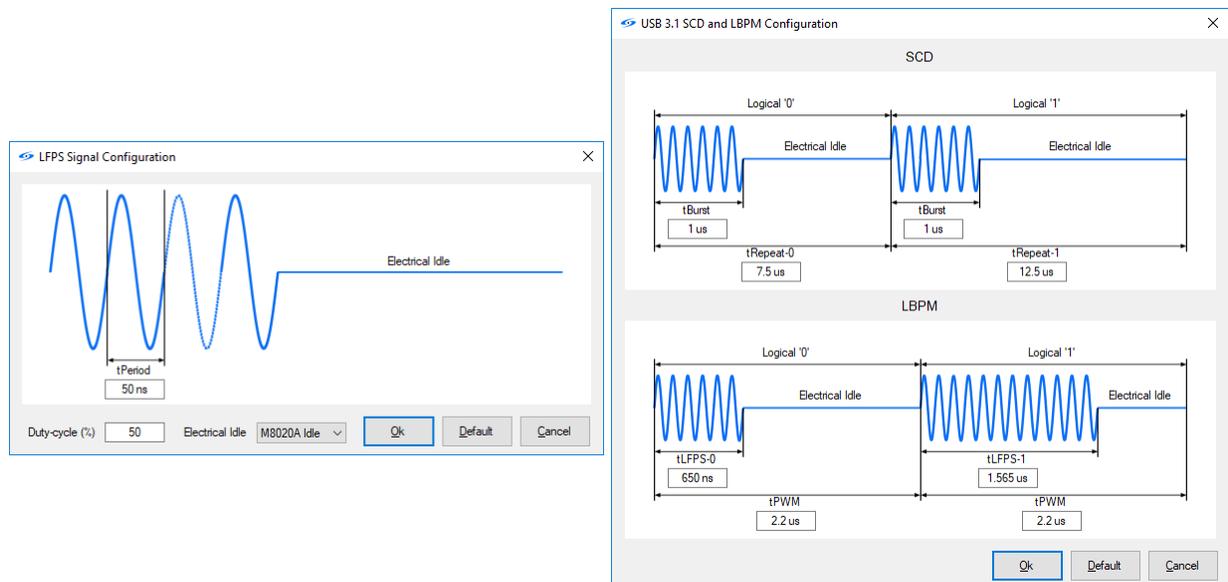


Figure 9: Modify LFPS, SCD and LBPM time definitions

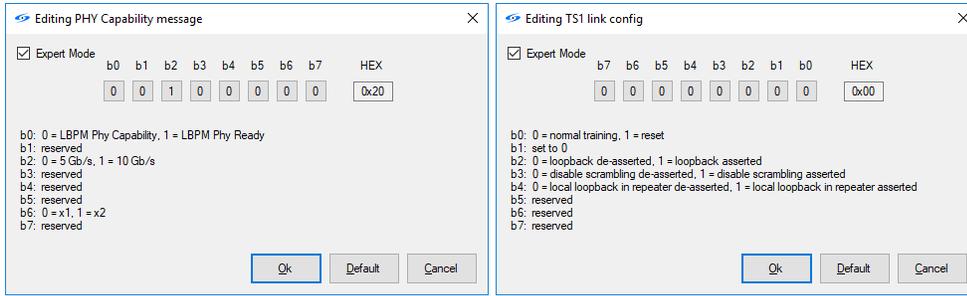


Figure 10: Edit LBPM message content and TS1/TS2 link configuration field

Advanced users can leverage the N5991U32E scripting language, enabling full control of the LTSSM. For more details about the scripting language, please refer to the “Keysight N5991U32E USB 3.2 Link Training Suite User Guide”. Once the LTSSM has been adjusted, the resulting Link Training Suite script can be exported and used later in the test automation, ensuring that the optimal settings are used for compliance testing.

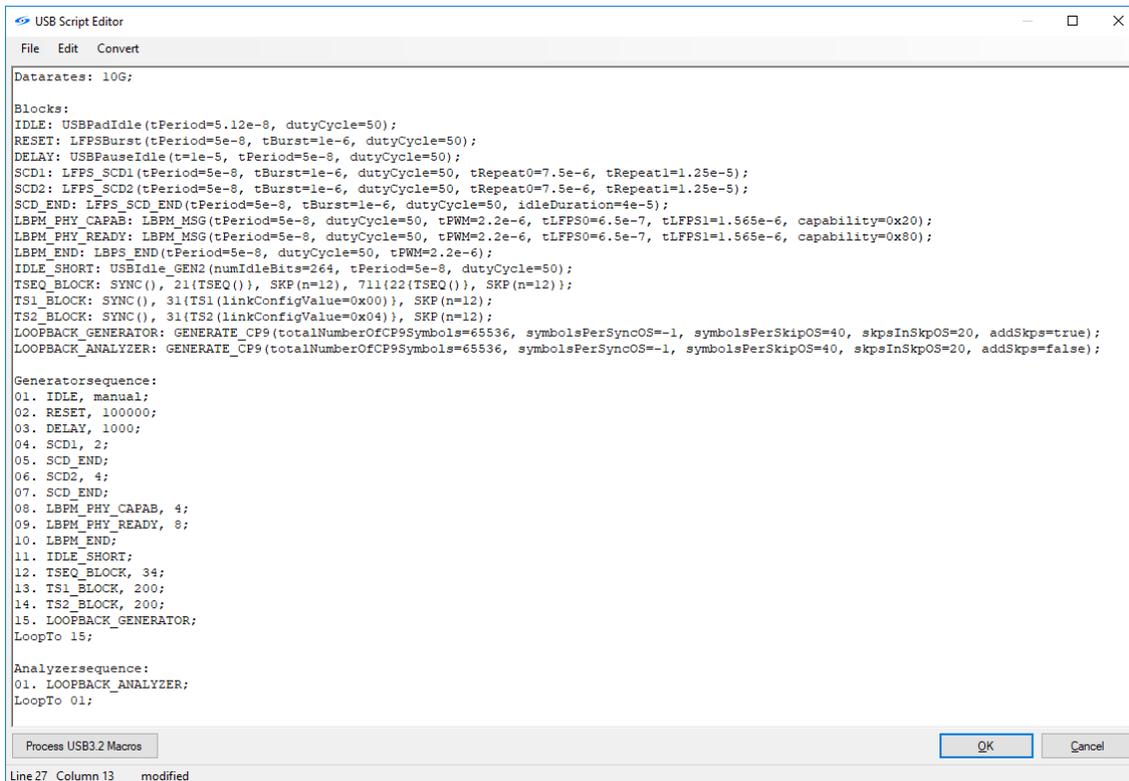


Figure 11: Link Training Suite script editor

Ordering Information

N5991U32A USB 3.2 Receiver Test

N5991U32A-1FP	Perpetual node-locked license
N5991U32A-1TP	Perpetual transportable single license
N5991U32A-SFM	SW maintenance, 12 Months, Node-locked License
N5991U32A-STM	SW maintenance, 12 Months, Transportable License

N5991U32A USB 3.2 Receiver Test Add-ons

N5991U3IY-ADD	USB 3.x Integrated BER Reader Support Add-on
N5991U3PY-ADD	USB 3.x Type-C PDO Support Add-on
N5991U3RY-ADD	USB 3.x Component Retimer Support Add-on

N5991U32E USB 3.2 Debug Tools Link Training Suite

N5991U32E-1FP	Perpetual node-locked license
N5991U32E-1TP	Perpetual transportable single license
N5991U32E-SFM	SW maintenance, 12 Months, Node-locked License
N5991U32E-STM	SW maintenance, 12 Months, Transportable License

License Types

Node-locked – License can be used on one specified computer.

Transportable – License can be used on one computer at a time but may be transferred to another using the BitifEye License Manager.

Instrument Requirements

The N5991U32A USB 3.2 Receiver Test application supports the Keysight M8020A and M8040A High-Performance BERT platforms. The BERT must be equipped appropriately to cover the required data rates, jitter injection, transmitter and receiver equalization and USB link training capabilities.

Keysight recommends using a real-time oscilloscope with a bandwidth of at least 25 GHz, although a bandwidth of 33 GHz is preferred for most accurate receiver calibration at 10 Gb/s.

System Requirements

Software

Requirements

- OS: Windows 10 - 64-Bit, English version
- Microsoft .NET Framework version 4.7.1 or higher
- Keysight IO Libraries Suite 18.1 or higher

Recommendation

- Microsoft Office Excel 2016 or higher, English version

Hardware

Requirements

- Connectivity hardware for instrumentation, depending on configuration e.g. USB 3.0, Ethernet

Recommendations

- Multicore processor with 12 logical processors or more
- 16GB RAM or higher

Remote Power Cycling

All N5991 Receiver Test Automation products can control power strips from Koukaam, Allnet and Synaccess to power cycle a device under test remotely.

Remote Programming

The N5991 ValiFrame remote interface allows ValiFrame functionality, such as test setup information, calibration, test procedures and results, to be accessed from external programming environments. The remote interface does not need a special license to be used, it is included in the base product.

Related Products

D9020USBC USB 3.2 Tx Compliance Test Software

M8020A J-BERT High-Performance BERT

M8040A 64 Gbaud High-Performance BERT

N5991 Receiver Compliance Test Automation Platform

N7015A Type-C High-Speed Test Fixture

N7018A Type-C Test Controller

U7242A USB 3.0 test fixture

Learn more at: www.keysight.com

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