Keysight N4917B Optical Receiver Stress Test

User Guide

KEYSIGHT TECHNOLOGIES

Notices

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1 Overview

KEYSIGHT TECHNOLOGIES

Optical Receiver Stress Test Solution—At a Glance

The Keysight N4917B Optical Receiver Stress Test Solution provides a platform for stressed receiver sensitivity test, which is compliant to automated standards for 100G Optical Receiver Stress Testing. 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 N4917B software package.

Some salient features of the N4917B Optical Receiver Stress Test Solution include:

- remote control of all the test instrumentation
- automated calibration of the optical stressed eye parameters (ER, VECP/SEC J2, J4, J9, and OMA)
- adjustable target values for ER, VECP/SEC, J2, J4, J9, and OMA
- jitter tolerance compliance and margin tests

Applicable Standards

The N4917B Optical Receiver Stress Test software supports automated optical stressed receiver sensitivity test, based on the following standards:

Test Name	Reference Standard	Configuration	Fiber Type
100GBASE-LR4	IEEE 802.3 2015 Clause 88	4x lambda WDM	single mode
100GBASE-ER4	IEEE 802.3 2015 Clause 88	4x lambda WDM	single mode
100GBASE-SR4	IEEE 802.3 2015 Clause 95	4x fiber	multi mode
100G 4WDM-10	100G 4WDM-10 MSA Rel. 1.0	4x lambda CWDM	single mode
100G 4WDM-20	4WDM-20 & 4WDM-40 MSA Rel. 1.0	4x lambda WDM	single mode
100G 4WDM-40	4WDM-20 & 4WDM-40 MSA Rel. 1.0	4x lambda WDM	single mode
100G-CLR4	100G-CLR4 Rev.1.5.2	4x lambda CWDM	single mode
100G CWDM4	100G CWDM4 MSA Rev 1.1	4x lambda CWDM	single mode

System Description

The N4917B 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 and Figure 2 show typical Optical Receiver Stressed Test equipment setups for 100G single mode flavors and 100GBASE-SR4, respectively.

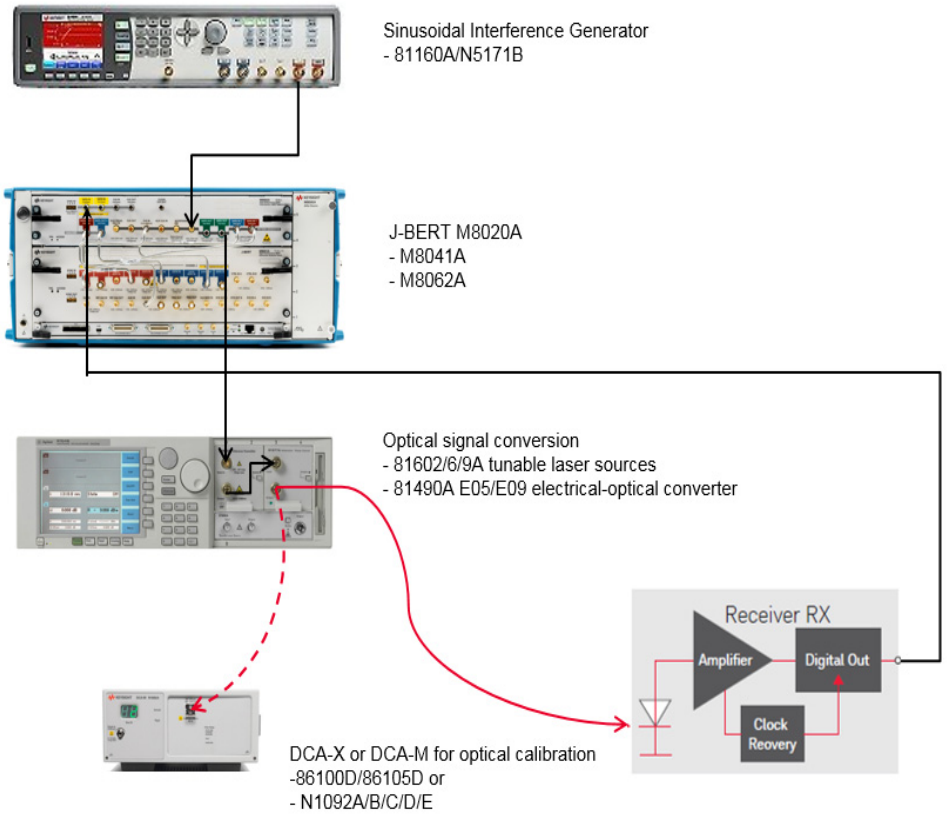

Figure 1 Example setup for 100GBASE-LR4/ER4, CLR4, 4WDM and CWDM4

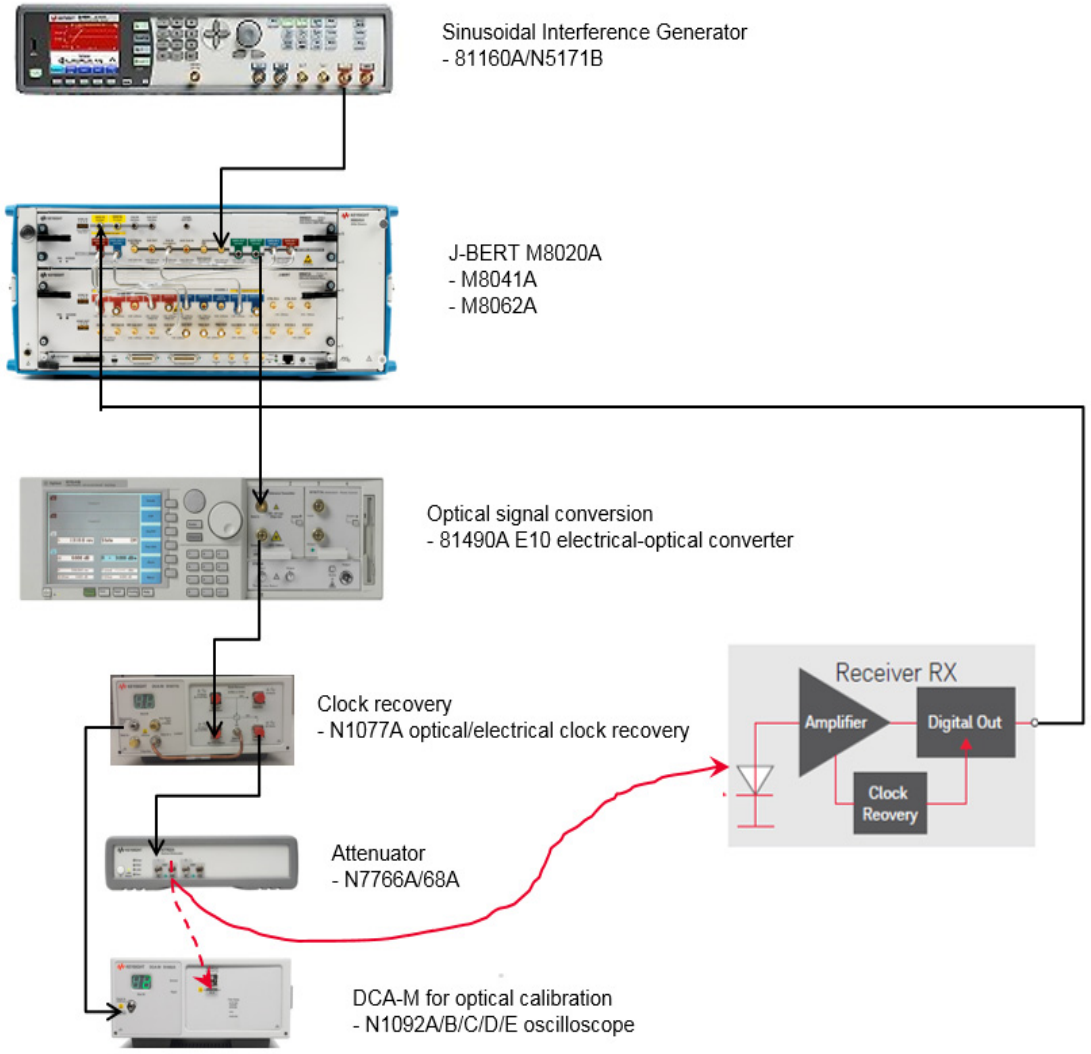

Figure 2 Example setup for 100GBASE-SR4

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 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 81490A electrical-optical converter to modulate the laser and create a stressed optical signal.

For 100G single mode standards, an 8160xA tunable laser is used to set the wavelength for each of the 4-lanes in turn. For 100GBASE-SR4, a fixed wavelength 850nm laser is included in the 81490A Reference Transmitter. The optical output of the 81490A 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 Infiniium 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 N4917B 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 N4917B Optical Receiver Stress Test Solution software also allows for precise repeatable calibration of an optical stressed eye.

Once you achieve the calibrated stressed eye, proceed to test an actual device (DUT). You may either use the Jitter Tolerance test routines within the N4917B Test Solution Software or use the equivalent measurement method on a Bit Error Rate Tester (BERT) for guidance on performing stressed receiver sensitivity test.

2 System Requirements For N4917B

KEYSIGHT TECHNOLOGIES

Hardware and Software Requirements

NOTE The N4917B Optical Receiver Stress Test Solution Software runs on an external PC.

PC Hardware Requirements

Operating system

- Microsoft Windows 7 (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 system software for M8000 series

- Ver.4.5.70.2 or later

N1010A FlexDCA Remote Access System

- A.05.71.22 or later (if using DCA-M)

PC Interfaces

- USB
- LAN
- GPIB (optional)

Instrument Firmware Requirements

M8020A J-BERT

- M8070A System Software as specified earlier

81600D DCA-X

- FlexDCA version A.05.71.22 or later

8164B LMS

- Ver.V5.25 or later

81490A Ref Tx

- Ver.5.01 or later

Supported Equipment

As mentioned earlier, the N4917B 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 N4917B Optical Receiver Stress Test Solution.

BERT

- M8020A-BU2 mainframe with USB option
- M8070A-0TP System Software

Full BERT

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

Generator only

- M8041A-G16/0G2/0G3 High Performance Pattern Generator module
- M8062A-G32/0G4/0G5 Generator Front End

Signal Generator for Sinusoidal Interference

- 81150A-001/81160A-001 Pulse Function Arbitrary Noise Generator or
- N5171B-503 EXG X-series RF 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 (LR4/ER4/100G MSAs and SR4) or
- 8163B LMS Mainframe (SR4 only)

Tunable lasers for LR4/ER4/100G MSAs:

- 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

- 81490A-E05 Reference Transmitter (LR4/ER4/100G MSAs) or
- 81490A-E09 Reference Transmitter (LR4/ER4/100G MSAs) or
- 81490A-E10 Reference Transmitter (SR4)

LR4/ER4/100G MSAs 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)

SR4 attenuators:

- N7766A external attenuator (2 ch straight MMF) or
- N7768A external attenuator (4 ch straight MMF)

DCA-X Oscilloscope

- 86100D-ETR/PTB/200/300 DCA-X mainframe
- 86105D-281/IRC Electrical/Optical SMF module or
- 86115D-282 /IRC Dual Optical SMF 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 (SR4)

- N1077A-232/SMS Optical/Electrical Clock Recovery

Equipment Configuration

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

The N4917B Optical Receiver Stress Test supports two modes of operation:

- Single mode fiber configuration for 100GBASE-LR4/ER4, 100G CLR4, 100G CWDM4, 100G 4WDM-10/20/40
- Multi mode fiber configuration for 100GBASE-SR4

The recommended configuration for single and multi mode standards is described below. For assistance with other variants of equipment configuration, contact your local Keysight technical support.

Recommended Setups for Single Mode Standards

Figure 3 and Figure 4 illustrate the single mode fiber setups with DCA-M and DCA-X oscilloscopes, respectively.

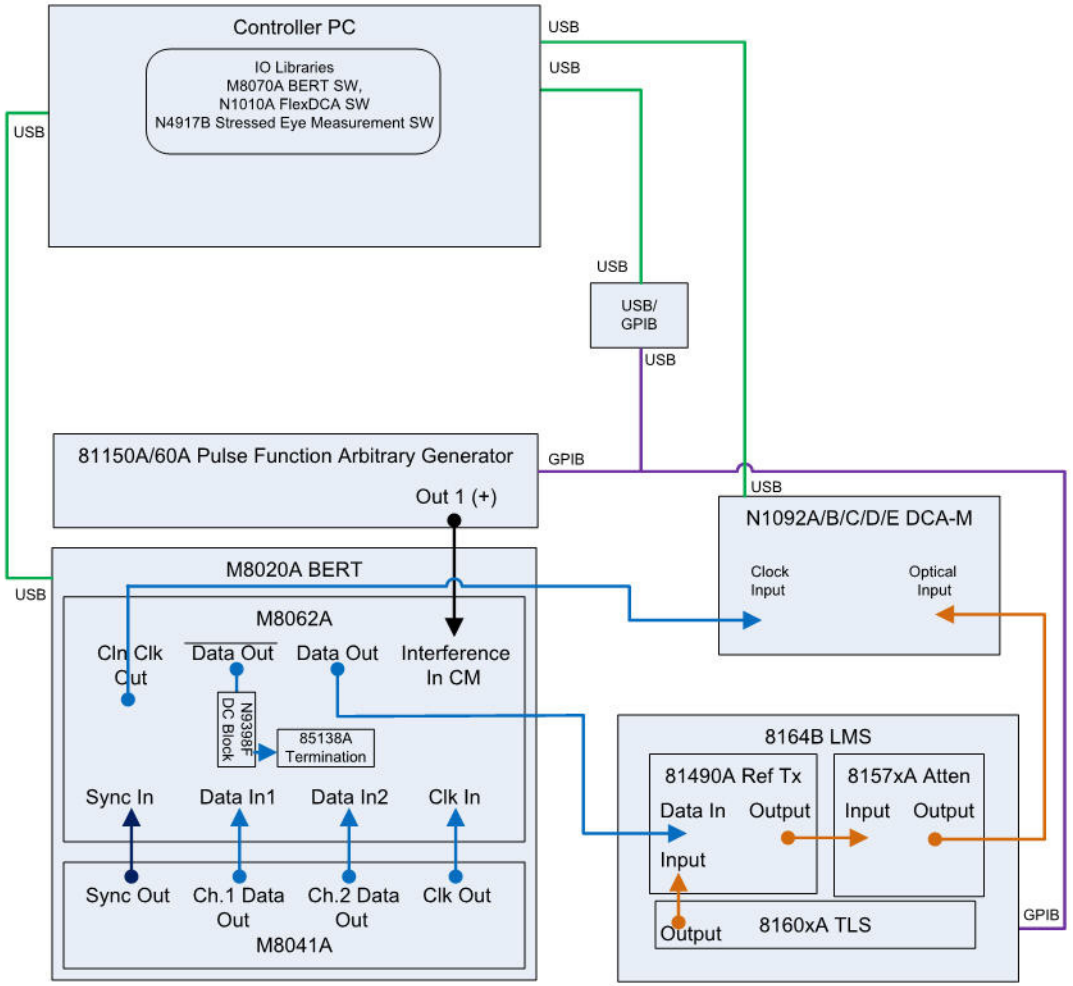

Figure 3 Single mode fiber setup with DCA-M

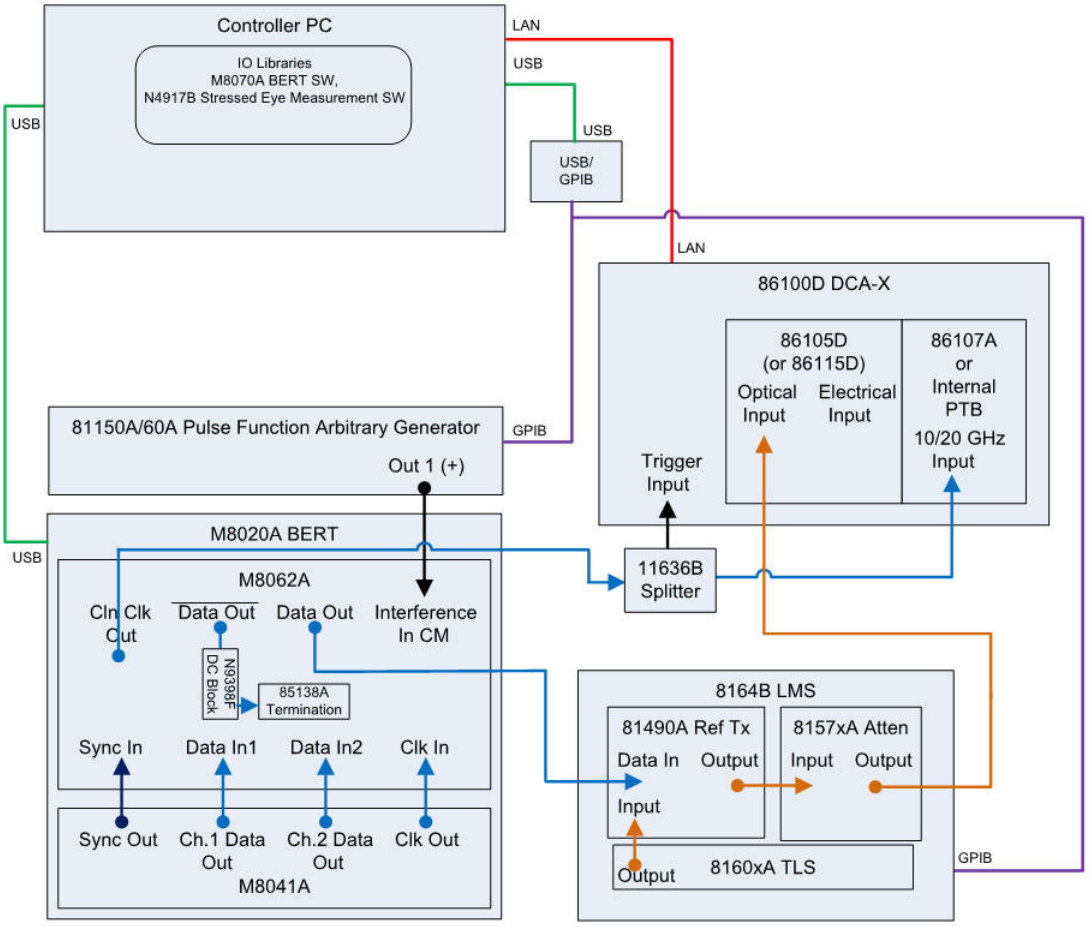

Figure 4 Single mode fiber setup with DCA-X

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

Recommended Setups for Multi mode Standards

Figure 5 and Figure 6 illustrate the multi mode fiber setups with DCA-M and DCA-X oscilloscopes, respectively.

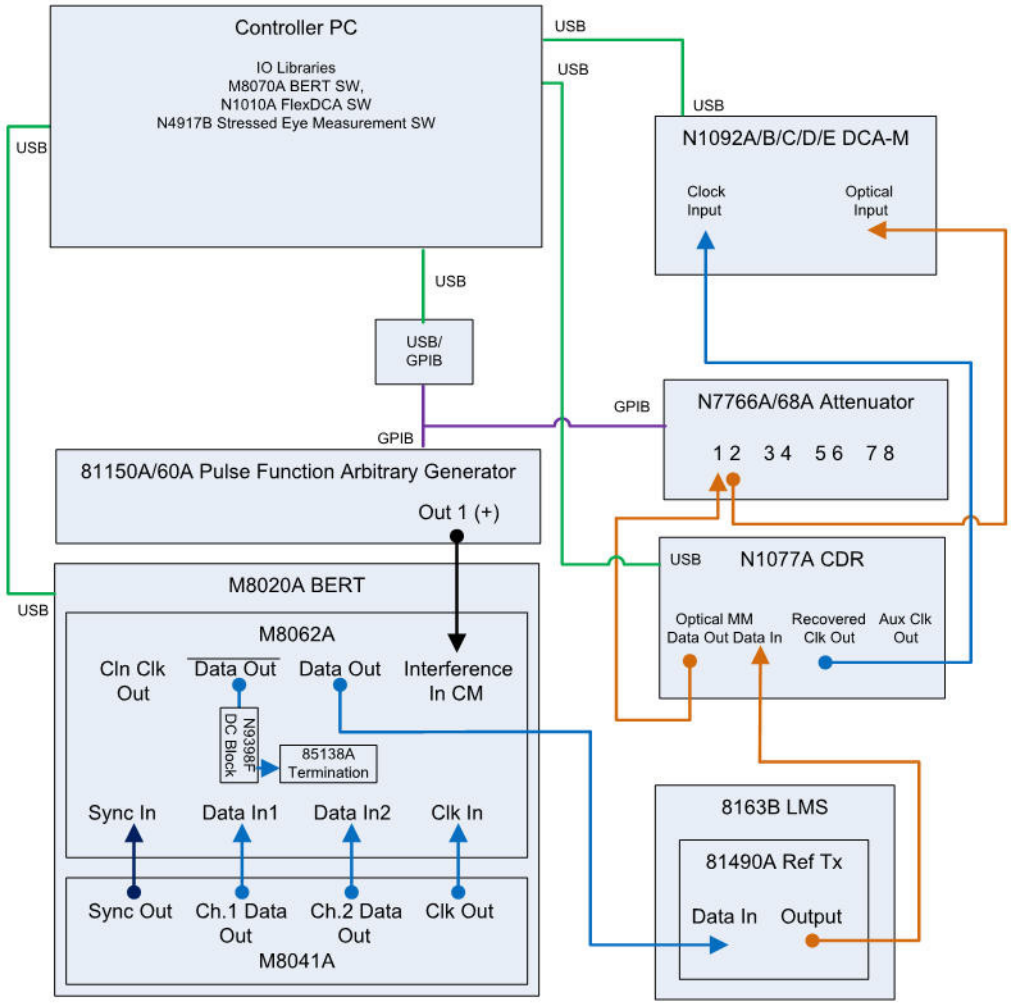

Figure 5 Multi mode fiber setup with DCA-M

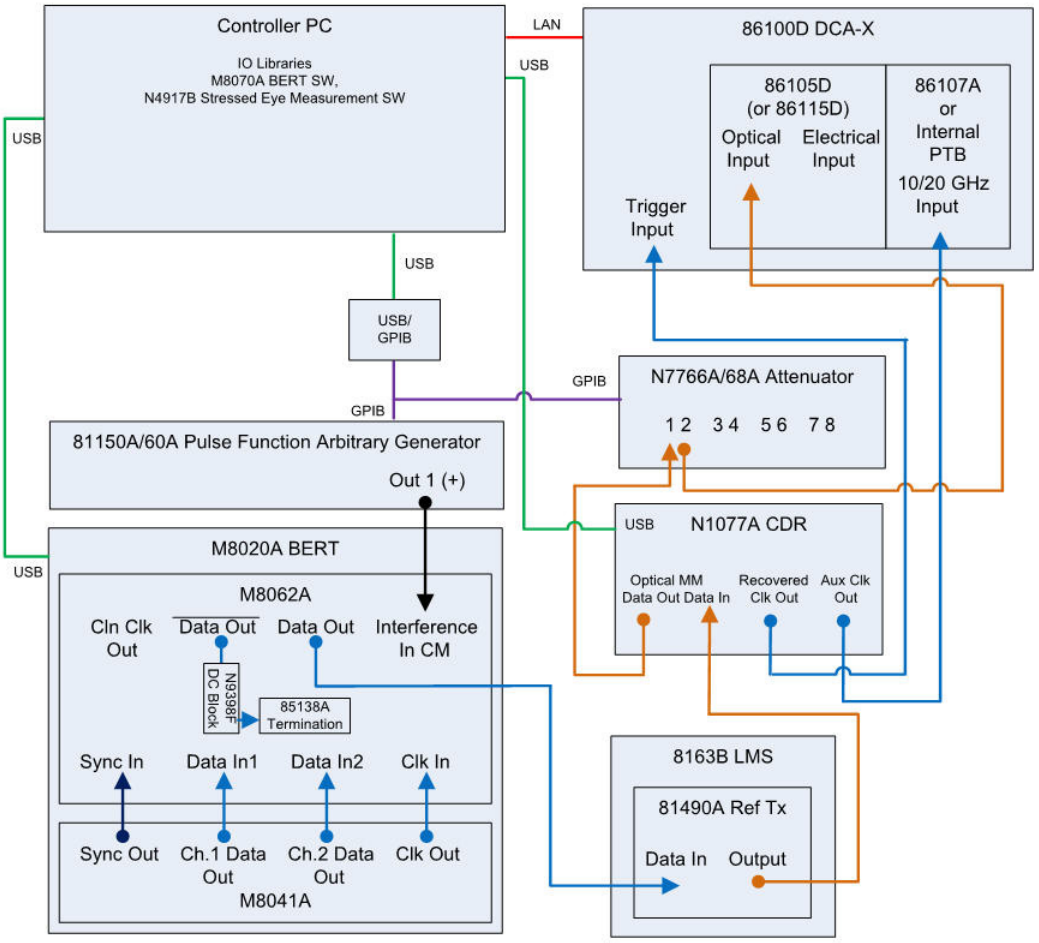

Figure 6 Multi mode fiber setup with DCA-X

Other options to these configurations include:

- using an external clock
- using a signal generator instead of the pulse function generator for the interference source
- using LAN connections to the pulse function generator and LMS mainframe

- using without the N1077A CDR

3 Concepts and Features of N4917B Software

KEYSIGHT TECHNOLOGIES

Software concept and flow of Optical Receiver Test

The N4917B 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.

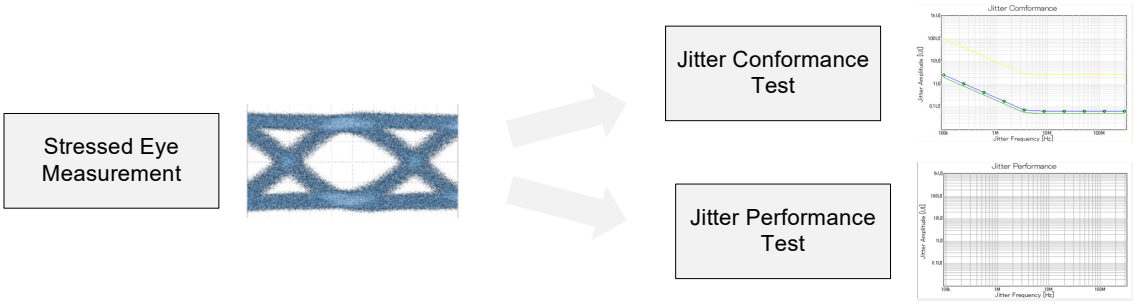

Figure 7 Stressed Eye Calibration and Measurement flow

The calibrated parameters in the stressed eye are Extinction Ratio, VECP or SEC, J2, J4 or J9, and Eye Mask. 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.

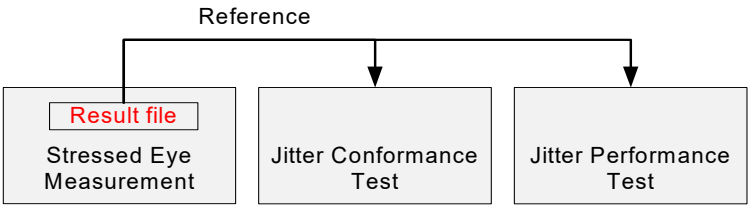

Figure 8 Using the Stressed Eye Calibration Results as reference

Software Functions and Features

The N4917B 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. 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 N4917B software creates a stressed eye, based on the applicable standards, for stressed receiver sensitivity testing.

Table 1 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})
		Bit Rate (Gb/s)
		De-Emphasis cursors (dB)
Measurement Parameters		[ER] Extinction Ratio (dB)
		Initial [VECP] Vertical Eye Closure Penalty (dB) or Initial [SEC] Stressed Eye Closure (dB)
		[VECP] Vertical Eye Closure Penalty (dB) or [SEC] Stressed Eye Closure (dB)
		J2 jitter (UI_{pp})
		J4 jitter (UIpp) or J9 jitter (UI_{pp})
		Calibration level OMA (dBm)
		Eye Mask margin

To speed up the stressed eye calibration, the starting values for data amplitude, ISI amplitude, SI amplitude, PJ2 and RJ are contained in the Parameter files for each standard. 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/SEC, J2 and J4/J9—are adjusted using the parameters—data amplitude, ISI amplitude, SI amplitude, PJ2 amplitude, RJ amplitude. Initial VECP or Initial SEC is the portion created from ISI (inter-symbol interference). Initial VECP should be at least 2/3 VECP, and initial SEC should be at least 2.5 dB.

The full values of VECP and SEC are then achieved by adding additional SI (sinusoidal interference) and jitter.

After completion of a stressed eye calibration, the starting values for data, ISI, SI, PJ2 and RJ amplitude are overwritten with the final values required to create the calibrated stressed eye. At this point, the loaded parameter file can be re-saved (or a new parameter file created) with these final values. Loading this modified parameter file in future sessions reduces the time to calibrate a new stressed eye.

Jitter Conformance Test

This feature of the N4917B 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 N4917B 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/SEC, VECP/SEC, J2, J4/J9, Eye Mask Margin, 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.

Navigate to *C:\Users\Public\Public Documents\N4917B\Parameter* to access the default Parameter files. There are sub-folders for each supported standard:

- LR4/ER4
- SR4
- CLR4
- CWDM4
- 4WDM

Each sub-folder contains default parameter files for each data lane/wavelength.

Stressed Receiver Sensitivity Specifications

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	CLR4 w/o FEC	CLR4 w/ FEC	CWDM4	4WDM -10	4WDM -20	4WDM -40	100G BASE -SR4
Conditions for Stressed Receiver Sensitivity Test									
Extinction Ratio	4 dB	8 dB	3.5 dB	3.5 dB	3.5 dB	3.5 dB	4.0 dB	4.5 dB	2 dB
Initial Vertical eye closure penalty (VECP) (SEC for SR4)	1.2 dB min	2.33 dB min	1.3 dB min	1.3 dB min	1.27 dB min	1.73 dB min	1.67 dB min	1.67 dB min	2.5 dB min
Vertical eye closure penalty (VECP), (Stressed eye closure for SR4)	1.8 dB	3.5 dB	1.95 dB	1.95 dB	1.9 dB	2.6 dB	2.5 dB	2.5 dB	4.3 dB
J2 Jitter	0.3 UI	0.3 UI	0.3 UI	0.33 UI	0.33 UI	0.33 UI	0.33 UI	0.33 UI	0.39 UI
J4 Jitter	-	-	-	0.48 UI	0.48 UI	0.48 UI	0.48 UI	0.48 UI	0.53 UI (max)
J9 Jitter	0.47 UI	0.47 UI	0.5 UI	-	-	-	-	-	-
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	0.39, 0.5,0.5, 0.39, 0.39, 0.4	0.39, 0.5,0.5, 0.39, 0.39, 0.4	0.28, 0.5,0.5, 0.33, 0.33, 0.4
Optical Wavelength Assignments									
Spacing	5nm	5nm	20nm	20nm	20nm	20nm	5nm	5nm	-
Lane L0 Nominal Wavelength	1295.56 nm	1295.56 nm	1271 nm	1271 nm	1271 nm	1271 nm	1295.56 nm	1295.56 nm	850 nm
Lane L1 Nominal Wavelength	1300.05 nm	1300.05 nm	1291 nm	1291 nm	1291 nm	1291 nm	1300.05 nm	1300.05 nm	850 nm
Lane L2 Nominal Wavelength	1304.58 nm	1304.58 nm	1311 nm	1311 nm	1311 nm	1311 nm	1304.58 nm	1304.58 nm	850 nm

	100G BASE -LR4	100G BASE -ER4	CLR4 w/o FEC	CLR4 w/ FEC	CWDM4	4WDM -10	4WDM -20	4WDM -40	100G BASE -SR4
Lane L3 Nominal Wavelength	1309.14 nm	1309.14 nm	1331 nm	1331 nm	1331 nm	1331 nm	1309.14 nm	1309.14 nm	850 nm
Stressed receiver sensitivity, OMA	-6.8 dBm	-17.9 dBm	-5.6 dBm	-8.5 dBm	-7.3 dBm	-8.6 dBm	-10.0 dBm	-16.0 dBm	-5.2 dBm
Aggressor lane OMA	-1.3 dBm	-13.4 dBm	-0.1 dBm	-3.0 dBm	-2.8 dBm	-4.1 dBm	-4.5 dBm	-9.5 dBm	+3 dBm

Example LR4/ER4 parameter file

```
File Type,                  Eye             File type
[Tag Data]
OperatorName,
ResultFile,
EyeFile,                    C:\Users\Public\Documents\N4917B\
                            Parameter\LR4-ER4\
                            Eye_parameters_LR4_L0.csv
Comment,
[Measurement Condition]
Measurement Mode,           LR4/ER4         Measurement type
ERTgt[dB],                  4.25            Target values for defining
ERDelta[dB],                0.25            a Stressed Optical waveform
                                            according to standard.
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	Target values for defining a Stressed Optical waveform according to standard.
J2Delta[UIpp],	0.01	
J2Adj,	True	
J9Tgt[UIpp],	0.47	
J9Delta[UIpp],	0.04	
J9Adj,	True	
FinalOMA[dBm],	-6.8	
DataAmpDef[Vpp],	0.276	Starting values of adjustable parameters that are modified to achieve a compliant stressed eye
ISIAmpDef[dB],	-0.13	
SIAmpDef[Vpp],	0.15	
PJ2AmpDef[UIpp],	0.125	
RJAmpDef[UIrms],	0.01	
AvgOpticalPower[dBm],	0	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	
PJ2Freq[MHz],	100.07	Frequency of 2nd periodic jitter
ISIFreq[GHz],	12.890625	Frequency point for ISI amplitude setting
SIFreq[MHz],	150.13	Frequency of sinusoidal interference
SourcePower[dBm],	9.0	Tunable laser power
DataPattern,	PRBS9,PRBS9	do not adjust these values
BitRate[Gbps],	25.78125,25.78125	

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

Example SR4 parameter file

```
File Type,              Eye             File type
[Tag Data]
OperatorName,
ResultFile,
EyeFile,                C:\Users\Public\Documents\N4917B\Parameter\
                        SR4\Eye_parameters_SR4.csv
Comment,
[Measurement
Condition]
Measurement Mode,       SR4             Measurement type
ERTgt[dB],              2.2             Target values for defining a
                                        Stressed Optical waveform
ERDelta[dB],            0.2             according to standard.
ERAdj,                  True            waveform according to the
                                        standard
InitialSECTgt[dB],      3.3
InitialSECDelta[dB],    0.1
InitialSECAdj,          True
SECTgt[dB],             4.3
SECDelta[dB],           0.1
SECAdj,                 True
J2Tgt[UIpp],            0.39
J2Delta[UIpp],          0.03
J2Adj,                  True
J4Tgt[UIpp],            0.53
```

J4Delta[UIpp],	0.06	
J4Adj,	True	
MaskMarginTgt,	5E-05	
MaskMarginDelta[%],	5	
MaskMarginAdj,	True	
FinalOMA[dBm],	-5.2	
DataAmpDef[Vpp],	0.13	Starting values of adjustable parameters that are modified to achieve a compliant stressed eye
ISIAmpDef[dB],	-1.7	
SIAmpDef[Vpp],	0.18	
PJ2AmpDef[UIpp],	0.02	
RJAmpDef[UIrms],	0	
AvgOpticalPower[dBm],	2	average power level for calibration
PJ1Freq[MHz],	25	Sinusoidal jitter parameter to be swept for Jitter Conformance and Jitter Performance tests
PJ1AmpDef[UIpp],	0.05	
PJ2Freq[MHz],	100.07	Frequency of 2nd periodic jitter
ISIFreq[GHz],	12.890625	Frequency point for ISI amplitude setting
SIFreq[MHz],	150.13	Frequency of sinusoidal interference
DataPattern,	PRBS9,PRBS9	do not adjust these values
BitRate[Gbps],	25.78125,25.78125	
WaveLength[nm],	850	

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],	0	
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

4 Using the N4917B Software

Starting the System Software

NOTE

Before launching the N4917B Optical Receiver Stress Test software, ensure that the BERT M8070A System software is running, and, if applicable, the DCA N1010A FlexDCA Remote Access System software is running. Also make sure that all the physical cabling connections are in place.

To launch the N4917B Test Solution software, click **Start**. From the **Start** menu, click **All Programs>Keysight N4917B>Keysight N4917B**.

The main window of the N4917B software is displayed (see Figure 9).

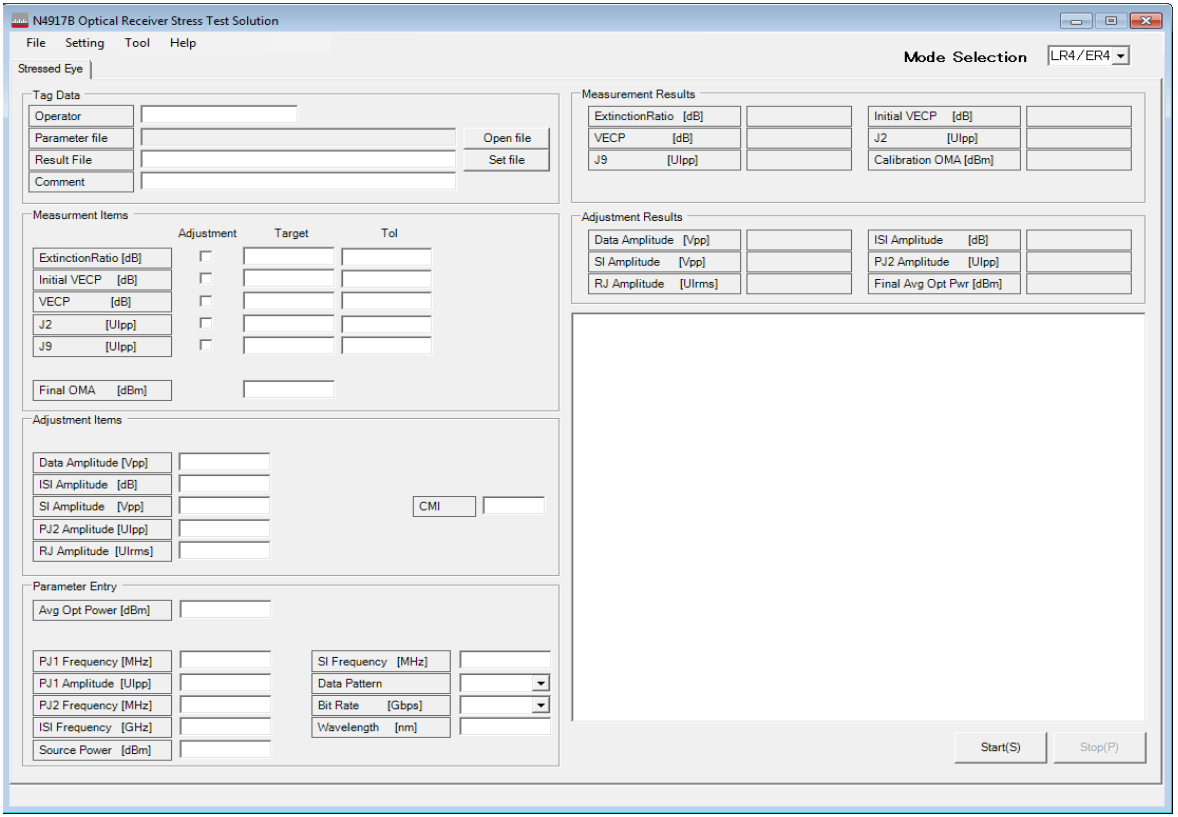

Figure 9 N4917B Software Main window

Selecting a Standard for Optical Receiver Stress Test

The N4917B Software supports different standards for optical receiver stress testing. Select the required standard from the **Mode Selection** drop-down box. (see Figure 10)

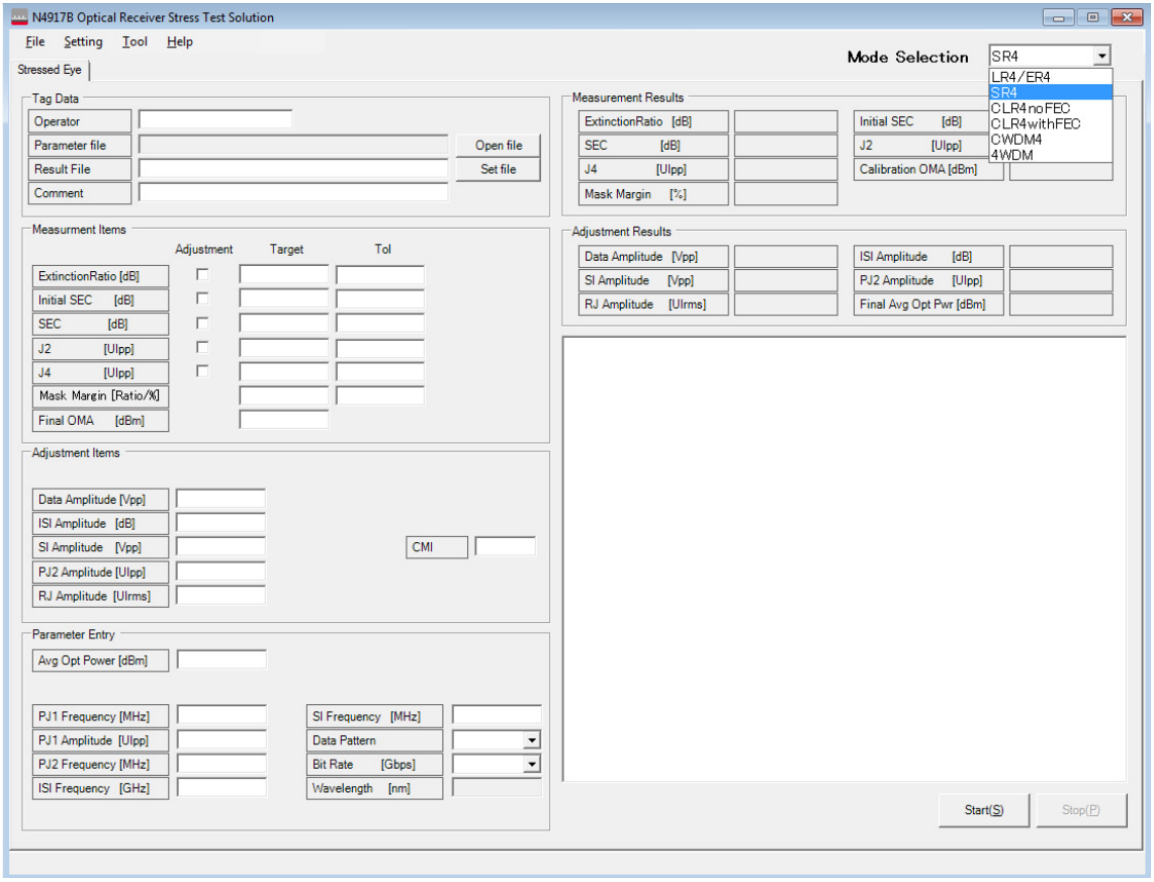

Figure 10 N4917B Mode Selection

Connecting to Equipment

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

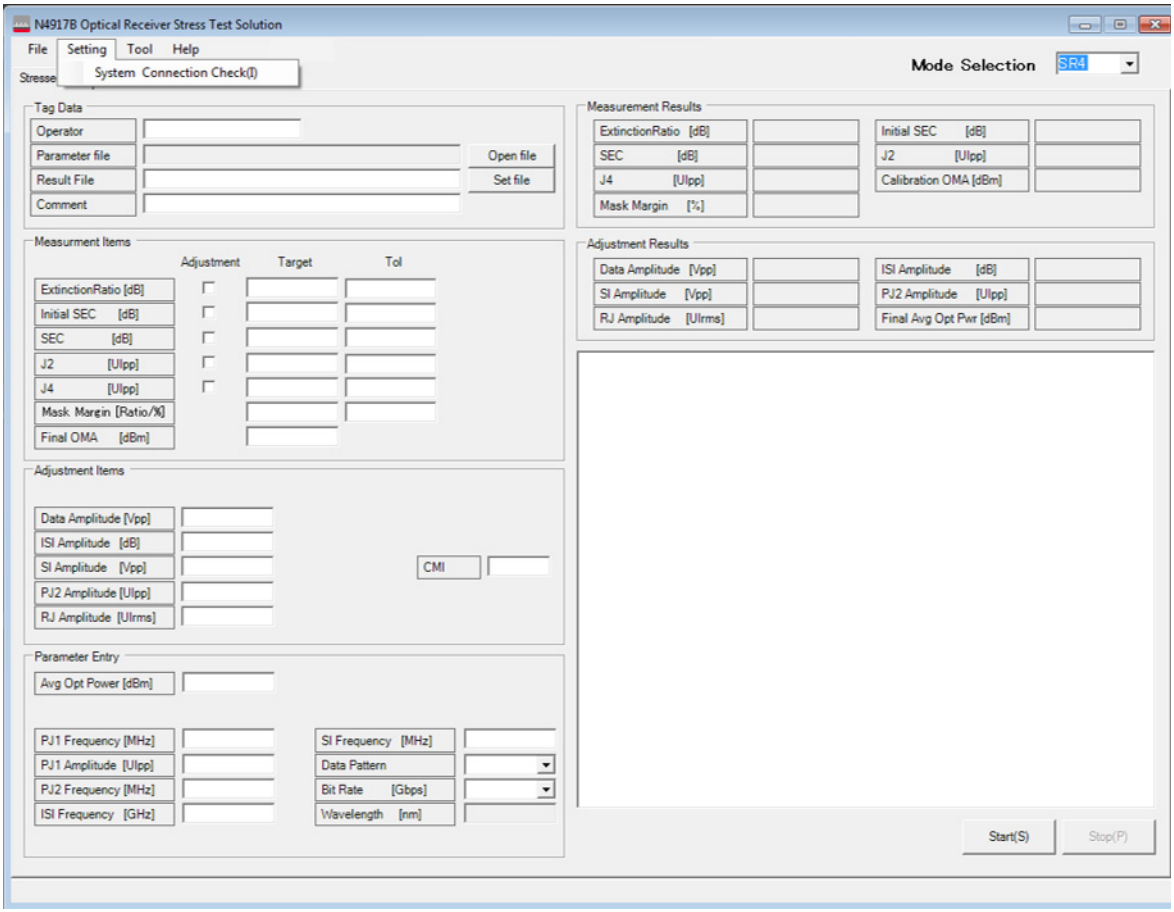

Figure 11 N4917B System Connection Check

NOTE Instruments may need to be connected or discovered with Keysight IO Libraries Connection Expert before running the N4917B Software.

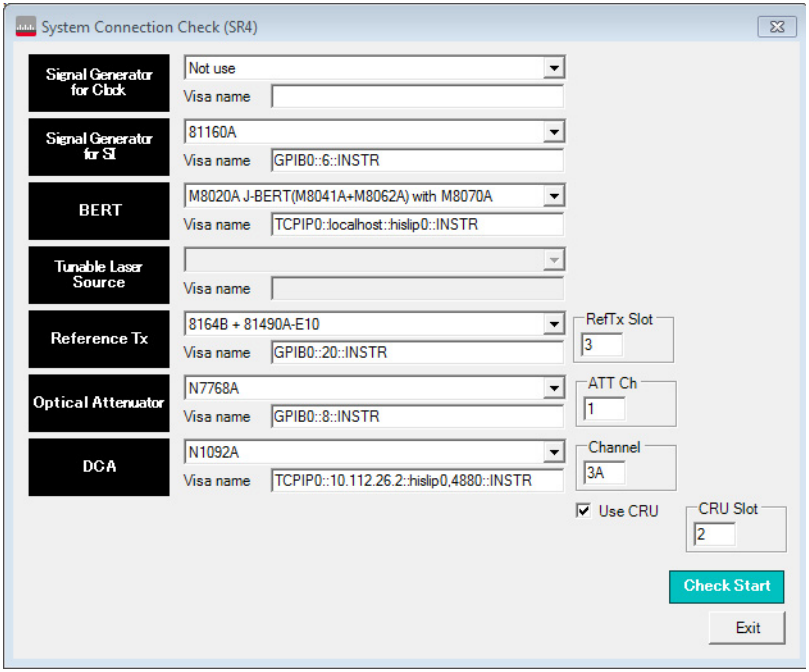

Figure 12 System Connection Check window

The N4917B 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. Exact choices of equipment available for connection depends on which standard was selected in the Mode Selection box.

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

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 N4917B Software.

NOTE For any optical equipment that is installed in an 8163B or 8164B LMS mainframe, use the VISA address of the 8163B/4B mainframe plus slot number to identify it.
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.

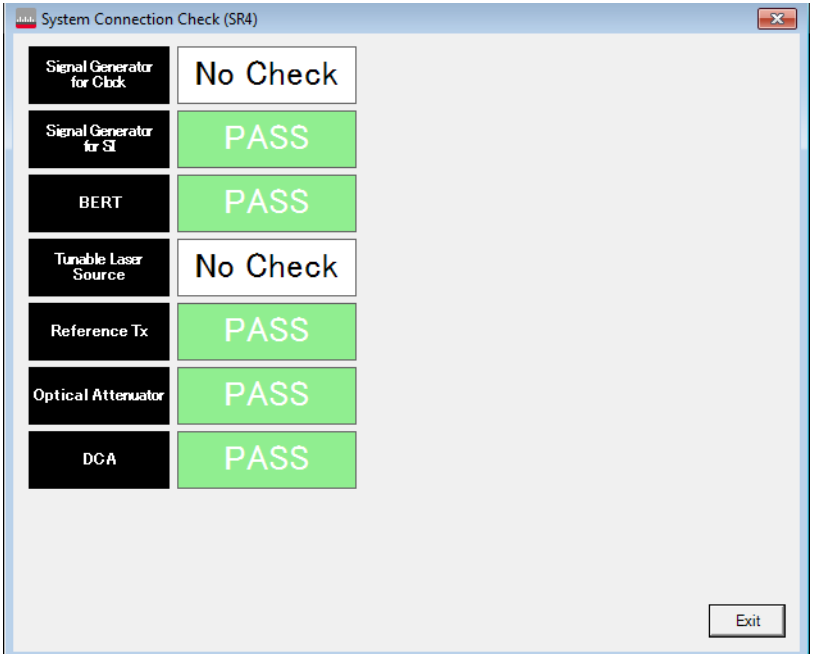

Figure 13 Successful System Connection Check

System Performance Check

Prior to running the N4917B 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**.

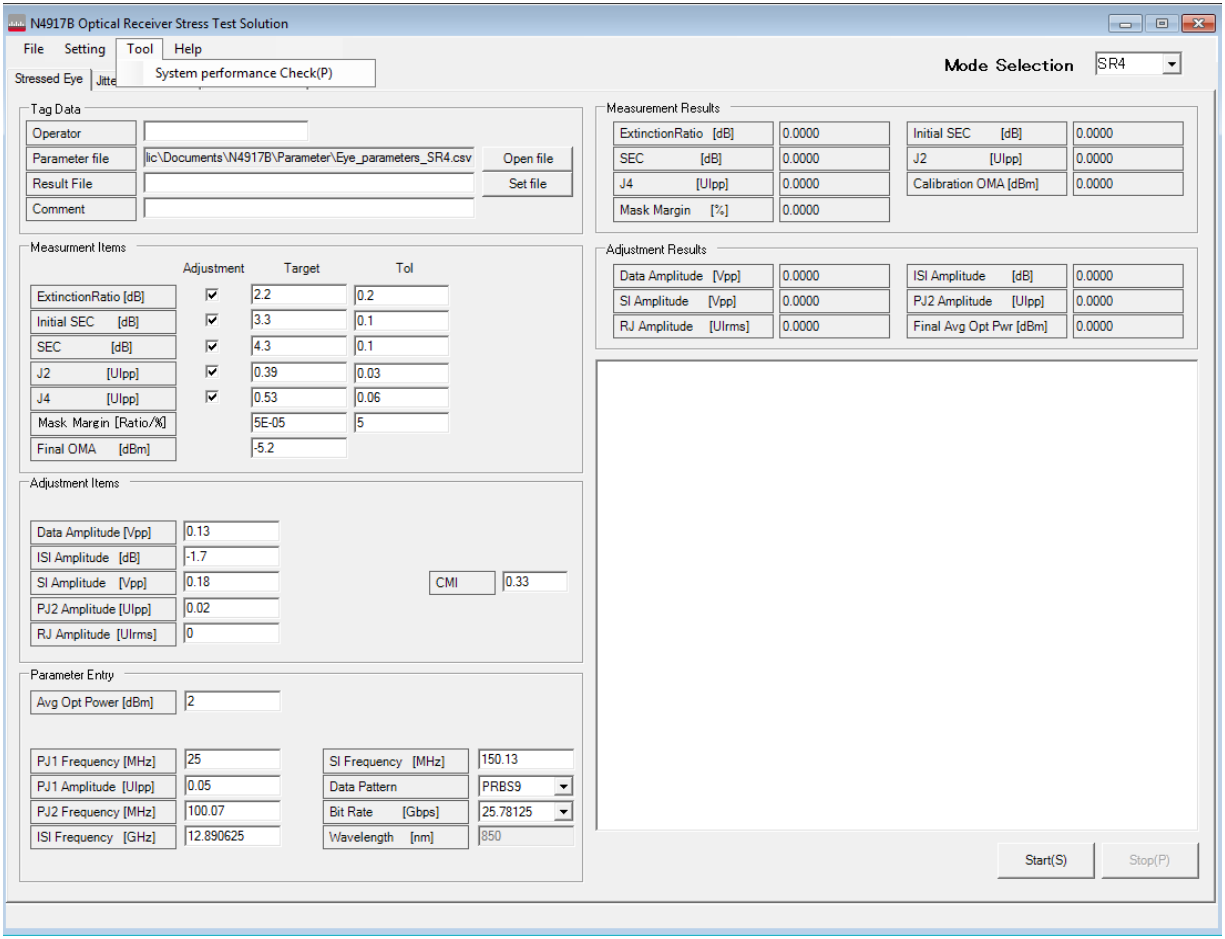

Figure 14 N4917B System Performance Check

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. (Normally for single-mode configurations around -2dB of Post-cursor 1 is only required, and for mulit-mode configurations no de-emphasis is necessary). 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.

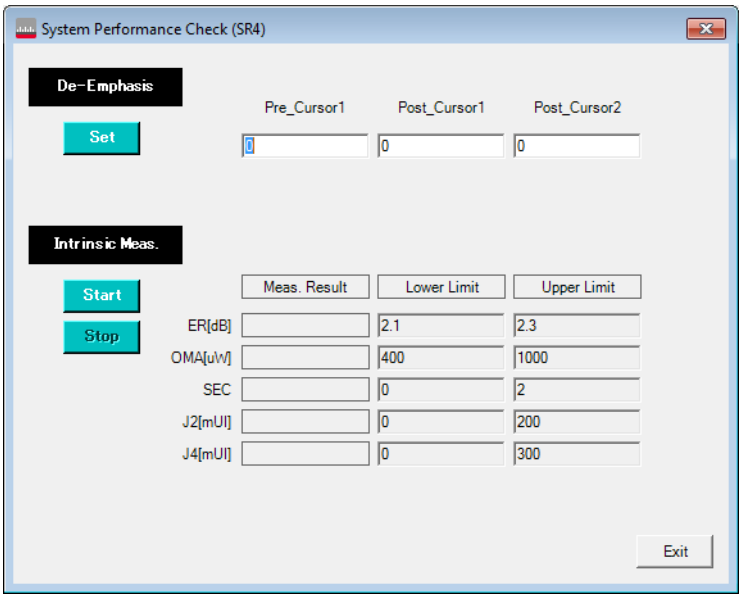

Figure 15 System Performance Check window

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) or stressed eye closure (SEC), jitter J2, and jitter J4 or 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 16 shows the results of a System Performance Check for an SR4 configuration. Results are highlighted (see ER results) 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 J4/J9. For best performance and likelihood of achieving a

successful stressed eye calibration there should be more margin for the J4/J9 results than the J2 results, since the J4/J9 parameter is most sensitive to the addition of the other eye impairments.

In the example shown below, the J2 margin: 390 mUI - J2 (mUI) [243 mUI] is less than the J4 margin: 530 mUI - J4 (mUI) [330 mUI].

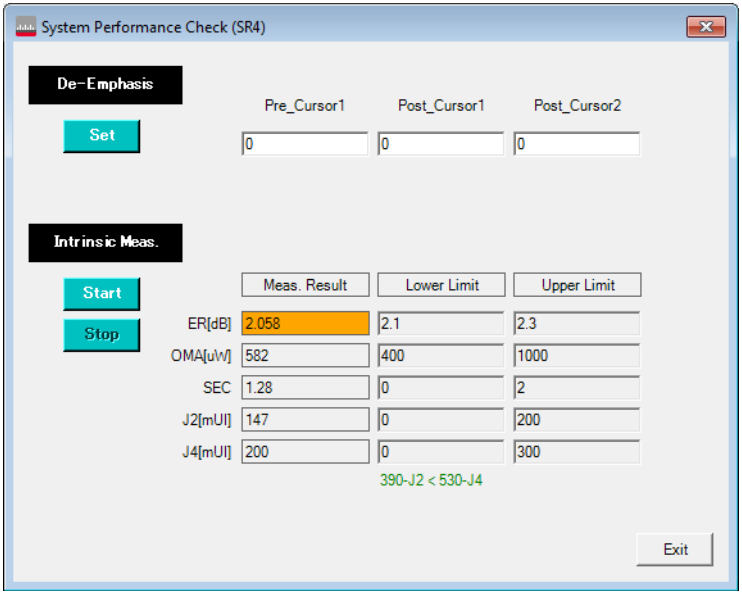

Figure 16 Results of a System Performance Check for an SR4 configuration

Main GUI

Figure 17 shows the different areas on the main window of the N4917B 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.

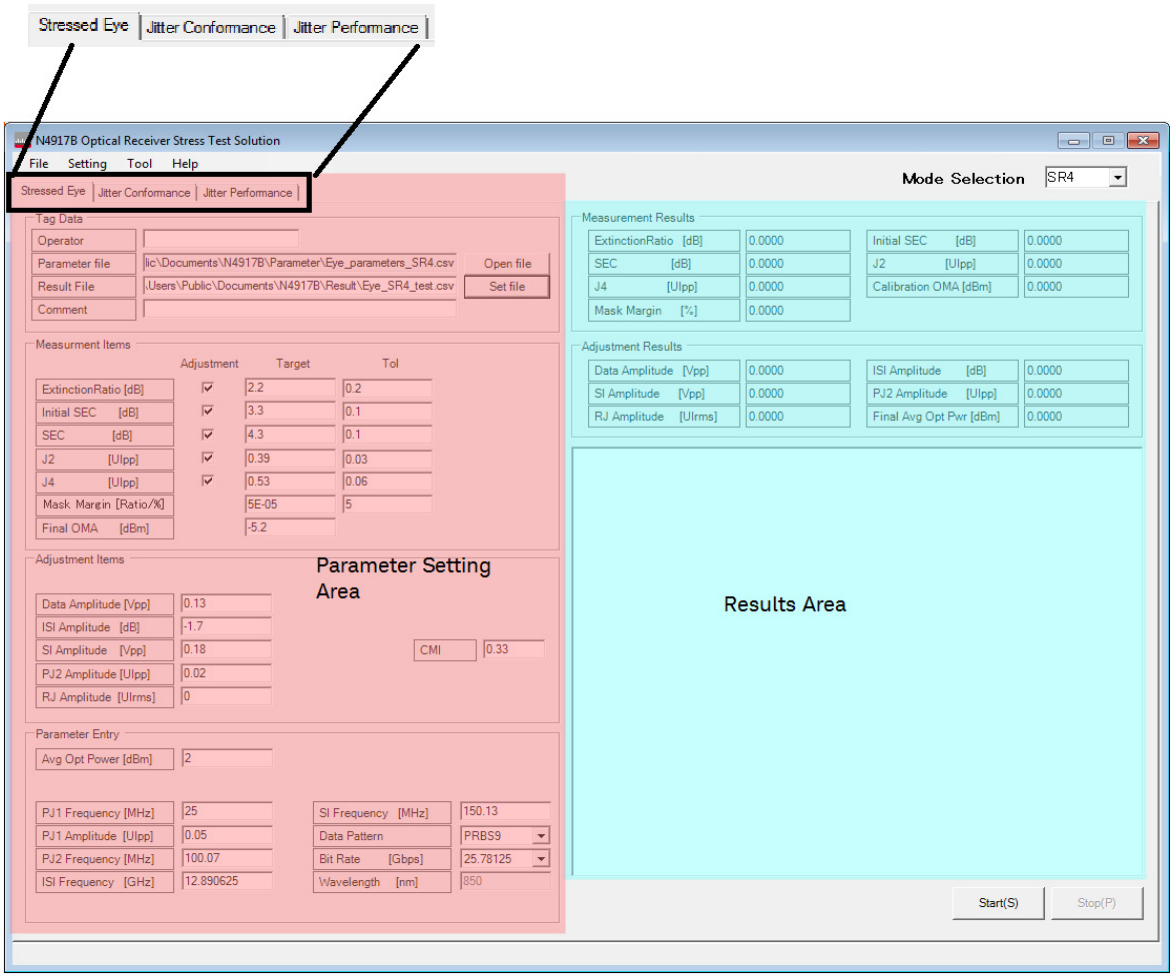

Figure 17 Parameter settings and Results area on main window

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

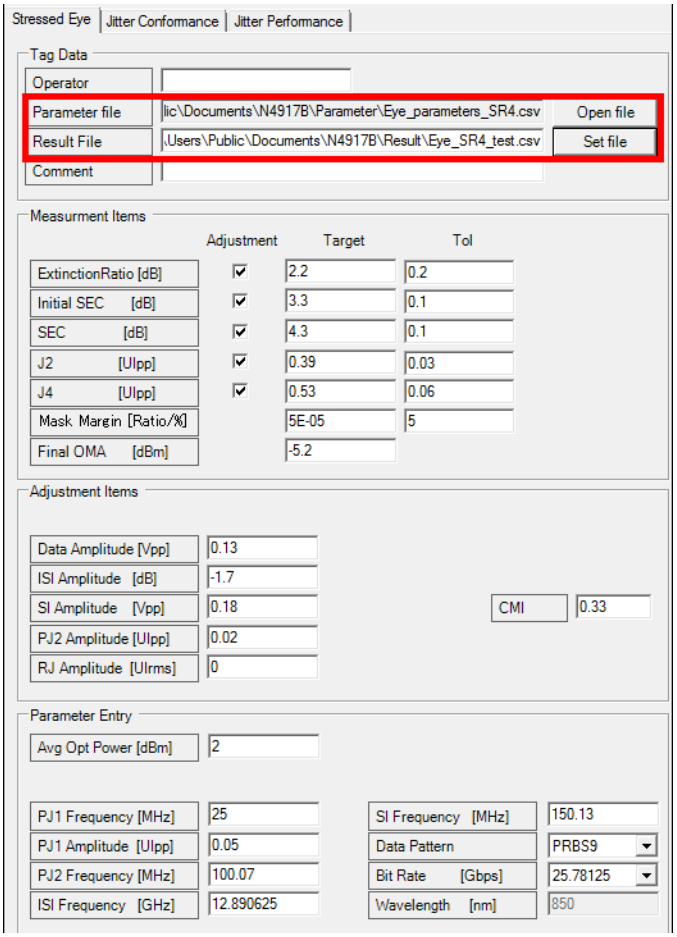

Figure 18 Setting Parameter and Result file locations

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\N4917B\Parameter*. These files have a file name of the form: *Eye_parameters_xxx_yy.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 N4917B 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\N4917B\Result*. These files can have any name format but it is recommend to keep a similar name format as the parameter files e.g. Eye_parameter_xxx_yy_test.csv

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.

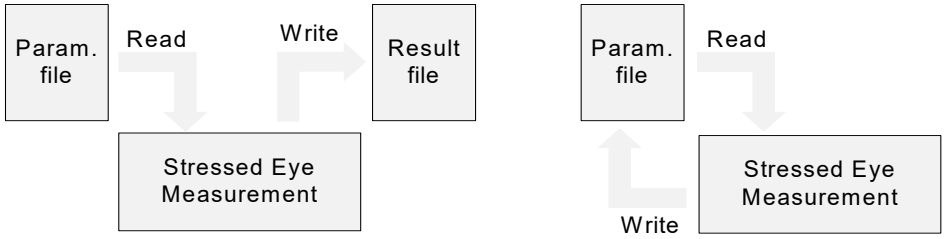

Figure 19 Parameter and Result files interaction

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.

Parameter details

Figure 20 shows the stressed eye calibration targets and tolerance.

The **Adjustment** check box, if checked, adjusts the parameters shown in Figure 20 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.

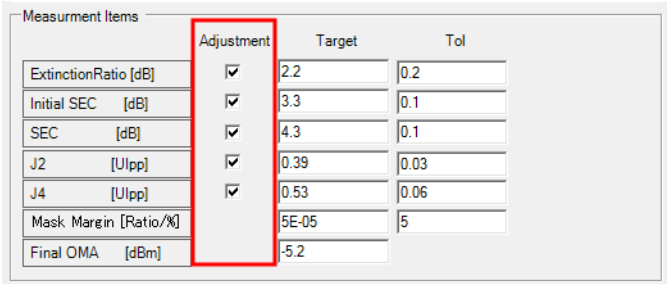

Figure 20 Measurement Items

Figure 21 shows the parameters that are adjusted by the N4917B 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.

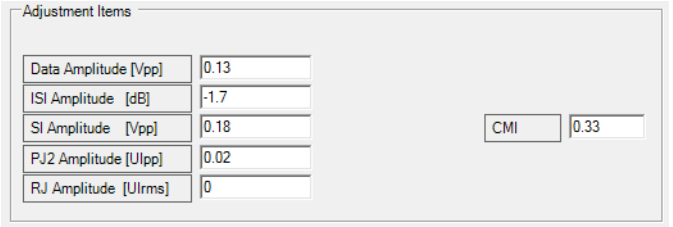

Figure 21 Adjustment Parameters

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/SEC	ISI amplitude	VECP is calculated from OMA and Ao; SEC is a modified TDEC measurement
3	VECP/SEC	SI amplitude	VECP is calculated from OMA and Ao; SEC is a modified TDEC measurement
4	J2	PJ2 amplitude	
5	J4/J9	RJ amplitude	

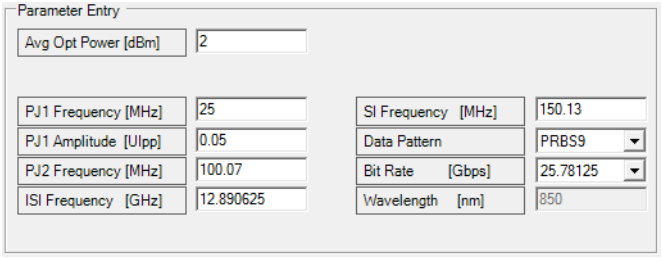

Figure 22 Other Parameters

Generally, there is no need to make any changes to the remaining parameters, except for wavelength (LR4/ER4/100G MSAs only), which can be changed in the respective field shown in Figure 22 or by creating/editing another parameter file.

NOTE

You cannot edit the Data Pattern and Bit Rate here. These are fixed values and the drop-down style box is reserved for future use. Also, the software does not only use PRBS9 data pattern. It also uses PRBS31 for the Jitter Conformance/Performance test. The N4917B Test Solution software automatically toggles between these patterns, when required.

Running the Stressed Eye calibration

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

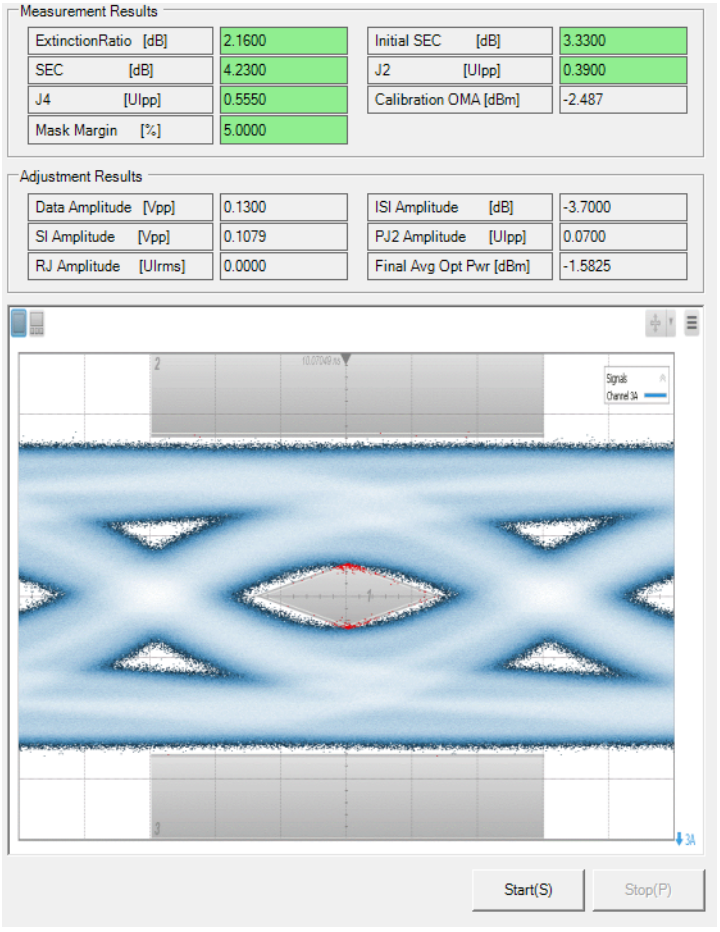

Figure 23 Main window Results area

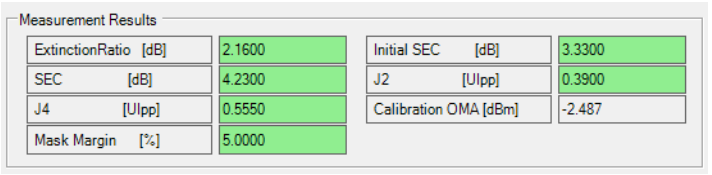

Figure 24 Measurement results

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 24, 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/SEC, followed by iterating a repetitive loop of setting VECP/SEC, J2 and J4/J9; until either all measurements meet the target +/- tolerance values or at least 10 loops have been run. Additionally for some standards, an Eye Mask measurement is performed on the final stressed eye.

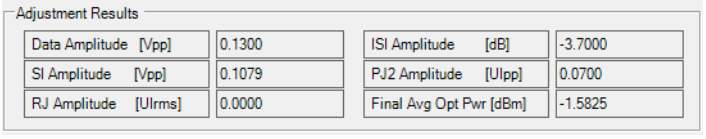

Figure 25 Adjustment parameter results

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 25.

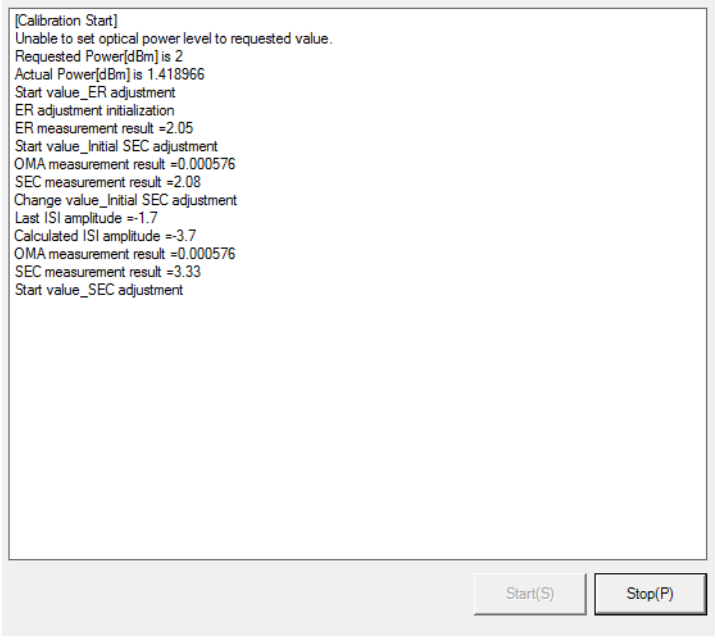

Figure 26 Stressed eye calibration status messages

During the stressed eye calibration, the lower part of the results area shows status messages and progress of the calibration, as shown in Figure 26.

When the calibration is complete, the N4917B Test Solution software displays a screen capture of the stressed eye taken from the DCA, as shown in Figure 27.

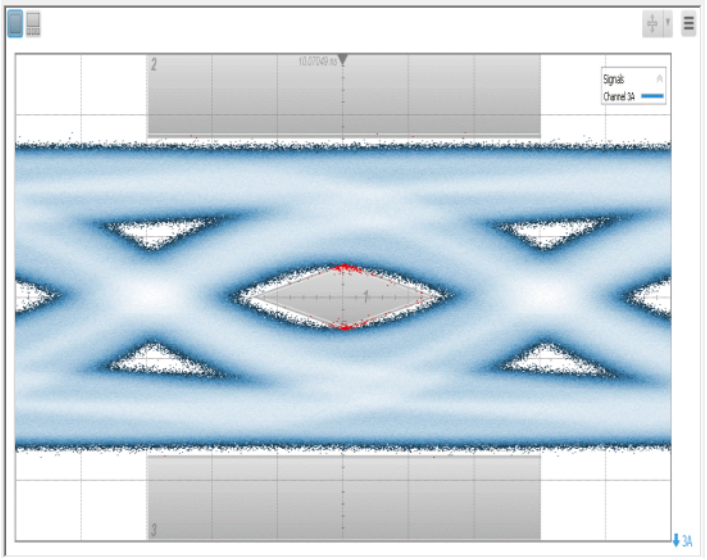

Figure 27 Stressed eye calibration complete, waveform capture from DCA

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.

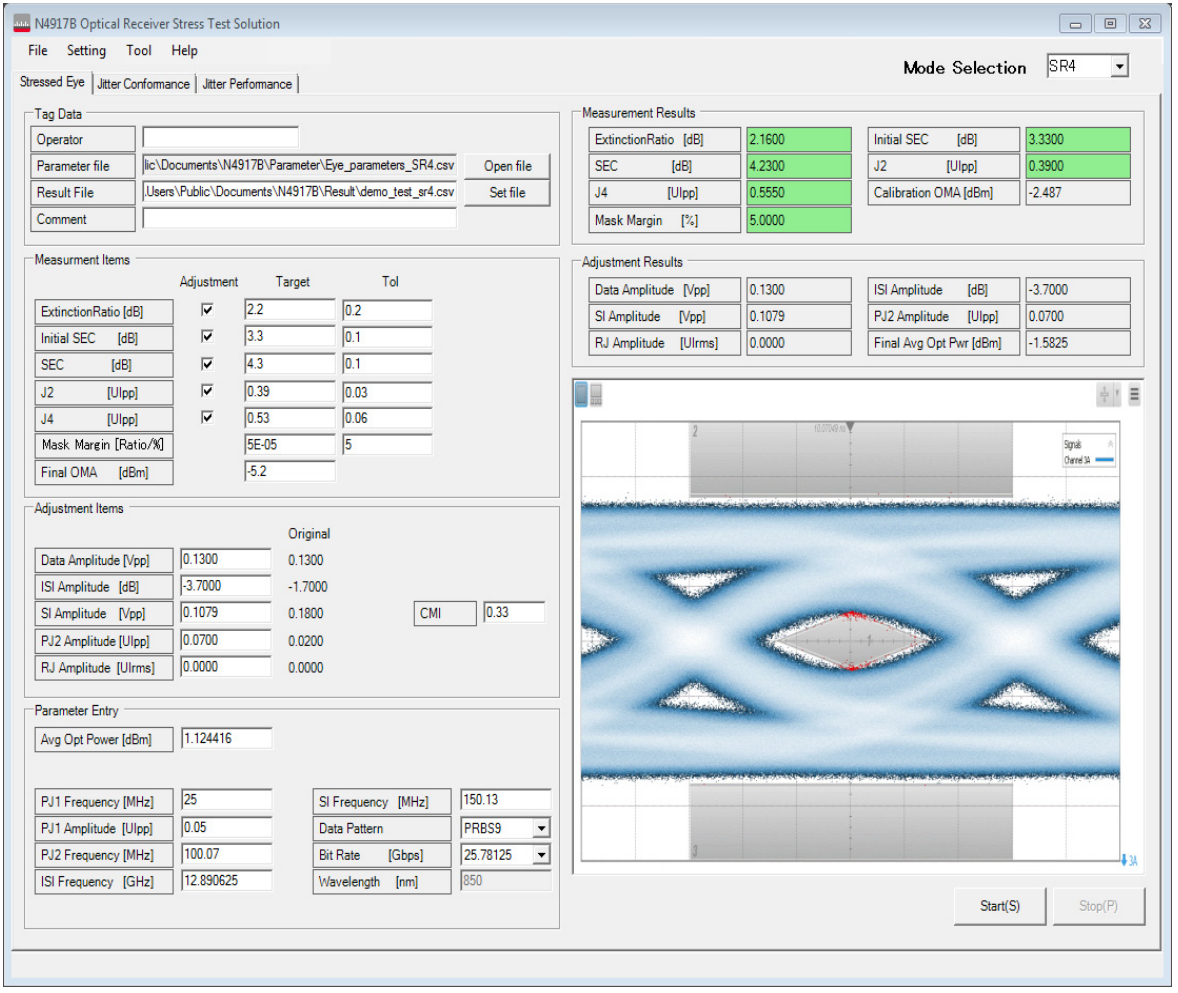

Figure 28 Main window after Stressed Eye Calibration is complete

Testing a 100 Gb/s DUT

Once the Stressed Eye Calibration is complete, each lane of the DUT should be tested in turn, with valid signals present on the other lanes. Exact connection details and setup depend on the type of device being tested. A couple of examples are shown below.

Transceiver test for ER4, LR4, CLR4, CWDM4 and 4WDM

In this example, an Optical De-Multiplexer is used to bring out the 4 lanes on 4 individual fibers. Attenuators in each lane are used to set the relative Optical Modulation Amplitude (OMA) with respect to the lane under test. The calibrated stressed eye signal is connected to the lane under test at the Optical Multiplexer, which combines all four lanes onto one fiber.

BER measurement during the Jitter Tolerance test sweep can either be read from the DUT or optionally looped back to the BERT for fully automated JTOL testing (see "Fully Automated Jitter Tolerance Testing").

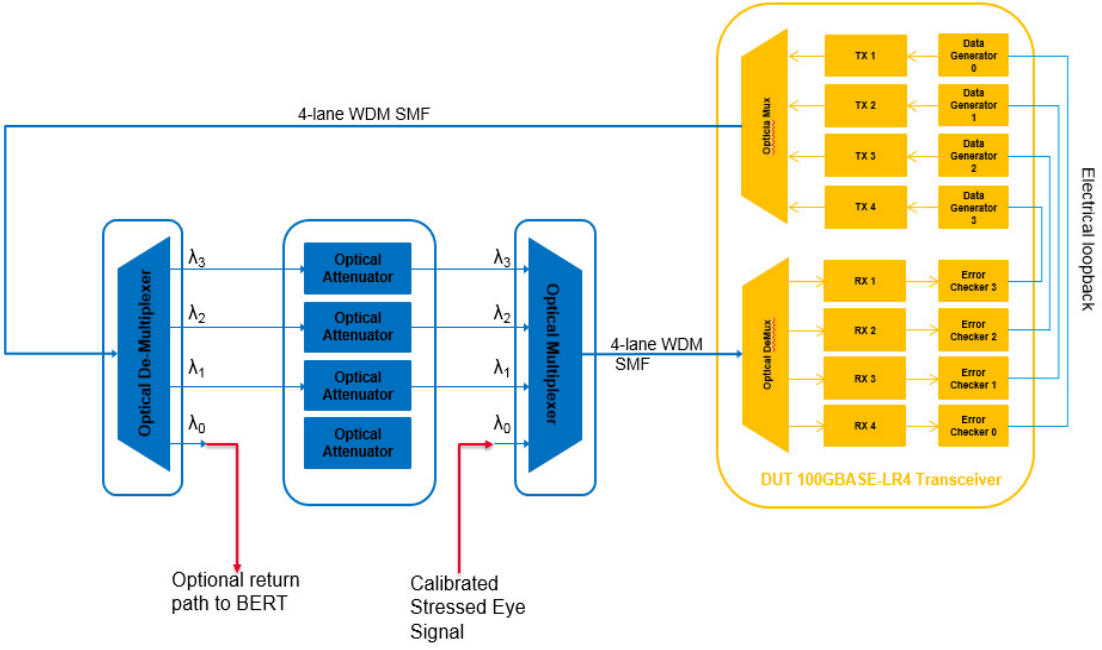

Figure 29 Example 100GBASE-LR4 setup for running a stressed receiver sensitivity testing on a DUT

Transceiver Test for SR4

In this example, there are four separate fibers, carrying one signal per fiber. Attenuators in each fiber are used to set the relative optical modulation amplitude with respect to the lane under test. The calibrated stressed eye signal is connected to the lane under test.

BER measurement during the Jitter Tolerance test sweep can either be read from the device under test or optionally looped back to the BERT for fully automated JTOL testing. (see "Fully Automated Jitter Tolerance Testing").

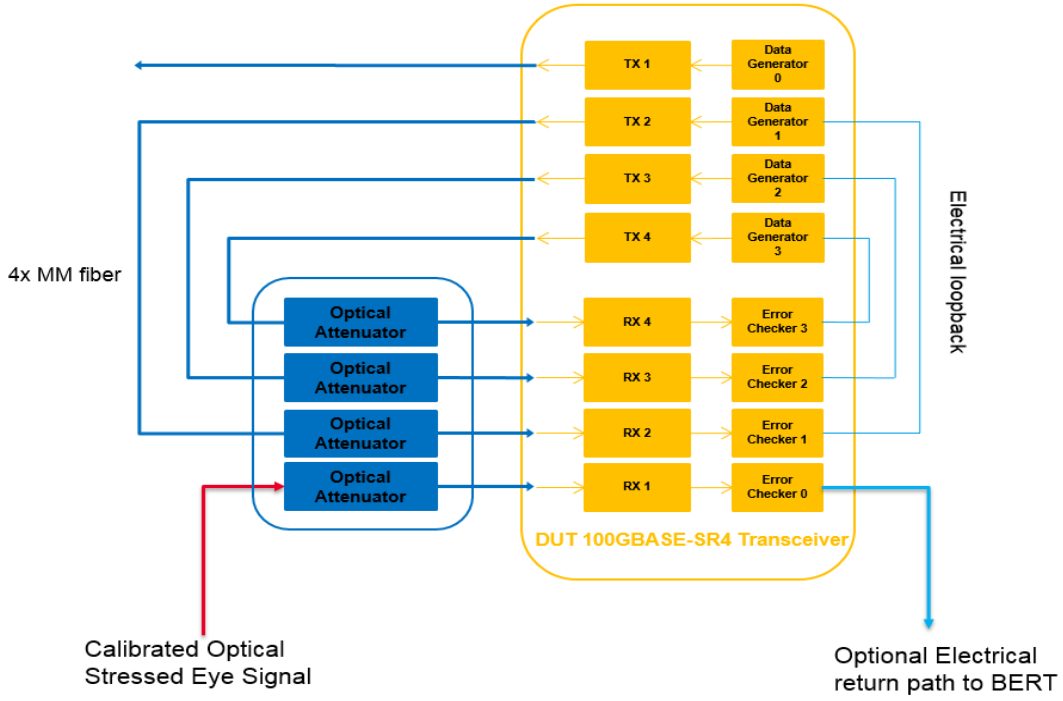

Figure 30 Example 100GBASE-SR4 setup for running a stressed receiver sensitivity test on a device

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.

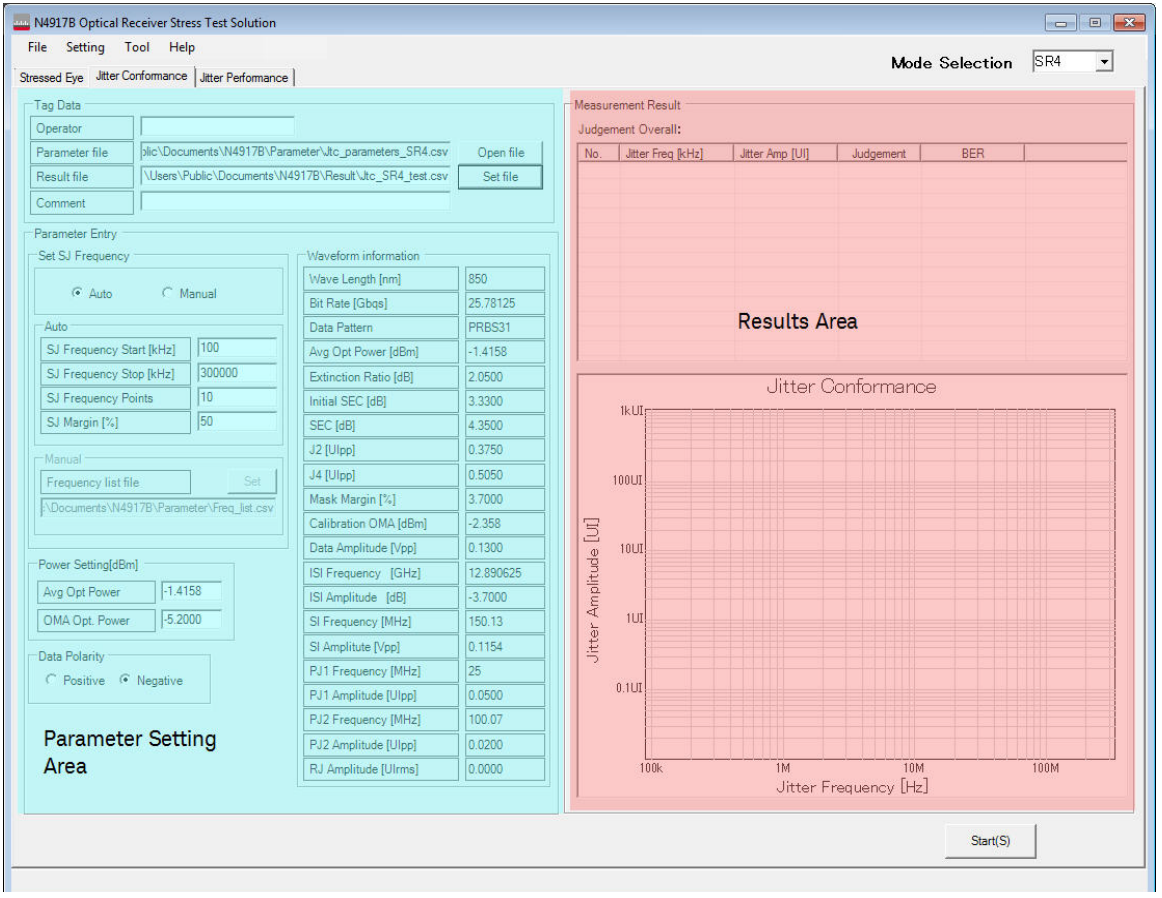

Figure 31 Jitter Conformance test window

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

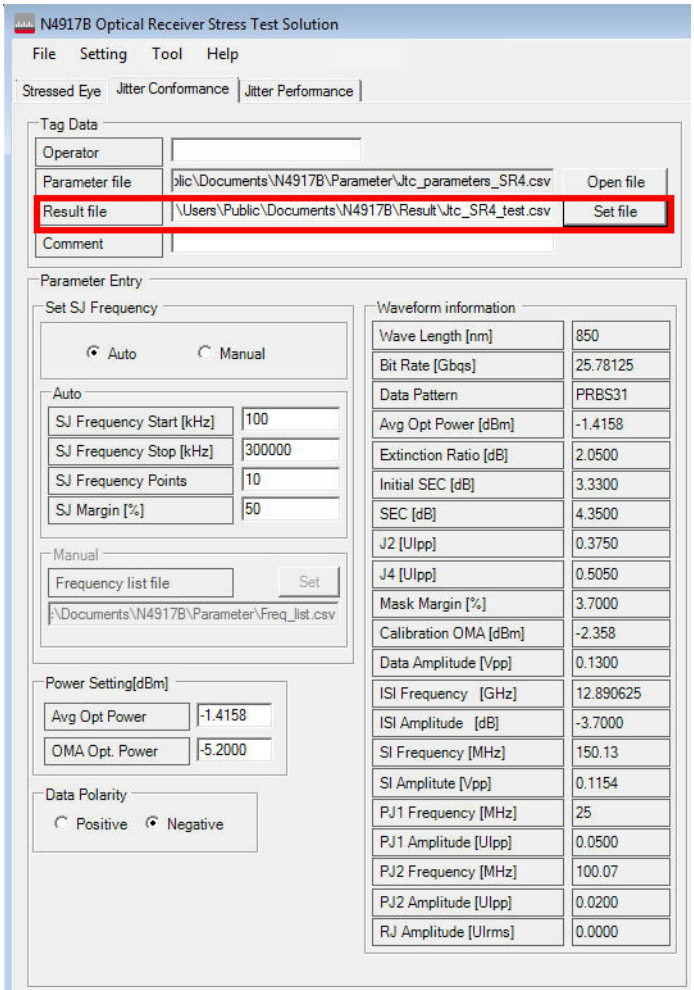

Figure 32 Setting Result file location

The N4917B 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\N4917B\Result*

Parameter Details

The Jitter Conformance measurement sweeps sinusoidal jitter from a maximum range of 100 kHz to 300 MHz. You may set the Start frequency to a value, which is greater than or equal to 100 kHz 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.

The Jitter Conformance specification is defined as follows:

- for jitter frequency 'f' between 100 kHz and 10 MHz, jitter amplitude = 5x10^5/f, and
- for jitter frequency 'f' above 10 MHz, jitter amplitude = 0.05 UI

Therefore, a jitter conformance measurement with four points from 100 kHz to 100 MHz, and 0% margin would test at the points shown in the following table.

Frequency (kHz)	Amplitude (UI)
100	5
1000	0.5
10000	0.05
100000	0.05

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\N4917B\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 Example 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

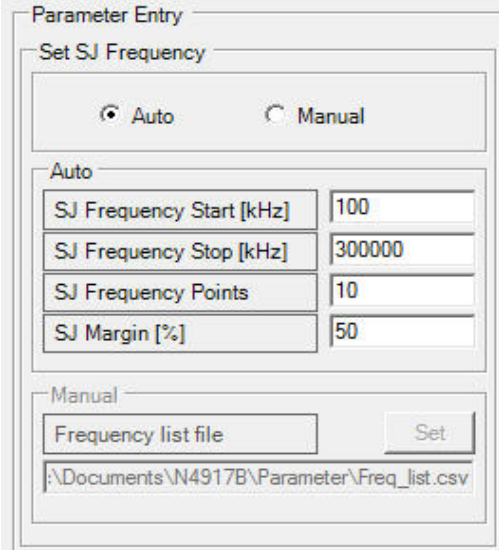

Figure 33 Jitter Conformance test parameters

Generally, you are not required to make any changes to the remaining parameters as the N4917B 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 34.

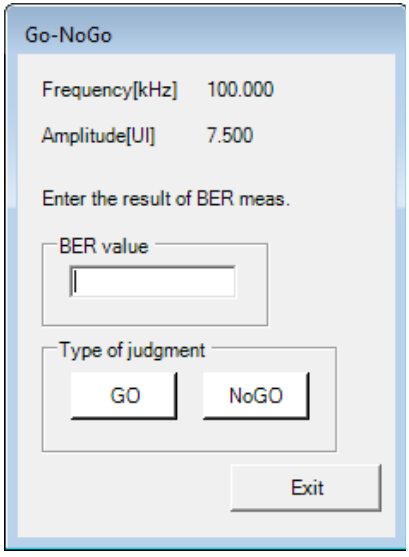

Figure 34 GO/NoGO Dialog Box

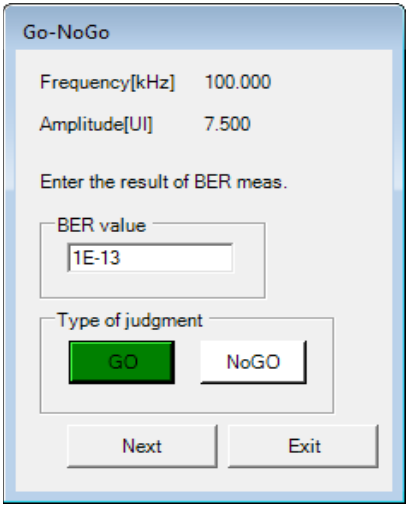

Figure 35 GO/NoGO dialog box with BER and judgment entered

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.

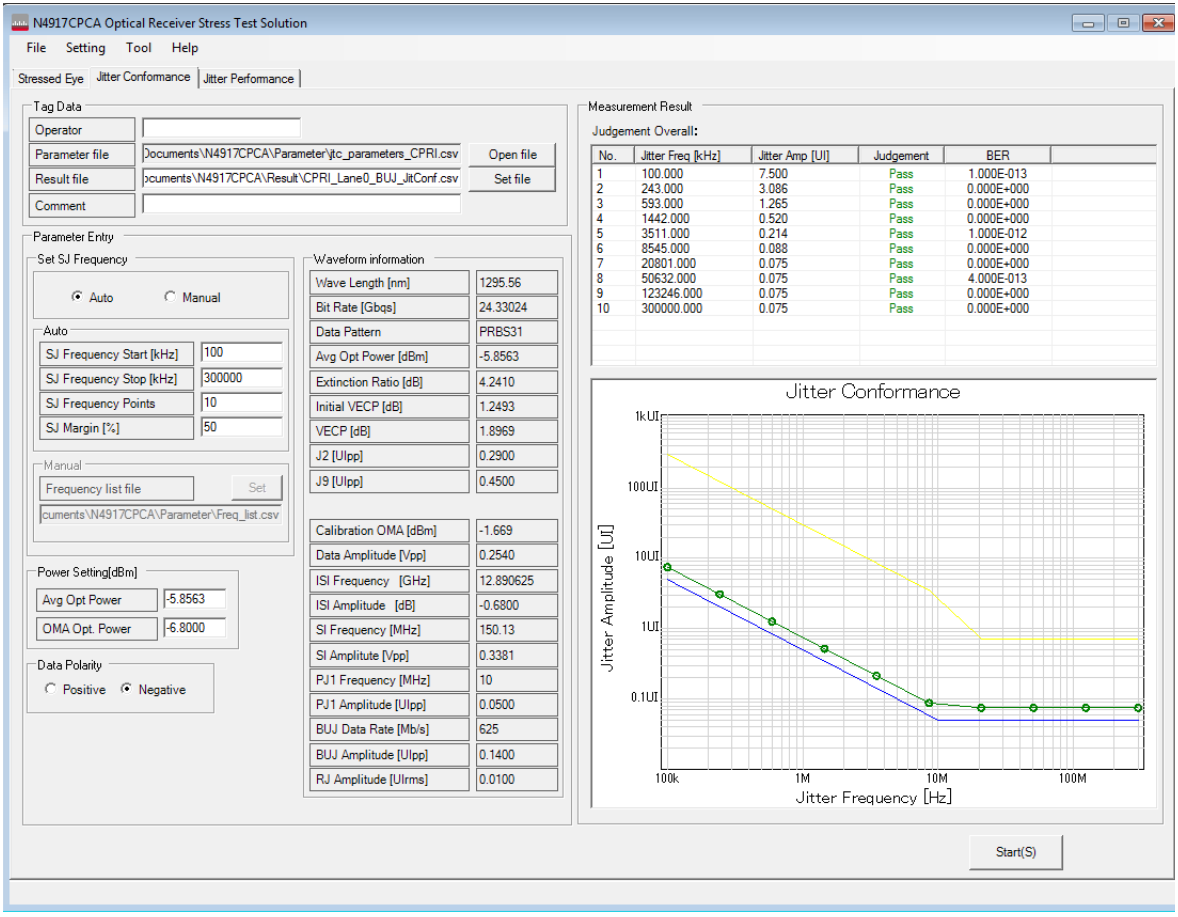

Figure 36 Jitter Conformance window after the test is complete

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**).

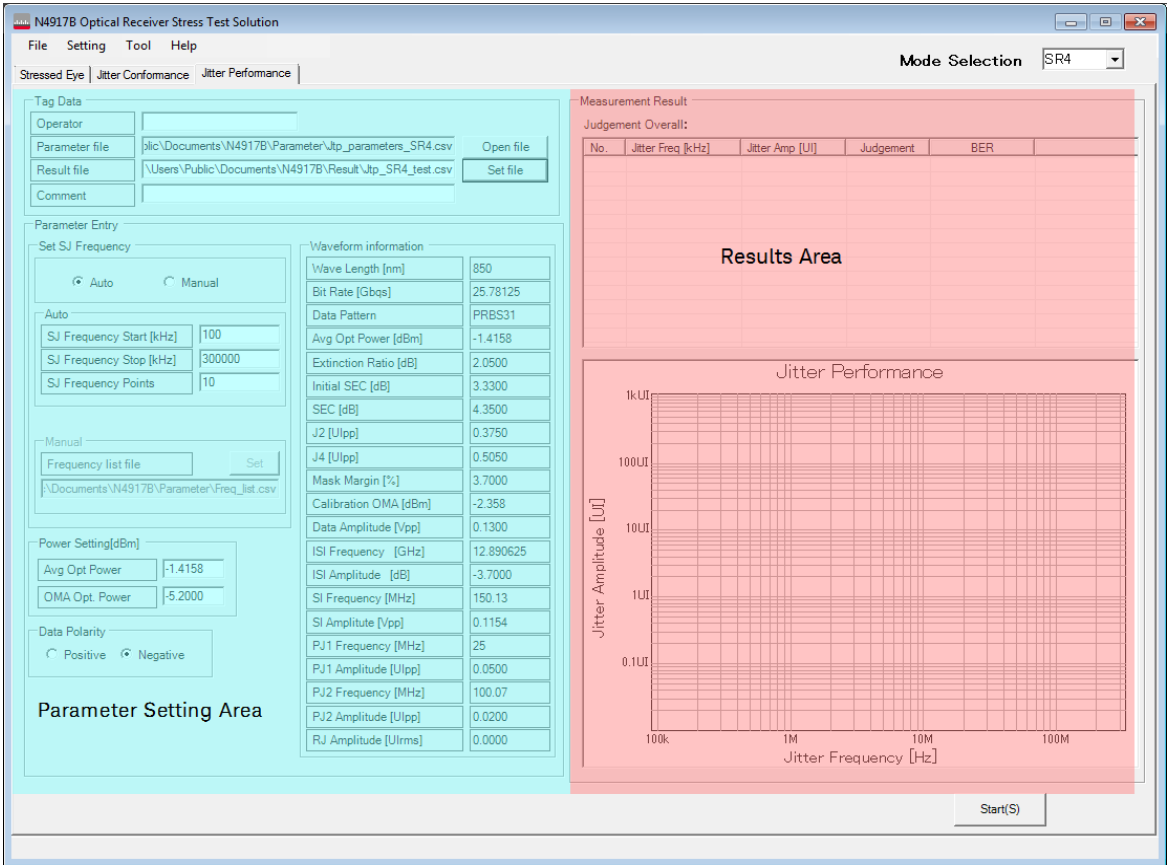

Figure 37 Jitter Performance Test Window

Set Result file

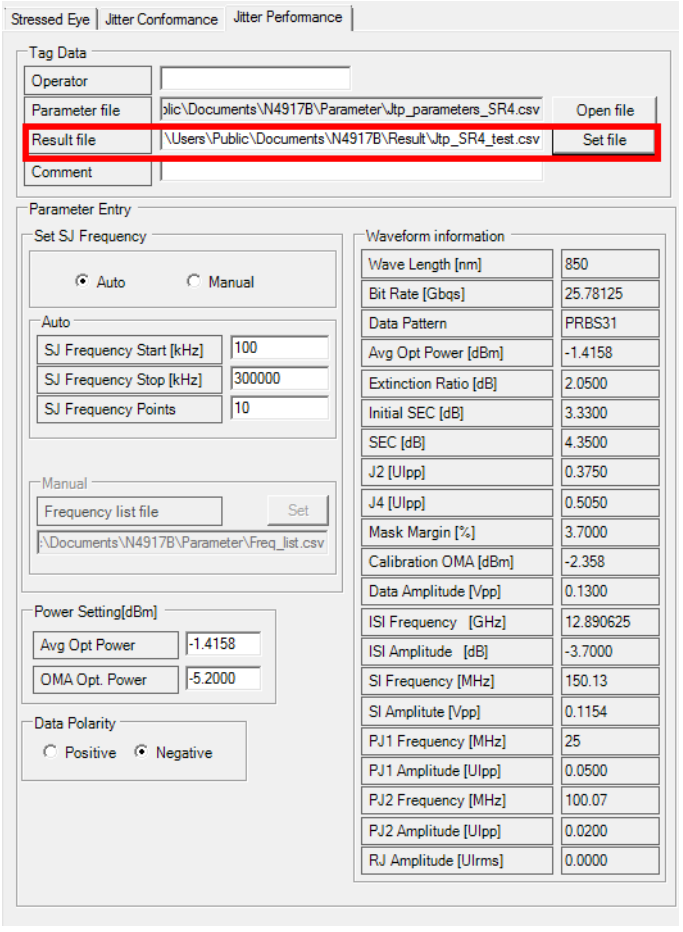

Figure 38 Setting Result File location

The N4917B 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\N4917B\Result*

Parameter Details

The Jitter Performance measurement sweeps sinusoidal jitter from a maximum range of 100 kHz to 300 MHz. You may set the Start frequency to a value, which is greater than or equal to 100 kHz 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\N4917B\Parameter*.

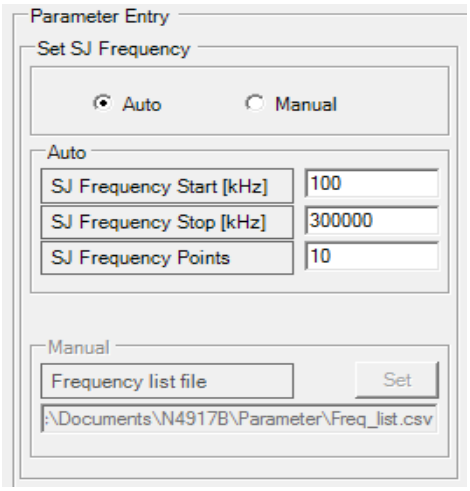

Figure 39 Jitter Performance Test Parameters

Generally, you are not required to make any changes to the remaining parameters as the N4917B 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 40.

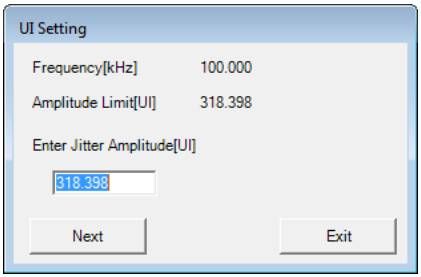

Figure 40 Enter SJ Amplitude Dialog Box

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.

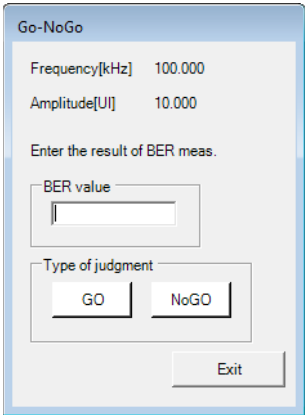

Figure 41 GO/NoGO Dialog Box for Enter SJ Amplitude Dialog Box

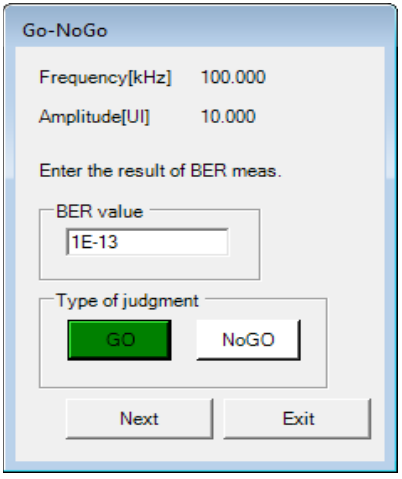

Figure 42 GO/NoGO dialog box with BER and judgment entered

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.

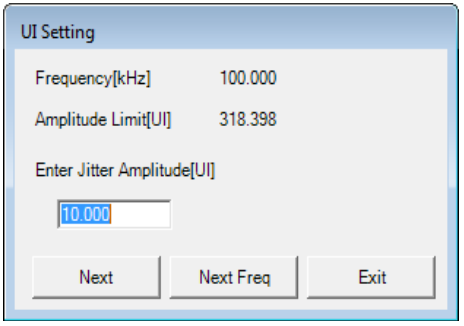

Figure 43 Enter new SJ Amplitude or proceed to the next SJ Frequency Dialog

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

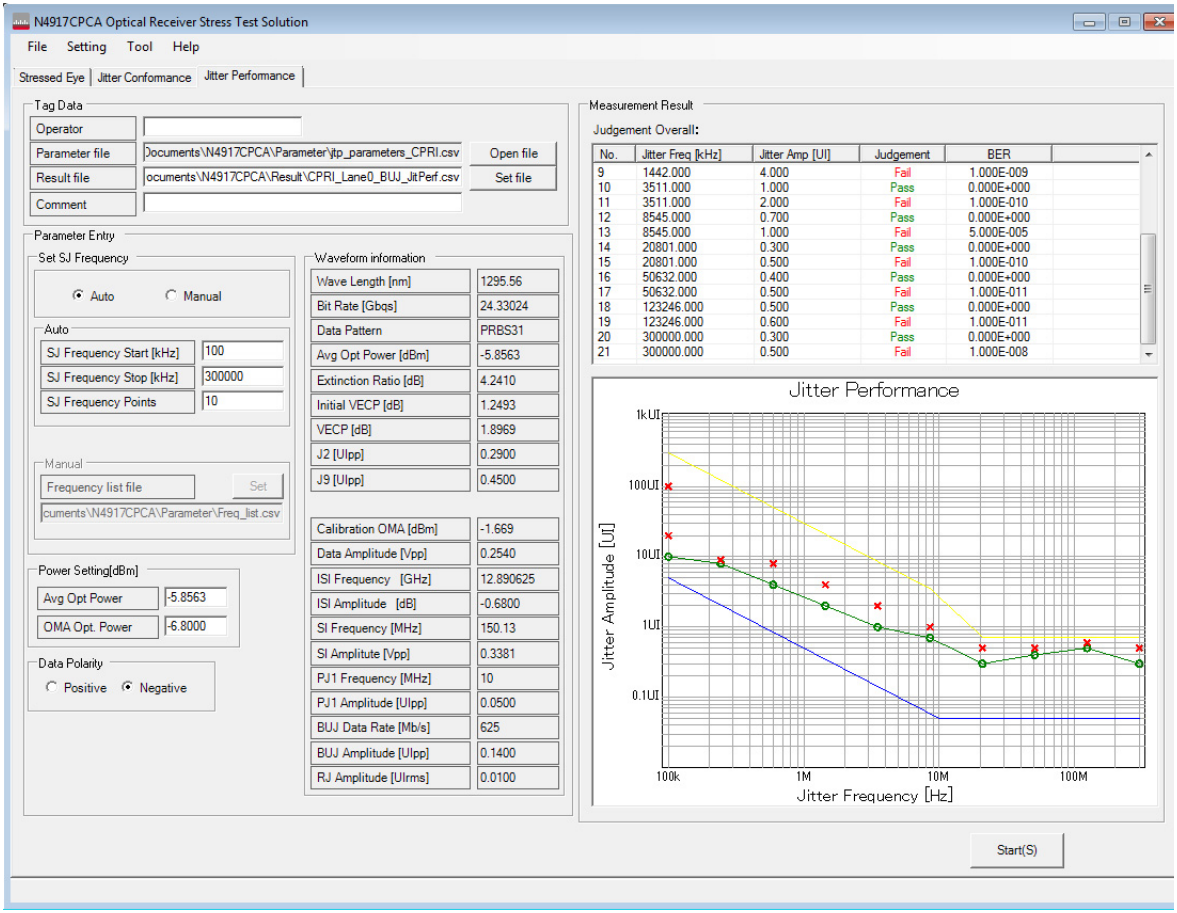

Figure 44 Jitter Performance window after the test is complete

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 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 software using the 'DUT Control Interface' (license required) to read the BER directly from the DUT internal error checker counters.

The M8070A 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.

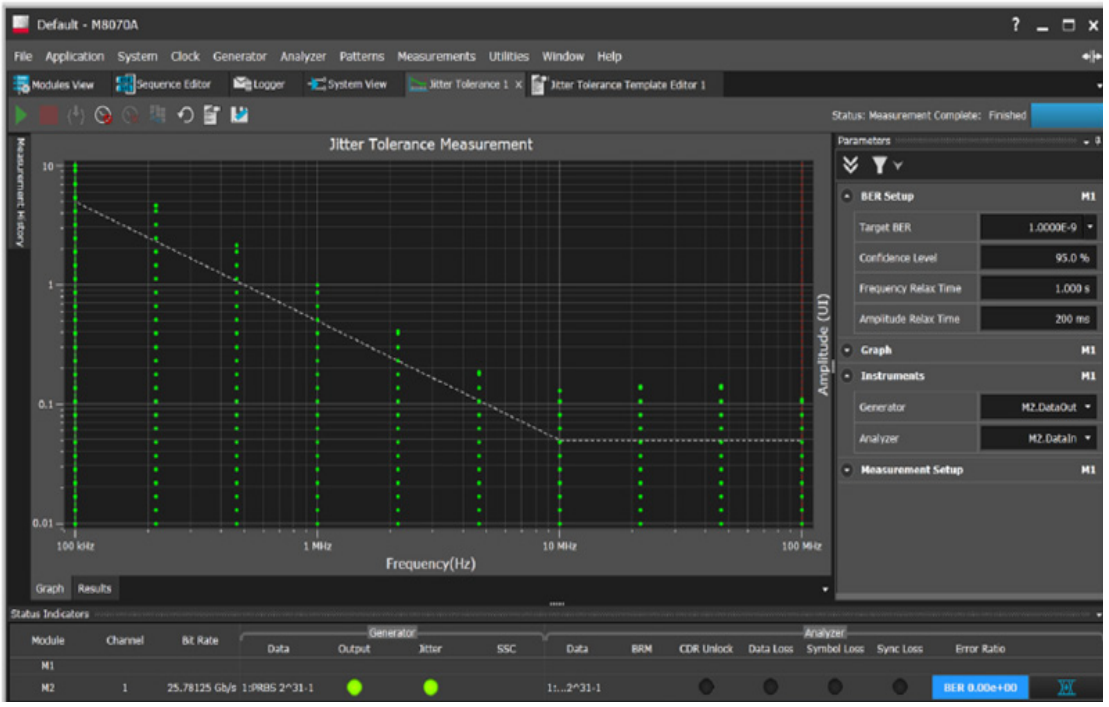

Figure 45 Jitter Tolerance Measurement System Results within M8070A software

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

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