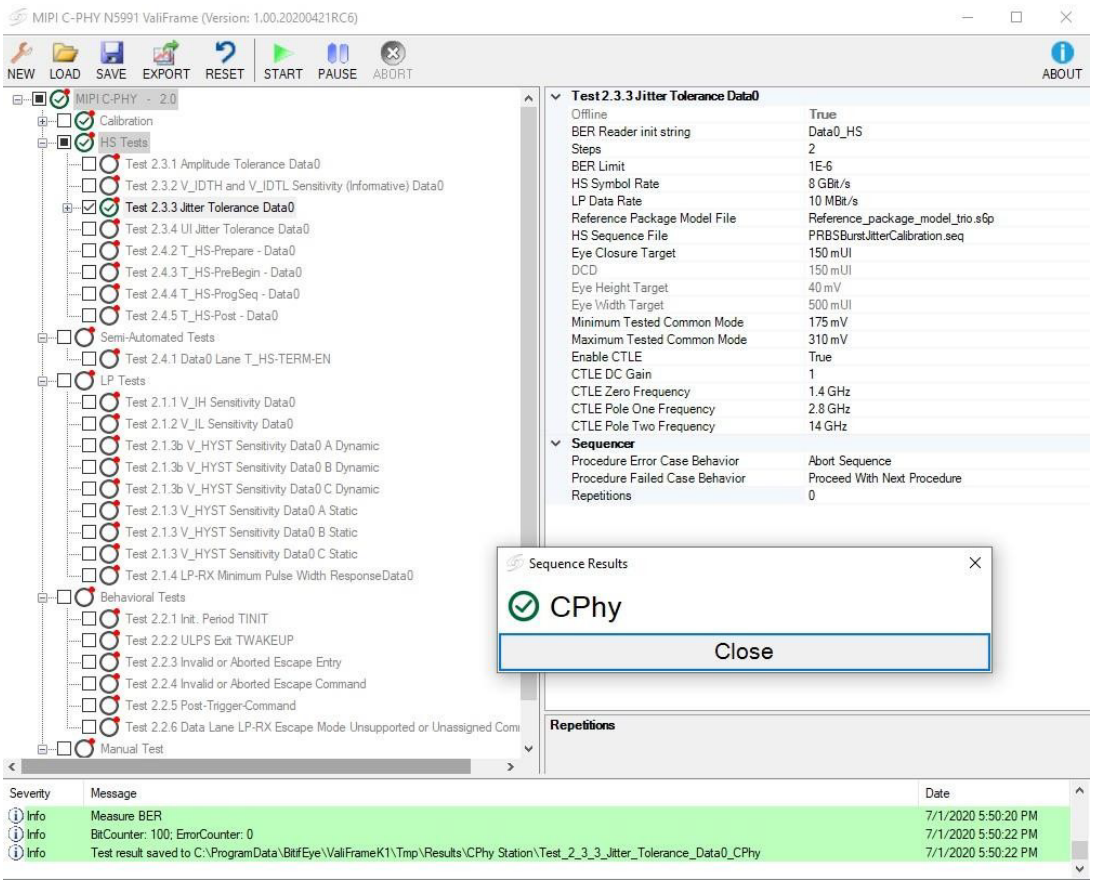
N5991 MIPI C-PHY 2.0

Receiver Conformance Test Automation Platform
N5991MC2A and N5991MC2E



KEYSIGHT

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 MIPI® C-PHYSM, 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 and frame generator applications that include features for debugging of DUTs
- Node-locked and transportable licenses plus annual service, support and update licenses
- Characterization mode for in-depth testing

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 C-PHY standard is tested using the N5991 software, you can test the receivers of products that use the MIPI CSI or DSI standards, whether they are production-ready prototypes, development boards, or chipsets.

Standardize your tests

The N5991 receiver-test options provide dedicated receiver conformance 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 MIPI C-PHY, 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).

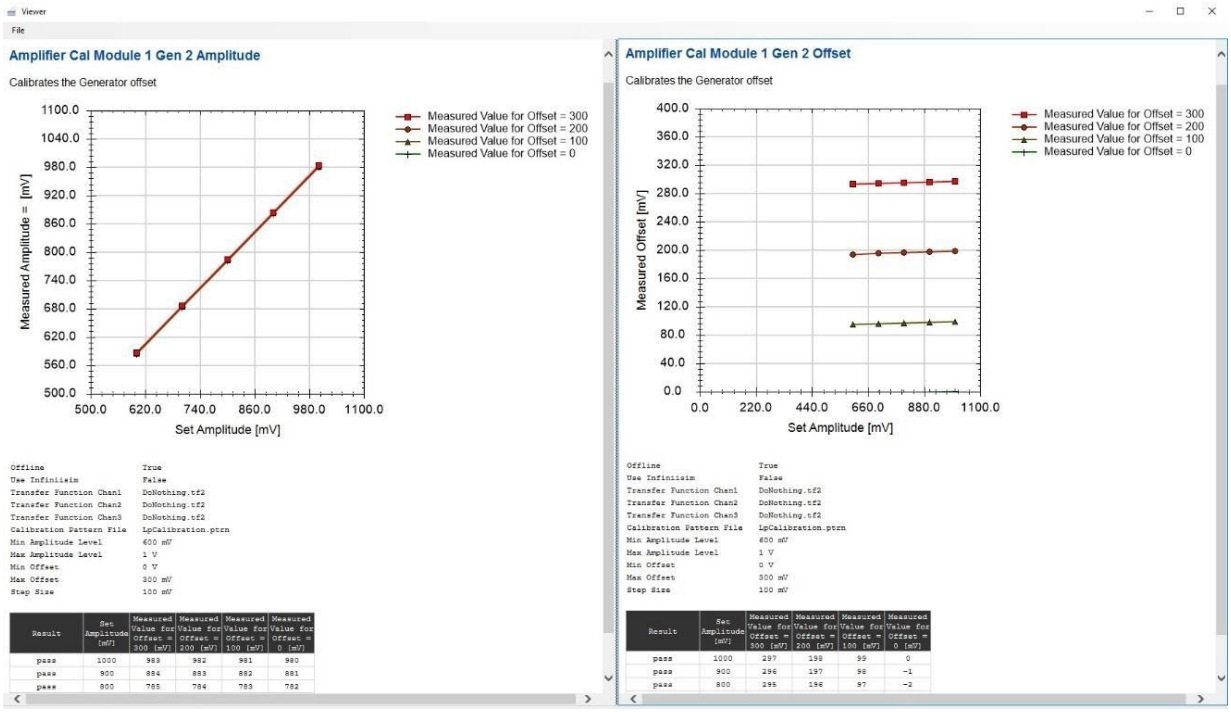


Figure 1. Amplifier level calibration report

N5991MC2A MIPI C-PHY 2.0 Receiver Tests

The N5991MC2A application is designed to help verify and debug designs using the MIPI C-PHY 2.0 interface. It provides great value on top of the test instruments by offering an intuitive user interface, which hides the complexity of test system calibration and test procedures, automating the whole process and minimizing the sources of errors.

Calibrations

The N5991MC2A fully automates the complex calibration procedures described in the Conformance Test Suite for MIPI C-PHY 2.0 to generate the stress signal by finely adjusting the Arbitrary Waveform Generator levels for low power (LP) and high speed (HS) signals, transmitter equalization, transition time, duty cycle distortion and inter symbol interference (ISI) calibration. Calibrations are made at user selectable symbol rates to obtain correct eye opening that fits the device under test (DUT) speed class. In addition, the application gives you clear guidance how to connect the generator outputs to the oscilloscope for the selected calibration.

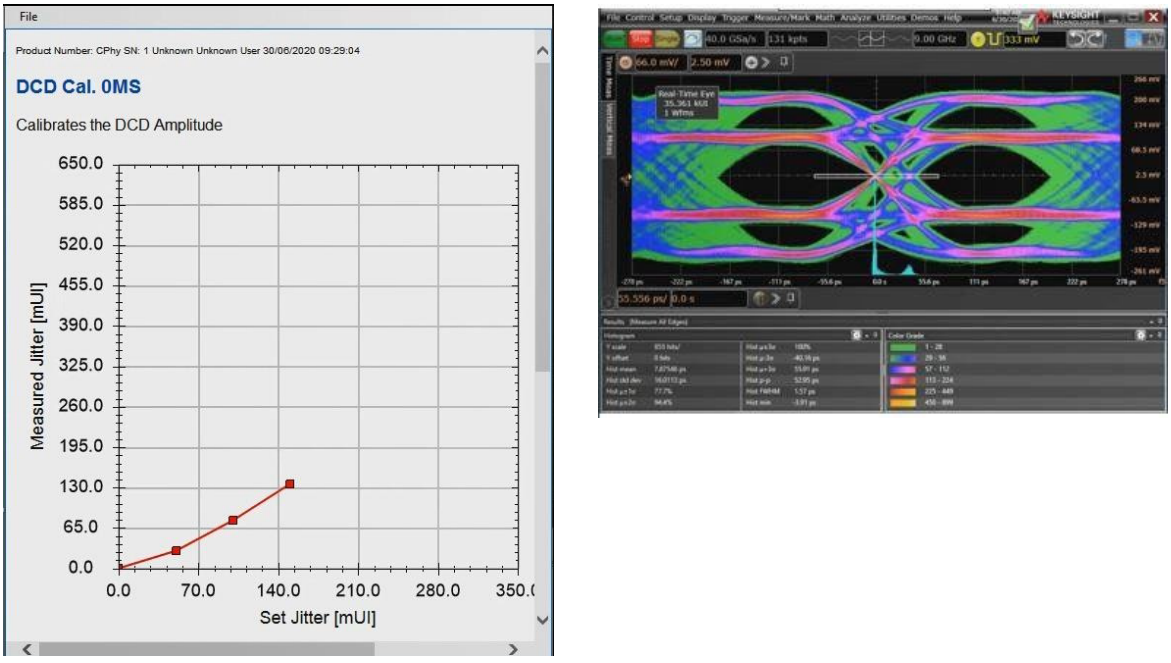


Figure 2. Example of DCD calibration with triggered eye

Receiver Tests

The MIPI C-PHY 2.0 Conformance Test Suite (CTS) defines test procedures for transmitter, receiver and impedance/return loss testing. The tests are designed to determine if a product conforms to specifications defined in the MIPI Alliance Specification for C-PHY. Successful completion of all tests contained in the suite, combined with a satisfactory level of interoperability testing, will provide a reasonable level of confidence that the DUT will function properly in many environments.

Section 2 of the CTS contains the tests that verify various RX signaling voltage, timing and behavioral requirements of C-PHY transceivers.

The N5991MC2A application implements all test procures defined in the CTS for MIPI C-PHY 2.0. The user can choose parameters like HS and LP symbol rate, default timings and levels or test pattern sequences that meet the DUT requirements. When in Expert Mode, the application allows testing the DUT beyond the requirements in the CTS.

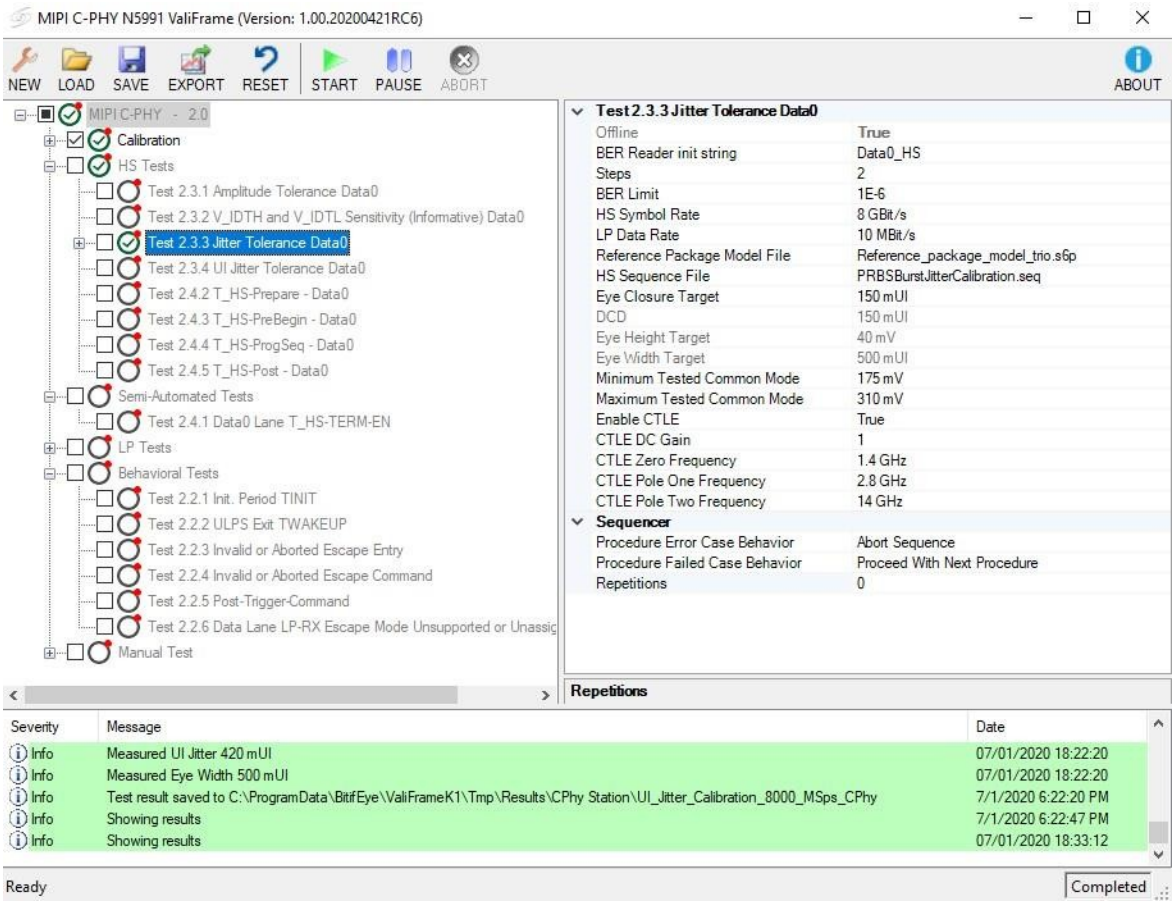


Figure 3. N5991MC2A test sequence and parameter dialog

The application provides clear guidance how to connect the test equipment to the DUT if any change is required.

While a test is running, the application may ask the user to reset or prepare the DUT for testing and if any data receive error had been recognized. To avoid being asked to answer these questions, you can use the Interactive BER Reader interface mentioned below to fully automate the testing process.

The N5991MC2A allows to view test results individually and to export a complete calibration and test report.

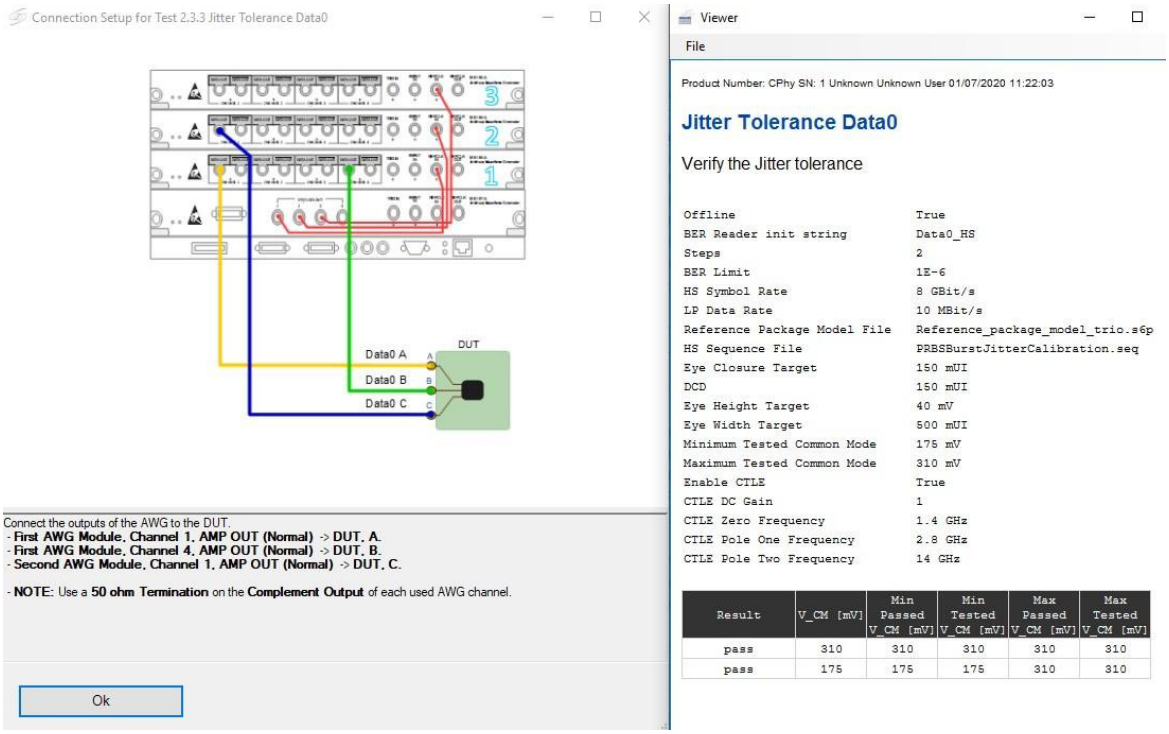


Figure 4. Connection Instructions dialog and Test Result Viewer

Add-ons

MIPI C-PHY 32G sample waveform generation

MIPI C-PHY 2.0 supports symbol rates up to 8 Gsps. In order to ensure accurately generate stimulus with precise impairments above 4 Gsps, an AWG sample rate higher than 16 Gsa/s is required. The Keysight M8195A AWG supports 32 Gsa/s if it is used in two channel mode.

The N5991MCHZ-ADD enables to generate a C-PHY trio signal using two M8195A running at up to 32 Gsa/s which is required for higher C-PHY symbol rates.

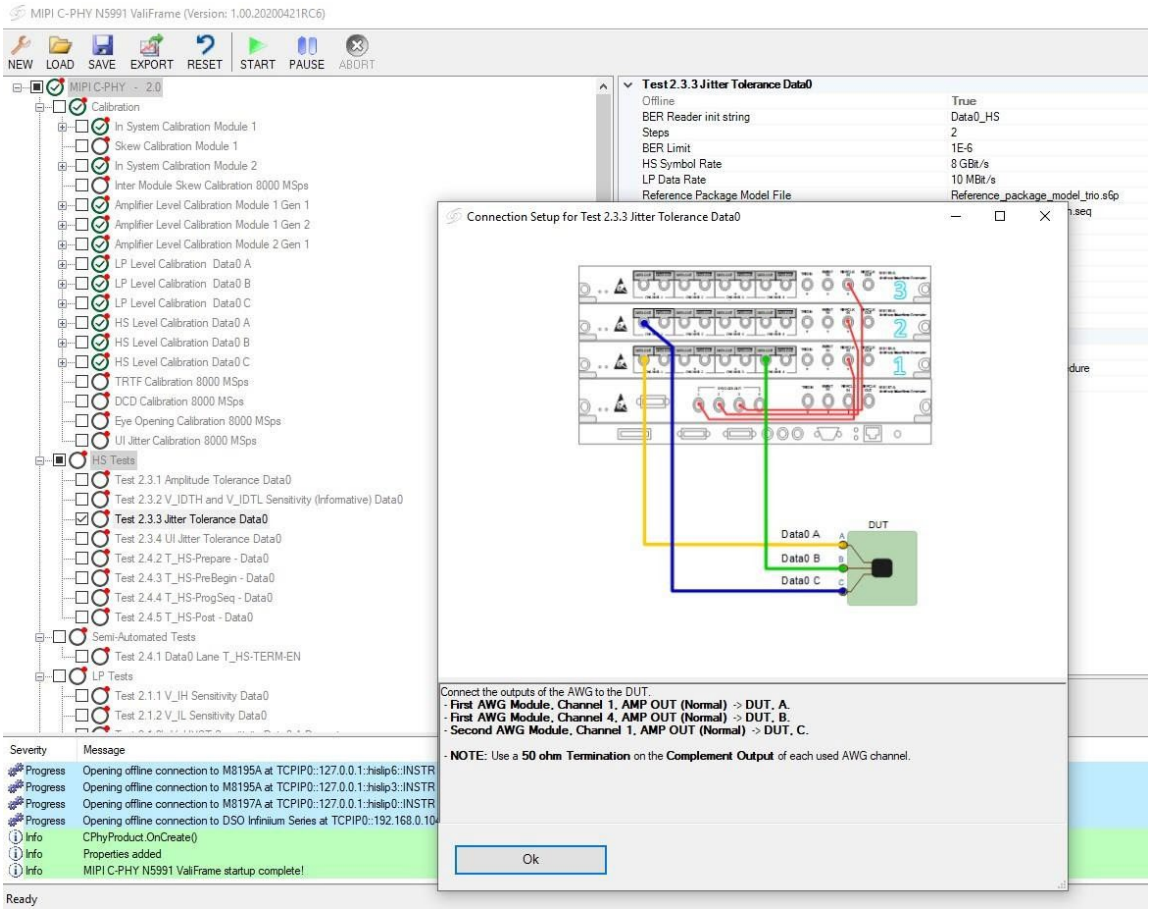


Figure 5. Two M8195A stimulating one C-PHY Lane at 32 Gsa/s

Integrated BER reader support

The Integrated BER Reader is designed to allow a custom way to read the bit error rate (BER) from the DUT. With product option N5991MCIY-ADD, MIPI C-PHY Integrated BER Counter Interface 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).

N5991MC2E MIPI C-PHY 2.0 Frame Generator

The test equipment used for stimulating C-PHY signal is created by the Keysight M8195A Arbitrary Waveform Generator (AWG). AWG instruments generate their output signal from a vector memory that contains the digitized waveform information. Usually, the waveform vectors must be generated by the user utilizing waveform synthesis tools such as MATLAB or equivalent.

The N5991MC2E is used to create valid C-PHY stimulus by just defining its parameters such as data rate up to 9 Gsps, HS and LP levels, rise and fall times, jitter, ISI or C-PHY related protocol timings. Using these parameters, it compiles the appropriate vector memory content and downloads this to the AWG, creating the appropriate signal.

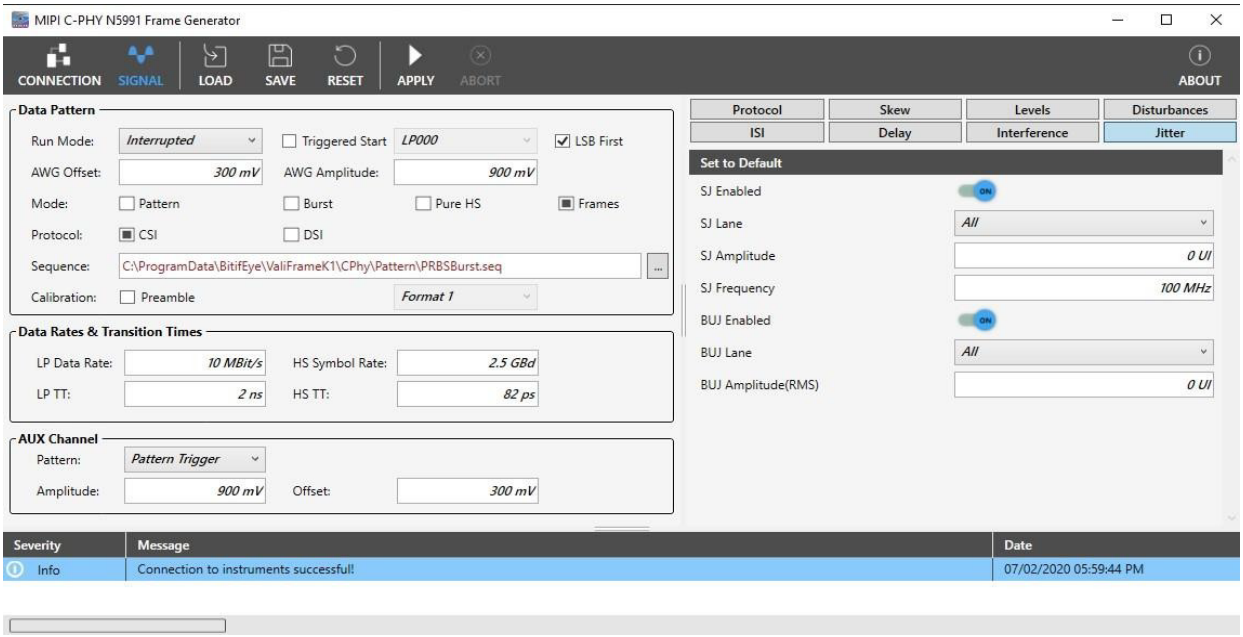
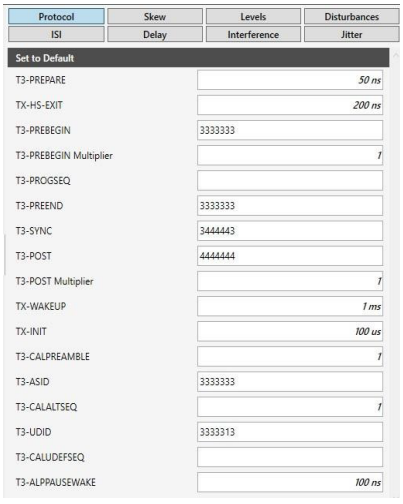


Figure 6. N5991MC2E MIPI C-PHY frame generator

The N5991MC2E supports legacy LP mode as well as alternate LP (ALP) mode. It offers great flexibility to program protocol timings and is for that reason the ultimate tool for debugging and exploring the boundaries of the new design.



In addition, the software gives you fine control of the data that is sent to the receiver. Depending on DUT requirements, the signal can be defined as LP or HS wire state data or byte data or even camera serial interface (CSI) or display serial interface (DSI) packets. Byte data will be automatically encoded into valid wire states. To make a definition of CSI or DSI packets easier the software provides different macros that calculate appropriate header and payload CRC and byte striping for multi lane setups. It also provides macros for the PRBS patterns used for PHY characterization defined in the C-PHY specification.

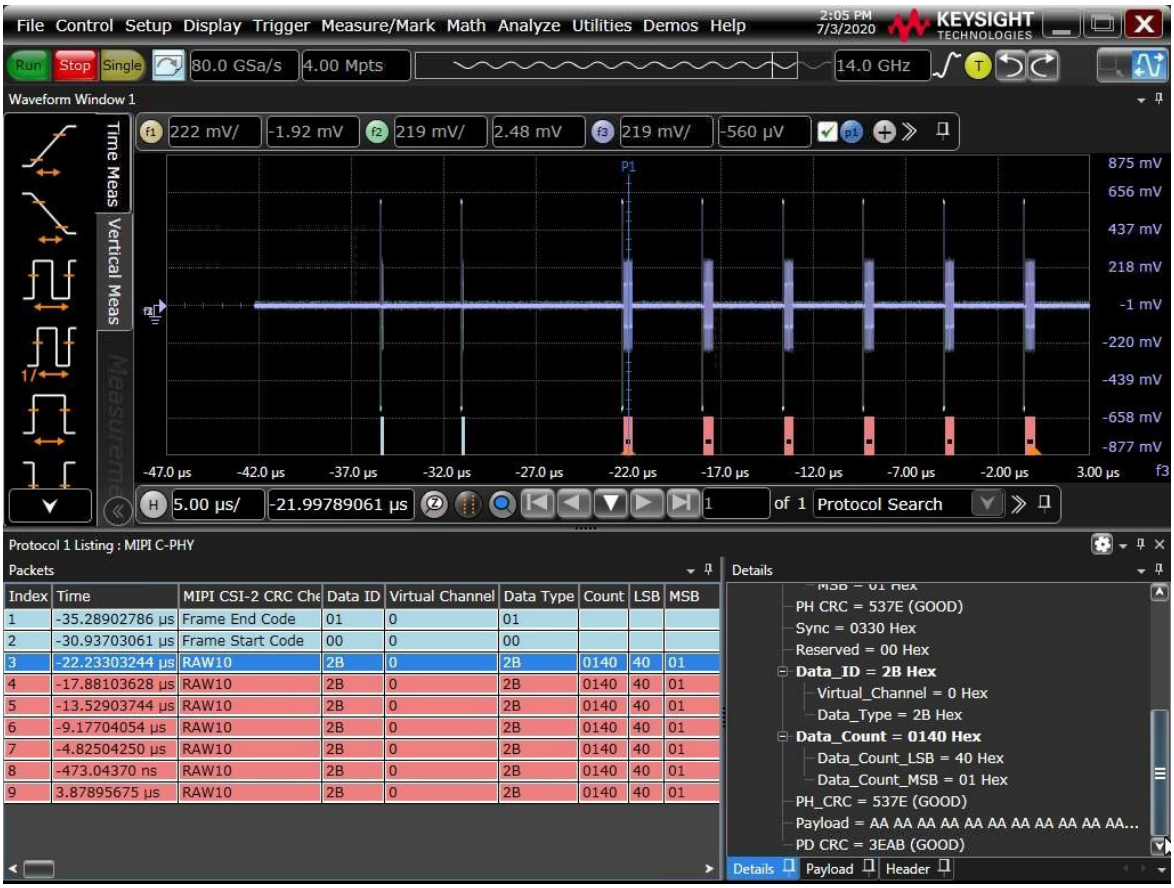


Figure 7. CSI short and long packets generated by the M8195A / N5991MC2E

Recommended Instrument Configurations for MIPI C-PHY 2.0 Receiver Testing

Number	Description	# lanes		
	AWG, Stress Generation and Calibration for data rate up to 3.5 Gsps	**1**	**2**	**3**
M8195A-BU1	Bundle consisting of one M9505A 5-slot AXIe chassis with USB option and one M9537A AXIe embedded PC controller	1	1	1
M8195A-004	Arbitrary waveform generator, 4 channels, 65 GSa/s	1	2	3
M8195A-16G	Upgrade to 16 GSa memory	1	2	3
M8195A-SEQ	Sequencer	1	2	3
M8197A	Synchronization module for the M8195A	0	1	1
	AWG, Stress Generation and Calibration for data rate up to 9 Gsps (requires N5991MCHZ-ADD)			
M8195A-BU1	Bundle consisting of one M9505A 5-slot AXIe chassis with USB option and one M9537A AXIe embedded PC controller	1	1	n/a
M8195A-002	Arbitrary waveform generator, 2 channels, 65 GSa/s	2	3	n/a
M8195A-16G	Upgrade to 16 GSa memory	2	3	n/a
M8195A-SEQ	Sequencer	2	3	n/a
M8197A	Synchronization module for the M8195A	1	1	n/a
	Scope for Calibration and Tx Test			
DSAV1604A or DSAZ2004A	Infiniium oscilloscope, 16 GHz bandwidth or higher *NOTE: 16 GHz BW is sufficient to calibrate symbol rates <=4Gsps. To calibrate symbol rates >4Gsps, a >16GHz scope is needed. For example: a 20GHz BW DSOV204A or UXR0204A.		1	
N7010A	30 GHz active termination adapter		3	
	Test Automation Software			
N5991MC2A-1FP	MIPI C-PHY 2.0 receiver test, node locked license		1	
N5991MC2A-1TP	MIPI C-PHY 2.0 receiver test, transportable license		1	
N5991MC2A-SFM	MIPI C-PHY 2.0 receiver test, SW maintenance, 12 months, node locked license		1	
N5991MC2A-STM	MIPI C-PHY 2.0 receiver test, SW maintenance, 12 months, transportable license		1	
N5991MC2E-1FP	MIPI C-PHY 2.0 debug tools frame generator, node locked license		1	
N5991MC2E-1TP	MIPI C-PHY 2.0 debug tools frame generator, transportable license		1	
N5991MC2E-SFM	MIPI C-PHY 2.0 debug tools, frame generator, SW maintenance, 12 months, node-locked license		1	
N5991MC2E-STM	MIPI C-PHY 2.0 debug tools, frame generator, SW maintenance, 12 months, transportable license		1	
N5991MCHZ-ADD	MIPI C-PHY 32G sample waveform generation add-on		1	
N5991MCIY-ADD	MIPI C-PHY integrated BER counter interface add-on		1	
D9010CPHC	MIPI C-PHY compliance application (required for N5991MC2A)		1	
	Cables			
M8195A-810	Matched cable pair for M8195A AWG, 2.92 mm	2	3	5

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
- Keysight M8195A 65 GSa/s Arbitrary Waveform Generator firmware version 4.0.0.0 or higher
- Keysight M8197A Multi-Channel Synchronization Module for M8195A firmware version 4.0.0.0 or higher

Recommendation

- Microsoft Office Excel 2016 or higher, English version

Hardware

Requirements

- Connectivity hardware for instrumentation, depending on configuration e.g. USB3, Ethernet

Recommendations

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

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

- D9010CPHC MIPI C-PHY Compliance Test Software for Infiniium Oscilloscope
- M8195A 65 GSa/s Arbitrary Waveform Generator
- M8197A Multi-Channel Synchronization Module for M8195A
- N5991 Receiver Compliance Test Automation Platform