
AE6980T nGBASE-AU Optical Automotive Ethernet Tx Compliance Software

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Software Version

Version 1.2.0.0 or greater

Manual Part Number

AE6980T-91001

Edition

August 2026

Published by:

Keysight Technologies
1900 Garden of the Gods Road
Colorado Springs, CO 80907 USA

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In this book

This document describes the tests that are performed by the Optical Automotive Ethernet Tx Compliance Software in more detail.

- **Chapter 1, "Introduction"** provides an overview of the compliance test application and the test groups included in the Optical Automotive Ethernet Tx Compliance Software.
- **Chapter 2, "Getting Started"** provides the necessary information to begin with the AE6980T Optical Automotive Ethernet Tx Compliance Software. This includes installing the application and licenses, connecting the required hardware, launching the software, and performing a measurement.
- **Chapter 3, "10GBASE-AU Tests"** provides the Methods of Implementation (MOIs) for the 10GBASE-AU tests using a supported Keysight DCA-M Sampling Oscilloscope, Clock Recovery Unit (CRU) and the AE6980T Optical Automotive Ethernet Tx Compliance Software.

See Also

The Optical Automotive Ethernet Tx Compliance Software's Online Help, which describes:

- Starting the Optical Automotive Ethernet Tx Compliance Software.
- Creating or opening a test project.
- Setting up the DCA Optical test environment.
- Selecting tests.
- Configuring selected tests.
- Defining compliance limits.
- Connecting the oscilloscope to the DUT.
- Running tests.
- Automating the application.
- Viewing test results.
- Viewing/exporting/printing the HTML test report.
- Understanding the Report.

- Exporting measurement results to web repository.
- Saving test projects.
- Controlling the application via a remote PC.

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1 Introduction

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Optical Automotive Ethernet uses optical fiber to transmit data between systems within a vehicle. IEEE Std 802.3cz defines optical connectivity standards supporting single-lane data rates up to 50 Gbps, with up to four in-line connectors and a maximum reach of 40 meters over OM3 multimode glass optical fiber.

The Keysight AE6980T Optical Automotive Ethernet Tx Compliance software, built on Keysight's FlexDCA platform, integrates Transmitter Distortion Figure of Merit (TDFOM)-assisted measurement capabilities in compliance with the IEEE 802.3cz standard. As the key metric for assessing optical signal quality, TDFOM enables predictive analysis of real-world performance and simplifies device debugging through detailed margin and eye-quality evaluations. The compliance application further enhances efficiency by automating complex test setups and generating comprehensive HTML reports for validation and engineering teams.

This chapter provides an overview of the compliance test application and the test groups in the Optical Automotive Ethernet Tx Compliance Software.

Optical Automotive Ethernet Tx Compliance Software – At A Glance

The AE6980T is an automated test software that enables measurement of a significant subset of optical transmitter parameters outlined in the IEEE 802.3cz specification through a set of logically grouped tests.

Use the Optical Automotive Ethernet Tx Compliance Software with the DCA-M (N1092A/C) sampling oscilloscope and the N1077A/B Clock Data Recovery (CDR) module. The N1077A/B CDR recovers the clock signal from the optical data stream allowing the sampling oscilloscope to accurately align waveform samples and properly trigger eye diagram acquisition.

The Optical Automotive Ethernet Tx Compliance Software:

- allows you to select individual or multiple tests to run.
- allows you to identify the device being tested and its configuration.
- shows you ways to make oscilloscope connections to the DUT.
- automatically checks for proper oscilloscope configuration.
- automatically sets up the oscilloscope for each test.
- provides detailed information for each test that has been run, and lets you specify the thresholds at which marginal or critical warnings appear.
- creates a printable HTML report of the tests that have been run.

Optical Automotive Ethernet Tx Compliance Software Test Groups

The group of tests specified in this MOI pertains to the IEEE 802.3cz specification. The relevant sections of the specifications define the optical requirements of the signals for the following transmission standards.

Table 1-1 Test and Clauses

Test	Clause
TDFOM Average Optical Power (AOP)	IEEE 802.3cz - Section 166.6.4.3, Open Alliance TC7 Test House - Section 10.3.2
TDFOM Optical Modulation Amplitude (OMA)	IEEE 802.3cz - Section 166.6.4.4, Open Alliance TC7 Test House - Section 10.3.3
TDFOM Extinction Ratio (ER)	IEEE 802.3cz - Section 166.6.4.5, Open Alliance TC7 Test House - Section 10.3.3
Transmitter Distortion Figure of Merit (TDFOM)	IEEE 802.3cz - Section 166.6.4.8, Open Alliance TC7 Test House - Section 10.3.3
TDFOM OAR (OMA to AOP Ratio)	IEEE 802.3cz - Section 166.6.4.13.2 ¹
Optical Transmitter AOP (when Tx is set to OFF)	IEEE 802.3cz - Section 166.6.4.3, Open Alliance TC7 Test House - Section 10.3.2
Uncorrelated Random Jitter	IEEE 802.3cz - Section 166.6.4.7, Open Alliance TC7 Test House - Section 10.3.3
RIN12OMA	IEEE 802.3cz - Section 166.6.4.6, Open Alliance TC7 Test House - Section 10.3.3
Transmitter Clock Frequency	IEEE 802.3cz - Section 166.6.3.2, Open Alliance TC7 Test House - Section 10.3.2
Center Wavelength	IEEE 802.3cz - Section 166.6.4.2, Open Alliance TC7 Test House - Section 10.3.1
RMS Spectral Width	IEEE 802.3cz - Section 166.6.4.2, Open Alliance TC7 Test House - Section 10.3.1
Optical Return Loss	IEEE 802.3cz - Section 166.6.4.2, Open Alliance TC7 Test House - Section 10.3.5

¹ Defined in IEEE 802.3cz as Γ_{tx} in 166.6.4.13.2.

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This chapter provides the necessary information for getting started with the AE6980T Optical Automotive Ethernet Tx Compliance Software, including installing the application and licenses, making the required hardware connections, starting the application, and taking a measurement.

Getting Started

Perform the following steps to get started with the Optical Automotive Ethernet Tx Compliance Software.

- 1 Review the system requirements. Refer to [“Required Equipment, Component and Software”](#) on page 17.
- 2 Install the AE6980T Optical Automotive Ethernet Tx Compliance Software. Refer to [“Installing the Software”](#) on page 18.
- 3 Install the required licenses. Refer to [“Installing the License Key”](#) on page 19.
- 4 Connect the hardware. Refer to [“Set Up Hardware Connections for Compliance Testing with Reflector”](#) on page 21.
- 5 Establish a connection between FlexDCA, oscilloscope, and the clock data recovery.
- 6 Start the AE6980T Optical Automotive Ethernet Tx Compliance Software. Refer to [“After 980 nm User Calibration”](#) on page 28.
- 7 Make a measurement using AE6980T Optical Automotive Ethernet Tx Compliance Software. Refer to [“Procedure for Measuring with Optical Automotive Ethernet Tx Compliance Software”](#) on page 31.

Required Equipment, Component and Software

The following equipment and software is required to run the Optical Automotive Ethernet Tx Compliance Software:

- DCA-M Oscilloscope: N1092A or N1092C
- Optical/Electric Clock Recovery: N1077A or N1077B
- FlexDCA Sampling Oscilloscope Software with Research and Development Package Option (L-RND), version A.07.90.172
- AE6980T Optical Automotive Ethernet Tx Compliance Software.
- Matlab runtime 2023b
- PLC fiber splitter cable
- Automotive Ethernet Glass Optical Fiber Cable (1–3m), automotive grade MM fiber
- Optical spectrum analyzer (designed for 980nm VCSEL measurement)
- Variable reflector

For the list of required licenses to run this application, refer to the Data Sheet for this application.

NOTE

- Required option for N1092A/C DCA-M: 280, 30A, FS1, IRC, LOJ, PLK
 - Required option for N1077A/B CDR: 264, SXT, EVA, JSA
-

NOTE

N1077A Optical/Electric Clock Recovery has been discontinued.

Installing the Software

Two licensed software is required to operate the AE6980T nGbase-AU optical transmitter test: FlexDCA with RnD option N1010100A, and AE6980T nGbase-AU compliance test software. A 30-day trial license is available for both application software from Keysight.

- 1** FlexDCA RnD option N1010100A – SW is downloadable from [N1010A FlexDCA Sampling Oscilloscope Software | Keysight](#)
- 2** AE6980T nGbase-AU compliance test SW – SW is downloadable from [AE6980T Optical Automotive Ethernet Tx Compliance Test Software | Keysight](#)
- 3** Ensure that the right version of FlexDCA with RnD option N1010100A software (version A.07.90.172) is installed on your PC (refer to the AE6980T release notes).
- 4** To obtain the AE6980T Optical Automotive Ethernet Tx Compliance Software, go to Keysight website.
- 5** Navigate to the Optical Automotive Ethernet Tx Compliance Software download page.
- 6** Follow the instructions to download and install the application software.

Installing the License Key

Install all the licenses required to run the Optical Automotive Ethernet Test Software using PathWave License Manager.

Table 2-1 Required Licenses for Optical Automotive Ethernet Test Software

Licenses	Required for
AE6980T	Optical Automotive Ethernet Tx Compliance Software
N1010100A	Research and Development Package for FlexDCA

Using PathWave License Manager to Install Licenses

- 1 Save the license files on the machine where the software application and its features will be executed.
- 2 Launch **PathWave License Manager** and click **+ Add a License File**.
- 3 Click **Browse** and choose the license file to add.

Request for the Free 30-Day Trial License

To request a free trial license use the following link:

Table 2-2 Obtaining Licenses Required for Optical Automotive Ethernet Test Software

Licenses	Link
AE6980T	Contact Keysight support.
N1010100A	Use Keysight Software Manager . Refer to Keysight Software Manager Overview .

To request for the free trial licenses, provide the machine's Host ID:

- Refer to [Getting the Machine's Address](#).

2 Getting Started

To install the free trial licenses:

- Refer to [Using PathWave License Manager to Install Licenses](#).

Getting the Machine's Address

To view and copy the machine's host ID from PathWave License Manager:

- 1 Launch PathWave License Manager.
- 2 Copy the Ethernet address.

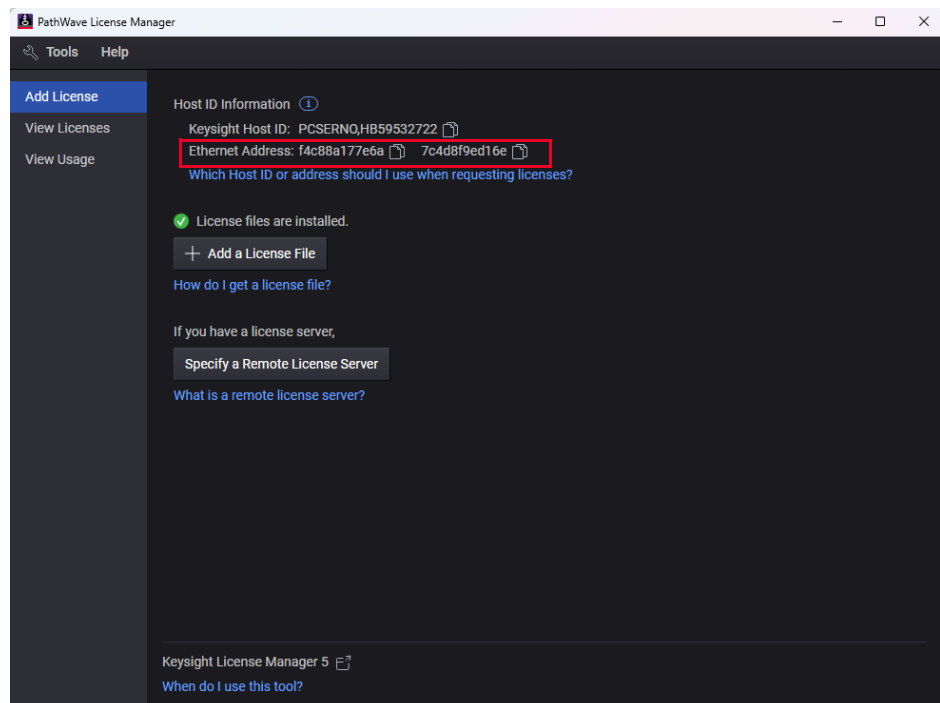


Figure 2-1 Viewing the Host ID Information in PathWave License Manager

Set Up Hardware Connections for Compliance Testing with Reflector

Connection diagram for nGBASE-AU optical automotive ethernet transmitter test

Set up the connections between the instruments as shown in [Figure 2-2](#) when an external CDR is used.

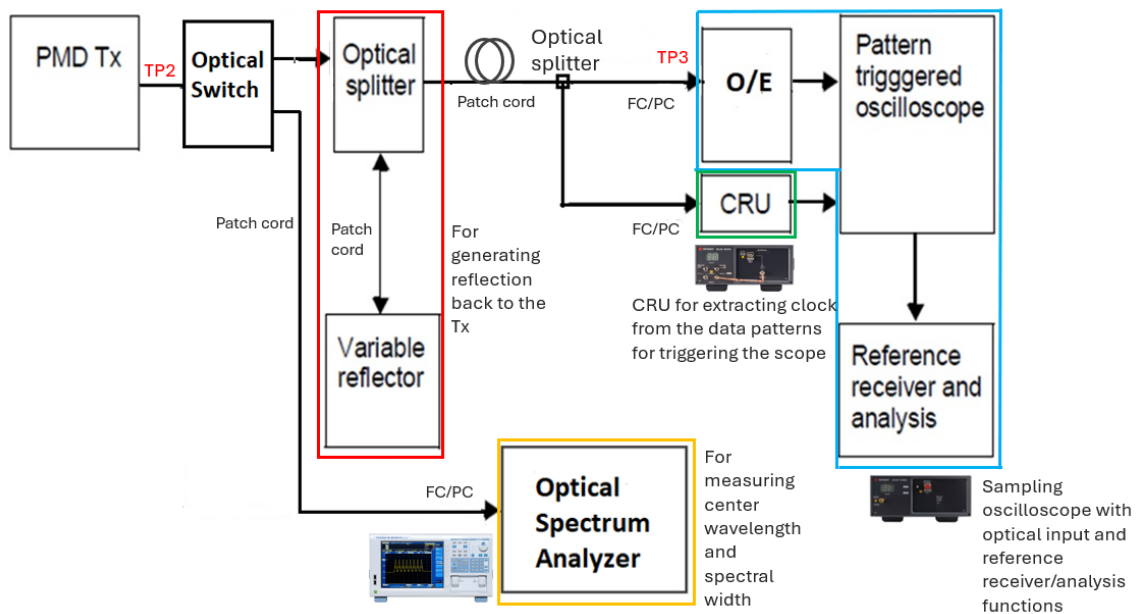


Figure 2-2 Overview of nGBASE-AU Tx Test Connection Setup

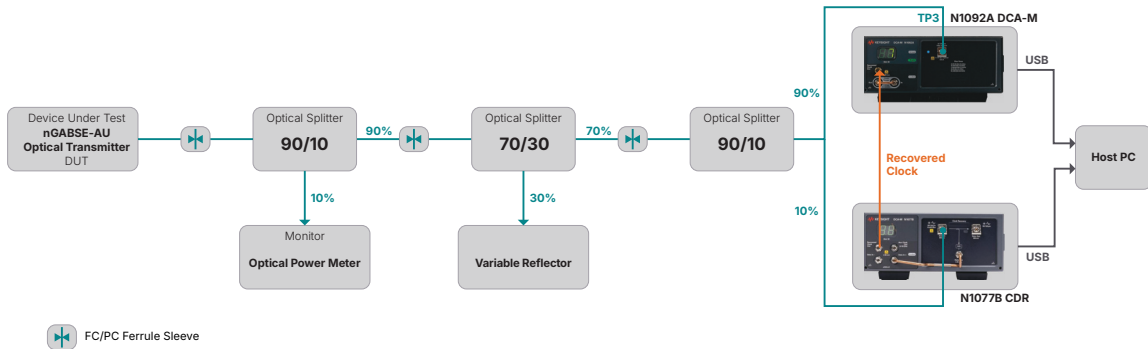


Figure 2-3 nGBASE-AU Tx Test Connection Example with Variable Reflector

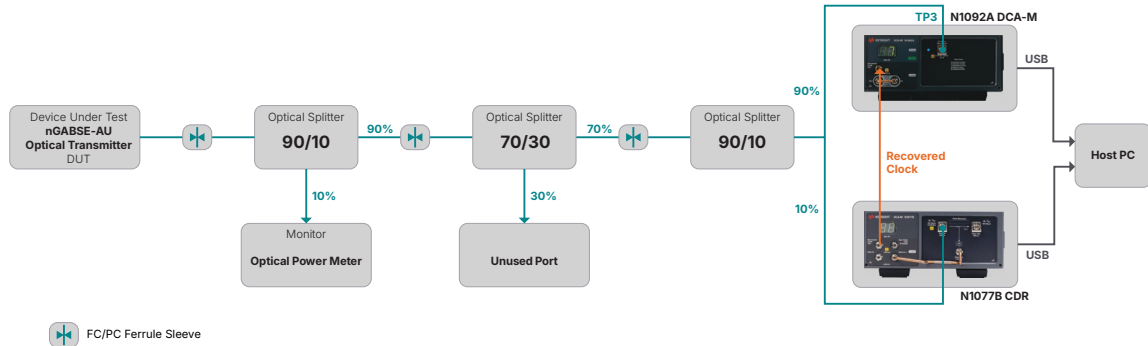


Figure 2-4 Transmitter Clock Frequency Connection Diagram

Setting up the variable reflector

One key requirement for TDFOM measurement as defined in IEEE 802.3cz is the inclusion of an optical splitter and variable reflector, which intentionally introduces a controlled -12 dB reflection back toward the transmitter to simulate worst case optical return loss. This is kind of a stress test for optical transmitter with reflected light coming back to the laser source and you ensure that the optical transmitter withstand without violating eye quality metrics.

Since reflection cannot be injected directly at TP2, establish a controlled reflection path at TP3, using:

- a variable reflector
- an optical splitter

- known splitter ratios to reverse calculate the reflection at TP2.

There are multiple methods to build the variable reflector setup. [Figure 2-3](#) illustrates one recommended approach. Alternatively, using a preassembled variable reflector product can simplify the set up process.

Testing with the variable reflector

Use this setup for the following transmitter compliance tests:

- TDFOM Average Optical Power (AOP)
- TDFOM Optical Modulation Amplitude (OMA)
- TDFOM Extinction Ratio (ER)
- Transmitter and Distortion Figure of Merit (TDFOM)
- TDFOM OAR (OMA to AOP Ratio)
- Uncorrelated Random Jitter
- RIN12OMA

These compliance tests are described in detail in [Chapter 3](#).

Set Up Hardware Connections for Compliance Testing without Reflector

Testing without a reflector

Use this setup for the following transmitter compliance tests:

- **Optical Transmitter AOP (Tx OFF)** (see Figure 2-5 for connection diagram).
- **Center Wavelength** (see Figure 2-6 for connection diagram).
- **RMS Spectral Width** (see Figure 2-6 for connection diagram).
- **Optical Return Loss** (see Figure 2-7 for connection diagram).



Figure 2-5 Optical Transmitter AOP (Tx OFF) Connection Diagram

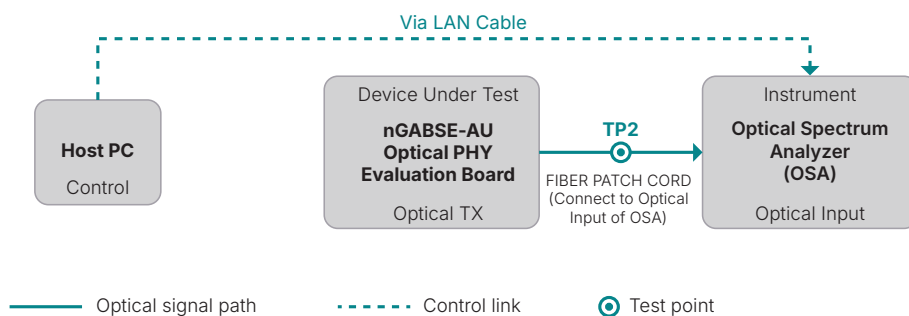


Figure 2-6 Center Wavelength & RMS Spectral Width Connection Diagram

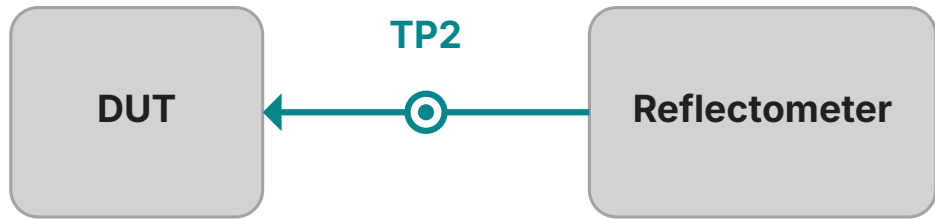


Figure 2-7 Optical Return Loss Connection Diagram

These compliance tests are described in detail in [Chapter 3](#).

Confirming Test Patterns Visually on the Oscilloscope and 980 nm User Calibration

Confirming Test Patterns Visually on the Oscilloscope

After installing the software with a valid license and completing the hardware setup, it is recommended to visually verify the test patterns on the oscilloscope before starting the compliance test.

Configure a few areas on the DCA-M and CDR to display the eye diagram and confirm the test pattern.

- 1 Launch the FlexDCA application.
- 2 Ensure that the 10.625 Gb/s test pattern is applied to the input of DCA-M and CDR.
- 3 When a raw waveform appears (prior to clock recovery and proper test pattern triggering), open the **CDR configuration** dialog box.

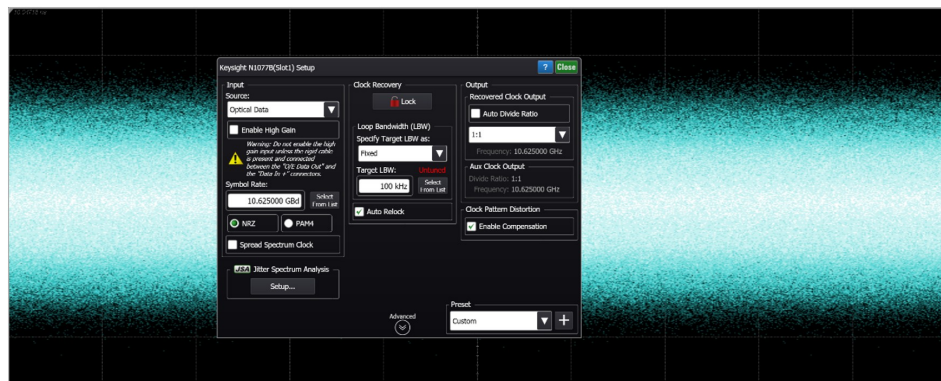


Figure 2-8 CDR Configuration Dialog Box

- 4 Configure the following:
 - Source: **Optical Data**
 - Symbol Rate: **10.625 GBd NRZ**
 - Recovered Clock Output: **1:1**
 - Click **Lock** to enable clock recovery.

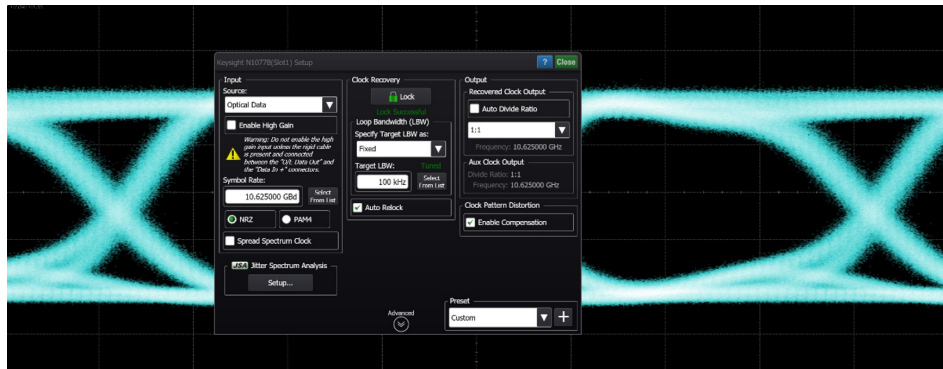


Figure 2-9 10.625 GBd Configuration

- 5 Run the **Bit Rate** measurement on the eye pattern to ensure it is 10.625 Gb/s.

980 nm Wavelength Calibration

The Keysight DCA-M series oscilloscope does not include factory calibration for 980 nm. Users must perform 980 nm user-calibration using:

- A 980 nm optical light source (CW laser)
- An optical power meter
- The DCA-M oscilloscope

Follow the procedure outlined in the FlexDCA software documentation:
[FlexDCA Optical Calibration Guide](#).

The FlexDCA software provides a straightforward step-by-step user-calibration process.

NOTE

- Calibration must be performed for each optical channel on the DCA-M.
- Once completed, calibration does not need to be repeated.
- After successful calibration, the 980 nm wavelength option becomes available in the compliance application.

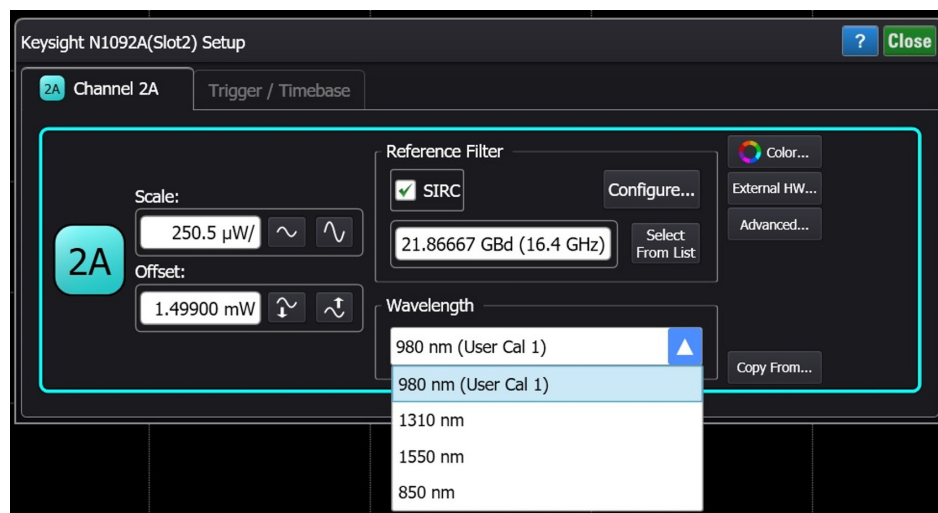


Figure 2-10 After 980 nm User Calibration

Starting the Optical Automotive Ethernet Tx Compliance Software

- 1 From the FlexDCA's main menu, choose **Apps > Automated Test Apps > AE6980T Optical Automotive Ethernet Test Application** to launch the AE6980T Optical Automotive Ethernet Tx Compliance Software as shown in [Figure 2-11](#).

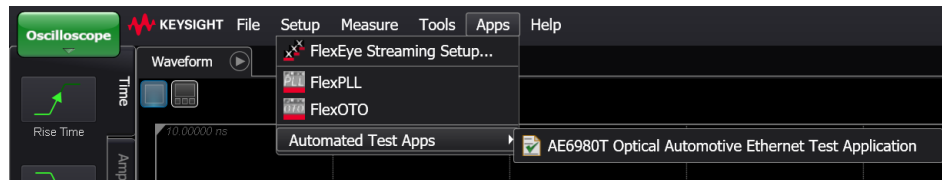


Figure 2-11 Start the AE6980T Optical Automotive Ethernet Test Application

Table 2-3 Tab and Description

Tab	Description
Set Up	Allows you to identify and set up the test environment, including information about the DUT.
Select Tests	Enables you to choose tests for execution. Tests are organized hierarchically, allowing selection of individual tests or entire groups. Upon execution, status indicators display results for each test and group: passed, failed, or not run.
Configure	Enables configuration of test parameters, which are included in the generated HTML report.
Connect	Provides instructions for connecting the oscilloscope to the DUT for the selected tests.
Run Tests	Initiates automated test execution. If connection changes to the DUT are required during multiple test runs, the process pauses, provides instructions for updating the connections, and resumes only after you confirm the changes.
Automation	Allows you to create command scripts that control application execution.
Results	Provides detailed information about executed tests and allows adjustment of thresholds for marginal or critical warnings.
HTML Report	Displays a compliance test report that can be printed.

NOTE

The configuration options in the **Set Up** tab of the Optical Automotive Ethernet Tx Compliance Software determine which tests are available in the **Select Tests** tab.

Procedure for Measuring with Optical Automotive Ethernet Tx Compliance Software

Perform the steps below to perform a measurement using the Optical Automotive Ethernet Tx Compliance Software.

- 1 In the **Set Up** tab, as shown in [Figure 2-12](#), select the **Specification**, **Data Rate**, and equipment or **Extended Module Configuration**.

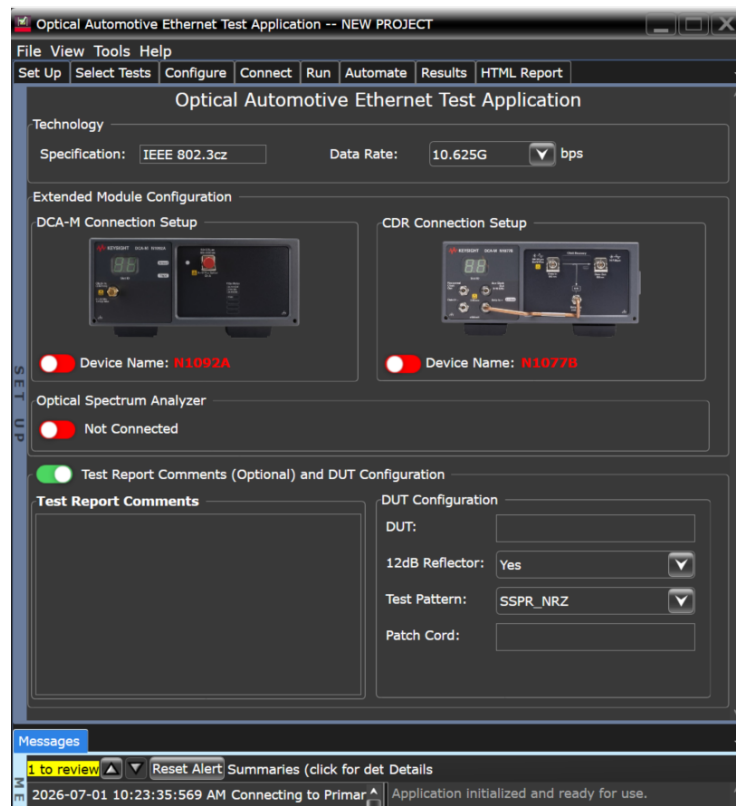


Figure 2-12 Set Up Tab

- Technology

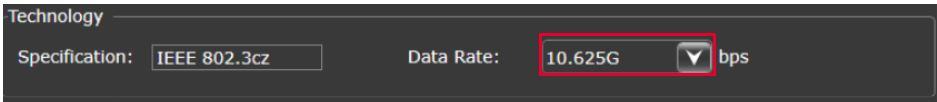


Figure 2-13 Technology

This section allows you to choose the technology standard applicable to the DUT. For each specification, the Compliance Application automatically assigns the corresponding data rate.

If the DUT complies with the IEEE 802.3cz standard for 10GBASE-AU, select **IEEE 802.3cz** from the **Specification** drop-down menu. This standard supports a data rate of **10.625 Gbps**, which the application selects by default.

- Extended Module Configuration



Figure 2-14 Extended Module Configuration

When the device is connected via USB, the **Extended Module Configuration** section dynamically displays the device name and displays the button in green to indicate an active connection.

Optical Spectrum Analyzer



Figure 2-15 Optical spectrum analyzer

- 1 The highlighted switch opens the External Instruments List dialogue box. Note that find and clear functions are located under the Action column.

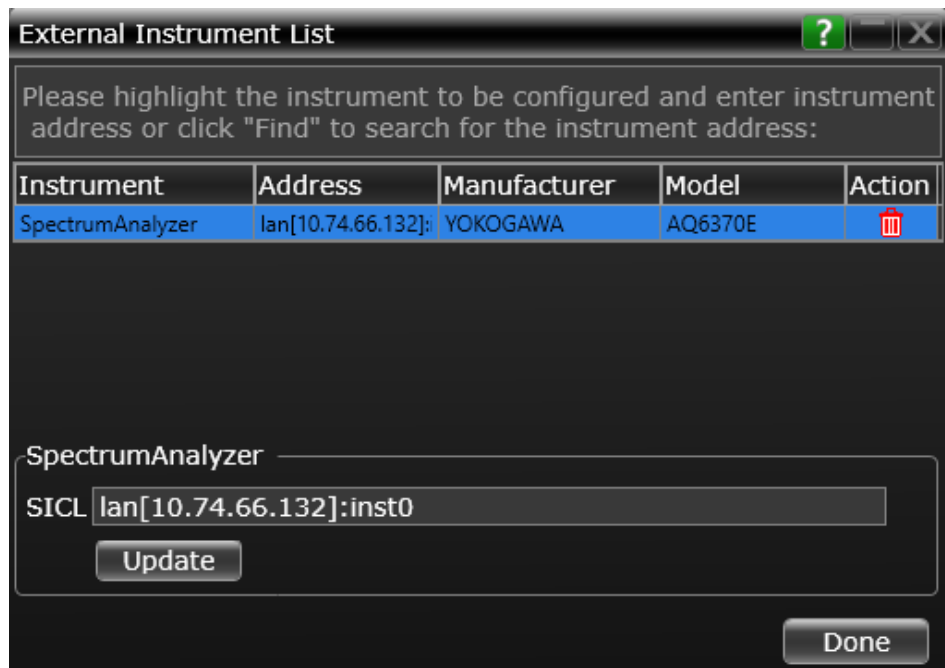


Figure 2-16 External instruments list dialogue box

- 2 Add instruments or interfaces to the Keysight Connection Expert according to the following steps. For all other interfaces, refer to the Keysight Connection Expert help file for guidance.

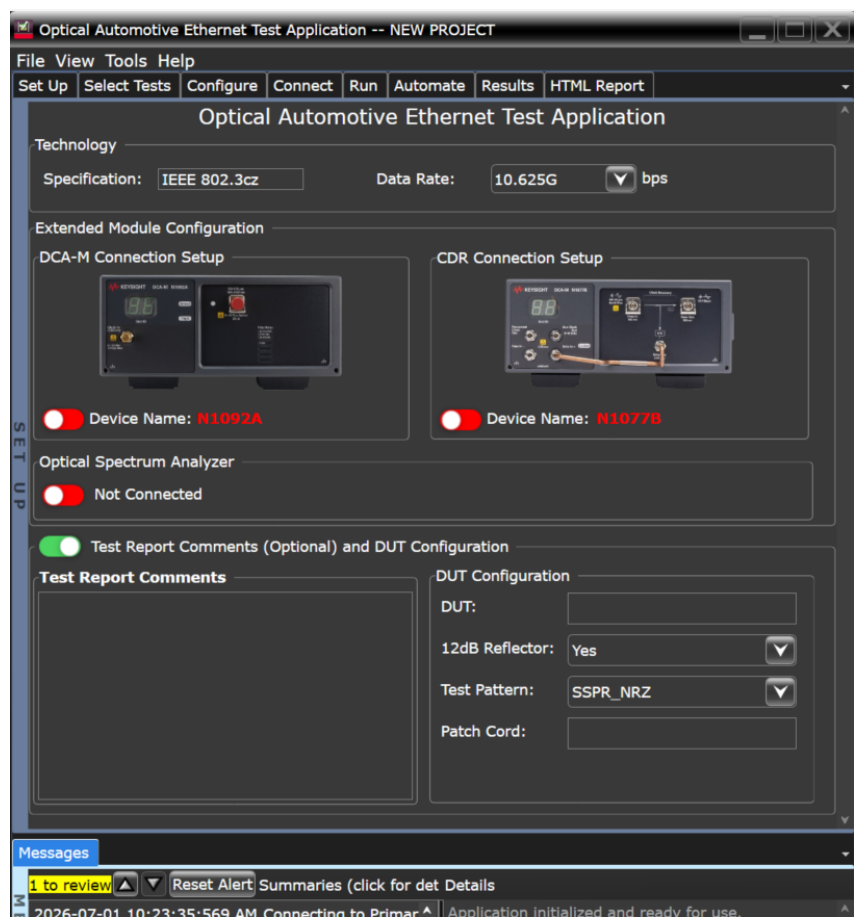


Figure 2-17 Devices Disconnected in Set Up Tab

If the device is disconnected by physically removing the USB cable, this section will update in real time, changing the device name and button to red to indicate disconnection. You can also manually connect or disconnect the device by clicking the  button.

If the device is not connected and you click the button, the application displays a warning dialog box, as shown in [Figure 2-18](#).

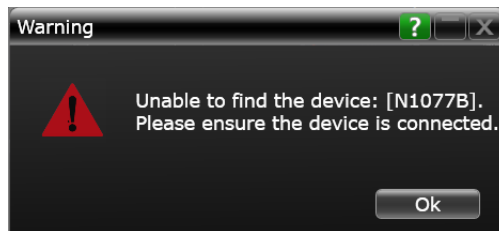


Figure 2-18 Device Not Connected

- Test Report Comments

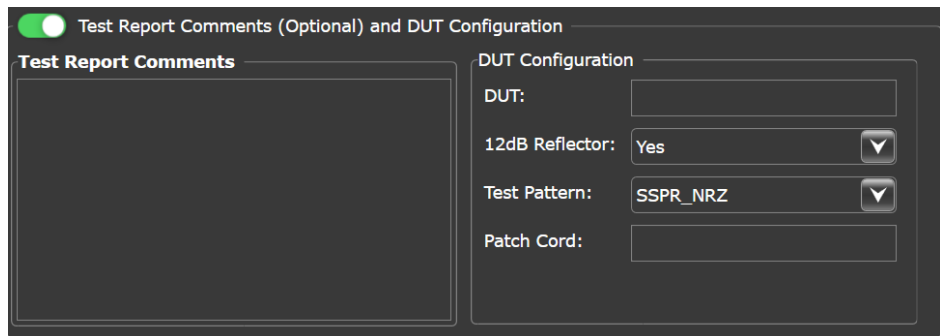


Figure 2-19 Test Report Comments

Test Report Comments (Optional) This section is optional but recommended. It allows you to add comments that would appear in the HTML report generated after execution.

DUT Configuration Test will filter based on 12dB Reflector and Test Pattern based on the DUT configuration.

- 2 In the **Select Tests** tab, as shown in [Figure 2-20](#), select one or more tests. the available tests appear based on the configuration performed in the **Set Up** tab.

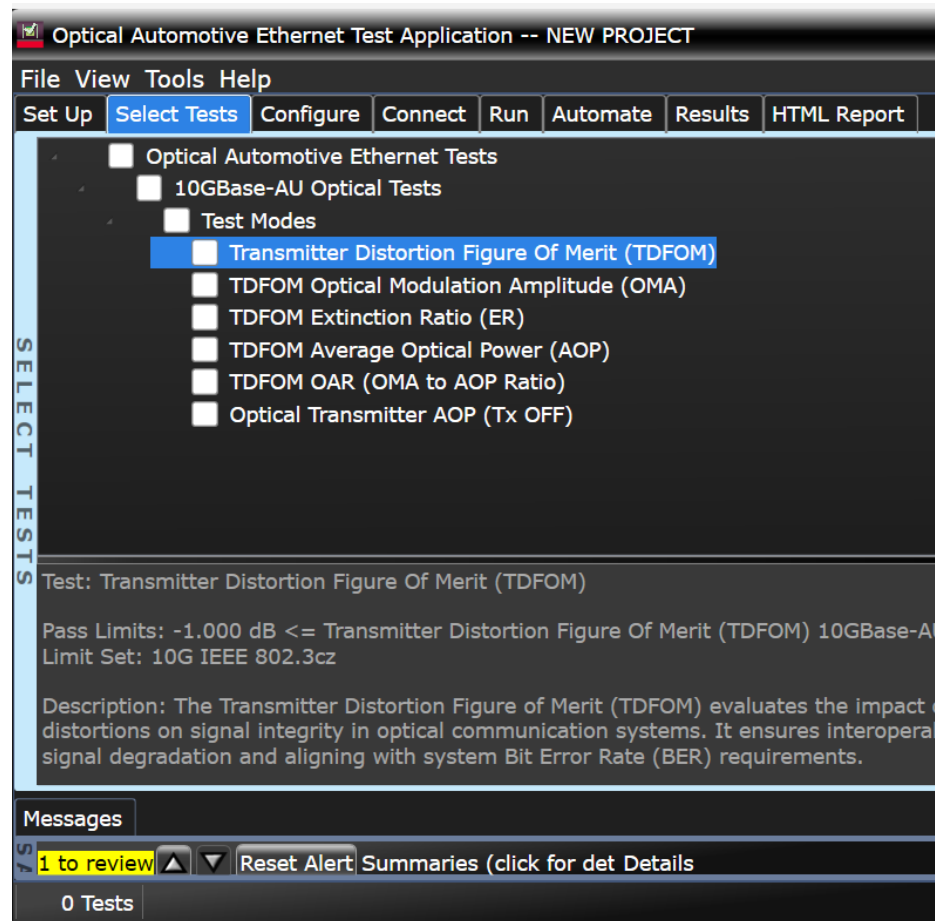


Figure 2-20 Select Tests Tab

- 3 In the **Configure** tab, you may adjust the values assigned to one or more options to meet the compliance requirements for the selected tests. By default, the Optical Automotive Ethernet Tx Compliance Software sets optimum values for each configuration parameter. To add channel loss at TP2 and TP3, refer to [“Channel Loss Compensation \(De-embedding\)”](#) on page 39.

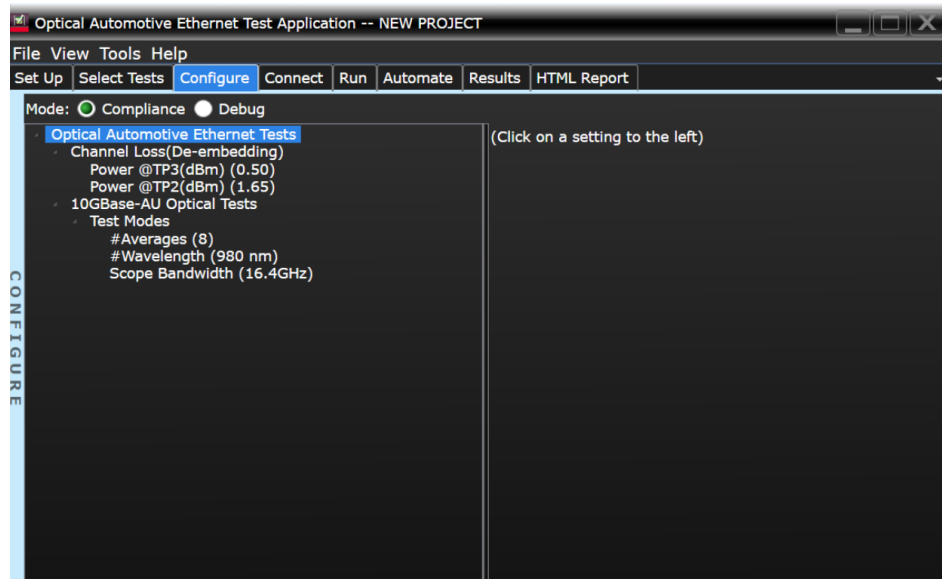


Figure 2-21 Configure Tab

- 4 In the **Connect** tab, review the instructions along with the connection diagram to ensure that all requirements for the physical setup of the testing instruments and the DUT are met. Click **Connection Completed** to confirm that the required hardware setup is completed.
- 5 Click **Run Tests** under this tab to execute tests. However, if you wish to modify the run settings before the test execution, switch to the **Run** tab.
- 6 In the **Run** tab, click **Run** to execute the test.

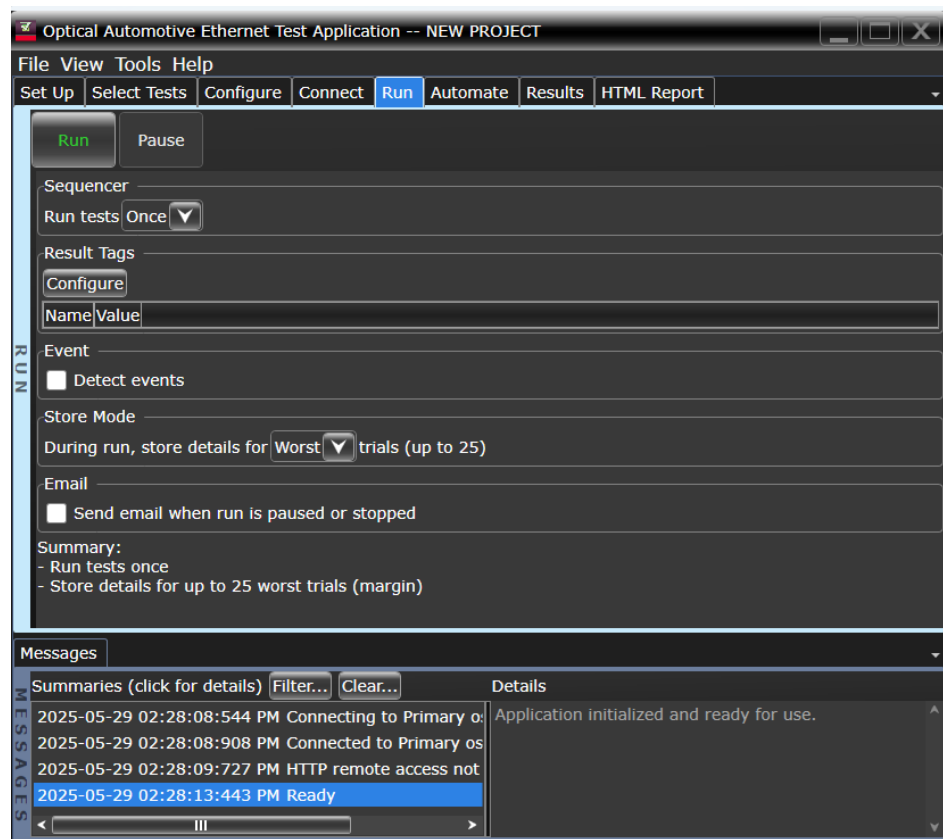


Figure 2-22 Run Tab

- 7 In the **Automate** tab, you may optionally configure automation scripts to perform specific actions or sequences within the Compliance Test Application.
- 8 The **Results** tab appears automatically after the test run is complete. It displays the results for the selected test.
- 9 The **HTML Report** tab provides a comprehensive report for each test. You can export these results in CSV, PDF, or HTML format for further analysis.

Channel Loss Compensation (De-embedding)

In IEEE 802.3cz (nGBASE-AU) Optical Automotive Ethernet, the reference measurement plane for transmitter (Tx) testing is Test Point 2 (TP2). All normative transmitter test parameters such as OMA, AOP, ER, TDFOM and OAR are specified at TP2, the Tx output reference plane.

However, in the physical test configuration, the Digital Communications Analyzer (DCA) measures the signal at Test Point 3 (TP3). To ensure accurate reporting of transmitter test parameters at TP2, the application should compensate for the channel loss between TP2 and TP3.

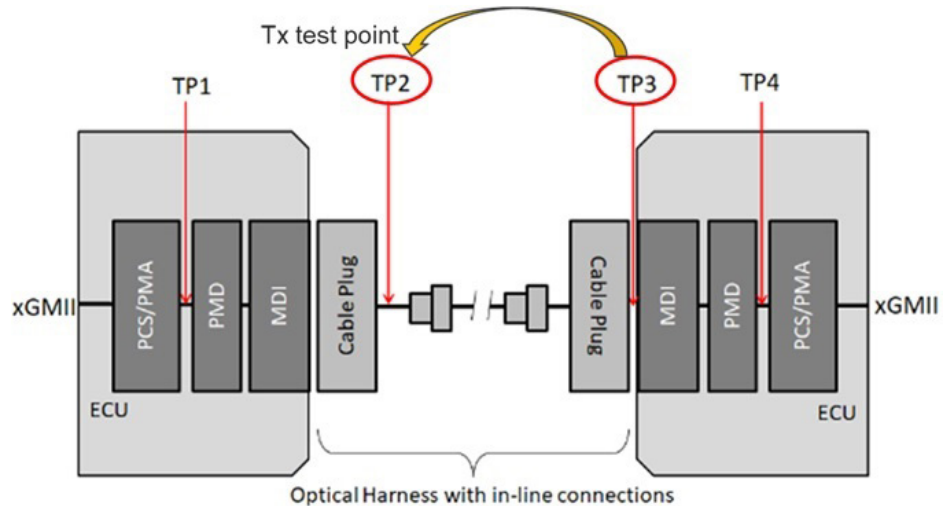


Figure 2-23 Test Point Definition of nGBASE-AU PHY Test

1 Measure Optical Power

Before performing the compensation, measure the optical power at both test points:

- Power @TP2 (dBm) – measured directly at the cable plug on the DUT transmitter output.
- Power @TP3 (dBm) – measured at the DCA input.

These measurements are entered in the compliance application under the Channel Loss (De-embedding) section.

2 Calculate Channel Loss

The Channel Loss is calculated using the formula:

$$\text{Channel Loss (dB)} = \text{Power @TP2 (dBm)} - \text{Power @TP3 (dBm)}$$

This represents the total optical attenuation between TP2 and TP3, including losses from optical splitters, connectors, and fiber patch cords.

Example:

If

- Power @TP2 = 1.65 dBm
- Power @TP3 = 0.50 dBm

Then,

$$\text{Channel Loss} = 1.65 - 0.50 = 1.15 \text{ dBm}$$

3 Apply Channel Loss Correction

Once calculated, the Channel Loss value is automatically applied by the software to compensate Transmitter test measurements. This ensures that the reported results correspond to the optical output at TP2 (the transmitter output) rather than TP3 (the measurement point).

The compensated results are used for compliance evaluation against the relevant nGBASE-AU optical transmitter specifications.

NOTE

- Ensure power readings are taken under stable conditions using a calibrated optical power meter.
 - Recalculate the channel loss if any optical connections, patch cords, or splitters are changed.
 - The application automatically updates the compensated test parameter values after the Channel Loss is compensated.
-

Calculate Channel Loss

Channel Loss can be calculated by finding the difference between the Optical Power at TP2 and Optical Power at TP3.

- 1 Measure optical power at TP2 using an optical power meter.

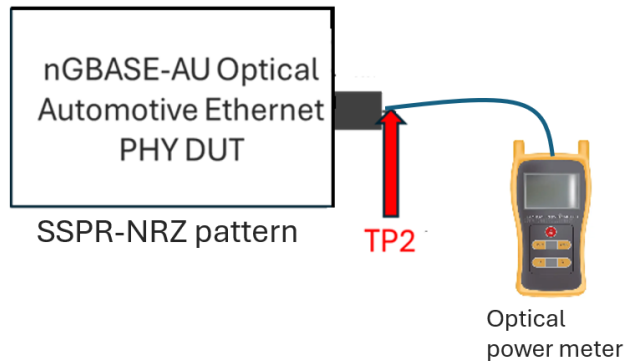


Figure 2-24 Measure Optical Power at TP2 Using an Optical Power Meter

- 2 Remove the fiber optic connection into the scope and CRU.
- 3 Connect the FC connector for scope into the power meter patch code using a ferrule sleeve.
- 4 Measure optical power at TP3 using the optical power meter.
- 5 Calculate the channel loss = power @TP2 – power @TP3

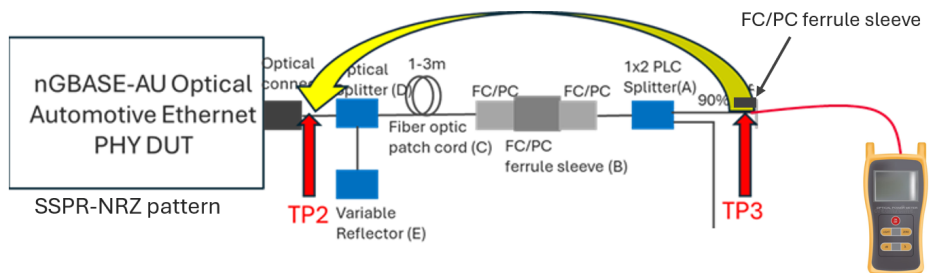


Figure 2-25 Calculate the Channel Loss

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3 10GBASE-AU Tests

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Connection for 10GBASE-AU Tests

When performing the 10GBASE tests, the Optical Automotive Ethernet Tx Compliance Software will prompt you to make the proper connections. The connections for these tests depend on the specific options selected under the **Set Up** tab. Refer to the **Connect** tab in the Optical Automotive Ethernet Tx Compliance Software for the exact connections. For more details, refer to either “Set Up Hardware Connections for Compliance Testing with Reflector” on page 21 or “Set Up Hardware Connections for Compliance Testing without Reflector” on page 24.

You can configure other settings used in these tests in the **Configure** tab of the Optical Automotive Ethernet Tx Compliance Software.

Test Procedure

- 1 Start the automated test application as described in “After 980 nm User Calibration” on page 28.
- 2 In the Optical Automotive Ethernet Tx Compliance Software, click **Set Up** tab.
- 3 Select the required specification from the drop-down list.
- 4 Select the specific 10GBASE data rate in the **Data Rate** section.
- 5 Click the **Select Tests** tab and check the tests you want to run. Check the parent node or group to check all the available tests within the group.
- 6 Follow the Optical Automotive Ethernet Tx Compliance Software's task flow to set up the configuration options, run the tests, and view the tests results.

10GBASE-AU Tests

The AE6980T transmitter test software provides TDFOM-assisted measurements. TDFOM-assisted measurement means that the transmitter must increase optical power or extinction ratio performance in proportional to its distortion. This ensures robust receiver operation across all PHY vendors and device qualities.

TDFOM Average Optical Power (AOP)

Test Setup

Connect the hardware as shown in [Figure 2-3](#).

Specification References

[1] IEEE 802.3cz™ - 2024, Section 166.6.4.3

TDFOM Average Optical Power (AOP) Test Information

Reference “[1]” Average Optical Power (AOP) refers to the mean optical power transmitted by the fiber-optic transceiver. It ensures consistent signal transmission and is crucial for maintaining network performance. Reference “[1]” AOP limit for 10GBASE-AU transmitter test, while in the ON state is -2.4 dBm (minimum) to 3.9 dBm (maximum), while in the OFF state, it must be below -30 dBm.

Typical Waveform

Refer to [Figure A-1](#).

NOTE

Average Optical Power (AOP) is also called as Average Launch Power (ALP) in the standard documents.

TDFOM Optical Modulation Amplitude (OMA)

Test Setup

Connect the hardware as shown in [Figure 2-3](#).

Specification References

[1] IEEE 802.3cz™ - 2024, Section 166.6.4.4

TDFOM Optical Modulation Amplitude (OMA) Test Information

Reference “[1]” Optical Modulation Amplitude ($\text{OMA}_{\text{outer}}$) represents the peak-to-peak difference in optical power levels between the highest and lowest transmitted states. It plays a critical role in signal clarity and minimizing errors in high-speed optical communication. The $\text{OMA}_{\text{outer}}$ limit for 10GBASE-AU is a maximum of 3.2 dBm, with a minimum value calculated as $\max(2 \text{ dB}, \text{TDFOM} - 1.0 \text{ dB})$. The minimum limit defines the amount of additional OMA (penalty) the transmitter must provide, depending on how much distortion it has. The transmitter must add an OMA penalty equal to either 2 dB or (TDFOM minus 1 dB), whichever is larger.

Typical Waveform

Refer to [Figure A-1](#).

TDFOM Extinction Ratio (ER)

Test Setup

Connect the hardware as shown in [Figure 2-3](#).

Specification References

[1] IEEE 802.3cz™ - 2024, Section 166.6.4.5

TDFOM Extinction Ratio (ER) Test Overview

Reference “[1]” Extinction Ratio (ER) measures the contrast between the optical power levels of the highest and lowest transmitted states, ensuring signal clarity. A higher extinction ratio signifies better modulation efficiency and reduced transmission errors in high-speed optical communication. The ER limit for 10GBASE-AU is a minimum of 4 dB.

Typical Waveform

Refer to [Figure A-1](#).

Transmitter and Distortion Figure of Merit (TDFOM)

Test Setup

Connect the hardware as shown in [Figure 2-3](#).

Specification References

[1] IEEE 802.3cz™ - 2024, Section 166.6.4.8

Transmitter and Distortion Figure of Merit (TDFOM) Test Information

Reference “[1]” Transmitter Distortion Figure of Merit (TDFOM) quantifies the optical signal quality, assessing waveform distortion caused by the transmitter. It helps evaluate signal integrity by considering nonlinearities and inter-symbol interference. The TDFOM limit for 10GBASE-AU is a maximum of 2 dB and a minimum of -1.0 dB.

Typical Waveform

Refer to [Figure A-1](#).

TDFOM OAR (OMA to AOP Ratio)

Test Setup

Connect the hardware as shown in [Figure 2-3](#).

Specification References

[1] IEEE 802.3cz™ - 2024, Section 166.6.4.13.2

TDFOM OAR (OMA to AOP Ratio) Test Overview

Reference “[1]” The OMA to AOP Ratio (OAR) is an optional test parameter for evaluating optical transmitter performance, expressed in decibels (dB). It indicates how much OMA a transmitter must increase to compensate for distortion and determines whether the transmitter meets the TDFOM-assisted OMA requirement. In IEEE 802.3cz, OAR is not part of the transmitter compliance. There is no test limit for this test.

Typical Waveform

Refer to [Figure A-1](#).

NOTE

OAR is not a required transmitter test parameter in IEEE 802.3cz.

Optical Transmitter AOP (Tx OFF)

Test Setup

Connect the hardware as shown in [Figure 2-5](#).

Specification References

[1] IEEE 802.3cz™ - 2024, Section 166.6.4.3

Optical Transmitter AOP (Tx OFF) Test Information

Reference “[1]” Optical Transmitter Average Optical Power (AOP) in the Tx OFF state refers to the mean optical power emitted by the fiber optic transceiver when the transmitter is disabled. This measurement ensures that no significant optical power leakage is present when transmission is turned OFF, which is essential for avoiding false signal detection and maintaining proper receiver operation.

Reference “[1]” AOP limit for the 10GBASE AU transmitter Tx OFF condition requires the average optical power to be below -30 dBm.

Typical Waveform

Refer to [Figure A-1](#).

NOTE

Average Optical Power (AOP) in the Tx OFF state refers to the mean optical power emitted by the optical transmitter when transmission is disabled.

Uncorrelated Random Jitter

Test Setup

Connect the hardware as shown in [Figure 2-3](#).

Specification References

[1] IEEE 802.3cz™ - 2024, Section 166.6.4.7

Uncorrelated random jitter Test Information

Reference “[1]” Uncorrelated Random Jitter refers to the random timing jitter component that is not correlated with the transmitted data pattern and originates from intrinsic noise sources within the optical transmitter. Reference “[1]” specifies that for 10GBASE AU transmitters, the measured uncorrelated random jitter shall not exceed 0.02 UI, as defined in Table 166-9 of IEEE 802.3cz.

Typical Waveform

Refer to [Figure A-1](#).

NOTE

Uncorrelated Random Jitter is evaluated at the transmitter output using a waveform analyzer and is expressed in Unit Intervals (UI) relative to the signaling rate.

RIN12OMA

Test Setup

Connect the hardware as shown in [Figure 2-3](#).

Specification References

[1] IEEE 802.3cz™ - 2024, Section 166.6.4.6

RIN12OMA Test Information

Reference “[1]” Relative Intensity Noise (RIN12OMA) refers to the noise caused by optical power fluctuations of the transmitter, normalized to the outer optical modulation amplitude (OMA_{outer}). It represents intensity noise contributions that degrade signal quality and impact receiver performance. Reference “[1]” specifies that for 10GBASE AU transmitters, the measured RIN12OMA shall not exceed -120 dB/Hz, as defined in Table 166-9 of IEEE 802.3cz.

Typical Waveform

Refer to [Figure A-1](#).

NOTE

RIN12OMA is measured using a waveform analyzer over the specified noise bandwidth and is expressed in dB/Hz relative to OMA_{outer}.

Transmitter Clock Frequency

Test Setup

Connect the hardware as shown in [Figure 2-4](#).

Specification References

[1] IEEE 802.3cz™ - 2024, Section 166.6.3.2

Transmitter Clock Frequency Test Information

Reference “[1]” Transmitter Clock Frequency refers to the signaling rate of the optical transmitter and represents the nominal baud rate at which data is transmitted. Accurate clock frequency is essential to ensure proper timing, interoperability, and reliable clock and data recovery at the receiver. Reference “[1]” specifies that for 10GBASE AU transmitters, the transmitter clock frequency shall be 10.625 GBd with a tolerance of ± 100 ppm, as defined in Table 166-9 of IEEE 802.3cz.

Typical Waveform

Refer to [Figure A-1](#).

NOTE

Transmitter clock frequency is measured using a waveform analyzer or clock recovery unit and is expressed relative to the nominal signaling rate.

Center Wavelength

Test Setup

Connect the hardware as shown in [Figure 2-6](#).

Specification References

[1] IEEE 802.3cz™ - 2024, Section 166.6.4.2

Center Wavelength Test Information

Reference “[1]” Center Wavelength refers to the mean optical wavelength of the transmitter output spectrum. Maintaining the center wavelength within the specified range is essential to ensure proper optical transmission characteristics and compatibility with the multimode fiber used in automotive Ethernet systems. Reference “[1]” specifies that for 10GBASE AU transmitters, the center wavelength shall be within the range of 970 nm to 990 nm, as defined in Table 166-9 of IEEE 802.3cz.

NOTE

Center wavelength is measured using an optical spectrum analyzer and is expressed in nanometers (nm).

RMS Spectral Width

Test Setup

Connect the hardware as shown in [Figure 2-6](#).

Specification References

[1] IEEE 802.3cz™ - 2024, Section 166.6.4.2

RMS Spectral Width Test Information

Reference “[1]” RMS Spectral Width refers to the root mean square width of the optical transmitter output spectrum and represents the spread of optical power around the center wavelength. Controlling the RMS spectral width is essential to ensure stable optical transmission and to limit dispersion effects in multimode fiber. Reference “[1]” specifies that for 10GBASE AU transmitters, the RMS spectral width shall not exceed 0.7 nm, as defined in Table 166-9 of IEEE 802.3cz.

NOTE

RMS Spectral Width is measured using an optical spectrum analyzer and is expressed in nanometers (nm).

Optical Return Loss

Test Setup

Connect the hardware as shown in [Figure 2-7](#).

Specification References

[1] IEEE 802.3cz™ - 2024, Section 166.6.4.2

Optical Return Loss Test Information

Reference “[1]” Optical Return Loss Tolerance refers to the transmitter's ability to operate correctly in the presence of reflected optical signals. Excessive reflections can degrade optical signal quality and system performance.

Reference “[1]” specifies that the Optical Return Loss Tolerance shall not exceed 12 dB, as defined in Table 166-9 of IEEE 802.3cz.

NOTE

Optical Return Loss Tolerance is measured using an optical reflectometer and is expressed in decibels (dB).

View Test Result

Refer to “[View Test Result](#)” on page 61.

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Keysight Connection Expert: Adding Instrument using LAN Instrument	63

Typical Waveform

The typical waveform of 10GBASE-AU Tests is as shown below.

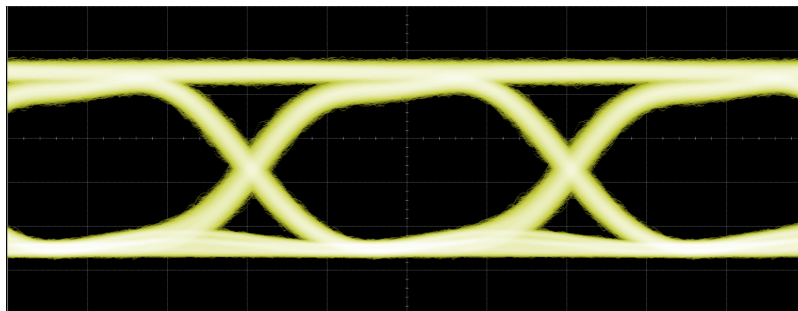


Figure A-1 Typical Output Waveform (using DCA-M and CDR)

View Test Result

After running any or all of the Compliance tests, the **Results** tab will display the tests that passed along with details for each individual test. To view the test details, select any test from the top pane. The corresponding information will appear as shown below.

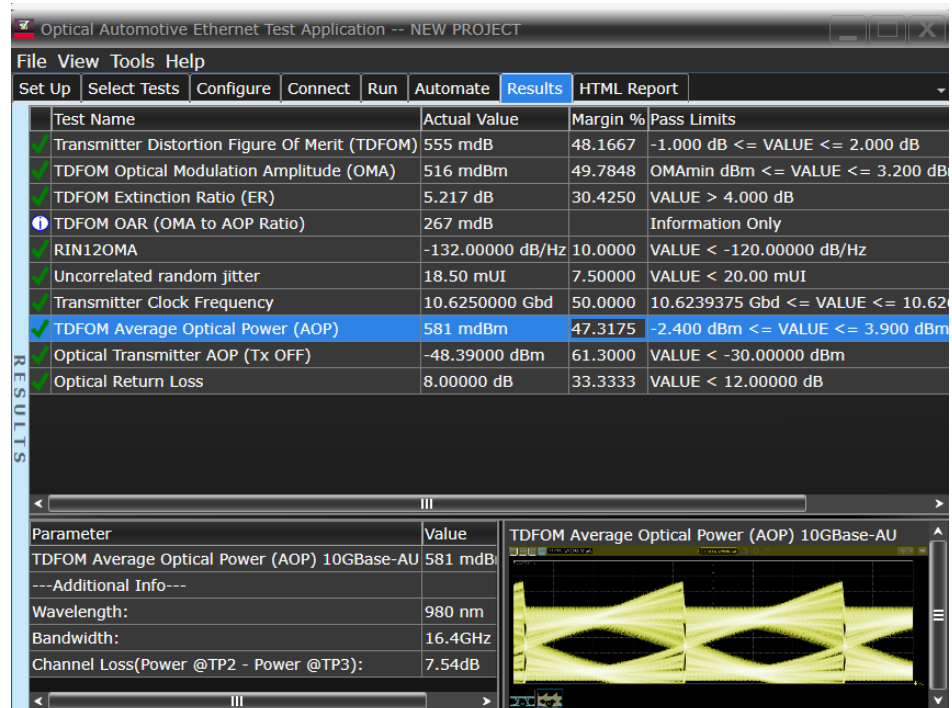


Figure A-2 Typical Results tab

Figure A-3 shows a portion of a typical HTML Report. Below this segment are waveforms and more test data.

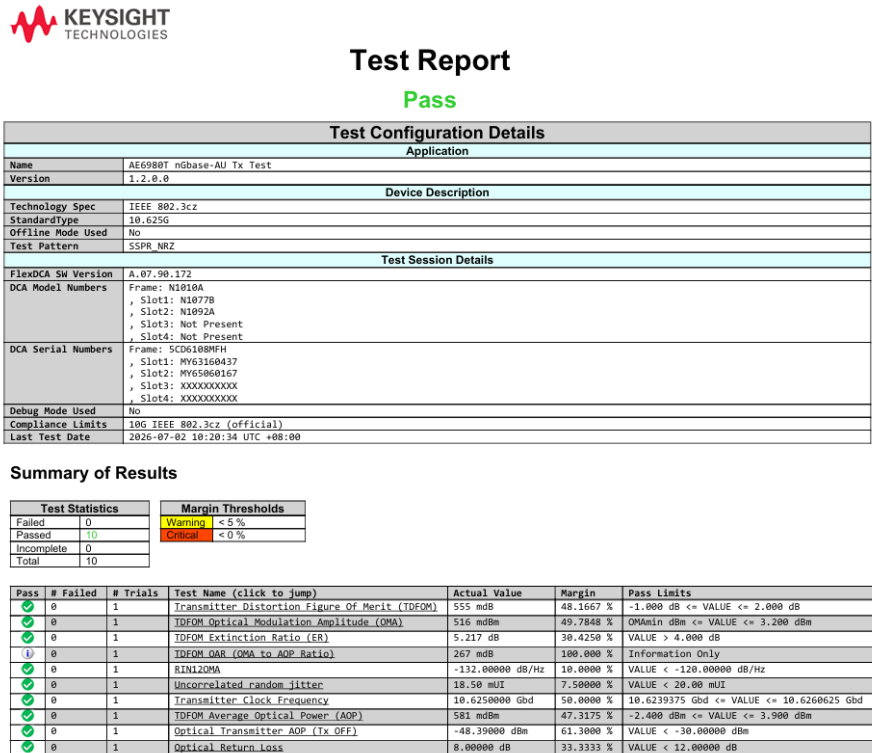


Figure A-3 Typical HTML Report

Keysight Connection Expert: Adding Instrument using LAN Instrument

The following steps describe how to add instruments or interfaces to the Keysight Connection Expert.

- 1 Launch your Keysight Connection Expert, as shown in [Figure 2-16](#).
- 2 Click **+Add > LAN** instrument.

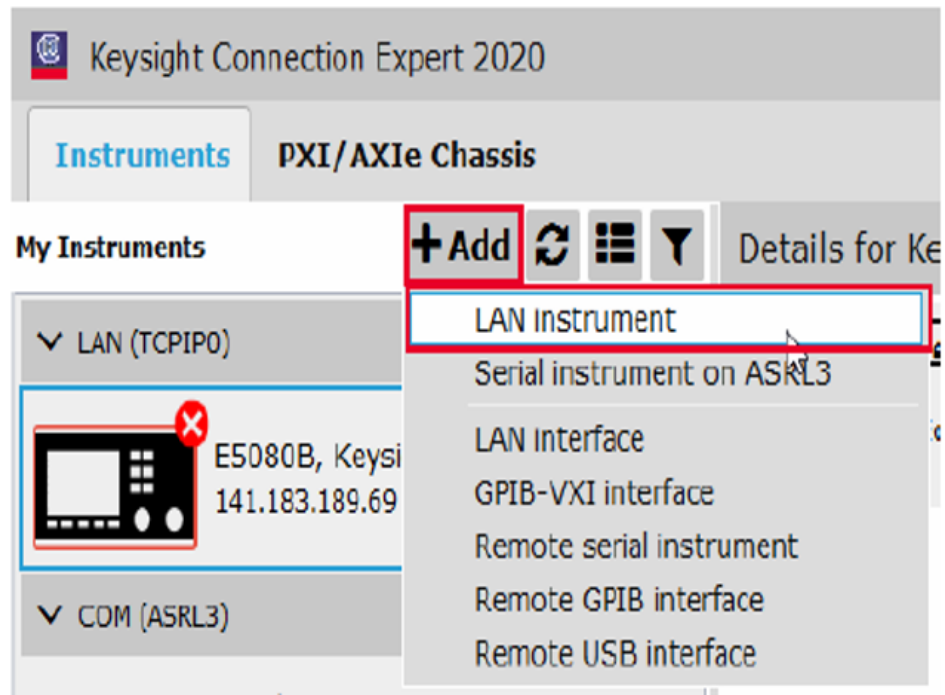


Figure A-4 Adding a LAN instrument

- 3 Select the **Enter Address** tab.
- 4 Enter the Hostname or IP address, then click the **Test This Visa Address** button. You will see the message, "Verified".

5 Click **OK**.

The screenshot shows a dialog box titled "Add a LAN device" with a close button (X) in the top right corner. The dialog has two tabs: "Select from List" and "Enter Address", with "Enter Address" being the active tab. Under the "Enter Address" tab, there are three main sections:

- Set LAN Address:** This section contains two fields. The "Hostname or IP Address:" field is set to "141.183.189.168". The "TCPIP Interface ID:" field is a dropdown menu currently showing "TCPIP0".
- Set Protocol:** This section contains three radio buttons: "Instrument (VXI-11)" (which is selected), "HiSlip", and "Socket". To the right of these are two more fields: "Remote Name:" set to "inst0" and "Port Number:" set to "5025".
- Verify Connection:** This section contains a checked checkbox labeled "Allow *IDN Query" and a button labeled "Test This VISA Address". To the right of this button, the text "TCPIP0::141.183.189.168::inst0::INSTR Verified" is displayed.

At the bottom of the dialog, there is a section labeled "View Web Page:" with a button labeled "Instrument Web Interface...". In the bottom right corner, there are two buttons: "OK" and "Cancel".

Figure A-5 Add a LAN instrument

6 You will see the instrument under **LAN (TCPIP0)**.

- 7 Copy the **SICL Address**. You will need to add this to configure the address of the LAN interface.

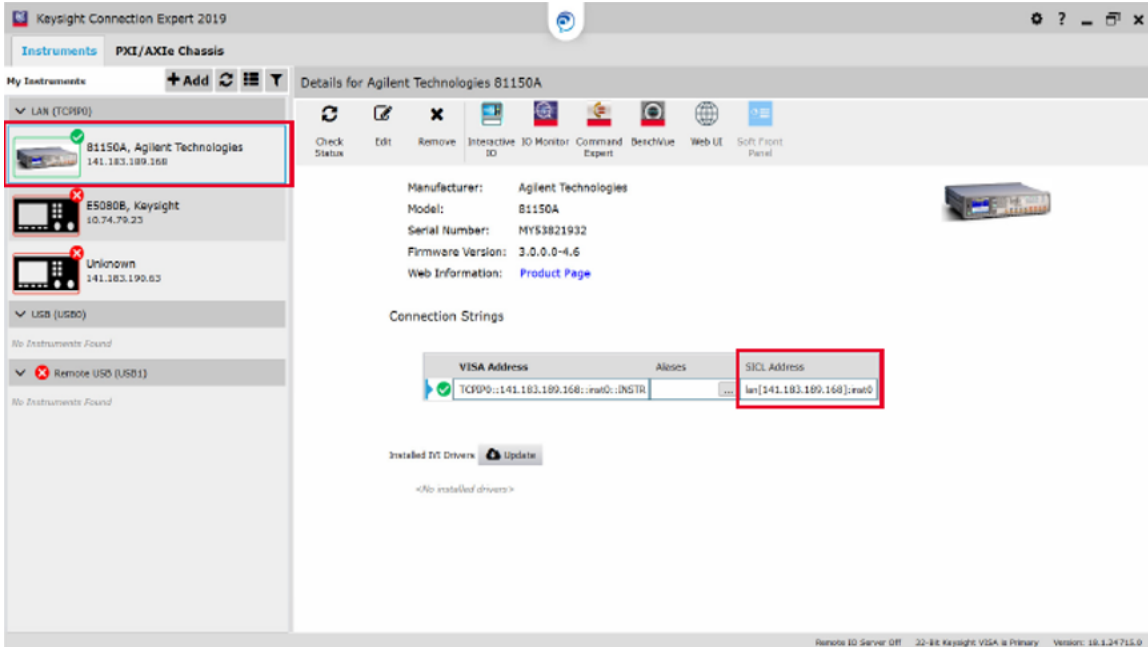


Figure A-6 Details for the added LAN device

List of Abbreviations

Table A-1 Abbreviation and Definition

Abbreviation	Definition
A	
AOP	Average Optical Power
C	
CDR	Clock Data Recovery
CRU	Clock Recovery Unit
D	
DCA	Digital Communications Analyzer
DCA-M	Digital Cathode-Ray Oscilloscope - Multimeter
DUT	Device Under Test
E	
ER	Extinction Ratio
O	
OAR	Optical Modulation Amplitude to Average Optical Power Ratio
OMA	Optical Modulation Amplitude
T	
TDFOM	Transmitter and Distortion Figure of Merit
TP	Test Point
Tx	Transmitter

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This information is subject to change without notice. Always refer to the English version at the Keysight website for the latest revision.



AE6980T-91001

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August 2026

Printed in Malaysia
www.keysight.com