N4917BACA Optical Receiver Stress Test Solution 100 Gb/s Ethernet

10GBASE-LR/-ER/-SR, 25GBASE-LR/-ER/-SR, 40BASE-LR4/-ER4/-SR4, 100BASE-LR4/-ER4/-SR4 and MSAs

Introduction

Complete optical receiver stress test solution for 100GbE optical transceivers with automated stress eye calibration and performance compliance testing

KEYSIGHT

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Optical Receiver Stress Test for 10/25GBASE-LR/ER/SR, 40/100GBASE-LR4/ER4/SR4 and MSAs

In recent years, transmission speeds in gigabit ethernet have continuously increased from 10 Gb/s to 40 Gb/s and are now reaching the 100 Gb/s speed class. 10 Gb/s Ethernet was designed based on a 10.3125 Gb/s line rate on one single-mode fiber per direction. The 40 Gb/s Ethernet speed class changed this to an architecture using the same 10.3125 Gb/s line rate but using four optical wavelengths in the O-Band on one single-mode fiber per direction. This increased the transmission capacity by a factor of four, without a need to make changes to the speed of the electrical components. In the last few years the 100 Gb/s speed class has been established, increasing the electrical line rate from 10.3125 Gb/s to 25.78125 Gb/s. It also uses both four optical wavelengths on one fiber as well as multiple fibers with one optical wavelength per fiber. The conformance test specification for 10/40/100 Gb/s transmission speed class is defined in the IEEE 802.3 standard. The N4917B optical receiver stress test solution provides an automated stressed receiver sensitivity test in accordance with the 10/25/40/100 GBASE test specifications as well as with the following 100G Multi Source Agreements: CLR4, CWDM4, 4WDM and PSM4.

To do this kind of test, several test instruments such as a bit error ratio tester, digital sampling oscilloscope, optical reference transmitter and tunable laser source are required to operate together to achieve a compliant, repeatable optical stressed eye. This stressed eye is then fed to the receiver under test, where bit error ratio is measured under the stress conditions as defined in the standard.

The N4917BACA solution provides:

- Automated calibration of the optical stressed eye according to IEEE 802.3 clauses 52,86,87,88,95,112 and 114 and related MSAs
- Calibration of ER, VECP/SEC, J2, J4, J9, OMA parameters
- Repeatable results
- Adjustable target values for ER, VECP/SEC, J2, J4, J9, OMA
- Jitter tolerance compliance and margin test
- Electrical loop back or optional DUT control interface for full automated JTOL test
- Remote control of all the test instrumentation

For this, the N4917BACA includes the following key equipment:

- A high-performance bit-error-rate tester
- An optical reference transmitter up to 25.78125 Gb/s
- A tunable laser covering the O-band for LR4/ER4 or an 850 nm laser for SR4 and a fixed 1310/1550 laser for 10GBASE

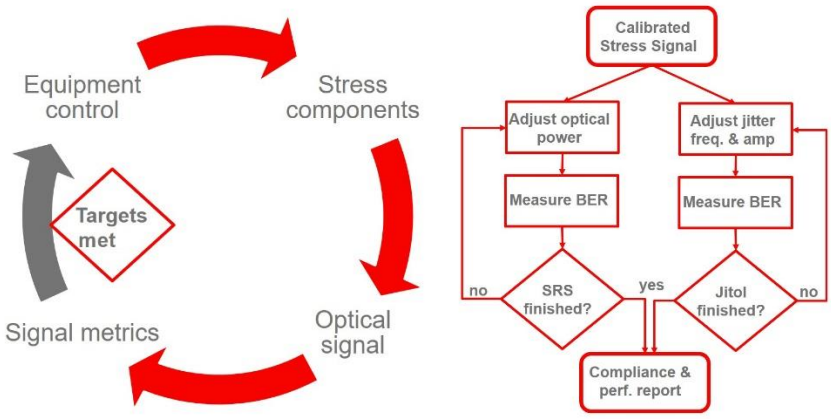

Figure 1. Calibration process and performance test steps as carried out by the N4917BACA software.

This equipment is fully compatible with the N4917BSCB 400G Optical Receiver Stress Test solution.

Typical Setup for 100GBASE-LR4/-ER4 Optical Stress Test

The N4917BACA optical receiver stress test solution consists of a M8040A BERT for electrical signal generation plus an arbitrary waveform generator or a pulse signal generator for 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 100GBASE-LR4/-ER4 using four 25 Gb/s lanes on four wavelengths in the O-band is shown in Figure 2, which assumes the use of a 100 GAUI-4 electrical interface. The IEEE 802.3ba standard establishes two ways to provide a clock signal to the digital sampling oscilloscope:

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

Refer to the configuration guide section for the detailed setup.

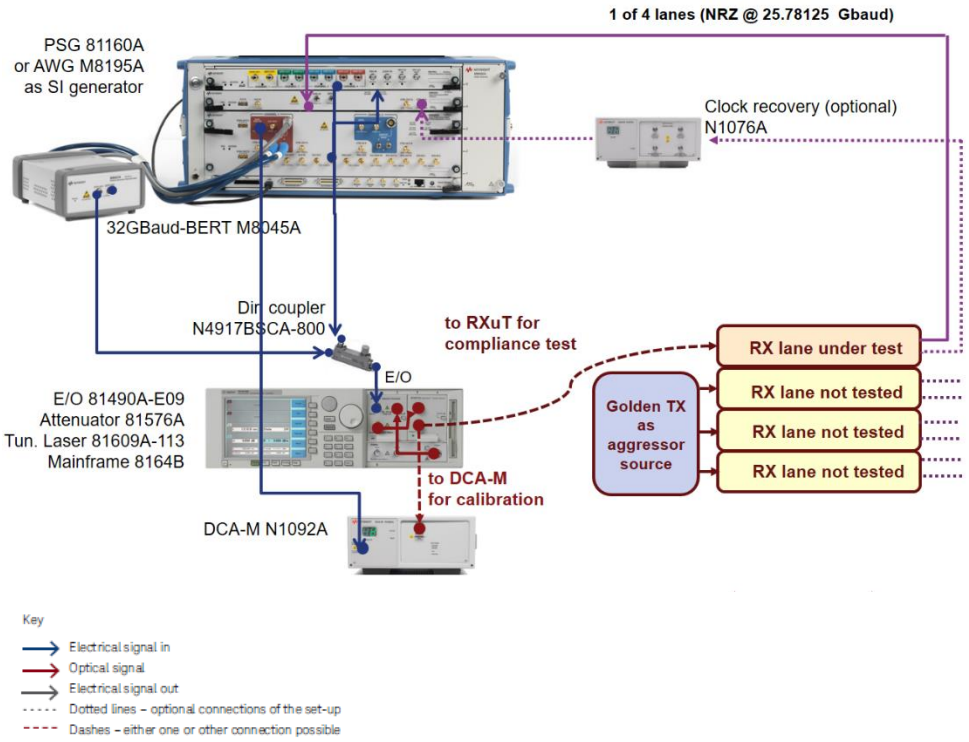

Figure 2. Optical receiver stress test setup for 100 GBASE-LR4/ER4.

100GBASE-LR4/ER4/SR4 Optical Receiver Stressed Test Challenges

The IEEE 802.3 standard, clauses 88.7, 95.7 describe the optical specifications for 100GBASE-LR4, -ER4 and -SR4 optical receivers. The following table contains the salient conditions required for stressed receiver sensitivity test.

	100GBASE-LR4	100GBASE-ER4	CLR4 w/o FEC
Reference Standard	IEEE 802.3-2015 Clause 88	IEEE 802.3-2015 Clause 88	100G-CLR4 MSA Rev 1.5.2 3/22/2015
Configuration	1x SMF, WDM	1x SMF, WDM	1x SMF, CWDM
Nominal wavelength	5nm spacing, L0: 1295.56 nm L1: 1300.05 nm L2: 1304.58 nm L3: 1309.14 nm	5nm spacing, L0: 1295.56 nm L1: 1300.05 nm L2: 1304.58 nm L3: 1309.14 nm	20 nm spacing, L0: 1271 nm L1: 1291 nm L2: 1311 nm L3: 1331 nm
Reach (max)	10 km	40 km	2 km
Bit rate	25.78125 Gb/s	25.78125 Gb/s	25.78125 Gb/s
BER target	1.00E-12	1.00E-12	1.00E-12
Extinction Ratio	4 dB	8 dB	3.5 dB
VECP	1.8 dB	3.5 dB	1.95 dB
SEC	-	-	-
J2 Jitter	0.3 UI	0.3 UI	0.3 UI
J4 Jitter	-	-	-
J9 Jitter	0.47 UI	0.47 UI	0.5 UI
Eye mask (X1, X2, X3, Y1, Y2, Y3)	-	-	-
Stressed receiver sensitivity, OMA	-6.8 dBm	-17.9 dBm	-5.6 dBm
Aggressor lane OMA	–1.3 dBm	-13.4 dBm	-0.1 dBm

	CLR4 w/FEC	CWDM4 w/ FEC	4WDM-10 w/ FEC
Reference Standard	100G-CLR4 MSA Rev 1.5.2 3/22/2015	100G CWDM4 MSA Rev 1.1 11/23/2015	100G 4WDM-10 MSA Rev 1 3/10/2017
Configuration	1x SMF, WDM	1x SMF, WDM	1x SMF, CWDM
Nominal wavelength	20 nm spacing, L0: 1271 nm L1: 1291 nm L2: 1311 nm L3: 1331 nm	20 nm spacing, L0: 1271 nm L1: 1291 nm L2: 1311 nm L3: 1331 nm	20 nm spacing, L0: 1271 nm L1: 1291 nm L2: 1311 nm L3: 1331 nm
Reach (max)	2 km	2 km	10 km
Bit rate	25.78125 Gb/s	25.78125 Gb/s	25.78125 Gb/s
BER target	2.10E-05	5.00E-05	5.00E-05
Extinction Ratio	3.5 dB	3.5 dB	3.5 dB
VECP	1.95 dB	1.9 dB	2.6 dB
SEC	-	-	-

	CLR4 w/FEC	CWDM4 w/ FEC	4WDM-10 w/ FEC
J2 Jitter	0.33 UI	0.33 UI	0.33 UI
J4 Jitter	0.48 UI	0.48 UI	0.48 UI
J9 Jitter	-	-	-
Eye mask (X1, X2, X3, Y1, Y2, Y3)	-	0.39, 0.5, 0.5, 0.39, 0.39, 0.4	0.39, 0.5, 0.5, 0.39, 0.39, 0.4
Stressed receiver sensitivity, OMA	-8.5 dBm	-7.3 dBm	-8.6 dBm
Aggressor lane OMA	-3.0 dBm	-2.8 dBm	-4.1 dBm

	4WDM-20 w/ FEC	4WDM-40 w/ FEC	PSM4 w/ FEC
Reference Standard	100G 4WDM-20 MSA Rev 1 7/28/2017	100G 4WDM-40 MSA Rev 1 7/28/2017	100G-PSM4 Rev 2 9/15/2014 IEEE 802.3 Clause 52 (10G) with exceptions
Configuration	1x SMF, WDM	1x SMF, WDM	4x SMF
Nominal wavelength	5 nm spacing, L0: 1295.56 nm L1: 1300.05 nm L2: 1304.58 nm L3: 1309.14 nm	5 nm spacing, L0: 1295.56 nm L1: 1300.05 nm L2: 1304.58 nm L3: 1309.14 nm	1310 nm
Reach (max)	20 km	40 km	500 m
Bit rate	25.78125 Gb/s	25.78125 Gb/s	25.78125 Gb/s
BER target	5.00E-05	5.00E-05	5.00E-05
Extinction Ratio	4 dB	4.5 dB	3.5 dB
VECP	2.5 dB	2.5 dB	1.9 dB
SEC	–	–	-
J2 Jitter	0.33 UI	0.33 UI	0.27 UI
J4 Jitter	0.48 UI	0.48 UI	0.39 UI
J9 Jitter	–	–	–
Eye mask (X1, X2, X3, Y1, Y2, Y3)	0.39 ,0.5, 0.5, 0.39, 0.39, 0.4	0.39, 0.5, 0.5, 0.39, 0.39, 0.4	0.24,0.5,0.5, 0.24,0.24,0.4
Stressed receiver sensitivity, OMA	–10.0 dBm	–16.0 dBm	-8.79 to -7.04 dBm
Aggressor lane OMA	–4.5 dBm	–9.5 dBm	+3 dBm

	100GBASE-SR4 w/ FEC	40GBASE-LR4	40GBASE-ER4	40GBASE-SR4	25GBASE-LR
Reference Standard	IEEE 802.3-2015 Clause 95	IEEE 802.3ba Clauses 87.8.11.2, 87.8.11.3, 87.8.11.4	IEEE 802.3ba Clauses 87.8.11.2, 87.8.11.3, 87.8.11.4	IEEE 802.3bj/bm clauses 86.8.4.7, 52.9.9.3 and 52.9.9.4	IEEE 802.3cc clause 114
Configuration	MMF	SMF	SMF	MMF	SMF
Nominal wavelength	850 nm	20 nm spacing, L0: 1271 nm L1: 1291 nm L2: 1311 nm L3: 1331 nm	20 nm spacing, L0: 1271 nm L1: 1291 nm L2: 1311 nm L3: 1331 nm	850nm	1295 to 1325nm
Reach (max)	100 m	10km	40km	100 m	10 km
Bit rate	25.78125 Gb/s	25.78125 Gb/s	25.78125 Gb/s	25.78125 Gb/s	25.78125 Gb/s
BER target	5.00E-05	1.00E-12	1.00E-12	1.00E-12	5.00E-05
Extinction Ratio	2 dB	3.5 dB	5.5 dB	3 dB	3 dB
VECP	–	1.9 dB	2.2 dB	1.9 dB	-
SEC	4.3 dB	>= 2/3 VECP tgt	>= 2/3 VECP tgt	>= 2/3 VECP tgt	2.5 dB
J2 Jitter	0.39 UI	0.3 UI	0.3 UI	0.3 UI	0.27 UI
J4 Jitter	0.53 UI (max)	-	-	-	0.39 UI
J9 Jitter	–	0.47 UI	0.47 UI	0.47 UI	-
Eye mask (X1, X2, X3, Y1, Y2, Y3)	0.28, 0.5, 0.5, 0.33, 0.33, 0.4	-	-	-	0.31,0.4,0.45, 0.34,0.38,0.4
Reference Standard	IEEE 802.3-2015 Clause 95	IEEE 802.3ba Clauses 87.8.11.2, 87.8.11.3, 87.8.11.4	IEEE 802.3ba Clauses 87.8.11.2, 87.8.11.3, 87.8.11.4	IEEE 802.3bj/bm clauses 86.8.4.7, 52.9.9.3 and 52.9.9.4	IEEE 802.3cc clause 114
Configuration	MMF	SMF	SMF	MMF	SMF
Nominal wavelength	850 nm	20 nm spacing, L0: 1271 nm L1: 1291 nm L2: 1311 nm L3: 1331 nm	20 nm spacing, L0: 1271 nm L1: 1291 nm L2: 1311 nm L3: 1331 nm	850nm	1295 to 1325nm
Reach (max)	100 m	10km	40km	100 m	10 km
Bit rate	25.78125 Gb/s	25.78125 Gb/s	25.78125 Gb/s	25.78125 Gb/s	25.78125 Gb/s
BER target	5.00E-05	1.00E-12	1.00E-12	1.00E-12	5.00E-05
Extinction Ratio	2 dB	3.5 dB	5.5 dB	3 dB	3 dB
VECP	–	1.9 dB	2.2 dB	1.9 dB	-
SEC	4.3 dB	>= 2/3 VECP tgt	>= 2/3 VECP tgt	>= 2/3 VECP tgt	2.5 dB
J2 Jitter	0.39 UI	0.3 UI	0.3 UI	0.3 UI	0.27 UI
J4 Jitter	0.53 UI (max)	-	-	-	0.39 UI
J9 Jitter	–	0.47 UI	0.47 UI	0.47 UI	-
Eye mask (X1, X2, X3, Y1, Y2, Y3)	0.28, 0.5, 0.5, 0.33, 0.33, 0.4	-	-	-	0.31,0.4,0.45, 0.34,0.38,0.4
Stressed receiver sensitivity, OMA	–5.2 dBm	-9.6 dBm	-16.8 dBm	-5.4 dBm	-9.5 dBm
Aggressor lane OMA	+3 dBm	-2.1 dBm	-9.8 dBm	-0.4 dBm	NA

	25GBASE-ER	25GBASE-SR	10GBASE-LR	10GBASE-ER	10GBASE-SR
Reference Standard	IEEE 802.3cc clause 114	IEEE 802.3by clause 112 IEEE (802.3by)	IEEE 802.3ae Clauses 52.9.9.3, 52.9.9.4	IEEE 802.3ae Clauses 52.9.9.3, 52.9.9.4	IEEE 802.3ae Clauses 52.9.9.3, 52.9.9.4
Configuration	SMF	MMF	SMF	SMF	MMF
Nominal wavelength	1295 to 1325nm	850 nm	1310nm	1550nm	850nm
Reach (max)	40 km	100 m	10km	40km	100 m
Bit rate	25.78125 Gb/s	25.78125 Gb/s	25.78125 Gb/s	25.78125 Gb/s	25.78125 Gb/s
BER target	5.00E-05	5.00E-05	1.00E-12	1.00E-12	1.00E-12
Extinction Ratio	4 dB	2 dB	3.5 dB	3 dB	3 dB
VECP	-	-	2.2 dB	2.7 dB	3.5 dB
SEC	2.5 dB	4.3 dB	>= 2/3 VECP tgt	>= 2/3 VECP tgt	>= 2/3 VECP tgt
J2 Jitter	0.27 UI	0.39 UI	0.3 UI	0.3 UI	0.3 UI
J4 Jitter	0.39 UI	0.53 UI (max)	-	-	-
J9 Jitter	-	-	-	-	-
Eye mask (X1, X2, X3, Y1, Y2, Y3)	0.31,0.4,0.45, 0.34,0.38,0.4	0.28,0.5,0.5, 0.33,0.33,0.4	Note: different mask can be used depending on the hit ratio definition	Note: different mask can be used depending on the hit ratio definition	Note: different mask can be used depending on the hit ratio definition
Reference Standard	IEEE 802.3cc clause 114	IEEE 802.3by clause 112 IEEE (802.3by)	IEEE 802.3ae Clauses 52.9.9.3, 52.9.9.4	IEEE 802.3ae Clauses 52.9.9.3, 52.9.9.4	IEEE 802.3ae Clauses 52.9.9.3, 52.9.9.4
Configuration	SMF	MMF	SMF	SMF	MMF
Nominal wavelength	1295 to 1325nm	850 nm	1310nm	1550nm	850nm
Reach (max)	40 km	100 m	10km	40km	100 m
Bit rate	25.78125 Gb/s	25.78125 Gb/s	25.78125 Gb/s	25.78125 Gb/s	25.78125 Gb/s
BER target	5.00E-05	5.00E-05	1.00E-12	1.00E-12	1.00E-12
Extinction Ratio	4 dB	2 dB	3.5 dB	3 dB	3 dB
VECP	-	-	2.2 dB	2.7 dB	3.5 dB
SEC	2.5 dB	4.3 dB	>= 2/3 VECP tgt	>= 2/3 VECP tgt	>= 2/3 VECP tgt
J2 Jitter	0.27 UI	0.39 UI	0.3 UI	0.3 UI	0.3 UI
J4 Jitter	0.39 UI	0.53 UI (max)	-	-	-
J9 Jitter	-	-	-	-	-
Eye mask (X1, X2, X3, Y1, Y2, Y3)	0.31,0.4,0.45, 0.34,0.38,0.4	0.28,0.5,0.5, 0.33,0.33,0.4	Note: different mask can be used depending on the hit ratio definition	Note: different mask can be used depending on the hit ratio definition	Note: different mask can be used depending on the hit ratio definition
Stressed receiver sensitivity, OMA	-16.5 dBm	-5.2 dBm	-10.3 dBm	-11.3 dBm	-7.5 dBm
Aggressor lane OMA	NA	NA	-	-	-

The specified stressed receiver conformance test signal with a given stressed eye closure (SEC) 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
- 2 sinusoidal jitter sources PJ1 and PJ2
- Sinusoidal amplitude interferer (100 MHz < fSI < 2 GHz, non-harmonic to data signal and other stress components)
- Random jitter

The N4917BACA solution software automatically adjusts the setting of the different equipment to generate the stress signal with the desired characteristics.

Table 1. Applied sinusoidal jitter.

Frequency range	Sinusoidal, jitter, peak to peak (UI)
f < 100 kHz	Not specified
100 kHz < f ≤ 10 MHz	$5 \times 10^5 / f$
10 MHz < f < 10 LB [1]	0.05

1. LB = loop bandwidth; upper frequency bound for added sine jitter should be at least 10 times the loop bandwidth of the receiver being tested.

The metrics employed for stress signal calibration are detailed below:

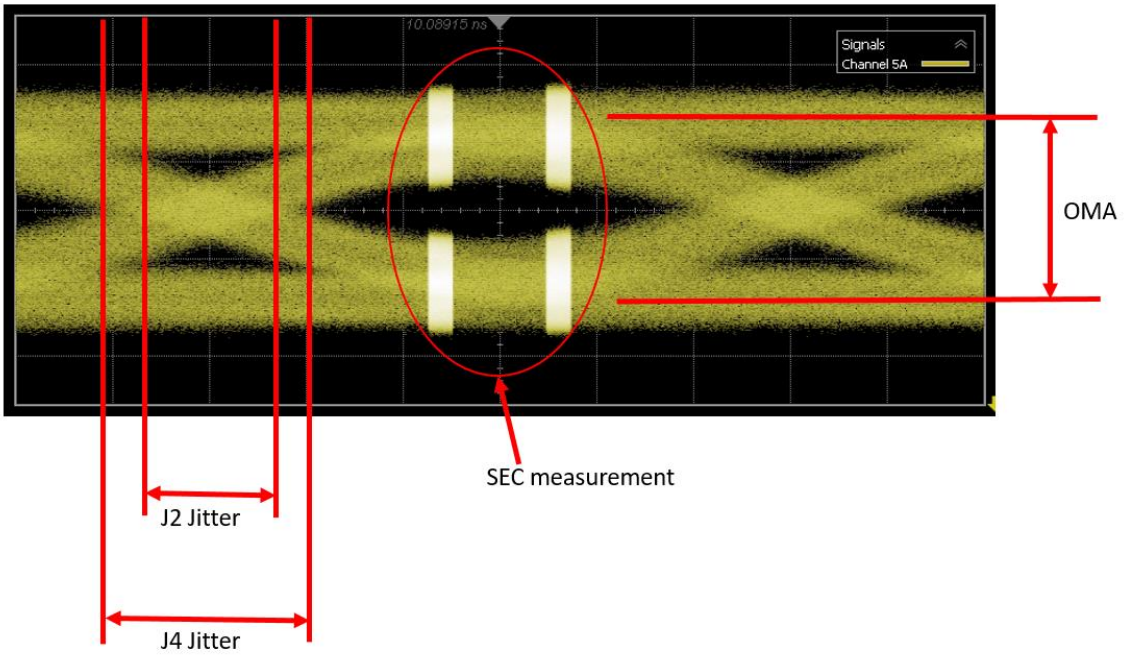

Figure 3. Definition of 100GBASE-SR4 optical stress parameters.

$SEC = 10\ log10\ \left[\frac{OMA}{2} \times \frac{1}{3.8906 - R}\right]$ with R as combined noise term of Tx and Ref Rx

BER of 5×10^{-5}

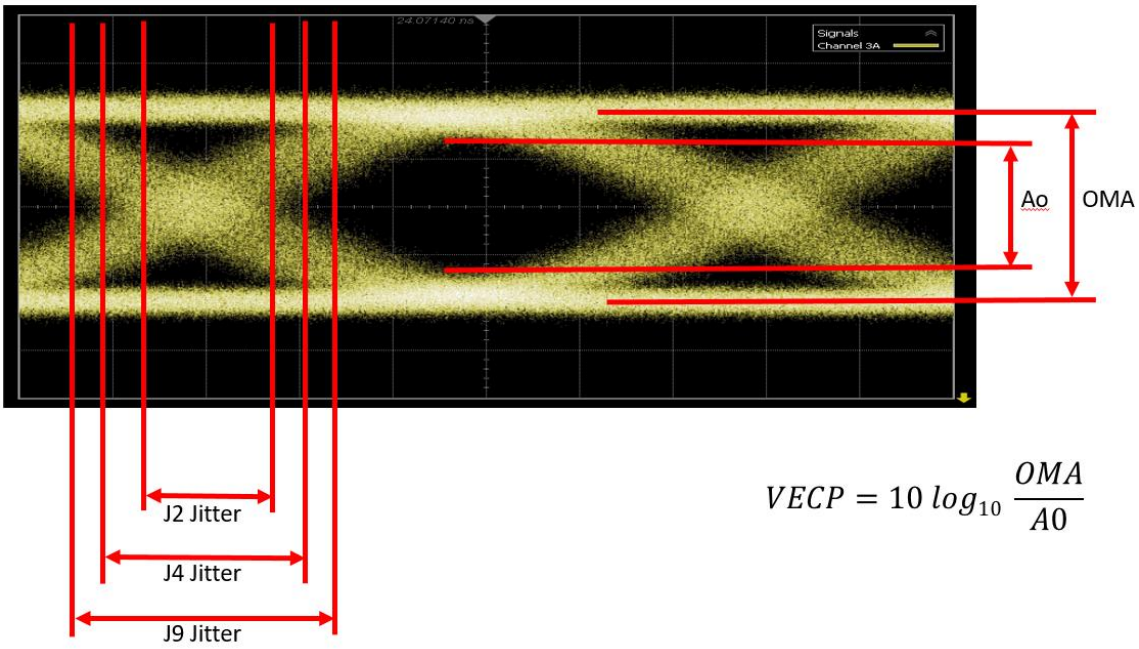

Figure 4. Definition of 100GBASE-LR4/ER4 and 100G MSA optical stress parameters

N4917BACA User Interface

The N4917BACA 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 SEC 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. User-defined "tags" can be added for each calibration or test.

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 N4917BACA 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

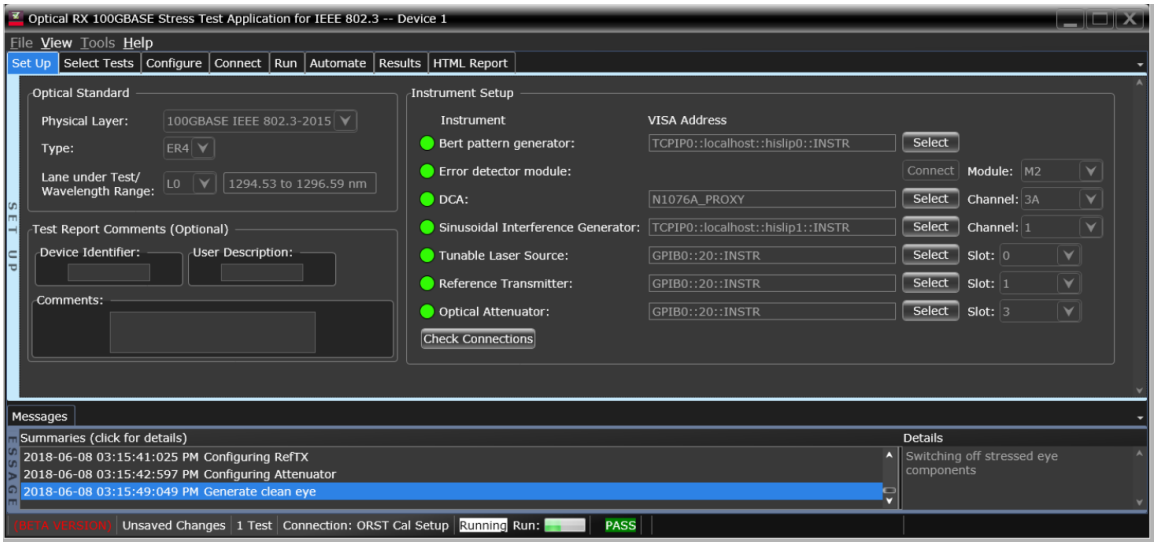

Figure 5. The N4917BACA software Set Up tab is used to connect and check equipment

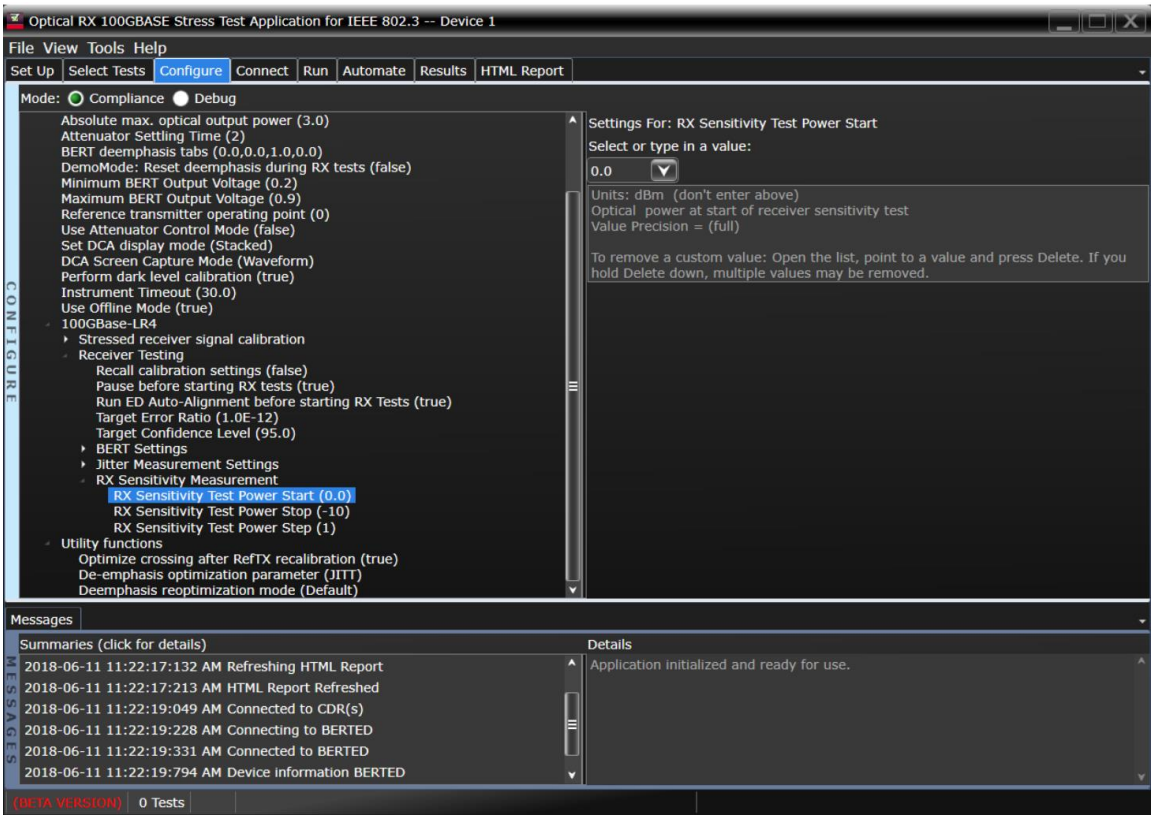

Figure 6. The N4917BACA software **Configure** tab lets the user fine-tune the standard compliant stressed receiver test or adapt to the test to other standards by offering multiple, user-editable settings, such as the stress signal parameters or test conformance limits

N4917BACA Features

The N4917BACA software creates a stressed NRZ optical waveform from the following setting parameters.

Settable parameters

- Data amplitude (mV pp) [1]
- Sinusoidal interferer amplitude (Vpp) [1]
- Sinusoidal interferer frequency (Hz)
- Periodic jitter 1 and Periodic jitter 2 amplitude (UI)
- Periodic jitter 1 and Periodic jitter 2 frequency (Hz)
- Baud rate (GBd/s)
- Optical power for calibration (dbm)
- OMA for DUT test (dBm) [1]
- Extinction ratio for DUT test (dB) [1]
- Optical wavelength (nm)
- De-emphasis coefficients
- Random jitter amplitude RMS (UI) [1]

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)
- VECP, SEC (dB)
- OMA for DUT test (dBm)
- Jitter conformance (pass/fail)
- Jitter performance (UI)
- Stressed receiver sensitivity (BER vs. dBm)
- Eye mask test (mask margin)
- Jitter measurements J2/J4/J9 (acc. Standard definition) (UI)
- Receiver conformance (pass/fail)

N4917BACA Requirements

The N4917BACA 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

- M8070B: 9.5.560.12;
- FlexDCA: A.07.40.319;
- M8195A: 4.0.0.0,
- M8196A: 2.1.1.0,
- M8054A: 1.0.23.0
- Keysight IO Libraries Suite rev. 18.1
- N1010A FlexDCA remote access system A.06.60

PC interfaces

- USB, LAN

Instrument firmware requirements

- M8040A BERT:
  - M8070B system software as above
  - M8079ADVB Advanced Measurement Package
- 8163B/ 8164B LMS: Version V5.25 or later
- 81491A Ref Tx: Version V5.01 or later

Configuration Guide

The N4917BACA optical stress test solution is built up from a variety of instruments. For some of the instruments, alternative selections are supported by the N4917BACA 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 needs.

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	Pattern generator one channel NRZ, data rate up to 32 GBaud
M8045A-0G3	Advanced jitter sources for receiver characterization, license
M8045A-0G4	De-emphasis, 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/B	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-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	
M8070B	System software for M8000 Series of BER test solutions
Select One of the M8000 System Software License Options	
M8070ADVB	Advanced Measurement Package for M8000 Series of BERT Test Solutions (node-locked, transportable, floating or USB license)
Step 5. Interference Source Minimum required Configuration (Select One of the Listed Signal Generators for Sinusoidal and Gaussian Noise Interference)	
M8054A	32GHz interference source
M8195A	1-, 2- or 4-channel 65 GSa/s arbitrary waveform generator
M8195A-002	2 GSa per module
M8196A	2- or 4-channel 92 GSa/s arbitrary waveform generator
M8196A-002	512 kSa per channel
81150A	Pulse Function Arbitrary Generator
81150A-001	One output channel for 81150A
81160A	1 or 2 Channel Pulse Function Arbitrary Generator
81160A-001	1 Channel 330 MHz Pulse Function Arbitrary Generator
N5171B	EXG X-Series RF Analog Signal Generator, 9 kHz to 6 GHz
N5171B-503	Frequency Range, 9 kHz to 3 GHz
N5172B	EXG X-Series RF Vector Signal Generator, 9 kHz to 6 GHz
N5172B-503	Frequency Range, 9 kHz to 3 GHz

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)	
8163B	2-slot lightwave multimeter (recommended for multimode flavors only)
8164B	5-slot lightwave measurement system mainframe
Step 7. Tunable Laser Source Configuration (Select One of the Tunable Lasers)	
N7776C	Tunable Laser Source, High Power and Lowest SSE
N7776C-113	Tunable Laser 1240-1380 nm
N7778C	Tunable Laser Source, High Power and Low SSE, Value Line
N7778C-113	Tunable Laser 1240-1380
N7779C	Step-Tunable Laser Source, High Power and Low SSE, Basic Line
N7779C-113	Tunable Laser 1240-1380
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)	
81491A	Reference transmitter
81491A-135	Ref Tx Single Mode with external Input and internal 1310nm / 1550nm Sources
81491A-085	Ref Tx Multimode with internal 850nm Source
81492A	Reference transmitter
81492A-E01	Ref Tx special with external laser input and internal 1310/1550 nm laser
81492A-135	Ref Tx with external laser input and internal 1310/1550 nm laser
Optical Connector Interface	
81000FI	FC/PC interface (1 required for -E05, -E09)
81000NI	Connector interface, FC - narrow key way, (1 required for 81490-E05/E10 and 81491A-085, 2 otherwise)
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
N7766A	Two-Channel Multimode Optical Attenuator
N7766A-050	50/125 um multimode fiber interface
N7768A	Four-Channel Multimode Optical Attenuator
N7768A-050	50/125 um multimode fiber interface

3. Select the configuration for the DCA and N4917BACA 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

Step 11. DCA Minimum required Configuration (Select either a DCA-X Mainframe/plugin/time Base or a DCA-M Model/FlexDCA SW Configuration)

DCA-M minimum required configuration (select one DCA-M model)	
N1092A	One optical channel
N1092A-IRC	Impulse response correction to provide ideal channel response
N1092B	Two optical channels
N1092B-IRC	Impulse response correction to provide ideal channel response
N1092C	One optical, two electrical channels
N1092C-IRC	Impulse response correction to provide ideal channel response
N1092D	Four optical channels
N1092D-IRC	Impulse response correction to provide ideal channel response
N1092E	Two optical, two electrical channels
N1092E-IRC	Impulse response correction to provide ideal channel response
DCA-M minimum required option configuration	
Option LOJ	Reduce residual jitter from 400 fs to < 200 fs
Option PLK	Pattern Lock capability
Choose legacy DCA option OR	
Option 200	Enhanced Jitter Analysis (can also be ordered as N1010A-200 FlexDCA license)
Option 201	Advanced Waveform analysis (can also be ordered as N1010A-201 FlexDCA license)
Option 300	Advanced Amplitude Analysis/Rin/Q-Factor (can also be ordered as N1010A-300 FlexDCA license)
Option 500	Productivity Package (Rapid Eye, TDEC) (can also be ordered as N1010A-500 FlexDCA license)
Option 9FP	PAM-N Analysis SW, (can also be ordered as N1010A-9FP FlexDCA license)
Choose FlexDCA R&D package	
N1010100A	Research and Development Package for FlexDCA
DCA-X mainframe minimum configuration	
N1000A	DCA-X Wide-Bandwidth Oscilloscope Mainframe
N1000A-LOJ	Low Jitter Timebase

N1000A-PLK	Pattern Lock Trigger Hardware
Optical Plug-in Module	
N1030A/B	Optical plug-in module for the N1000A DCA-X mainframe
N1030A/B-IRC	Impulse response correction (optical and electrical channels)
N1030A/B-280	Hardware filters for 25-28 NRZ Gbaud rates
Optical/Electrical Clock Recovery (select if external clock recovery is required for calibration or BER measured using ED). No electrical CDR is required if M8046A-A04 has been chosen	
N1076A	Electrical Clock Recovery (discontinued)
N1076A-232	Supported input rates: 50 MBd to 32 GBd (discontinued)
N1076B	Electrical Clock Recovery
N1076B-232	Supported input rates: 125 MBd to 32 GBd
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
N1078A	Optical/Electrical Clock Recovery
N1078A-232	Supported input rates: 125 MBd to 32 GBd
N1078A-264[1]	Supported input rates: 125 MBd to 64 GBd

Step 12. N4917BACA Optical Receiver Stress Test Software Configuration	
N4917BACA	Optical receiver stress test for 100G solution software (select one license option)
N4917BACA-1xx	Optical Receiver Stress Test compliance app for 100G IEEE and MSAs, license (node-locked or transportable or floating or USB)

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 (choose if using single mode ref Tx)
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 trigger M8045A to M8195, terminate complement output)
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)
N4917B-805	Patchcord Cable MM-Fiber 50 Micro m 2xFC/PC-wide Key, Length 2m required (choose if the 81490A-E10 or 81491A-085 multimode Ref Tx)
N4917B-806	Patchcord Cable MM-Fiber 50 Micro m FC/APC-narrow Key - FC/PC-wide Key, Length 2m (choose if using the 81490A-E10 or 81491A-085 multimode Ref Tx)
N4917B-801	Cable Assembly coaxial Rg/223 50 Ohm BNC-male to BNC-male (choose if using the 81160A as interference source)
N4917B-802	Adapter-coaxial straight female-BNC male-SMA , (choose if using the 81160A as interference source)
N4917B-808	Adapter, coaxial N-type (m) to BNC (f), (choose if using the N517xB as interference source)

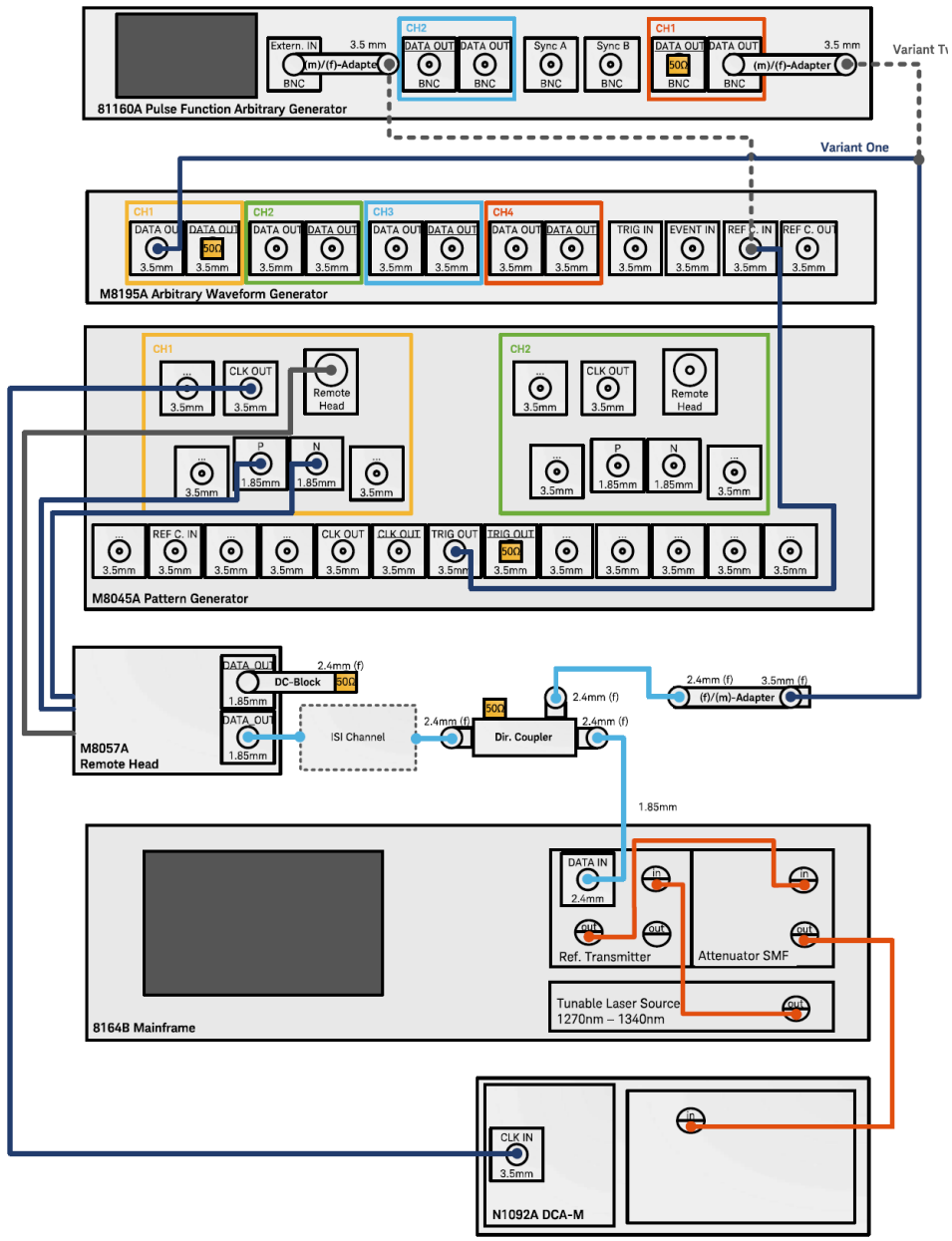

Figure 7. Setup for stressed eye signal calibration for 100GBASE ER4/-LR4 and 100G MSAs with clean clock

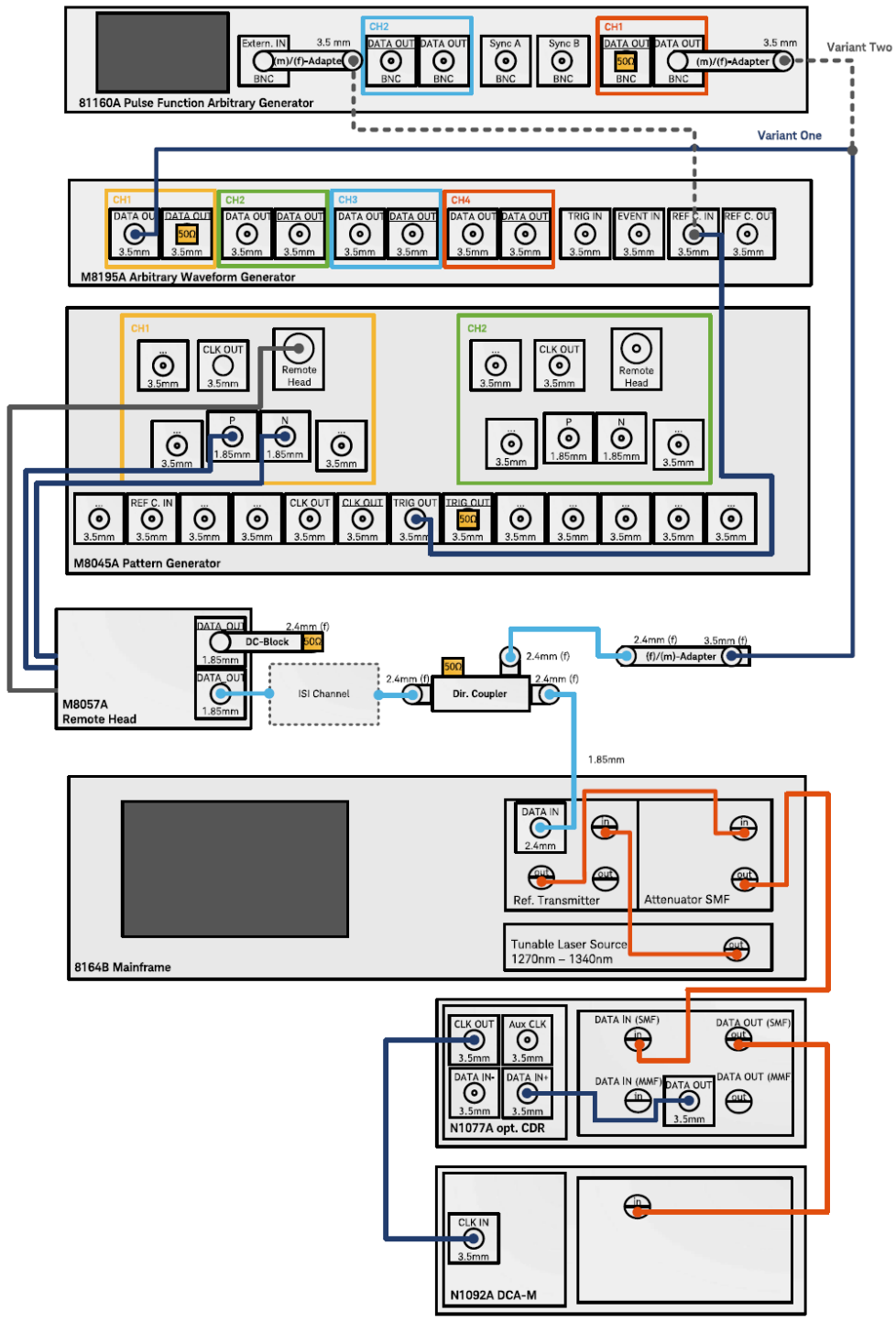

Figure 8. Setup for stressed eye signal calibration for 100 GBASE ER4/-LR4 and 100G MSAs with recovered clock.

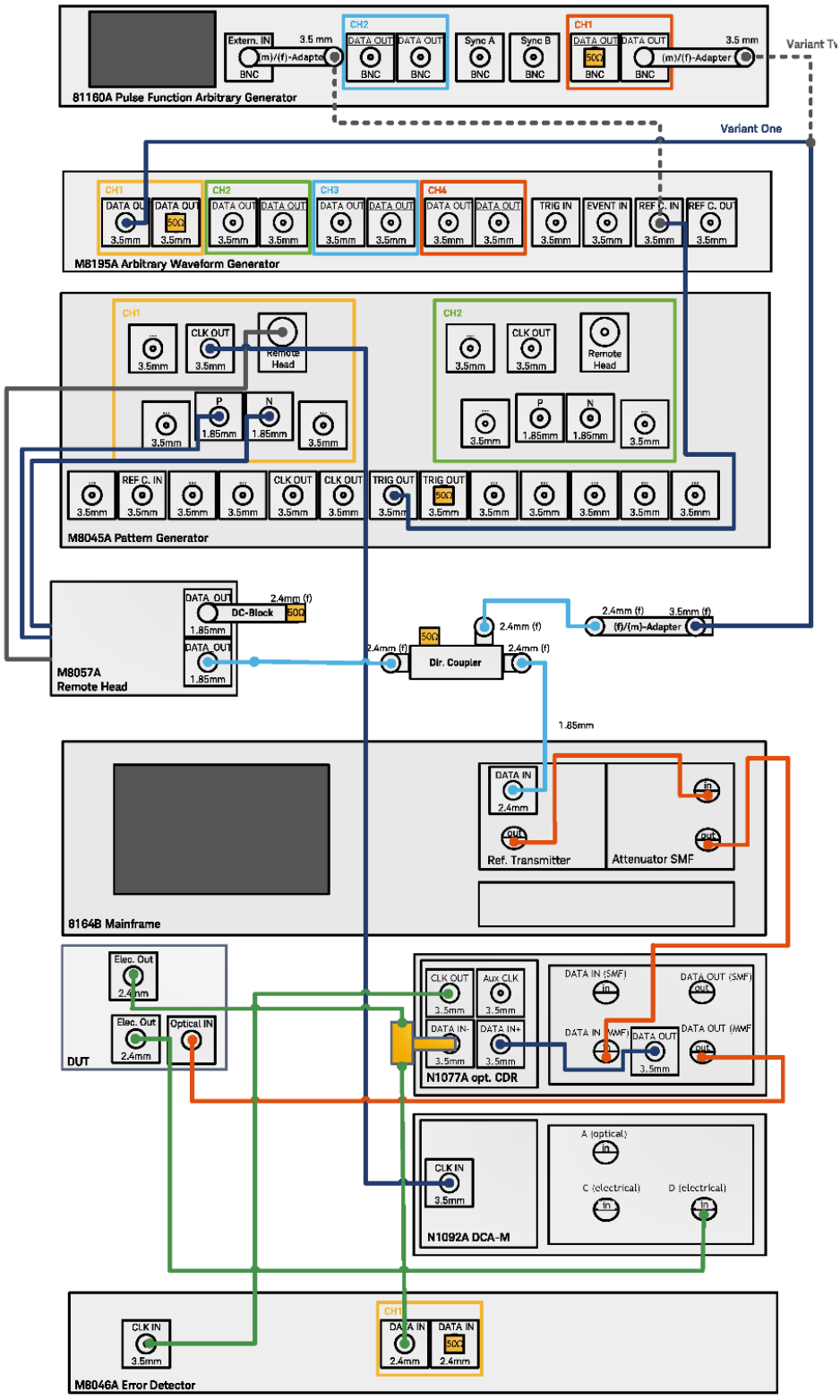

Figure 9. Setup for stressed eye signal calibration for 100 GBASE-SR4 with recovered clock

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
N7779C Tunable Laser - Data Sheet	5992-4217EN
81491A Reference Transmitter - Data Sheet	5992-3358EN
8157xA Optical Attenuators - Data Sheet	5988-2696EN
N77-Series Attenuators - Data Sheet	5990-4394EN
81492A Reference Transmitter - Data Sheet	3120-1071EN
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
N1010100A Research and Development Package - Configuration guide	5992-3372EN
N4917BSCB datasheet	5992-4040EN