Keysight N4917CPCA Optical Receiver Stress Test for CPRI Fronthaul Networks

User Guide

KEYSIGHT TECHNOLOGIES

Notices

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1 Overview

KEYSIGHT TECHNOLOGIES

Optical Receiver Stress Test Solution for CPRI Fronthaul Networks – At a Glance

The N4917CPCA Optical Receiver Stress Test solution for CPRI Fronthaul Networks is based on the N4917B Optical Receiver Stress Test solution for 100GBASE transceivers, with some modifications to the stress calibration recipe and adjustable bit rate to meet the needs of CPRI Fronthaul Network Testing.

The Keysight N4917CPCA Optical Receiver Stress Test Solution provides a platform for stressed receiver sensitivity test, which can be used with 10GBASE, 40GBASE, and 100GBASE devices in a CPRI Fronthaul environment. The solution consists of several test instruments such as a Bit Error Rate Tester (BERT), Digital Sampling Scope (DCA), Optical Reference Transmitter, Tunable Laser, and Optical Attenuator operating together with the N4917CPCA software package.

Some salient features of the N4917CPCA Optical Receiver Stress Test Solution include:

- remote control of all the test instrumentation
- automated calibration of the optical stressed eye parameters (ER, VECP J2, J9, and OMA)
- adjustable target values for ER, VECP, J2, J9, and OMA
- jitter tolerance compliance and margin tests

Applicable Standards

The N4917CPCA Optical Receiver Stress Test software supports automated optical stressed receiver sensitivity test for optical transceivers in a CPRI Fronthaul environment that are compliant with the following standards:

Test Name	Reference Standard
10GBASE-LR/ER/SR	IEEE 802.3 2018 Clause 52
40GBASE-LR4/ER4	IEEE 802.3 2018 Clause 87
100GBASE-LR4/ER4	IEEE 802.3 2018 Clause 88
-	CPRI Specification V7.0

System Description

The N4917CPCA Test Solution for Optical Stressed Eye consists of:

- a BERT to generate electrical signal
- an electrical-optical converter that modulates the optical signal from a fixed or tunable laser
- a digital sampling oscilloscope required for calibration of the stressed eye

Figure 1 shows a typical Optical Receiver Stressed Test equipment setup.

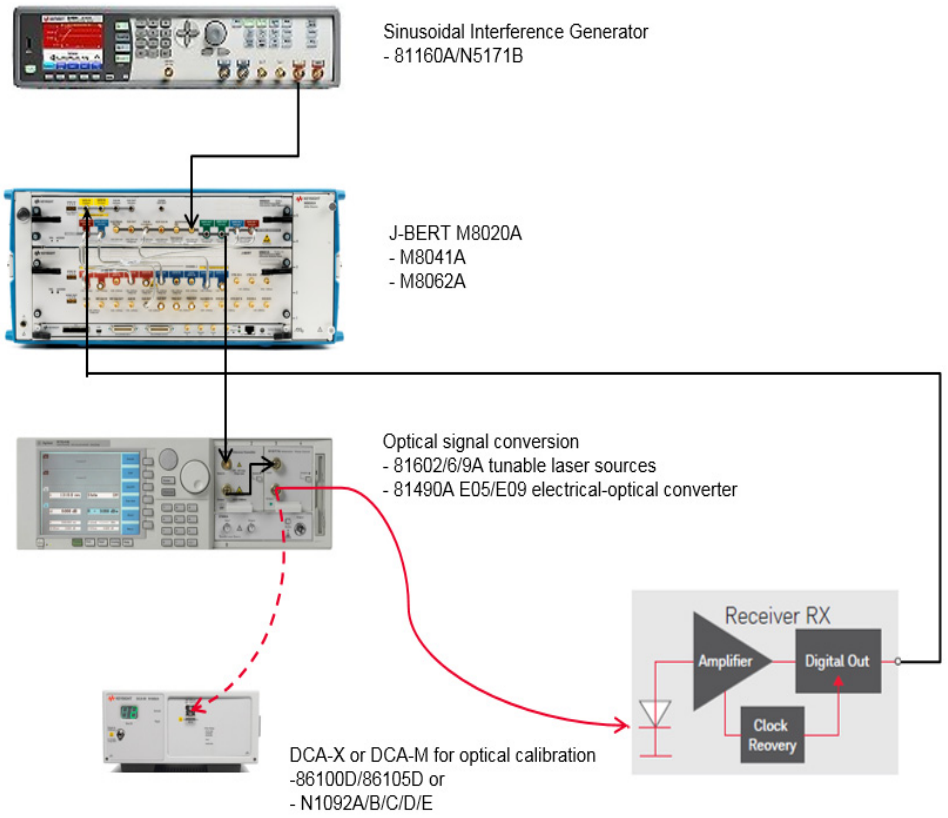


Figure 1 Example setup

In the Optical Stressed Eye Test Setup, the J-BERT M8020A High-Performance BERT system is the core instrument that generates an electrical signal with all the required impairments (random, BUJ and sinusoidal timing jitter, ISI and sinusoidal amplitude interference) at the data signal output. It uses a combination of built-in stress sources along with an external generator.

The electrical signal generated from the BERT is fed into an 81490/91A electrical-optical converter to modulate the laser and create a stressed optical signal.

Depending on which standard is being tested, either an 8160xA tunable laser or the internal 8149xA laser can be used. The optical output of the 8149xA is attenuated to achieve the required optical power level at the input of the receiver under test.

Prior to testing the receiver, the optical signal for each wavelength is calibrated using an N1092x DCA-M Sampling Oscilloscope or an 86100D/N1000A DCA-X Wide-Bandwidth Oscilloscope with an 86105D optical module set up as a reference receiver.

The equipment used in the Optical Stressed Eye Test Setup is under control of the N4917CPCA Test Solution software, which takes care of the various equipment settings and performs an iterative adjustment of the BERT stresses until the optical signal measured on the DCA meets the required stressed eye parameters.

The N4917CPCA Optical Receiver Stress Test Solution software also allows for precise repeatable calibration of an optical stressed eye. The N4917CPCA Optical Receiver Stress Test solution enables an additional stress source, bounded uncorrelated jitter (BUJ) to be used as an alternative to sinusoidal jitter or random jitter when calibrating the stressed eye. BUJ can provide a better model for crosstalk in CPRI fronthaul network testing. A simple switch in the software GUI enables the user to choose between BUJ and PJ2 (sinusoidal jitter) for 40/100GBASE standards, or BUJ and RJ (random jitter) for the 10GBASE standard.

Additionally CPRI fronthaul networks generally run at slightly different line rates, e.g. CPRI option 10 bit rate is 24.33024 Gb/s instead of 25.78125 Gb/s. The N4917CPCA lets the user adjust the bit rate prior to a stressed eye calibration.

Once you achieve the calibrated stressed eye, proceed to test an actual device (DUT). In fronthaul testing priority is placed on the impact of jitter on the recovered clock frequency, which is usually measured with an oscilloscope. Consequently, DUT BER measurements at the receiver are not common. However if required, the N4917CPCA does provide semi-automated Jitter Tolerance measurements routines or you can perform the equivalent fully automated measurement on a Bit Error Rate Tester (BERT).

2 System Requirements For N4917CPCA

KEYSIGHT TECHNOLOGIES

Hardware and Software Requirements

NOTE The N4917CPCA Optical Receiver Stress Test Solution Software runs on an external PC.

PC Hardware Requirements

Operating system

- Microsoft Windows 7 (64 bit)
- Microsoft Windows 10 (64 bit)

Memory

- 8 GB RAM [minimum]

Monitor Resolution

- WXGA+ (1440 x 900) [minimum]

PC Software Requirements

Keysight IO Libraries Suite (Software)

- Ver.17.2.x or later

M8070A/B system software for M8000 series

- M8070A version 5.1 or later
- M8070B version 6.0 or later

N1010A FlexDCA Remote Access System

- A.06.02 or later

PC Interfaces

- USB
- LAN

Instrument Firmware Requirements

M8020A J-BERT

- M8070A/B System Software as specified earlier

86100D DCA-X

- FlexDCA version A.06.02 or later

8164B LMS

- Ver.V5.25 or later

81490A/81491A Ref Tx

- Ver.5.01 or later

Supported Equipment

As mentioned earlier, the N4917CPCA Optical Receiver Stress Test Solution comprises of a variety of instruments. For some of the instruments, alternative selections are supported. The following sections detail the equipment, including the **minimum** option requirements, which are compatible with the N4917CPCA Optical Receiver Stress Test Solution.

BERT

- M8020A-BU2 mainframe with USB option
- M8070A-0TP System Software Or
  M8070B + M8070ADVB System Software

Pattern Generator only

- M8041A-G16/0G2/0G3 High Performance BERT module
- M8062A-G32/0G4/0G5 32 Gb/s Front End

Full BERT

- M8041A-C16/0G2/0G3/0A2 High Performance BERT module
- M8062A-C32/0G4/0G5/0A4 32 Gb/s Front End

Signal Generator for Sinusoidal Interference

- 81150A-001, M81160A-001 Pulse Function Arbitrary Noise Generator or
- N5171B-501, N5173B-513 EXG X-series RF Analog Signal Generator
- N5181B-503, N5183B-513 MXG X-series Analog Signal Generator
- E8257D PSG Analog Signal Generator
- Any other source that is SCPI code compatible with the Signal Generator listed above for setting frequency and output amplitude

Signal Generator for System Clock

You may optionally use system clock, if the internal clock of the BERT is not used.

- E8257D PSG Analog Signal Generator up to 67 GHz or
- N5173B EXG X-series Microwave Analog Signal Generator up to 40 GHz or
- N5183B MXG X-series Microwave Analog Signal Generator up to 40 GHz or

- any other source that is SCPI code compatible with the Signal Generators listed above for setting frequency and output amplitude

Lightwave Measurement System

- 8164B LMS Mainframe
- 8163B LMS Mainframe

Tunable lasers (1310 nm):

- 81600B-132 Tunable Laser 1260-1375 nm or
- 81602A-013 Tunable Laser 1250-1370 nm or
- 81606A-113 Tunable Laser 1240-1380 nm or
- 81608A-113 Tunable Laser 1240-1380 nm or
- 81609A-113 Tunable Laser 1240-1380 nm

Tunable lasers (1550 nm):

- 81606A-116 Tunable laser 1490-1640 nm
- 81606A-216 Tunable laser 1450-1650 nm
- 81607A-116 Tunable laser 1490-1640 nm
- 81608A-116 Tunable laser 1490-1640 nm
- 81608A-216 Tunable laser 1450-1650 nm
- 81609A-116 Tunable laser 1490-1640 nm
- 81609A-216 Tunable laser 1450-1650 nm

Reference transmitters

- 81490A-E05 Reference Transmitter
- 81490A-E09 Reference Transmitter
- 81490A-135 Reference Transmitter
- 81490A-E10 Reference Transmitter
- 81490A-E03 Reference Transmitter
- 81490A-E06 Reference Transmitter
- 81491A-135 Reference Transmitter
- 81491A-085 Reference Transmitter

Attenuators:

- 81576A Attenuator module (straight SMF) or
- 81577A Attenuator module (angled SMF) or
- N7761A external Attenuator (1 ch straight SMF) or
- N7762A external Attenuator (2 ch straight SMF) or
- N7764A external Attenuator (4 ch straight SMF)
- N7766A external Attenuator (2 ch MMF)
- N7768A external Attenuator (4 ch MMF)

DCA-X Oscilloscope

- 86100D-ETR/PTB/200/300 DCA-X mainframe
- N1000A-PLK/LOJ/PTB DCA-X mainframe

- 86105D-281/IRC 50 GHz Electrical, 34 GHz Optical module or
- 86115D-282/IRC dual 34 GHz Optical module or
- 86105C-200/IRC 20 GHz Electrical, 9 GHz Optical module

- 86107A-020 Precision Time Base (not required, if DCA-X has the option –PTB)

DCA-M Oscilloscope

- N1092A one optical channel or
- N1092B two optical channels or
- N1092C one optical, two electrical channels or
- N1092D four optical channels or
- N1092E two optical, two electrical channels
- options LOJ/PLK/IRC/200/300/500

Clock Recovery

- N1077A-216-SMS Clock Recovery 50 Mbd - 16 Gbd
- N1077A-232-SMS Clock Recovery 50 Mbd - 32 Gbd
- N1078A-216-S50 Clock Recovery 125 Mbd - 16 Gbd

- N1078A-225-S50 Clock Recovery 25 - 29 Gbd
- N1078A-232-S50 Clock Recovery 125 Mbd - 32 Gbd
- N1078A-264-S50 Clock Recovery 125 Mbd - 64 Gbd

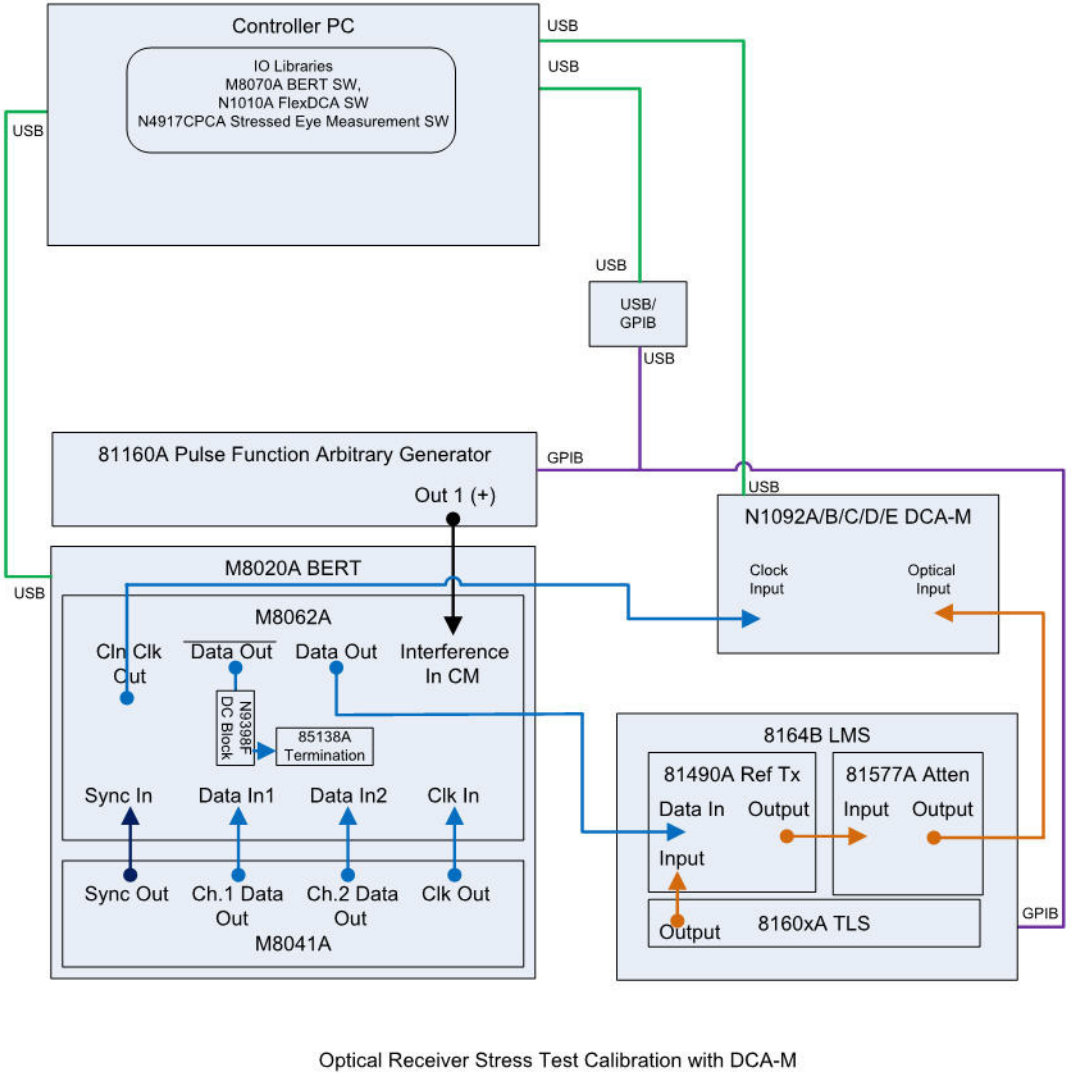
Equipment Configuration

The supported equipment described in the previous section provides the flexibility to assemble the system configuration in various ways.

The N4917CPCA Optical Receiver Stress Test recommended configurations are described below. For assistance with other variants of equipment configuration, contact your local Keysight technical support.

Recommended Setup using DCA-M

Connect the equipment and cabling as shown in Figure 2.

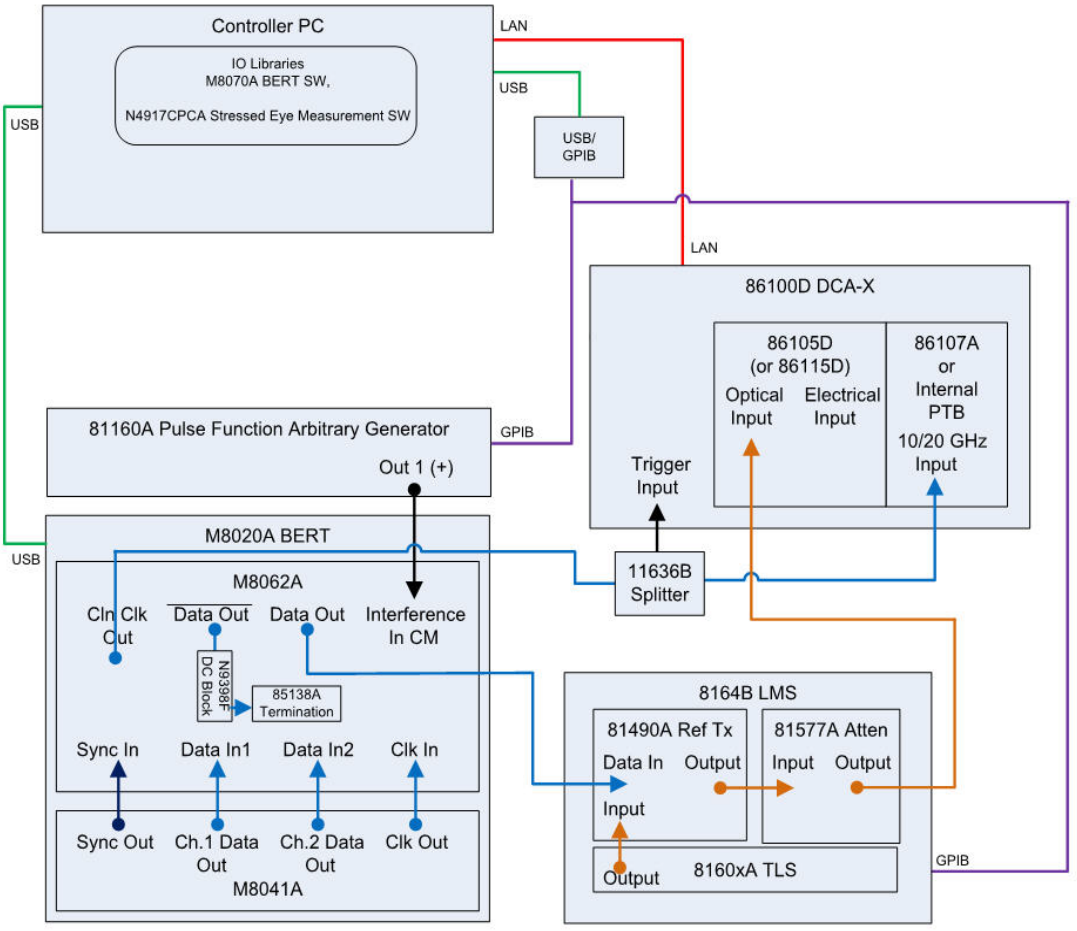


Optical Receiver Stress Test Calibration with DCA-M

Figure 2 Optical Receiver Stress Test Calibration with DCA-M

Recommended Setup using DCA-X

Connect the equipment and cabling as shown in Figure 3.



Optical Receiver Stress Test Calibration Setup with DCA-X

Figure 3 Optical Receiver Stress Test Calibration with DCA-X

Other options to these configurations include:

- using an external system clock
- using a signal generator instead of the pulse function generator for the interference source
- using an external optical attenuator instead of 8157xA
- using an external tunable or fixed wavelength laser
- using LAN connections to the pulse function generator and LMS mainframe

3 Concepts and Features of N4917CPCA Software

KEYSIGHT TECHNOLOGIES

Software concept and flow of Optical Receiver Test

The N4917CPCA Optical Receiver Stress Test solution software includes three main functions—Stressed Eye Calibration, Jitter Conformance Test and Jitter Performance Test.

A Stressed Eye calibration is required first to provide an optical waveform with jitter and interference impairments per the applicable standard. This stressed signal is then used in conjunction with a Jitter Conformance/Performance routine to test one channel at a time of the DUT.

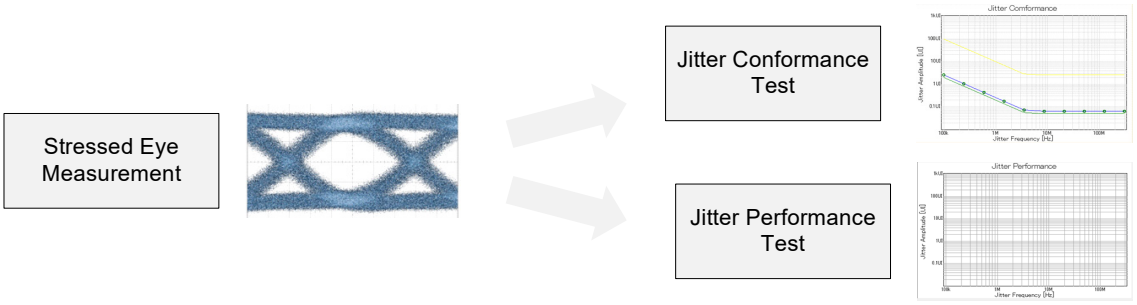


Figure 4 Stressed Eye Calibration and Measurement flow

The calibrated parameters in the stressed eye are Extinction Ratio, VECP, J2, and J9. The Stressed Eye Calibration adjusts the values of these parameters until the respective values meet the limits defined in the specification.

The results and parameter settings from the Stressed Eye Calibration are saved in a file. These parameters are automatically referred to while running the Jitter Conformance Test and the Jitter Performance Test.

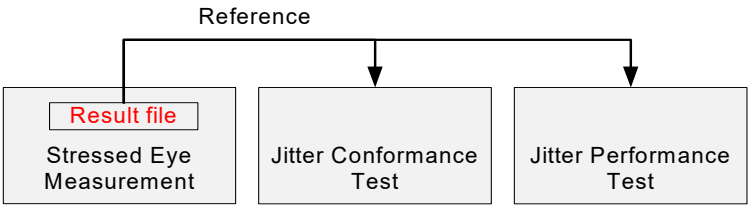


Figure 5 Using the Stressed Eye Calibration Results as reference

Software Functions and Features

The N4917CPCA Optical Receiver Stress Test solution software has the ability to create any stressed optical eye waveform and performs DUT testing based on the parameter settings provided. Load the parameters for the test from the Parameter file (or from a previous Results file). Once loaded, you may also adjust the parameter values in the software GUI prior to running the Stressed Eye Calibration.

Stressed Eye Calibration

This feature of the N4917CPCA software creates a stressed eye, based on the applicable standards, for stressed receiver sensitivity testing.

Table 4 lists the setting and measurement parameters for Stressed Eye Calibration. The Measurement Parameters are used to characterize the stressed eye.

Table 1 Parameters for Stressed Eye Calibration

		Parameters
Setting Parameters	**Optical**	Power level for calibration (dBm)
		OMA for DUT test (dBm)
		Laser Wavelength (nm)
	Electrical	Data Amplitude (mV_{pp})
		Intersymbol interference frequency (GHz)
		Intersymbol interference amplitude (dB)
		Sinusoidal interference frequency (MHz)
		Sinusoidal interference amplitude (mV_{pp})
		Common mode interference gain
		Periodic jitter 1 frequency (MHz)
		Periodic jitter 1 amplitude (UI_{pp})
		Periodic jitter 2 frequency (MHz)
		Periodic jitter 2 amplitude (UI_{pp})
		Random jitter amplitude (UI_{rms})
		Bounded uncorrelated jitter amplitude (UIpp)
		Bounded uncorrelated jitter PRBS rate (Gb/s)
		Bounded uncorrelated jitter polynomial
		Bounded uncorrelated jitter filter (MHz)
		Bit Rate (Gb/s)
		DCA Reference Receiver BW
		De-Emphasis cursors (dB)

	Parameters
Measurement Parameters	[ER] Extinction Ratio (dB)
	Initial [VECP] Vertical Eye Closure Penalty (dB)
	[VECP] Vertical Eye Closure Penalty (dB)
	J2 jitter (UI_{pp})
	J9 jitter (UI_{pp})
	[DDPWS] Data Dependent Pulse Width Shrinkage (ps)
	Calibration level OMA (dBm)

To speed up the stressed eye calibration, you may set the starting values for data amplitude, ISI amplitude, SI amplitude, PJ2/BUJ, and RJ/BUJ. Once the software achieves the initial stressed eye waveform from the setting parameters, the system adjusts those parameters until the measurement parameter targets are achieved. The measurement parameters—ER, VECP, J2 and J9—are adjusted using the parameters—data amplitude, ISI amplitude, SI amplitude, PJ2 or BUJ amplitude, RJ or BUJ amplitude. Initial VECP is the portion created from ISI (inter-symbol interference). Initial VECP should be at least 2/3 of the VECP target.

The full value of VECP is then achieved by adding additional SI (sinusoidal interference) and jitter.

Jitter Conformance Test

This feature of the N4917CPCA software performs a jitter tolerance test based on the applicable standards, to confirm that the DUT meets the required Bit Error Rate (BER) when the specified SJ amplitude is applied at each SJ frequency. Note that the Jitter Conformance Test sets up only the SJ stress level. You must manually enter the device BER and the Pass/Fail criteria. The test builds a table and a plot for SJ frequency/amplitude versus BER.

As a prerequisite, you must run the Stressed Eye Calibration prior to running the Jitter Conformance Test.

Table 2 lists the Setting and Measurement Parameters for Jitter Conformance Test:

Table 2 Parameters for Jitter Conformance Test

Parameters	
Setting Parameters	SJ start frequency (kHz)
	SJ stop frequency (kHz)
	SJ number of frequency points
	SJ margin (%)
	Optical power (dBm)
	Data Polarity
Measurement Parameters	User entered BER
	User entered pass/fail (GO/NoGO)

Jitter Performance Test

This feature of the N4917CPCA software performs a jitter tolerance test based on the applicable standards, to explore the DUT margin and to find the maximum amplitude limits that meet the required Bit Error Rate (BER). Note that the Jitter Performance Test sets up only the SJ stress level. You must manually enter the device BER and the Pass/Fail criteria. The test builds a table and a plot for SJ frequency/amplitude versus BER.

As a prerequisite, you must run the Stressed Eye Calibration prior to running the Jitter Performance Test.

Table 3 lists the Setting and Measurement Parameters for Jitter Performance Test:

Table 3 Parameters for Jitter Performance Test

Parameters	
Setting Parameters	SJ start frequency (kHz)
	SJ stop frequency (kHz)
	SJ number of frequency points
	SJ amplitude (UI)
	Optical power (dBm)
	Data Polarity
Measurement Parameters	User entered BER
	User entered pass/fail (GO/NoGO)

Parameter files

These files store parameters to be used for stressed eye calibration or stressed eye test or both. An extended version of the files is used to store the stressed eye calibration results.

The parameter file contains all the necessary instrument parameter values to setup a stressed eye calibration or jitter measurement, including the target stressed eye parameters—ER, initial VECP, VECP, J2, J9, DDPWS, and final OMA. Default parameter files are provided as part of the software installation. However, in general, you must customize some of the values in the file for your own system.

Existing or new parameter files can also be saved/created directly from the N4917CPCA user interface, e.g. after a successful calibration, the actual instrument parameters will be updated. Saving a new/updated parameter file at this point means the starting values for data, ISI, SI, PJ2/RJ/BUJ amplitude will be close to final values for subsequent calibrations, resulting in a faster stressed eye calibration.

Navigate to *C:\Users\Public\Public Documents\N4917CPCA\Parameter* to access the default Parameter files.

There are sub-folders for each supported standard:

- 10GBASE
- 40GBASE
- 100GBASE

Each sub-folder contains default parameters for each data lane/ wavelength/ reach.

Stressed Receiver Sensitivity Specifications

For reference, Table 4 lists the salient conditions required for stressed receiver sensitivity test.

Table 4 Stressed Receiver Sensitivity Test Specifications

	100G BASE -LR4	100G BASE -ER4	40G BASE- LR4	40G BASE -ER4	10G BASE -LR	10G BASE -ER	10G BASE -SR
Conditions for Stressed Receiver Sensitivity Test							
Extinction Ratio	4 dB	8 dB	3.5 dB	5.5 dB	3.5 dB	3.0 dB	3.0 dB
Initial Vertical eye closure penalty (VECP) (SEC for SR4)	1.2 dB min	2.33 dB min	1.27 dB min	1.47 dB min	1.47 dB min	1.8 dB min	2.33 dB min
Vertical eye closure penalty (VECP), (Stressed eye closure for SR4)	1.8 dB	3.5 dB	1.9 dB	2.2 dB	2.2 dB	2.7 dB	3.5 dB
J2 Jitter	0.3 UI	0.3 UI	0.3 UI	0.3 UI	0.3 UI	0.3 UI	0.3 UI
J9 Jitter	0.47 UI	0.47 UI	0.47 UI	0.47 UI	-	-	-
DDPWS	-	-	-	-	5 ps	5 ps	5 ps
Optical Wavelength Assignments							
Spacing	5nm	5nm	20nm	20nm	-	-	-
Lane L0 Nominal Wavelength	1295.56 nm	1295.56 nm	1271 nm	1271 nm	1310 nm	1550 nm	850 nm
Lane L1 Nominal Wavelength	1300.05 nm	1300.05 nm	1291 nm	1291 nm			
Lane L2 Nominal Wavelength	1304.58 nm	1304.58 nm	1311 nm	1311 nm			
Lane L3 Nominal Wavelength	1309.14 nm	1309.14 nm	1331 nm	1331 nm			
Stressed receiver sensitivity, OMA	-6.8 dBm	-17.9 dBm	-9.6 dBm	-16.8 dBm	-10.3 dBm	-11.3 dBm	-7.5 dBm
Aggressor lane OMA	-1.3 dBm	-13.4 dBm	-2.1 dBm	-9.8 dBm	-	-	-

Example CPRI parameter file

File Type,	Eye	File type
[Tag Data]		
OperatorName,		
ResultFile,		
EyeFile,	C:\Users\Public\Documents\N4917CPCA\Parameter\100GBASE\Eye_parameters_100G_LR4_PJ2_L0.csv	
Comment,		
[Measurement Condition]		
Measurement Mode,	100GBASE-LR4/ER4	Measurement type
ERTgt[dB],	4.25	Target values for defining a Stressed Optical waveform according to standard.
ERDelta[dB],	0.25	
ERAdj,	True	
InitialVECPTgt[dB],	1.3	
InitialVECPDelta[dB],	0.1	
InitialVECPAdj,	True	
VECPTgt[dB],	1.8	
VECPDelta[dB],	0.1	
VECPAdj,	True	
J2Tgt[UIpp],	0.3	
J2Delta[UIpp],	0.01	
J2Adj,	True	
J9Tgt[UIpp],	0.47	
J9Delta[UIpp],	0.04	
J9Adj,	True	
FinalOMA[dBm],	-6.8	

DataAmpDef[Vpp],	0.24	Starting values of adjustable parameters that are modified to achieve a compliant stressed eye.
ISIAmpDef[dB],	-0.8	
SIAmpDef[Vpp],	0.2	
RJAmpDef[UIrms],	0.01	
AvgOpticalPower[dBm],	3	Average power level for calibration
PJ1Freq[MHz],	10	Sinusoidal jitter parameter to be swept for Jitter Conformance and Jitter Performance tests
PJ1AmpDef[UIpp],	0.05	
ISIFreq[GHz],	12.890625	Frequency point for ISI amplitude setting
SIFreq[MHz],	150.13	Frequency of sinusoidal interference
SourcePower[dBm],	13	Tunable laser power
DataPattern,	PRBS9	Do not adjust
BitRate[Gbps],	24.33024	Data rate
WaveLength[nm],	1295.56	Wavelength of lane under test
Pre_Cursor1[dB],	0	De-emphasis settings, adjust to achieve optimum optical waveform before impairments are added. Use values established during System Performance Check.
Post_Cursor1[dB],	-2	
Post_Cursor2[dB],	0	
ISI Effect,	1	Do not adjust
CMI[0.1-1.0],	0.33	Sinusoidal interference input gain
DCA_offset[dB],	0	Offset for DCA average power measurement
J2SignalType,	PJ2	J2 stressor signal
PJ2Freq[MHz],	100.7	Frequency of 2nd periodic jitter
PJ2AmpDef[UIpp],	0.1	Starting value of PJ2 amplitude

BUJAmpDef[UIpp],	0.1	Starting value of BUJ amplitude
BUJDataRate[Mb/s],	625	BUJ PRBS data rate
BUJPolynomial,	2^7-1	BUJ PRBS pattern
BUJFilterType[MHz],	200	BUJ filter
RefRcvrBwVCouplingOn,	0	0 = set DCA reference receiver to value in next row 1 = let DCA automatically set reference receiver bandwidth to ~ 75% of data bit rate
RefRcvrBw[GHz],	19.34	DCA reference receiver bandwidth

4 Using the N4917CPCA Software

Starting the System Software

NOTE Before launching the N4917CPCA Optical Receiver Stress Test software, ensure that the BERT M8070A/B System software is running, and, if applicable, the DCA N1010A FlexDCA Remote Access System software is also running. Also make sure that all the physical cabling connections are in place.

To launch the N4917CPCA Test Solution software, click **Start**. From the **Start** menu, click **All Programs>Keysight N4917CPCA>Keysight N4917CPCA**.

The main window of the N4917CPCA software is displayed (see Figure 6).

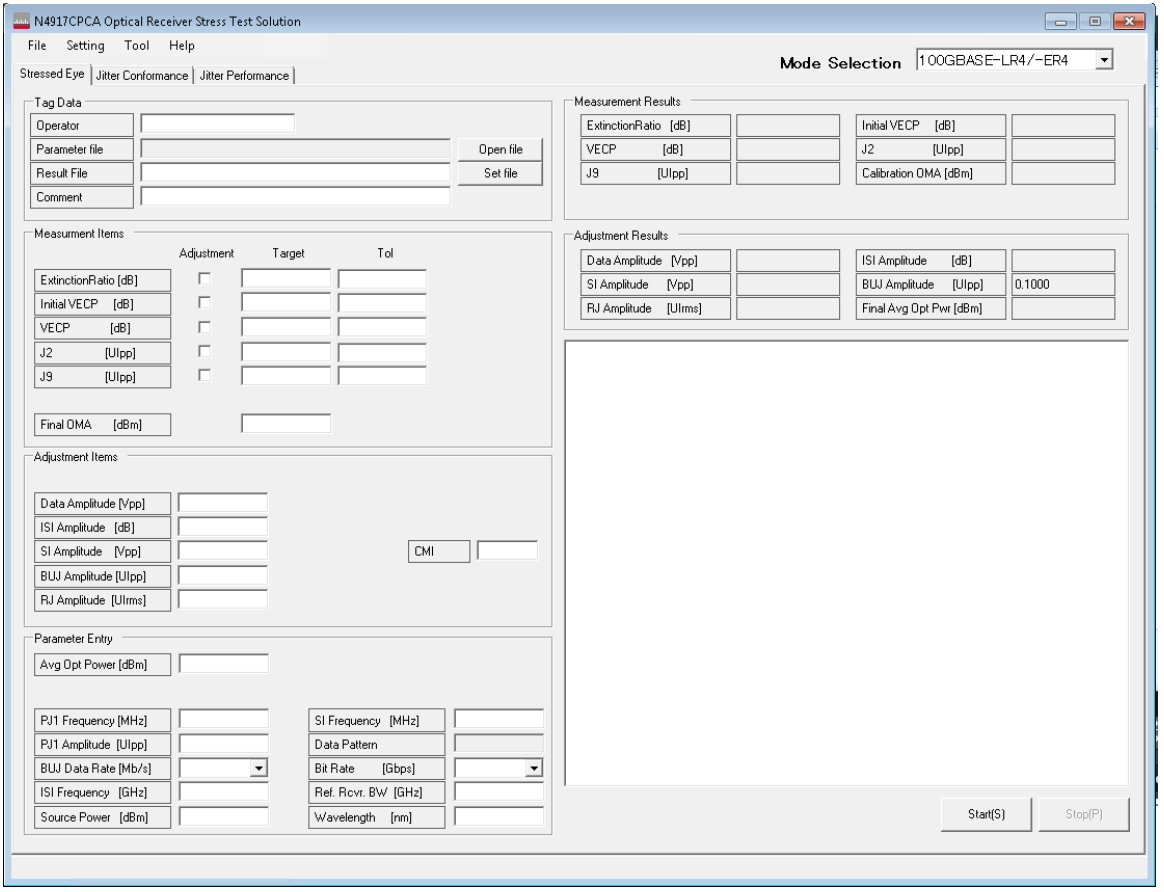


Figure 6 N4917CPCA Software Main window

Selecting a Standard for Optical Receiver Stress Test

The N4917CPCA software supports different standards for optical receiver stress testing. Select the required standard from the Mode Selection drop-down list.

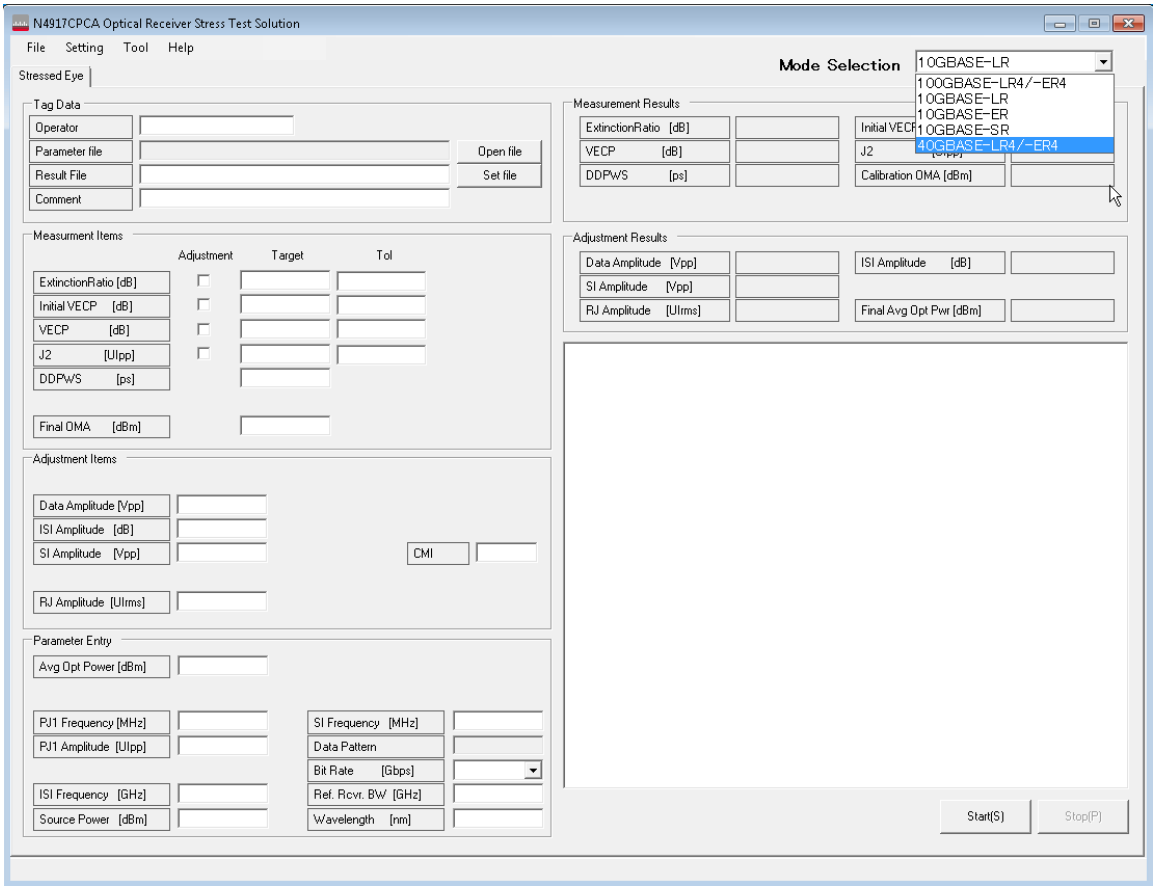


Figure 7 N4917CPCA Mode Selection

Connecting to Equipment

From the **Setting** menu select **System Connection Check** to enter the remote control addresses for each instrument to be controlled.

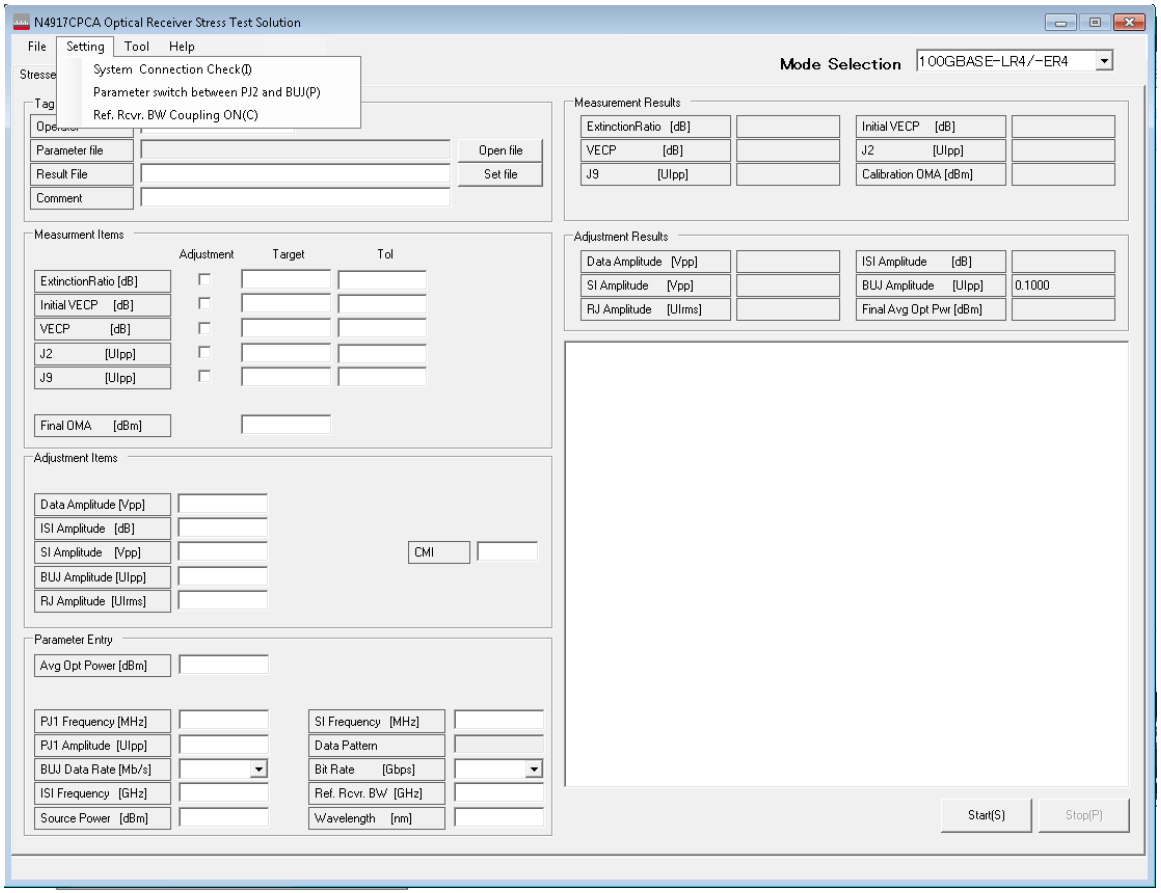


Figure 8 N4917CPCA System Connection Check

NOTE Instruments may need to be connected or discovered with Keysight IO Libraries Connection Expert before running the N4917CPCA Software.

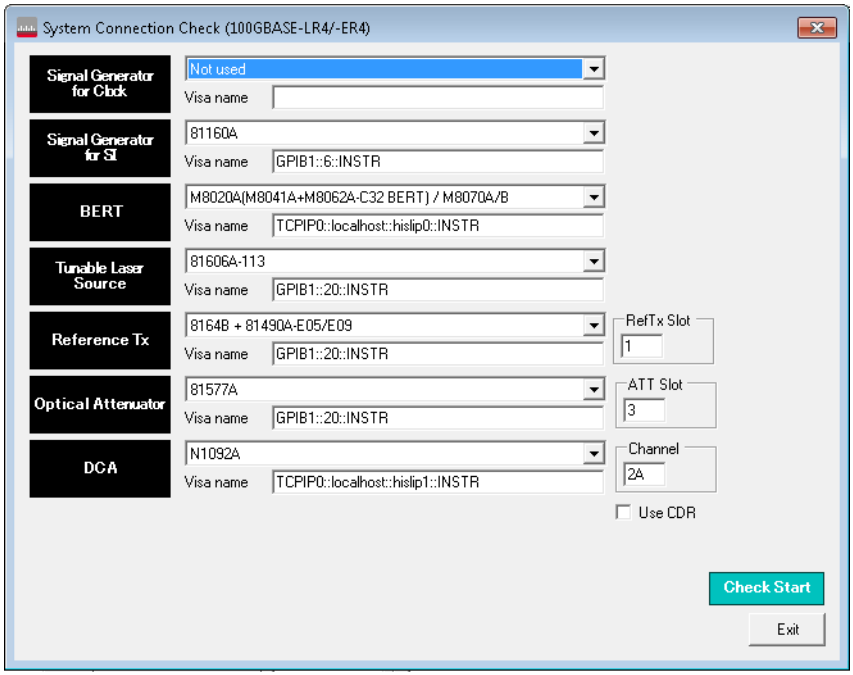


Figure 9 System Connection Check window

The N4917CPCA Software supports GPIB, LAN and USB connections to equipment, provided the instrument hardware supports those interfaces. For each instrument in use, select the correct model number, enter the VISA address and where necessary the slot or channel number.

NOTE For LAN connections use either HISLIP or VXI-11 (INST) connections. Connections via SOCKET or TELNET are not supported.

A selection of instruments is supported, including in some cases the option for non-remote control. If either "w/o control" (i.e. manual control of instrument) or "not use" is selected then the contents of the VISA address box are not used and it can be left blank.

NOTE VISA IP addresses starting with TCPIP0::127.0.0.1:: or TCPIP0::localhost:: can be used if a remote instrument GUI (e.g. M8070A BERT SW or N1010A FlexDCA SW) is running on the same computer as the N4917CPCA Software.

For any optical equipment that is installed in an 8163B/8164B LMS mainframe, use the VISA address of the 8163B/8164B mainframe plus slot number to identify it.

NOTE Use of an external Tunable Laser Source is also supported but it will not be remotely controlled. You must set its power level and wavelength manually.

Once all the equipment connections have been configured, click the **Check Start** button to test the connections. Connection to each instrument will be verified and either shown as a pass or fail with error information.

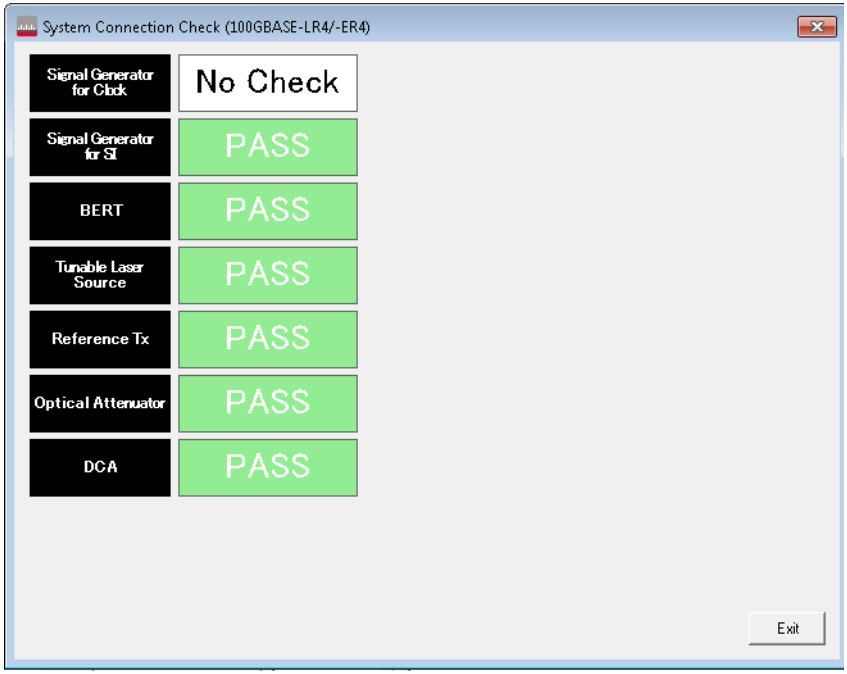


Figure 10 Successful System Connection Check

System Performance Check

Prior to running the N4917CPCA Test Solution software for the first time, or whenever equipment is re-configured, it is recommended to verify the intrinsic system performance. The System Performance Check ensures that all connections are correct and that the basic system performance is sufficient before running a stressed eye calibration.

Power on all equipment and allow them to warm up before you run the system performance verification process. Recommended warm up time is at least one hour.

Before running a System Performance Check you must run the System Connection Check per the previous section and also load an Eye Parameter file (see “Stressed Eye Calibration”).

From the **Tool** menu select **System Performance Check**.

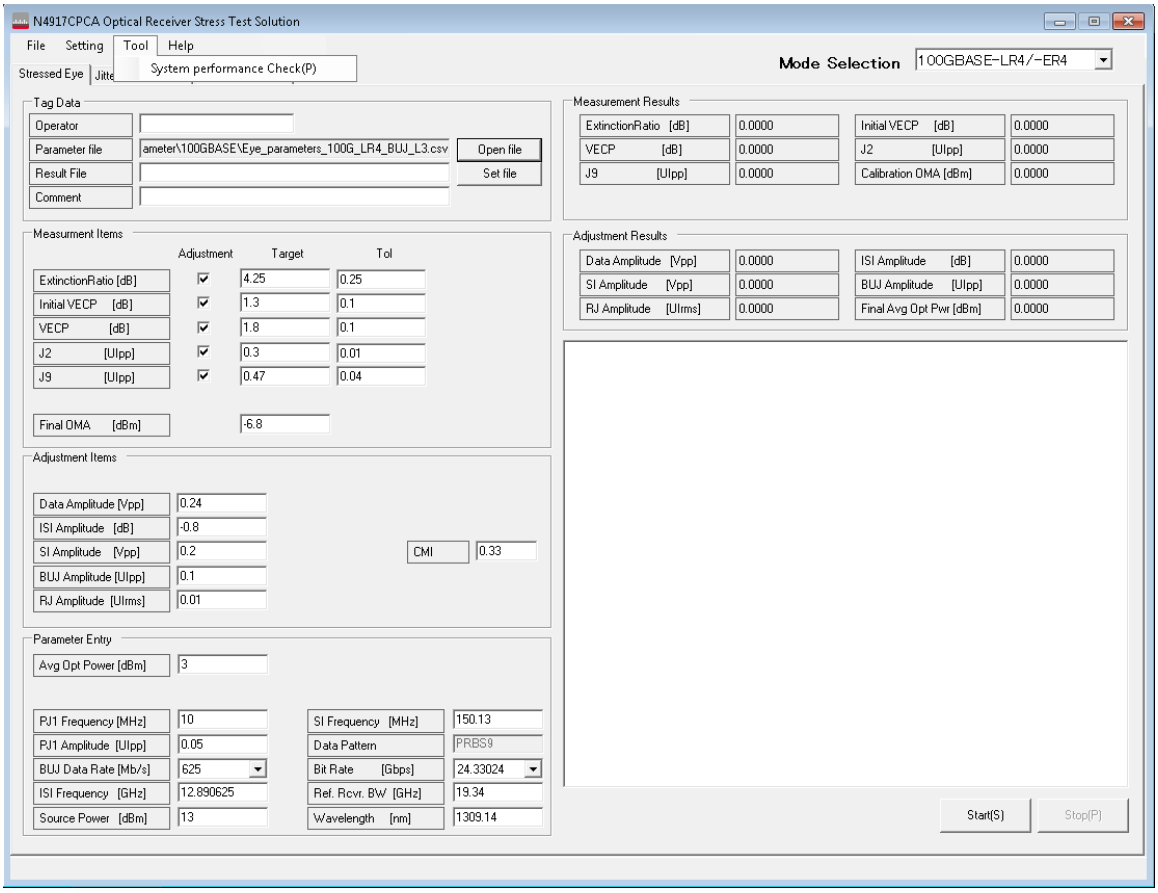


Figure 11 N4917CPCA System Performance Check

From the **System Performance Check** window you can set the BERT de-emphasis Pre-cursor1 and Post-cursors 1,2, if desired, to obtain an optimum optical waveform with minimum jitter. Usually, for 100GBASE configurations around -2 dB of Post-cursor 1 is all that is required. For 40GBASE/10GBASE configurations usually 0 to -0.5 dB of Post-cursor 1 is sufficient. Select the appropriate de-emphasis values and click the **Set** button to send to the hardware; observe the resulting optical waveform on the DCA.

Note the set of values for De-emphasis. You must also enter these values into the respective Eye Parameter files. Refer to the "Stressed Eye Calibration" section for more information on Parameter Files.

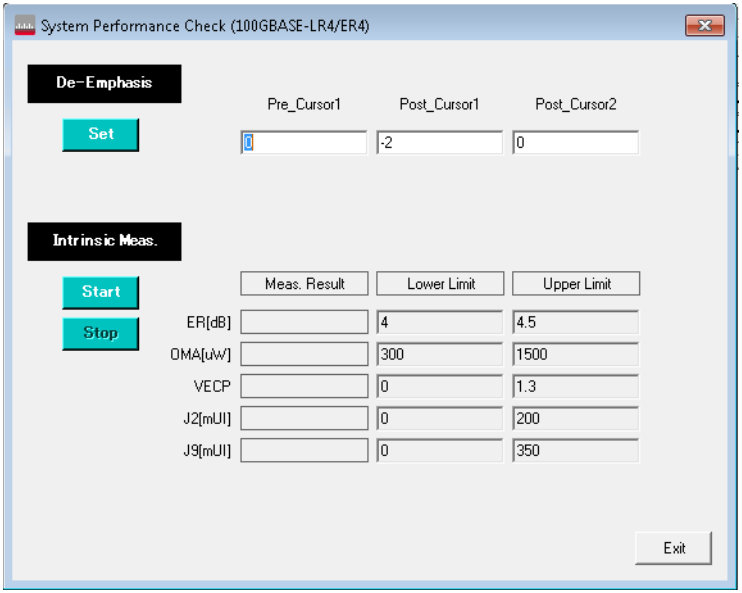


Figure 12 System Performance Check window

To measure the basic system performance click the **Start** button under **Intrinsic Meas**. This initiates a sequence of tests with all jitter/impairment sources turned off, and measures extinction ratio (ER), optical modulation amplitude (OMA), vertical eye closure penalty (VECP), jitter J2, and jitter J9. The results of this clean optical signal are displayed in the first column of the table. The other columns, **Lower Limit** and **Upper Limit** are not hard limits; they are just a typical range of values that might be expected. Results above or below these limits might still be acceptable.

Figure 13 shows the results of a System Performance Check. Results are highlighted if the measured value falls outside of the lower/upper limits, as a warning only. In addition to checking whether the measured results fall within the limits, there is also a check on the amount of margin to the stressed eye specification for J2 and J9. For best performance and likelihood of achieving a successful stressed eye calibration there should be more margin for the J9 results than the J2 results, since the J9 parameter is most sensitive to the addition of the other eye impairments.

In the example shown below, the J2 margin: 300 mUI - J2 (mUI) [76 mUI] is less than the J9 margin: 470 mUI - J9 (mUI) [160 mUI].

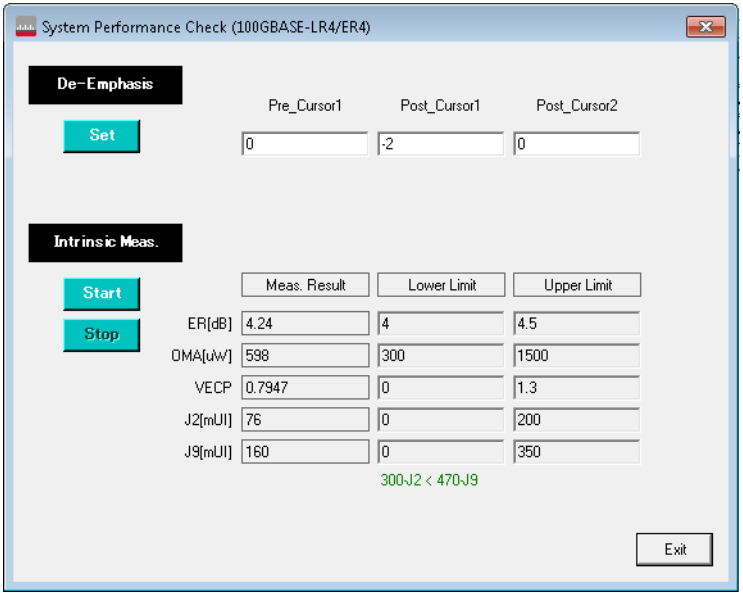


Figure 13 Results of a System Performance Check

Main GUI

Figure 14 shows the different areas on the main window of the N4917CPCA Optical Receiver Stress Test Solution software. Also, there are three tabs—**Stressed Eye**, **Jitter Conformance** and **Jitter Performance**—that define the functions performed by the software. Switch tabs to access each function.

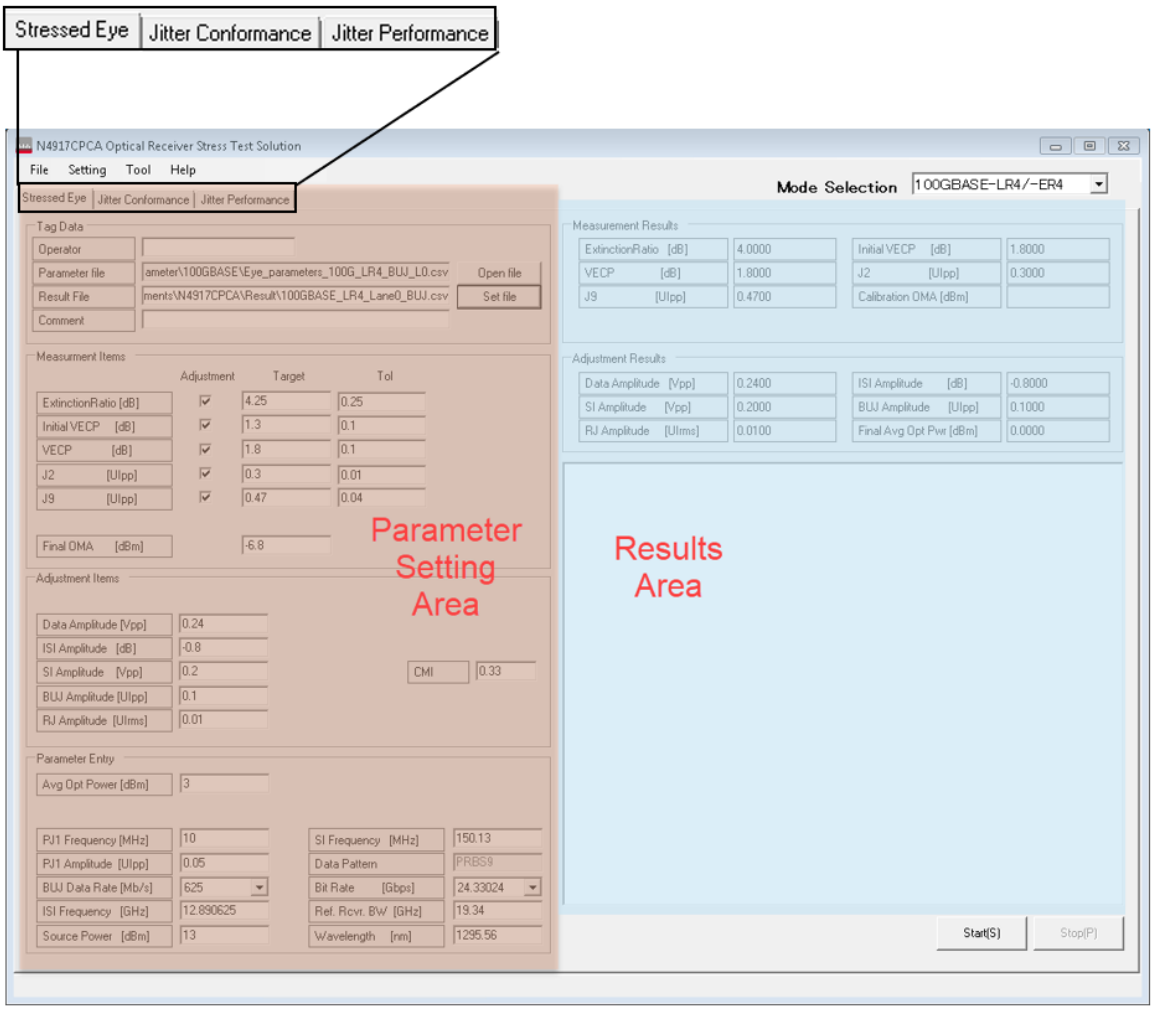


Figure 14 Parameter settings and Results area on main window

Under each tab, you will commonly find that the left side of the window is an area to set parameters for measurements and the right side is an area that displays information and measurements results in the end.

Stressed Eye Calibration

Set Parameter file and Result file

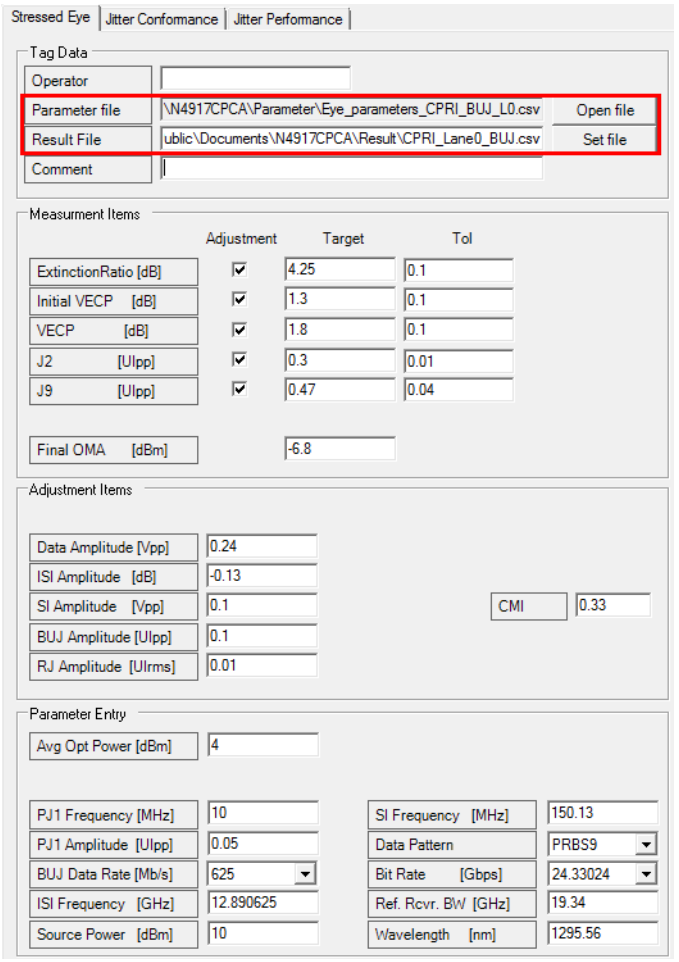


Figure 15 Setting Parameter and Result file locations

To set the **Parameter file** and **Result file**:

1 Click the **Open file** button and select a parameter file. Default location for parameter files is *C:\Users\Public\Public Documents\N4917CPCA\Parameter*. There are sub-folders for each supported standard:

- 10GBASE
- 40GBASE
- 100GBASE

Each sub-folder contains default parameters for each data lane/ wavelength/ reach. These files have a file name of form *Eye_parameters_uuuu_xxxx_yyy_zz.csv*.
It takes **about 1.5 minutes** to load a parameter file since the SW also establishes communication between the control PC and measurement instruments and sets up all the necessary parameters for the instruments. The status bar on the main window of the N4917CPCA software displays **Initializing instruments now...** at the bottom left corner until the set up is complete.

2 Click the **Set file** button to specify a result file. Default location for results files is *C:\Users\Public\Public Documents\N4917CPCA\Result*. These files can have any name format but it is recommend to keep a similar name format as the parameter files.

Since parameter files and results files have the same format, after at least one stressed calibration run, you could select a previous results file as a parameter file for the next stressed eye calibration run.

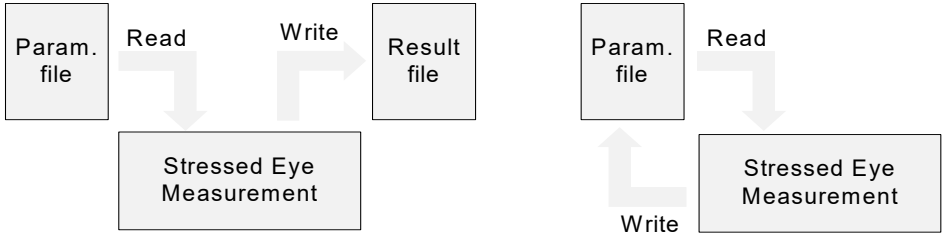


Figure 16 Parameter and Result files interaction

The **Parameter file** loads all of the parameters in the left side of the main window. If required, you may adjust parameters directly on the main window before clicking **Start(S)** to commence a stressed eye calibration.

The choice between PJ2 sinusoidal or RJ random jitter and BUJ, as well as the bit rate and DCA reference receiver bandwidth, can all be defined in the parameter file. There are default parameter files for each optical lane

for both PJ2/RJ and BUJ. In the default files, the bit rate is set to the CPRI line rate, and the DCA reference receiver bandwidth is set to 75% of the bit rate.

PJ2/BUJ or RJ/BUJ: The dominant driving parameter for J2 is the BERT PJ2, RJ, or BUJ amplitude. The choice can be made by loading a parameter file or can also be chosen in the N4917CPCA GUI.

Bit Rate: The N4917CPCA can calibrate a stressed eye at either the IEEE802.3 standard rates or the CPRI rates e.g. for 100GBASE standards 25.78125 or 24.33024 Gb/s, for 10/40GBASE standards 10.3125, 10.1376 or 9.8304 Gb/s. This choice can be made in the parameter file or from a bit rate selection in the N4917CPCA GUI.

DCA Reference Receiver Bandwidth: IEEE 802.3 10/40/100GBASE sections define the DCA reference receiver bandwidth to be 75% of the bit rate e.g. 19.34 GHz BW for 25.78125 Gb/s data rate and 7.465 GHz BW for 10.3215 Gb/s date rate. This is achieved by using either hardware filters or the SIRC function in the DCA, so that the DCA has the same bandwidth as a compliant DUT when calibrating the stressed eye parameters.

When using IEEE 802.3 compliant devices in a CPRI fronthaul network application, even though the bit rate is different, the DUT receiver bandwidth should not change. To accommodate this, the DCA Ref Rcvr BW is user- adjustable. If Ref Rcvr BW Coupling is set to ON then the DCA receiver bandwidth will be set to 75 % of the bit rate, e.g., 19.34 GHz for 25.78125 Gb/s or 18.25 GHz for 24.33024 Gb/s. If Ref Rcvr BW Coupling is set to OFF, then initially, the value from the last loaded parameter file will be used, and the user can edit this value in the N4917CPCA GUI prior to starting a stressed eye calibration.

The default and the recommendation is Ref Rcvr BW Coupling = OFF, i.e., BW is always 75 % of the IEEE 802.3 data rates.

Parameter details

Figure 17 shows the stressed eye calibration targets and tolerance.

The **Adjustment** check box, if checked, adjusts the parameters shown in Figure 17 to meet the target values during the stressed eye calibration. (This is equivalent to a value of TRUE for these parameters in the parameter file). If an item is unchecked, it is measured but not optimized. You may uncheck all the items and still run the test to verify performance. It is not recommended to check some but uncheck others as these items, in general, are interdependent.

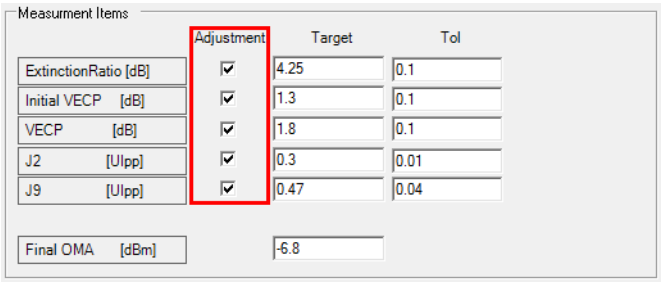


Figure 17 Measurement Items

Figure 18 and Figure 19 show the PJ2 and BUJ views of the parameters, respectively, that are adjusted by the N4917CPCA Test Solution software in order to meet the stressed eye calibration targets. Starting values, loaded from the parameter file, speed up the calibration. It is not recommended to put **0** as a value in for any of these parameters because doing so limits the initial adjustment in only one direction and can lead to long calibration times.

NOTE For the 10GBASE standards, the selection is RJ or BUJ as there is no PJ2 component in the stressed eye for 10GBASE standards.

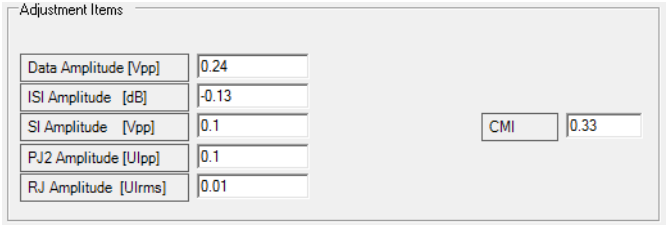


Figure 18 Adjustment Parameters (PJ2)

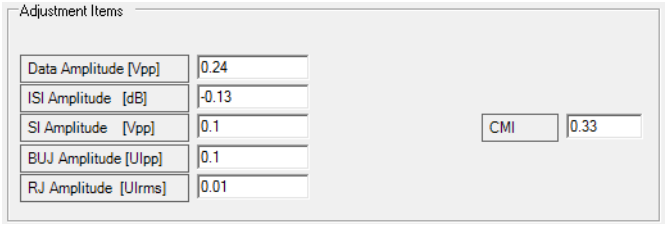


Figure 19 Adjustment Parameters (BUJ)

Although interdependent, Table 5 indicates which adjustment parameter has the most effect on each measurement item.

Table 5 Measurement Item/Adjustment Parameter Relationship

Order	Measurement Item	Adjustment Item	Note
1	Extinction Ratio	Data amplitude	
2	Initial VECP	ISI amplitude	VECP is calculated from OMA and Ao
3	VECP	SI amplitude	VECP is calculated from OMA and Ao
4	J2	PJ2/RJ amplitude or BUJ amplitude	
5	J9	RJ amplitude	

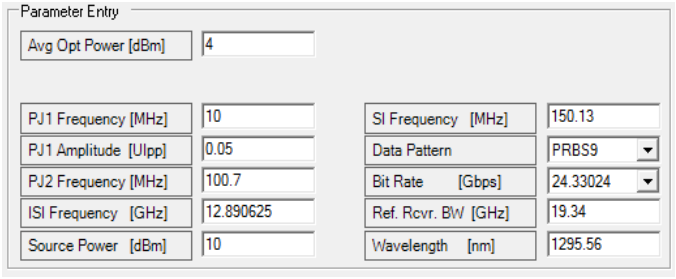


Figure 20 Other Parameters (PJ2)

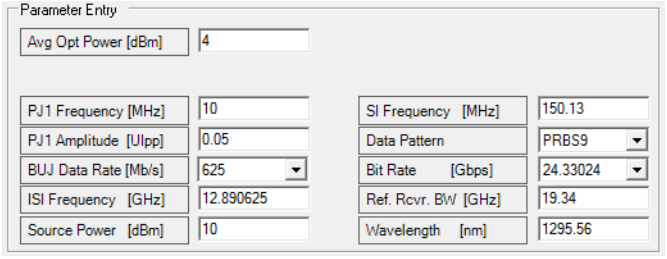


Figure 21 Other Parameters (BUJ)

Generally, there is no need to make any changes to the remaining parameters.

NOTE You cannot edit the Data Pattern here. This is fixed by the software. 40/100GBASE standards use PRBS9 for stressed eye calibration; 10GBASE uses PRBS11. In all the cases, the pattern is changed to PRBS31 for DUT Jitter Conformance/Performance testing. The N4917CPCA Test Solution software automatically toggles between these patterns, when required.

PJ2/BUJ or RJ/BUJ selection

Select between PJ2/RJ or BUJ from the **Setting** menu in the GUI. The following example shows PJ2/BUJ setting.

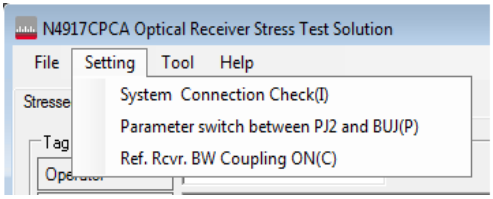


Figure 22 Selecting between PJ2 and BUJ from the Setting menu

Selecting **Parameter switch between PJ2/RJ and BUJ(P)** displays another dialog where the PJ2/BUJ or RJ/BUJ selection can be made. Additionally, you can select the BUJ Polynomial and Filter from this dialog.

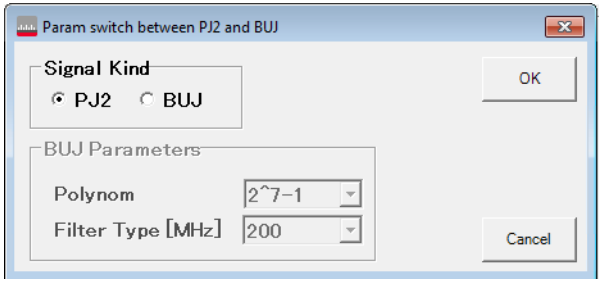


Figure 23 Selecting the signal kind and BUJ parameters

BUJ amplitude and BUJ data rate can be edited in the main window.

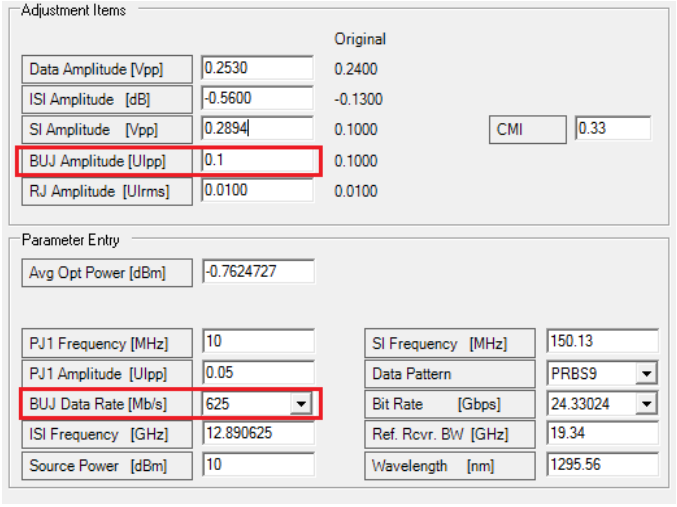


Figure 24 Editing BUJ parameters

BUJ or PJ2/RJ items are displayed in the main window depending on which is the currently active selection between BUJ and PJ2/RJ.

Bit Rate: Select the operating bit rate from the drop-down list. Ensure that you select a bit rate that is compatible with the selected standard.

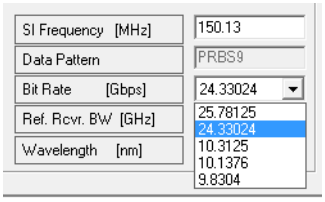


Figure 25 Selecting bit rate

DCA Reference Receiver Bandwidth: Select Ref Rcvr BW Coupling ON or OFF from the **Setting** menu.

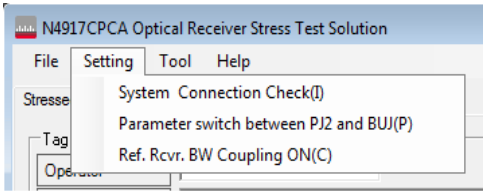


Figure 26 Ref Rcvr BW Coupling is OFF

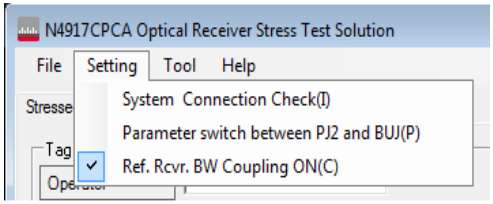


Figure 27 Ref Rcvr BW Coupling is ON

When Ref Rcvr BW is ON, the Ref. Rcvr. BW [GHz] parameter on the main window is grayed out and uneditable. The value shown in the box may be updated shortly after a stressed eye calibration is started to reflect the automatically set DCA Reference Receiver Bandwidth.

Running the Stressed Eye calibration

1 Click **Start(S)** to commence the Stressed Eye calibration.

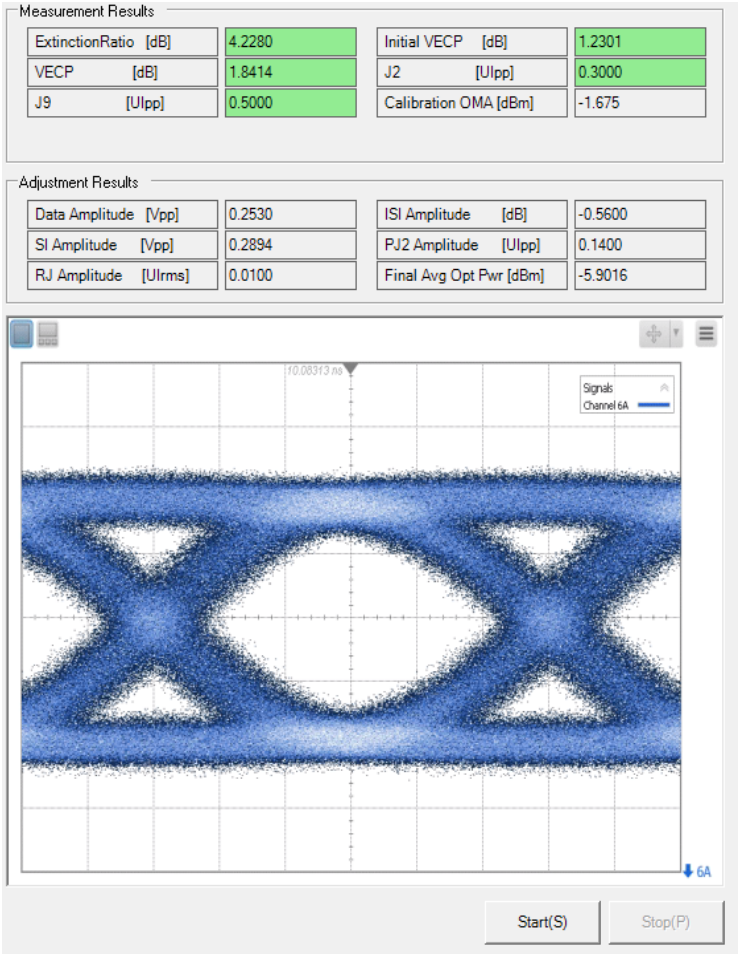


Figure 28 Main window Results area (PJ2)

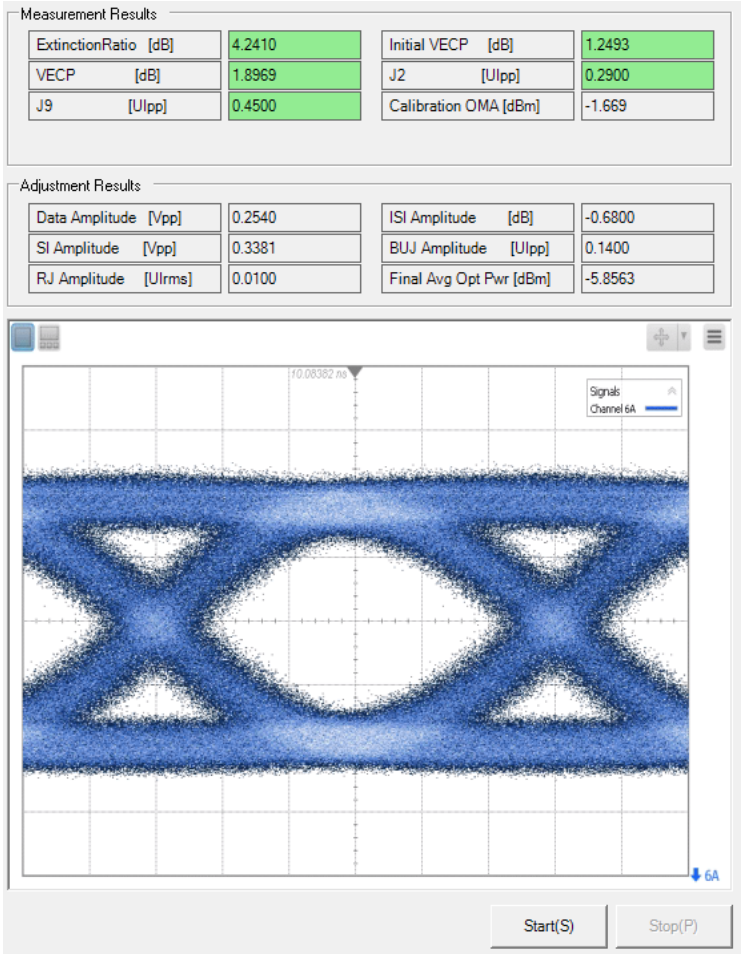


Figure 29 Main window Results area (BUJ)

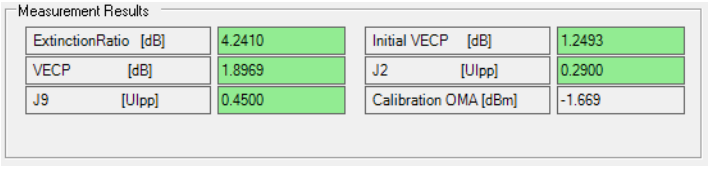


Figure 30 Measurement results

During the stressed eye calibration, current values of the measured results are shown on the GUI. When the calibration is complete, items highlighted with a green background, as shown in Figure 30, indicate that they have met the target +/- tolerance value. Items highlighted with an amber background indicate that calibration was not successful.

The stressed eye calibration sets the desired Extinction Ratio, then sets the initial VECP, followed by iterating a repetitive loop of setting VECP, J2 and J9; until either all measurements meet the target +/- tolerance values or at least 10 loops have been run.

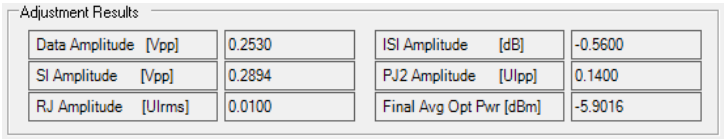


Figure 31 Adjustment parameter results (PJ2)

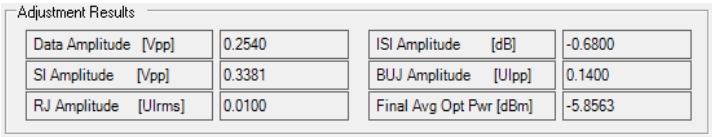


Figure 32 Adjustment parameter results (BUJ)

During the stressed eye calibration, current values of adjustment parameters are also shown on the GUI. When the calibration has completed, the final values of the adjustment parameters are displayed, as shown in Figure 31 and Figure 32.

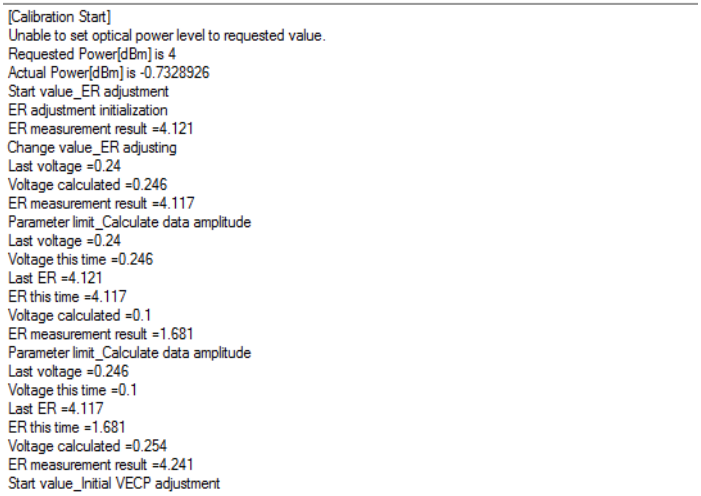


Figure 33 Stressed eye calibration status messages

During the stressed eye calibration, the lower part of the results area shows status messages and progress of the calibration, as shown in Figure 33.

When the calibration is complete, the N4917CPCA Test Solution software displays a screen capture of the stressed eye taken from the DCA, as shown in Figure 34.

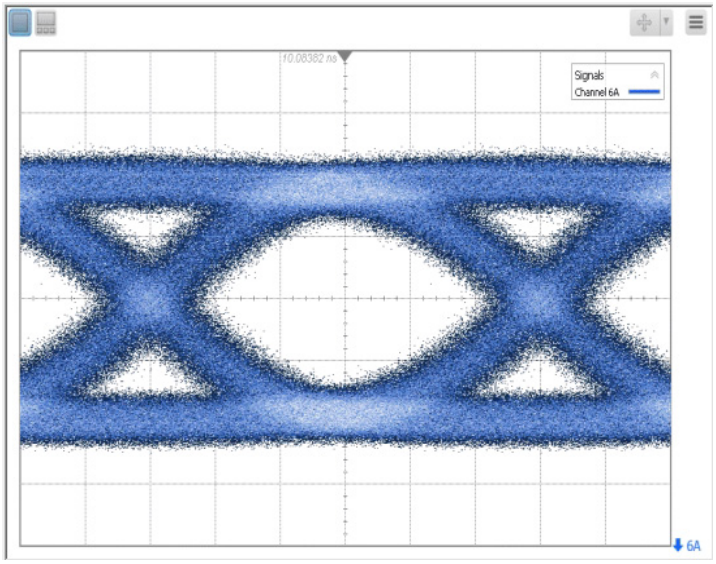


Figure 34 Stressed eye calibration complete, waveform capture from DCA

Results of the calibration along with complete parameter settings are saved in the specified Results file.

OMA setting for DUT measurement

When a successful stressed eye calibration is achieved, the optical attenuator is adjusted to set the OMA to the level specified for DUT measurement and the data pattern is changed to PRBS31.

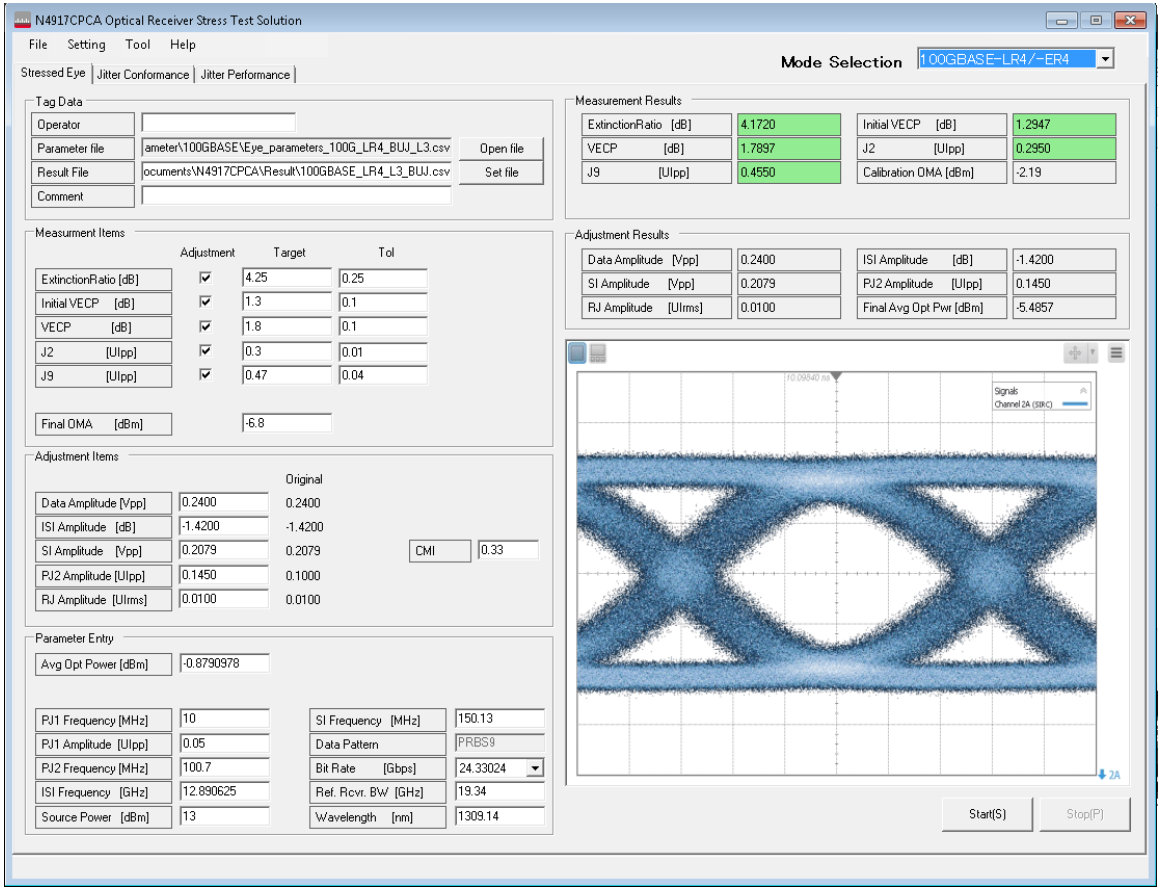


Figure 35 Main window after Stressed Eye Calibration is complete (PJ2)

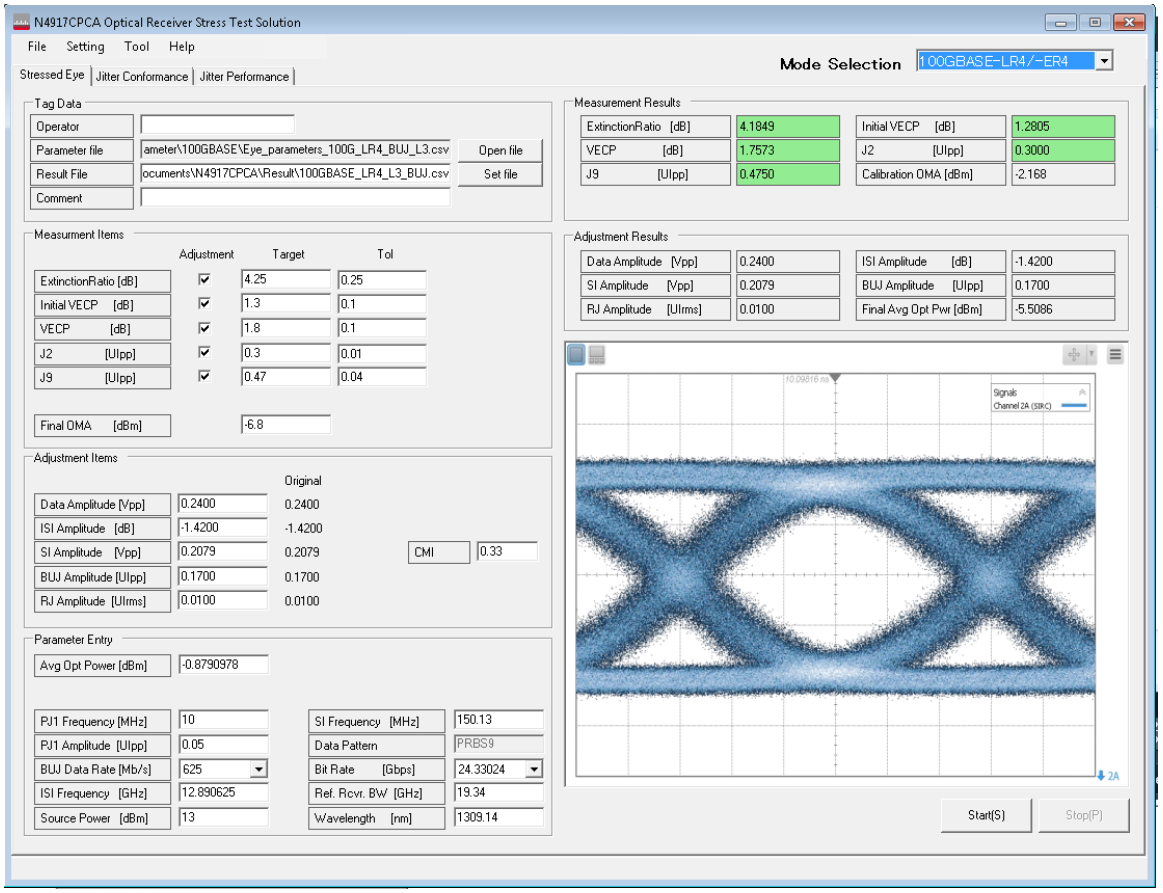


Figure 36 Main window after Stressed Eye Calibration is complete (BUJ)

Testing a CPRI Interface

Once the Stressed Eye Calibration is complete, remove the optical fiber connection from the DCA input and connect it to the input of the CPRI interface device under test. Exact connection details and setup depend on the system architecture being tested and are therefore not covered in detail in this guide.

CPRI Fronthaul Radio Equipment Input Test

Typically the calibrated stressed eye signal is connected to the input of the CPRI radio equipment lane under test, and either BER or Clock frequency stability and noise measurements are performed.

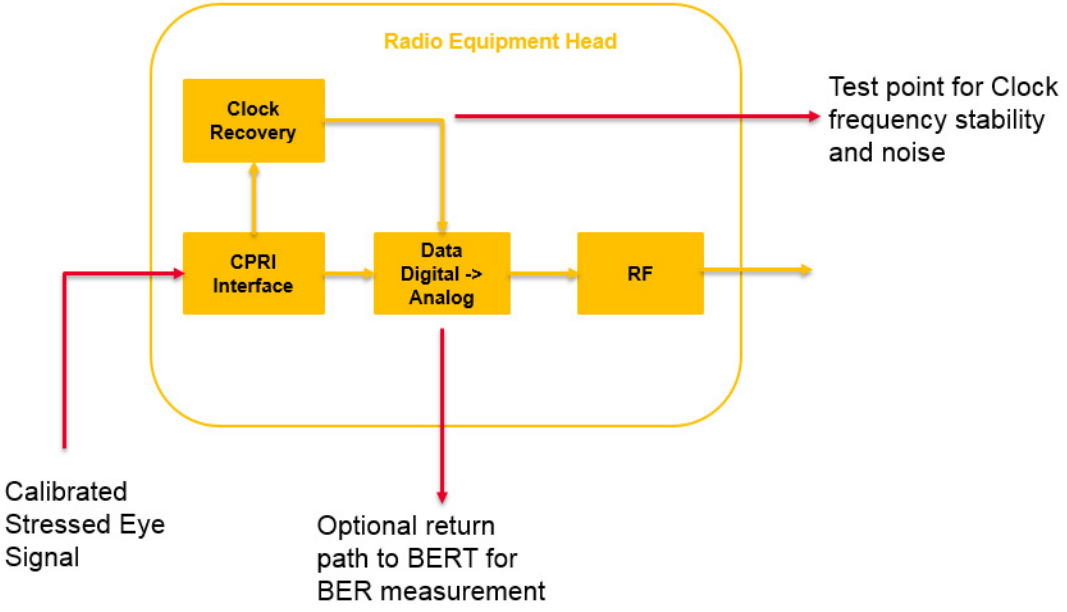


Figure 37 Example CPRI setup for running a stressed receiver sensitivity testing on a DUT

Jitter Conformance Test

The Jitter Conformance Test is a semi-automatic test to check the DUT stressed receiver sensitivity in accordance with the applicable standard.

You must run the Stressed Eye Calibration before running the Jitter Conformance Test.

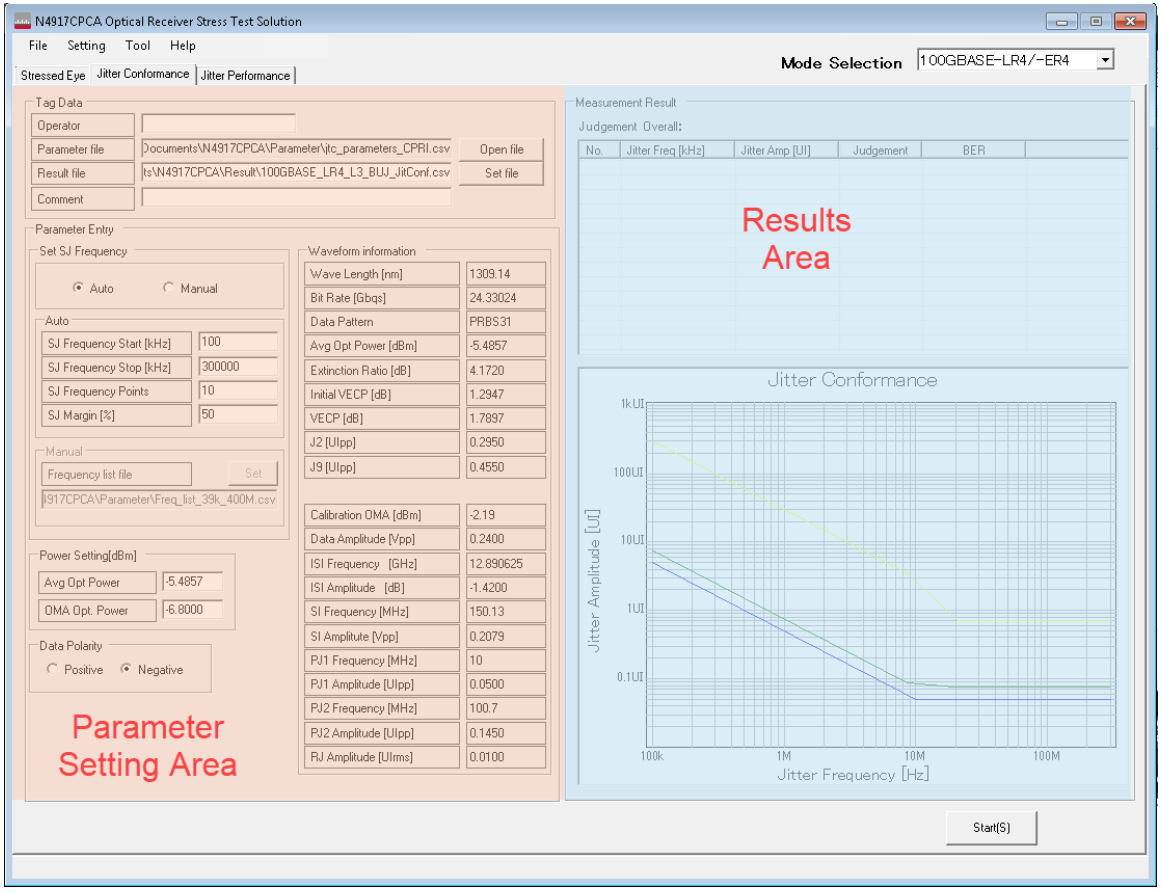


Figure 38 Jitter Conformance test window

The Jitter Conformance Test routine sets up the jitter frequency and amplitude for each test point. You must enter the BER value and make a **judgment** of whether the result is a pass (**GO**) or fail (**NoGO**).

Set Result file

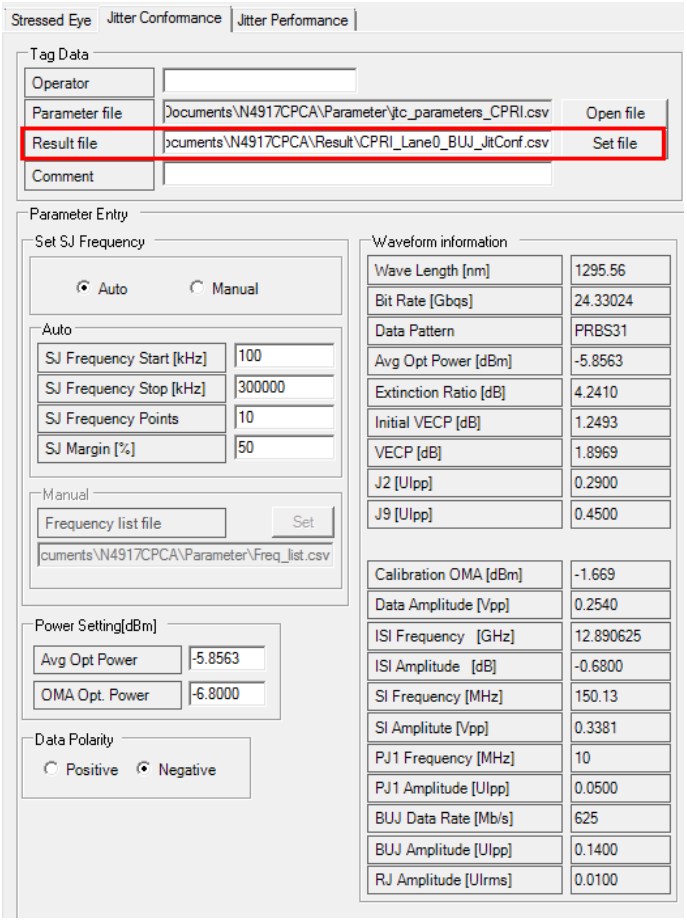


Figure 39 Setting Result file location

The N4917CPCA Test Solution software automatically loads parameters from the most recent Stressed Eye Calibration.

1 Click the **Set file** button and specify a Results file. Default location for the results files is *C:\Users\Public\Public Documents\N4917CPCA\Result*

Parameter Details

The Jitter Conformance measurement sweeps sinusoidal jitter (PJ1) from a maximum range of 40/100 kHz to 300 MHz. You may set the Start frequency to a value, which is greater than or equal to the minimum and you may set the Stop frequency to a value, which is less than or equal to 300 MHz. Also, set the number of frequency points and the optional margin percentage (%).

In **Auto** mode, the specified number of test frequencies are equally spaced between the specified start and stop frequency. Jitter amplitude is set either to the specified compliance value or to a percentage (%) higher than the compliance value, if a non-zero value is entered in the **SJ Margin [%]** field.

In **Manual** mode, the SJ frequencies and amplitudes are defined in a Frequency List file. Default location for the Frequency List file is *C:\Users\Public\Public Documents\N4917CPCA\Parameter*. The Frequency List file in the **.csv** format, consists of a simple list of SJ frequency and amplitude values as shown in Table 6:

Table 6 An example of Manual mode jitter frequency/amplitude list

Frequency (kHz)	Amplitude (UI)
100	10
300	5
1000	2
3000	1
10000	0.4
30000	0.3
100000	0.2
300000	0.15

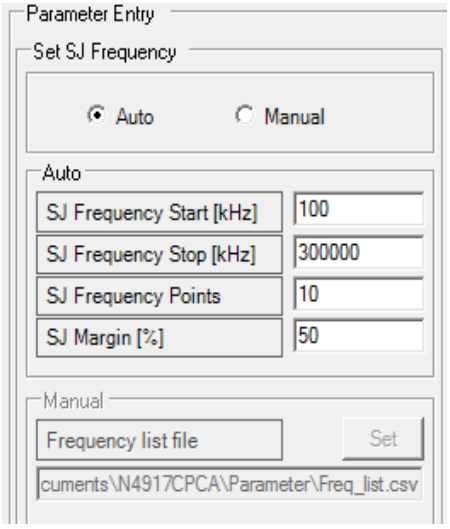


Figure 40 Jitter Conformance test parameters

Generally, you are not required to make any changes to the remaining parameters as the N4917CPCA Test Solution software automatically loads such parameters from the Stressed Eye Calibration Results file.

Running the Jitter Conformance Test

1 Click **Start(S)** to commence the Jitter Conformance Measurement.

For each SJ frequency/amplitude test point, a dialog box appears where you must enter the BER value, read from the DUT, and decide on selecting either **GO** or **NoGO** for the test point. See Figure 41.

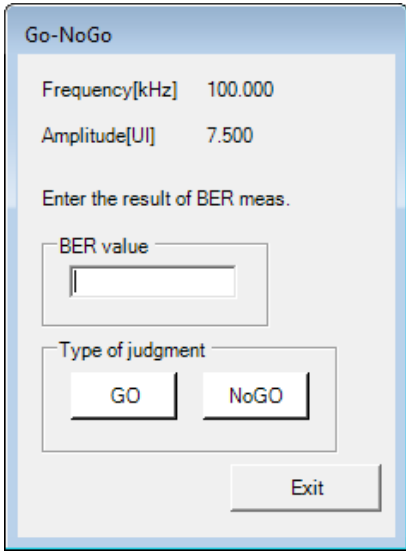


Figure 41 GO/NoGO Dialog Box

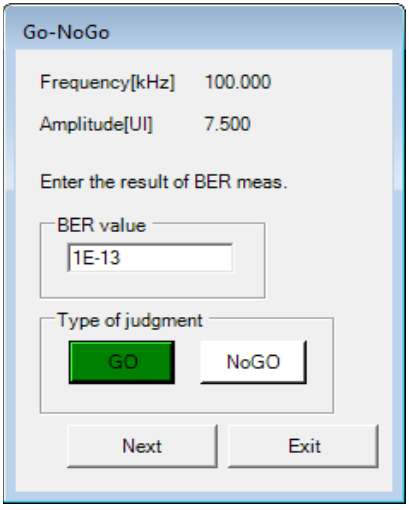


Figure 42 GO/NoGO dialog box with BER and judgment entered

2 Click **Next** to proceed to the next SJ test point, or click **Exit** to abort the Jitter Conformance Test.

Results of the Jitter Conformance test are saved in the specified Results file.

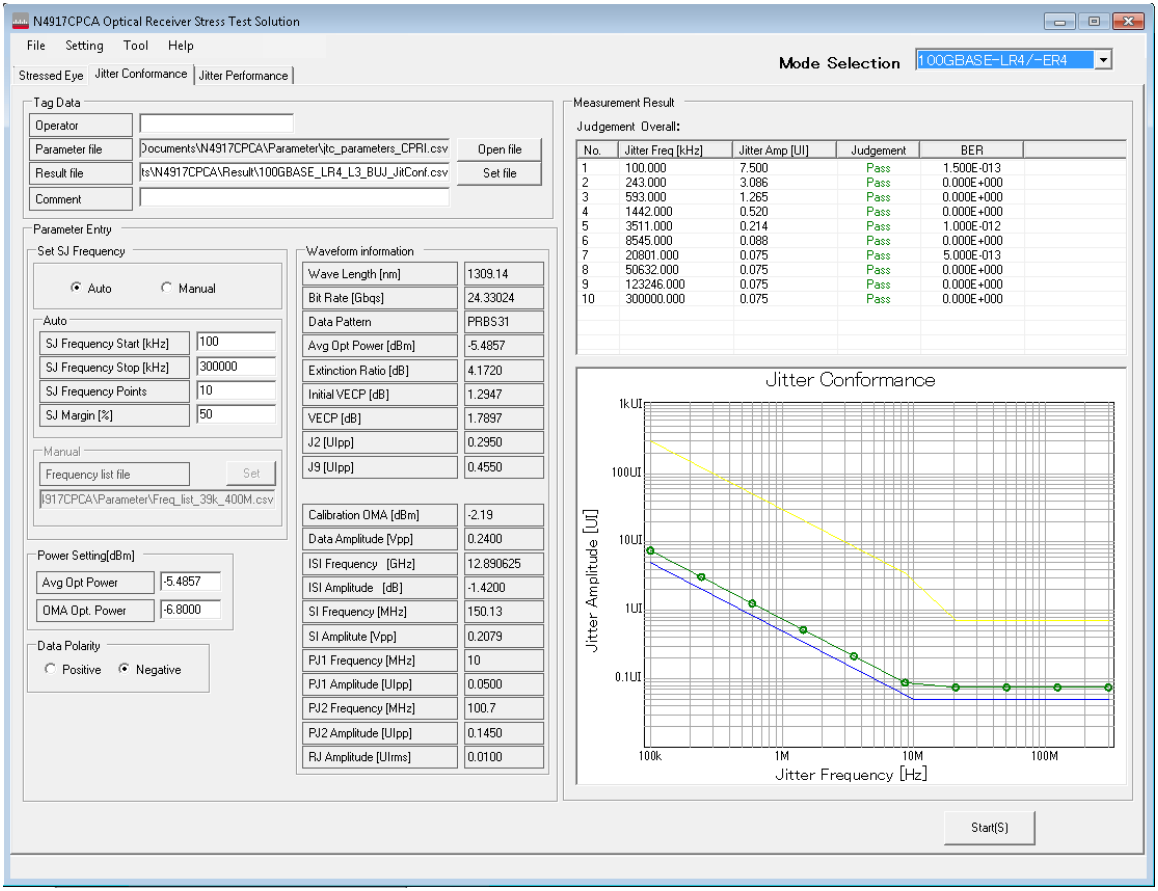


Figure 43 Jitter Conformance window after the test is complete

Jitter Performance Test

The Jitter Performance Test is a semi-automatic test to check the DUT margin for stressed receiver sensitivity.

You must run the Stressed Eye Calibration before running the Jitter Performance Test. The Jitter Performance test routine sets up the jitter frequency and amplitude for each test point. You must enter the SJ amplitude for each test point as well as the BER result and make a **judgment** of whether the result is a pass (**GO**) or fail (**NoGO**).

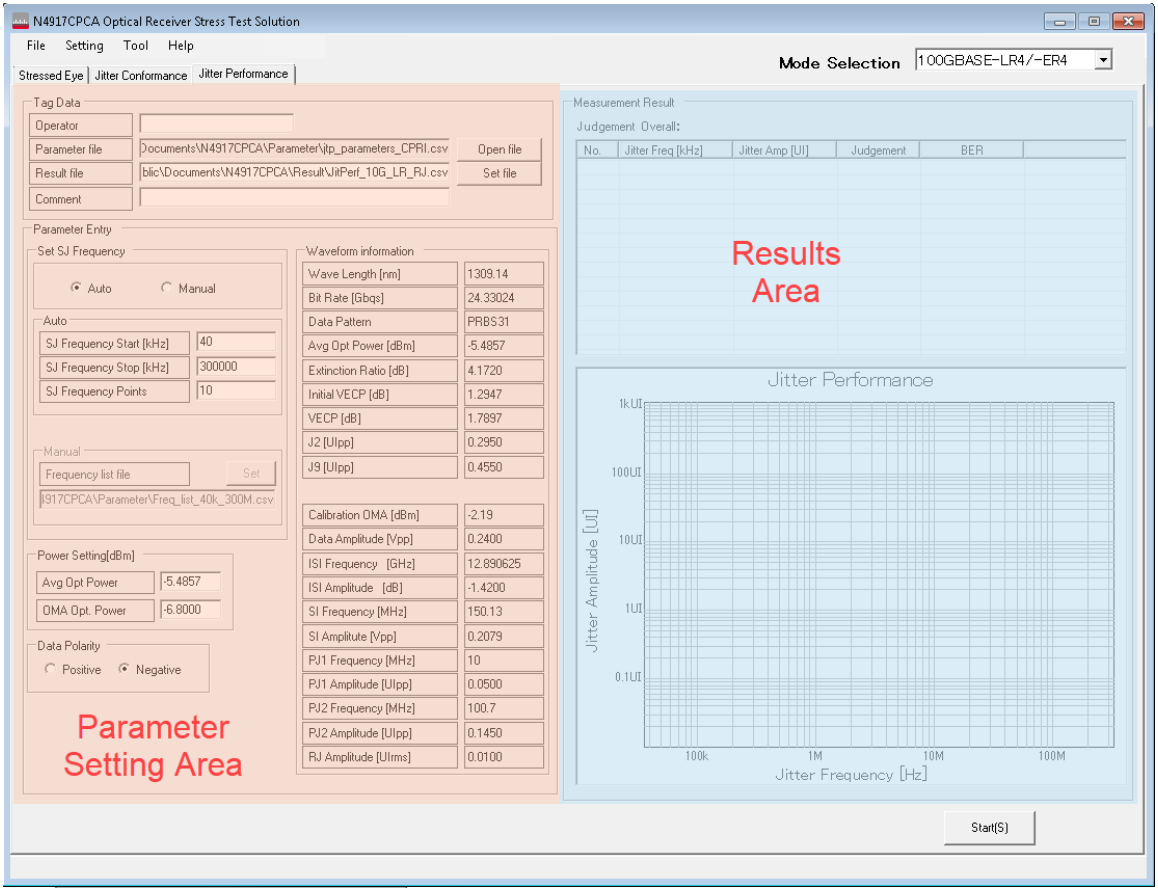


Figure 44 Jitter Performance Test Window

Set Result file

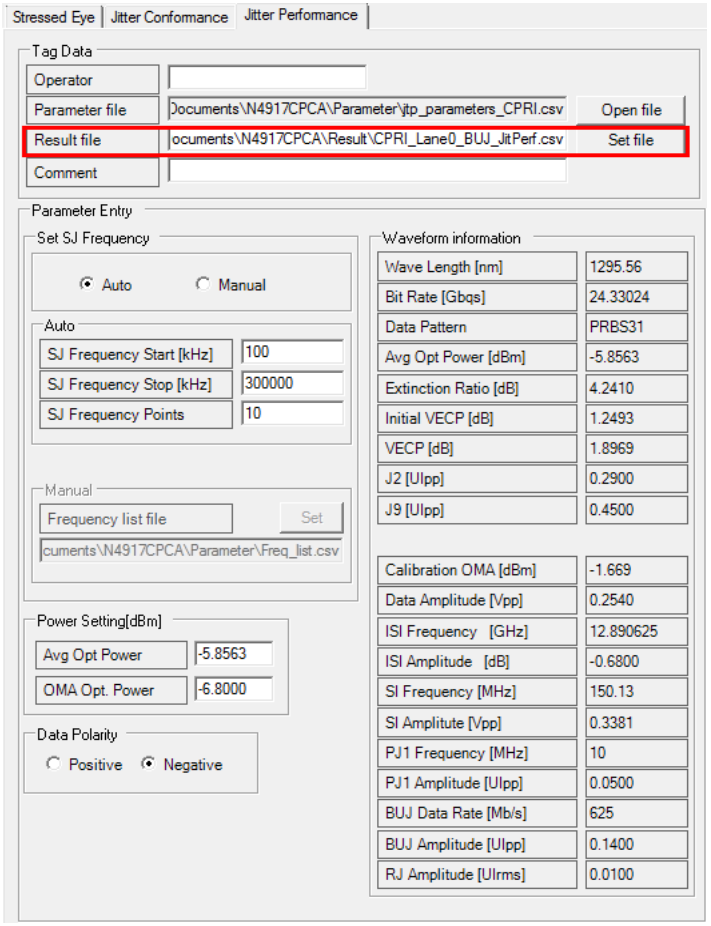


Figure 45 Setting Result File location

The N4917CPCA Test Solution software automatically loads parameters from the most recent Stressed Eye Calibration.

1 Click the **Set file** button and specify a Results file. Default location for the Results files is *C:\Users\Public\Public Documents\N4917CPCA\Result*

Parameter Details

The Jitter Performance measurement sweeps sinusoidal jitter (PJ1) from a maximum range of 40/100 kHz to 300 MHz. You may set the Start frequency to a value, which is greater than or equal to the minimum and you may set the Stop frequency to a value, which is less than or equal to 300 MHz. Also, set the number of frequency points.

In **Auto** mode, the specified number of test frequencies are equally spaced between the specified start and stop frequency values.

In **Manual** mode, the SJ frequency and amplitude values are defined in a Frequency List file. Default location for the Frequency List file is *C:\Users\Public\Public Documents\N4917CPCA\Parameter*.

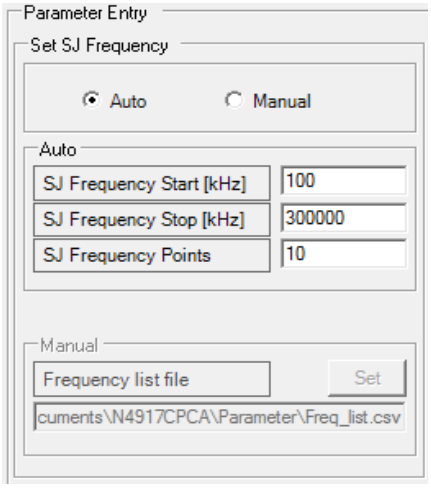


Figure 46 Jitter Performance Test Parameters

Generally, you are not required to make any changes to the remaining parameters as the N4917CPCA Test Solution software automatically loads such parameters from the Stressed Eye Calibration Results file.

Running the Jitter Performance Test

1 Click **Start(S)** to commence the Jitter Performance Measurement.

For each SJ frequency test point, a dialog box appears where you must enter the desired SJ amplitude value. See Figure 47.

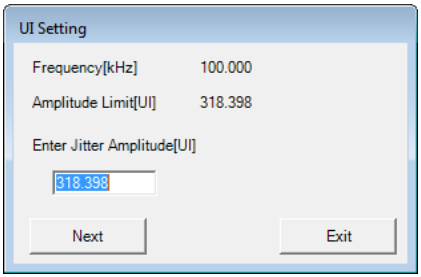


Figure 47 Enter SJ Amplitude Dialog Box

2 Click **Next**. A dialog box appears where you must enter the BER value, read from the DUT, and decide on selecting either **GO** or **NoGO** for the test point.

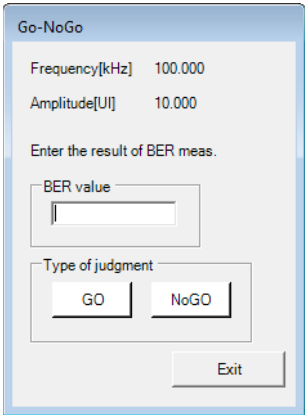


Figure 48 GO/NoGO Dialog Box for Enter SJ Amplitude Dialog Box

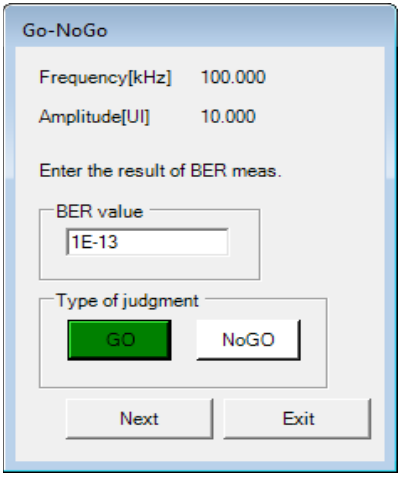


Figure 49 GO/NoGO dialog box with BER and judgment entered

3 Click **Next** to proceed to the next step, or click **Exit** to abort the Jitter Performance Test.

4 You may now enter another Jitter amplitude to test at the same SJ frequency, or click **Next Freq** to proceed to the next SJ frequency.

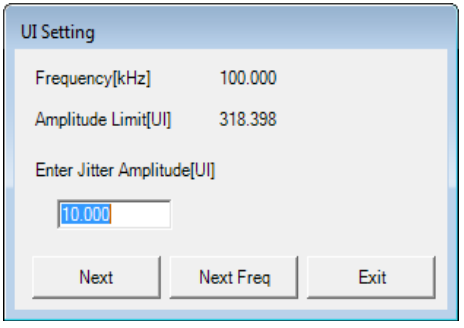


Figure 50 Enter new SJ Amplitude or proceed to the next SJ Frequency Dialog

Results of the Jitter Performance test are saved in the specified Results file.

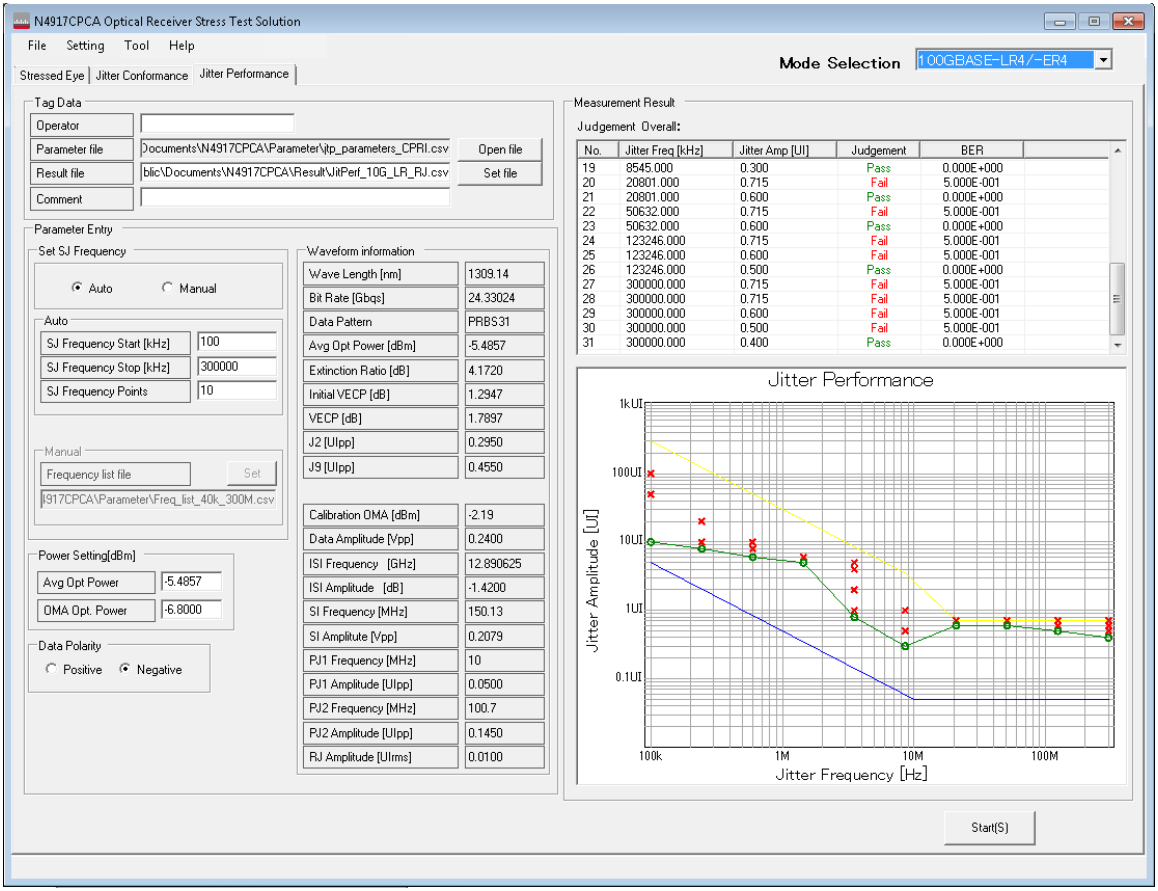


Figure 51 Jitter Performance window after the test is complete

Fully Automated Jitter Tolerance Testing

Depending on the test setup and DUT capabilities, it is also possible to run fully automated jitter tolerance measurements using the built-in JTOL measurement feature within the M8070A or M8070B JBERT System Software.

Use this test when either:

a the DUT can be put into a loopback mode and a signal from the lane under test can be fed back to the BERT Analyzer input, or

b the DUT can be controlled directly from the M8070A/B software using the 'DUT Control Interface' to read the BER directly from the DUT internal error checker counters.

The M8070A/B JTOL measurement can also be run as a compliance test with/without margin or a tolerance test to find the limits of the DUT. It has several additional features such as a choice of search algorithm, user definable BER depth, and so on.

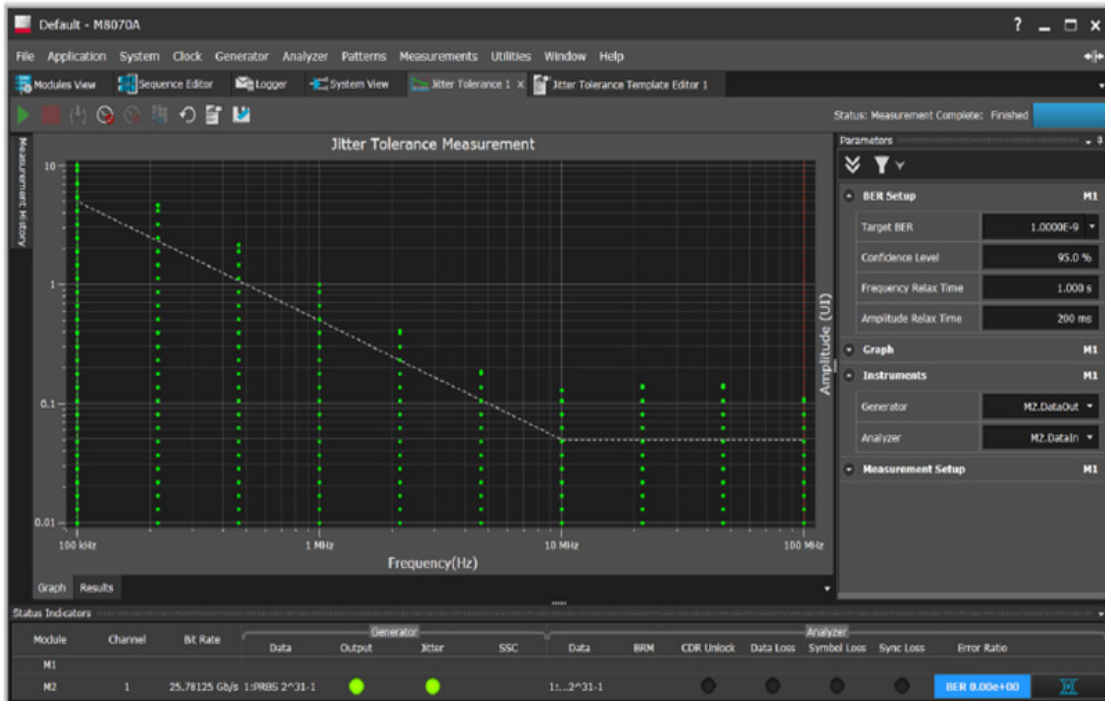


Figure 52 Jitter Tolerance Measurement System Results within M8070A software

For more information on the M8070A/B Jitter Tolerance measurement capabilities, refer to M8070A/B System Software for M8000 Series of BER Test Solutions User Guide.

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