DATA SHEET

N4917BSCA Optical Receiver Stress Test Solution

400 Gb/s Ethernet - IEEE 802.3bs

Complete optical receiver stress test solution for 400GbE optical transceivers with automated stress eye calibration and performance compliance testing

KEYSIGHT TECHNOLOGIES

Optical Receiver Stress Test for 400 Gb/s Ethernet

The telecommunications industry represented by the IEEE decided to address the steadily increasing need for more bandwidth at a lower cost for the intra and inter data centers by combining the spectral efficient PAM-4 modulation with the mature direct modulation/direct detection technology. The shift from NRZ to PAM-4 modulation effectively doubles the line rates, as compared to optical 100 Gigabit ethernet transceivers, while maintaining modulation speed at 26.56125 Gbaud and enabling continued use of some of the existing 100 G components.

Consequently, the compliance test procedures defined for next-generation 400 GBase transceivers are similar to those adopted in IEEE 802.3ba for NRZ-based 100 GBASE transceivers. But there are noticeable differences:

- A new TDECQ metric is employed to characterize the quality of a transmitted/ received signal instead of the traditional eye mask analysis.
- A digital reference equalizer is required to compute various signal metrics during transmitter performance testing or during stress signal calibration for receiver stress testing.
- Because of the significant sensitivity penalty resulting from the shift from NRZ to PAM4, the optical transceiver is not expected to operate error-free under the stress conditions defined by the standards or during typical use, while forward error correction (FEC) is typically performed outside the transceiver module.

In addition, some flavors like 400 GBASE-DR4 are based on 53.125 Gbaud, increasing the requirements for test and measurement equipment. Therefore, achieving accurate, stable and repeatable stress signal calibration, to ensure reliable transceiver performance test and qualification, has become even more challenging. Optical receiver stress test procedures, defined by the IEEE, are performed using several instruments such as a bit error ratio tester, digital sampling oscilloscope, optical reference transmitter and tunable laser source. The purpose of the test is to generate a stable and repeatable stressed optical signal with specific characteristics, and send it to the receiver under test to measure the resulting bit error ratio. However, achieving this is not a trivial task as the combination of different stress factors (inter symbol interference, jitter, sinusoidal interferences, Gaussian noise, optical power level) gives rise to complex dependencies on the target metrics.

Keysight's N4917BSCA software enables a complete test solution from instrument configuration and control to automated stressed signal calibration and system performance test, according to IEEE 802.3bs specifications (clauses 121, 122 and 124) for following standards:

- 200 GBASE-FR4/-LR4/-DR4 IEEE 802.3bs
- 400 GBASE-FR8/-LR8 IEEE 802.3bs
- 400GBASE-DR4 IEEE 802.3bs and 400G-FR4 100G lambda MSA

Automation of the stress signal calibration and conformance tests results in considerable time savings. In addition, the N4917BSCA optical receiver stress test solution provides:

- Automated calibration of the optical stressed eye according to IEEE 802.3bs clause 121, 122 and 124
- Adjustable target values for outer extinction ratio (OER), transmission and dispersion eye closure (TDECQ), optical modulation amplitude (OMA) enabling user-defined stress signal calibration
- Repeatable and stable calibration of optical stressed PAM-4 eye
- Unified instrument control and setup
- Customized device testing and reporting via DUT control and scripting interface

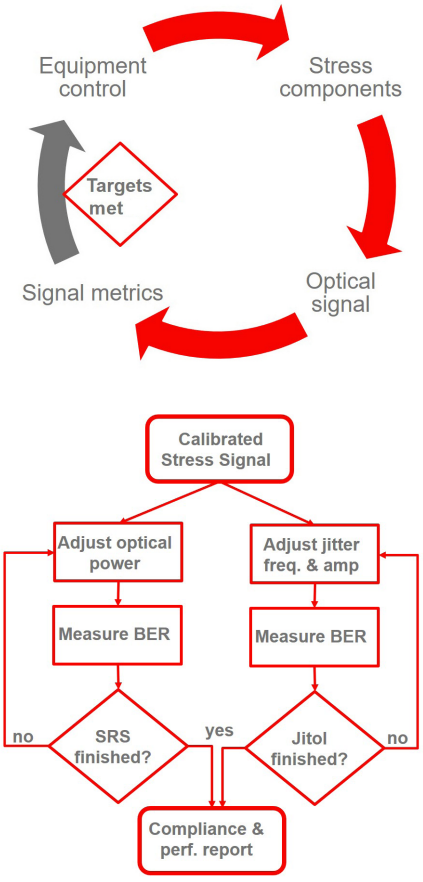

Figure 1. Calibration process and performance test steps as carried out by the N4917BSCA software.

Typical Setup for 200 GBASE-LR4/-FR4 Optical Stress Test

The N4917BSCA optical receiver stress test solution consists of a M8040A BERT plus an arbitrary waveform generator for electrical signal and stress generation; an electro-optical converter that modulates the optical signal and a digital sampling oscilloscope which is required for calibration of the stressed eye.

An example setup for 200GBASE-LR4/-FR4 using four 50 Gb/s lanes on four wavelengths in the O-band is shown in Figure 2, which assumes the use of a 200 GAUI-8 electrical interface. The IEEE 802.3bs standard establishes two ways to provide a clock signal to the digital sampling oscilloscope:

1. Using the 'clean clock' of the pattern generator or
2. Extracting it from the stressed signal using an external clock recovery

Refer to the configuration guide section for the detailed setup.

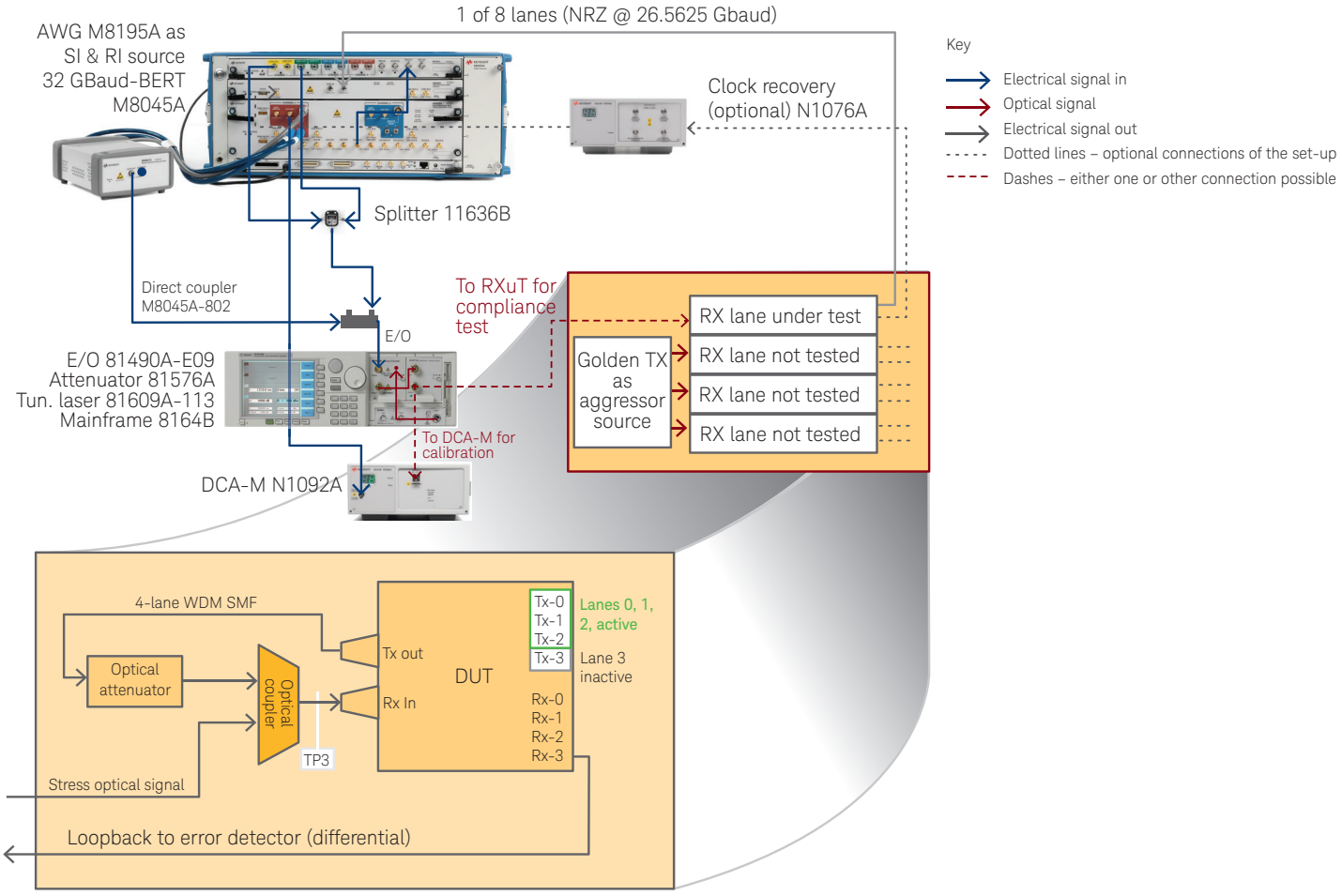

Figure 2. Optical receiver stress test setup for 200 GBASE-LR4/-FR4.

200 GBASE-FR4/LR4/DR4, 400 GBASE-FR8/-LR8/-DR4 Optical Receiver Stressed Test Challenges

The IEEE 802.3 standard, clauses 120, 121 and 124 describes the optical specifications for 200 GBASE-FR4, -LR4, -DR4 and 400 GBASE-FR8, -LR8/-DR4 optical receivers. The following tables contain the key characteristics [1] of the stress signal measured at TP3 (**see Figure 2**) to perform stressed receiver sensitivity and jitter tolerance compliance tests.

Parameter description	**200 GBASE-FR4**	**200 GBASE-LR4**	**200 GBASE-DR4**
Stressed receiver conformance test signal calibration pattern	SSPRQ	SSPRQ	SSPRQ
Stressed receiver sensitivity (OMA_{outer}), each lane (max)	–6 dBm	–7.7 dBm	–4.1 dBm
Extinction ratio, each lane (min)	3.5 dB	3.5 dB	3.5 dB
Conditions of stressed receiver sensitivity test			
Stressed receiver sensitivity pattern	PRBS31Q	PRBS31Q	PRBS31Q
Stressed eye closure for PAM4 (SECQ), lane under test	3.3 dB	3.4 dB	3.4 dB

Parameter description	**400 GBASE-FR8**	**200 GBASE-LR8**	**400G-DR4**	**400G-FR4**
Stressed receiver conformance test signal calibration pattern	SSPRQ	SSPRQ	SSPRQ	SSPRQ
Stressed receiver sensitivity (OMA_{outer}), each lane (max)	–3.1 dBm	–4.7 dBm	–1.9 dBm SRS (OMA)	SECQ-dependent
Extinction ratio, each lane (min)	3.5 dB	3.5 dB	3.5dB ER	3.5dB ER
Conditions of stressed receiver sensitivity test				
Stressed receiver sensitivity pattern	PRBS31Q	PRBS31Q	PRBS31Q	PRBS31Q
Stressed eye closure for PAM4 (SECQ), lane under test	3.1 dB	3.3 dB	3.4	From 0.9 to 3.4

The specified stressed received conformance test signal with a given stressed eye closure (SECQ) is generated by creating a mixture of the following stress components:

- Inter-symbol interferences (ISI) by means of low-pass filter and frequency response of E/O converter
- Sinusoidal jitter (see specification below)
- Sinusoidal amplitude interferer (100 MHz < f_{SI} < 2 GHz, non-harmonic to data signal and other stress components)
- Gaussian noise with a bandwidth of at least half the signal baud rate

The N4917BSCA solution software automatically adjusts the setting of the different equipment to generate the stress signal with the desired characteristics.

1. 802.3bs, draft 3.5 (October 10th, 2017). This information is subject to change without notice.

200 GBASE-FR4/LR4/DR4, 400 GBASE-FR8/-LR8/-DR4 Optical Receiver Stressed Test Challenges (Continued)

Applied sinusoidal jitter:

Frequency range	Sinusoidal jitter; peak-to-peak(UI)
f < 40 kHz	Not specified
40 kHz ≤ f ≤ 4 MHz	$2 \times 10^5 / f$
4 MHz ≤ f ≤ 10 times loop bandwidth	0.05

The metrics employed for stress signal calibration are detailed below:

OMA_{outer}

The outer *Optical Modulation Amplitude OMA* of an PAM4 signal is the difference between average optical launch power level 3 and power level 0 over a defined run of PAM4 symbols and is measured using a SSPRQ or a PRBS13Q test pattern (defined in sub-clauses 120.5.11.2.2 and 120.5.11.2.3).

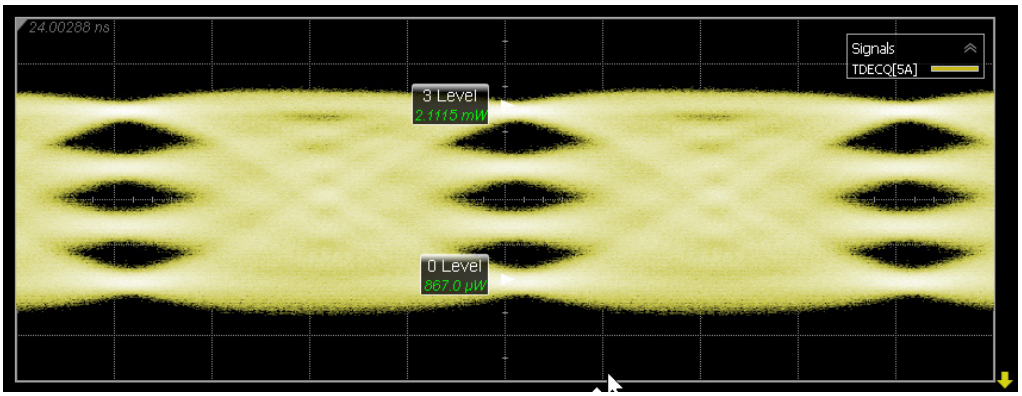

Figure 3. Calculated OMA_{outer} (1.2445 mW = 0.95 dBm).

Extinction ratio

The extinction ratio of an PAM-4 signal is measured using a SSPRQ or a PRBS13Q test pattern and defined as the ratio of the average launch power level 3 and average launch power level 0 over a defined run of PAM4 symbols.

200 GBASE-FR4/LR4/DR4, 400 GBASE-FR8/-LR8/-DR4 Optical Receiver Stressed Test Challenges (Continued)

SECQ/TDECQ

The Transmitter and Dispersion Eye Closure Quaternary (TDECQ) is a measure of the optical transmitter's vertical eye closure as if observed at the end of a worst case fiber. It is defined as the ratio of the amount of noise a reference receiver could add to an ideal signal (with same OMA_{outer}) to the noise it could add to the transmitter under test after transmission over a worst case fiber in order to achieve the same BER. Expressed in decibels, the TDECQ is given by:

$$TDECQ = 10\ log_{10}\left[\frac{OMA_{outer}}{6} \times \frac{1}{Qt \cdot R}\right]$$

with Q_t as Q-function consistent with target BER
(Q_t = 3.414 for 2.4e-4 BER)
with R as RMS noise term of the receiver

The Stress Eye Closure Quaternary (SECQ) metric is identical to TDECQ but refers to the stress signal used for the receiver stress test, while TDECQ is a metric for the transmitter. For stress signal calibration, the SECQ/TDECQ measurement should be performed using a SSPRQ test pattern captured by a sampling scope with a specific bandwidth and after digital equalization. Details can be found in IEEE802 clause 121.8.

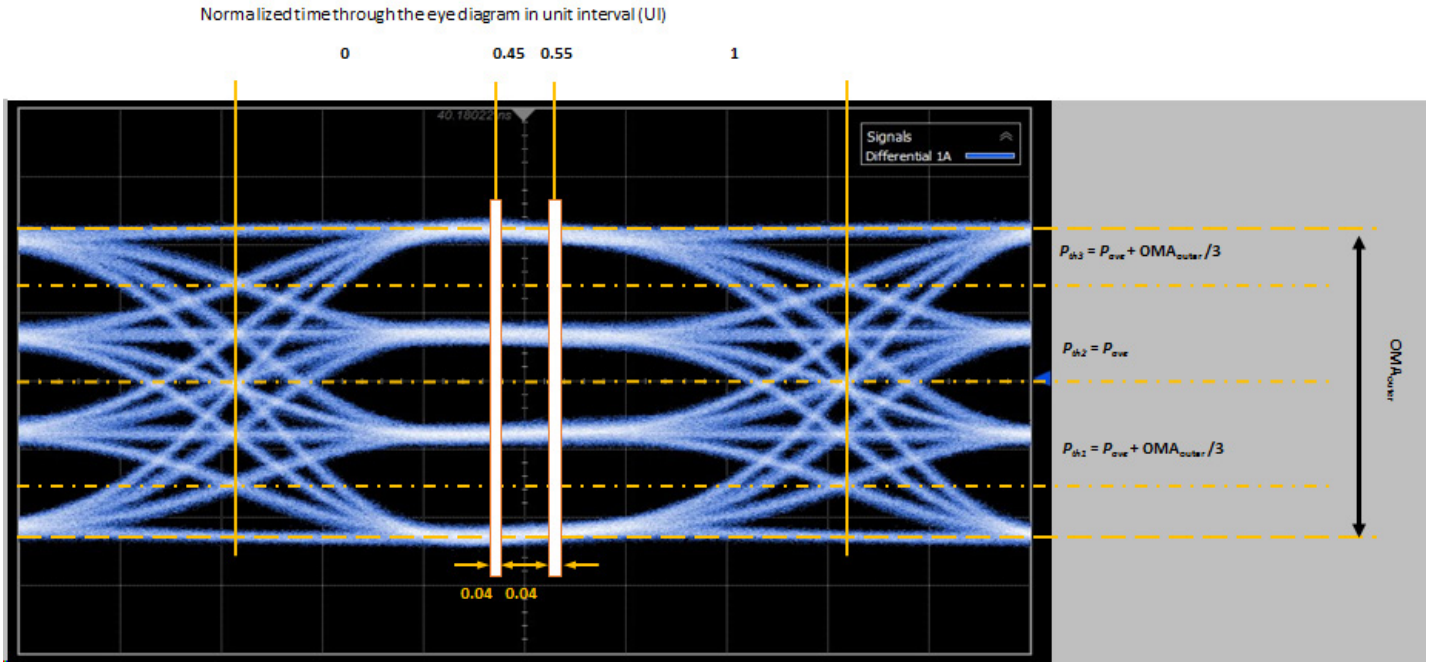

Figure 4. Measurement of TDECQ/SECQ for PAM4 signal.

Setting-up a stressed eye compliant with the standard's specifications can be a very time consuming task because stressed eye parameters are interdependent and therefore several iterations of the optimization cycle are required to converge on the solution. In addition, it is important that the setup is repeatable and remains stable from initiation of the stressed eye calibration to the end of the DUT measurement.

The N4917BSCA optical receiver stress test solution provides a repeatable and stable measurement in a fraction of time compared to manual setup of the stress signal. This not only results in a major time saving during daily measurements, but also speeds-up development of a standard compliant test solution, when compared to a self-made solution.

N4917BSCA User Interface

The N4917BSCA user interface is structured to follow the generic workflow of an automated test application (Figure 5).

1. **Set Up** tab
   Check connection to instruments (USB, LAN or GPIB connections are supported) and specify the standard to be checked. This step sets the default values for the stress signal metrics and performance targets listed in the **Configure** tab. You can deactivate the connection check of a particular device by selecting 'not used' in the corresponding **Channel** or **Slot** field. This lets you use the internal laser of the reference transmitter instead of the tunable laser source or deactivate one of the interference sources.

2. **Select Tests** tab
   Select the actions or tests you want to perform. For example, you can perform a signal calibration, load settings from a previous calibration, measure characteristics of the current optical signal or perform automated performance measurements. These tests are performed one by one in the order they are listed. Additional functionalities, such as optimization of the reference transmitter bias and optical power adjustment, are available.

3. **Configure** tab
   Specify key instrument settings (de-emphasis, max-min voltage, active ports) as well as the target value for the calibration metrics. The **debug** mode enables you to modify the original standard specifications, such as the TDECQ and ER of the stress signal or the jitter profile to be tested (see Figure 6.). It is also possible to adjust the calibration conditions to your own setup by deactivating the optical power control or accounting for additional loss present in the optical link to the DUT.

4. **Connect** tab
   Displays the hardware connection diagram before the start of a test. This optional step allows the user to check the physical connections between the devices to ensure compliance with the standards.

5. **Run** and **Automate** tabs
   Run the selected tests and measurements or use your own commands sequence implemented with a python script

6. **HTML Report** and **Results** tabs
   Displays high-level and detailed measurement results. Some tests return a pass/fail value and others return detailed measurement results (e.g. jitter tolerance measurement).

In addition, information about the measurement status, test progress and reports possible errors during the test to the user are listed in the **Messages** tab located on the bottom.

After selecting the optical standard and connecting to all required instruments in the tab, the user selects the measurement tasks and receiver tests to be performed in the **Select Tests** tab. Hence a complete conformance test and characterization would include the following tasks, provided by the N4917BSCA software:

- Automatic calibration of the stressed receiver conformance test signal
- Perform a receiver conformance test
- Perform a receiver sensitivity measurement
- Perform a jitter conformance test
- Perform a jitter performance measurement

N4917BSCA User Interface (Continued)

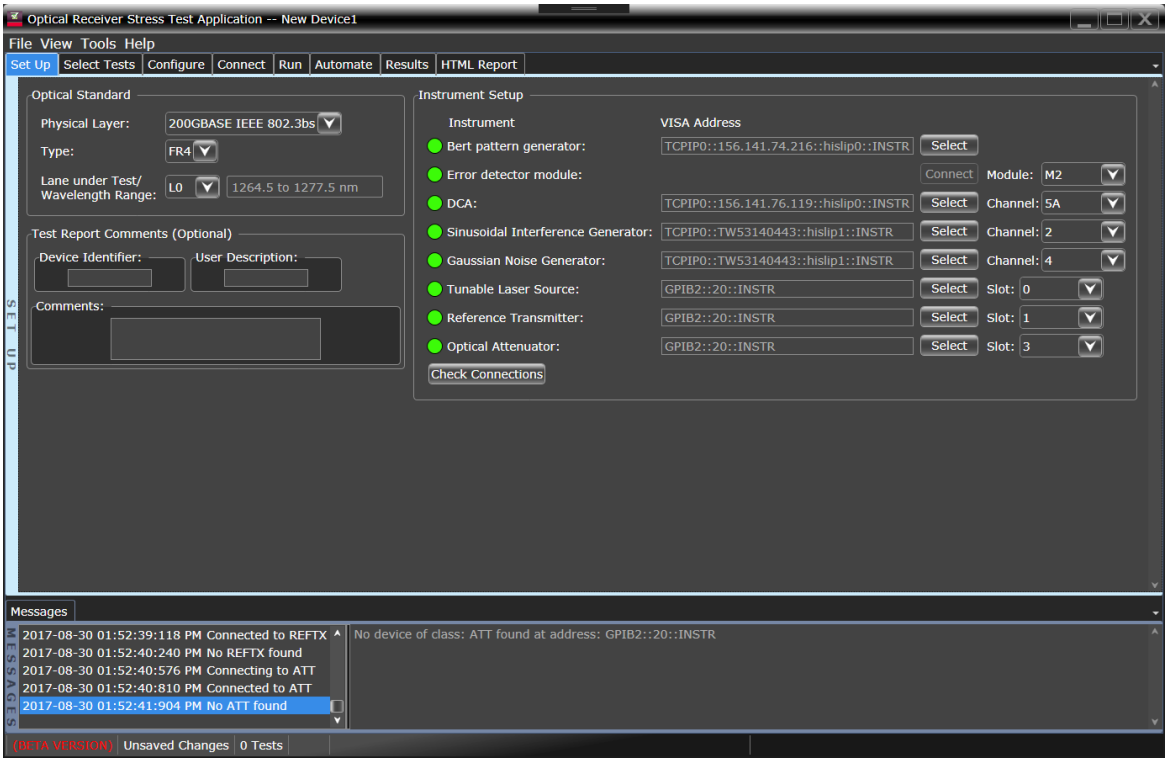

Figure 5. The N4917BSCA software Set Up tab is used to connect and check equipment.

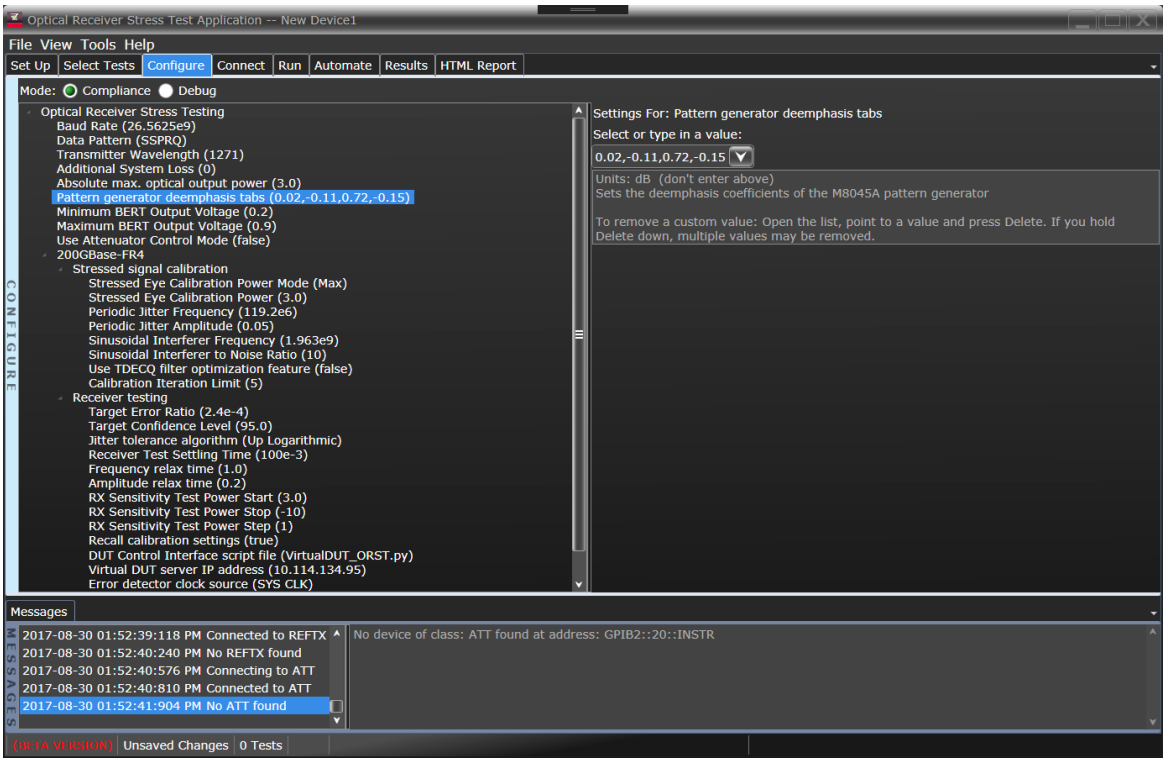

Figure 6. The N4917BSCA software Configure tab lets the user fine-tune the standard compliant stressed receiver test or adapt to the test to other standards by offering multiple, user-editable settings, such as the stress signal parameters or test conformance limits.

N4917BSCA User Interface (Continued)

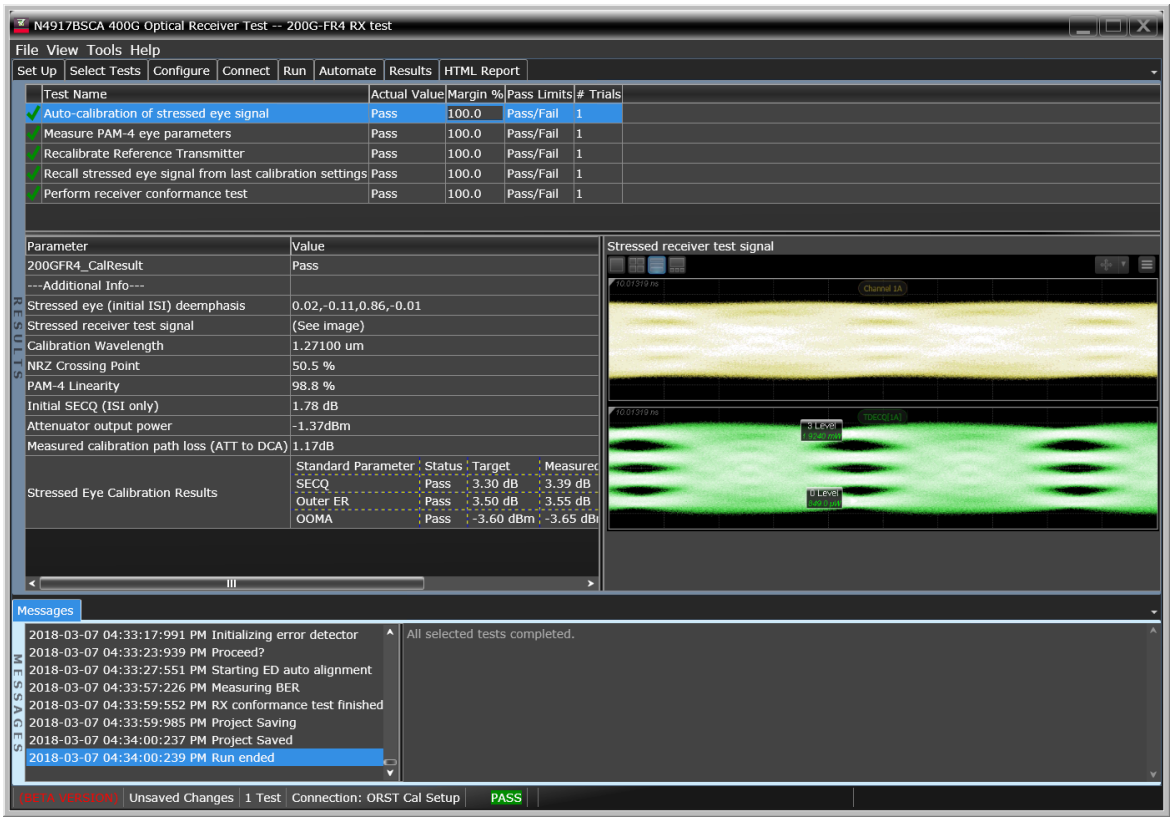

Figure 7. The N4917BSCA Results tap provides an overview of the calibration and compliance test outcomes.

N4917BSCA Features

The N4917BSCA software creates a stressed PAM-4 optical waveform from the following setting parameters.

Settable parameters

- Data amplitude (mV pp) [1]
- Sinusoidal interferer amplitude (Vpp) [1]
- Sinusoidal interferer frequency (Hz)
- Gaussian noise power [1]
- Sinusoidal interferer to Gaussian noise ratio
- Periodic jitter amplitude (UI)
- Periodic jitter frequency (Hz)
- Baud rate (GBd/s)
- Optical power for calibration (dBm)
- OMAouter for DUT test (dBm) [1]
- Extinction ratio for DUT test (dB) [1]
- Optical wavelength (nm)
- De-emphasis coefficients

1. These values will be adjusted by the software during the calibration process to meet the calibration parameter targets.

Calibration and measurement parameters

- Extinction ratio (dB)
- Initial SECQ (dB)
- TDECQ/SECQ (dB)
- OMA_{outer} for DUT test (dBm)
- Jitter conformance (pass/fail)
- Jitter performance margin (UI)
- Stressed receiver sensitivity (BER vs. dBm)

N4917BSCA Requirements

The N4917BSCA software runs on an external PC or on M9537A embedded controller.

PC hardware requirements

- Operating system: Microsoft Windows 7, Windows 8, Windows 10, (64 bit)
- Memory: 8 GB RAM minimum
- Monitor resolution: WXGA+ (1440 x 900) minimum

PC installed software requirements

- Keysight IO Library Suite Rev. 18.1 x or later
- M8070A system software for M8000 Series version 4.0.x or later
- M8195A soft front panel version 3.5
- N1010A FlexDCA remote access system A.05.71 or later (if using DCA-M)
- N1010AT-9TP PAM-N analysis SW
- IRC option for DCA-M or DCA-X module

PC interfaces

USB, LAN

Instrument firmware requirements

- M8040A BERT: M8070A system software as above
- 81600D DCA-X: FlexDCA version A.05.71 or later
- 8164B LMS: Version V5.25 or later
- 81490A Ref Tx: Version V5.01 or later

Configuration Guide

The N4917BSCA optical stress test solution is built up from a variety of instruments. For some of the instruments, alternative selections are supported by the N4917BSCA software. Each instrument is an individual order and not part of a bundle. This configuration guide is designed to help you determine the best configuration for your particular needs. The [1] indicates options required for 400 GBASE-DR4 and 400 G FR4 (53 Gbaud).

1. Select the configuration for the M8040A high-performance BERT 64 Gbaud and interference generator

Step 1. BERT chassis configuration	
M8040A	**High-performance BERT 64 Gbaud**
M8040A-BU2	M9505A 5-slot AXIe chassis with USB option, (requires external PC with USB connection)
Step 2. 1st BERT module minimum required configuration	
M8045A	**Pattern generator and clock module 32/64 Gbaud, 3 slot AXIe**
M8045A-G32/G64 [1]	Pattern generator one channel NRZ, data rate up to 32/64 Gbaud
M8045A-0G3	Advanced jitter sources for receiver characterization, license
M8045A-0G4	De-emphasis, module-wide license
M8045A-0P3	PAM-4 encoding up to 32 Gbaud, module-wide license
M8045A-0P6 [1]	PAM-4 Extension up to 64 Gbaud, module-wide license
M8045A-801	Short cable 1.85 mm (m) to 1.85 mm (m), 0.15 m, absolute matching 699 ps ± 1 ps, Qty 2 recommended
M8057A	Remote head for M8045A pattern generator, 1 channel
Step 3. 2nd BERT module minimum required configuration	
M8046A	**Analyzer module, 32/64 Gbaud, 1-slot AXIe**
M8046A-A32	Analyzer, one channel, data rate up to 32 Gbaud, NRZ
M8046A-0P3 [1]	PAM-4 decoding up to 32 Gbaud, license (optional)
M8046A-801	Cable 2.92 mm (m) to 2.92 mm (m), 0.5 m for clock input, Qty 1 recommended
Step 4. M8000 system software configuration	
M8070A	**System software for M8000 Series of BER test solutions**
Select one of the M8000 system software license options	
M8070A-0TP	System software for M8000 Series of BER test solutions, transportable, perpetual license
M8070A-0NP	System software for M8000 Series of BER test solutions, network/floating, perpetual license
Select one of the M8000 DUT control Interface license options (if reading BER from DUT)	
M8070A-1TP	DUT control Interface, transportable, perpetual license(optional)
M8070A-1NP	DUT control Interface, network/floating, perpetual license (optional)
Step 5. Interference source minimum required configuration (select one of the listed signal generators for sinusoidal and Gaussian noise interference)	
M8195A	**2- or 4-channel 65 GSa/s arbitrary waveform generator**
M8195A-002	2-channel, 65 GSa/s, 2 GSa per module
M8196A	2- or 4-channel 92 GSa/s arbitrary waveform generator
M8196A-002	2-channels, 92 GSa/s, 512 kSa per channel

Configuration Guide (Continued)

2. Select the configuration for the optical components of the solution.

Step 6. Lightwave measurement system mainframe (select one of the lightwave measurement system mainframes)	
8164B	5-slot lightwave measurement system mainframe
Step 7. Tunable laser source configuration (select one of the tunable lasers)	
81602A	Extra high power tunable laser
81602A-013	1250 nm to 1370 nm wavelength range, +17 dBm peak
81606A	Tunable laser family, high power with low SSE
81606A-113	Tunable laser source 1240 nm to 1380 nm, +13 dBm peak
81608A	Tunable laser family, value line, high power low SSE
81608A-113	Tunable laser source 1240 nm to 1380 nm, +13 dBm peak
81609A	Tunable laser family, basic line, high power low SSE
81609A-113	Tunable laser source 1240 nm to 1380 nm, +13 dBm peak
Optical connector interface	
81000NI	Connector interface, FC - narrow key way (1 required)
Step 8. Electrical–optical converter configuration (select one of the single-mode fiber reference transmitters)	
81490A	Reference transmitter
81490A-E09	Ref Tx special with external laser input and internal 1310/1550 nm laser
81490A-E05	Ref Tx special with external laser input and without internal laser
81492A-E01 [1]	Reference transmitter pre-CPL 81492A Special, 53 Gbaud, single mode with external input and internal 1310 nm/1550 nm sources
Optical connector interface	
81000FI	FC/PC interface (1 required for -E05, -E09)
81000NI	Connector interface, FC - narrow key way, (1 required for -E05, 2 required for -E09)
Step 9. Optical attenuator configuration (select one of the single-mode fiber attenuators)	
81576A	Optical attenuator high power, power control, straight SMF
81000FI	FC/PC interface (2 required)
81577A	Optical attenuator high power, power control, angled SMF
81000NI	Connector interface, FC - narrow key way (2 required)
N7761A	Optical attenuator (1 channel), SMF
N7761A-022	Angled connectors
N7762A	Optical attenuator (2 channels), SMF
N7762A-022	Angled connectors
N7764A	Optical attenuator (4 channels), SMF
N7764A-022	Angled connectors
N7751A	Optical attenuator (1 channel) with 2 optical power meter channels, SMF
N7751A-022	Angled connectors
N7752A	Optical attenuator (2 channels) with 2 optical power meter channels, SMF
N7752A-022	Angled connectors

Configuration Guide (Continued)

3. Select the configuration for the DCA and N4917BSCA software components of the solution

Step 10. Optical/electrical clock recovery (select if clock recovery is required)	
N1077A	**Optical/electrical clock recovery**
N1077A-232	Supported input rates: 50 MBd to 32 GBd
N1077A-SMS	Internal single-mode (9/125 µm) and multimode (50/125 µm) splitter
N1077A-JSA	Jitter spectrum analysis and clock recovery emulation
Step 11. DCA minimum required configuration (select either a DCA-X mainframe/plugin/time base or a DCA-M model/FlexDCA SW configuration)	
DCA-X mainframe minimum required configuration	
86100D	Infiniium DCA-X oscilloscope mainframe
86100D-ETR	Enhanced trigger, 13 GHz BW, pattern and module trigger
86100D-PTB	Internal precision timebase
86100D-200	Enhanced jitter analysis SW
86100D-201	Advanced waveform analysis software
86100D-300	Advanced amplitude analysis/Rin/Q-factor
DCA-X module. Select one of the DCA-X- modules, minimum required configuration	
86105D	Module, 34 GHz optical/50 GHz electrical, 750 to 1650 nm SMF/MMF
86105D-281	34 GHz optical/50 GHz electrical hardware
86105D-IRC	Optical channel impulse response measurement/data
86115D	Module, 20/34 GHz optical, 750 to 1650 nm SMF/MMF
86115D-282	Dual input 28 GHz optical sampling module 750 to 1650 nm for SM and MM fiber
86115D-IRC	Optical channel impulse response measurement/data
DCA-M minimum required configuration (select one DCA-M model)	
N1092A	One optical channel
N1092B	Two optical channels
N1092C	One optical, two electrical channels
N1092D	Four optical channels
N1092E	Two optical, two electrical channels
DCA-M minimum required option configuration	
Option LOJ	Reduce residual jitter from 400 fs to < 200 fs
Option PLK	Pattern lock capability
Option IRC	Extend optical channel bandwidth to 45 GHz and allow creation of reference receiver filters at any data rate from 8 to 42 Gb/s
Option 200	Enhanced jitter analysis, transportable license (can also be ordered as N1010A-200 FlexDCA license)
Option 201	Advanced waveform analysis software, fixed perpetual license (can also be ordered as N1010A-201 FlexDCA license)
Option 300	Advanced amplitude analysis/Rin/Q-factor, transportable license (can also be ordered as N1010A-200 FlexDCA license)
Option 500	Productivity package, transportable license (Rapid eye, TDEC) (can also be ordered as N1010A-200 FlexDCA license)
N1010A	FlexDCA remote access software
Step 12. N4917BSCA optical receiver stress test software configuration	
N4917BSCA	**Optical receiver stress test solution software (Select one of the N4917BSCA single-mode fiber license options for the Optical Receiver Stress Test compliance app single mode 200G and 400G IEEE only)**
N4917BSCA-1TP	Optical Receiver Stress Test compliance app single mode 200G and 400G IEEE transportable, perpetual license
N4917BSCA-1NP	Optical Receiver Stress Test compliance app single mode 200G and 400G IEEE network/floating

Configuration Guide (Continued)

4. Select the accessory components of the solution

Step 13. Select accessories as needed	
N4917B-800	Fiber optic cable, PMF, protected 37 cm narrow key FC/APC (only required for 81490A-E05 or 81490A-E09)
N4917B-803	Patchcord FC/PC-FC/PC connector SM fiber 2 m
N4917B-803	Patchcord FC/PC-FC/PC connector SM fiber 2 m (choose only if using O-CDR)
N4917B-804	Patchcord FC/APC narrow key - FC/PC wide key SM fiber 2 m (choose -803 or -804 depending on attenuator connectors)
M8195A-820	Coaxial termination 50 Ω DC to 26.5 GHz, 3.5 mm (male) (for combing SI and RI, terminate complement output)
M8195A-820	Coaxial termination 50 Ω DC to 26.5 GHz, 3.5 mm (male) (for combing SI and RI, terminate complement output)
M8195A-820	Coaxial termination 50 Ω DC to 26.5 GHz, 3.5 mm (male) (for trigger M8045A to M8195, terminate complement output)
11636B	Power splitter DC to 26.5 GHz (for combing SI and RI)
11901D	Coaxial adapter 3.5 mm (male) to 2.4 mm (female) (for combing SI and RI)
M8195A-810	Cable, 2.92 mm (m) to 2.92 mm (m), length 0.85 m (for combing SI and RI)
M8195A-810	Matched pair cable, 2.92 mm (m) to 2.92 mm (m), length 0.85 m
N4917BSCA-800	Directional coupler 50 GHz, 13 dB, 2.4 mm (recommended for external interference source RI/SI)
11900A	Coaxial adapter, 2.4 mm (m) to 2.4 mm (m), DC to 50 GHz
N9398F	DC block 50 kHz to 50 GHz, 2.4 mm (male). (For unused M8057A data output)
85138A	Coaxial termination 50 Ω DC to 50 GHz, 2.4 mm (male). (For unused M8057A data output)
11636B	Power splitter DC to 26.5 GHz (choose only if using DCA-X)
83059A	Coaxial adapter 3.5 mm (male) to 3.5 mm (male) (choose only if using DCA-X)
M8195A-810	Matched pair cable, 2.92 mm (m) to 2.92 mm (m), length 0.85 m (choose only if using DCA-X)
82357B	USB/GPIB interface
10833A	GPIB cable, 1 m (choose quantity)
8490D-010	Coaxial fixed attenuator, DC to 50 GHz

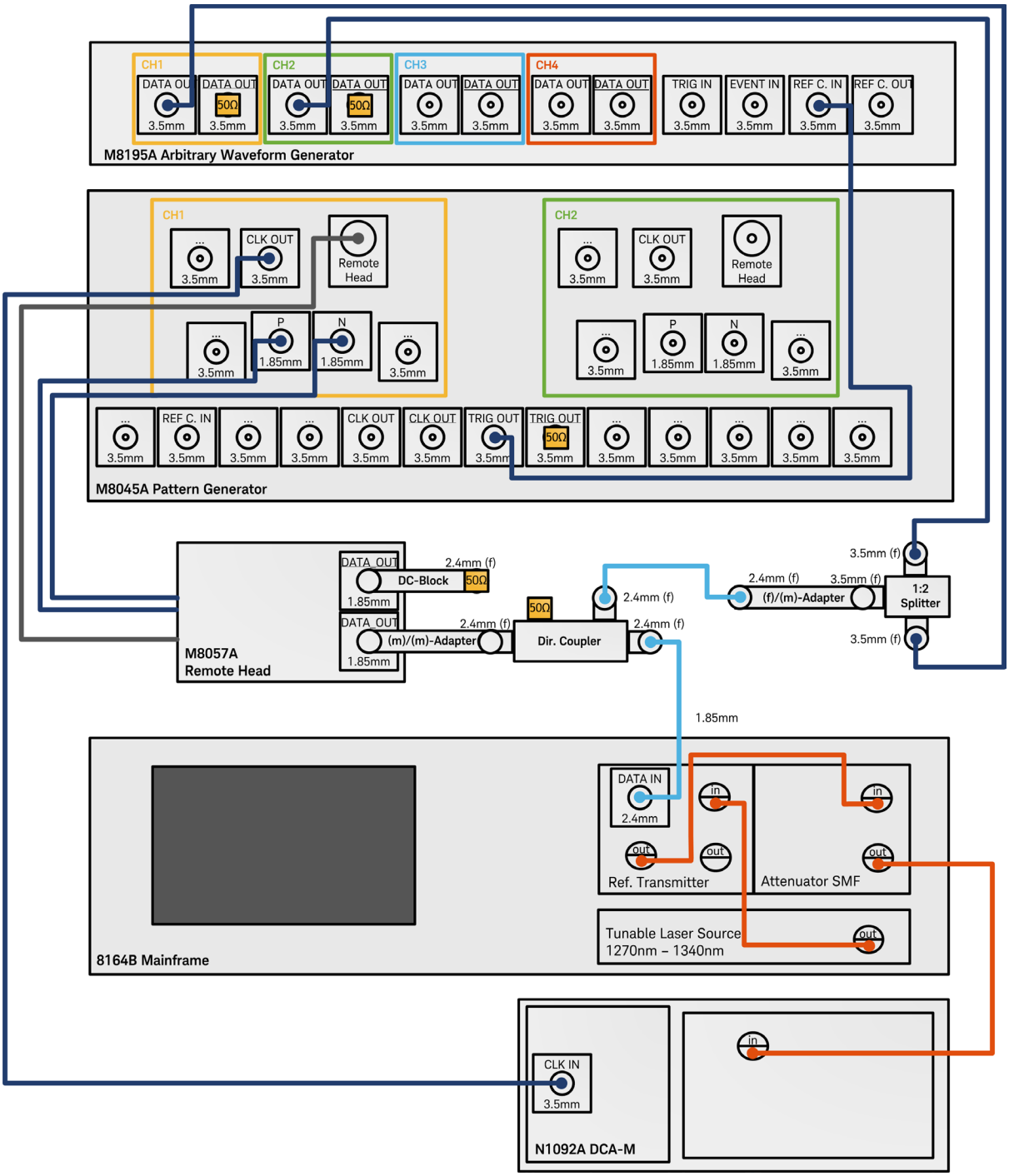

Figure 8. Setup for stressed eye signal calibration for 200 GBASE-FR4/-LR4/-DR4 and 400 GBASE-FR8/LR8 with clean clock.

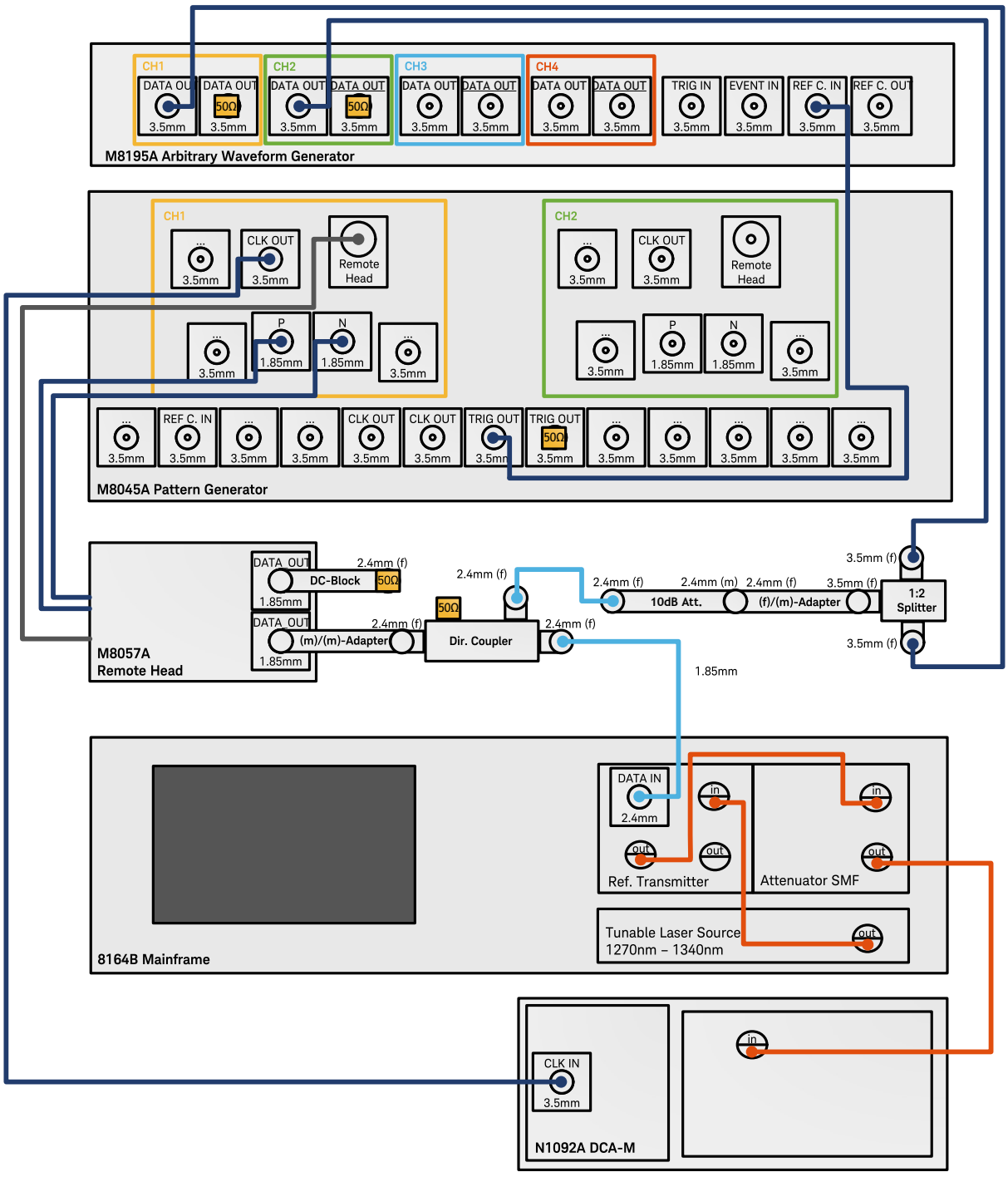

Figure 9. Setup for stressed eye signal calibration for 400G-FR4 with clean clock.

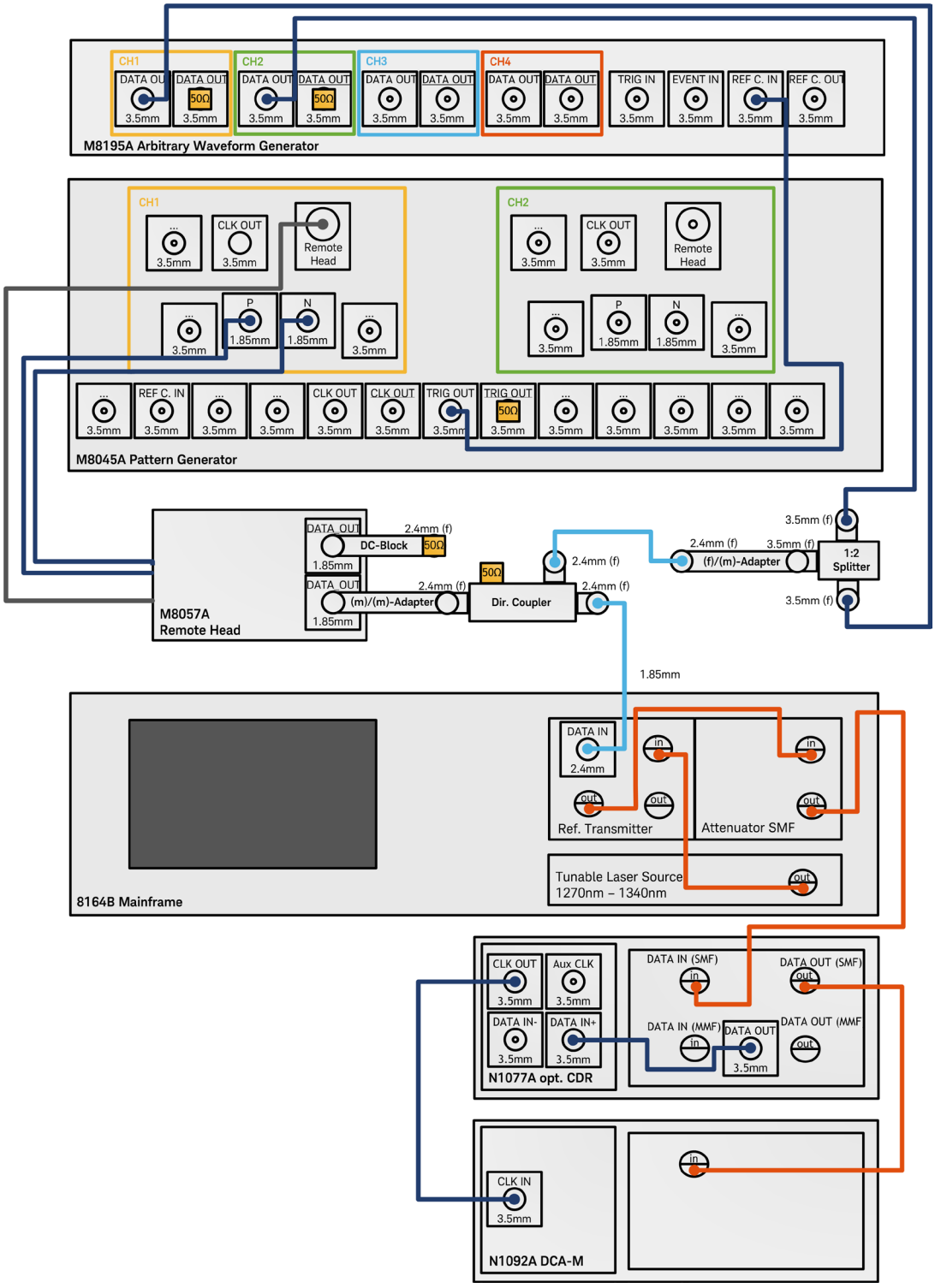

Figure 10. Setup for stressed eye signal calibration for 200 GBASE-FR4/-LR4/-DR4 and 400 GBASE-FR8/LR8 with recovered clock.

Keysight Related Literature

Publication name	Publication number
M8040A 64 GBaud High-Performance BERT 64 Gbaud - Data Sheet	5992-1525EN
M8195A 65 GSa/s Arbitrary Waveform Generator and M8197A Multi-Channel Synchronization Module - Data Sheet	5992-0014EN
8160xx Family of Tunable Laser Sources - Data Sheet	5989-7321EN
81490A Reference Transmitter - Data Sheet	5989-7326EN
8157xA Optical Attenuators - Data Sheet	5988-2696EN
N77-Series Attenuators - Data Sheet	5990-4394EN
Infiniium DCA-X 86100D Wide-Bandwidth Oscilloscope Mainframe and Modules - Data Sheet	5990-5824EN
N1090A, N1092A/B/C/D/E and N1094A/B DCA-M Optical and Electrical Sampling Oscilloscopes - Data Sheet	5992-1454EN
Electrical and Optical Clock Data Recovery Solutions - Data Sheet	5992-1620EN
86100D-9FP PAM-N Analysis Software for 86100D DCA-X Oscilloscopes - Data Sheet	5992-0424EN

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