AE6910T/AE6920T Automotive Ethernet Compliance Solution

Compliant to IEEE & OPEN Alliance Specifications

KEYSIGHT

USER GUIDE & METHODS OF IMPLEMENTATION

Notices

Manual Part Number

AE690-9101T

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Warranty

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Contents

1 Introduction

KEYSIGHT TECHNOLOGIES

Overview of Keysight AE6910T/AE6920T Automotive Ethernet Compliance Test Application

The Keysight AE6910T/AE6920T Automotive Ethernet Transmitter Test Application lets you automatically execute physical-layer (PHY) electrical tests for transmitter compliance using IEEE and/or Open Alliance (OABR) specifications. In addition to the measurement data, the report provides a margin analysis that shows how closely your device passed or failed each test.

The AE6910T/AE6920T software performs a wide range of electrical tests required to meet the current Automotive Ethernet specifications all in one installation. The application helps you execute a wide subset of the conformance tests performed with a variety of Keysight equipment.

The AE6910T/AE6920T Automotive Ethernet Transmitter Test Application allows you to select the reference specification and the test plan depending on the selected specification and currently supports the following data rates and standards:

- 10BASE-T1S, IEEE 802.3cg-2019 and OPEN Alliance TC14[1]
- 100BASE-T1, IEEE 802.3bw-2015 and OPEN Alliance TC1[1]
- 100BASE-T1 OPEN Alliance TC8 ECU Layer 1, ver 3.0
- 1000BASE-T1 OPEN Alliance TC8 ECU Layer 1, ver 1.0
- 1000BASE-T1, IEEE 802.3bp-2016 and OPEN Alliance TC12[1]
- 2.5/5/10GBASE-T1, IEEE 802.3ch-2020 and OPEN Alliance TC15[1]

1 The software does not have drop-down selection for all of the OA standards. However, the cross reference is very close between IEEE and OA.

Table 1-1 IEEE 802.3cg 10BASE-T1S Test

Test	Test Mode/Configuration	Test Classification
Transmitter Output Voltage	Test Mode 1	–
Transmitter Timing Jitter		
Transmitter Output Droop	Test Mode 2	–
Transmitter Power Spectral Density (PSD) (Point-to-Point)	Test Mode 3	–
Transmitter Power Spectral Density (PSD) (MultiDrop)		
Rise and Fall Time for Transmitter		
High Impedance	Test Mode 4	–

Table 1-2 IEEE 802.3bw 100BASE-T1 Tests

Test	Test Mode/Configuration	Test Classification
Transmitter Output Droop	Test Mode 1	–
Clock Frequency and Jitter Tests	Test Mode 2 Master	–
Transmit Clock Frequency and Jitter Tests	Test Mode 3	–

Table 1-2 IEEE 802.3bw 100BASE-T1 Tests

Test	Test Mode/Configuration	Test Classification
Transmitter Distortion	Test Mode 4	–
MDI Return Loss Tests	Slave Mode. No test mode transmitted	–
MDI Mode Conversion Loss Tests	Slave Mode. No test mode transmitted	–
Transmitter Power Spectral Density (PSD) and Transmitter Peak Differential Output Tests	Test Mode 5	–

Table 1-3 IEEE 802.3bp 1000BASE-T1 Tests

Test	Test Mode/Configuration	Test Classification
TX_TCLK125 Frequency and Transmit Jitter Tests	Test Mode 1	–
Transmit Clock Frequency and MDI Output Jitter Tests	Test Mode 2 Master	–
Transmitter Distortion	Test Mode 4	–
MDI Return Loss Tests	Slave Mode. No test mode transmitted	–
MDI Mode Conversion Loss Tests	Slave Mode. No test mode transmitted	–
Transmitter Power Spectral Density, Power Level, and Transmitter Peak Differential Output Tests	Test Mode 5	–
Output Droop Tests	Test Mode 6	–

Table 1-4 IEEE 802.3ch 2.5GBASE-T1, 5GBASE-T1 and 10GBASE-T1 Tests

Test	Test Mode/Configuration	Measurement
Transmitter Timing Jitter	Test Mode 1 Master / Slave in Linked Mode	TX_TCLK_175 RMS / Peak to Peak Jitter
Transmit MDI Random Jitter	Test Mode 2 Master	MDI RMS / Peak to Peak Jitter
Transmit MDI Deterministic Jitter	Test Mode 2 (Test Pattern JP03A and JP03B) Master	Peak to Peak Deterministic Jitter / Even Odd Jitter
Transmitter Linearity	Test Mode 4	SNDR (Signal-to-Noise and Distortion Ratio)
MDI Return Loss Tests	Slave Mode. No test mode transmitted	Reflections at the MDI

Table 1-4 IEEE 802.3ch 2.5GBASE-T1, 5GBASE-T1 and 10GBASE-T1 Tests

Test	Test Mode/Configuration	Measurement
Transmitter PSD, Power Level, and Transmitter Peak Differential Output	Test Mode 5 Normal Operation, Idle Mode	-
Transmitter Clock Frequency	Test Mode 2 (Test Pattern JP03A)	Repeating {0,3} sequence
Maximum Output Droop	Test Mode 6	Positive / Negative Droop

Table 1-5 TC8 10BASE-T1S ECU Tests

Test	Test Mode/Configuration	Test Classification
Transmitter Output Voltage	Test Mode 1	Mandatory
Transmitter Output Droop	Test Mode 2	Mandatory
Transmitter Timing Jitter	Test Mode 1	Mandatory
Transmitter Power Spectral Density	Test Mode 4	Mandatory
Transmitter Rising and Falling	Test Mode 6	Mandatory
MDI Return Loss	Slave Mode. No test mode transmitted	Mandatory
MDI Mode Conversion	Slave Mode. No test mode transmitted	Mandatory
MDI Differential Input Capacitance	Test Mode 4	Mandatory

Table 1-6 TC8 100BASE-T1 ECU Tests

Test	Test Mode/Configuration	Test Classification
Transmitter Output Droop	Test Mode 1	Optional[1]
Transmitter Timing Jitter	Test Mode 2 Master	Mandatory[2]
Transmit Clock Frequency	Test Mode 2	Mandatory
Transmitter Power Spectral Density	Test Mode 5	Optional
MDI Return Loss	Slave Mode. No test mode transmitted	Mandatory
MDI Mode Conversion	Slave Mode. No test mode transmitted	Mandatory
MDI Common Mode Emission	Test Mode 5	Optional
Transmitter Distortion	Test Mode 4	Optional

1 The test could be executed but is not required for an official qualification pass/fail criterion.

2 Required test which needs to be evaluated according to the specified pass/fail criterion.

Table 1-7 TC8 1000BASE-T1 ECU Tests

Test	Test Mode/Configuration	Test Classification
Transmitter Output Droop	Test Mode 1	Optional
Transmitter Output Droop	Test Mode 2 Master	Mandatory
Transmit Clock Frequency	Test Mode 2	Mandatory
Transmitter Power Spectral Density	Test Mode 5	Optional
MDI Return Loss	Slave Mode. No test mode transmitted	Mandatory
MDI Mode Conversion	Slave Mode. No test mode transmitted	Mandatory
MDI Common Mode Emission	Test Mode 5	Optional
Transmitter Distortion	Test Mode 4	Optional

Table 1-8 TC8 10BASE-T1S PMA Tests

Test	Test Mode/Configuration	Test Classification
Transmitter Timing Jitter	Test Mode 3	Mandatory
Transmitter Power Spectral Density (Ext Frq Cls 3)	Test Mode 3	Mandatory
Transmitter Power Spectral Density (Ext Frq Cls 4)	Test Mode 3	Mandatory

Using the Keysight AE6910T/AE6920T Automotive Ethernet Compliance Test Application along with the AE6941A Automotive Ethernet Fixture or the N5395C Ethernet Test Fixture, greatly simplifies compliance testing. The software automatically configures all the necessary test equipment as well as reducing the overall test time.

The AE6910T/AE6920T Software:

- Allows you to select individual or multiple tests to run.
- Allows you to identify the tested device and its configuration.
- Shows you how to make oscilloscope connections to the device under test.
- Automatically checks for proper oscilloscope configuration.
- Automatically sets up the oscilloscope for each test.
- Allows you to determine the number of trials for averaging in each test.
- Provides detailed information on each test that ran, displaying the results of a maximum of 64 worst trials at any one time.
- Creates a printable HTML report of the tests that ran. This report includes pass/fail limits, margin analysis, and screen captures.

Installing the Test Application and Licenses

If you purchased the AE6910T/AE6920T Automotive Ethernet Compliance Test Application separate from your Infiniium oscilloscope, you must install the software and license key.

Installing the Test Application

1 Make sure you have the right version of Infiniium Oscilloscope software installed on your oscilloscope (see the AE6910T/AE6920T release notes). To ensure that you have the right version, select **Help > About Infiniium...** from the main menu.

2 To obtain the Automotive Ethernet Compliance Test Application, go to Keysight website:
   - www.keysight.com/find/AE6910T-SW
   - www.keysight.com/find/AE6920T-SW

3 In the web page's **Trials & Licenses** tab, click the **Details and Download** button to view instructions for downloading and installing the application software.

Installing the License Key

To procure a license, you require the Host ID information that is displayed in the Keysight License Manager application installed on the same machine where you wish to install the license.

Using Keysight License Manager 5

To view and copy the Host ID from Keysight License Manager 5:

1 Launch Keysight License Manager on your machine, where you wish to run the Test Application and its features.

2 Copy the Host ID that appears on the top pane of the application. Note that x indicates numeric values.

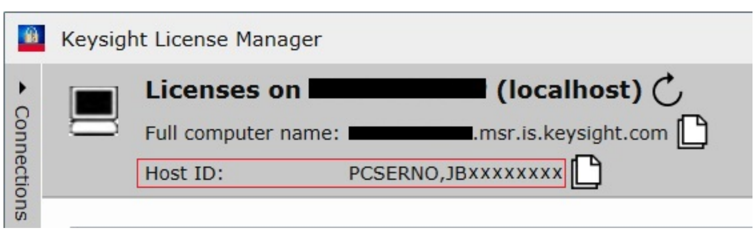


Figure 1-1 Viewing the Host ID information in Keysight License Manager 5

To install one of the procured licenses using Keysight License Manager 5 application,

1 Save the license files on the machine, where you wish to run the Test Application and its features.

2 Launch Keysight License Manager.

3 From the configuration menu, use one of the options to install each license file.

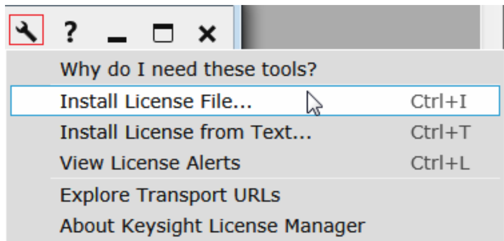


Figure 1-2 Configuration menu options to install licenses on Keysight License Manager 5

For more information regarding installation of procured licenses on Keysight License Manager 5, refer to Keysight License Manager 5 Supporting Documentation.

Using Keysight License Manager 6

To view and copy the Host ID from Keysight License Manager 6:

1 Launch Keysight License Manager 6 on your machine, where you wish to run the Test Application and its features.

2 Copy the Host ID, which is the first set of alphanumeric value (as highlighted in Figure 1-3) that appears in the Environment tab of the application. Note that x indicates numeric values.

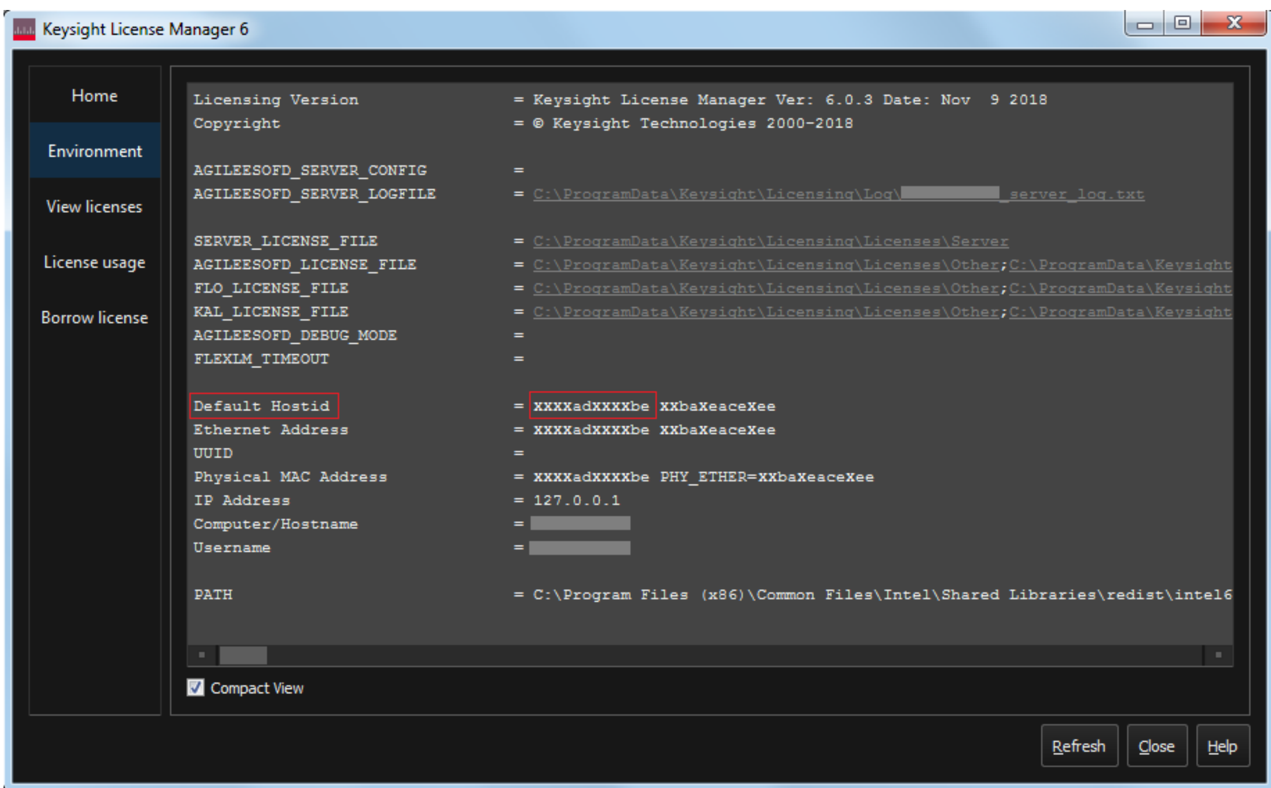


Figure 1-3 Viewing the Host ID information in Keysight License Manager 6

To install one of the procured licenses using Keysight License Manager 6 application,

1 Save the license files on the machine, where you wish to run the Test Application and its features.
2 Launch Keysight License Manager 6.
3 From the Home tab, use one of the options to install each license file.

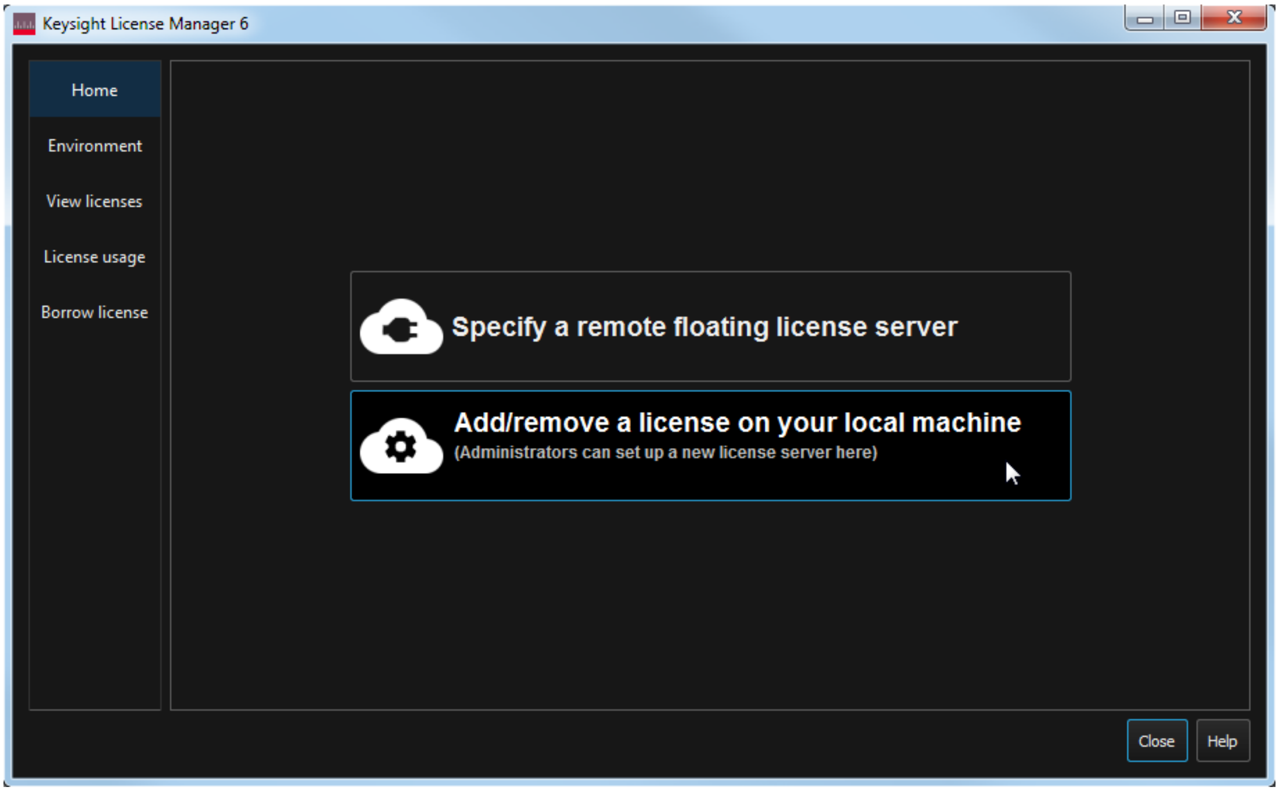


Figure 1-4 Home menu options to install licenses on Keysight License Manager 6

For more information regarding installation of procured licenses on Keysight License Manager 6, refer to Keysight License Manager 6 Supporting Documentation.

Preparing to Take Measurements

Before running the AE6910T/AE6920T automated compliance tests, you should calibrate the oscilloscope and probe (if applicable). After calibrating the oscilloscope and probe (if applicable), you are ready to start the Compliance Test Application and perform the measurements.

Calibrate the Oscilloscope

For information on performing the internal diagnostic and calibration cycle for your Keysight Infiniium oscilloscope, refer to the “User Calibration” topic in your oscilloscope’s online help.

NOTE **If the ambient temperature changes more than 5 °C from the calibration temperature, perform the internal calibration again. The delta between the calibration temperature and the present operating temperature is as shown in the Utilities > Calibration menu.**

NOTE **If you switch cables between channels or other oscilloscopes, it is necessary to perform cable and probe calibration again. Keysight recommends that, once you complete the calibration, label the cables with the calibrated channel.**

Probe Calibration (if applicable)

Most of the automotive ethernet transmitter compliance test can be done by using a cabled connection. In case you are using a probe to connect the DUT to the input of the oscilloscope, we recommend that you use a differential probe, meeting the bandwidth and amplitude requirements.

These are the recommended differential probe configurations for each data rate.

- 10base-T1S -- DP0012A 1.0 GHz differential
- 100base-T1 -- N2750A 1.5 GHz differential
- 1000base-T1 -- N2751A 3.5 GHz differential
- MultiGbase-T1 -- 1168B or MX0021A 13 GHz InfiniiMax differential with SMA head (MX0105A)

Before performing the compliance test, it is highly advisable to perform the probe calibration. For more information about the probe calibration procedures for your probe, refer to the probe's user's guide on Keysight.com.

General Test Setup for 10BASE-T1S, ECU and PMA

10BASE-T1S

The AE6910T/20T supports four test cases in 10BASE-T1S transmitter compliance test utilizing four test modes -- test mode 1, 2, 3 and 4. The test setup is described as follows. Supply the Differential Signal to the Oscilloscope by using one of the following two ways:

- **Two Channels** connect the differential automotive pair to two oscilloscope input channels using two coaxial cables. Refer to "Two Channels Connection to Oscilloscope" on page 20 for more details.
- **One Channel** that connects the differential automotive pair to one oscilloscope input channels using a single differential probe. Refer to "One Channel Connection to Oscilloscope" on page 20 for more details.

The type of connection accepted can be selected in the **Set Up** tab of the test application.

Keysight does not recommend any variation from the above definition of differential signaling type.

Test Mode 3 PSD tests can also use the N9010B Signal Analyzer. Refer to "Test Mode 3. Transmitter Power Spectral Density (PSD) (Point to Point), Transmitter Power Spectral Density (PSD) (MultiDrop) and Rise & Fall Transmitter Test" on page 44 for specific setup details.

NOTE For all tests, use the software supplied with your transmitter PHY to control the Device Under Test.

General Test Setup for 100BASE-T1 and ECU

100BASE-T1 and ECU

Transmitter Output Droop, Transmitter Timing Jitter, Transmit Clock Frequency, Power Spectral Density, and MDI Common Mode Emission require only the Infiniium oscilloscope and the device to be tested (Device Under Test or DUT). The test setup is described as follows. The signal supplied to the oscilloscope can either be **Two Channels** or a **One Channel**.

- **Two Channels** connect the differential automotive pair to two oscilloscope input channels using two coaxial cables. Refer to "Two Channels Connection to Oscilloscope" on page 20 for more details.
- **One Channel** connects the differential automotive pair to the Oscilloscope using a single differential probe. Refer to "One Channel Connection to Oscilloscope" on page 20 for more details. The only variation would be the Power Level Test that requires a balun.

Keysight does not recommend any variation from the above definition of the signaling type. The type of connection accepted can be selected in the **Set Up** tab of the test application.

Transmitter Distortion requires the AE6941A Automotive Ethernet Fixture or the N5395C Ethernet Test Fixture and an Arbitrary Waveform Generator (AWG). Refer to "OABR_PMA_TX_08" on page 155 for specific setup details.

Test Mode 4 requires the AE6941A Automotive Ethernet Fixture or the N5395C Ethernet Test Fixture as well as an Arbitrary Waveform Generator (AWG). Refer to "Test Mode 4. Transmitter Distortion Test" on page 62 for specific setup details.

MDI Return Loss and MDI Mode Conversion require a VNA to execute. Refer to "MDI Return Loss Test" on page 69 or "MDI Mode Conversion Loss Test" on page 71. Also, the DUT has to be in the Slave mode with no transmitted test mode. Refer to "OABR_PMA_TX_05" on page 150 and "OABR_PMA_TX_06" on page 151.

You can execute the Power Spectral Density with just an oscilloscope. Alternatively, you can also use the N9010B Signal Analyzer. Refer to "Test Mode 5. Transmitter Power Spectral Density (PSD) and Transmitter Peak Differential Output Tests" on page 73 and "OABR_PMA_TX_04" on page 148.

Similarly, you can also use the N9010B Signal Analyzer for testing the MDI Common Mode Emission. Refer to "OABR_PMA_TX_07" on page 153.

General Test Setup for 1000BASE-T1 and ECU

1000BASE-T1 and ECU

Test Modes 1, 2, 5, and 6 require only the Infiniium oscilloscope and the device to be tested (Device Under Test or DUT). The test setup is described as follows.. Supply the Differential Signal to the Oscilloscope by using one of the following two ways:

- **Two Channels** connect the differential automotive pair to two oscilloscope input channels using two coaxial cables. Refer to "Two Channels Connection to Oscilloscope" on page 20 for more details.
- **One Channel** connects the differential automotive pair to the Oscilloscope using a single differential probe. Refer to "One Channel Connection to Oscilloscope" on page 20 for more details. The only variation would be the Power Level Test that requires a balun.

The accepted connection type can be selected in the **Set Up** tab of the test application.

Keysight does not recommend any variation from the above definition of differential signaling type.

Test Mode 4 requires the AE6941A Automotive Ethernet Fixture or the N5395C Ethernet Test Fixture as well as an Arbitrary Waveform Generator (AWG). Refer to "Test Mode 4. Transmitter Distortion Test" on page 82 for specific setup details.

MDI Return Loss and MDI Mode Conversion requires a VNA to execute. Also, the DUT has to be in the Slave mode with no transmitted test mode. Refer to "MDI Return Loss Test" on page 85 or "MDI Mode Conversion Loss Test" on page 87.

Test Mode 5 can also use the N9010B Signal Analyzer. Refer to "Test Mode 5. Transmitter Power Spectral Density, Transmitter Power Level, and Transmitter Peak Differential Output Tests" on page 90 for specific setup details.

General Test Setup for 2.5GBASE-T1, 5GBASE-T1, and 10GBASE-T1

2.5GBASE-T1, 5GBASE-T1, and 10GBASE-T1

Test Modes 1, 2, 4, 5, and 6 require only the Infiniium oscilloscope and the device to be tested (Device Under Test or DUT). The test setup is described as follows. Supply the Differential Signal to the Oscilloscope by using one of the following two ways:

- **Two Channels** connect the differential automotive pair to two oscilloscope input channels using two coaxial cables. Refer to "Two Channels Connection to Oscilloscope" on page 20 for more details.
- **One Channel** connects the differential automotive pair to the Oscilloscope using a single differential probe. Refer to "One Channel Connection to Oscilloscope" on page 20 for more details. The only variation would be the Power Level Test that requires a balun.

The type of connection accepted can be selected in the **Set Up** tab of the test application.

Keysight does not recommend any variation from the above definition of differential signaling type.

Test Mode 5 can also use the N9010B Signal Analyzer. Refer to "Test Mode 5. Transmitter Power Spectral Density, Transmitter Power Level, and Transmitter Peak Differential Output Tests" on page 105 for specific setup details.

NOTE For all tests, use the software supplied with your transmitter PHY to control the Device Under Test.

Connection Diagrams

Two Channels Connection to Oscilloscope

Two SMA cables are needed to directly connect the output of the transmitter (DUT) to the oscilloscope. The specific oscilloscope channel used can be selected in the **Configure** tab of the application.

An optional TX_TCLK may be supplied to the oscilloscope to run the tests.

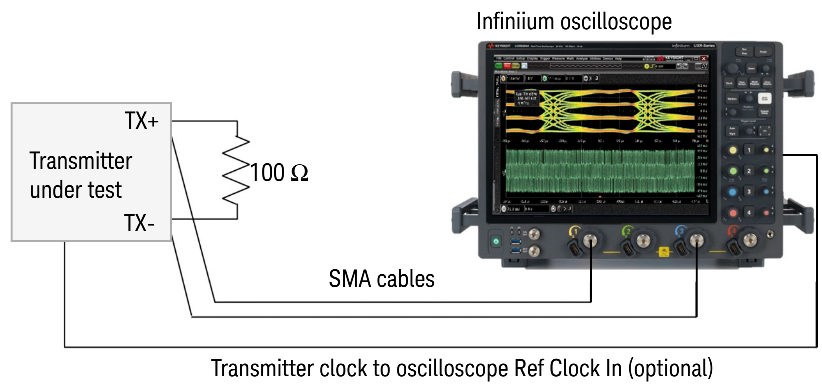


Figure 1-5 Connection to the Oscilloscope Using a Pair of SMA Cables

One Channel Connection to Oscilloscope

Use a differential probe to connect the output of the transmitter (DUT) to the oscilloscope. The specific oscilloscope channel used can be selected in the **Configure** tab of the application.

An optional TX_TCLK may be supplied to the oscilloscope to run the tests.

To learn more about Keysight high impedance differential probes, check out:
https://www.keysight.com/us/en/lib/resources/selection-guides/oscilloscope-probes.html#HVDiffActiveProbes

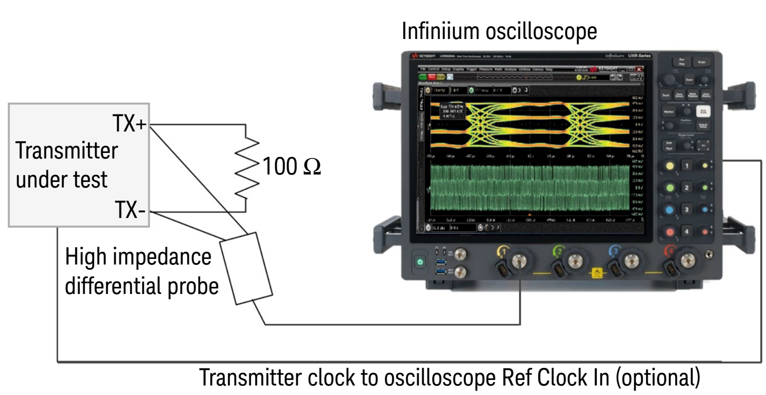


Figure 1-6 Connection to the Oscilloscope using a Differential Probe

Connection Using the Automotive Ethernet Adapters

Alternately, you can use the MDI adapter provided by Keysight, AE6942A (SMA to Mini-50), AE6943A (SMA to MATEnet), and AE6960A (SMA to H-MTD), to make connections between the DUT and the test instrument. Besides the available adapters, you can also use any similarly customized adapter.

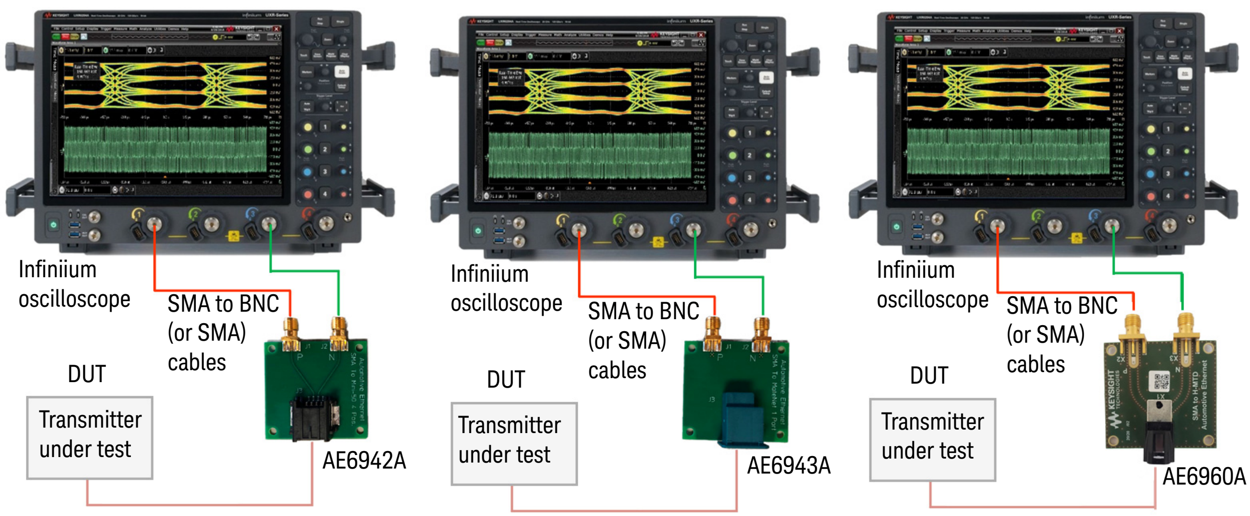


Figure 1-7 General Test Setup using the AE6942A, AE6943A, or AE6960A Automotive Ethernet adapter

NOTE For all tests, use the software supplied with your transmitter PHY to control the Device Under Test.

NOTE

Keysight recommends Automotive Ethernet SMA adapter for ECU test cases. If you need a similar fixture, contact your Keysight sales representative for more details.

Besides the available adapters, another option would be to use the adapter to make connections to the DUT.

The design of the Automotive Ethernet SMA adapter is as outlined in OPEN Alliance Automotive Ethernet Test Specification, v2.0, Section 2.2.2, Test OABR_PMA_TX_05 and OABR_PMA_TX_06. Its design is in line with the definitions of IEEE 100BASE-T1 Definitions for Communication Channel, Version 1.0.

Connection Using the Common Mode Emission Test Adapter

NOTE

The MDI common mode emission test (test mode 5 of 100M ECU test) requires a use of special test fixture as shown below in the Figure 1-8 and Figure 1-9.

The design of the Common Mode Emission test adapter is as outlined in OPEN Alliance Automotive Ethernet ECU Test Specification, v2.0, Section 2.2.2, Test OABR_PMA_TX_07. The design of this adapter is in line with the definitions of IEEE 100BASE-T1 EMC Test Specifications for Transceivers, Appendix D, D.1 Test Conditions.

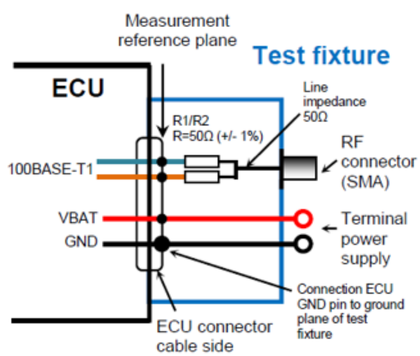


Figure 1-8 Diagram of Recommended Common Mode Emission Test Fixture

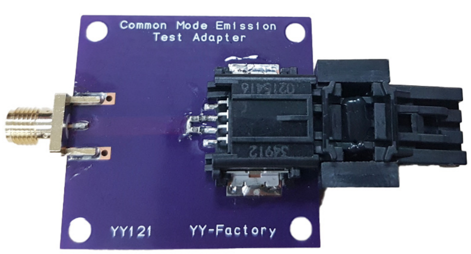


Figure 1-9 Common Mode Emission Test Adapter (Molex to SMA) available from the Third Party Vendor in the Market

Connection Using the N5395C Ethernet Transmitter Test Fixture

Besides that, you can use Section 1 of the N5395C Ethernet 10/100/1G Transmitter Electrical Test Fixture to make connections to the transmitter under test. The SMA connections shown are for wire pair A (DA+ and DA-). This connection is only valid if the DUT has an RJ45 connector. To test wire pair B, C, or D, connect the oscilloscope SMA cables to the appropriate Evaluation Board SMA connectors. See Figure 1-10. In the event the DUT does not have an RJ45 connector, you will need to replace Section 1 with an adapter that converts the differential automotive pair to SMA.

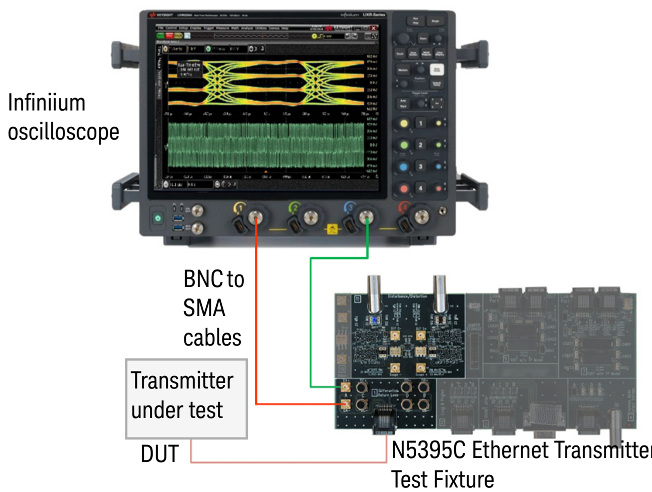


Figure 1-10 General Test Setup using the N5395C Evaluation Board

Starting the Automotive Ethernet Compliance Test Application

1 Ensure that the PHY transmitter (DUT) is operating and set to desired test modes.

2 To start the Automotive Ethernet Compliance Test Application from the Infiniium oscilloscope's main menu, select **Analyze > Automated Test Apps > AE6910T/AE6920T Automotive Ethernet Test App**.

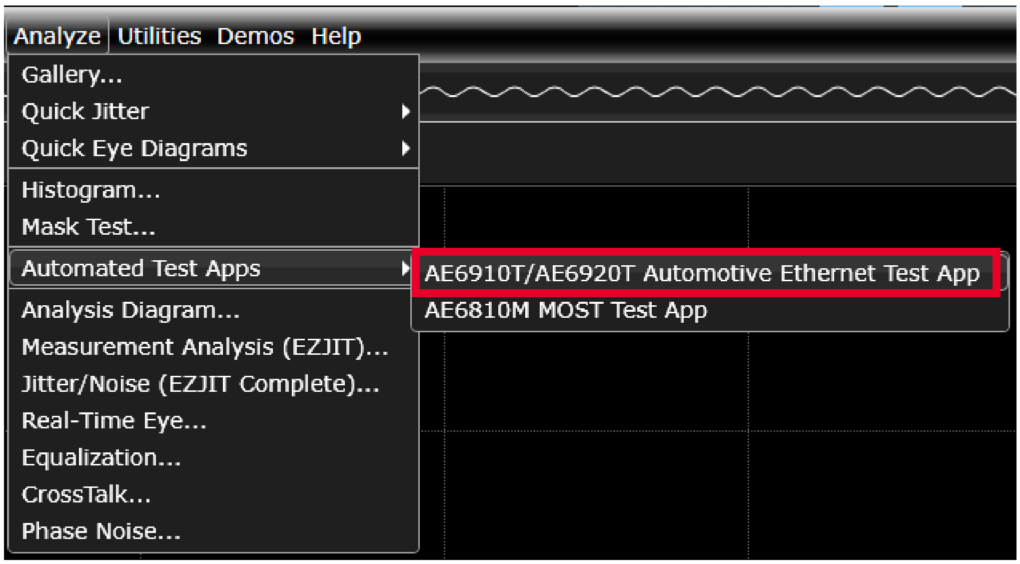


Figure 1-11 Launching the AE6910T/AE6920T Compliance Test Application

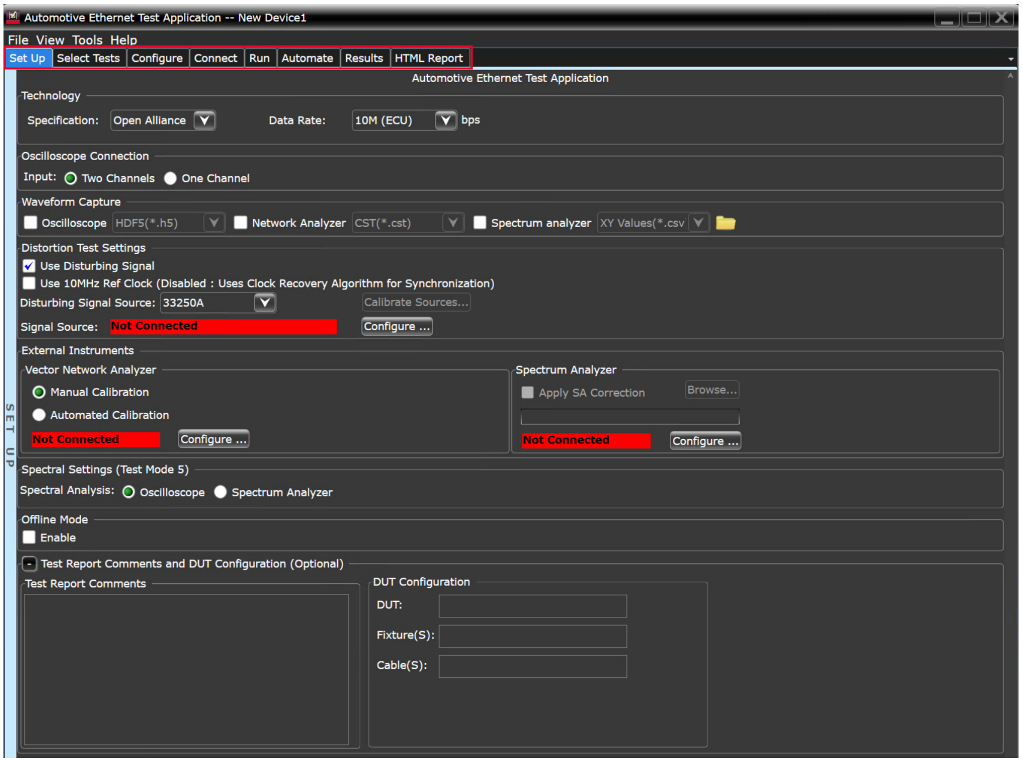


Figure 1-12 Automotive Ethernet Compliance Test Application Main Window

The test app consists of eight primary tabs, described as follows:

Tab	Description
Set Up	Lets you identify and set up the test environment.
Select Tests	Lets you select the tests you want to run. After running the tests, status indicators show which tests have passed, failed, or have not run.
Configure	Lets you configure test parameters (for example, oscilloscope channels used in the test, number of averages, and other configuration).
Connect	Shows you how to connect the oscilloscope to the device under test.
Run	Starts the automated tests, if the connections to the device under test need to be changed, the test pauses and shows you how to change the connection, then waits for you to confirm that you made the changes before continuing.
Automate	Lets you construct scripts of commands to drive execution of the application.
Results	Contains more detailed information about the ran tests allowing you to change the thresholds where marginal or critical warnings appear.
HTML Report	Shows a compliance test report that you can print. See "Viewing the Test Report" on page 157.

The **Set Up** tab consists of 9 sections.

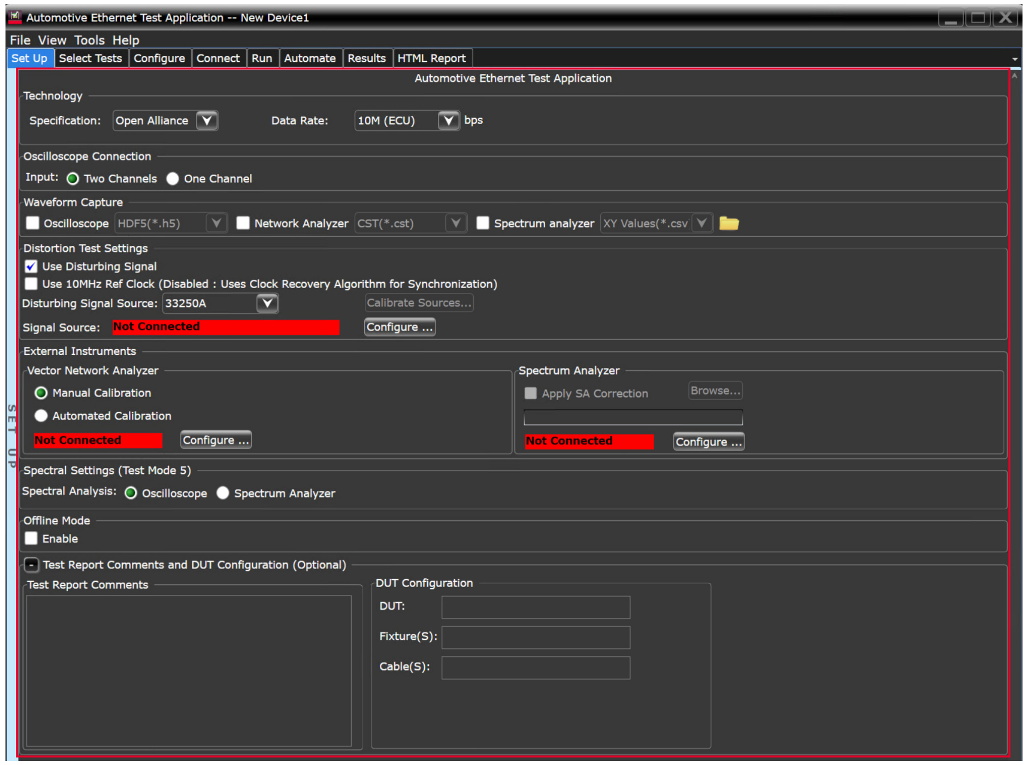


Figure 1-13 Set Up tab sections

Technology

This section allows you to select the technology standard you wish to test on the DUT.

For different specifications, the Compliance Application automatically defines certain data rates.

Select the **IEEE** option from the **Specification:** drop-down menu, if the DUT is designed based on the IEEE standard for 10BASE-T1S, 100BASE-T1, 1000BASE-T1, 2.5GBASE-T1, 5GBASE-T1 or 10GBASE-T1. It supports Data Rate of 10Mbps, 100Mbps, 1000Mbps, 2.5Gbps, 5Gbps, or 10Gbps. Selected by default is the 100Mbps.

Figure 1-14 Technology section for IEEE specification

Select the **Open Alliance** option from the **Specification:** drop-down menu if the DUT is designed based on the Open Alliance standard for TC8 ECU. It only supports the **Data Rate** of 100Mbps.

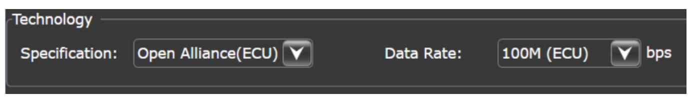


Figure 1-15 Technology section for Open Alliance (ECU) specification

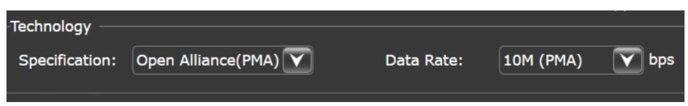


Figure 1-16 Technology section for Open Alliance (PMA) specification

Channel De-embedding feature will be applicable only for MultiGig (2.5G/5G/10G) Data Rate with two channels connection to oscilloscope

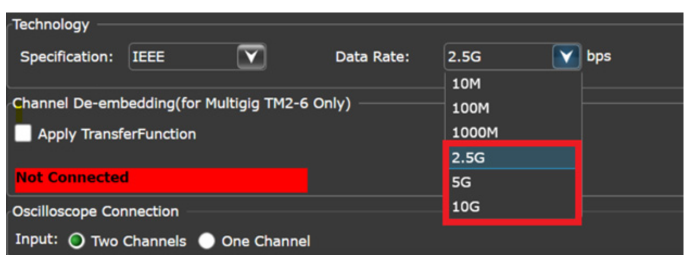


Figure 1-17 Technology section for IEEE specification

User can select predefined Transfer Function files, as listed below, from the drop-down menu.

- N5448B+AE6960A+HMTD(1M).tf4
- N5448B+AE6960A+HMTD(2M).tf4
- N5448B+AE6965A.tf4

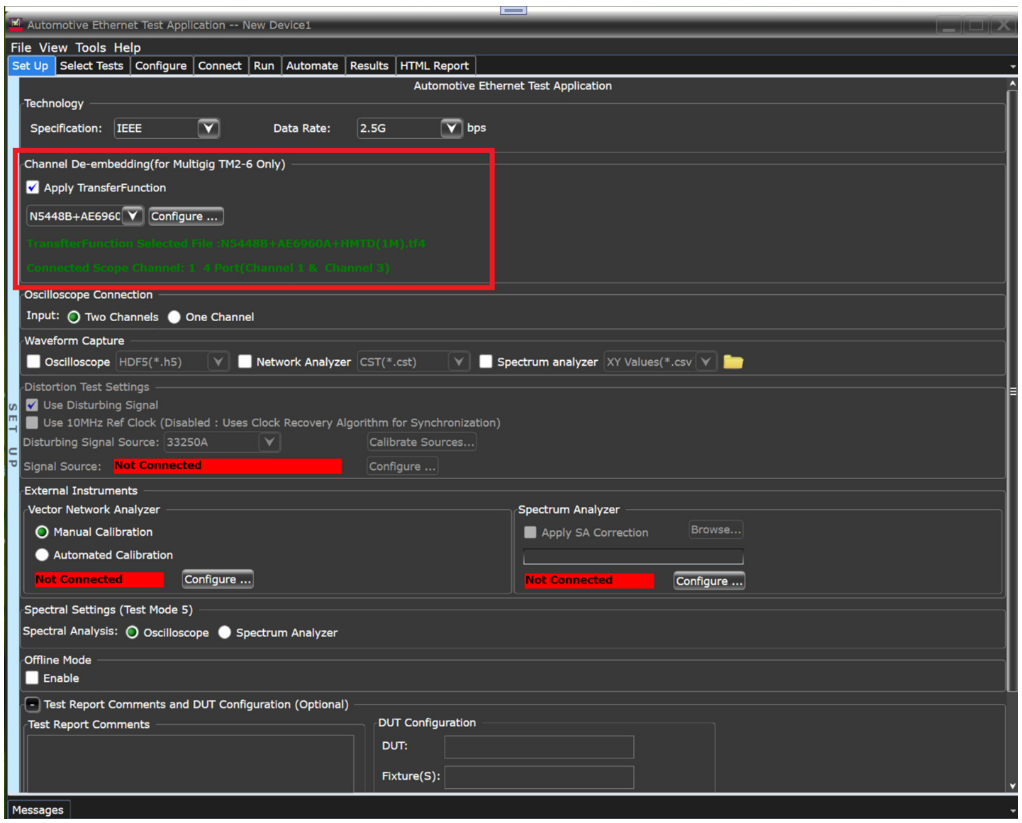


Figure 1-18 Transfer Function Files

The configure option customizes channels and selects the Transfer Function file.

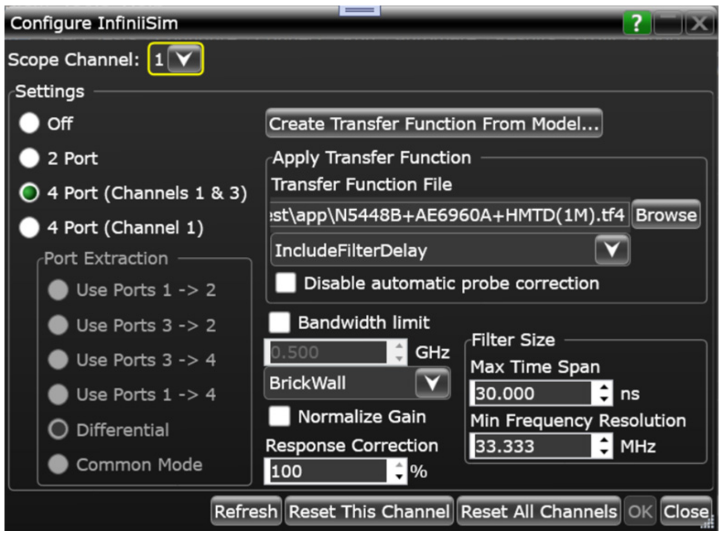


Figure 1-19 Configure Option

Oscilloscope Connection

This section allows you to select how to connect the automotive ethernet differential signal pair to the Oscilloscope. You have the following selections:

- **Two Channels**: Supports two coax cable connection.
- **One Channel**: Supports one differential probe or one coax cable connection.

NOTE

The application will permit a specific **Data Rate**(2.5G,5G&10G) for the configuration of the Signal Differential Probe. Remaining Data Rate must be explicitly configured in scope.

Figure 1-20 Connection section

Refer to "Two Channels Connection to Oscilloscope" on page 20 and "One Channel Connection to Oscilloscope" on page 20.

Infiniium Probe Configuration

- Click **Configure...** button. When the probe is not connected, an error message stating **No Probe Connected** will appear.

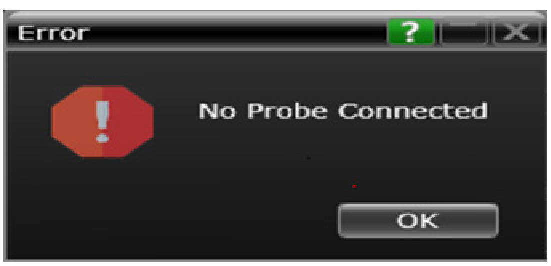


Figure 1-21 No Probe Connected - Error Message

- Upon clicking the **Configure...** button, with a mismatched probe amp attached to the scope, an error message stating **The probe is unsupported** will appear.

Figure 1-22 The probe is unsupported - Error Message

- The Probe Amp to Probe Head match should be done as shown in Table 1-9.

Table 1-9 Probe Amp and Probe Head Match

Probe Amp	Probe Head
1130A/B	N5380A/B or MX0105A
1131A/B	
1132A/B	
1134A/B	
1168A/B	
1169A/B	
MX0020A	
MX0021A	
MX0022A	
MX0023A	
MX0024A	
MX0025A	

- Clicking the **Configure...** button in the **Setup** tab, opens the **Probe Configuration** window after connecting the probe amp and the head attached to the scope.

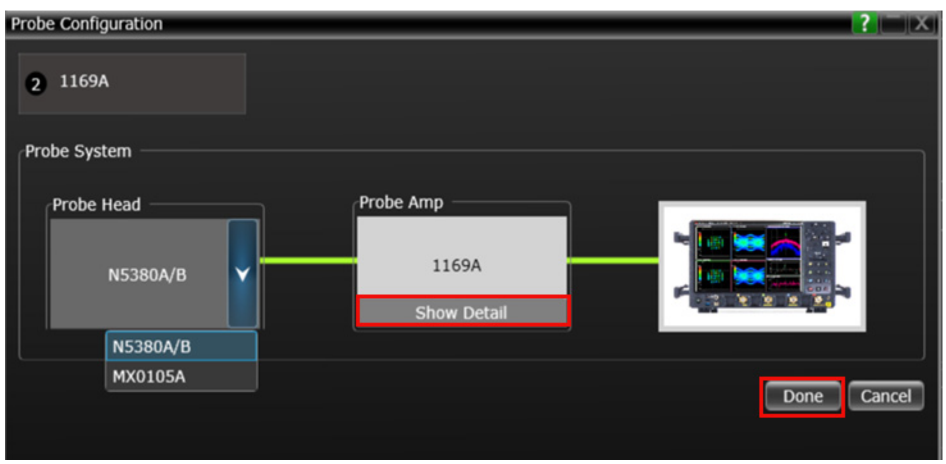


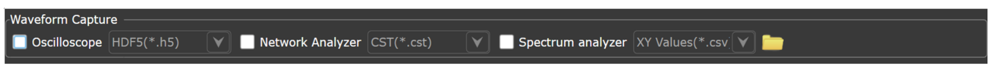
Figure 1-23 Probe Configuration Window

- The **Show Details** button will provide more details about the Probe Amp.

Figure 1-24 Probe Detail Window

- Select the indicated probe in the Probe Head. Click **Done** after selecting the connected head model for the scope as shown in Figure 1-23. InfiniiMax probe provides S-parameter correction for probe amp and probe head. Selecting correct probe model numbers will ensure flat frequency response and more accurate measurement result with the probe.

Waveform Capture



- Depending on the option enabled and the format chosen, it enables the waveform to be captured and saved for Oscilloscope, Network Analyzer, and Spectrum Analyzer.

Table 1-10 **Types for waveform capture format**

Types	Waveform Capture Format
Oscilloscope	HDF5(*.h5), Internal(*.wfm), XY Values(*.csv)
Network Analyser	XY Values(*.csv), CST(*.cst)
Spectrum Analyzer	XY Values(*.csv), State(*.state)

Distortion Test Settings

NOTE

Distortion Test Settings are available for the **IEEE** specifications for the **Data Rate** of 100Mbps or 1000Mbps only. This option is not available for 10 Mbps, 2.5Gbps, 5Gbps and 10Gbps.

The Distortion Test Settings section allows you to select and configure a Disturbing Signal for testing. Use a disturbing signal to emulate a remote transmitter. Its definition is a sine wave that emulates the potential disturbing effect of another transmitter.

- Use Disturbing Signal - Select this checkbox to add a disturbing signal (noise) to the primary signal when running the transmitter distortion test. By default, this option is enabled.
- Use 10MHz Ref Clock - When disabled, a clock recovery algorithm is used for synchronization when running the distortion test. When enabled, an exposed TX_TCLK reference clock and the Keysight Frequency Divider Board are required for synchronization. By default, this option is disabled.
- Disturbing Signal Source - Allows you to select the source used to add a disturbing signal to the Test Mode 4 signal. Available sources for selection differ based on the selections made in the Technology section.
- Calibrate Sources - If you have configured the selected Disturbing Signal Source, this button is enabled to start the calibration process. Else, the selected Disturbing Signal Source is not configured, and the button is not enabled.
- Configure - Allows you to configure the selected Disturbing Signal Source. Refer to "Configuring External Instruments" on page 197.

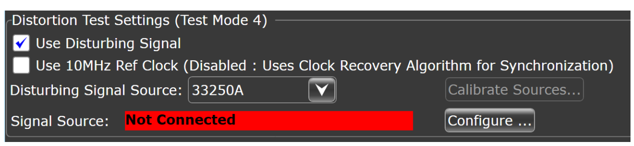


Figure 1-25 Distortion Test Settings (Test Mode 4) section

External Instruments

NOTE

External Instruments available for the **IEEE** and **Open Alliance** specifications for the **Data Rate** of 100Mbps, 1000Mbps, 2.5Gbps, 5Gbps, or 10Gbps only.

Use the External Instruments section to configure the Vector Network Analyzer and Spectrum Analyzer.

Refer to "Configuring External Instruments" on page 197.

Figure 1-26 External Instruments section

Spectral Settings

It allows you to select either an Oscilloscope or a Spectrum Analyzer to perform spectral analysis of the DUT.

- Click the **Use Oscilloscope** if you wish to use the Keysight Infiniium Oscilloscope to perform spectral analysis. By default, this option is selected.
- Click the **Use Spectrum Analyzer** if you wish to connect an external spectrum analyzer to perform spectral analysis on the DUT.

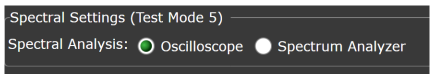


Figure 1-27 Spectral Settings section

Offline Mode

Enable offline mode to configure waveform files and run tests for various transmitter tests when offline, that is, when the DUT is not connected to a live (or online) oscilloscope. The available tests differ based on the selection made in the Technology section. By default, offline mode is not enabled. Refer to "Offline Mode" on page 215 for more details.

Figure 1-28 Offline Mode section

Test Report Comments (Optional)

This section allows you to add the **Test Report Comments and DUT Configuration** details such as DUT model, fixture model, and cable information. These updates will be reflected in the Test Report.

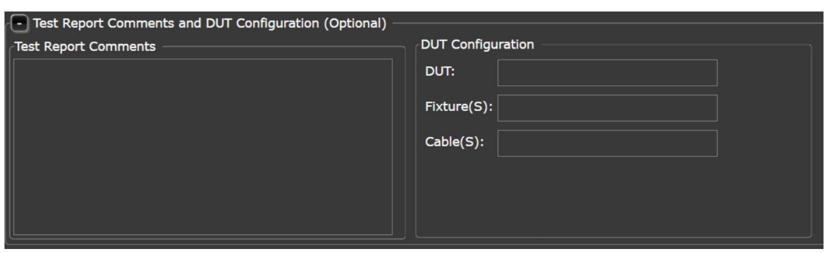


Figure 1-29 Test Report Comments and DUT Configuration (Optional) section

The Configure Tab allows you to select different oscilloscope channels and measurement attributes.

For example, you can change the signal input from a differential probe to two SMA cables.

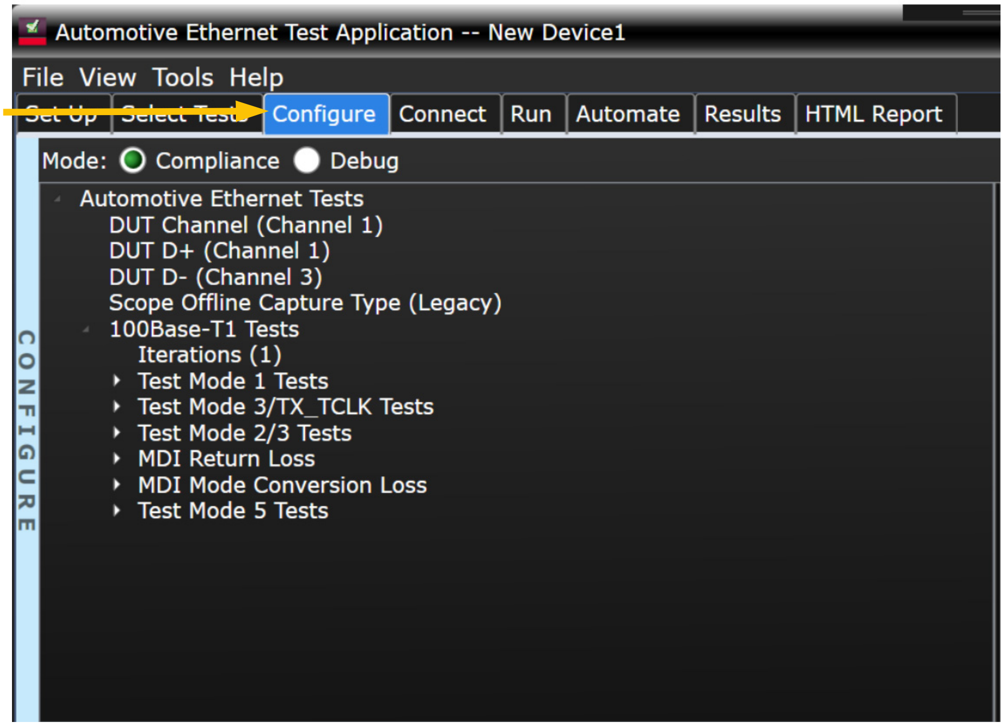


Figure 1-30 Configure Tab for Transmitter Droop Tests

The test connections are identified clearly, including additional hardware and cables. When you select multiple tests where the connections must be changed, the software prompts you with appropriate connection diagrams.

Click Connection Completed before clicking Run Tests.

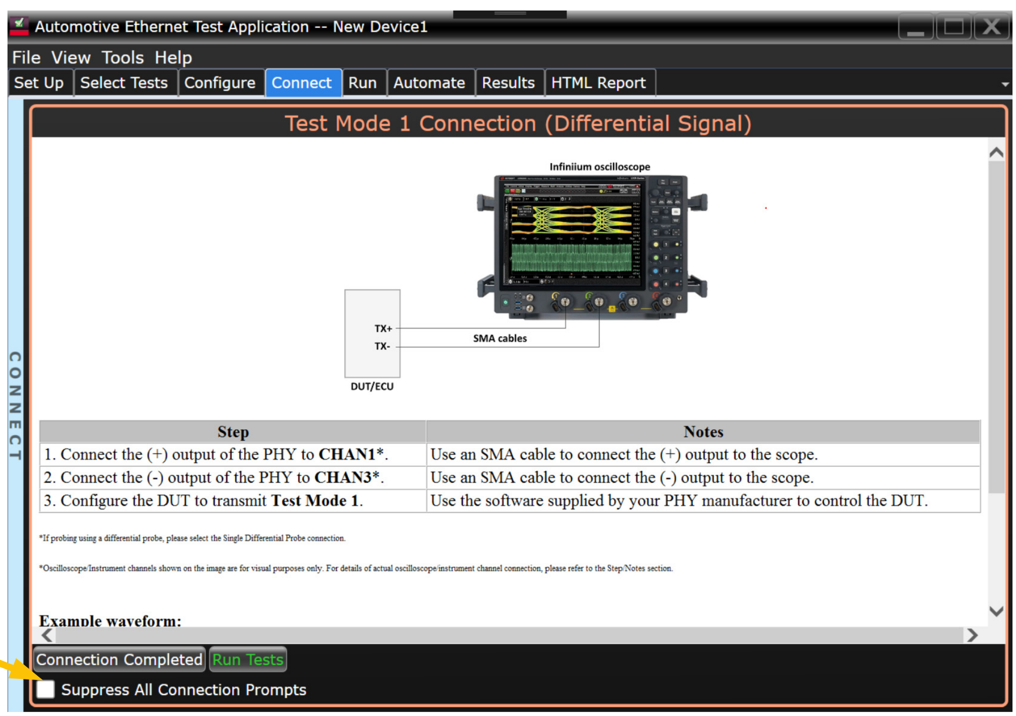


Figure 1-31 Connect Tab for Transmitter Droop Tests

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2 10BASE-T1S Tests and Test Report

Test Mode 1. Transmitter Output Voltage, Transmitter Timing Jitter

The test modes for 10BASE-T1S are somewhat different between the IEEE 802.3cg and Open Alliance TC14 PMA CTS. Note that the test mode definition in this section follows the IEEE 802.3cg clause 147 spec.

Table 2-1 IEEE 802.3cg and Open Alliance TC14 PMA CTS Test Modes for 10BASE-T1S

	IEEE 802.3cg		Open Alliance TC14 PMA	
Transmitter tests (147.5.4)	147.5.4.1	Transmitter output voltage (TM1)	5.1.1	Transmitter output voltage (TM1)
	147.5.4.2	Transmitter output droop (TM2)	5.1.2	Transmitter output droop (TM2)
	147.5.4.3	Transmitter timing jitter (TM1)	5.1.3	Transmitter timing jitter (TM3)
	147.5.4.4	Transmitter Power Spectral Density (TM3) (tested to 40MHz)	5.1.4	Transmitter Power Spectral Density (TM3) (tested to 250MHz)
	147.5.4.5	Transmitter High Impedance Mode (TM4)	5.3.1	Transmitter High Impedance Mode (TM4)
	6.3.2.2 (TC14 system implementation spec)	Transmitter rise/fall time slope at MDI (send mode)	5.1.5	Rise and fall time for transmitter (TM3)

Test Setup

You can run this test using either **Two Channels** or a **One Channel** from the transmitter (MDI). Refer to "General Test Setup for 10BASE-T1S, ECU and PMA" on page 16 for connection details.

NOTE Use the software supplied with your transmitter PHY to control the Device Under Test.

Specification References

[1] 10BASE-T1S, IEEE Std 802.3cg™ - 2019, Section 147.5.4.1.

[2] 10BASE-T1S, IEEE Std 802.3cg™ - 2019, Section 147.5.4.3.

[3] 10BASE-T1S, Open Alliance TC14 PMA v1.0.

[4] 10BASE-T1S, Open Alliance TC8 ECU v0.47.

Transmitter Output Voltage Test Information

Reference "[1]" specifies that with the transmitter in Test Mode 1, the transmitter output voltage shall be 1V ± 20% peak-to-peak differential.

Typical Waveform

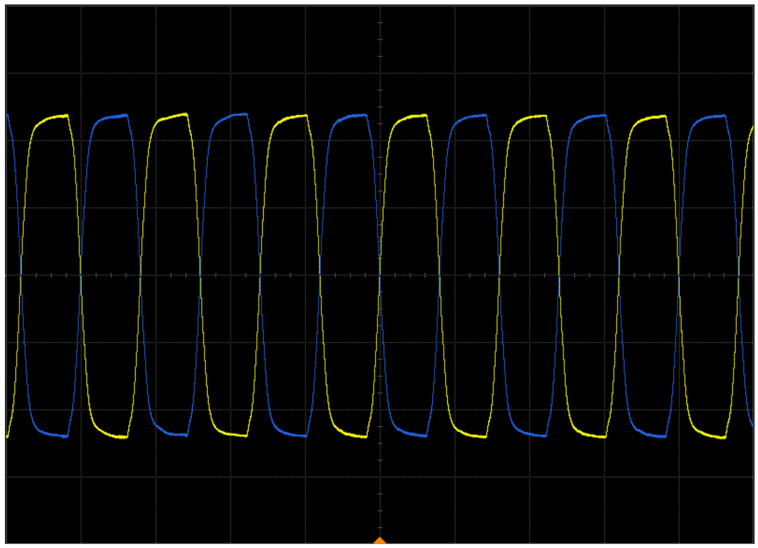


Figure 2-1 Typical Output Voltage Waveform (using a pair of SMA cables)

The 10BASE-T1S Transmitter timing jitter test is also implemented under Open Alliance (PMA) and Open Alliance (ECU), 10M menu following each Open Alliance TC14 PMA v1.0 and TC8 ECU v0.47. Key differences in timing jitter test are shown below in the table.

IEEE 802.3cg	Open Alliance TC14 PMA	Open Alliance TC8 ECU
▪ Test Mode 1	▪ Test Mode 3	▪ Test Mode 1
▪ DUT in Multidrop mode with 50 ohm termination	▪ DUT in Multidrop mode with 50 ohm termination	▪ DUT in Multidrop mode with 50 ohm termination
	▪ 10 iterated test sets	▪ No test iterations defined
▪ Max 5 nsec symbol-to-symbol TIE jitter at the transmitter	▪ Max p-p TIE jitter is 2.5 nsec	▪ Same specification as PMA

Transmitter Timing Jitter Test Information

Reference "[1]" specifies that with the transmitter in Test Mode 1, the maximum jitter at the transmitter side shall be less than 2.5 ns symbol-to-symbol.

This test measures the data time interval error of the Test Mode 1 signal at the MDI. The ideal reference data rate is selected automatically by the oscilloscope and compared to the original signal to determine the data time interval error.

Typical Waveform

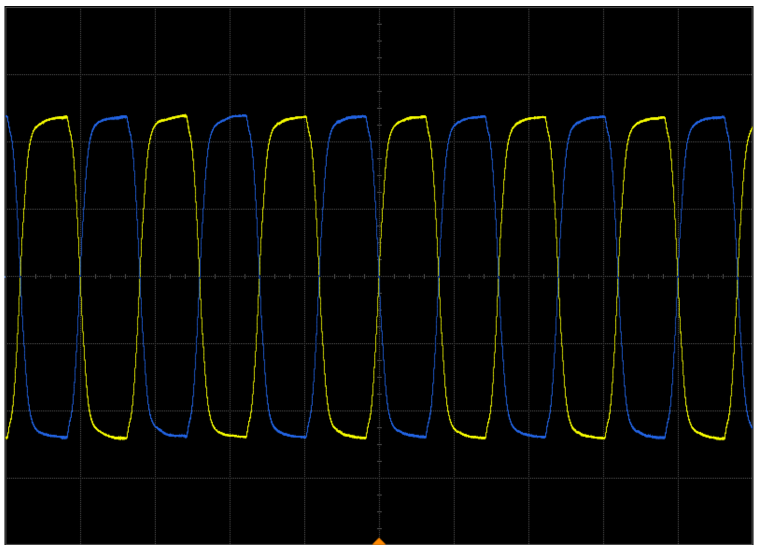


Figure 2-2 Typical Timing Jitter Test Waveform (using a pair of SMA cables)

Test Mode 2. Output Droop Tests

Test Setup

You can run this test using either **Two Channels** or a **One Channel** from the transmitter (MDI). Refer to “General Test Setup for 10BASE-T1S, ECU and PMA” on page 16 for connection details.

NOTE Use the software supplied with your transmitter PHY to control the Device Under Test.

Specification References

[1] 10BASE-T1S, IEEE Std 802.3cg^{TM} - 2019, Section 147.5.4.2

Transmitter Output Droop Positive Test Information

This test measures the positive output droop of the transmitter.

Reference “[1]” specifies the positive output droop of a compliant PHY. The positive droop measured with the initial peak value after the zero-crossing and the value 800 ns after the initial peak, shall be less than 30%.

The application triggers the Test Mode 2 signal on the rising edge and determines the time the positive peak occurred and the voltage at that specific instance. This application then measures the voltage 800 ns after the peak; with the Droop calculated as follows:

Droop = 100 × (Vd/Vpk)%

Where:

- **Vd** is the magnitude of the droop.
- **Vpk** is the initial peak after the zero-crossing.

Typical Waveform

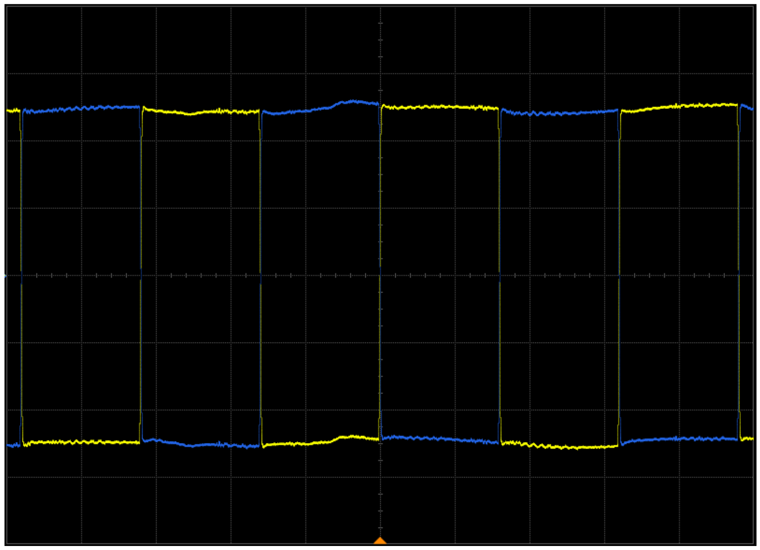


Figure 2-3 Typical Positive Droop Test Waveform (using a pair of SMA cables)

Transmitter Output Droop Negative Test Information

This test measures the negative output droop of the transmitter.

Reference "[1]" specifies the negative output droop of a compliant PHY. The negative droop measured with the initial peak value after the zero-crossing and the value 800 ns after the initial peak, shall be less than 30%.

The application triggers the Test Mode 2 signal on the falling edge and determines the time the negative peak occurred and the voltage at that specific instance. This application then measures the voltage 800 ns after the peak; with the Droop calculated as follows:

Droop = 100 × (Vd/Vpk)%

Where:

- **Vd** is the magnitude of the droop.
- **Vpk** is the initial peak after the zero-crossing.

Typical Waveform

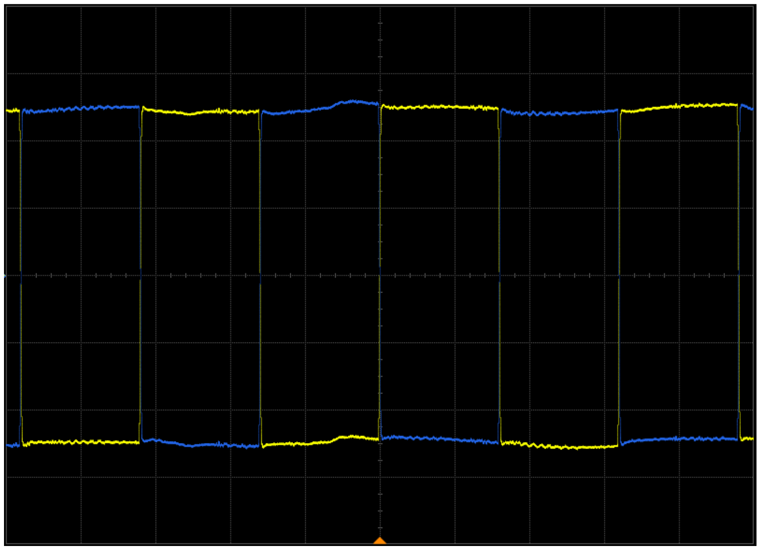


Figure 2-4 Typical Negative Droop Test Waveform (using a pair of SMA cables)

Test Mode 3. Transmitter Power Spectral Density (PSD) (Point to Point), Transmitter Power Spectral Density (PSD) (MultiDrop) and Rise & Fall Transmitter Test

Test Setup

The Power Spectral Density (PSD) Test can run using either a spectrum analyzer or an oscilloscope. When using the Oscilloscope to run, refer to “General Test Setup for 10BASE-T1S, ECU and PMA” on page 16 for testing using the oscilloscope.

If you use the N9010B Signal Analyzer, convert the differential output to a single-ended output using a balun. Use the balun on either the AE6941A Automotive Ethernet Fixture, as shown in Figure 2-5 on page 44 or the N5395C Ethernet Test Fixture, as shown in Figure 2-6 on page 45.

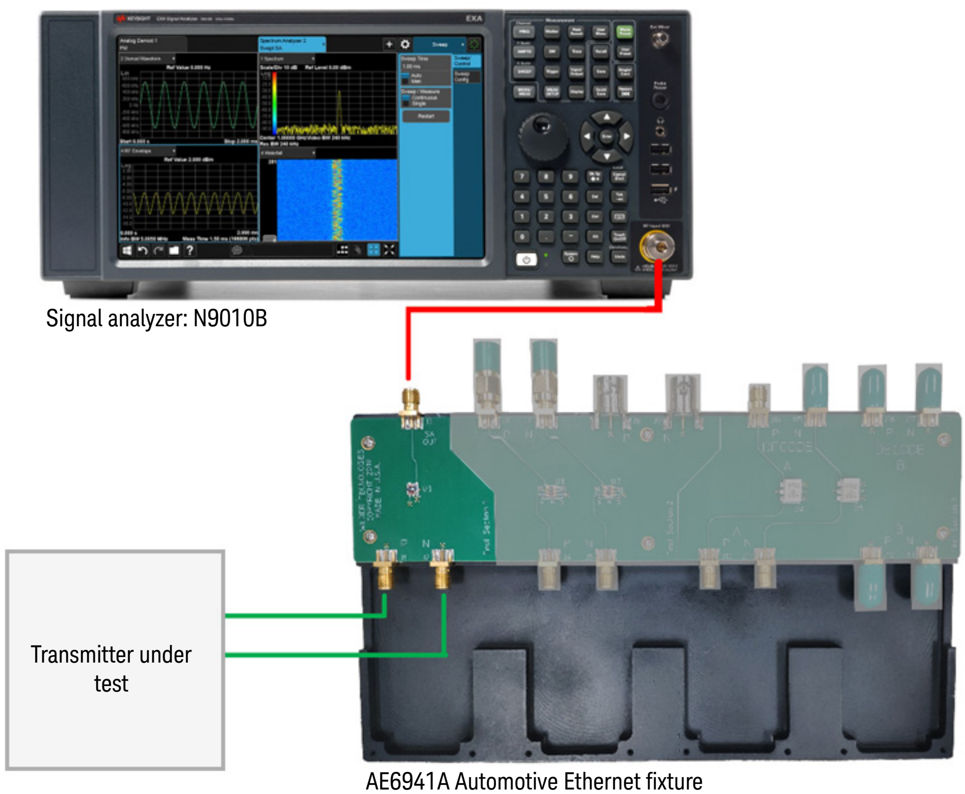


Figure 2-5 Power Spectral Density Test Using N9010B Signal Analyzer with AE6941A

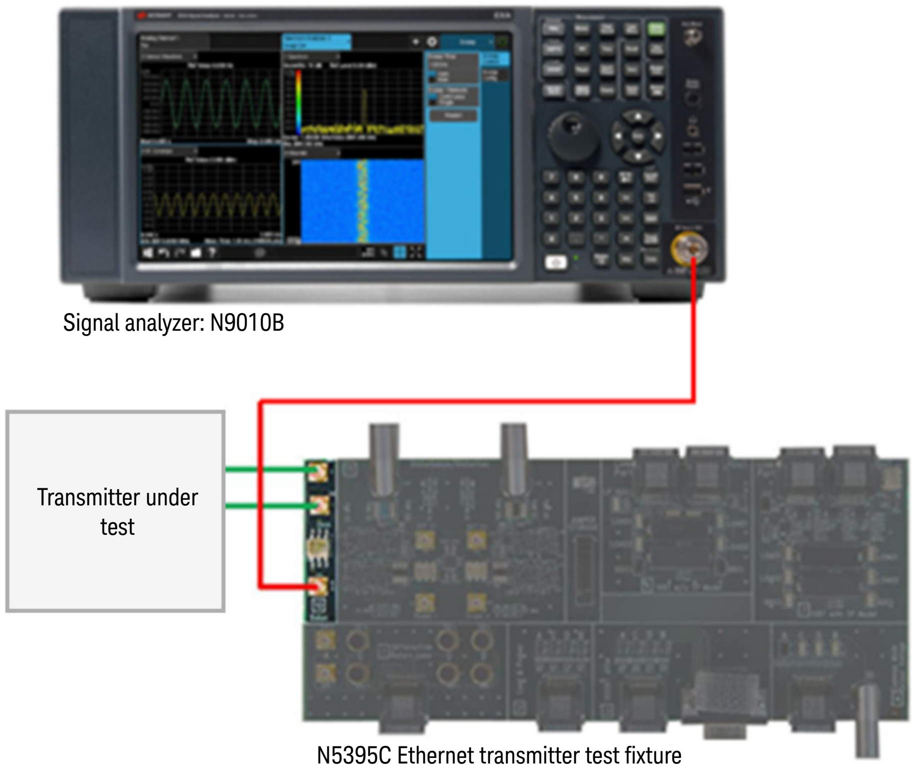


Figure 2-6 Power Spectral Density Test Using N9010B Signal Analyzer with N5395C

NOTE Use the software supplied with your transmitter PHY to control the Device Under Test.

Specification References

[1] 10BASE-T1S, IEEE Std 802.3cg™ - 2019, Section 147.5.4.2.

PSD (MultiDrop) Test Information based on IEEE 802.3cg

Reference "[1]" specifies that in Test Mode 3, the power spectral density (PSD) of the transmitter shall be between the upper and lower bounds specified in the following tables.

Table 2-2 PSD Upper Bounds

Frequency	PSD Upper Bound (dBm/Hz)[1]
@0.3 MHz	-61
@15 MHz	-61
@25 MHz	-75
25 MHz-40 MHz	-75

1 Settings: RBW=10 kHz, VBW=30 kHz, sweep time >1 min, RMS detector.

Table 2-3 PSD Lower Bounds

Frequency	PSD Lower Bound (dBm/Hz)[1]
@5 MHz	-77
@10 MHz	-67
@15 MHz	-77

1 Settings: RBW=10 kHz, VBW=30 kHz, sweep time >1 min, RMS detector.

The upper and lower limits are piece-wise linear masks connecting points given in Table 2-2 on page 46 and Table 2-3 on page 46. Provided is a lower PSD mask to ensure tolerances.

Typical Waveform

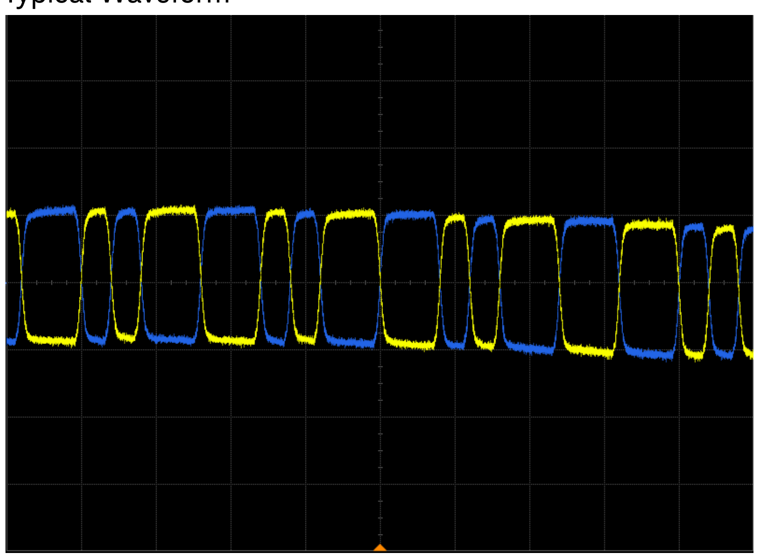


Figure 2-7 Typical Power Spectral Density Test Waveform TM3

PSD (Point to Point) Test Information based on IEEE 802.3cg

Reference "[1]" specifies that in Test Mode 3, the power spectral density (PSD) of the transmitter shall be between the upper and lower bounds specified in the following tables. In point-to-point mode both upper and lower limits are 3 dB lower than those for multidrop mode.

Table 2-4 PSD Upper Bounds

Frequency	PSD Upper Bound (dBm/Hz)[1]
@0.3 MHz	-64
@15 MHz	-64
@25 MHz	-78
25 MHz-40 MHz	-78

1 Settings: RBW=10 kHz, VBW=30 kHz, sweep time >1 min, RMS detector.

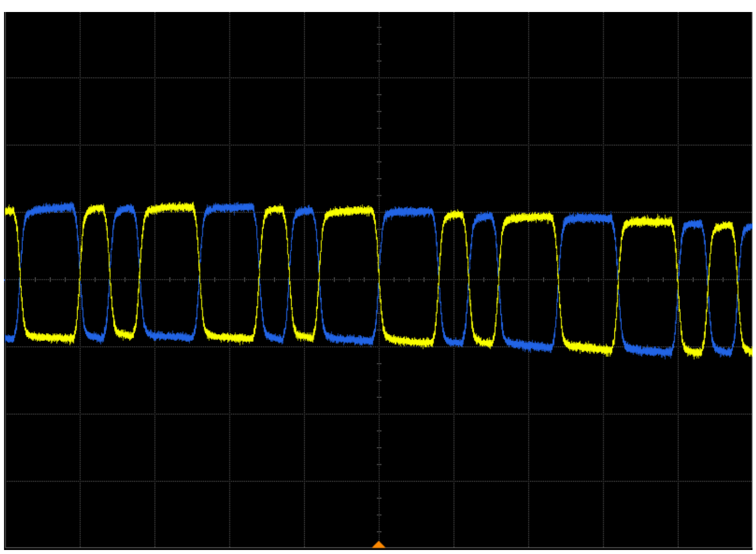
Table 2-5 PSD Lower Bounds

Frequency	PSD Lower Bound (dBm/Hz)[1]
@5 MHz	-80
@10 MHz	-70
@15 MHz	-80

1 Settings: RBW=10 kHz, VBW=30 kHz, sweep time >1 min, RMS detector.

The upper and lower limits are piece-wise linear masks connecting points given in Table 2-4 on page 47 and Table 2-5 on page 47. Provided is a lower PSD mask to ensure tolerances.

Typical Waveform



Typical Power Spectral Density Test Waveform TM3

PSD (MultiDrop) information - based on Open Alliance TC14 PMA

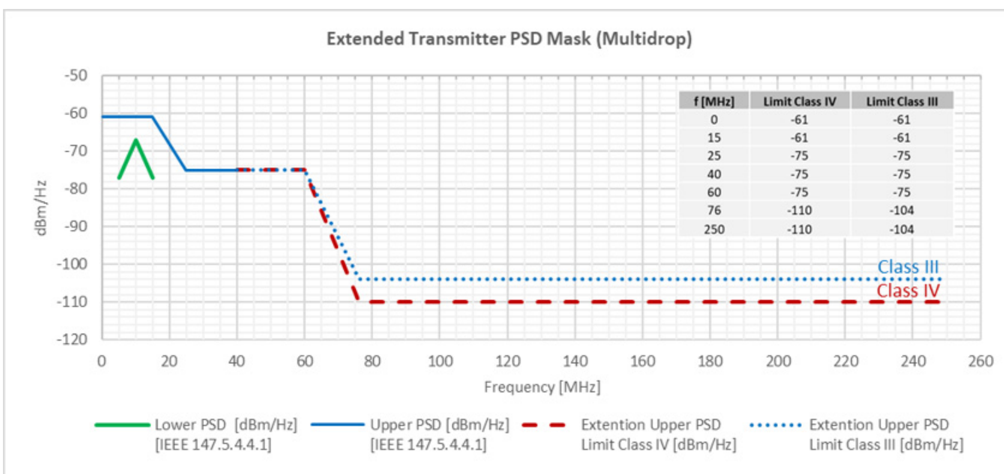
Note that the Open Alliance TC14 PMA spec suggests somewhat different test spec for 10BASE-T1S PSD test.

Below 40 MHz both classes continue to use the same IEEE 802.3cg transmitter-PSD mask. The only divergence appears in the extra, 40 MHz –250 MHz "extension" that OA TC14 adds to the test:

Frequency, f (MHz)	IEEE Upper Mask, † (dBm/Hz)	Class III extension (dBm/Hz)	Class IV extension (dBm/Hz)
40	-50	-50	-47
100	-60	-60	-57
250	-90	-90	-87

What that means in practice

- Class III mask – the tighter line.
  - Targeted at ECUs that sit in the "body/interior" EMC environment (OA Class III).
  - If you pass this mask you automatically pass Class IV.
- Class IV mask – the looser line, fixed +3 dB above Class III at every frequency in the 40-250 MHz range.
  - Intended for harsher "power-train/battery" harness zones where a few extra decibels of out-of-band energy do not raise EMC concerns.



Test Mode 4. High Impedance

Specification References

[1] 10BASE-T1S, IEEE Std 802.3cg™ - 2019, Section 147.9.2.

[2] Open Alliance 10BASE-T1S_PMA_Compliance Test Suite_V1_022224-CB Version 5.3.1. **Test 147.5.4.5 - Transmitter High Impedance Mode**

147.9.2 MDI electrical specification

When not in multidrop mode, the MDI shall meet the return loss limits as specified in 96.8.2.1 Equation (96-12).

When in multidrop mode, the MDI shall present a minimum parallel impedance across the MDI attachment points per Equation (147-8) and the limits for R, L, C_{tot} and C_{node} given in Table 147—4 over the stated frequency range C_{tot} is the maximum total capacitance across all MDI attachment points, while R, L, and C_{node} are the resistance. inductance. and capacitance for each MDI attachment point.

Inductive elements are often used when power is applied across the data lines. and may be absent in non-powered implementations. Removing the parallel inductance is equivalent to setting L to infinity in "Equation (147-8)". The parasitic capacitance of inductive elements forms a portion of C_{node}.

Equation (147-8)

$$|Z| = \frac{1}{\sqrt{\frac{1}{R^2} + \left(\frac{1}{2\pi \cdot f \cdot L} - 2\pi \cdot f \cdot C_{node}\right)^2}}$$

Where f is the frequency in MHz; $0.3 \le f \le 40$

Table 2-6 MDI Impedance Limit Parameters

Parameter Name	Unit of measure	Minimum Value	Maximum Value
R	kΩ	10	-
L	µH	80	-
C_{tot}	pF	-	180
C_{node}	pF	-	15

NOTE The implementer is cautioned that loading the mixing segment with multiple nodes with worst case capacitance at the same location on the mixing segment may cause the mixing segment to exceed its return loss specification.

Rise and Fall Time for Transmitter

Test Setup

You can run this test using either Two Channel or One Channel from the transmitter (MDI).

Refer to "General Test Setup for 10BASE-T1S, ECU and PMA" on page 16 for connection details.

NOTE **Use the software supplied with your transmitter PHY to control the Device Under Test.**

Specification References

[1] 10BASE-T1S, IEEE Std 802.3cg^{TM} - 2019, Section 147.5.2.

[2] Open Alliance TC14 Physical Media Attachment Test Suite, Ver 12, Section 5.1.5

Transmitter Rising Timing Minimum/Maximum

This test measures the rising timing minimum/maximum of the transmitter.

Reference "[1]" specifies the rising timing minimum/maximum of a compliant PHY. The rising timing measured minimum/maximum at the transmitter side shall be less than 15ns and greater than 7.5ns symbol-to-symbol.

This test requires the DUT to operate in transmitter test mode 3. While in test mode 3, the DUT shall generate DME-encoded PRBS ones and zeros. This sequence is repeated continuously. The differential peak-to-peak voltage is then measured.

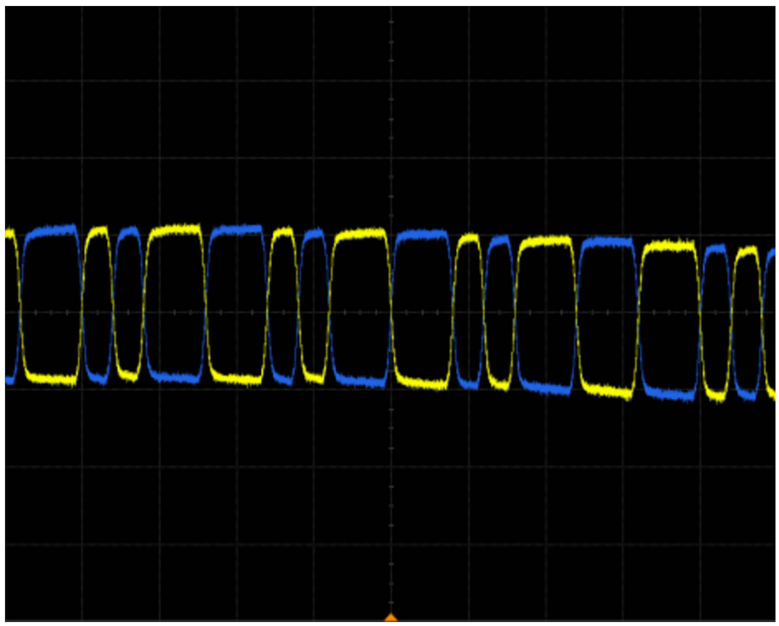


Figure 2-8 Typical TM3 Waveform

Transmitter Falling Timing Minimum/Maximum

This test measures the falling timing minimum/maximum of the transmitter.

Reference "[1]" specifies the falling timing minimum/maximum of a compliant PHY. The falling timing measured Maximum at the transmitter side shall be less than 15ns and greater than 7.5ns symbol-to-symbol.

This test requires the DUT to operate in transmitter test mode 3. While in test mode 3, the DUT shall generate DME-encoded PRBS ones and zeros. This sequence is repeated continuously. The differential peak-to-peak voltage is then measured.

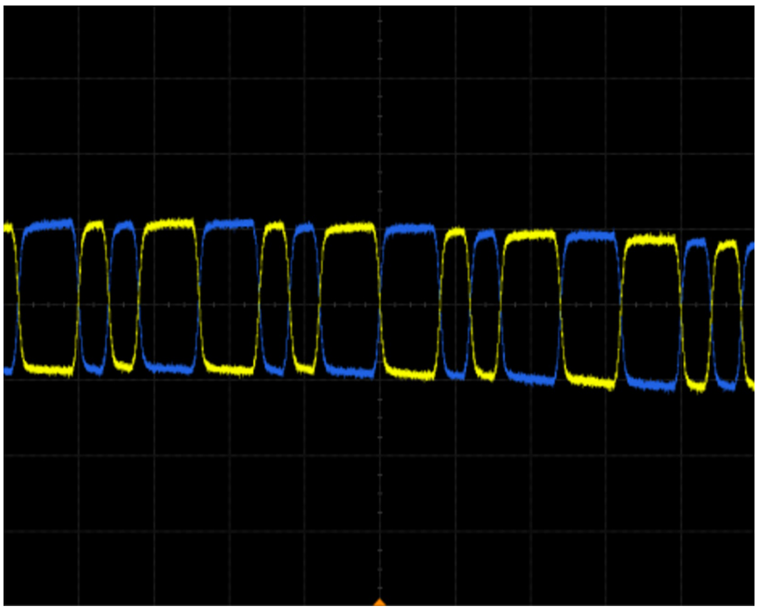


Figure 2-9 Typical TM3 Waveform

Viewing the Test Report

After running any or all of the Compliance tests, the **Results** tab will show the passed tests and details about the individual tests. For test result details, select any one of the tests from the top pane with the test details shown as follows. In Figure 2-10, selected is the Transmitter Power Spectral Density test, and the test results, with waveform, are shown as follows.

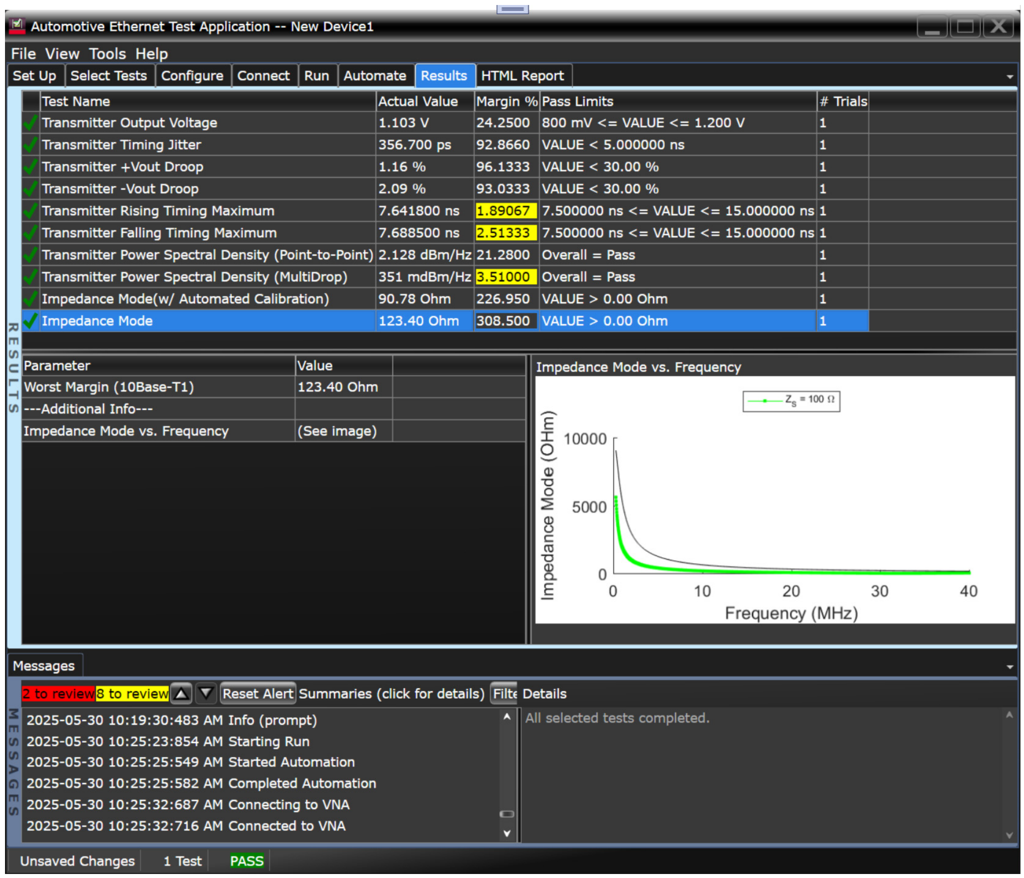
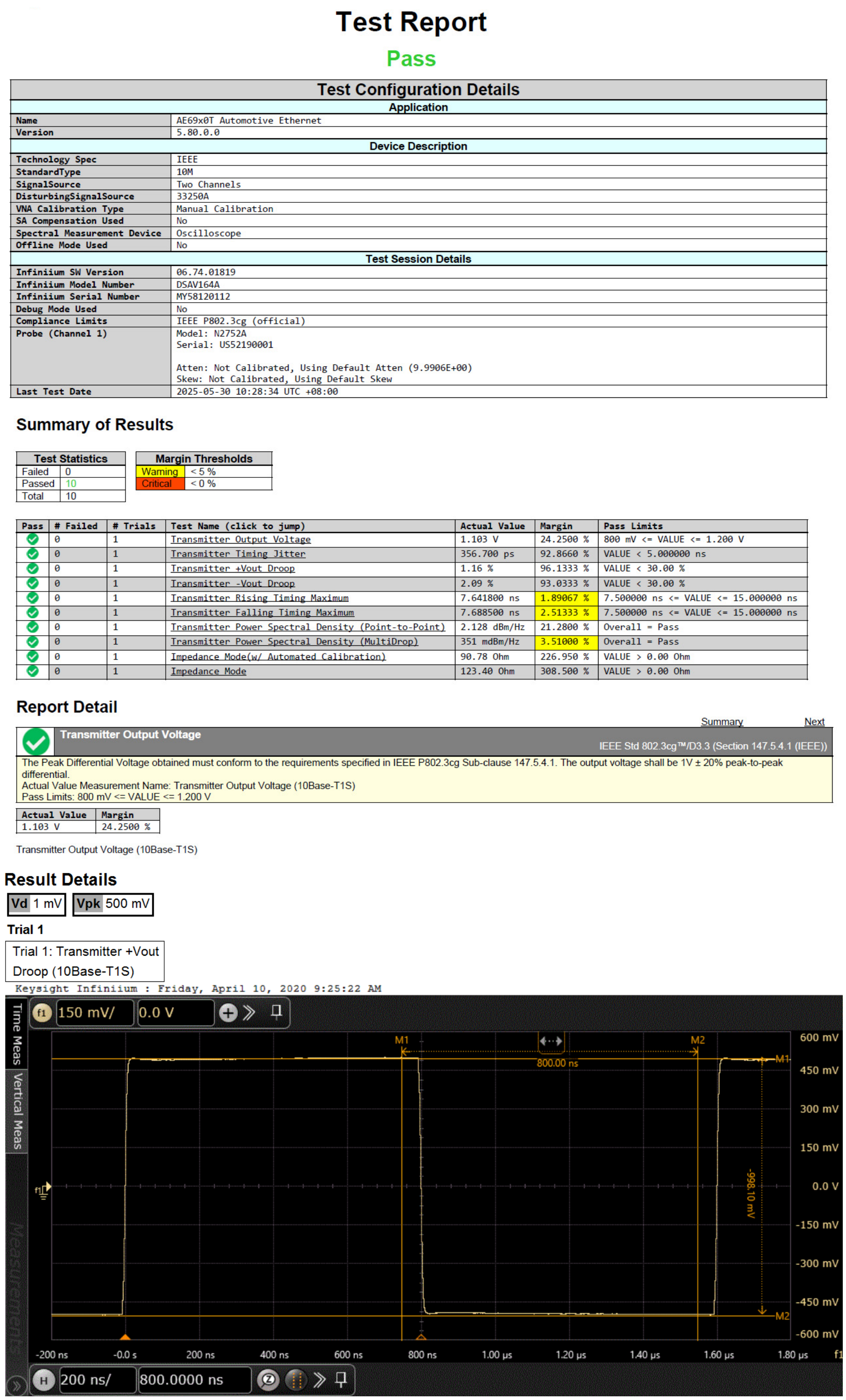


Figure 2-10 Typical Results tab

The following Figure 2-11 shows a portion of a typical **HTML Report** with waveforms and more test data below this segment.



Test Report

Pass

Test Configuration Details	
Application	
Name	AE69x0T Automotive Ethernet
Version	5.80.0.0
Device Description	
Technology Spec	IEEE
StandardType	10M
SignalSource	Two Channels
DisturbingSignalSource	33250A
VNA Calibration Type	Manual Calibration
SA Compensation Used	No
Spectral Measurement Device	Oscilloscope
Offline Mode Used	No
Test Session Details	
Infiniium SW Version	06.74.01819
Infiniium Model Number	DSAV164A
Infiniium Serial Number	MY58120112
Debug Mode Used	No
Compliance Limits	IEEE P802.3cg (official)
Probe (Channel 1)	Model: N2752A Serial: US52190001 Atten: Not Calibrated, Using Default Atten (9.9906E+00) Skew: Not Calibrated, Using Default Skew
Last Test Date	2025-05-30 10:28:34 UTC +08:00

Summary of Results

Test Statistics	
Failed	0
Passed	10
Total	10

Margin Thresholds	
Warning	< 5 %
Critical	< 0 %

Pass	# Failed	# Trials	Test Name (click to jump)	Actual Value	Margin	Pass Limits
✓	0	1	Transmitter Output Voltage	1.103 V	24.2500 %	800 mV <= VALUE <= 1.200 V
✓	0	1	Transmitter Timing Jitter	356.700 ps	92.8660 %	VALUE < 5.000000 ns
✓	0	1	Transmitter +Vout Droop	1.16 %	96.1333 %	VALUE < 30.00 %
✓	0	1	Transmitter -Vout Droop	2.09 %	93.0333 %	VALUE < 30.00 %
✓	0	1	Transmitter Rising Timing Maximum	7.641800 ns	1.89067 %	7.500000 ns <= VALUE <= 15.000000 ns
✓	0	1	Transmitter Falling Timing Maximum	7.688500 ns	2.51333 %	7.500000 ns <= VALUE <= 15.000000 ns
✓	0	1	Transmitter Power Spectral Density (Point-to-Point)	2.128 dBm/Hz	21.2800 %	Overall = Pass
✓	0	1	Transmitter Power Spectral Density (MultiDrop)	351 mdBm/Hz	3.51000 %	Overall = Pass
✓	0	1	Impedance Mode(w/ Automated Calibration)	90.78 Ohm	226.950 %	VALUE > 0.00 Ohm
✓	0	1	Impedance Mode	123.40 Ohm	308.500 %	VALUE > 0.00 Ohm

Report Detail

Summary Next

Transmitter Output Voltage

IEEE Std 802.3cg™/D3.3 (Section 147.5.4.1 (IEEE))

The Peak Differential Voltage obtained must conform to the requirements specified in IEEE P802.3cg Sub-clause 147.5.4.1. The output voltage shall be 1V ± 20% peak-to-peak differential.
Actual Value Measurement Name: Transmitter Output Voltage (10Base-T1S)
Pass Limits: 800 mV <= VALUE <= 1.200 V

Actual Value	Margin
1.103 V	24.2500 %

Transmitter Output Voltage (10Base-T1S)

Result Details

Vd 1 mV | Vpk 500 mV

Trial 1

Trial 1: Transmitter +Vout Droop (10Base-T1S)

Keysight Infiniium : Friday, April 10, 2020 9:25:22 AM

Figure 2-11 Top portion of a typical HTML report

3 100BASE-T1 Tests and Test Report

Test Mode 1. Output Droop Tests

Test Setup

You can run this test using either **Two Channels** or a **One Channel** from the transmitter (MDI). Refer to "General Test Setup for 100BASE-T1 and ECU" on page 17 for connection details.

NOTE Use the software supplied with your transmitter PHY to control the Device Under Test.

Specification References

[1] 100BASE-T1, IEEE Std 802.3bw™ – 2015, Section 96.5.4.1

Transmitter Output Droop Positive Test Information

This test measures the positive output droop of the transmitter.

Reference "[1]" specifies the positive output droop of a compliant PHY. The positive droop measured with the initial peak value after the zero-crossing and the value 500 ns after the initial peak, shall be less than 45%.

The application triggers the Test Mode 1 signal on the rising edge and determines the time the positive peak occurred and the voltage at that specific instance. This application then measures the voltage 500 ns after the peak; with the Droop calculated as follows:

Droop = 100 × (Vd/Vpk)%

Where:

- **Vd** is the magnitude of the droop.
- **Vpk** is the initial peak after the zero-crossing.

Typical Waveform

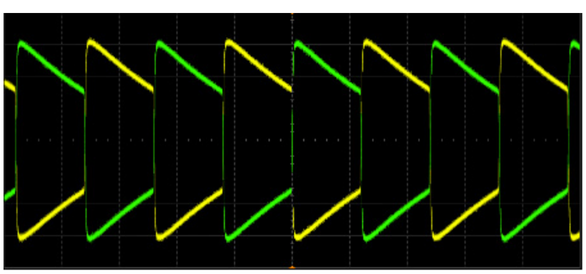


Figure 3-1 Typical Positive Droop Test Waveform (using a pair of SMA cables)

Transmitter Output Droop Negative Test Information

This test measures the negative output droop of the transmitter.

Reference "[1]" specifies the negative output droop of a compliant PHY. The negative droop measured with the initial peak value after the zero-crossing and the value 500 ns after the initial peak, shall be less than 45%.

The application triggers the Test Mode 1 signal on the falling edge and determines the time the negative peak occurred and the voltage at that specific instance. This application then measures the voltage 500 ns after the peak; with the Droop calculated as follows:

Droop = 100 × (Vd/Vpk)%

Where:

- **Vd** is the magnitude of the droop.
- **Vpk** is the initial peak after the zero-crossing.

Typical Waveform

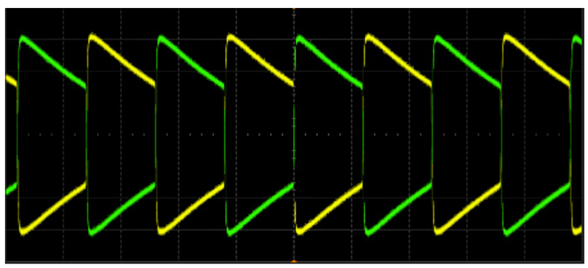


Figure 3-2 Typical Negative Droop Test Waveform (using a pair of SMA cables)

Test Mode 2. MASTER Clock Frequency and Jitter Tests

Test Setup

You can run this test using either **Two Channels** or a **One Channel** from the transmitter (MDI). Refer to “General Test Setup for 100BASE-T1 and ECU” on page 17 for connection details.

NOTE Use the software supplied with your transmitter PHY to control the Device Under Test.

Specification References

[1] 100BASE-T1, IEEE Std 802.3bw™ – 2015, Section 96.5.4.5.

[2] 100BASE-T1, IEEE Std 802.3bw™ – 2015, Section 96.5.2.

[3] 100BASE-T1, IEEE Std 802.3bw™ – 2015 Section 96.5.4.3.

Transmit Clock Frequency (MASTER) Test Information

This test measures the frequency of the transmitter clock when the PHY is operating in MASTER mode.

Reference “[1]” specifies the symbol transmission rate of a compliant PHY. The symbol transmission rate of the MASTER PHY shall be within the range if 66 2/3 MHz ±100 ppm.

Reference “[2]” specifies that Test Mode 2 shall transmit the data symbol sequence {+1,- 1} repeatedly on the channel. The transmitter shall time the transmitted symbols from a symbol rate clock in the MASTER timing mode. The measured data rate of the Test Mode 2 signal is thus equal to the MASTER Transmit Clock Frequency of the PHY.

Typical Waveform

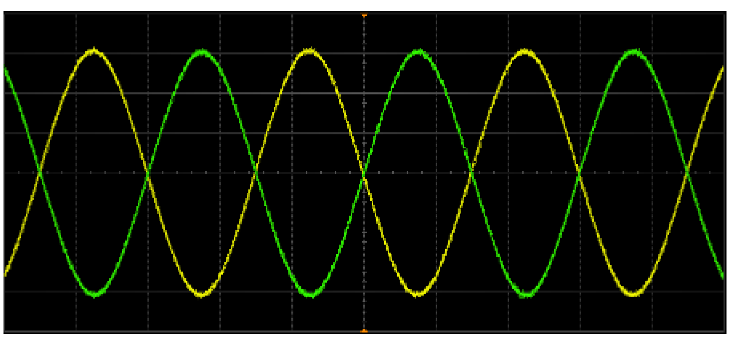


Figure 3-3 Typical MASTER Clock Test Waveform (using a pair of SMA cables)

MASTER TxOut Jitter Test Information

Reference "[3]" specifies that when in Test Mode 2, the RMS (Root Mean Square) value of the MDI output jitter, JTXOUT, relative to an unjittered reference shall be less than 50 ps.

This test measures the data time interval error of the Test Mode 2 signal at the MDI. The ideal reference data rate is selected automatically by the oscilloscope and compared to the original signal to determine the data time interval error.

Typical Waveform

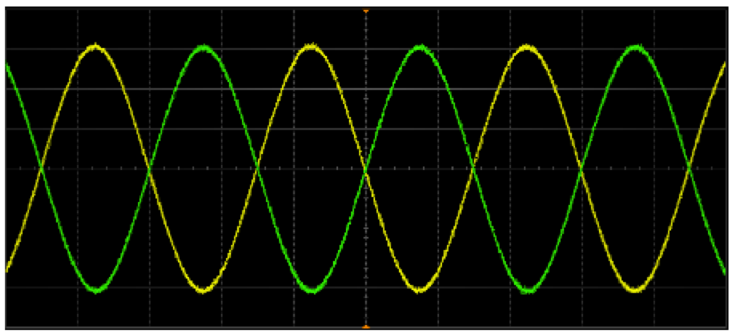


Figure 3-4 Typical MASTER TX Out Test Waveform (using a pair of SMA cables)

Test Mode 3. SLAVE Transmit Clock Frequency and Jitter Tests

Test Setup

You can run this test using either **Two Channels** or a **One Channel** from the transmitter (MDI). Alternatively, you can also run this test using the TX_TCLK. Refer to "General Test Setup for 100BASE-T1 and ECU" on page 17 for connection details.

NOTE Use the software supplied with your transmitter PHY to control the Device Under Test.

Specification References

[1] 100BASE-T1, IEEE Std 802.3bw™ – 2015, Section 96.5.4.5.

[2] 100BASE-T1, IEEE Std 802.3bw™ – 2015, Section 96.5.2.

[3] 100BASE-T1, IEEE Std 802.3bw™ – 2015, Section 96.5.4.3.

Transmit Clock Frequency (SLAVE) Test Information

Reference "[1]" specifies the symbol transmission rate of a compliant PHY. The symbol transmission rate of the MASTER PHY shall be within the range if 66 2/3 MHz ±100 ppm.

The specification does not specify the conformance limit for a PHY that is operating in SLAVE mode, but the SLAVE is supposed to have a symbol clock rate that is equal to the MASTER PHY.

Reference "[2]" specifies that Test Mode 3 shall transmit the data symbol sequence {+1,- 1} repeatedly on the channel. The transmitter shall time the transmitted symbols from a symbol rate clock in the SLAVE timing mode.

Alternatively, an external TX_TCLK could be used to measure the frequency.

Typical Waveform

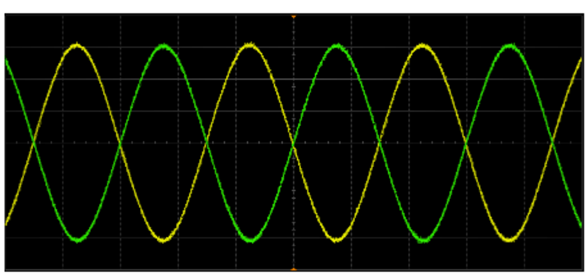


Figure 3-5 Typical TX Test Waveform (using a pair of SMA cables)

Slave TX_TCLK Jitter Test Information

Reference "[3]" specifies that the RMS value of the SLAVE TX_TCLK jitter relative to an unjittered reference shall be less than 0.01 UI (Unit Interval) after the receiver is properly receiving the data. This test measures the data time interval error at the MDI. The ideal reference data rate is selected automatically by the oscilloscope and compared to the original signal to determine the data time interval error.

Alternatively, an external TX_TCLK could be used to measure the jitter.

Typical Waveform

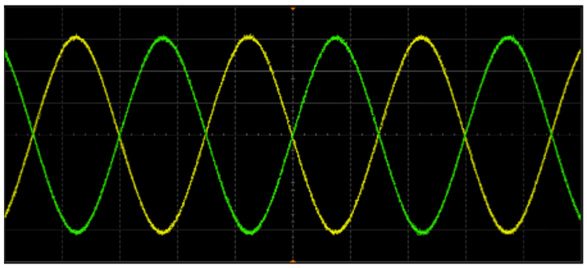


Figure 3-6 Typical TX-TCLK Test Waveform (using a pair of SMA cables)

Test Mode 4. Transmitter Distortion Test

Test Setup

You have the option to use either Section 2 of the AE6941A Automotive Ethernet Fixture or Sections 1 and 11 of the N5395C Ethernet Test Fixture in this test.

A disturbing signal source is required to test for compliance. There is an option to test without a disturbing signal source, but the test result is not applicable for compliance. The test accepts only a differential signal.

When using a supported function generator, there is an automatic calibration process to calibrate the function generators. If you use an unsupported model, you will have to calibrate the function generators manually. Refer to the individual user manuals to determine calibration steps as well as the respective standard specification for calibration settings.

Table 3-1 List of supported function generators

Supported Function Generators	Number Required	Notes	Connection diagram with AE6941A	Connection diagram with N5395C
Keysight 33250A	2	Keysight 82357B USB/GPIB interface and one additional GPIB cable required.	Figure 3-8	Figure 3-11
Keysight 33622A	1	LAN/ USB Cable required.	Figure 3-7	Figure 3-10
Keysight 81150A/81160A	1	LAN/ USB Cable required.	Figure 3-9	Figure 3-12

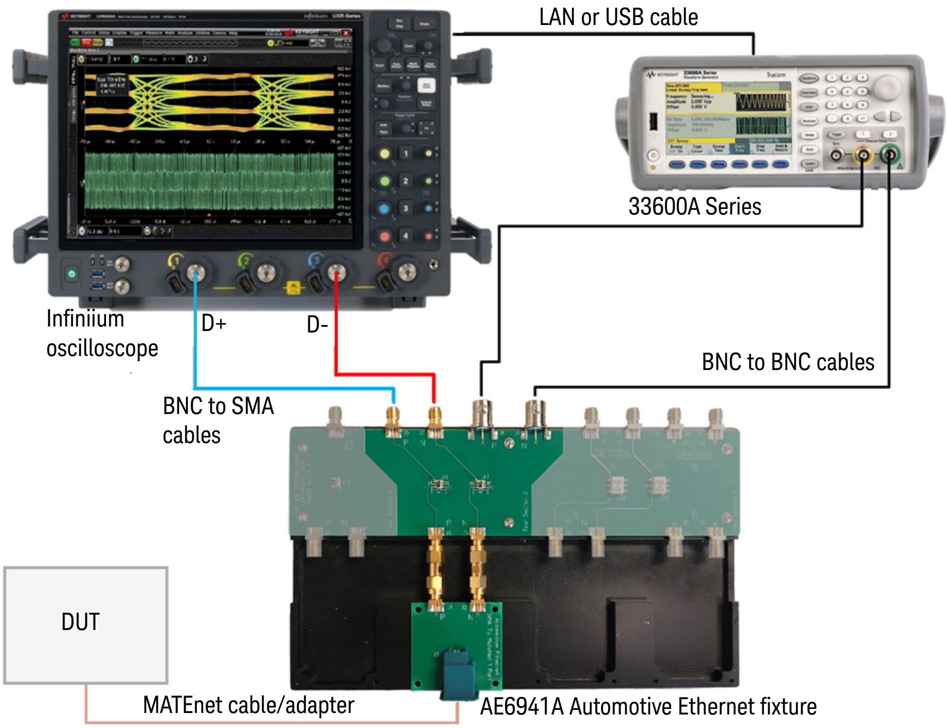


Figure 3-7 Connection for Transmitter Distortion Test Using Keysight 33622A Function Generator with AE6941A

Open Alliance TC12 recommends to use a low-pass filter at each output of the function generator to reduce high frequency noise above 125 MHz. Keysight recommends to use Mini-circuits model BLP-150+.

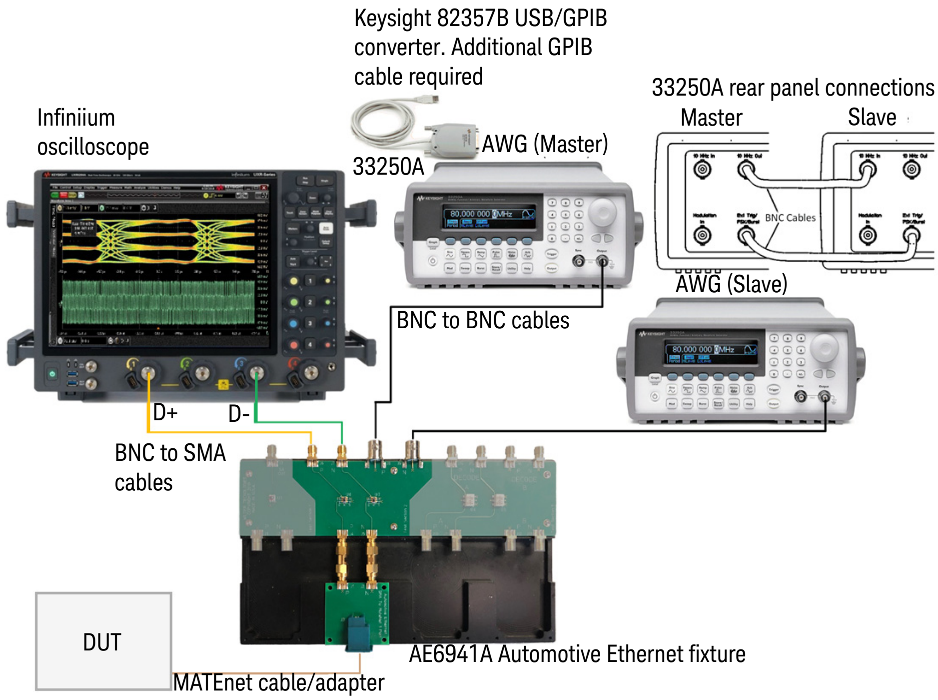


Figure 3-8 Transmitter Distortion Test Connection Using two Keysight 33250A Function Generators with AE6941A

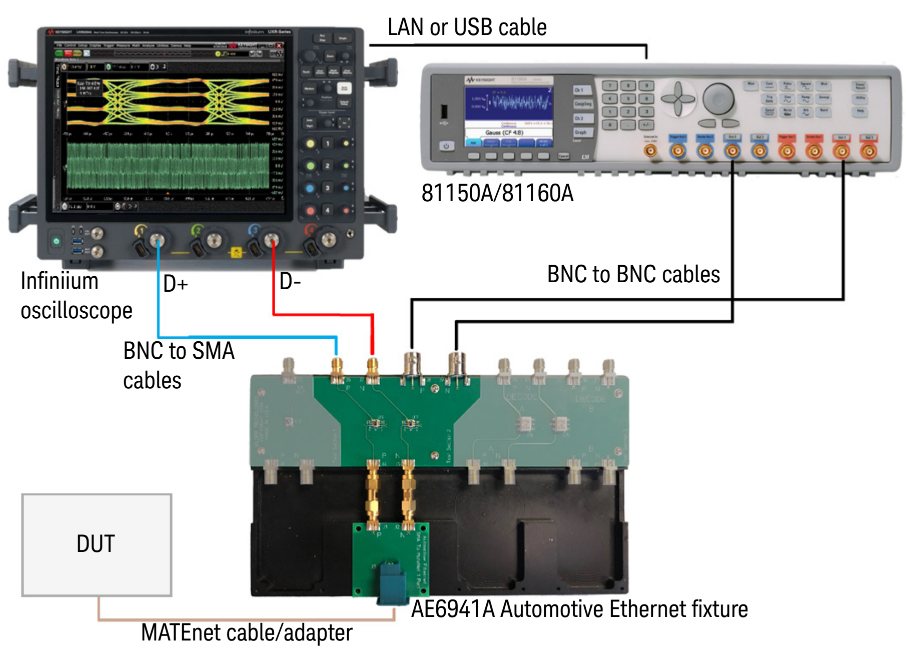


Figure 3-9 Connection for Transmitter Distortion Test Using Keysight 81150A/81160A Function Generator with AE6941A

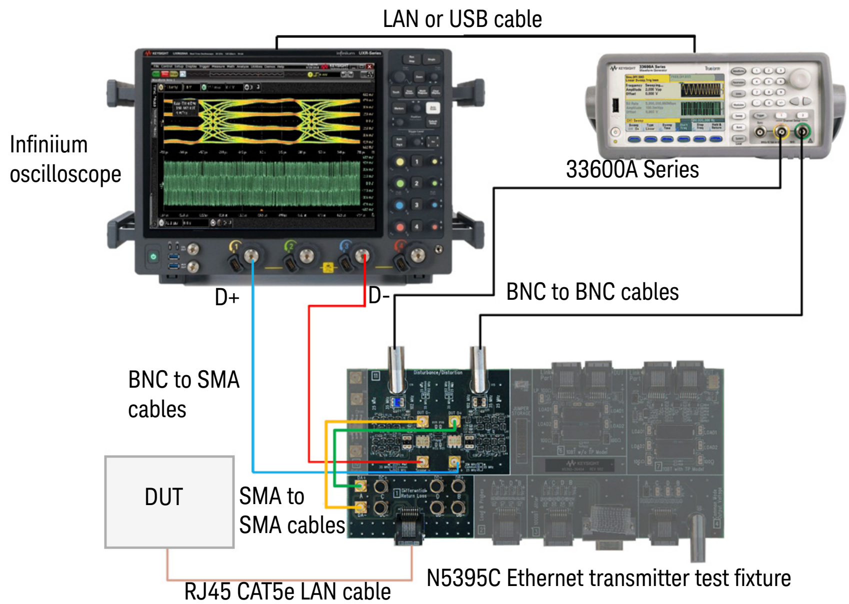


Figure 3-10 Connection for Transmitter Distortion Test Using Keysight 33622A Function Generator with N5395C

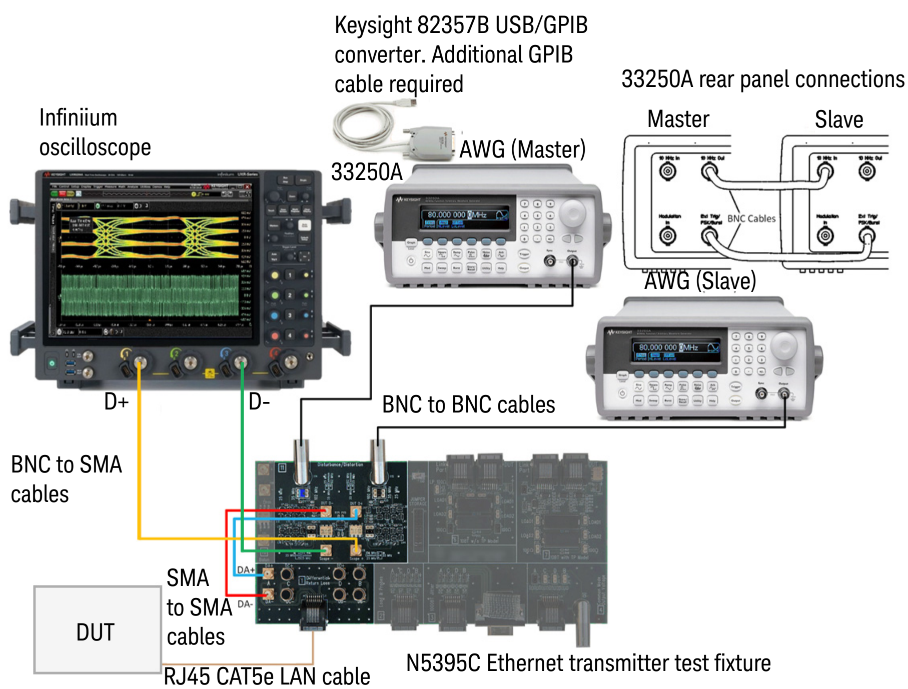


Figure 3-11 Transmitter Distortion Test Connection Using two Keysight 33250A Function Generators with N5395C

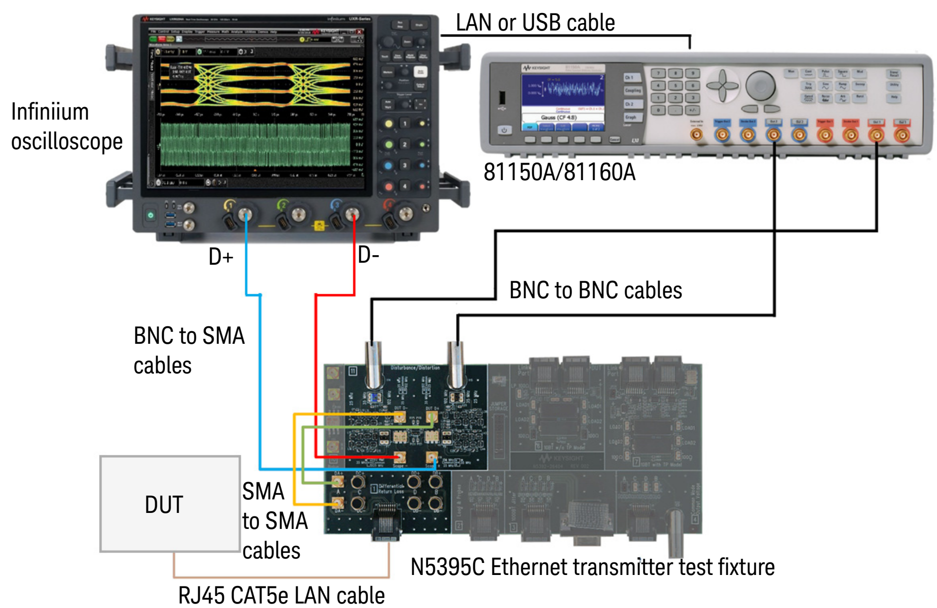


Figure 3-12 Connection for Transmitter Distortion Test Using Keysight 81150A/81160A Function Generator with N5395C

Using the Optional AE6950A Frequency Divider Board

If you want to use the optional AE6950A Frequency Divider Board to provide a stable 10 MHz reference clock, refer to "Using the AE6950A Frequency Divider Board" on page 224 for detailed information.

Specification References

[1] 100BASE-T1, IEEE Std 802.3bw™ – 2015, Section 96.5.4.2.

Transmitter Distortion Tests Information

When operating in Test Mode 4 and capturing the waveform using the recommended fixture, the peak distortion values, measured at a minimum of 10 equally-spaced phases of a single symbol period, shall be less than 15 mV.

NOTE If using the Frequency Divider, connect the 10 MHz output(s) of the divider to the 10 MHz Ref In Input of the oscilloscope and function generator for clock synchronization.

Reference "[1]" specifies that the peak distortion is determined by sampling the differential signal output with the symbol rate clock at an arbitrary phase and processing a block of any 2047 consecutive samples with MATLAB code in reference "[1]".

Apply a software high pass filter to the sampled signal before post-processing.

Alternatively, you can also run this test without the disturbing signal, but you cannot use the result to determine compliance.

Transmitter Distortion Enhance Clock Recovery Algorithm

Keysight employs an enhanced clock recovery algorithm when the TX_TCLK is not available. The algorithm conditions the signal to the nominal bitrate. It is enabled by default when the **Use 10MHz Ref Clock** checkbox is disabled.

When the **Use 10MHz Ref Clock** checkbox is enabled, the AE6950A Frequency Divider board, and access to TX_TCLK, is required for synchronization.

NOTE You can only run this test using a differential output (Two Channels option) from the transmitter (MDI). Refer to "General Test Setup for 100BASE-T1 and ECU" on page 17 for connection details. Do not use a differential probe for this test.

Typical Waveform

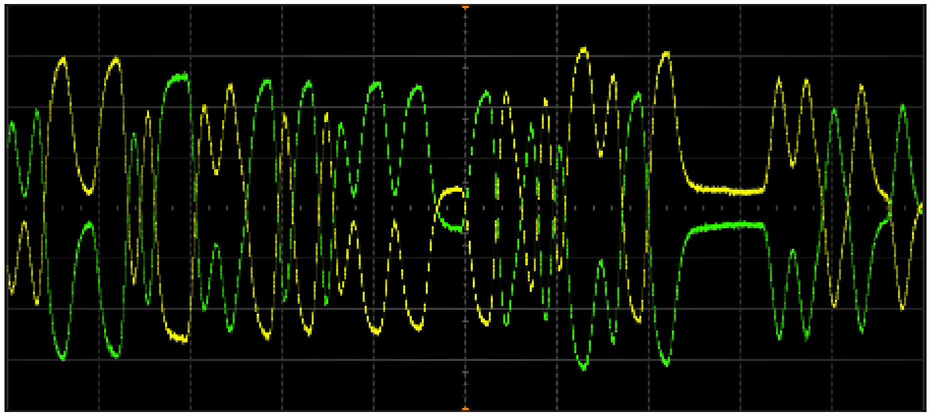


Figure 3-13 Typical Distortion Test Waveform (using a pair of SMA cables)

MDI Return Loss Test

Test Setup

Run the Management Data Input (MDI) Return Loss test with the E5080B Vector Network Analyzer connected externally to the oscilloscope.

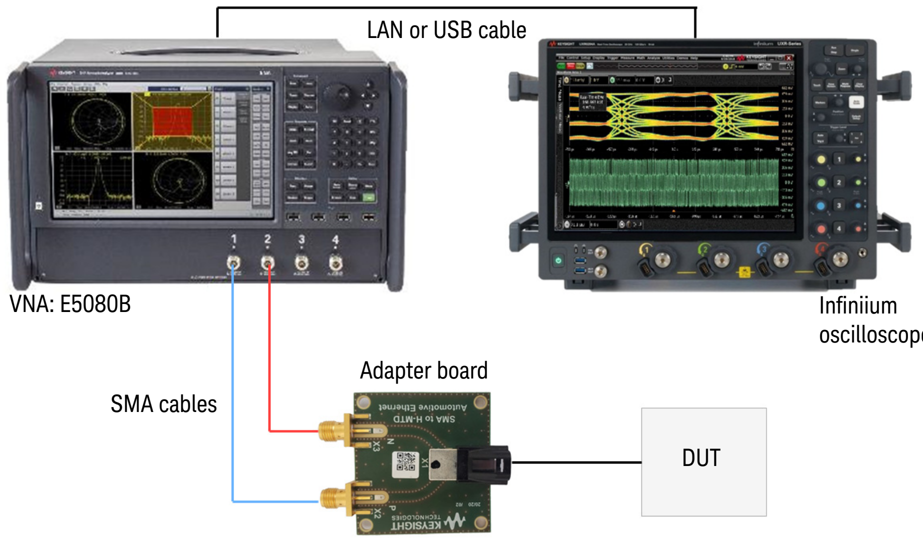


Figure 3-14 Connection Setup for MDI Return Loss and MDI Mode Conversion Loss Tests

Specification Reference

[1] 100BASE-T1, IEEE Std 802.3bw^{TM} – 2015, Section 96.8.2.1.

MDI Return Loss Test Information

This test can run with an external vector network analyzer. However, you can also use a VNA exported data file in the Touchstone or CITI format in place of the external vector network analyzer.

NOTE The DUT must be set to SLAVE Mode of operation and not transmitting any test symbols.

NOTE Calibrate the VNA before running the tests. Set the VNA as follows:

- Measurement: Return Loss S_{dd11}
- Start Frequency: 1 MHz
- Stop Frequency: 66 MHz
- Sweep Type: Logarithmic
- Sweep Points: 1600
- Output Power: minimum -10 dBm
- Measurement Bandwidth: 100 Hz
- Logic Port Impedance Differential Mode: 100 Ω
- Logic Port Impedance Common Mode: 25 Ω
- Smoothing function is deactivated

Refer to “Calibrating the VNA” on page 208.

Reference “[1]” specifies that the MDI return loss shall meet or exceed the following equation for all frequencies ranging from 1 MHz to 66 MHz (with 100 Ω reference impedance) at all times when the PHY is transmitting data or control symbols.

Table 3-2 Frequency and Return Loss

Frequency	Return Loss (dB)
1 - 30 MHz	20
30 - 66 MHz	20 - 20*log(f/30)

MDI Mode Conversion Loss Test

Test Setup

Run the Management Data Input (MDI) Mode Conversion Loss test with the E5080B Vector Network Analyzer connected externally to the oscilloscope. Refer to Figure 3-14 for the connection diagram.

Specification Reference

[1] 100BASE-T1, IEEE Std 802.3bw^{TM} – 2015, Section 96.8.2.2.

MDI Mode Conversion Loss Test Information

This test can run with an external vector network analyzer. However, you can also use a VNA exported data file in the Touchstone or CITI format in place of the external vector network analyzer.

NOTE The DUT must be set to SLAVE Mode of operation and not transmitting any test symbols.

NOTE Calibrate the VNA before running the tests. Set the VNA as follows:

- Measurement: Return Loss S_{dc11}
- Start Frequency: 1 MHz
- Stop Frequency: 200 MHz
- Sweep Type: Logarithmic
- Sweep Points: 1600
- Output Power: minimum -10 dBm
- Measurement Bandwidth: 100 Hz
- Logic Port Impedance Differential Mode: 100 Ω
- Logic Port Impedance Common Mode: 25 Ω
- Smoothing function is deactivated

Refer to "Calibrating the VNA" on page 208.

Reference "[1]" specifies that the MDI mode conversion loss shall meet or exceed the following equation for all frequencies ranging from 1 MHz to 200 MHz (with 100 Ω reference impedance) at all times when the PHY is transmitting data or control symbols.

NOTE MDI mode conversion loss test is very sensitive to the test configuration. It is very important that you maintain the same cable layout used for the VNA calibration to make the measurement. No bending or twisting of the cable from the calibration to measurement. Also, use a quality SMA or 2.92mm coaxial cable for testing.

Table 3-3 100base-T1 Mode Conversion Loss Limit

Frequency	Mode Conversion Loss (dB)
@1 MHz	–60
@22 MHz	–60
@100 MHz	–47
@200 MHz	–37

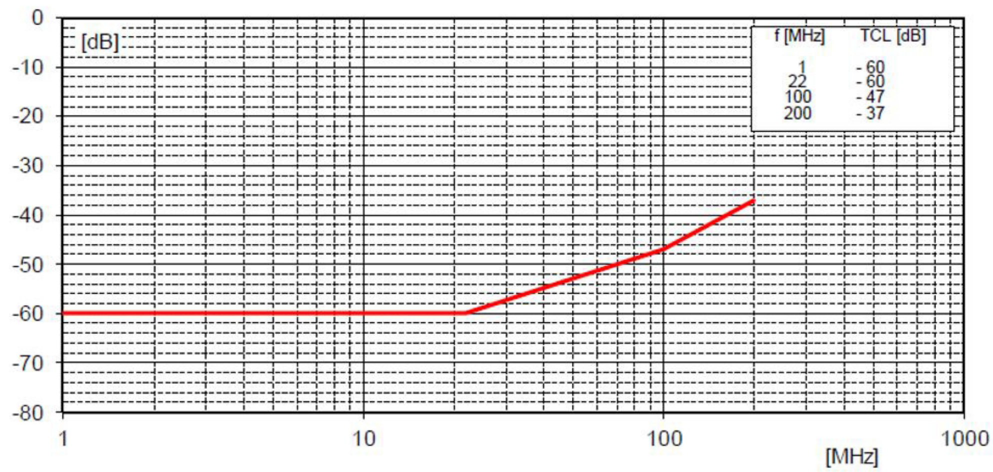


Figure 3-15 100base-T1 Mode Conversion Loss Limit

Test Mode 5. Transmitter Power Spectral Density (PSD) and Transmitter Peak Differential Output Tests

Test Setup

You can run the Power Spectral Density (PSD) Test using either a spectrum analyzer or an oscilloscope. When using the Oscilloscope, refer to "General Test Setup for 100BASE-T1 and ECU" on page 17 for connection details.

If you use the N9010B Signal Analyzer, convert the differential output to a single-ended output using a balun. Use the balun on either the AE6941A Automotive Ethernet Fixture, as shown in Figure 2-5 on page 44 or the N5395C Ethernet Test Fixture, as shown in Figure 2-6 on page 45

NOTE **Use the software supplied with your transmitter PHY to control the Device Under Test.**

Specification References

[1] 100BASE-T1, IEEE Std 802.3bw™ – 2015, Section 96.5.4.4.

[2] 100BASE-T1, IEEE Std 802.3bw™ – 2015, Section 96.5.6.

PSD Test Information

Reference “[1]” specifies that in Test Mode 5, the power spectral density (PSD) of the transmitter shall be between the upper and lower bounds specified in the following table.

Table 3-4 PSD Upper and Lower Bounds

Frequency	PSD Upper Bound (dBm/Hz)[1]	PSD Lower Bound (dBm/Hz)[1]
@1 MHz	-63.3	-70.9
@20 MHz	-64.8	-75.8
@40 MHz	-68.5	-89.2
57 MHz–200 MHz	-76.5	–

1 Settings: RBW=10 kHz, VBW=30 kHz, sweep time >1 min, RMS detector.

The upper and lower limits are piece-wise linear masks connecting points given in Table 3-4 on page 74. Provided is a lower PSD mask to ensure tolerances.

Typical Waveform

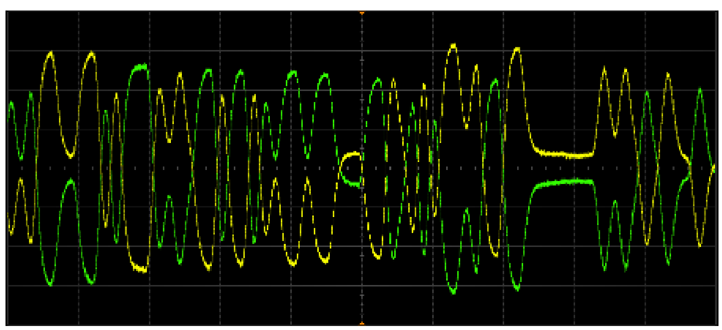


Figure 3-16 Typical Spectral Density Loss Test Waveform

Transmitter Peak Differential Output

Reference “[2]” specifies that in Test Mode 5, when measured with 100 Ω termination, the transmit differential signal at MDI shall be less than 2.2 Volt peak-to-peak.

Viewing the Test Report

After running any or all of the Compliance tests, the **Results** tab will show the passed tests and details about the individual tests. For test result details, select any one of the tests from the top pane with the test details shown as follows. In Figure 3-17, selected is the Transmitter +Vout Droop test, and the test results, with waveform, are shown as follows.

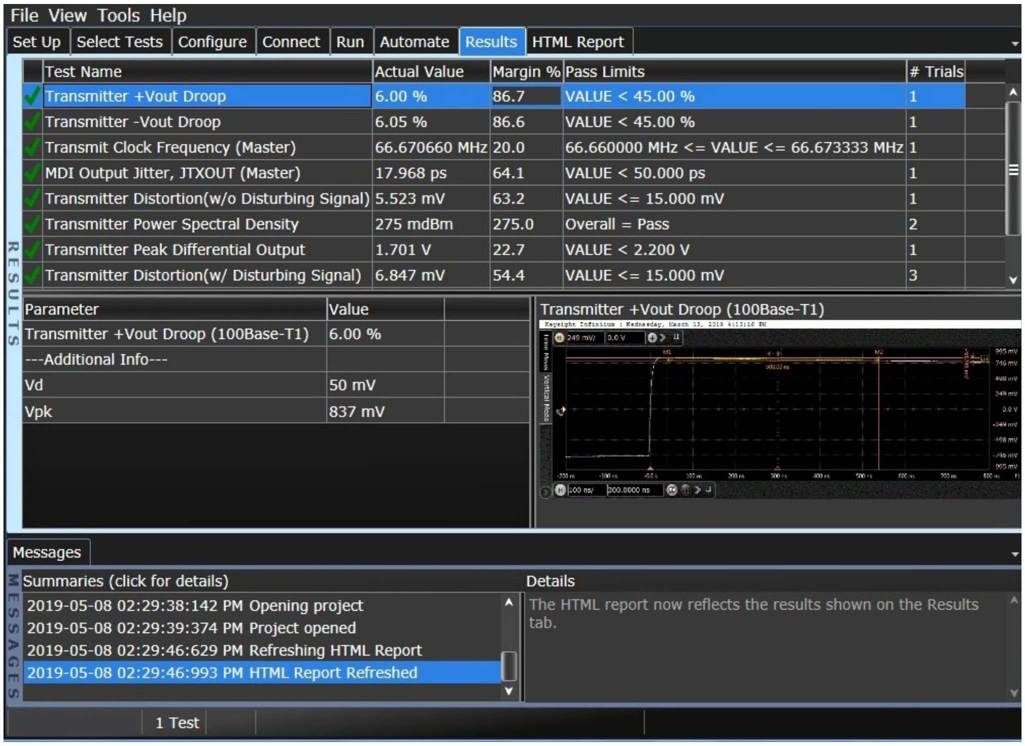


Figure 3-17 Typical Results tab

Figure 3-18 shows a portion of a typical **HTML Report**. Below this segment are waveforms and more test data.

Test Report

Pass

Test Configuration Details	
Application	
Name	AE6910T/AE6920T Automotive Ethernet Test Application
Version	1.30.0000.0
Device Description	
Technology Spec	IEEE
StandardType	100M
Spectral Measurement Device	Oscilloscope
Bandpass Filter	No
DisturbingSignalSource	81150A/60A
VNA Calibration Type	Manual Calibration
SA Compensation Used	No
Offline Mode Used	No
Test Session Details	
Infiniium SW Version	06.60.00403
Infiniium Model Number	DSAV164A
Infiniium Serial Number	MY58120112
Debug Mode Used	No
Compliance Limits	IEEE 802.3bw-2015 (official)
Last Test Date	2021-03-24 09:49:34 UTC +08:00

Summary of Results

Test Statistics	
Failed	0
Passed	10
Total	10

Margin Thresholds	
Warning	< 5 %
Critical	< 0 %

Pass	# Failed	# Trials	Test Name (click to jump)	Actual Value	Margin	Pass Limits
✓	0	1	Transmitter +Vout Droop	6.34 %	85.9 %	VALUE < 45.00 %
✓	0	1	Transmitter -Vout Droop	6.43 %	85.7 %	VALUE < 45.00 %
✓	0	1	Transmit Clock Frequency (Master)	66.668159 MHz	38.8 %	66.660000 MHz <= VALUE <= 66.673333 MHz
✓	0	1	MDI Output Jitter, JTXOUT (Master)	25.380 ps	49.2 %	VALUE < 50.000 ps
i	0	1	TX_TCLK Frequency (Slave)	66.668024 MHz	100.0 %	Information Only
✓	0	1	Slave TX_TCLK jitter (w/o TX_TCLK)	1.686 mUI	83.1 %	VALUE < 10.000 mUI
✓	0	1	Transmitter Distortion(w/o Disturbing Signal)	4.287 mV	71.4 %	VALUE <= 15.000 mV
✓	0	1	Transmitter Power Spectral Density	2.453 dBm/Hz	24.5 %	Overall = Pass
✓	0	1	Transmitter Peak Differential Output	1.698 V	22.8 %	VALUE < 2.200 V
✓	0	1	Transmitter Distortion(w/ Disturbing Signal)	6.420 mV	57.2 %	VALUE <= 15.000 mV

Report Detail

Summary Next

Transmitter +Vout Droop

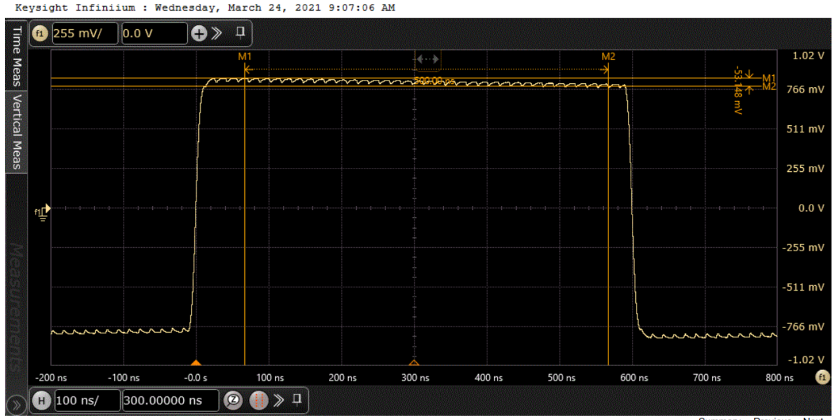
IEEE Std 802.3bw™-2015 (Section 96.5.4.1 (IEEE))

The magnitude of both the positive and negative droop measured with respect to an initial peak value after the zero crossing and the value 500ns after the initial peak, shall be less than 45%.
Actual Value Measurement Name: Transmitter +Vout Droop (100Base-T1)
Pass Limits: VALUE < 45.00 %

Actual Value	Margin	Vd	Vpk
6.34 %	85.9 %	53 mV	838 mV

Transmitter +Vout Droop (100Base-T1)

Keysight Infiniium : Wednesday, March 24, 2021 9:07:06 AM



Summary Previous Next

Figure 3-18 Top portion of a typical HTML report

4 1000BASE-T1 Tests and Test Report

Test Mode 1. TX_TCLK125 Frequency and Transmit Jitter Tests

Test Setup

You can run this test using either **Two Channels** or a **One Channel** from the transmitter (MDI). Refer to "General Test Setup for 2.5GBASE-T1, 5GBASE-T1, and 10GBASE-T1" on page 19 for connection details.

NOTE Use the software supplied with your transmitter PHY to control the Device Under Test.

Specification References

[1] 1000BASE-T1 IEEE Std 802.3bp™ - 2016, Section 97.5.3.6.

[2] 1000BASE-T1 IEEE Std 802.3bp™ - 2016, Section 97.5.2.

[3] 1000BASE-T1 IEEE Std 802.3bp™ - 2016, Section 97.5.3.3.

TX_TCLK125 Frequency Test

This test measures the frequency of the TX_TCLK125 clock.

Reference "[1]" specifies the symbol transmission rate of a compliant PHY. The symbol transmission rate of the MASTER PHY shall be within the range of 750 MHz ±100 ppm.

Reference "[2]" specifies that Test Mode 1 shall provide access to a frequency reduced version of the transmit symbol clock or TX_TCLK125. This 125 MHz test clock is a one-sixth frequency divided version of the TX_TCLK that times the transmitted symbols.

The measured frequency of TX_TCLK125 should fall within 125 MHz ±100 ppm.

Transmit Clock Jitter (MASTER/SLAVE)

Test Mode 1 enables testing of timing jitter on MASTER and SLAVE transmitters. Connect MASTER and SLAVE transmitters over a link segment. The transmitter timing jitter is measured by capturing the TX_TCLK125 waveforms in both MASTER and SLAVE configurations.

Reference "[3]" specifies that when in Test Mode 1, and the link is up with the two PHYs having an established link, the RMS (Root Mean Square) value of the MASTER TX_TCLK125 jitter relative to an unjittered reference shall be less than 5 ps. The peak-to-peak value of the MASTER TX_TCLK125 jitter relative to an unjittered reference shall be less than 50 ps.

Reference "[3]" specifies that when in Test Mode 1, and the link is up with the two PHYs having an established link, the RMS (Root Mean Square) value of the SLAVE TX_TCLK125 jitter relative to an unjittered reference shall be less than 10 ps. The peak-to-peak value of the SLAVE TX_TCLK125 jitter relative to an unjittered reference shall be less than 100 ps.

This test measures the clock time interval error of the TX_TCLK125 signal at the MDI. The ideal reference clock is selected automatically by the oscilloscope and compared to the original signal to determine the clock time interval error.

Typical Waveform

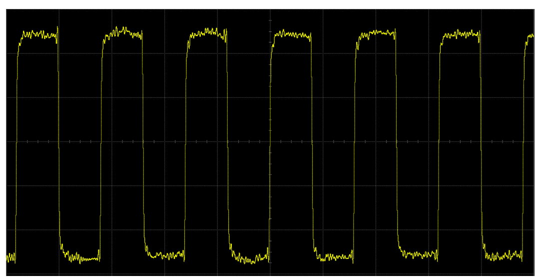


Figure 4-1 Typical TX_TCLK Test Waveform (using a pair of SMA cables)

Test Mode 2. Transmit Clock Frequency (MASTER) and MDI Output Jitter (MASTER) Tests

Test Setup

You can run this test using either **Two Channels** or a **One Channel** from the transmitter (MDI). Refer to "General Test Setup for 2.5GBASE-T1, 5GBASE-T1, and 10GBASE-T1" on page 19 for connection details.

NOTE Use the software supplied with your transmitter PHY to control the Device Under Test.

Specification References

[1] 1000BASE-T1 IEEE Std 802.3bp™ - 2016, Section 97.5.3.6.

[2] 1000BASE-T1 IEEE Std 802.3bp™ - 2016, Section 97.5.2.

[3] 1000BASE-T1 IEEE Std 802.3bp™ - 2016, Section 97.5.3.3.

Transmit Clock Frequency

Reference "[1]" specifies the symbol transmission rate of a compliant PHY. The symbol transmission rate of the MASTER PHY shall be within the range of 750 MHz ±100 ppm.

Reference "[2]" specifies that in Test Mode 2, the PHY shall transmit a continuous pattern of three {+1} symbols followed by three {-1} symbols, with the transmitted symbols timed from its local clock source of 750 MHz. The transmitter output is a 125 MHz signal. Hence the accuracy of the transmit clock frequency is also 125 MHz ±100 ppm.

MDI Output Jitter (MASTER)

Reference "[3]" specifies that when in Test Mode 2, the RMS (Root Mean Square) value of the MDI output jitter, relative to an unjittered reference, shall be less than 5 ps.

Reference "[3]" specifies that when in Test Mode 2, the peak-to-peak value of the MDI output jitter, relative to an unjittered reference, shall be less than 50 ps.

This test measures the data time interval error of the Test Mode 2 signal at the MDI. The ideal reference data rate is selected automatically by the oscilloscope and compared to the original signal to determine the data time interval error.

Typical Waveform

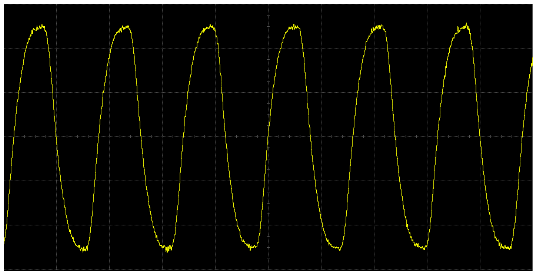


Figure 4-2 Typical Test Mode 2 Waveform (using a pair of SMA cables)

Test Mode 4. Transmitter Distortion Test

Test Setup

You have the option to use either Section 2 of the AE6941A Automotive Ethernet Fixture or Sections 1 and 11 of the N5395C Ethernet Test Fixture in this test.

A disturbing signal source is required to test for compliance. There is an option to test without a disturbing signal source, but the test result is not applicable for compliance. The test accepts only a differential signal.

When using a supported function generator, there is an automatic calibration process to calibrate the function generators. If you use an unsupported model, you will have to calibrate the function generators manually. Refer to the individual user manuals to determine calibration steps as well as the respective standard specification for calibration settings.

Table 4-1 List of supported function generators

Supported Function Generators	Number Required	Notes	Connection diagram with AE6941A	Connection diagram with N5395C
Keysight 33622A	1	LAN/ USB Cable required.	Figure 3-7	Figure 3-10
Keysight 81150A/ 81160A	1	LAN/ USB Cable required.	Figure 3-9	Figure 3-12

Using the Optional AE6950A Frequency Divider Board

If you want to use the optional AE6950A Frequency Divider Board to provide a stable 10 MHz reference clock, refer to Appendix "Using the AE6950A Frequency Divider Board" on page 224 for detailed information.

Specification References

[1] 1000BASE-T1 IEEE Std 802.3bp™ - 2016, Section 97.5.3.2.

Transmitter Distortion Tests Information

When operating in Test Mode 4 and capturing the waveform using the recommended fixture, the peak distortion values, measured at a minimum of 10 equally-spaced phases of a single symbol period, shall be less than 15 mV.

NOTE **If using the Frequency Divider, connect the 10 MHz output(s) of the divider to the 10 MHz Ref In Input of the oscilloscope and function generator for clock synchronization.**

Reference "[1]" specifies that the peak distortion is determined by sampling the differential signal output with the symbol rate clock at an arbitrary phase and processing a block of any 2047 consecutive samples with MATLAB code in Reference "[1]".

Alternatively, you can run this test without the disturbing signal, but you cannot use the result to determine compliance.

Transmitter Distortion Enhance Clock Recovery Algorithm

Keysight employs an enhanced clock recovery algorithm when the TX_TCLK is not available. The algorithm conditions the signal to the nominal bitrate. It is enabled by default when the **Use 10MHz Ref Clock** checkbox is disabled.

When the **Use 10MHz Ref Clock** checkbox is enabled, the AE6950A Frequency Divider board and access to TX_TCLK are required for synchronization.

NOTE **You can only run this test using a differential output (two channels option) from the transmitter (MDI). Refer to "General Test Setup for 2.5GBASE-T1, 5GBASE-T1, and 10GBASE-T1" on page 19 for connection details. You cannot use a differential probe for this test.**

Typical Waveform

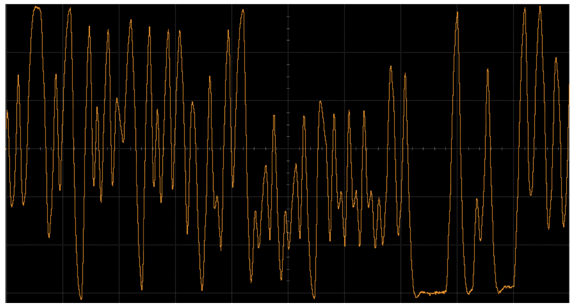


Figure 4-3 Typical Test Mode 4 Waveform (using a pair of SMA cables)

MDI Return Loss Test

Test Setup

Run this test with the E5080B Vector Network Analyzer. However, you can use a VNA exported data file in the Touchstone or CITI format in place of the external vector network analyzer. Refer to Figure 3-14 for the connection diagram.

Specification Reference

[1] 1000BASE-T1 IEEE Std 802.3bp™ - 2016, Section 97.7.2.1.

MDI Return Loss Test Information

Reference "[1]" specifies that the differential impedance at the MDI for each transmit/receive channel shall be such that any attenuated reflection is relative to the incident signal as per the following equation. This reflection must be due to differential signals incident upon the MDI with a test port having a differential impedance of 100 Ω.

$$ReturnLoss(f) \geq \begin{bmatrix} 18 - 18(\log_{10})\frac{20}{f} & 2 \leq f < 20 \\ 18 & 20 \leq f < 100 \\ 18 - 16.7(\log_{10})\frac{f}{100} & 100 \leq f \leq 600 \end{bmatrix}$$

Where f is the frequency in MHz.

In other words, the return loss shall meet or exceed the equation shown for all frequencies ranging from 2 MHz to 600 MHz (with 100 Ω differential impedance) at all times when the PHY is transmitting data or control symbols.

NOTE **The DUT must be set to SLAVE Mode of operation and not transmit any test symbols.**

NOTE

Calibrate the VNA before running the tests. Set the VNA as follows:

- Measurement: Return Loss S_{dd11}
- Start Frequency: 2 MHz
- Stop Frequency: 600 MHz
- Sweep Type: Logarithmic
- Sweep Points: 1600
- Output Power: minimum -10 dBm
- Measurement Bandwidth: 100 Hz
- Logic Port Impedance Differential Mode: 100 Ω
- Logic Port Impedance Common Mode: 25 Ω
- Smoothing function is deactivated

Refer to "Calibrating the VNA" on page 208.

MDI Mode Conversion Loss Test

Test Setup

Run the Management Data Input (MDI) Mode Conversion Loss test with a vector network analyzer connected externally to the oscilloscope. Refer to Figure 3-14 for the connection diagram.

Specification Reference

[1] 1000BASE-T1 IEEE Std 802.3bp^{TM} - 2016, Section 97.7.2.2.

[2] Open Alliance TC9 MultiGBASE-T1 channel and components STP, v1.0.

NOTE **MDI mode conversion loss test is very sensitive to the test configuration. It is very important that you maintain the same cable layout used for the VNA calibration to make the measurement. No bending or twisting of the cable from the calibration to measurement. Also, use a quality SMA or 2.92mm coaxial cable for testing.**

MDI Mode Conversion Loss Test Information

This test can run with an external vector network analyzer. However, a VNA exported data file in the Touchstone or CITI format can also be used in place of the external vector network analyzer.

NOTE **The DUT must be set to SLAVE Mode of operation and not transmit any test symbols.**

NOTE **Calibrate the VNA before running the tests. Set the VNA as follows:**

- **Measurement: Mode Conversion S_{dc11}**
- **Start Frequency: 10 MHz**
- **Stop Frequency: 600 MHz**
- **Sweep Type: Logarithmic**
- **Sweep Points: 1600**
- **Output Power: minimum -10 dBm**
- **Measurement Bandwidth: 100 Hz**
- **Logic Port Impedance Differential Mode: 100 Ω**
- **Logic Port Impedance Common Mode: 25 Ω**
- **Smoothing function is deactivated**

Refer to “Calibrating the VNA” on page 208.

Reference “[1]” and “[2]” specify that the MDI Mode Conversion Loss shall meet or exceed the following equation for all frequencies ranging from 10 MHz to 600 MHz at all times.

Table 5 [1]

Frequency	Mode Conversion Loss (dB)
10 – 80 MHz	55
80 – 600 MHz	77 – 11.51*log(*f*)

Table 6 [2]

Frequency	Mode Conversion Loss (dB)
10 – 50 MHz	56
50 – 600 MHz	81.2 – 14.83 $\log_{10}(f)$ where frequency, (*f*) is in MHz

Normal Mode: Transmitter Link Sync Pulse Amplitude

Test Setup

You can run this test using One Channel from the transmitter (MDI).

Refer to "General Test Setup for 2.5GBASE-T1, 5GBASE-T1, and 10GBASE-T1" on page 19 for connection details.

NOTE

Use the software supplied with the transmitter PHY to control the DUT.

Specification References

[1] 1000BASE-T1 IEEE Std 802.3bp^{TM} - 2016, Section 97.5.3.5

Transmitter Link Sync Pulse Amplitude

This test measures peak-to-peak differential amplitude of Link Sync Pulse meets a specified minimum amount and does not exceed the specified maximum amount

Reference "[1]" states that any 1000BASE-T1 transmitter peak-to-peak differential amplitude shall be less than 1.3 V_{PP}. The Transmitter Link Sync Pulse Amplitude shall be more than 0.75 V_{PP} and shall be less than 1.3 V_{PP} when measured with a link partner.

Therefore, normal operation after DUT initialization shall be adequate for this test. The DUT shall be tested in both a Master and a Slave configuration

Test Mode 5. Transmitter Power Spectral Density, Transmitter Power Level, and Transmitter Peak Differential Output Tests

Test Setup

You can run the Power Spectral Density (PSD) Test using either a spectrum analyzer or an oscilloscope. When using the oscilloscope, refer to "General Test Setup for 2.5GBASE-T1, 5GBASE-T1, and 10GBASE-T1" on page 19 for connection details.

If you use the N9010B Signal Analyzer, convert the differential output to a single-ended output using a balun. Use the balun on the AE6941A Automotive Ethernet Fixture, as shown in Figure 2-5 or the N5395C Ethernet Test Fixture, as shown in Figure 2-6.

You can run the Power Level Test using either the spectrum analyzer or an oscilloscope. For this particular test, irrespective of equipment used, convert the differential output to a single-ended output using a balun. Use the balun on the AE6941A Automotive Ethernet Fixture, as shown in Figure 2-5 or the N5395C Ethernet Test Fixture, as shown in Figure 2-6.

NOTE Use the software supplied with your transmitter PHY to control the Device Under Test.

Specification References

[1] 1000BASE-T1 IEEE Std 802.3bp™ - 2016, Section 97.5.3.4.

[2] 1000BASE-T1 IEEE Std 802.3bp™ - 2016, Section 97.5.3.5.

Transmitter Power Spectral Density (PSD)

Reference "[1]" specifies that in Test Mode 5, the power spectral density (PSD) of the transmitter shall be between the specified upper and lower masks of the following equations.

$$UpperPSD(f) = \begin{bmatrix} -80 & \frac{dBm}{Hz} & 0 < f \le 100 \\ -76 - \frac{f}{25} & \frac{dBm}{Hz} & 100 < f \le 400 \\ -85.6 - \frac{f}{62.5} & \frac{dBm}{Hz} & 400 < f \le 600 \end{bmatrix}$$

$$LowerPSD(f) = \begin{bmatrix} -86 & \frac{dBm}{Hz} & 40 < f \le 100 \\ -82 - \frac{f}{25} & \frac{dBm}{Hz} & 100 < f \le 400 \end{bmatrix}$$

Where f is the frequency in MHz.

Consider the resolution bandwidth of 100 kHz and sweep time of larger than 1 second in PSD measurements.

You can run this test using an external spectrum analyzer or the oscilloscope.

Transmitter Power Level

Reference “[1]” specifies that in Test Mode 5, the transmit power shall be less than 5 dBm.

Transmitter Peak Differential Output

Reference “[2]” specifies that in Test Mode 5, when measured with 100 Ω termination, the transmit differential signal at MDI shall be less than 1.30 Volt peak-to-peak.

Typical Waveform

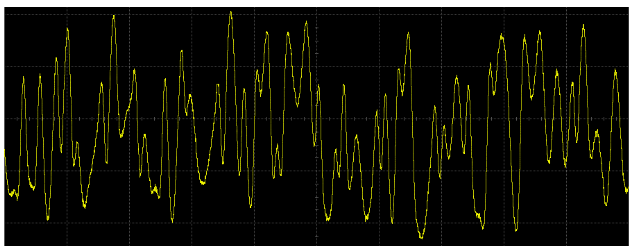


Figure 4-4 Typical Test Mode 5 Waveform (using a pair of SMA cables)

Test Mode 6. Output Droop Tests

Test Setup

You can run this test using either **Two Channels** or a **One Channel** from the transmitter (MDI). Refer to "General Test Setup for 2.5GBASE-T1, 5GBASE-T1, and 10GBASE-T1" on page 19 for connection details.

NOTE Use the software supplied with your transmitter PHY to control the Device Under Test.

Specification References

[1] 1000BASE-T1 IEEE Std 802.3bp™ - 2016, Section 97.5.3.1.

Transmitter Output Droop Positive Test Information

This test measures the positive output droop of the transmitter.

Reference "[1]" specifies the positive output droop of a compliant PHY. The positive droop measured with an initial value at 4 ns after the zero-crossing and a final value of 16 ns after the zero-crossing, shall be less than 10%.

The application triggers the Test Mode 6 signal on the rising edge and determines the time the positive peak occurred at 4 ns after the zero-crossing. This application then measures the voltage 12 ns after the initial peak crossing; with the Droop calculated as follows:

Droop = 100 × (Vd/Vpk)%

Where:

- **Vd** is the magnitude of the droop.
- **Vpk** is the initial peak after the zero-crossing.

Typical Waveform

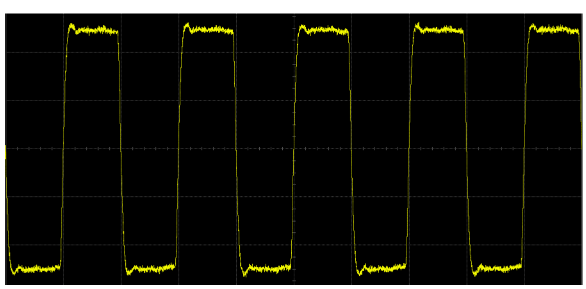


Figure 4-5 Typical Positive Droop Test Waveform (using a pair of SMA cables)

Transmitter Output Droop Negative Test Information

This test measures the negative output droop of the transmitter.

Reference "[1]" specifies the negative output droop of a compliant PHY. The negative droop measured with an initial value at 4 ns after the zero-crossing and a final value of 16 ns after the zero-crossing, shall be less than 10%.

The application triggers the Test Mode 6 signal on the falling edge and determines the time the negative peak occurred at 4 ns after the zero-crossing. This application then measures the voltage 12 ns after the initial peak crossing; with the Droop calculated as follows:

Droop = 100 × (Vd/Vpk)%

Where:

- **Vd** is the magnitude of the droop.
- **Vpk** is the initial peak after the zero-crossing.

Typical Waveform

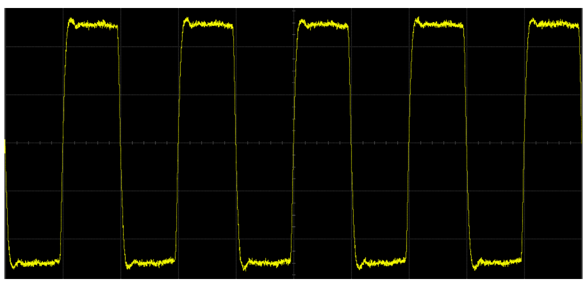


Figure 4-6 Typical Negative Droop Test Waveform (using a pair of SMA cables)

Viewing the Test Report

After running any or all of the Compliance tests, the **Results** tab will show the passed tests and details about the individual tests. For test result details, select any one of the tests from the top pane with the test details shown as follows. In Figure 4-7 selected is the Transmitter +Vout Droop test, and the test results, with waveform, are shown as follows.

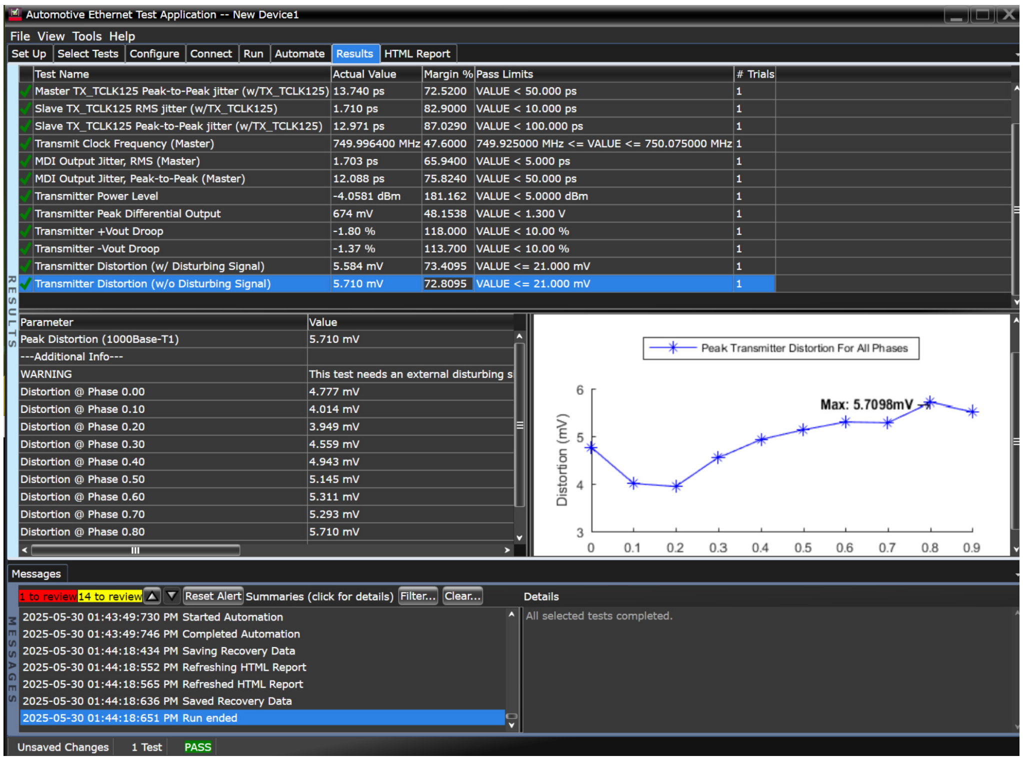


Figure 4-7 Typical Results Tab

Figure 4-8 shows a portion of a typical **HTML Report**. Below this segment are waveforms and more test data.

Test Report

Pass

Test Configuration Details	
Application	
Name	AE69x0T Automotive Ethernet
Version	5.80.0.0
Device Description	
Technology Spec	IEEE
StandardType	1000M
SignalSource	Two Channels
DisturbingSignalSource	81150A/60A
VNA Calibration Type	Manual Calibration
SA Compensation Used	No
Spectral Measurement Device	Oscilloscope
Offline Mode Used	No
Test Session Details	
Infiniium SW Version	06.74.01819
Infiniium Model Number	DSAV164A
Infiniium Serial Number	MY58120112
Debug Mode Used	No
Compliance Limits	802.3bp-2016 Specification - Amendment 4 (official)
Last Test Date	2025-05-30 13:44:08 UTC +08:00

Summary of Results

Test Statistics	
Failed	0
Passed	14
Total	14

Margin Thresholds	
Warning	< 5 %
Critical	< 0 %

Pass	# Failed	# Trials	Test Name (click to jump)	Actual Value	Margin	Pass Limits
✓	0	1	TX_TCLK125 Frequency	124.999410 MHz	47.6400 %	124.987500 MHz <= VALUE <= 125.012500 MHz
✓	0	1	Master TX_TCLK125 RMS jitter (w/TX_TCLK125)	1.643 ps	67.1400 %	VALUE < 5.000 ps
✓	0	1	Master TX_TCLK125 Peak-to-Peak jitter (w/TX_TCLK125)	13.740 ps	72.5200 %	VALUE < 50.000 ps
✓	0	1	Slave TX_TCLK125 RMS jitter (w/TX_TCLK125)	1.710 ps	82.9000 %	VALUE < 10.000 ps
✓	0	1	Slave TX_TCLK125 Peak-to-Peak jitter (w/TX_TCLK125)	12.971 ps	87.0290 %	VALUE < 100.000 ps
✓	0	1	Transmit Clock Frequency (Master)	749.996400 MHz	47.6000 %	749.925000 MHz <= VALUE <= 750.075000 MHz
✓	0	1	MDI Output Jitter, RMS (Master)	1.703 ps	65.9400 %	VALUE < 5.000 ps
✓	0	1	MDI Output Jitter, Peak-to-Peak (Master)	12.088 ps	75.8240 %	VALUE < 50.000 ps
✓	0	1	Transmitter Power Level	-4.0581 dBm	181.162 %	VALUE < 5.0000 dBm
✓	0	1	Transmitter Peak Differential Output	674 mV	48.1538 %	VALUE < 1.300 V
✓	0	1	Transmitter +Vout Droop	-1.80 %	118.000 %	VALUE < 10.00 %
✓	0	1	Transmitter -Vout Droop	-1.37 %	113.700 %	VALUE < 10.00 %
✓	0	1	Transmitter Distortion (w/ Disturbing Signal)	5.584 mV	73.4095 %	VALUE <= 21.000 mV
✓	0	1	Transmitter Distortion (w/o Disturbing Signal)	5.710 mV	72.8095 %	VALUE <= 21.000 mV

Report Detail

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TX_TCLK125 Frequency

Physical Layer Transceiver 802.3bp-2016 Specification - Amendment 4 (Section 97.5.3.6 / Section 97.5.2)

The symbol transmission rate of the MASTER PHY shall be within the range 750 MHz ± 100 ppm. TX_TCLK125 is the frequency reduced version (one sixth) of the transmit symbol clock and hence shall be within the range 125 MHz ± 100 ppm.
Actual Value Measurement Name: TX_TCLK125 Frequency (1000Base-T1)
Pass Limits: 124.987500 MHz <= VALUE <= 125.012500 MHz

Actual Value	Margin	Datarate
124.999410 MHz	47.6400 %	249.999120000 Mb/s

TX_TCLK125 Frequency (1000Base-T1)

Result Details

Power Spectral Density	(See image)	Measurement Device	Oscilloscope

Trial 1

Trial 1: Power Spectral Density

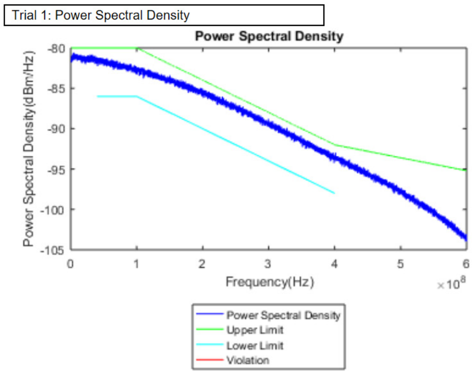


Figure 4-8 Top Portion of a Typical HTML Report

5 2.5GBASE-T1, 5GBASE-T1, and 10GBASE-T1 Tests and Test Report

Test Mode 1. Transmit Jitter Tests

Test Mode 1. Transmit Clock Frequency (MASTER) and Transmit Jitter Tests

Test Setup

You can run this test using either **Two Channels** or a **One Channel** from the transmitter (MDI). Refer to "General Test Setup for 2.5GBASE-T1, 5GBASE-T1, and 10GBASE-T1" on page 19 for connection details.

NOTE Use the software supplied with your transmitter PHY to control the Device Under Test.

Specification References

[1] IEEE Std 802.3ch™ - 2020, Section 149.5.2.3.

Transmit Clock Jitter (MASTER/SLAVE)

Test Mode 1 enables testing of timing jitter on MASTER and SLAVE transmitters. Connect MASTER and SLAVE transmitters over a link segment. The transmitter timing jitter is measured by capturing the TX_TCLK175 waveforms in both MASTER and SLAVE configurations.

Reference "[1]" specifies that when in Test Mode 1, and the link is up with the two PHYs having an established link, the RMS (Root Mean Square) value of the MASTER TX_TCLK175 jitter relative to an unjittered reference shall be less than 1/S ps. The peak-to-peak value of the MASTER TX_TCLK175 jitter relative to an unjittered reference shall be less than 10/S ps.

Reference "[1]" specifies that when in Test Mode 1, and the link is up with the two PHYs having an established link, the RMS (Root Mean Square) value of the SLAVE TX_TCLK175 jitter relative to an unjittered reference shall be less than 2/S ps. The peak-to-peak value of the SLAVE TX_TCLK175 jitter relative to an unjittered reference shall be less than 20/S ps.

Table 5-1 Scaling Parameter

PHY Type	S
2.5GBASE-T1	0.25
5GBASE-T1	0.5
10GBASE-T1	1

This test measures the clock time interval error of the TX_TCLK175 signal at the MDI. The ideal reference clock is selected automatically by the oscilloscope and compared to the original signal to determine the clock time interval error.

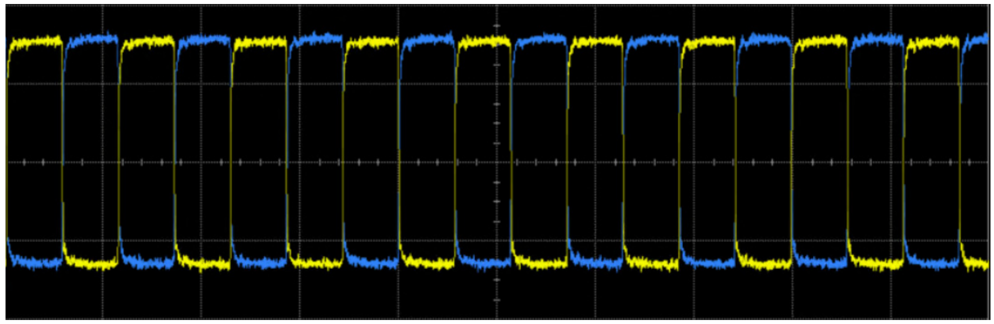


Figure 5-1 Typical Waveform

Test Mode 2. MDI Output Jitter (MASTER) Tests and Transmit Clock Frequency (MASTER)

Test Setup

You can run this test using either **Two Channels** or a **One Channel** from the transmitter (MDI). Refer to "General Test Setup for 2.5GBASE-T1, 5GBASE-T1, and 10GBASE-T1" on page 19 for connection details.

NOTE Use the software supplied with your transmitter PHY to control the Device Under Test.

Specification References

[1] IEEE Std 802.3ch™ - 2020, Section 149.5.2.3.1.

[2] IEEE Std 802.3ch™ - 2020, Section 149.5.2.3.2.

[3] IEEE Std 802.3ch™ - 2020, Section 149.5.2.6

MDI Output Jitter (MASTER)

Reference "[1]" specifies that when in Test Mode 2, and the PHY transmitting the TX_TCLK175 Square Wave test pattern, the RMS (Root Mean Square) value of the MDI output jitter, relative to an unjittered reference, shall be less than 1/S ps. Refer to Table 5-1 for the definition of S.

Reference "[1]" specifies that when in Test Mode 2, the peak-to-peak value of the MDI output jitter, relative to an unjittered reference, shall be less than 10/S ps. Refer to Table 5-1 for the definition of S.

This test measures the data time interval error of the Test Mode 2 signal at the MDI. The ideal reference data rate is selected automatically by the oscilloscope and compared to the original signal to determine the data time interval error.

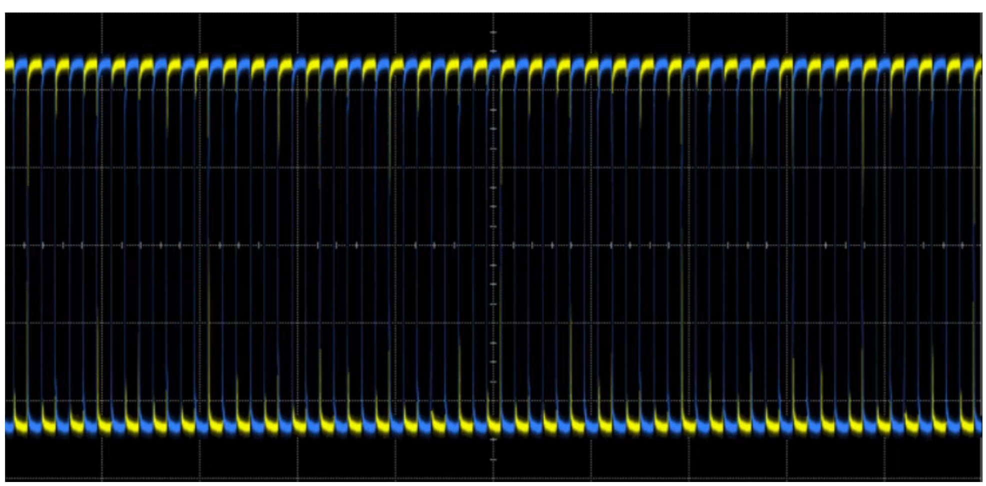


Figure 5-2 Typical Waveform

MDI Deterministic Jitter (MASTER)

Reference "[2]" specifies that when in Test Mode 2, and the PHY transmitting test pattern JP03A timed from the local clock source, the peak-to-peak deterministic jitter shall be less than 9/S ps. Refer to Table 5-1 for the definition of S.

This test measures the DJ_{pk-pk} of the Test Mode 2, JP03A test pattern at the MDI. The ideal reference data rate is selected automatically by the oscilloscope. EZJIT Jitter separation tool is used to measure the peak-to-peak Deterministic Jitter value.

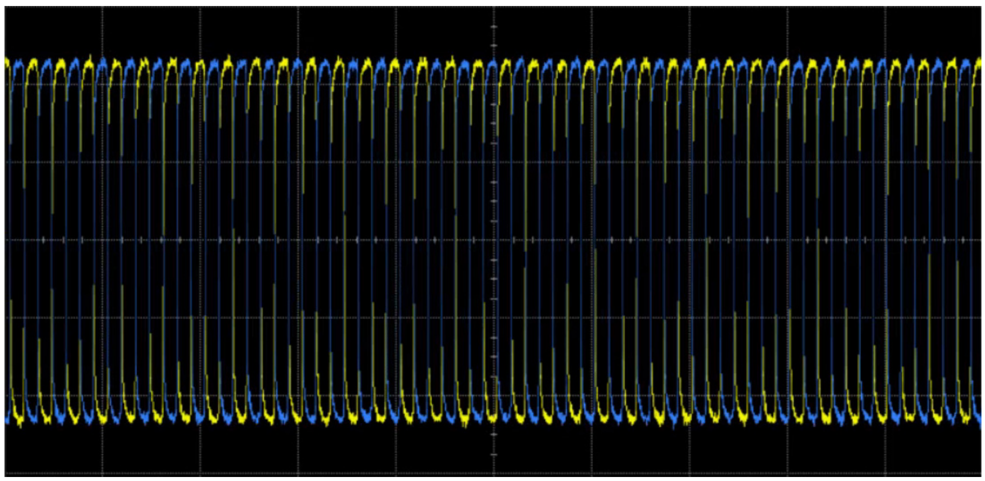


Figure 5-3 Typical Waveform

Transmit Clock Frequency (MASTER) Test

Reference "[3]" specifies the symbol transmission rate of a compliant PHY. The symbol transmission rate of the MASTER PHY shall be within the range of 5625 x S MHz ±50 ppm. Refer to Table 5-1 for the definition of S.

Reference "[3]" specifies that when in Test Mode 2, and the PHY transmitting test pattern JP03A timed from the local clock source.

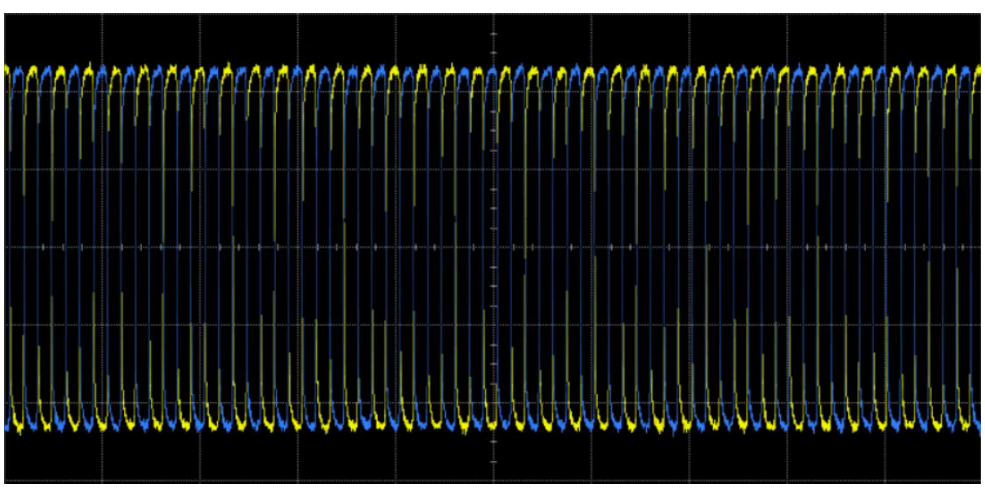


Figure 5-4 Typical Waveform

MDI Even-Odd Jitter (MASTER)

Reference "[2]" specifies that when in Test Mode 2, and the PHY transmitting test pattern JP03B timed from the local clock source, the peak-to-peak Even-Odd jitter shall be less than 4/S ps. Refer to Table 5-1 for the definition of S.

This test measures the EOJ_{pk-pk} of the Test Mode 2, JP03B test pattern at the MDI. The ideal reference data rate is selected automatically by the oscilloscope. EZJIT Jitter separation tool is used to measure the peak-to-peak Even-Odd Jitter value.

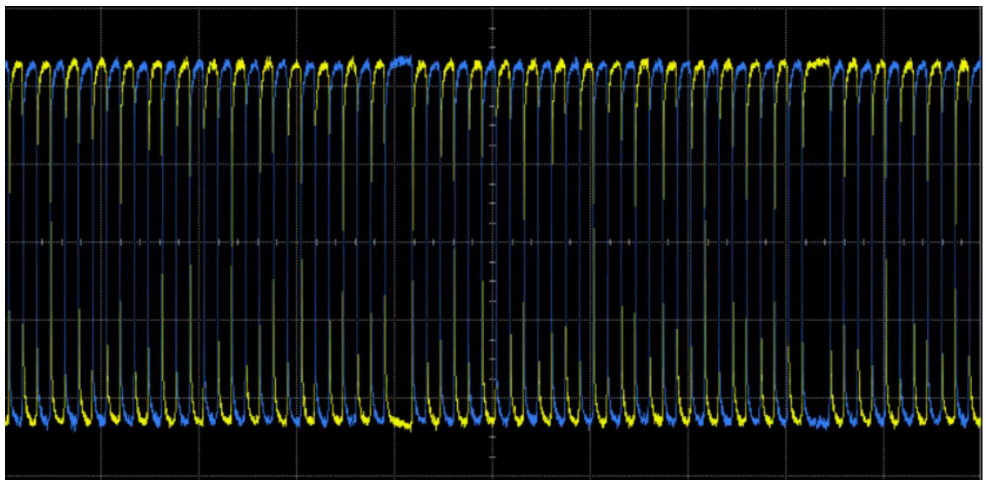


Figure 5-5 Typical Waveform

Test Mode 4. Transmitter Linearity Test

Test Setup

You can run this test using either **Two Channels** or a **One Channel** from the transmitter (MDI). Refer to "General Test Setup for 2.5GBASE-T1, 5GBASE-T1, and 10GBASE-T1" on page 19 for connection details.

NOTE Use the software supplied with your transmitter PHY to control the Device Under Test.

Specification References

[1] IEEE Std 802.3ch™ - 2020, Section 149.5.2.2.

Transmitter Linearity Test Information

When operating in Test Mode 4 and capturing the waveform using the recommended fixture, the test defined in section 120D.3.1.2. of the IEEE 802.3-2022 spec shall be performed. The ideal PAM4 level of 1/3 should be used for effective symbol levels of ES1 and ES2.

Reference "[1]" specifies that the transmitter SNDR as specified in section 120D.3.1.6 of the IEEE Spec, shall exceed 38 dB in 10GBASE-T1, 36 dB in 5GBASE-T1 and 35 dB in 2.5GBASE-T1 mode.

PRBS13Q test pattern is used for the Linearity test. There are two parts to this SNDR measurement. For linearity test, we use the "averaged" PRBS13Q PAM4 waveform to calculate the linear fit pulse response to determine P_{max} and Sigma_e. where P_{max} is the peak of the linear fit and Sigma_e is the difference between the measured waveform with averaging and the linear fit pulse. In other words, Sigma_e is the error or deviation due to non linearities in measured waveform.

There is a second measurement to determine the uncorrelated noise, Sigma_n. It is derived by measuring the variance of repeated patterns per each PAM amplitude level. The SNDR measurement is essentially to solve the equation.

$$SNDR = 10 \times \log_{10}\left(\frac{{P_{max}}^2}{(\sigma_e^2) + (\sigma_n^2)}\right)$$

The AE6910T/20T version 1.81 or higher offers an option to use the 4th order Bessel Thomson filter as the input filter for the oscilloscope. By default, the oscilloscope input filter should be Brickwall filter. Using the 4th order Bessel Thomson filter typically improves the SNDR calculation due to lower sigma N measurement when compared to using the Brickwall filter.

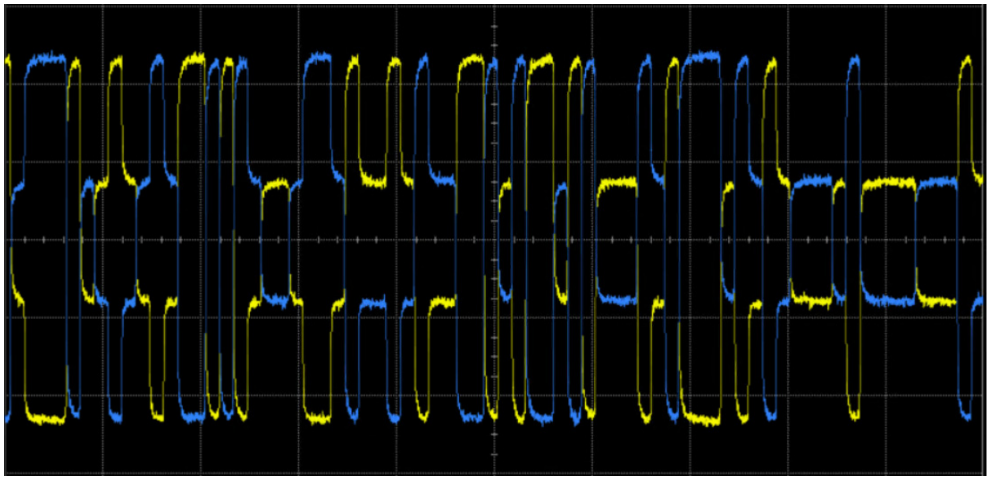


Figure 5-6 Typical Waveform

Test Mode 5. Transmitter Power Spectral Density, Transmitter Power Level, and Transmitter Peak Differential Output Tests

Test Setup

You can run the Power Spectral Density (PSD) Test using either a spectrum analyzer or an oscilloscope. When using the oscilloscope, refer to "General Test Setup for 2.5GBASE-T1, 5GBASE-T1, and 10GBASE-T1" on page 19 for connection details.

If you use the N9010B Signal Analyzer, convert the differential output to a single-ended output using a balun. Use the balun on the AE6941A Automotive Ethernet Fixture, as shown in Figure 2-5 or the N5395C Ethernet Test Fixture, as shown in Figure 2-6.

NOTE Use the software supplied with your transmitter PHY to control the Device Under Test.

Specification References

[1] IEEE Std 802.3ch™ - 2020, Section 149.5.2.4.

[2] IEEE Std 802.3ch™ - 2020, Section 149.5.2.5.

Transmitter Power Spectral Density (PSD)

Reference "[1]" specifies that in Test Mode 5, the power spectral density (PSD) of the transmitter shall be between the specified upper and lower masks of the following equations.

$$UpperPSD(f) = \begin{bmatrix} -90 - K & \frac{dBm}{Hz} & 0 < f \le 600 \times S \\ -89 - K - \frac{f}{600 \times S} & \frac{dBm}{Hz} & 600 \times S < f \le 3000 \times S \\ -82 - K - \frac{f}{250 \times S} & \frac{dBm}{Hz} & 3000 \times S < f \le 5500 \times S \end{bmatrix}$$

$$LowerPSD(f) = \begin{bmatrix} -96 - K & \frac{dBm}{Hz} & 5 < f \le 400 \times S \\ -95 - K - \frac{f}{400 \times S} & \frac{dBm}{Hz} & 400 \times S < f \le 2000 \times S \\ -90 - K - \frac{f}{200 \times S} & \frac{dBm}{Hz} & 2000 \times S < f \le 3000 \times S \end{bmatrix}$$

Where:

- f is the frequency in MHz
- K equals to $10\log_{10}(S)$

Refer to Table 5-1 for the definition of S.

Figure 5-7 shows the graphical representation of the specifications above.

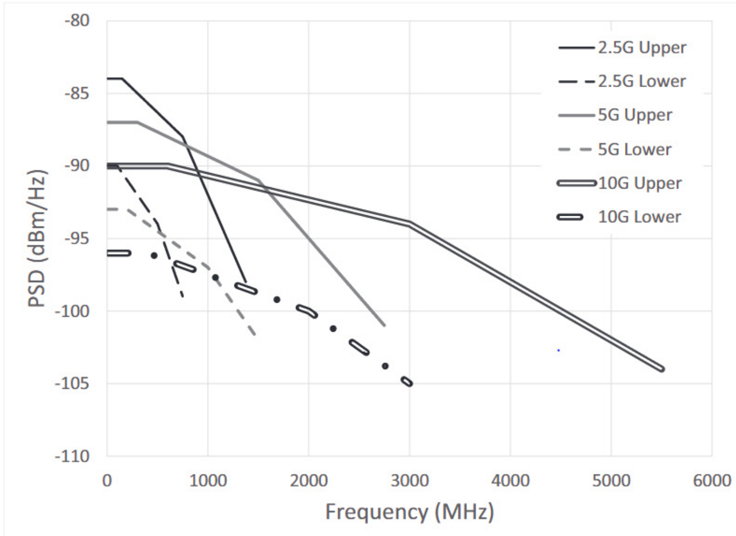


Figure 5-7 PSD Specifications

Transmitter Power Level

Reference "[1]" specifies that in Test Mode 5 (normal operation), the transmit power shall be in the range of -1 dBm to 2 dBm.

Transmitter Peak Differential Output

Reference "[2]" specifies that in Test Mode 5, when measured with 100 Ω termination, the transmit differential signal at MDI shall be less than 1.30 Volt peak-to-peak.

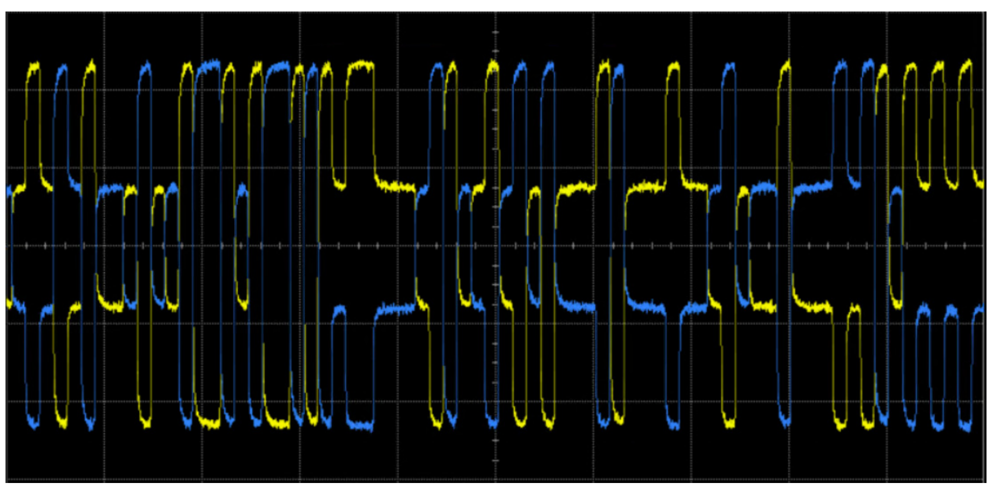


Figure 5-8 Typical Waveform

Test Mode 6. Output Droop Tests

Test Setup

You can run this test using either **Two Channels** or a **One Channel** from the transmitter (MDI). Refer to "General Test Setup for 2.5GBASE-T1, 5GBASE-T1, and 10GBASE-T1" on page 19 for connection details.

NOTE Use the software supplied with your transmitter PHY to control the Device Under Test.

Specification References

[1] IEEE Std 802.3ch™ - 2020, Section 149.5.2.1.

Transmitter Output Droop Positive Test Information

This test measures the positive output droop of the transmitter.

Reference "[1]" specifies the positive output droop of a compliant PHY. The positive droop measured with an initial value at 4 ns after the zero-crossing and a final value of 16 ns after the zero-crossing, shall be less than 15%.

The application triggers the Test Mode 6 signal on the rising edge and determines the time the positive peak occurred at 4 ns after the zero-crossing. This application then measures the voltage 12 ns after the initial peak crossing; with the Droop calculated as follows:

Droop = 100 × (Vd/Vpk)%

Where:

- **Vd** is the magnitude of the droop.
- **Vpk** is the initial peak after the zero-crossing.

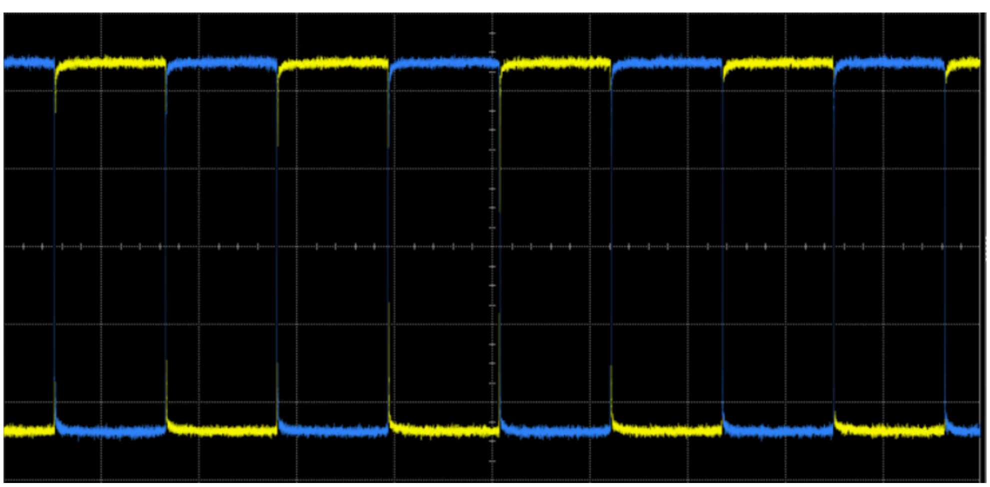


Figure 5-9 Typical Waveform

Transmitter Output Droop Negative Test Information

This test measures the negative output droop of the transmitter.

Reference “[1]” specifies the negative output droop of a compliant PHY. The negative droop measured with an initial value at 4 ns after the zero-crossing and a final value of 16 ns after the zero-crossing, shall be less than 15%.

The application triggers the Test Mode 6 signal on the falling edge and determines the time the negative peak occurred at 4 ns after the zero-crossing. This application then measures the voltage 12 ns after the initial peak crossing; with the Droop calculated as follows:

Droop = 100 × (Vd/Vpk)%

Where:

- **Vd** is the magnitude of the droop.
- **Vpk** is the initial peak after the zero-crossing.

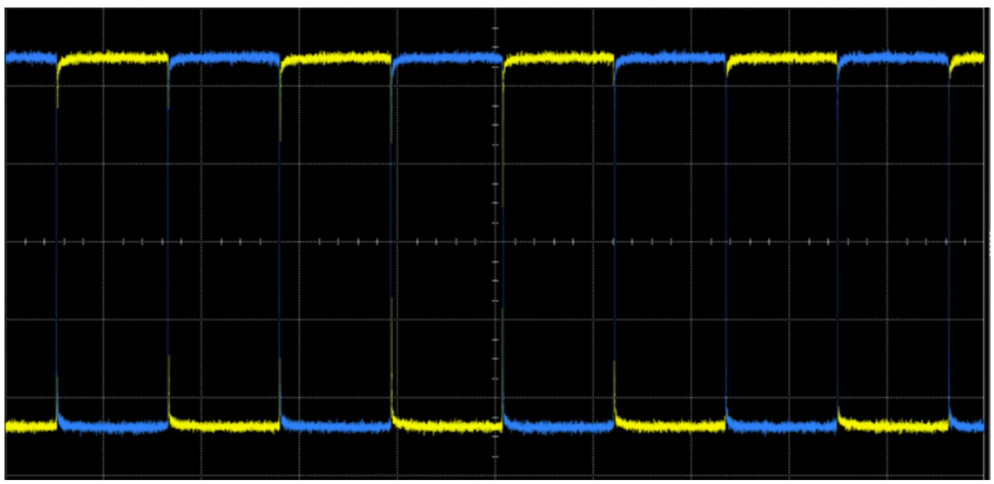


Figure 5-10 Typical Waveform

MDI Return Loss Test

Test Setup

Run this test with the E5080B Vector Network Analyzer. However, you can use a VNA exported data file in the Touchstone or CITI format in place of the external vector network analyzer. Refer to Figure 3-14 for the connection diagram.

Specification Reference

[1] IEEE Std 802.3ch™ - 2020, Section 149.8.2.1.

MDI Return Loss Test Information

Reference "[1]" specifies that the differential impedance at the MDI for each transmit/receive channel shall be such that any reflection (due to differential signals incident upon the MDI with the test port having a differential impedance of 100 Ω) is attenuated relative to the incident signal as per the following equation.

$$MDI\_Return\_Loss(f) \leq \left\{ \begin{array}{cc} 20 - 20\left(\log_{10}\frac{10}{f}\right) & 1 \leq f < 10 \\ 20 & 10 \leq f < 280S \\ 20 - 10\log_{10}(f/(280S)) & 280S \leq f \leq 2800S \\ 10 - 16\log_{10}(f/(2800S)) & 2800S \leq f \leq F_{MAX} \end{array} \right\} (\text{dB})$$

Where f is the frequency in MHz.

For 2.5GBASE-T1, 5GBASE-T1, and 10 GBASE-T1, the maximum applicable frequency for the MDI return loss is 4000 × S MHz. See Table 5-1 for the definition of S.

In other words, the return loss shall meet or exceed the equation shown for all frequencies ranging from 1 MHz to 4000 × S MHz (with 100 Ω differential impedance) at all times when the PHY is transmitting data or control symbols.

NOTE **The DUT must be set to SLAVE Mode of operation and not transmit any test symbols.**

NOTE

Calibrate the VNA before running the tests. Set the VNA as follows:

- Measurement: Return Loss S_{dd11}
- Start Frequency: 1 MHz
- Stop Frequency: 4000 × S MHz
  (Refer to Table 5-1 for the definition of S)
- Sweep Type: Linear
- Sweep Points: 1600
- Output Power: minimum -10 dBm
- Measurement Bandwidth: ≤ 3 kHz
- Logic Port Impedance Differential Mode: 100 Ω
- Logic Port Impedance Common Mode: 25 Ω
- Smoothing function is deactivated

Refer to “Calibrating the VNA” on page 208.

Viewing the Test Report

After running any or all of the Compliance tests, the Results tab will show the passed tests and details about the individual tests. For test result details, select any one of the tests from the top pane with the test details shown as follows. In Figure 5-11 selected is the Transmitter Linearity test, and the test results, with waveform, are shown as follows.

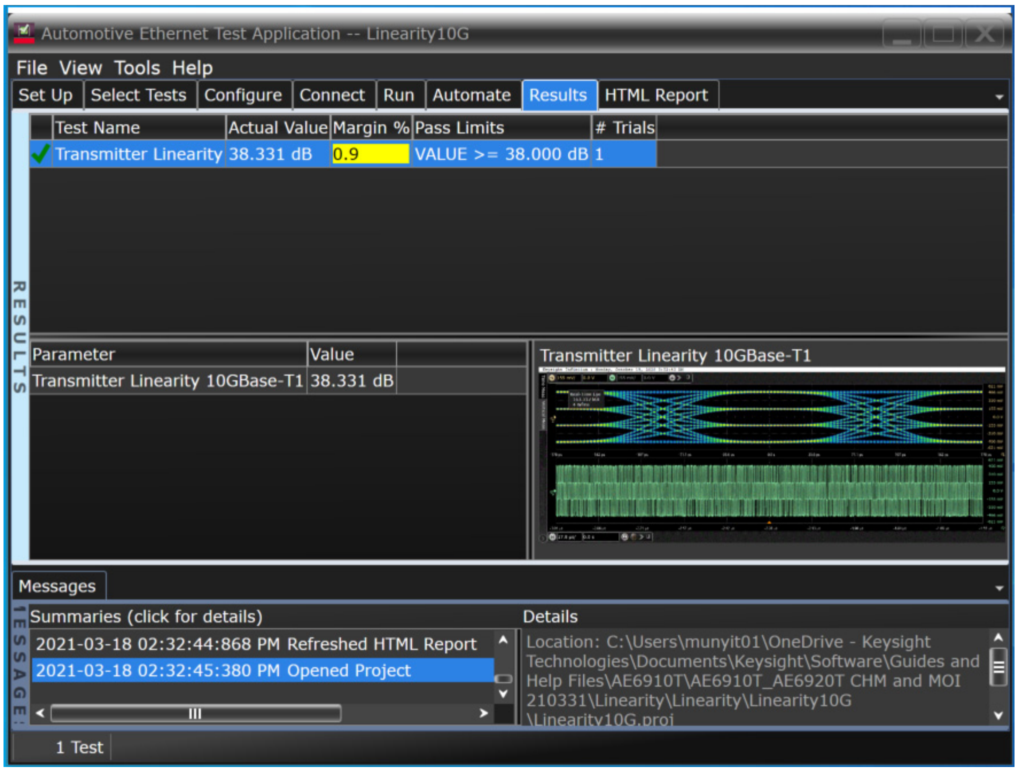


Figure 5-11 Typical Results Tab

Figure 5-12 shows a portion of a typical **HTML Report**. Below this segment are waveforms and more test data.

Test Report

Pass

Test Configuration Details	
Application	
Name	AE6910T/AE6920T Automotive Ethernet Test Application
Version	1.30.0000.0
Device Description	
Technology Spec	IEEE
StandardType	10G
Spectral Measurement Device	Oscilloscope
Bandpass Filter	Yes
DisturbingSignalSource	33250A
VNA Calibration Type	Manual Calibration
SA Compensation Used	No
Offline Mode Used	No
Test Session Details	
Infiniium SW Version	06.60.00403
Infiniium Model Number	DSAV164A
Infiniium Serial Number	MY58120112
Debug Mode Used	No
Compliance Limits	10G IEEE P802.3ch (official)
Last Test Date	2020-10-19 08:52:43 UTC +08:00

Summary of Results

Test Statistics	
Failed	0
Passed	1
Total	1

Margin Thresholds	
Warning	< 5 %
Critical	< 0 %

Pass	# Failed	# Trials	Test Name	Actual Value	Margin	Pass Limits
✓	0	1	Transmitter Linearity	38.331 dB	0.9 %	VALUE >= 38.000 dB

Report Detail

Next

✓ Transmitter Linearity

Reference: IEEE Std P802.3ch™/D3.0 (Section 149.5.2.2)

Test Summary: Pass

Test Description: The transmitter SNDR distortion, shall exceed 38dB.

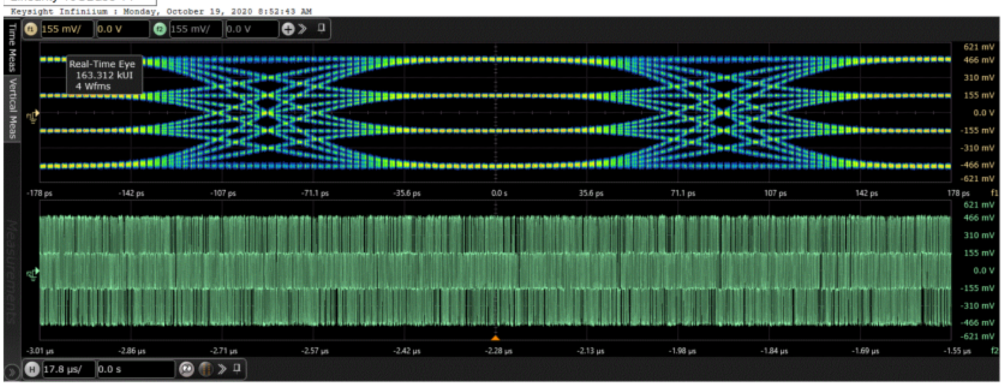
Pass Limits:	>= 38.000 dB	Transmitter Linearity 10GBase-T1	38.331 dB

Result Details

Trial 1

Trial 1: Transmitter Linearity 10GBase-T1

Keysight Infiniium : Monday, October 19, 2020 8:52:43 AM



Top Previous

Figure 5-12 Top Portion of a Typical HTML Report

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6 2.5GBASE-T1, 5GBASE-T1, and 10GBASE-T1 Tests and Test Report with De-embedding

Test Mode 2. MDI Output Jitter (MASTER) Tests and Transmit Clock Frequency (MASTER)

Test Setup

You can run this test using either **Two Channels** or a **One Channel** from the transmitter (MDI). Refer to "General Test Setup for 2.5GBASE-T1, 5GBASE-T1, and 10GBASE-T1" on page 19 for connection details.

NOTE Use the software supplied with your transmitter PHY to control the Device Under Test.

Specification References

[1] IEEE Std 802.3ch™ - 2020, Section 149.5.2.3.1.

[2] IEEE Std 802.3ch™ - 2020, Section 149.5.2.3.2.

[3] IEEE Std 802.3ch™ - 2020, Section 149.5.2.6

MDI Output Jitter (MASTER)

Reference "[1]" specifies that when in Test Mode 2, and the PHY transmitting the TX_TCLK175 Square Wave test pattern, the RMS (Root Mean Square) value of the MDI output jitter, relative to an unjittered reference, shall be less than 1/S ps. Refer to Table 5-1 for the definition of S.

Reference "[1]" specifies that when in Test Mode 2, the peak-to-peak value of the MDI output jitter, relative to an unjittered reference, shall be less than 10/S ps. Refer to Table 5-1 for the definition of S.

This test measures the data time interval error of the Test Mode 2 signal at the MDI. The ideal reference data rate is selected automatically by the oscilloscope and compared to the original signal to determine the data time interval error.

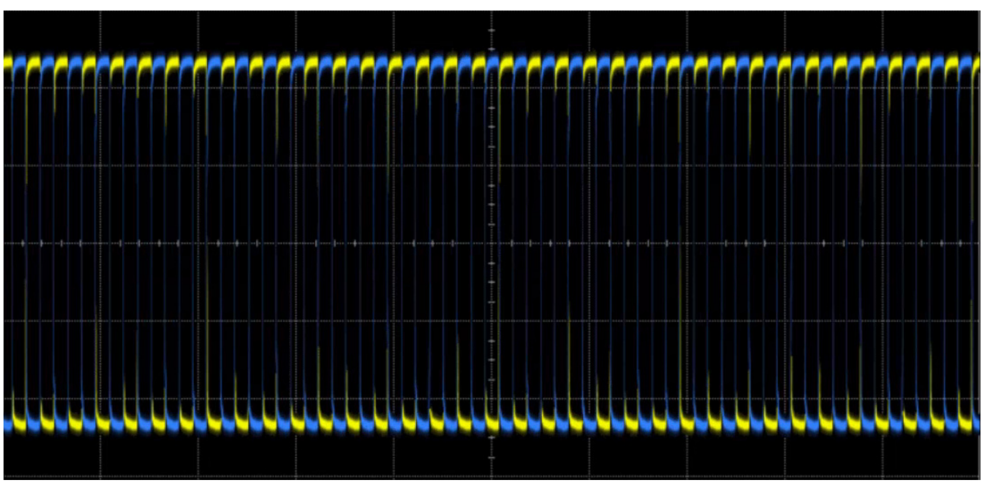


Figure 6-1 Typical Waveform

MDI Deterministic Jitter (MASTER)

Reference “[2]” specifies that when in Test Mode 2, and the PHY transmitting test pattern JP03A timed from the local clock source, the peak-to-peak deterministic jitter shall be less than 9/S ps. Refer to Table 5-1 for the definition of S.

This test measures the DJ_{pk-pk} of the Test Mode 2, JP03A test pattern at the MDI. The ideal reference data rate is selected automatically by the oscilloscope. EZJIT Jitter separation tool is used to measure the peak-to-peak Deterministic Jitter value.

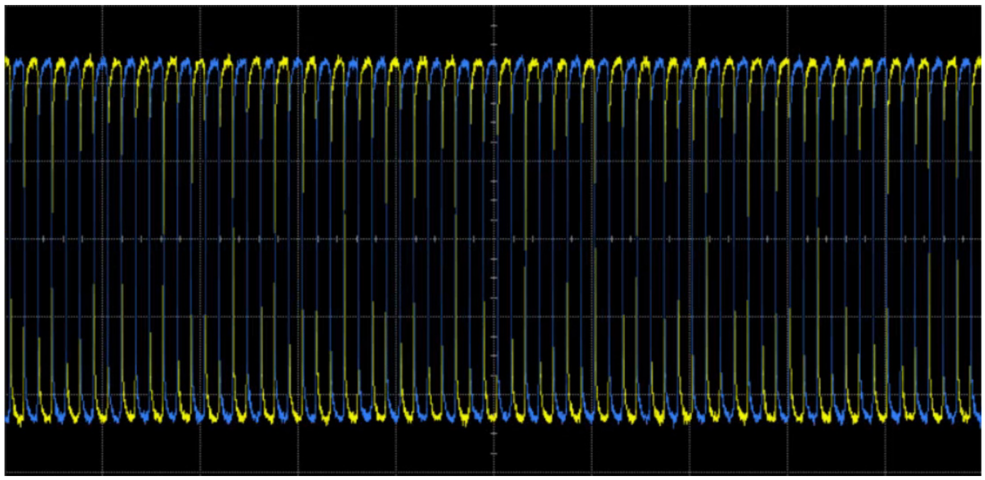


Figure 6-2 Typical Waveform

Transmit Clock Frequency (MASTER) Test

Reference “[3]” specifies the symbol transmission rate of a compliant PHY. The symbol transmission rate of the MASTER PHY shall be within the range of 5625 x S MHz ±50 ppm. Refer to Table 5-1 for the definition of S.

Reference “[3]” specifies that when in Test Mode 2, and the PHY transmitting test pattern JP03A timed from the local clock source.

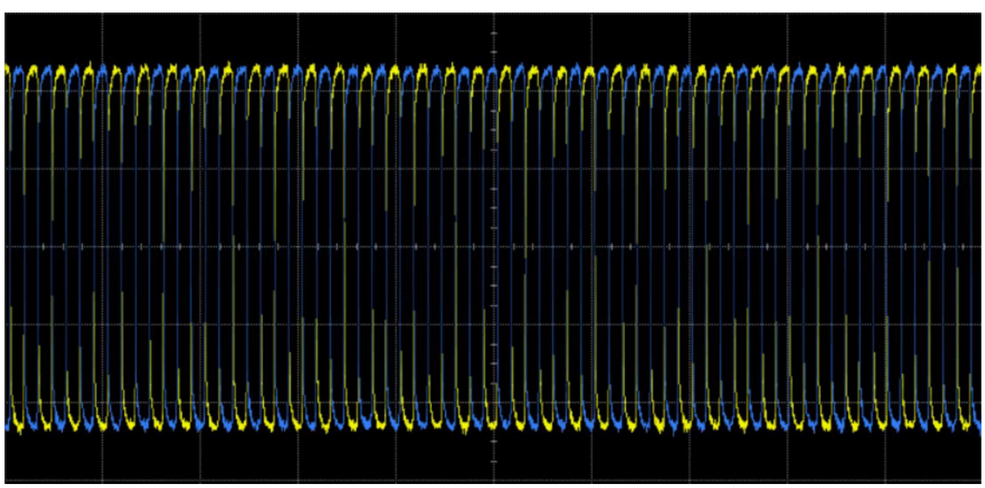


Figure 6-3 Typical Waveform

MDI Even-Odd Jitter (MASTER)

Reference "[2]" specifies that when in Test Mode 2, and the PHY transmitting test pattern JP03B timed from the local clock source, the peak-to-peak Even-Odd jitter shall be less than 4/S ps. Refer to Table 5-1 for the definition of S.

This test measures the EOJ_{pk-pk} of the Test Mode 2, JP03B test pattern at the MDI. The ideal reference data rate is selected automatically by the oscilloscope. EZJIT Jitter separation tool is used to measure the peak-to-peak Even-Odd Jitter value.

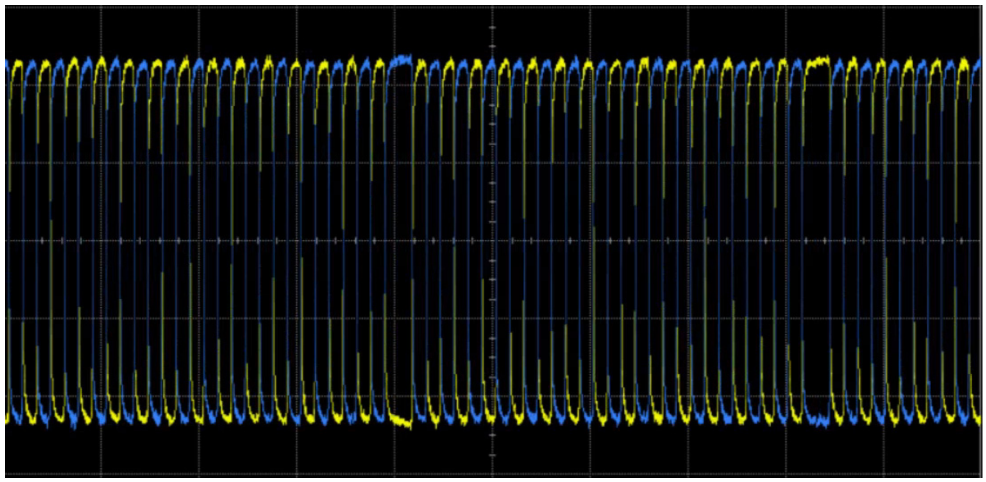


Figure 6-4 Typical Waveform

Test Mode 4. Transmitter Linearity Test

Test Setup

You can run this test using either **Two Channels** or a **One Channel** from the transmitter (MDI). Refer to "General Test Setup for 2.5GBASE-T1, 5GBASE-T1, and 10GBASE-T1" on page 19 for connection details.

NOTE **Use the software supplied with your transmitter PHY to control the Device Under Test.**

Specification References

[1] IEEE Std 802.3ch™ - 2020, Section 149.5.2.2.

Transmitter Linearity Test Information

When operating in Test Mode 4 and capturing the waveform using the recommended fixture, the test defined in section 120D.3.1.2. of the IEEE 802.3-2022 spec shall be performed. The ideal PAM4 level of 1/3 should be used for effective symbol levels of ES1 and ES2.

Reference "[1]" specifies that the transmitter SNDR as specified in section 120D.3.1.6 of the IEEE Spec, shall exceed 38 dB in 10GBASE-T1, 36 dB in 5GBASE-T1 and 35 dB in 2.5GBASE-T1 mode.

PRBS13Q test pattern is used for the Linearity test. There are two parts to this SNDR measurement. For linearity test, we use the "averaged" PRBS13Q PAM4 waveform to calculate the linear fit pulse response to determine P_{max} and Sigma_e. where P_{max} is the peak of the linear fit and Sigma_e is the difference between the measured waveform with averaging and the linear fit pulse. In other words, Sigma_e is the error or deviation due to non linearities in measured waveform.

There is a second measurement to determine the uncorrelated noise, Sigma_n. It is derived by measuring the variance of repeated patterns per each PAM amplitude level. The SNDR measurement is essentially to solve the equation.

$$SNDR = 10 \times \log_{10}\left(\frac{P_{max}^{\;2}}{(\sigma_e^2) + (\sigma_n^2)}\right)$$

The AE6910T/20T version 1.81 or higher offers an option to use the 4th order Bessel Thomson filter as the input filter for the oscilloscope. By default, the oscilloscope input filter should be Brickwall filter. Using the 4th order Bessel Thomson filter typically improves the SNDR calculation due to lower sigma N measurement when compared to using the Brickwall filter.

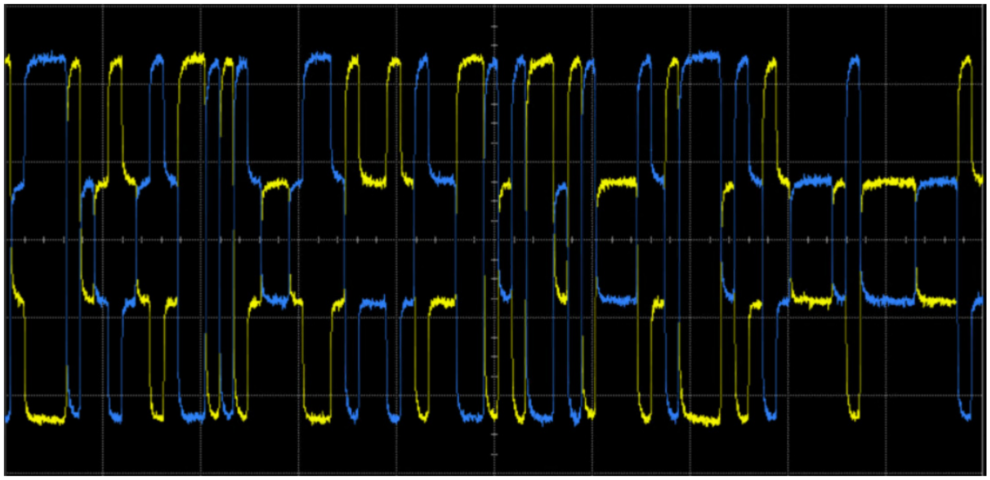


Figure 6-5 Typical Waveform

Test Mode 5. Transmitter Power Spectral Density, Transmitter Power Level, and Transmitter Peak Differential Output Tests

Test Setup

You can run the Power Spectral Density (PSD) Test using either a spectrum analyzer or an oscilloscope. When using the oscilloscope, refer to "General Test Setup for 2.5GBASE-T1, 5GBASE-T1, and 10GBASE-T1" on page 19 for connection details.

If you use the N9010B Signal Analyzer, convert the differential output to a single-ended output using a balun. Use the balun on the AE6941A Automotive Ethernet Fixture, as shown in Figure 2-5 or the N5395C Ethernet Test Fixture, as shown in Figure 2-6.

NOTE Use the software supplied with your transmitter PHY to control the Device Under Test.

Specification References

[1] IEEE Std 802.3ch™ - 2020, Section 149.5.2.4.

[2] IEEE Std 802.3ch™ - 2020, Section 149.5.2.5.

Transmitter Power Spectral Density (PSD)

Reference "[1]" specifies that in Test Mode 5, the power spectral density (PSD) of the transmitter shall be between the specified upper and lower masks of the following equations.

$$UpperPSD(f) = \begin{bmatrix} -90-K & \frac{dBm}{Hz} & 0 < f \le 600 \times S \\ -89-K-\frac{f}{600 \times S} & \frac{dBm}{Hz} & 600 \times S < f \le 3000 \times S \\ -82-K-\frac{f}{250 \times S} & \frac{dBm}{Hz} & 3000 \times S < f \le 5500 \times S \end{bmatrix}$$

$$LowerPSD(f) = \begin{bmatrix} -96-K & \frac{dBm}{Hz} & 5 < f \le 400 \times S \\ -95-K-\frac{f}{400 \times S} & \frac{dBm}{Hz} & 400 \times S < f \le 2000 \times S \\ -90-K-\frac{f}{200 \times S} & \frac{dBm}{Hz} & 2000 \times S < f \le 3000 \times S \end{bmatrix}$$

Where:

- f is the frequency in MHz
- K equals to $10\log_{10}(S)$

Refer to Table 5-1 for the definition of S.

Figure 6-6 shows the graphical representation of the specifications above.

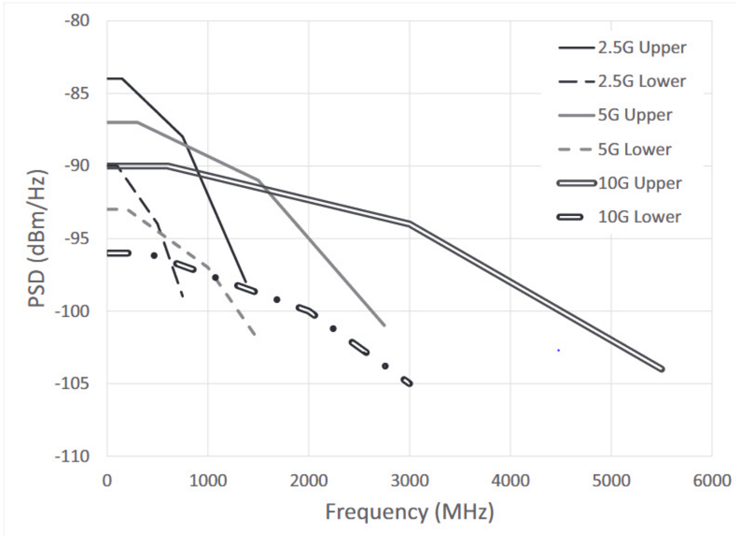


Figure 6-6 PSD Specifications

Transmitter Power Level

Reference "[1]" specifies that in Test Mode 5 (normal operation), the transmit power shall be in the range of -1 dBm to 2 dBm.

Transmitter Peak Differential Output

Reference "[2]" specifies that in Test Mode 5, when measured with 100 Ω termination, the transmit differential signal at MDI shall be less than 1.30 Volt peak-to-peak.

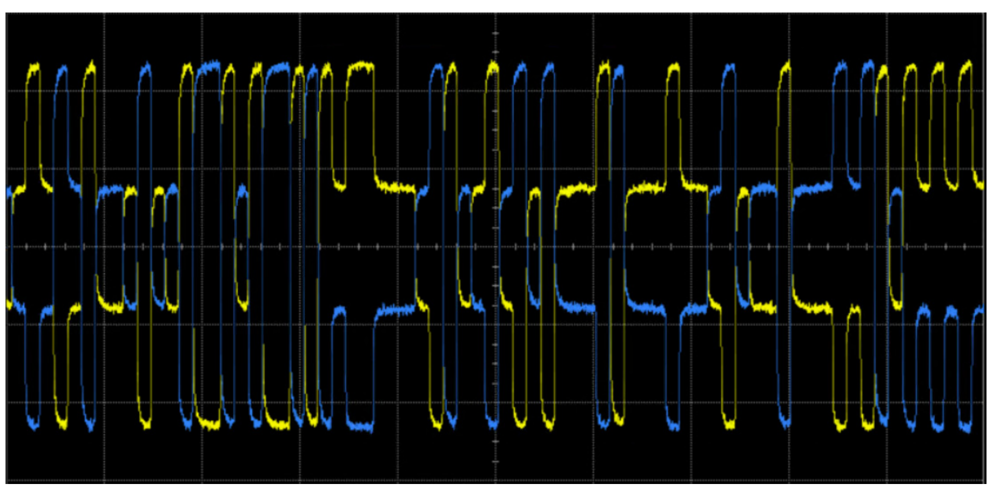


Figure 6-7 Typical Waveform

Test Mode 6. Output Droop Tests

Test Setup

You can run this test using either **Two Channels** or a **One Channel** from the transmitter (MDI). Refer to "General Test Setup for 2.5GBASE-T1, 5GBASE-T1, and 10GBASE-T1" on page 19 for connection details.

NOTE Use the software supplied with your transmitter PHY to control the Device Under Test.

Specification References

[1] IEEE Std 802.3ch™ - 2020, Section 149.5.2.1.

Transmitter Output Droop Positive Test Information

This test measures the positive output droop of the transmitter.

Reference "[1]" specifies the positive output droop of a compliant PHY. The positive droop measured with an initial value at 4 ns after the zero-crossing and a final value of 16 ns after the zero-crossing, shall be less than 15%.

The application triggers the Test Mode 6 signal on the rising edge and determines the time the positive peak occurred at 4 ns after the zero-crossing. This application then measures the voltage 12 ns after the initial peak crossing; with the Droop calculated as follows:

Droop = 100 × (Vd/Vpk)%

Where:

- **Vd** is the magnitude of the droop.
- **Vpk** is the initial peak after the zero-crossing.

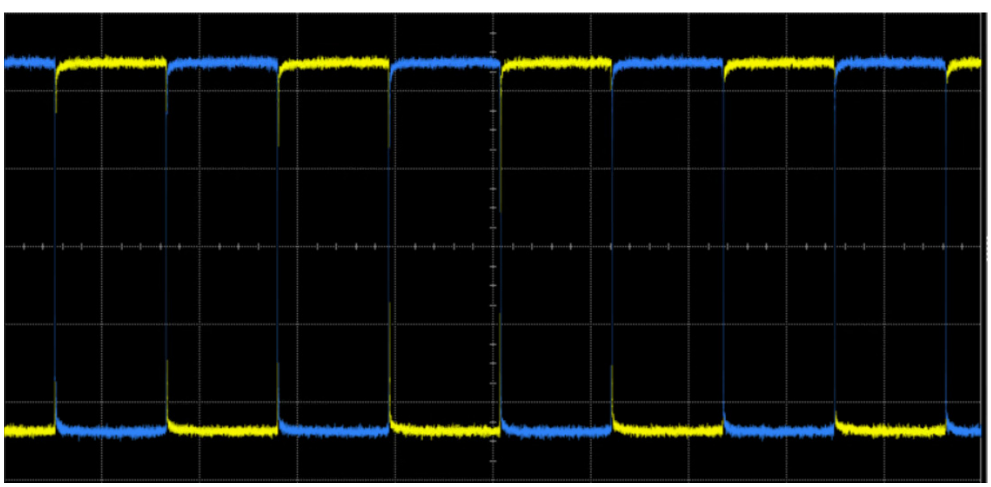


Figure 6-8 Typical Waveform

Transmitter Output Droop Negative Test Information

This test measures the negative output droop of the transmitter.

Reference “[1]” specifies the negative output droop of a compliant PHY. The negative droop measured with an initial value at 4 ns after the zero-crossing and a final value of 16 ns after the zero-crossing, shall be less than 15%.

The application triggers the Test Mode 6 signal on the falling edge and determines the time the negative peak occurred at 4 ns after the zero-crossing. This application then measures the voltage 12 ns after the initial peak crossing; with the Droop calculated as follows:

Droop = 100 × (Vd/Vpk)%

Where:

- **Vd** is the magnitude of the droop.
- **Vpk** is the initial peak after the zero-crossing.

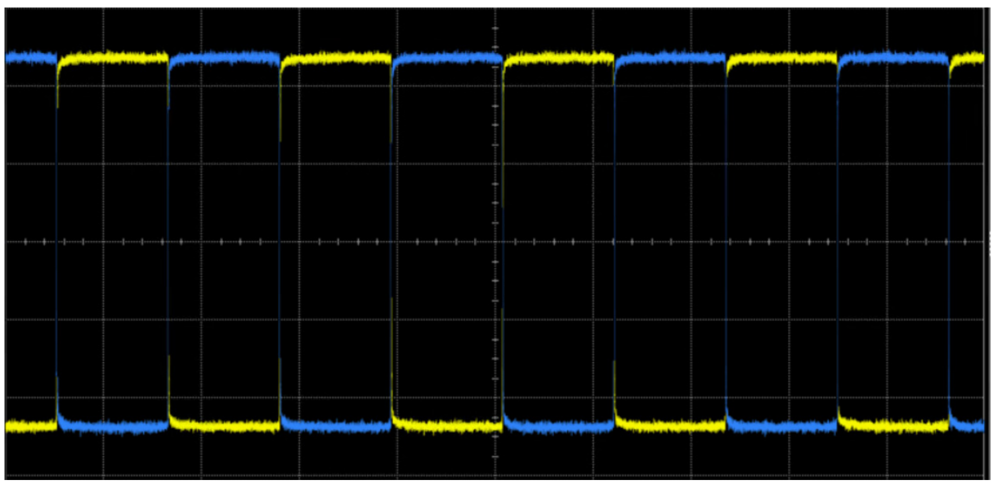


Figure 6-9 Typical Waveform

Viewing the Test Report

After running any or all of the Compliance tests, the **Results** tab will show the passed tests and details about the individual tests. For test result details, select any one of the tests from the top pane with the test details shown as follows. In Figure 6-10 selected is the Transmitter Linearity test, and the test results, with waveform, are shown as follows.

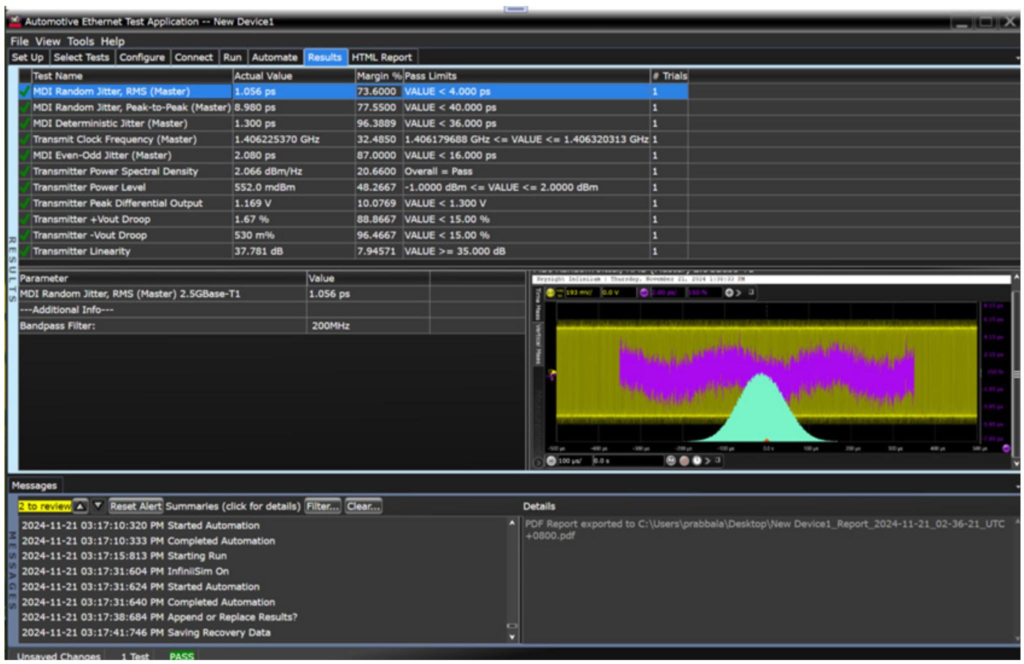
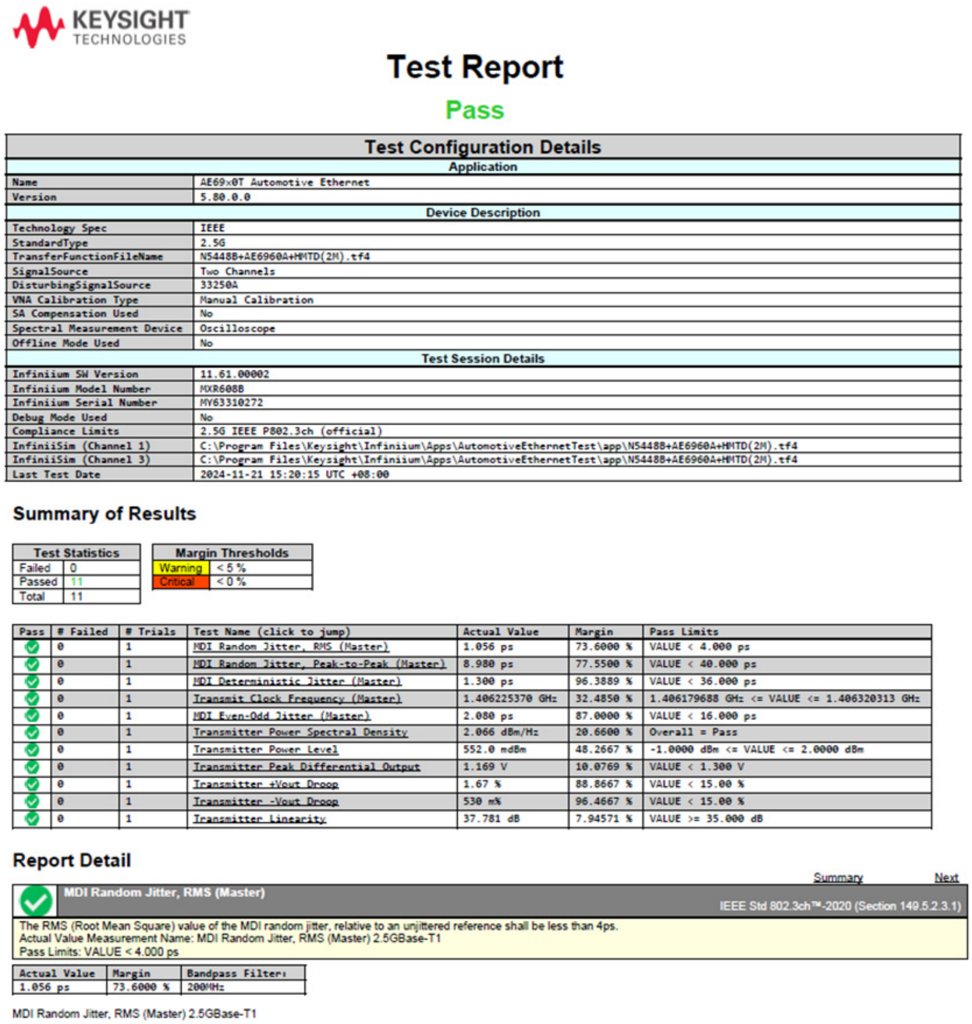


Figure 6-10 Typical Results Tab

Figure 6-11 shows a portion of a typical **HTML Report**. Below this segment are waveforms and more test data.



Test Report

Pass

Test Configuration Details	
Application	
Name	AE69x0T Automotive Ethernet
Version	5.80.0.0
Device Description	
Technology Spec	IEEE
StandardType	2.5G
TransferFunctionFileName	N5448B+AE6960A+HMTD(2M).tf4
SignalSource	Two Channels
DisturbingSignalSource	33250A
VNA Calibration Type	Manual Calibration
SA Compensation Used	No
Spectral Measurement Device	Oscilloscope
Offline Mode Used	No
Test Session Details	
Infiniium SW Version	11.61.00002
Infiniium Model Number	MXR608B
Infiniium Serial Number	MY63310272
Debug Mode Used	No
Compliance Limits	2.5G IEEE P802.3ch (official)
InfiniiSim (Channel 1)	C:\Program Files\Keysight\Infiniium\Apps\AutomotiveEthernetTest\app\N5448B+AE6960A+HMTD(2M).tf4
InfiniiSim (Channel 3)	C:\Program Files\Keysight\Infiniium\Apps\AutomotiveEthernetTest\app\N5448B+AE6960A+HMTD(2M).tf4
Last Test Date	2024-11-21 15:20:15 UTC +08:00

Summary of Results

Test Statistics	
Failed	0
Passed	11
Total	11

Margin Thresholds	
Warning	< 5 %
Critical	< 0 %

Pass	# Failed	# Trials	Test Name (click to jump)	Actual Value	Margin	Pass Limits
	0	1	MDI Random Jitter, RMS (Master)	1.056 ps	73.6000 %	VALUE < 4.000 ps
	0	1	MDI Random Jitter, Peak-to-Peak (Master)	8.980 ps	77.5500 %	VALUE < 40.000 ps
	0	1	MDI Deterministic Jitter (Master)	1.300 ps	96.3889 %	VALUE < 36.000 ps
	0	1	Transmit Clock Frequency (Master)	1.406225370 GHz	32.4850 %	1.406179688 GHz <= VALUE <= 1.406320313 GHz
	0	1	MDI Even-Odd Jitter (Master)	2.080 ps	87.0000 %	VALUE < 16.000 ps
	0	1	Transmitter Power Spectral Density	2.066 dBm/Hz	20.6600 %	Overall = Pass
	0	1	Transmitter Power Level	552.0 mdBm	48.2667 %	-1.0000 dBm <= VALUE <= 2.0000 dBm
	0	1	Transmitter Peak Differential Output	1.169 V	10.0769 %	VALUE < 1.300 V
	0	1	Transmitter +Vout Droop	1.67 %	88.8667 %	VALUE < 15.00 %
	0	1	Transmitter -Vout Droop	530 m%	96.4667 %	VALUE < 15.00 %
	0	1	Transmitter Linearity	37.781 dB	7.94571 %	VALUE >= 35.000 dB

Report Detail

Summary Next

MDI Random Jitter, RMS (Master)

IEEE Std 802.3ch™-2020 (Section 149.5.2.3.1)

The RMS (Root Mean Square) value of the MDI random jitter, relative to an unjittered reference shall be less than 4ps.
Actual Value Measurement Name: MDI Random Jitter, RMS (Master) 2.5GBase-T1
Pass Limits: VALUE < 4.000 ps

Actual Value	Margin	Bandpass Filter:
1.056 ps	73.6000 %	200MHz

MDI Random Jitter, RMS (Master) 2.5GBase-T1

Figure 6-11 Top Portion of a Typical HTML Report

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7 10BASE-T1S ECU Tests and Test Report

CT_OA_PMA_TX_01

Test Setup

You can run this test using either **Two Channels** or a **One Channel** from the transmitter (MDI). Refer to "General Test Setup for 10BASE-T1S, ECU and PMA" on page 16 for connection details.

NOTE **Use the software supplied with your transmitter PHY to control the Device Under Test. This test requires Test Mode 1 enabled. The default iteration of test is 10, as per specification.**

Specification References

[1] OPEN Alliance 10BASET1S_PMA_Compliance Test Suite_V1_081524. Test 5.1.1

[2] IEEE Std 802.3cg™ – 2019 Amendment 52. Sub-clause 147.5.4.1

Check the Transmitter Output Voltage in Master Mode Test Information

Reference "[1]" states that a 10BASE-T1S device shall implement 4 test modes. These test modes are provided to measure electrical characteristics and verify compliance.

Reference "[2]" defines the test fixture to be used to perform the test.

Reference "[1]" defines the operation of a device while in test mode 1. This test requires the DUT to operate in transmitter test mode 1. While in test mode 1, the DUT shall generate DME-encoded ones. This sequence is repeated continually. The differential peak-to-peak voltage is then measured.

Typical Waveform

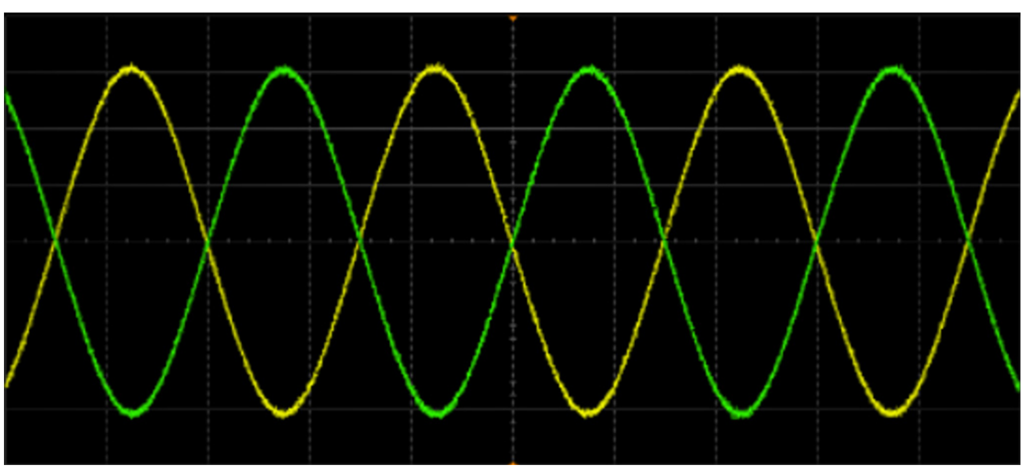


Figure 7-1 Typical Output Voltage Waveform (using a pair of SMA cables)

CT_OA_PMA_TX_02

Test Setup

You can run this test using either **Two Channels** or a **One Channel** from the transmitter (MDI). Refer to "General Test Setup for 10BASE-T1S, ECU and PMA" on page 16 for connection details.

NOTE **Use the software supplied with your transmitter PHY to control the Device Under Test. This test requires Test Mode 1 enabled. The default iteration of test is 10, as per specification.**

Specification References

[1] OPEN Alliance 10BASET1S_PMA_Compliance Test Suite_V1_081524. Test 5.1.2

[2] IEEE Std 802.3cg[TM] – 2019 Amendment 52. Sub-clause 147.5.4.2.

Check the Transmitter Output Droop (Positive and Negative) in Master Mode Test Information

This test requires the DUT to operate in transmitter test mode 2. While in test mode 2, the DUT shall generate a positive differential voltage of 1.6 µs followed by a negative differential voltage level of 1.6 µs. This sequence is repeated continually. Droop is calculated after measuring the peak voltage after the initial zero crossings (V_{pk}) and the voltage 800 ns after the zero crossing (V_{delay}). The droop is calculated as follows:

$$\textbf{Droop} = (V_d/V_{pk}) \times 100\%$$

Where:

- $V_d = V_{pk} - V_{delay}$.

This is performed on both the positive and negative peaks of the waveform transmitted by test mode 2. The magnitude of the droop should be less than 30.0%.

Typical Waveform

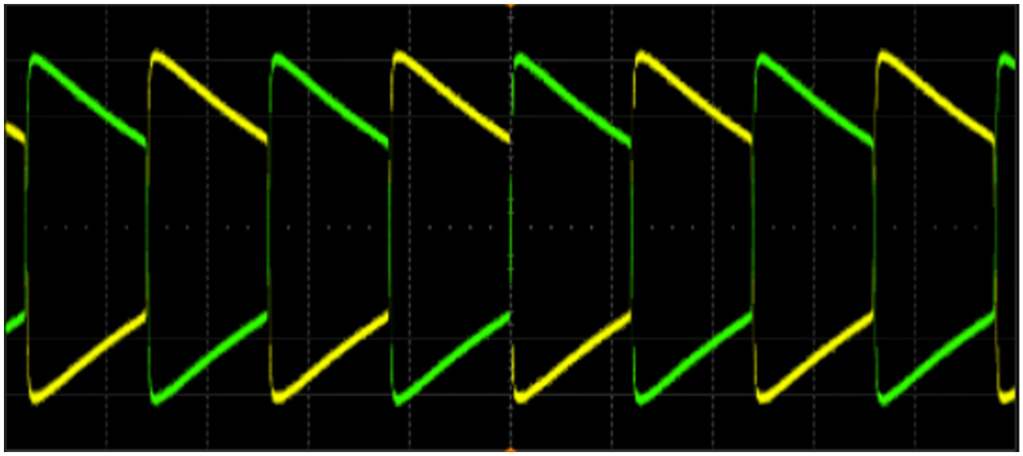


Figure 7-2 Typical Output Droop Waveform (using a pair of SMA cables)

CT_OA_PMA_TX_03

Test Setup

You can run this test using either **Two Channels** or a **One Channel** from the transmitter (MDI). Refer to "General Test Setup for 10BASE-T1S, ECU and PMA" on page 16 for connection details.

NOTE **Use the software supplied with your transmitter PHY to control the Device Under Test. This test requires Test Mode 1 enabled. The default iteration of test is 10, as per specification.**

Specification References

[1] OPEN Alliance 10BASET1S_PMA_Compliance Test Suite_V1_081524. Test 5.1.3

[2] IEEE Std 802.3cg™ – 2019 Amendment 52. Sub-clause 147.5.4.2.

Check the Transmitter Output Jitter in Master Mode Test Information

Reference "[1]" states that a 10BASE-T1S device shall implement 4 test modes. These test modes are provided to measure electrical characteristics and verify compliance. Reference "[2]" defines the test fixture to be used to perform the test. Reference [3] provides a specification for the maximum allowable timing jitter for the transmitter.

Typical Waveform

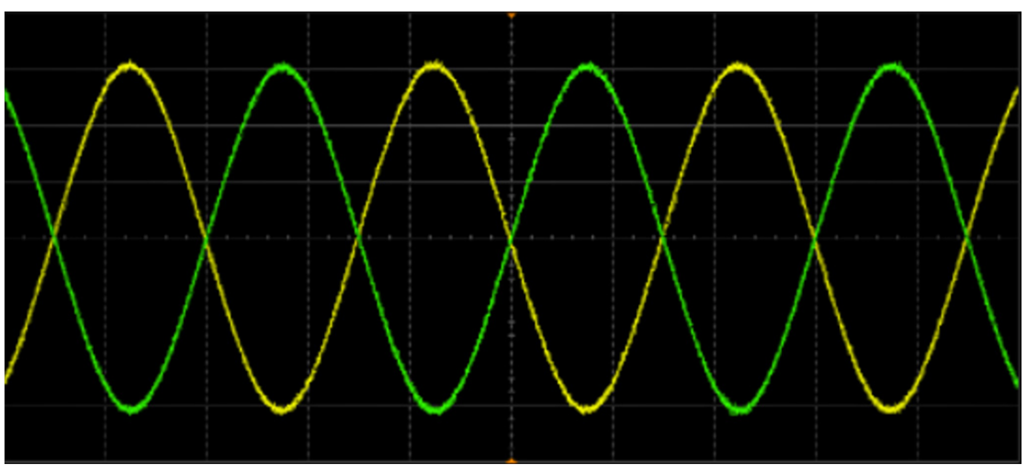


Figure 7-3 Typical Output Jitter Waveform (using a pair of SMA cables)

CT_OA_PMA_TX_04

Test Setup

You can run this test using either **Two Channels** or a **One Channel** from the transmitter (MDI). Refer to "General Test Setup for 10BASE-T1S, ECU and PMA" on page 16 for connection details.

NOTE

Use the software supplied with your transmitter PHY to control the Device Under Test. This test requires Test Mode 1 enabled. The default iteration of test is 10, as per specification.

Specification References

[1] OPEN Alliance 10BASET1S_PMA_Compliance Test Suite_V1_081524. Test 5.1.4.

[2] IEEE Std 802.3cg™ – 2019 Amendment 52. Sub-clause 147.5.4.4.

Check the Transmitter Power Spectral Density in Master Mode Test Information

Reference "[1]" states that a 10BASE-T1S device shall implement 4 test modes. These test modes are provided to measure electrical characteristics and verify compliance. Reference "[2]" defines the test fixture to be used to perform the test. Reference "[1]" defines the operation of a device while in test mode 3.

Typical Waveform

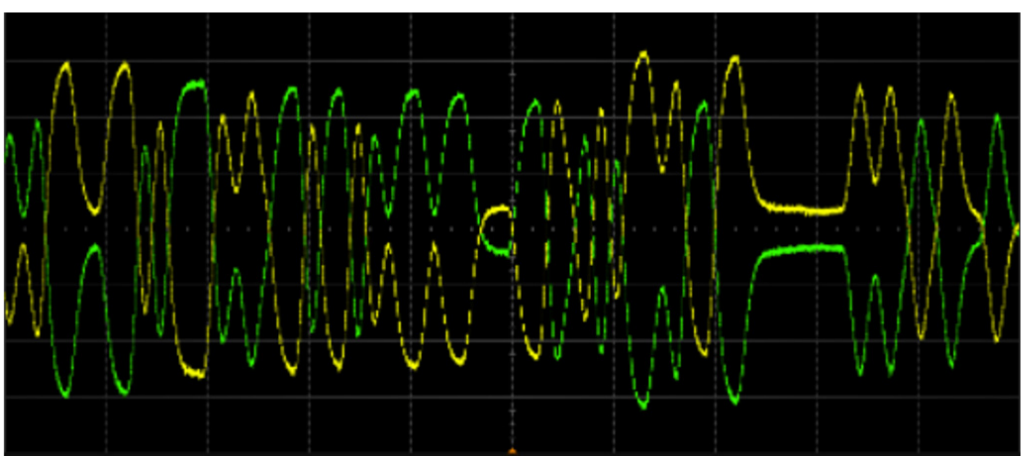


Figure 7-4 Typical Power Spectral Density Waveform (using a pair of SMA cables)

CT_OA_PMA_TX_06

Test Setup

You can run this test using either **Two Channels** or a **One Channel** from the transmitter (MDI). Refer to "General Test Setup for 10BASE-T1S, ECU and PMA" on page 16 for connection details.

NOTE **Use the software supplied with your transmitter PHY to control the Device Under Test. This test requires Test Mode 1 enabled. The default iteration of test is 10, as per specification.**

Specification References

[1] OPEN Alliance 10BASET1S_PMA_Compliance Test Suite_V1_081524. Test 5.1.5.

[2] IEEE Std 802.3cg™ – 2019 Amendment 52. Sub-clause 147.5.4.5.

Check the Rise and Fall Time for Transmitter in Master Mode Test Information

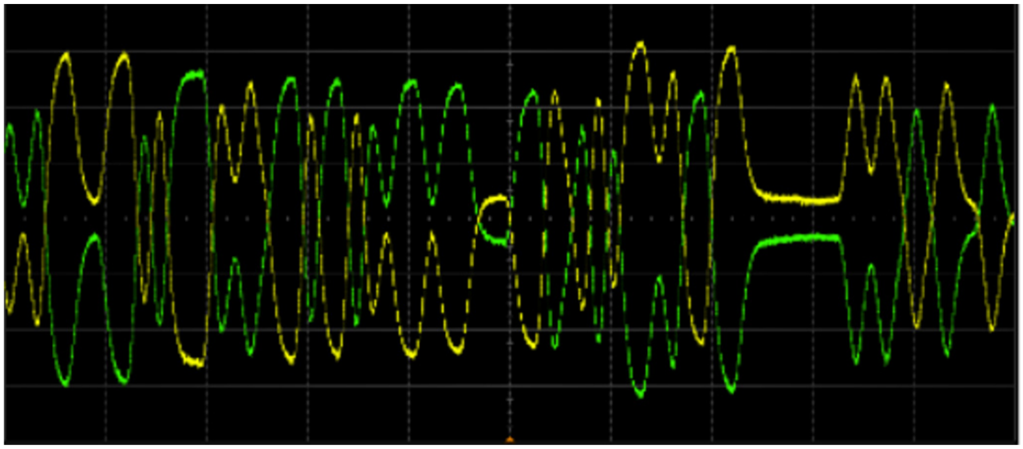
Reference "[1]" states that a 10BASE-T1S device shall implement 4 test modes. These test modes are provided to measure electrical characteristics and verify compliance. Reference "[2]" defines the test fixture to be used to perform the test. Reference "[1]" defines the operation of a device while in test mode 3. This test requires the DUT to operate in transmitter test mode 3. While in test mode 3, the DUT shall generate DME-encoded PRBS ones and zeros. This sequence is repeated continually. The differential peak-to-peak voltage is then measured.

Rise/Fall time for transmitter (send mode)

Table 7-1 Rise/Fall Time for Transmitter at MDI

	Min	Max
t_{rise}/t_{fall}	7.5 ns	15 ns

Typical Waveform



Typical Power Spectral Density Waveform (using a pair of SMA cables)

CT_OA_PMA_TX_07

MDI Return Loss Test

Test Setup

Run the Management Data Input (MDI) Return Loss test with the E5080B Vector Network Analyzer connected externally to the oscilloscope.

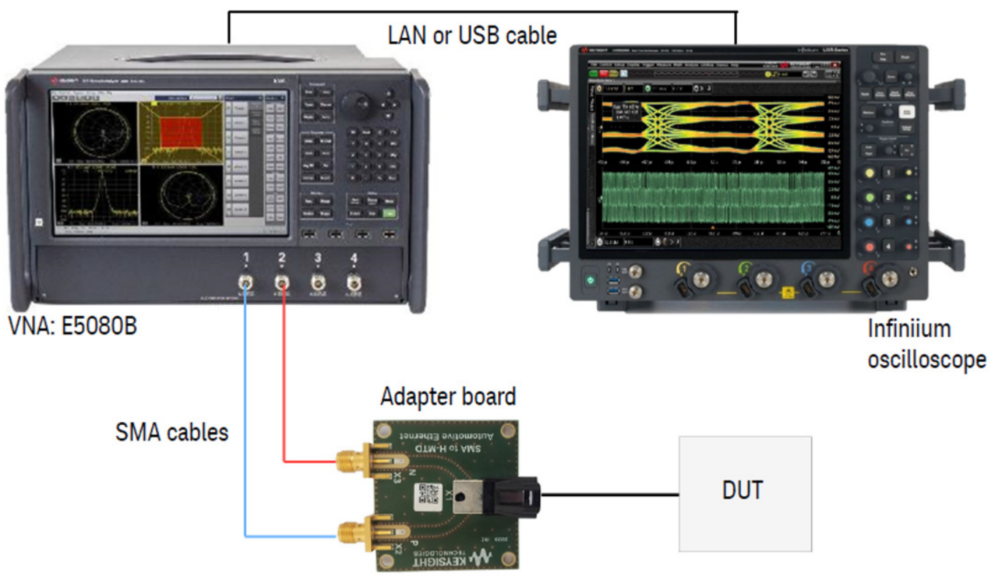


Figure 7-5 MDI Return Loss Test Hardware Setup

Connection Setup for MDI Return Loss and MDI Mode Conversion Loss Tests

Specification References

[1] OPEN Alliance 10BASET1S_PMA_Compliance Test Suite_V1_081524. Test 5.1.5.

[2] IEEE Std 802.3cg^{TM} – 2019 Amendment 52. Sub-clause 147.5.4.5.

MDI Return Loss Test Information

This test can run with an external VNA. However, you can also use a VNA exported data file in the Touchstone or CITI format in place of the external VNA.

NOTE The DUT must be set to SLAVE mode of operation and not transmitting any test symbols.

NOTE

Calibrate the VNA before running the tests. Set the VNA as follows:

- Measurement: Return Loss S_{dd11}
- Start Frequency: 100 kHz
- Stop Frequency: 1 GHz
- Sweep Type: Logarithmic
- Sweep Points: 1600
- Output Power: minimum -10 dBm
- Measurement Bandwidth: 100 Hz
- Logic Port Impedance Differential Mode: 100 Ω
- Logic Port Impedance Common Mode: 25 Ω
- Averaging function 16 times

Refer to "Calibrating the VNA" on page 208.

Reference "[1]" specifies that the MDI return loss shall meet or exceed the following equation for all frequencies ranging from 100 kHz to 1 GHz (with 100 Ω reference impedance) at all times when the PHY is transmitting data or control symbols.

Frequency and Return Loss

Table 7-2 Frequency and Return Loss

Frequency	Return Loss
0.3-6.0 MHz	25
6.0-40.0 MHz	$25-20 \log_{10}(f/6)$

CT_OA_PMA_TX_08

MDI Mode Conversion Loss Test

Test Setup

Run the Management Data Input (MDI) Mode Conversion Loss test with the E5080B Vector Network Analyzer connected externally to the oscilloscope. Refer to Figure 3-14 for the connection diagram.

Specification References

[1] IEEE Std 802.3cg™ – 2019 Amendment 52. Sub-clause 147.7.2.

MDI Mode Conversion Loss Test Information

This test can run with an external VNA. However, you can also use a VNA exported data file in the Touchstone or CITI format in place of the external VNA.

NOTE The DUT must be set to SLAVE mode of operation and not transmitting any test symbols.

NOTE Calibrate the VNA before running the tests. Set the VNA as follows:

- Measurement: Return Loss S_{dd11}
- Start Frequency: 100 kHz
- Stop Frequency: 1 GHz
- Sweep Type: Logarithmic
- Sweep Points: 1600
- Output Power: minimum -10 dBm
- Measurement Bandwidth: 100 Hz
- Logic Port Impedance Differential Mode: 100 Ω
- Logic Port Impedance Common Mode: 25 Ω
- Averaging function 16 times

Refer to "Calibrating the VNA" on page 208.

Reference "[1]" specifies that the MDI mode conversion loss shall meet or exceed the following equation for all frequencies ranging from 1 MHz to 200 MHz (with 100 Ω reference impedance) at all times when the PHY is transmitting data or control symbols.

NOTE

MDI mode conversion loss test is very sensitive to the test configuration. It is very important that you maintain the same cable layout used for the VNA calibration to make the measurement. No bending or twisting of the cable from the calibration to measurement. Also, use a quality SMA or 2.92 mm coaxial cable for testing.

Table 7-3 10Base-T1 ECU Mode Conversion Loss Limit

Frequency	Return Loss
0.3 to 20.0 MHz	46
20.0 to 200.0 MHz	46-20 $\log_{10}(f/20)$

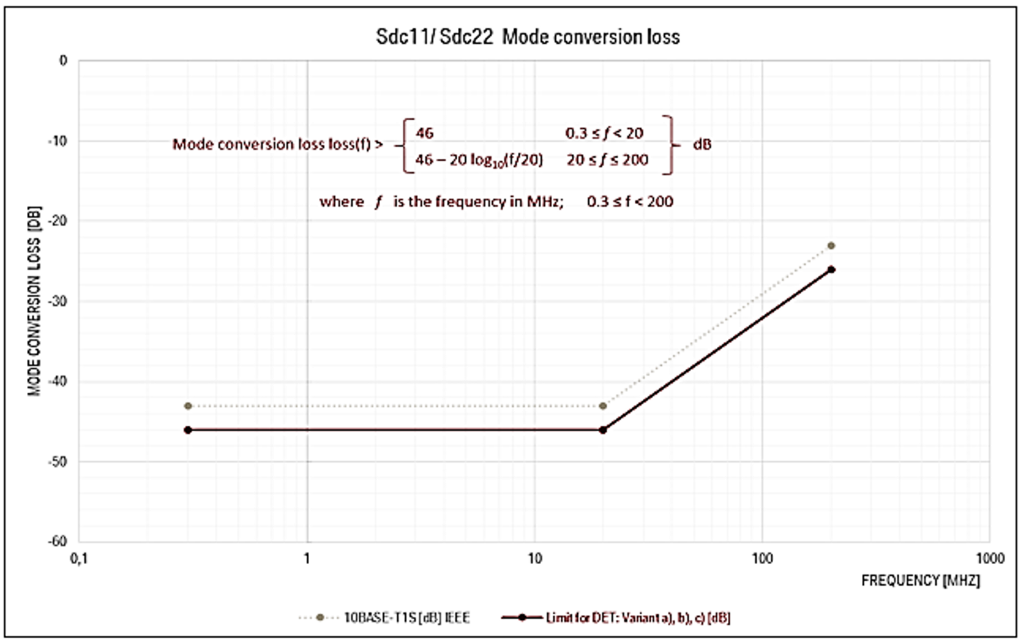


Figure 7-6 10Base-T1S ECU Mode Conversion Loss Limit

Viewing the Test Report

After running any or all of the Compliance tests, the **Results** tab will show the passed tests and details about the individual tests. For test result details, select any one of the tests from the top pane with the test details shown as follows. In Figure 7-7, selected is the Transmitter Power Spectral Density test, and the test results, with waveform, are shown as follows.

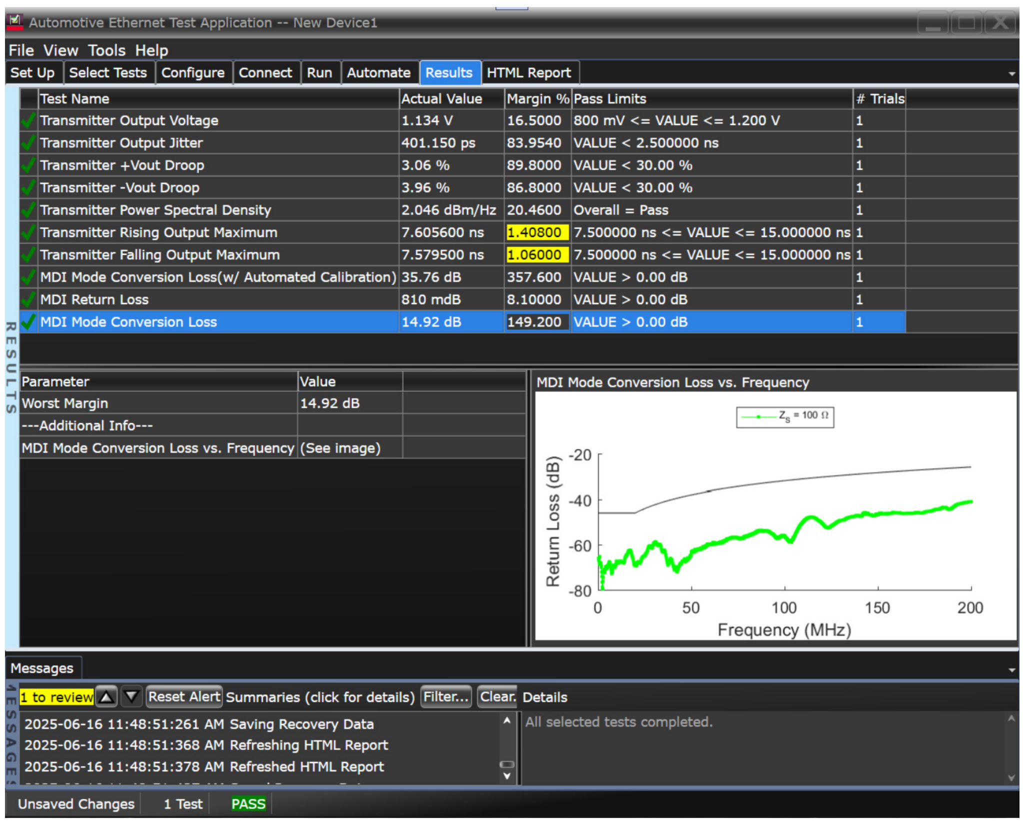


Figure 7-7 Results Tab

Test Report

Pass

Test Configuration Details	
Application	
Name	AE69x0T Automotive Ethernet
Version	5.80.0.0
Device Description	
Technology Spec	Open Alliance(ECU)
StandardType	10M (ECU)
SignalSource	Two Channels
DisturbingSignalSource	33250A
VNA Calibration Type	Manual Calibration
SA Compensation Used	No
Spectral Measurement Device	Oscilloscope
Offline Mode Used	No
DUT	Rad Meteor sn: MT0133
Cable(S)	SMA Cable 8121-3321 SN:-25237876
Test Session Details	
Infiniium SW Version	11.70.00013
Infiniium Model Number	MXR608B
Infiniium Serial Number	MY63310272
Debug Mode Used	No
Compliance Limits	ECU 10BaseP802.3cg (official)
Last Test Date	2025-06-16 11:48:37 UTC +08:00

Summary of Results

Test Statistics	
Failed	0
Passed	10
Total	10

Margin Thresholds	
Warning	< 5 %
Critical	< 0 %

Pass	# Failed	# Trials	Test Name (click to jump)	Actual Value	Margin	Pass Limits
✓	0	1	Transmitter Output Voltage	1.134 V	16.5000 %	800 mV <= VALUE <= 1.200 V
✓	0	1	Transmitter Output Jitter	401.150 ps	83.9540 %	VALUE < 2.500000 ns
✓	0	1	Transmitter +Vout Droop	3.06 %	89.8000 %	VALUE < 30.00 %
✓	0	1	Transmitter -Vout Droop	3.96 %	86.8000 %	VALUE < 30.00 %
✓	0	1	Transmitter Power Spectral Density	2.046 dBm/Hz	20.4600 %	Overall = Pass
✓	0	1	Transmitter Rising Output Maximum	7.605600 ns	1.40800 %	7.500000 ns <= VALUE <= 15.000000 ns
✓	0	1	Transmitter Falling Output Maximum	7.579500 ns	1.06000 %	7.500000 ns <= VALUE <= 15.000000 ns
✓	0	1	MDI Mode Conversion Loss(w/ Automated Calibration)	35.76 dB	357.600 %	VALUE > 0.00 dB
✓	0	1	MDI Return Loss	810 mdB	8.10000 %	VALUE > 0.00 dB
✓	0	1	MDI Mode Conversion Loss	14.92 dB	149.200 %	VALUE > 0.00 dB

Report Detail

Summary Next

Transmitter Output Voltage

Automotive Ethernet Test specification ECU v0.41 (Section 3.2.1.1 OA_PMA_TX_01)

The Peak Differential Voltage obtained must conform to the requirements specified in IEEE P802.3cg Sub-clause 147.5.4.1. The output voltage shall be 1V ± 20% peak-to-peak differential.
Actual Value Measurement Name: Transmitter Output Voltage (10Base-T1S)
Pass Limits: 800 mV <= VALUE <= 1.200 V

Actual Value	Margin
1.134 V	16.5000 %

Transmitter Output Voltage (10Base-T1S)

Figure 7-8 Test Report

8 100BASE-T1 ECU Tests and Test Report

KEYSIGHT TECHNOLOGIES

OABR_PMA_TX_01

Test Setup

You can run this test using either **Two Channels** or a **One Channel** from the transmitter (MDI). Refer to "General Test Setup for 100BASE-T1 and ECU" on page 17 for connection details.

NOTE **Use the software supplied with your transmitter PHY to control the Device Under Test. This test requires Test Mode 1 enabled. The default iteration of test is 10, as per specification.**

Specification References

[1] OPEN Alliance Automotive Ethernet ECU Test Specification, v3.0, Section 5.2.2.1.1, Test OABR_PMA_TX_01

[2] 100BASE-T1, IEEE Std 802.3bw^{TM} – 2015, Section 96.5.4.1

Check the Transmitter Output Droop (Positive) Test Information

This test measures the positive output droop of the transmitter.

Reference "[1]" specifies the positive output droop of a compliant PHY. The positive droop measured with the initial peak value after the zero-crossing and the value 500 ns after the initial peak, shall be less than 45%.

The application triggers the Test Mode 1 signal on the rising edge and determines the time the positive peak occurred and the voltage at that specific instance. This application then measures the voltage 500 ns after the peak; with the Droop calculated as follows:

Droop = 100 × (Vd/Vpk)%

Where:

- **Vd** is the magnitude of the droop.
- **Vpk** is the initial peak after the zero-crossing.

Typical Waveform

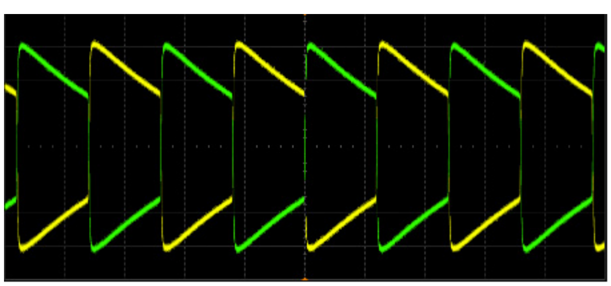


Figure 8-1 Typical Positive Droop Test Waveform (using a pair of SMA cables)

Check the Transmitter Output Droop (Negative) Test Information

This test measures the negative output droop of the transmitter.

Reference "[1]" specifies the negative output droop of a compliant PHY. The negative droop measured with the initial peak value after the zero-crossing and the value 500 ns after the initial peak, shall be less than 45%.

The application triggers the Test Mode 1 signal on the falling edge and determines the time the negative peak occurred and the voltage at that specific instance. This application then measures the voltage 500 ns after the peak; with the Droop calculated as follows:

$$\textbf{Droop} = 100 \times (V_d/V_{pk})\%$$

Where:

- $\mathbf{V_d}$ is the magnitude of the droop.
- $\mathbf{V_{pk}}$ is the initial peak after the zero-crossing.

Typical Waveform

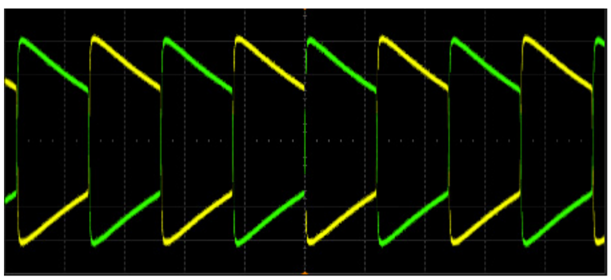


Figure 8-2 Typical Negative Droop Test Waveform (using a pair of SMA cables)

OABR_PMA_TX_02

Test Setup

You can run this test using either **Two Channels** or a **One Channel** from the transmitter (MDI). Refer to “General Test Setup for 100BASE-T1 and ECU” on page 17 for connection details.

NOTE **Use the software supplied with your transmitter PHY to control the Device Under Test. This test requires Test Mode 2 enabled. The default iteration of test is 10, as per specification.**

Specification References

[1] OPEN Alliance Automotive Ethernet ECU Test Specification, v3.0, Section 5.2.2.1.2, Test OABR_PMA_TX_02.

[2] 100BASE-T1, IEEE Std 802.3bw™ – 2015, Section 96.5.4.3

Check the Transmitter Timing Jitter in MASTER Mode Test Information

This test measures the data time interval error of the Test Mode 2 signal at the MDI. The ideal reference data rate is selected automatically by the oscilloscope and compared to the original signal to determine the data time interval error.

Reference “[1]” and “[2]” specifies that when in test mode 2, the RMS (Root Mean Square) TIE value of the MDI output jitter, JTXOUT, relative to an unjittered reference shall be less than 50 ps.

Typical Waveform

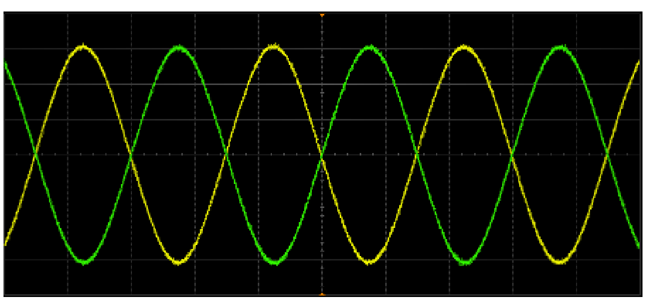


Figure 8-3 Typical MASTER TX Out Test Waveform (using a pair of SMA cables)

OABR_PMA_TX_03

Test Setup

You can run this test using either **Two Channels** or a **One Channel** from the transmitter (MDI). Alternatively, you can also run this test using the TX_TCLK. Refer to "General Test Setup for 100BASE-T1 and ECU" on page 17 for connection details.

NOTE Use the software supplied with your transmitter PHY to control the Device Under Test. This test requires Test Mode 2 enabled. The default iteration of test is 10, as per specification.

Specification References

[1] OPEN Alliance Automotive Ethernet ECU Test Specification, v3.0, Section 5.2.2.1.3, Test OABR_PMA_TX_03

[2] 100BASE-T1, IEEE Std 802.3bw^{TM} – 2015, Section 96.5.4.5

Check the Transmit Clock Frequency Test Information

This test measures the frequency of the transmitter clock when the PHY is operating in MASTER mode.

Reference "[1]" and "[2]" specifies the symbol transmission rate of a compliant PHY. The symbol transmission rate of the MASTER PHY shall be within the range of 66 2/3 MHz ±100 ppm.

The Reference "[1]" and "[2]" specifies that Test Mode 2 shall transmit the data symbol sequence {+1, - 1} repeatedly on the channel. The transmitter shall time the transmitted symbols from a symbol rate clock in the MASTER timing mode. The measured data rate of the Test Mode 2 signal is thus equal to the MASTER Transmit Clock Frequency of the PHY.

Typical Waveform

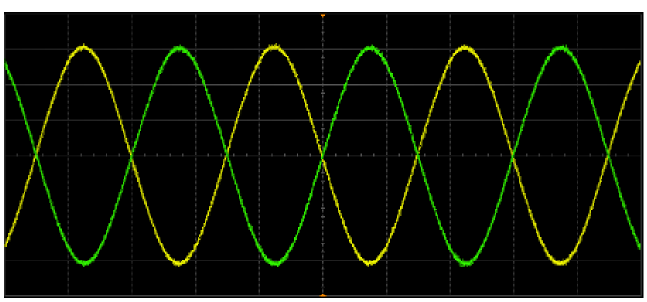


Figure 8-4 Typical MASTER Clock Test Waveform (using a pair of SMA cables)

OABR_PMA_TX_04

Test Setup

You can run the Power Spectral Density (PSD) Test using either a spectrum analyzer or an oscilloscope. When using the oscilloscope, refer to "General Test Setup for 100BASE-T1 and ECU" on page 17 for connection details.

If you use the N9010B Signal Analyzer, convert the differential output to a single-ended output using a balun. Use the balun on either the AE6941A Automotive Ethernet Fixture, as shown in Figure 2-5 or the N5395C Ethernet Test Fixture, as shown in Figure 2-6.

NOTE **Use the software supplied with your transmitter PHY to control the Device Under Test. This test requires Test Mode 5 enabled.**

Specification References

[1] OPEN Alliance Automotive Ethernet ECU Test Specification, v3.0, Section 5.2.2.1.4, Test OABR_PMA_TX04

[2] 100BASE-T1, IEEE Std 802.3bw™ – 2015, Section 96.5.4.4

Check the Power Spectral Density (PSD) Test Information

Reference "[1]" and "[2]" specifies that in Test Mode 5, the power spectral density (PSD) of the transmitter shall be between the upper and lower bounds specified in the following table.

Table 8-1 Power Spectral Density (PSD) Test Information

Frequency	PSD Upper Bound (dBm/Hz)[1]	PSD Lower Bound (dBm/Hz)[1]
@1 MHz	-63.3	-70.9
@20 MHz	-64.8	-75.8
@40 MHz	-68.5	-89.2
57 MHz–200 MHz	-76.5	–

1 Settings: RBW=10 kHz, VBW=30 kHz, sweep time >1 min, RMS detector.

The upper and lower limits are piece-wise linear masks connecting points given in the table above. Provided is a lower PSD mask to ensure tolerances.

You can run this test using an external spectrum analyzer or the oscilloscope.

Typical Waveform

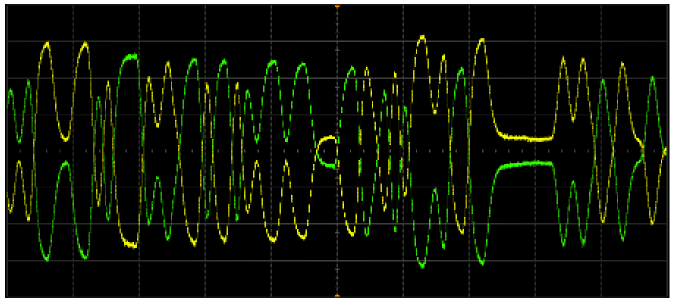


Figure 8-5 Typical Spectral Density Loss Test Waveform

OABR_PMA_TX_05

Test Setup

Run the Management Data Input (MDI) Return Loss test with E5080B Vector Network Analyzer connected externally to the oscilloscope. Refer to Figure 3-14 for the connection diagram.

Specification References

[1] OPEN Alliance Automotive Ethernet ECU Test Specification, v3.0, Section 5.2.2.1.5, Test OABR_PMA_TX05

[2] 100BASE-T1, IEEE Std 802.3bw™ – 2015, Section 96.8.2.1

Check MDI Return Loss Test Information

This test can run with an external vector network analyzer. However, you can use a VNA exported data file in the Touchstone or CITI format in place of the external vector network analyzer.

NOTE The DUT must be set to SLAVE Mode of operation and not transmitting any test symbols.

NOTE Calibrate the VNA prior to running the tests. Set the VNA as follows:

- Measurement: Return Loss S_{dd11}
- Start Frequency: 0.3 MHz
- Stop Frequency: 1 GHz
- Sweep Type: Logarithmic
- Sweep Points: 1600
- Output Power: minimum -10 dBm
- Measurement Bandwidth: 100Hz
- Logic Port Impedance Differential Mode: 100 Ω
- Logic Port Impedance Common Mode: 25 Ω
- Smoothing function is deactivated

Refer to “Calibrating the VNA” on page 208.

Reference “[1]” and “[2]” specifies that the MDI return loss shall meet or exceed the following equation for all frequencies ranging from 1 MHz to 66 MHz (with 100 reference impedance) at all times.

Frequency	Return Loss (dB)
1 – 30 MHz	20
30 – 66 MHz	20 – 20*log(f/30)

OABR_PMA_TX_06

Test Setup

Run the Management Data Input (MDI) Mode Conversion test with a vector network analyzer connected externally to the oscilloscope. Refer to Figure 3-14 for the connection diagram.

Specification References

[1] OPEN Alliance Automotive Ethernet ECU Test Specification, v3.0, Section 5.2.2.1.6, Test OABR_PMA_TX06

[2] 100BASE-T1, IEEE Std 802.3bw^{TM} – 2015, Section 96.8.2.2

Check MDI Mode Conversion Test Information

This test can run with an external vector network analyzer. However, you can also use a VNA exported data file in the Touchstone or CITI format in place of the external vector network analyzer. The DUT must be set to SLAVE Mode of operation and not transmitting any test symbols.

NOTE The DUT must be set to SLAVE Mode of operation and not transmitting any test symbols.

NOTE Calibrate the VNA prior to running the tests. Set the VNA as follows:

- Measurement: Mode Conversion S_{dc11}
- Start Frequency: 0.3 MHz
- Stop Frequency: 1 GHz
- Sweep Type: Logarithmic
- Sweep Points: 1600
- Output Power: minimum -10 dBm
- Measurement Bandwidth: 100Hz
- Logic Port Impedance Differential Mode: 100 Ω
- Logic Port Impedance Common Mode: 25 Ω
- Smoothing function is deactivated

Refer to “Calibrating the VNA” on page 208.

Reference “[1]” and “[2]” specifies that the MDI Mode Conversion shall meet or exceed the following equation for all frequencies ranging from 1 MHz to 200 MHz at all times.

Frequency	Mode Conversion (dB)
@1 MHz	–60
@22 MHz	–60
@100 MHz	–47
@200 MHz	–37

OABR_PMA_TX_07

Test Setup

You can run the MDI Common Mode Emission Test using either a signal analyzer (spectrum analyzer) or an oscilloscope.

When using the oscilloscope or N9010B Signal Analyzer, it is essential to use the Common Mode Emission Test adapter described on page 22 to condition and convert the signal to a single-ended output.

You can use any other test fixture/adapter, but it must meet the requirements as described in the IEEE 100BASE-T1 EMC Test Specifications for Transceivers, Appendix D, D.1. When you use an oscilloscope for running the MDI common mode emission test under Open Alliance 100M ECU spec, ensure to select the 'One Channel' under 'Set up' tab, and in 'Select Tests' tab, select the 'OABR_PMA_TX_07'.

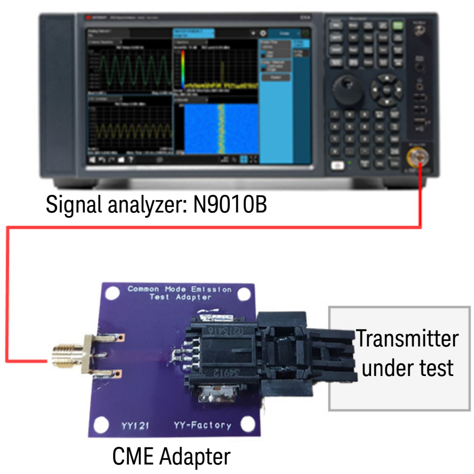


Figure 8-6 Common Mode Emission Test Using N9010B Signal Analyzer

NOTE Use the software supplied with your transmitter PHY to control the Device Under Test. The default iteration of test is 10, as per specification.

Specification References

[1] OPEN Alliance Automotive Ethernet ECU Test Specification, v3.0, Section 5.2.2.1.7, Test OABR_PMA_TX07

[2] 100BASE-T1, IEEE EMC Test Specification for Transceivers, Version 1, Appendix D

Check MDI Common Mode Emission Test Information

Reference “[1]” and “[2]” specifies that in Test Mode 5, the test shall be classified passed, if the value of the MDI common-mode emission (CME) of the transmitter, fulfills the limit specified in the following table.

Frequency	CME Limit (dBμV)
@2 MHz	24
@70 MHz	24

You can run this test using an external spectrum analyzer or the oscilloscope. The recommended settings for CME measurement at MDI are as follows.

Table 8-1 Settings for Measurement Device for CME Test

Measuring Equipment	Spectrum Analyzer	EMI Measuring Receiver	Oscilloscope with Spectrum Analyzer Functionality
Measurement unit	dBμV		
Detector	Peak		–
Frequency range	1 MHz to 200 MHz		
Resolution bandwidth (RBW)	10 kHz	9 kHz	10 kHz
Video bandwidth (VBW)	> 3 x RBW	–	–
Number of passes	10 (max hold)	1	in minimum 10 (max hold)
Measurement time per step	–	≥ 1 ms	–
Frequency sweep time	≥ 20 s	–	–
Frequency step width	–	≤ 0.4 x RBW	–
Time Base	–	–	50 μs/div 500 kS in minimum 1 GSa/s
Amplitude	–	–	≤ 2 mV/div
Input			DC 50 Ω

OABR_PMA_TX_08

Test Setup

You have the option to use either Section 2 of the AE6941A Automotive Ethernet Fixture or Sections 1 and 11 of the N5395C Ethernet Test Fixture in this test.

A disturbing signal source is required to test for compliance. There is an option to test without a disturbing signal source, but the test result is not applicable for compliance. The test accepts only a differential signal.

When using a supported function generator, there is an automatic calibration process to calibrate the function generators. If you use an unsupported model, you will have to calibrate the function generators manually. Refer to the individual user manuals to determine calibration steps as well as the respective standard specification for calibration settings.

NOTE **Use the software supplied with your transmitter PHY to control the Device Under Test. This test requires Test Mode 4 enabled. The default iteration of test is 10, as per specification.**

Supported Function Generators	Number Required	Notes	Connection diagram with AE6941A	Connection diagram with N5395C
Keysight 33250A	2	Keysight 82357B USB/GPIB interface and one additional GPIB cable required.	Figure 3-8	Figure 3-11
Keysight 33622A	1	LAN/ USB Cable required.	Figure 3-7	Figure 3-10
Keysight 81150A/81160A	1	LAN/ USB Cable required.	Figure 3-9	Figure 3-12

Using the Optional AE6950A Frequency Divider Board

If you want to use the optional AE6950A Frequency Divider Board to provide a stable 10 MHz reference clock, refer to "Using the AE6950A Frequency Divider Board" on page 224 for detailed information.

Specification References

[1] OPEN Alliance Automotive Ethernet ECU Test Specification, v3.0, Section 5.2.2.1.8, Test OABR_PMA_TX08

[2] 100BASE-T1, IEEE Std 802.3bw™ – 2015, Section 96.5.4.2

Check Transmitter Distortion Test Information

When operating in Test Mode 4 and capturing the waveform using the recommended fixture, the peak distortion values, measured at a minimum of 10 equally-spaced phases of a single symbol period, shall be less than 15 mV.

NOTE If using the Frequency Divider, connect the 10 MHz output(s) of the divider to the 10 MHz Ref In Input of the oscilloscope and function generator for clock synchronization.

Reference "[1]" and "[2]" specify that the peak distortion is determined by sampling the differential signal output with the symbol rate clock at an arbitrary phase and processing a block of any 2047 consecutive samples with MATLAB code in reference "[1]" and "[2]".

Apply a software high pass filter to the sampled signal before post-processing.

Alternatively, you can also run this test without the disturbing signal, but you cannot use the result to determine compliance.

Transmitter Distortion Enhance Clock Recovery Algorithm

Keysight employs an enhanced clock recovery algorithm when the TX_TCLK is not available. The algorithm conditions the signal to the nominal bitrate. It is enabled by default when the **Use 10MHz Ref Clock** checkbox is disabled.

When the **Use 10MHz Ref Clock** checkbox is enabled, the AE6950A Frequency Divider board, and access to TX_TCLK, is required for synchronization.

NOTE If using the Frequency Divider, connect the 10 MHz output(s) of the divider to the 10 MHz Ref In Input of the oscilloscope and function generator for clock synchronization.

Typical Waveform

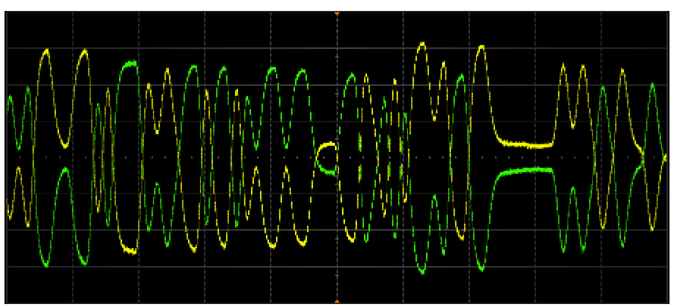


Figure 8-7 Typical Distortion Test Waveform (using a pair of SMA cables)

Viewing the Test Report

After running any or all of the Compliance tests, the **Results** tab will show the passed tests and details about the individual tests. For test result details, select any one of the tests from the top pane with the test details shown as follows. In Figure 8-8 selected is the Transmitter Power Spectral Density test, and the test results, with waveform, are shown as follows.

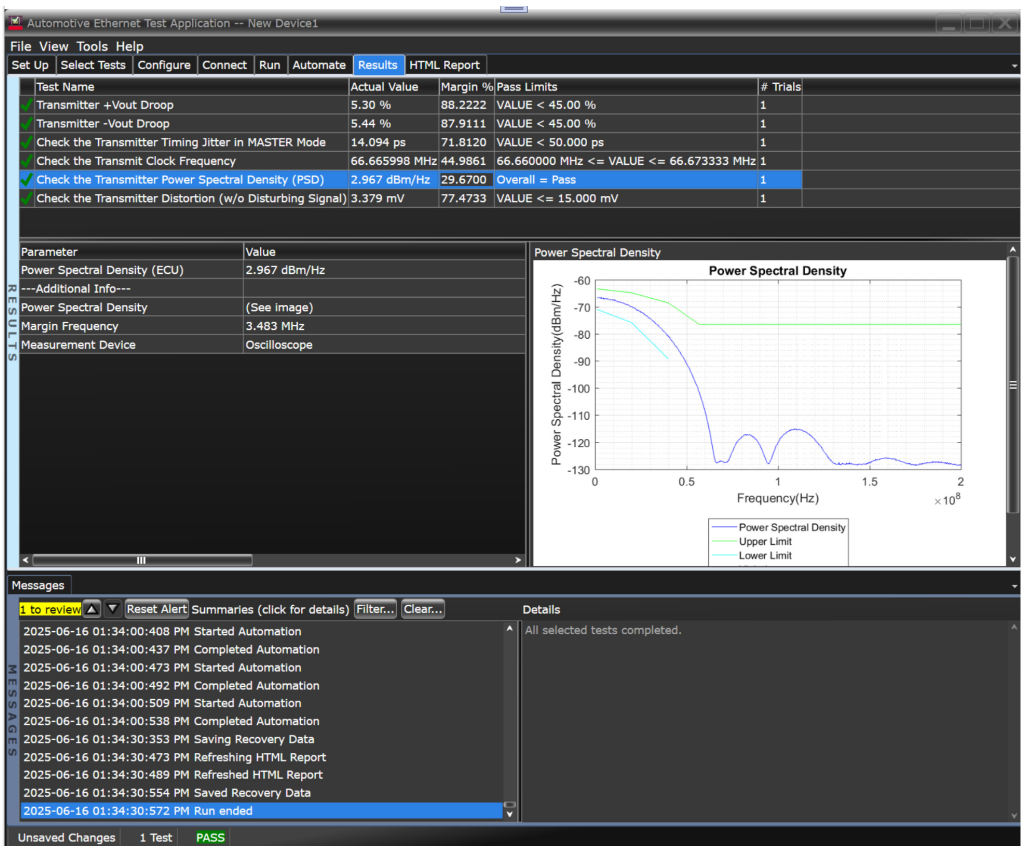


Figure 8-8 Typical results tab

Figure 8-9 shows a portion of a typical **HTML Report**.

Test Report

Pass

Test Configuration Details	
Application	
Name	AE69x0T Automotive Ethernet
Version	5.80.0.0
Device Description	
Technology Spec	Open Alliance(ECU)
StandardType	100M (ECU)
SignalSource	Two Channels
DisturbingSignalSource	33250A
VNA Calibration Type	Manual Calibration
SA Compensation Used	No
Spectral Measurement Device	Oscilloscope
Offline Mode Used	No
Test Session Details	
Infiniium SW Version	11.70.00013
Infiniium Model Number	MXR608B
Infiniium Serial Number	MY63310272
Debug Mode Used	No
Compliance Limits	TC8 ECU Specification Layer 1 v3.0 (official)
Last Test Date	2025-06-16 13:34:16 UTC +08:00

Summary of Results

Test Statistics	
Failed	0
Passed	6
Total	6

Margin Thresholds	
Warning	< 5 %
Critical	< 0 %

Pass	# Failed	# Trials	Test Name (click to jump)	Actual Value	Margin	Pass Limits
	0	1	Transmitter +Vout Droop	5.30 %	88.2222 %	VALUE < 45.00 %
	0	1	Transmitter -Vout Droop	5.44 %	87.9111 %	VALUE < 45.00 %
	0	1	Check the Transmitter Timing Jitter in MASTER Mode	14.094 ps	71.8120 %	VALUE < 50.000 ps
	0	1	Check the Transmit Clock Frequency	66.665998 MHz	44.9861 %	66.660000 MHz <= VALUE <= 66.673333 MHz
	0	1	Check the Transmitter Power Spectral Density (PSD)	2.967 dBm/Hz	29.6700 %	Overall = Pass
	0	1	Check the Transmitter Distortion (w/o Disturbing Signal)	3.379 mV	77.4733 %	VALUE <= 15.000 mV

Report Detail

Summary Next

Transmitter +Vout Droop

Automotive Ethernet ECU Test Specification Layer 1 v3.0 (Section 5.2.2.1.1 OABR_PMA_TX_01)

The magnitude of both the positive and negative droop measured with respect to an initial peak value after the zero crossing and the value 500ns after the initial peak, shall be less than 45%.
Actual Value Measurement Name: Transmitter +Vout Droop (ECU)
Pass Limits: VALUE < 45.00 %

Actual Value	Margin	Vd	Vpk
5.30 %	88.2222 %	54 mV	1.028 V

Figure 8-9 Top portion of a typical HTML report

9 1000BASE-T1 ECU Tests and Test Report

CT_1000BASE-T1_PMA_TX_01

Test Setup

You can run this test using either **Two Channels** or a **One Channel** from the transmitter (MDI). Refer to "General Test Setup for 1000BASE-T1 and ECU" on page 18 for connection details.

NOTE Use the software supplied with your transmitter PHY to control the Device Under Test. This test requires Test Mode 1 enabled. The default iteration of test is 10, as per specification.

Specification References

[1] OPEN Alliance Automotive Ethernet TC8 ECU Test Specification, v1.0, Section 4.2.2.1, Test CT_1000BASE-T1_PMA_TX_01

[2] 1000BASE-T1, IEEE Std 802.3bp^{TM} – 2016, Section 97.5.3.1

Check the Transmitter Output Droop (Positive) Test Information

This test measures the positive output droop of the transmitter.

Reference "[1]" specifies the positive output droop of a compliant PHY. The positive droop measured with an initial value at 4 ns after the zero-crossing and a final value of 16 ns after the zero-crossing, shall be less than 10%.

The application triggers the Test Mode 6 signal on the rising edge and determines the time the positive peak occurred at 4 ns after the zero-crossing. This application then measures the voltage 12 ns after the initial peak-crossing; with the Droop calculated as follows:

Droop = 100 × (Vd/Vpk)%

Where:

- **Vd** is the magnitude of the droop.
- **Vpk** is the initial peak after the zero-crossing.

Typical Waveform

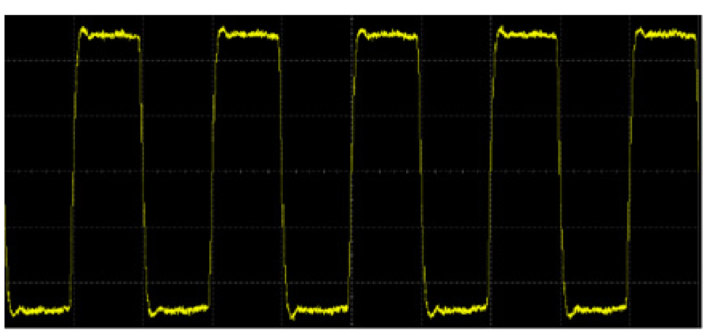


Figure 9-1 Typical Positive Droop Test Waveform (using a pair of SMA cables)

Check the Transmitter Output Droop (Negative) Test Information

This test measures the negative output droop of the transmitter.

Reference "[1]" specifies the negative output droop of a compliant PHY. The negative droop measured with an initial value at 4 ns after the zero-crossing and a final value of 16 ns after the zero-crossing, shall be less than 10%.

The application triggers the Test Mode 6 signal on the falling edge and determines the time the negative peak occurred at 4 ns after the zero-crossing. This application then measures the voltage 12 ns after the initial peak-crossing; with the Droop calculated as follows:

Droop = 100 × (Vd/Vpk)%

Where:

- **Vd** is the magnitude of the droop.
- **Vpk** is the initial peak after the zero-crossing.

Typical Waveform

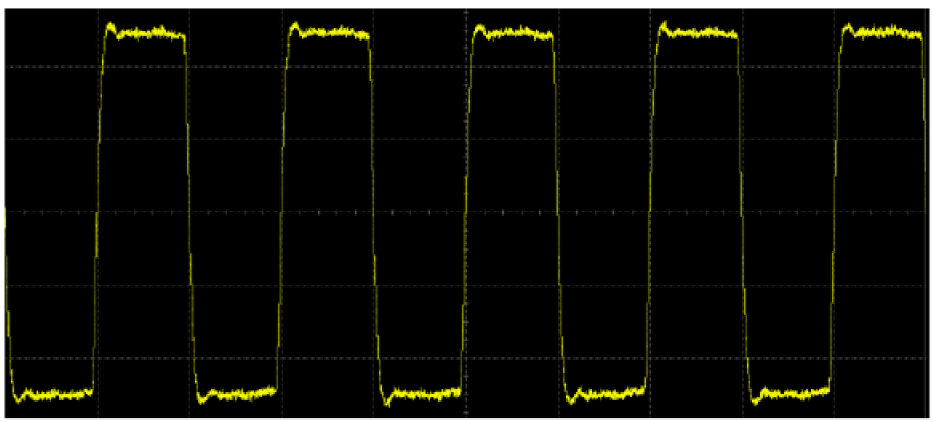


Figure 9-2 Typical Negative Droop Test Waveform (using a pair of SMA cables)

CT_1000BASE-T1_PMA_TX_02

Test Setup

You can run this test using either **Two Channels** or a **One Channel** from the transmitter (MDI). Refer to "General Test Setup for 1000BASE-T1 and ECU" on page 18 for connection details.

NOTE Use the software supplied with your transmitter PHY to control the Device Under Test. This test requires Test Mode 1 enabled. The default iteration of test is 10, as per specification.

Specification References

[1] OPEN Alliance Automotive Ethernet TC8 ECU Test Specification, v1.0, Section 4.2.2.2.

[2] 1000BASE-T1, IEEE Std 802.3bp™ – 2016, Section 97.5.3.3

MDI Output Jitter (MASTER)

Reference "[2]" specifies that when in Test Mode 2, the RMS (Root Mean Square) value of the MDI output jitter, relative to an unjittered reference, shall be less than 5 ps.

Reference "[2]" specifies that when in Test Mode 2, the peak-to-peak value of the MDI output jitter, relative to an unjittered reference, shall be less than 50 ps.

This test measures the data time interval error of the Test Mode 2 signal at the MDI. The ideal reference data rate is selected automatically by the oscilloscope and compared to the original signal to determine the data time interval error

Typical Waveform

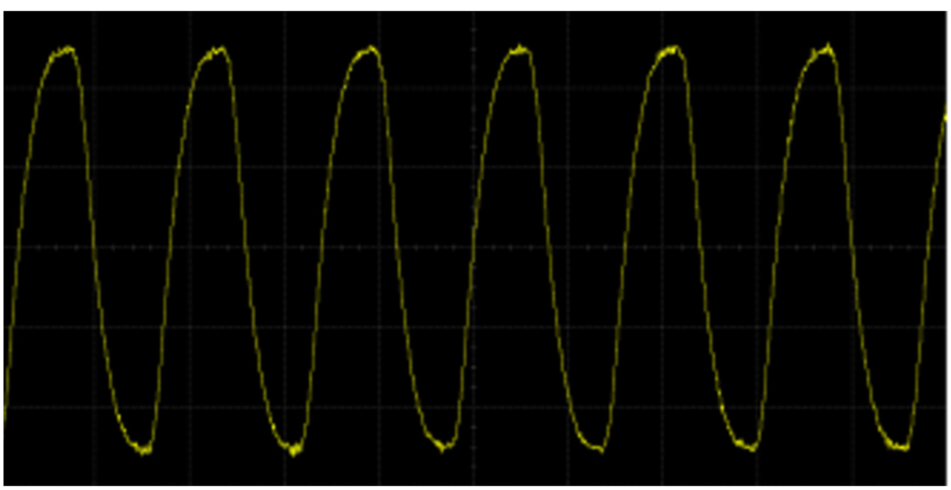


Figure 9-3 Typical Test Mode 2 Waveform (using a pair of SMA cables)

CT_1000BASE-T1_PMA_TX_03

Test Setup

You can run this test using either **Two Channels** or a **One Channel** from the transmitter (MDI). Refer to "General Test Setup for 1000BASE-T1 and ECU" on page 18 for connection details.

NOTE Use the software supplied with your transmitter PHY to control the Device Under Test. This test requires Test Mode 2 enabled. The default iteration of test is 10, as per specification.

Specification References

[1] OPEN Alliance Automotive Ethernet TC8 ECU Test Specification, v1.0, Section 4.2.2.3

[2] 1000BASE-T1, IEEE Std 802.3bp^{TM} – 2016, Section 97.5.3.6

Check the Transmit Clock Frequency Test Information

This test measures the frequency of the transmitter clock when the PHY is operating in MASTER mode.

Reference "[1]" specifies the symbol transmission rate of a compliant PHY. The symbol transmission rate of the MASTER PHY shall be within the range of 750 MHz ±100 ppm.

Reference "[2]" specifies that in Test Mode 2, the PHY shall transmit a continuous pattern of {+1} symbols followed by three {-1} symbols with the transmitted symbols timed from its local clock source of 750 MHz. The transmitter output is a 125 MHz signal. Hence, the accuracy of the Transmit Clock Frequency is also 125 MHz ±100 ppm.

Typical Waveform

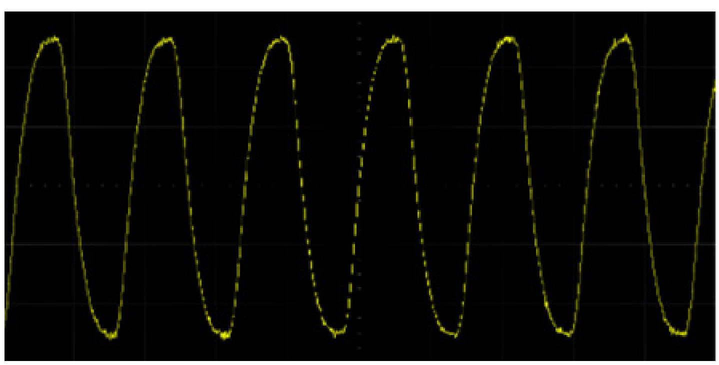


Figure 9-4 Typical MASTER Clock Test Waveform (using a pair of SMA cables)

CT_1000BASE-T1_PMA_TX_04

Test Setup

You can run this test using either **Two Channels** or a **One Channel** from the transmitter (MDI). Refer to "General Test Setup for 1000BASE-T1 and ECU" on page 18 for connection details.

NOTE

Use the software supplied with your transmitter PHY to control the Device Under Test.

Specification References

[1] OPEN Alliance Automotive Ethernet TC8 ECU Test Specification, v1.0, Section 4.2.2.4

[2] 1000BASE-T1, IEEE Std 802.3bp™ – 2016, Section 97.5.3.4

Check the Transmitter Power Spectral Density (PSD) Test Information

Reference "[1]" and "[2]" specifies that in Test Mode 5, the power spectral density (PSD) of the transmitter shall be between the specified upper and lower masks of the following equations.

$$UpperPSD(f) = \begin{bmatrix} -80 & \frac{dBm}{Hz} & 0 < f \leq 100 \\ -76 - \frac{f}{25} & \frac{dBm}{Hz} & 100 < f \leq 400 \\ -85.6 - \frac{f}{62.5} & \frac{dBm}{Hz} & 400 < f \leq 600 \end{bmatrix}$$

$$LowerPSD(f) = \begin{bmatrix} -86 & \frac{dBm}{Hz} & 40 < f \leq 100 \\ -82 - \frac{f}{25} & \frac{dBm}{Hz} & 100 < f \leq 400 \end{bmatrix}$$

Where f is the frequency in MHz.

Consider the resolution bandwidth of 100kHz and sweep time of larger than 1 second in PSD measurements.

You can run this test using an external spectrum analyzer or the oscilloscope.

CT_1000BASE-T1_PMA_TX_05

Test Setup

Run this test with the E5080B Vector Network Analyzer connected externally to the oscilloscope. Refer to Figure 3-14 for the connection diagram.

This test can run with an external vector network analyzer. However, you can use a VNA exported data file in the Touchstone or CITI format in place of the external vector network analyzer.

Specification References

[1] OPEN Alliance Automotive Ethernet TC8 ECU Test Specification, v1.0, Section 4.2.2.5

[2] 1000BASE-T1, IEEE Std 802.3bp™ – 2016, Section 97.7.2.1

Check MDI Return Loss Test Information

Reference "[1]" specifies that the differential impedance at the MDI for each transmit/receive channel shall be such that any attenuated reflection is relative to the incident signal as per the following equation. This reflection must be due to differential signals incident upon the MDI with a test port having a differential impedance of 100 Ω.

$$ReturnLoss(f) \geq \begin{bmatrix} 18 - 18(\log_{10})\frac{20}{f} & 2 \leq f < 20 \\ 18 & 20 \leq f < 100 \\ 18 - 16.7(\log_{10})\frac{f}{100} & 100 \leq f \leq 600 \end{bmatrix}$$

Where f is the frequency in MHz.

In other words, the return loss shall meet or exceed the following equation for all frequencies ranging from 2 MHz to 600 MHz (with 100Ω differential impedance) at all times when the PHY is transmitting data or control symbols.

NOTE

The DUT must be set to SLAVE Mode of operation and not transmitting any test symbols.

NOTE

Calibrate the VNA prior to running the tests. Set the VNA as follows:

- Measurement: Return Loss S_{dd11}
- Start Frequency: 300 kHz
- Stop Frequency: 1 GHz
- Sweep Type: Logarithmic
- Sweep Points: 1600
- Output Power: minimum -10 dBm
- Measurement Bandwidth: 100Hz
- Logic Port Impedance Differential Mode: 100 Ω
- Logic Port Impedance Common Mode: 25 Ω
- Smoothing function is deactivated

Refer to "Calibrating the VNA" on page 208.

CT_1000BASE-T1_PMA_TX_06

Test Setup

Run the Management Data Input (MDI) Mode Conversion Loss test with a vector network analyzer connected externally to the oscilloscope. Refer to Figure 3-14 for the connection diagram.

Specification References

[1] OPEN Alliance Automotive Ethernet TC8 ECU Test Specification, v1.0, Section 4.2.2.6

[2] 1000BASE-T1, IEEE Std 802.3bp^{TM} – 2016, Section 97.7.2.2

Check MDI Mode Conversion Loss Test Information

This test can run with an external vector network analyzer. However, you can also use a VNA exported data file in the Touchstone or CITI format in place of the external vector network analyzer.

NOTE The DUT must be set to SLAVE Mode of operation and not transmitting any test symbols.

NOTE Calibrate the VNA prior to running the tests. Set the VNA as follows:

- Measurement: Mode Conversion S_{dc11}
- Start Frequency: 300 kHz
- Stop Frequency: 1 GHz
- Sweep Type: Logarithmic
- Sweep Points: 1600
- Output Power: minimum -10 dBm
- Measurement Bandwidth: 100Hz
- Logic Port Impedance Differential Mode: 100 Ω
- Logic Port Impedance Common Mode: 25 Ω
- Smoothing function is deactivated

Refer to "Calibrating the VNA" on page 208.

CT_1000BASE-T1_PMA_TX_08

Test Setup

You have the option to use either Section 2 of the AE6941A Automotive Ethernet Fixture or Sections 1 and 11 of the N5395C Ethernet Test Fixture in this test.

A disturbing signal source is required to test for compliance. There is an option to test without a disturbing signal source, but the test result is not applicable for compliance. The test accepts only a differential signal.

When using a supported function generator, there is an automatic calibration process to calibrate the function generators. If you use an unsupported model, you will have to calibrate the function generators manually. Refer to the individual user manuals to determine calibration steps as well as the respective standard specification for calibration settings.

NOTE Use the software supplied with your transmitter PHY to control the Device Under Test. This test requires Test Mode 4 enabled. The default iteration of test is 10, as per specification.

Supported Function Generators	Number Required	Notes	Connection diagram with AE6941A	Connection diagram with N5395C
Keysight 33622A	1	LAN/ USB Cable required.	Figure 3-7	Figure 3-10
Keysight 81150A/81160A	1	LAN/ USB Cable required.	Figure 3-9	Figure 3-12

Using the Optional AE6950A Frequency Divider Board

If you want to use the optional AE6950A Frequency Divider Board to provide a stable 10 MHz reference clock, refer to "Using the AE6950A Frequency Divider Board" on page 224 for detailed information.

Specification References

[1] OPEN Alliance Automotive Ethernet TC8 ECU Test Specification, v1.0, Section 4.2.2.7

[2] 1000BASE-T1, IEEE Std 802.3bp^{TM} – 2016, Section 97.5.3.2

CT_1000BASE-T1_PMA_TX_09

Test Setup

You can run the Power Spectral Density (PSD) Test using either a spectrum analyzer or an oscilloscope. When using the oscilloscope, refer to "General Test Setup for 1000BASE-T1 and ECU" on page 18 for connection details.

Specification References

[1] OPEN Alliance Automotive Ethernet TC8 ECU Test Specification, v1.0, Section 4.2.2.8

[2] 1000BASE-T1, IEEE Std 802.3bp™ – 2016, Section 97.5.3.2

Transmitter Peak Differential Output

Reference "[2]" specifies that in Test Mode 5,when measured with 100 Ω termination, the transit differential signal at the MDI shall be less than 1.30 Volt peak-to-peak.

Typical Waveform

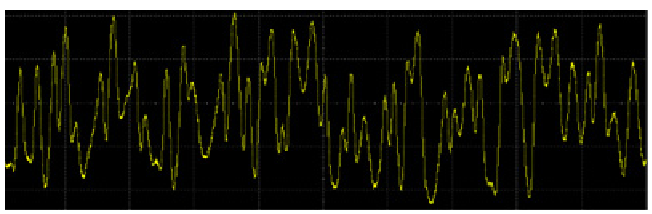


Figure 9-5 Typical Test Mode 5 Waveform (using a pair of SMA cables)

Viewing the Test Report

After running any or all of the Compliance tests, the **Results** tab will show the passed tests and details about the individual tests. For test result details, select any one of the tests from the top pane with the test details shown as follows. In Figure 9-6 selected is the Transmitter Power Spectral Density test, and the test results, with waveform, are shown as follows.

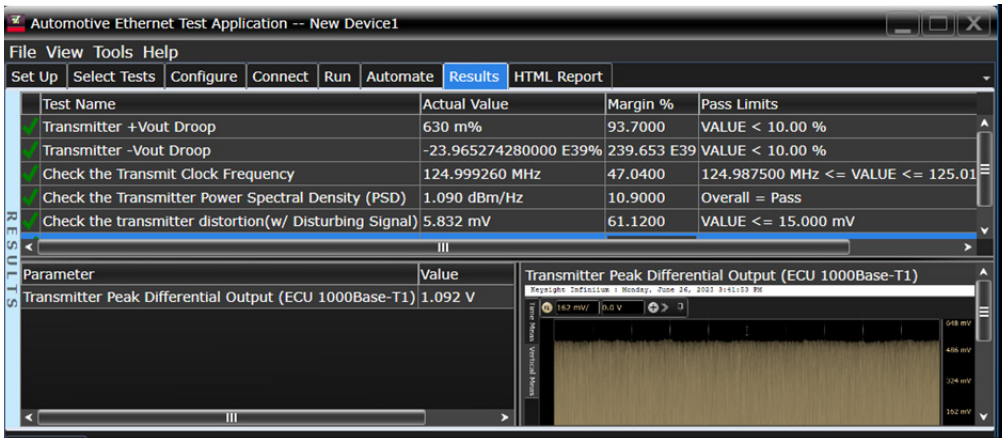
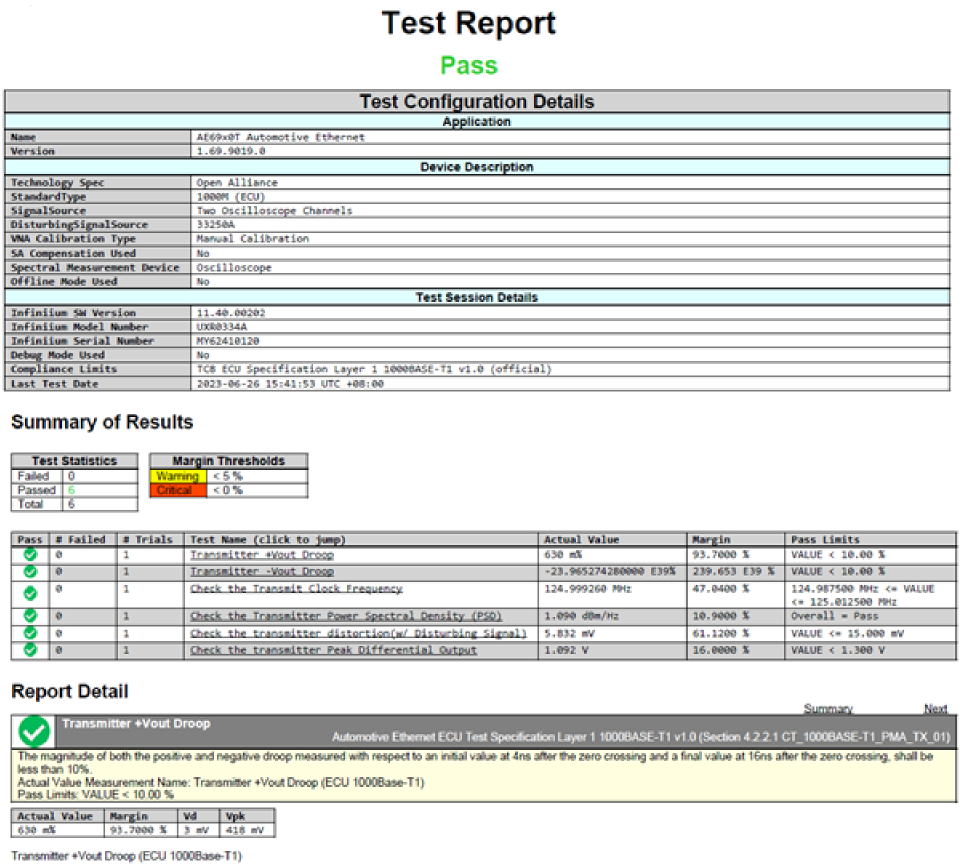


Figure 9-6 Typical results tab

Figure 9-7 shows a portion of a typical **HTML Report**.



Test Report

Pass

Test Configuration Details	
Application	
Name	AE69x0T Automotive Ethernet
Version	1.69.9019.0
Device Description	
Technology Spec	Open Alliance
StandardType	1000M (ECU)
SignalSource	Two Oscilloscope Channels
DisturbingSignalSource	33250A
VNA Calibration Type	Manual Calibration
SA Compensation Used	No
Spectral Measurement Device	Oscilloscope
Offline Mode Used	No
Test Session Details	
Infiniium SW Version	11.40.00202
Infiniium Model Number	UXR0334A
Infiniium Serial Number	MY62410120
Debug Mode Used	No
Compliance Limits	TCB ECU Specification Layer 1 1000BASE-T1 v1.0 (official)
Last Test Date	2023-06-26 15:41:53 UTC +08:00

Summary of Results

Test Statistics	
Failed	0
Passed	6
Total	6

Margin Thresholds	
Warning	< 5 %
Critical	< 0 %

Pass	# Failed	# Trials	Test Name (click to jump)	Actual Value	Margin	Pass Limits
	0	1	Transmitter +Vout Droop	630 m%	93.7000 %	VALUE < 10.00 %
	0	1	Transmitter -Vout Droop	-23.965274280000 E39%	239.653 E39 %	VALUE < 10.00 %
	0	1	Check the Transmit Clock Frequency	124.999260 MHz	47.0400 %	124.987500 MHz <= VALUE <= 125.012500 MHz
	0	1	Check the Transmitter Power Spectral Density (PSD)	1.090 dBm/Hz	10.9000 %	Overall = Pass
	0	1	Check the transmitter distortion(w/ Disturbing Signal)	5.832 mV	61.1200 %	VALUE <= 15.000 mV
	0	1	Check the transmitter Peak Differential Output	1.092 V	16.0000 %	VALUE < 1.300 V

Report Detail

Summary Next

Transmitter +Vout Droop

Automotive Ethernet ECU Test Specification Layer 1 1000BASE-T1 v1.0 (Section 4.2.2.1 CT_1000BASE-T1_PMA_TX_01)

The magnitude of both the positive and negative droop measured with respect to an initial value at 4ns after the zero crossing and a final value at 16ns after the zero crossing, shall be less than 10%.
Actual Value Measurement Name: Transmitter +Vout Droop (ECU 1000Base-T1)
Pass Limits: VALUE < 10.00 %

Actual Value	Margin	Vd	Vpk
630 m%	93.7000 %	3 mV	418 mV

Transmitter +Vout Droop (ECU 1000Base-T1)

Figure 9-7 Top portion of a typical HTML report

10 10BASE-T1S PMA Tests and Test Report

CT_OA_PMA_TX_03

Test Mode 3. Transmitter Timing Jitter, Transmitter Power Spectral Density (Ext Frq Cls3), Transmitter Power Spectral Density (Ext Frq Cls4)

Test Setup

You can run this test using either **Two Channels** or a **One Channel** from the transmitter (MDI). Refer to "General Test Setup for 10BASE-T1S, ECU and PMA" on page 16 for connection details.

NOTE Use the software supplied with your transmitter PHY to control the Device Under Test.

Specification References

[1] 10BASE-T1S, IEEE Std 802.3cg™ - 2019, Section 147.5.4.1.

[2] 10BASE-T1S, IEEE Std 802.3cg™ - 2019, Section 147.5.4.3.

Transmitter Timing Jitter Test Information

Reference "[1]" specifies that with the transmitter in Test Mode 3, the maximum jitter at the transmitter side shall be less than 2.5 ns symbol-to-symbol. This test measures the data time interval error of the Test Mode 3 signal at the MDI. The ideal reference data rate is selected automatically by the oscilloscope and compared to the original signal to determine the data time interval error.

Typical Waveform

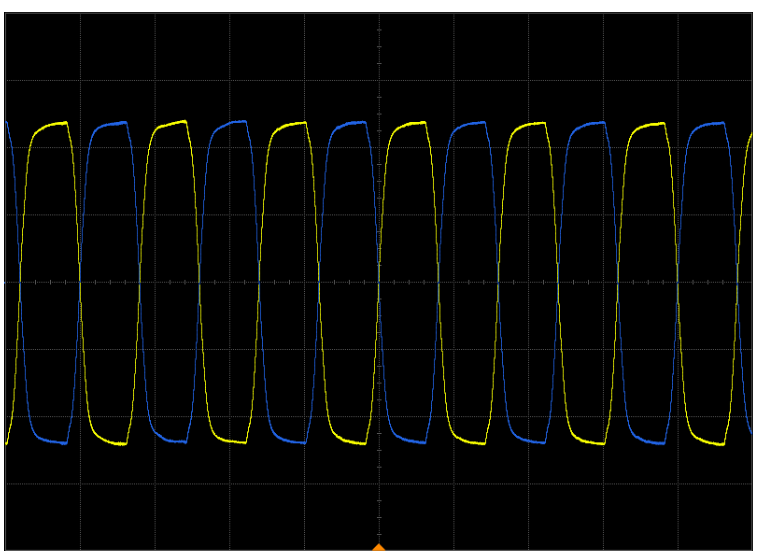


Figure 10-1 Typical Timing Jitter Waveform (using a pair of SMA cables)

Power Spectral Density (Ext Frq Cls3) Test Information

Reference "[1]" specifies that in Test Mode 3, the power spectral density (PSD) of the transmitter shall be between the upper and lower bounds specified in the following tables.

Table 10-1 PSD Upper Bounds

Frequency	PSD Upper Bound (dBm/Hz)[1]
@0 MHz	-61
@15 MHz	-61
@25 MHz	-75
@40 MHz	-75
@60 MHz	-75
@76 MHz	-104
@250 MHz	-104

1 Settings: RBW=10 kHz, VBW=30 kHz, sweep time >1 min, RMS detector.

Table 10-2 PSD Lower Bounds

Frequency	PSD Lower Bound (dBm/Hz)[1]
@0 MHz	-77
@15 MHz	-67
@25 MHz	-77

1 Settings: RBW=10 kHz, VBW=30 kHz, sweep time >1 min, RMS detector.

The upper and lower limits are piece-wise linear masks connecting points given in Table 10-1 on page 175 and Table 10-2 on page 175. Provided is a lower PSD mask to ensure tolerances.

Typical Waveform

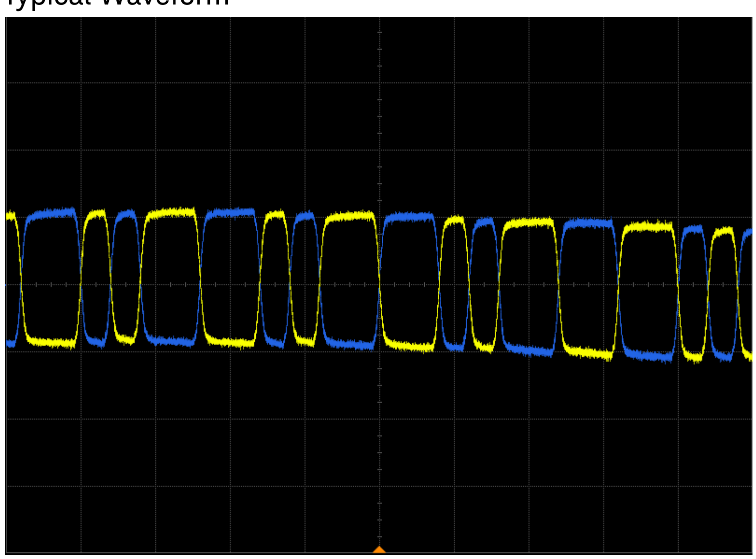


Figure 10-2 Typical Power Spectral Density Test Waveform TM3

Power Spectral Density (Ext Frq Cls4) Test Information

Reference "[1]" specifies that in Test Mode 3, the power spectral density (PSD) of the transmitter shall be between the upper and lower bounds specified in the following tables.

Table 10-3 PSD Upper Bounds

Frequency	PSD Upper Bound (dBm/Hz)[1]
@0 MHz	-61
@15 MHz	-61
@25 MHz	-75
@40 MHz	-75
@60 MHz	-75
@76 MHz	-114
@250 MHz	-114

1 Settings: RBW=10 kHz, VBW=30 kHz, sweep time >1 min, RMS detector.

Table 10-4 PSD Lower Bounds

Frequency	PSD Lower Bound (dBm/Hz)[1]
@0 MHz	-77
@15 MHz	-67
@25 MHz	-77

1 Settings: RBW=10 kHz, VBW=30 kHz, sweep time >1 min, RMS detector.

The upper and lower limits are piece-wise linear masks connecting points given in Table 10-3 on page 176 and Table 10-4 on page 176. Provided is a lower PSD mask to ensure tolerances.

Typical Waveform

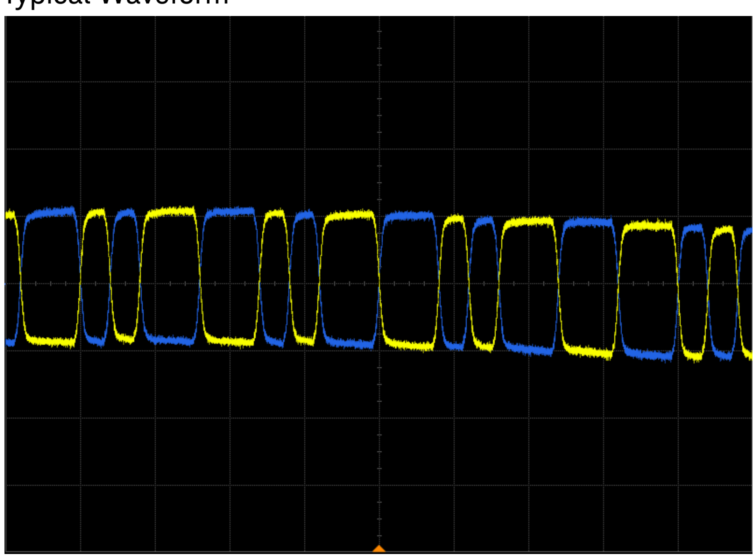


Figure 10-3 Typical Power Spectral Density Test Waveform TM3

Viewing the Test Report

After running any or all of the Compliance tests, the **Results** tab will show the passed tests and details about the individual tests. For test result details, select any one of the tests from the top pane with the test details shown as follows. In Figure 10-4 selected is the Transmitter Power Spectral Density test (Ext Frq Cls3 and Cls4), and the Transmitter Timing Jitter test results, with waveform, are shown as follows.

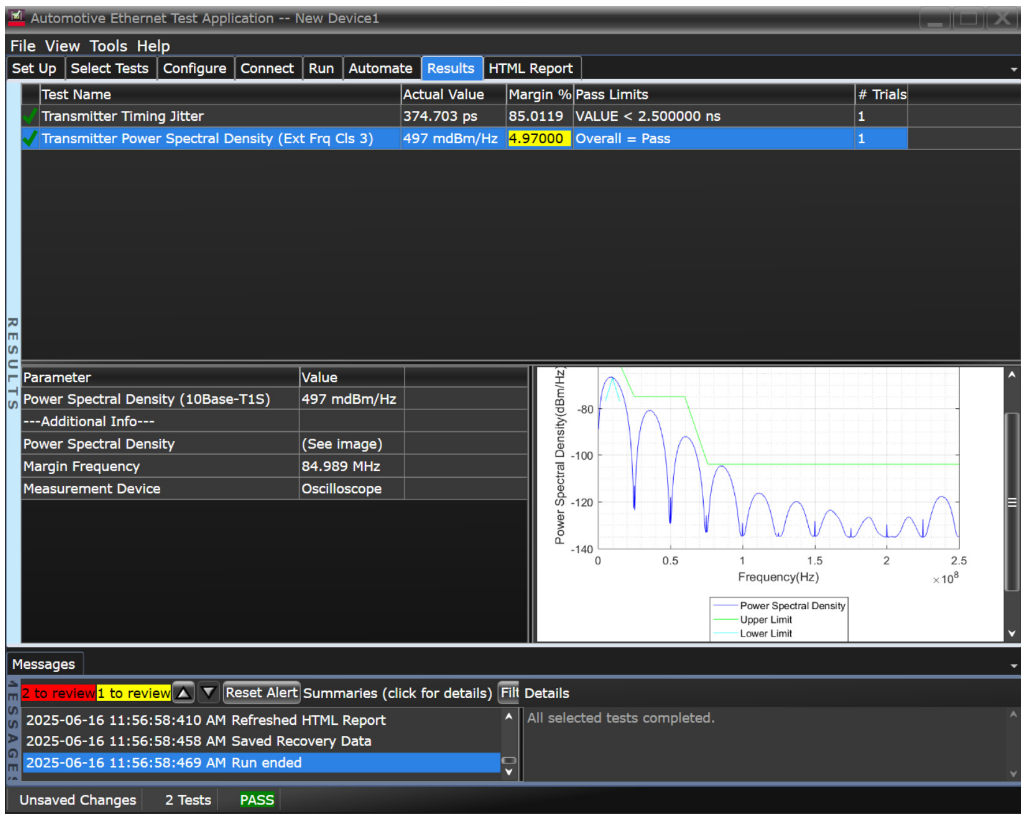


Figure 10-4 Typical results tab

Figure 10-5 shows a portion of a typical **HTML Report**.

Test Report

Pass

Test Configuration Details	
Application	
Name	AE69x0T Automotive Ethernet
Version	5.80.0.0
Device Description	
Technology Spec	Open Alliance(PMA)
StandardType	10M (PMA)
SignalSource	Two Channels
DisturbingSignalSource	33250A
VNA Calibration Type	Manual Calibration
SA Compensation Used	No
Spectral Measurement Device	Oscilloscope
Offline Mode Used	No
DUT	Rad Meteor sn: MT0133
Cable(S)	SMA Cable 8121-3321 SN:-25237876
Test Session Details	
Infiniium SW Version	11.70.00013
Infiniium Model Number	MXR608B
Infiniium Serial Number	MY63310272
Debug Mode Used	No
Compliance Limits	OAPMA_P802.3cg (official)
Last Test Date	2025-06-16 11:56:43 UTC +08:00

Summary of Results

Test Statistics	
Failed	0
Passed	2
Total	2

Margin Thresholds	
Warning	< 5 %
Critical	< 0 %

Pass	# Failed	# Trials	Test Name (click to jump)	Actual Value	Margin	Pass Limits
✓	0	1	Transmitter Timing Jitter	374.703 ps	85.0119 %	VALUE < 2.500000 ns
✓	0	1	Transmitter Power Spectral Density (Ext Frq Cls 3)	497 mdBm/Hz	4.97000 %	Overall = Pass

Report Detail

Summary Next

Transmitter Timing Jitter

OAPMA Std 802.3cg™/D3.3 (Section 147.5.4.3 (IEEE))

The maximum jitter at the transmitter side shall be less than 5ns symbol-to-symbol.
Actual Value Measurement Name: Transmitter Timing Jitter (10Base-T1S)
Pass Limits: VALUE < 2.500000 ns

Actual Value	Margin
374.703 ps	85.0119 %

Figure 10-5 Top portion of a typical HTML report

11 Appendix

KEYSIGHT TECHNOLOGIES

Reference Documents

OPEN Alliance / ECU Specifications:
www.opensig.org or
www.ieee802.org

AE6910T/AE6920T Automotive Ethernet Compliance Software:
www.keysight.com/find/AE6910T-SW
www.keysight.com/find/AE6920T-SW

AE6900T Automotive Ethernet Tx Solution:
www.keysight.com/find/AE6900T

Other Keysight Automotive Ethernet Applications and Software

- AE6910T/AE6920T Automotive Ethernet Compliance Software:
  www.keysight.com/find/AE6910T-SW
  www.keysight.com/find/AE6920T-SW
- AE6900T Automotive Ethernet Tx Solution:
  www.keysight.com/find/AE6900T
- AE6900R Automotive Ethernet Rx Compliance Solution:
  www.keysight.com/find/AE6900R
- Keysight AE6910L Automotive Ethernet Channel (Cable and Connector) Compliance software:
  https://www.keysight.com/us/en/lib/software-detail/instrument-firmware-software/ae6910l-automotive-ethernet-lx-compliance-software-and-30day-trial-3133298.html
- D9020AUTP High Speed Automotive Protocol Decode/ Trigger Software (100BASE-T1)
  www.keysight.com/find/D9020AUTP

Keysight Connection Expert - Adding Instrument Using Remote Interface

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

1 Launch your Keysight Connection Expert.

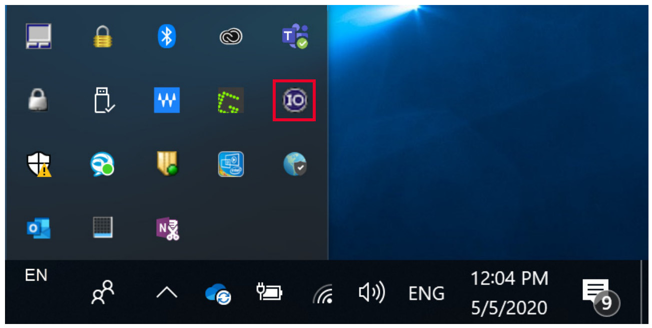


Figure 11-1 Launching the Keysight Connection Expert

2 Click the **+Add** button to add an instrument or interface. In this example, you will be adding a remote USB interface. So, click **+Add** > **Remote USB interface**.

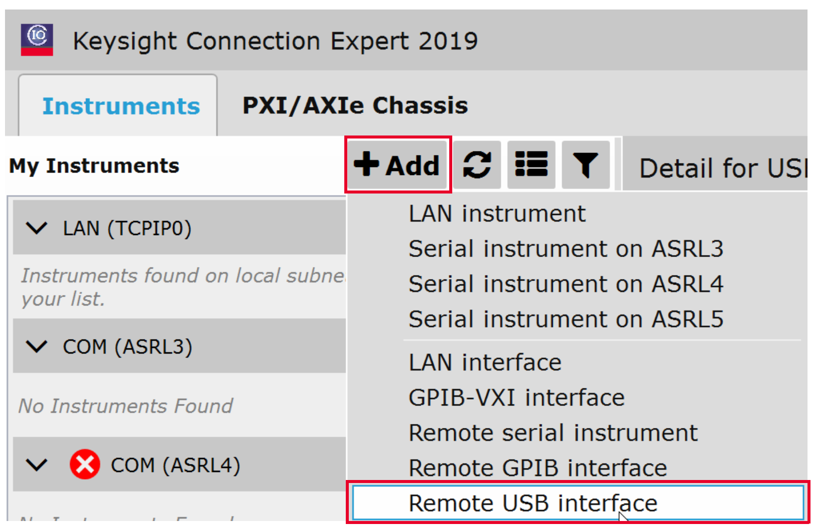


Figure 11-2 Adding a Remote USB interface

3 Enter the Hostname or IP address, then click the **Test Connection** button, you will see the message “Verified”.

4 Click **OK**.

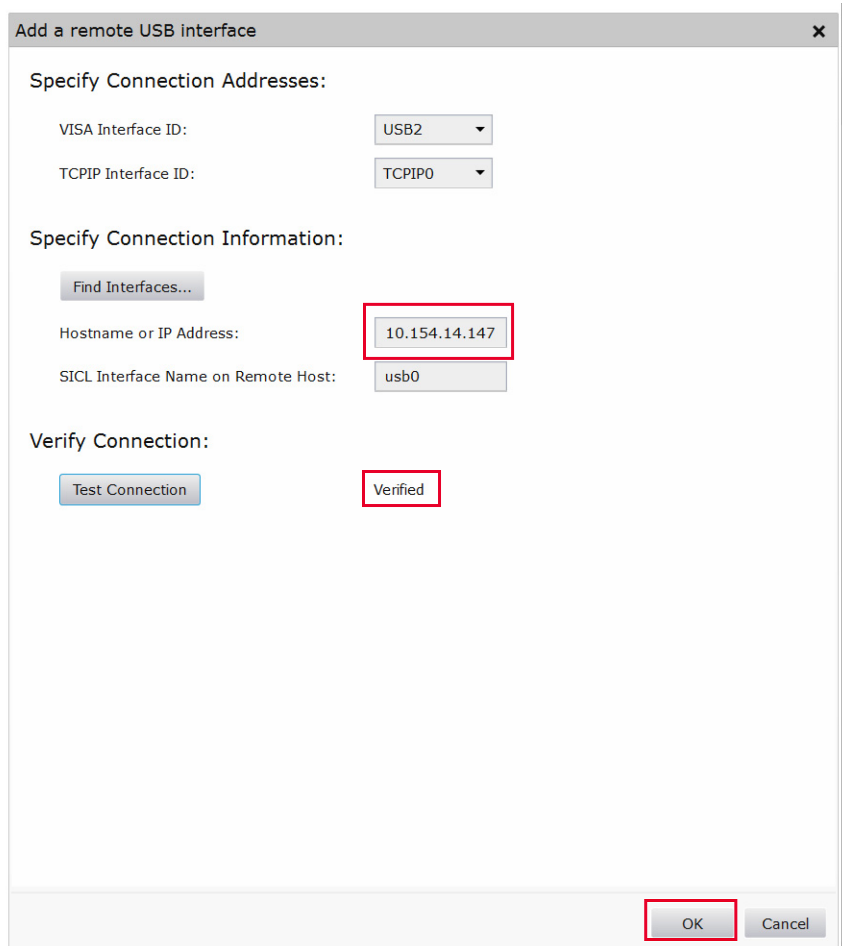


Figure 11-3 Add a remote USB interface

5 You will see the remote USB interface under **Remote USB**.

6 Copy the **SICL Address**. You will need to add this to configure the address of the remote USB interface.

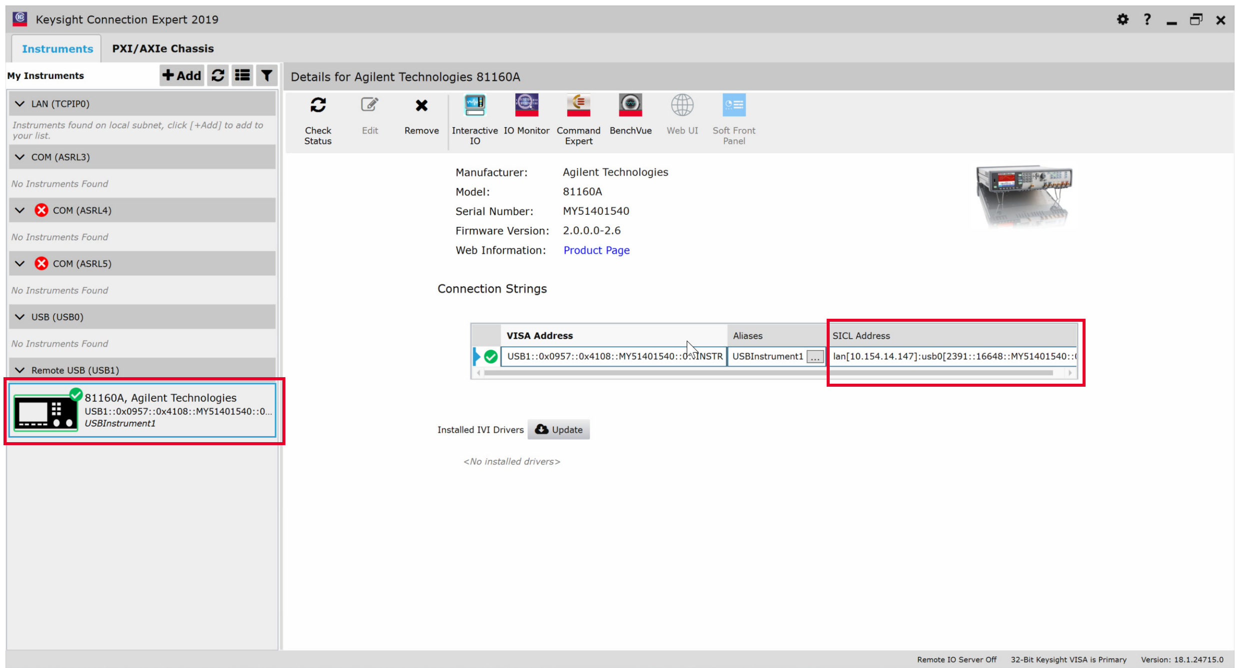


Figure 11-4 Details for the added instrument or interface

Keysight Connection Expert - Adding Instrument using LAN Instrument

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

1 Launch your Keysight Connection Expert as shown in Figure 11-1.

2 Click **+Add** > **LAN instrument**.

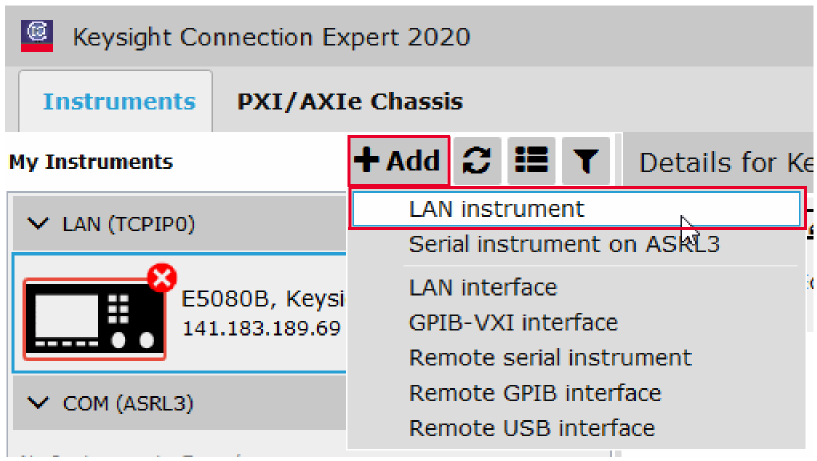


Figure 11-5 Adding a LAN instrument

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**.

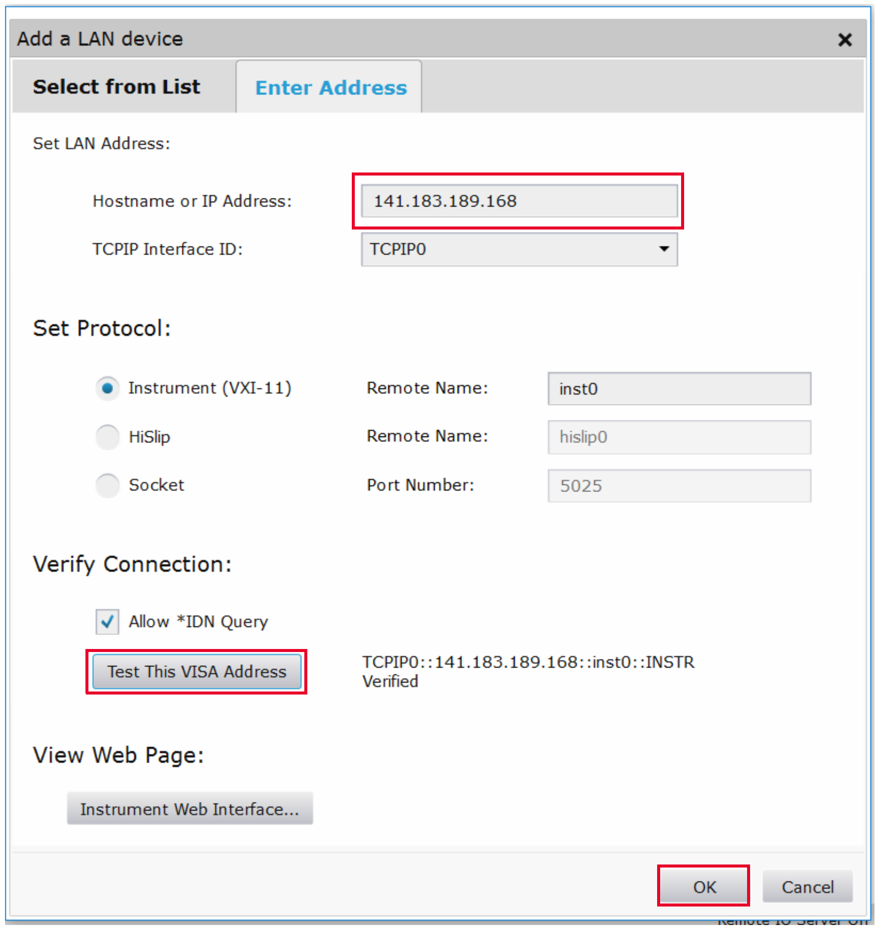


Figure 11-6 Add a LAN instrument

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.

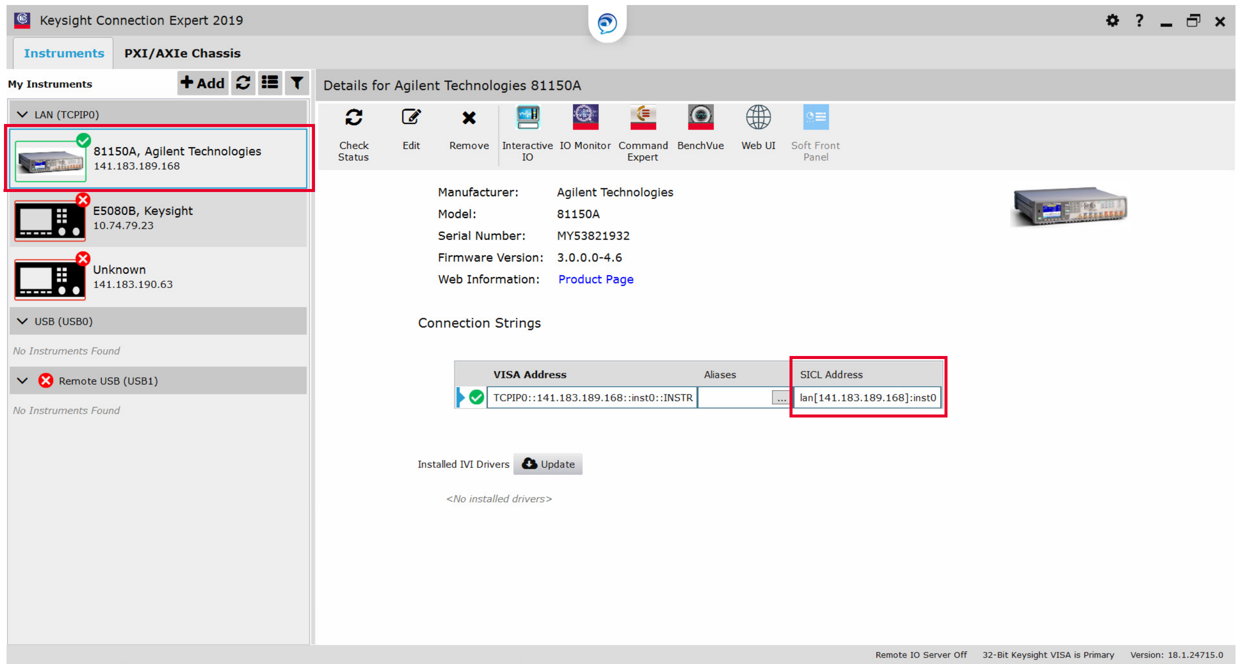


Figure 11-7 Details for the added LAN device

Keysight Connection Expert - Adding Instrument using HiSlip Interface

Perform the following steps on the VNA software followed by the Keysight Connection Expert.

On the VNA software

1 Go to the VNA software > System > System Setup > Remote Interface...
2 Check the HiSLIP checkboxes.
3 Set the Address numbering to your desired number, for instance “0”.

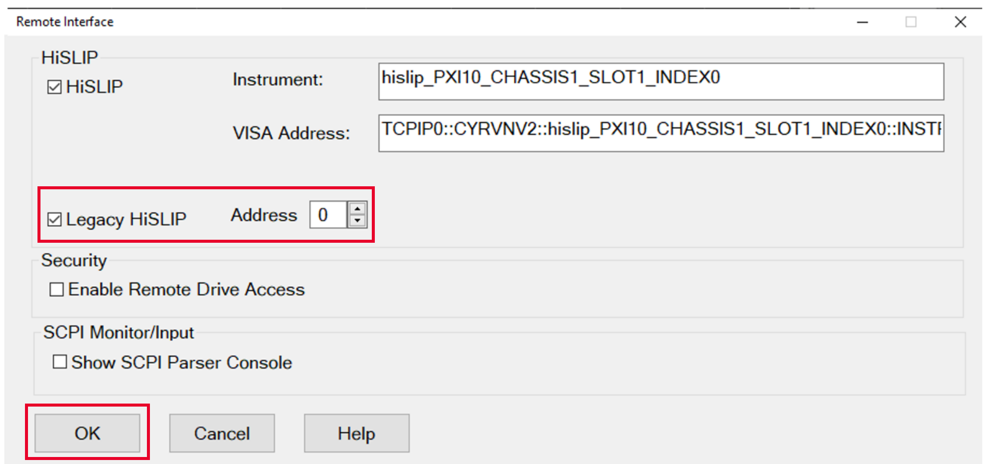


Figure 11-8 Enable HiSLIP on the VNA software

4 Click **OK**.

On the Keysight Connection Expert

On scope, connect to the PC over LAN using the Host PC IP address with following selections.

1 Launch your Keysight Connection Expert as shown in Figure 11-1.

2 Click the **+Add** > **LAN instrument** as shown in Figure 11-5.

3 Select the **Enter Address** tab.

4 Enter the **Hostname or IP Address:** localhost.

5 Under **Set Protocol**, select **HiSlip** and enter the **Remote Name**. Ensure your HiSlip number is the same as the Address numbering you entered above in step 3 on the VNA software, for instance “hislip0”.

6 Under **Verify Connection**, click **Test This VISA Address**.

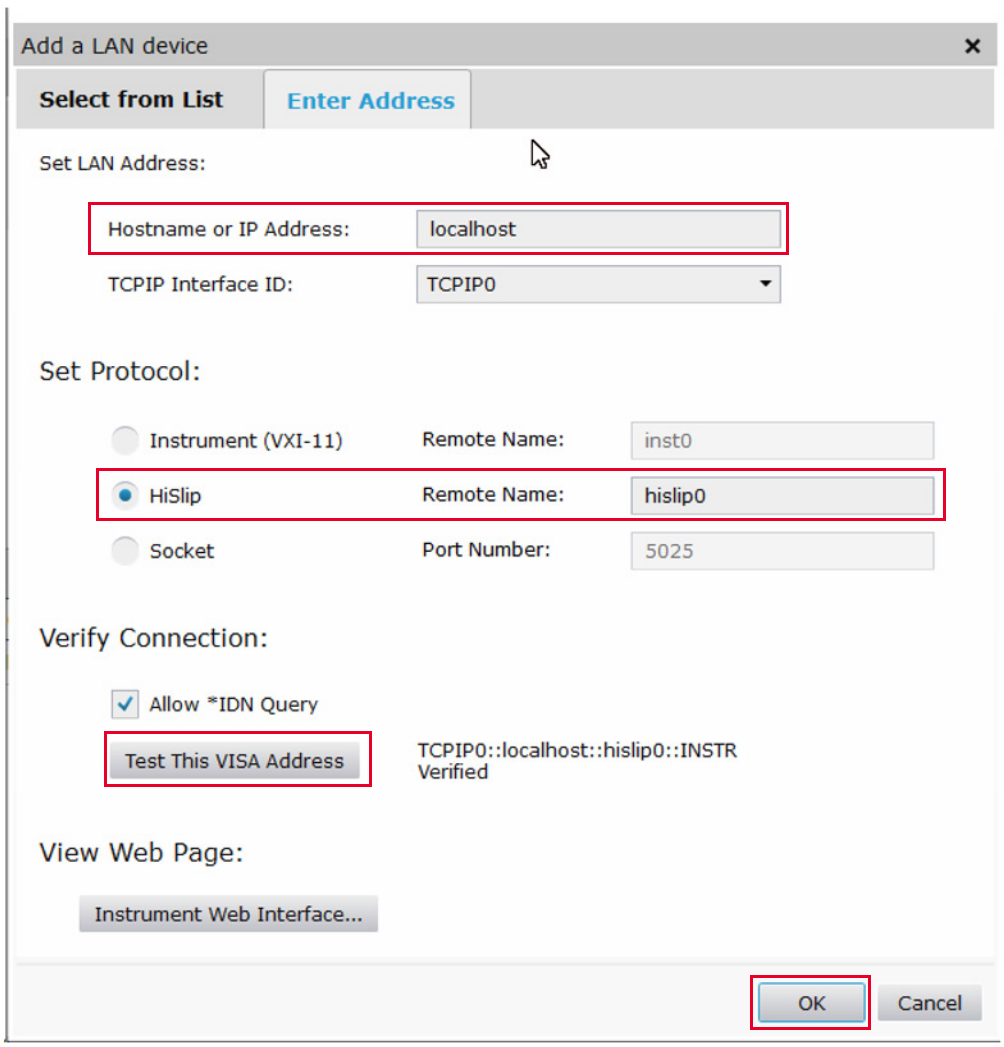


Figure 11-9 Enable HiSlip on Keysight Connection Expert

7 Click **OK**.

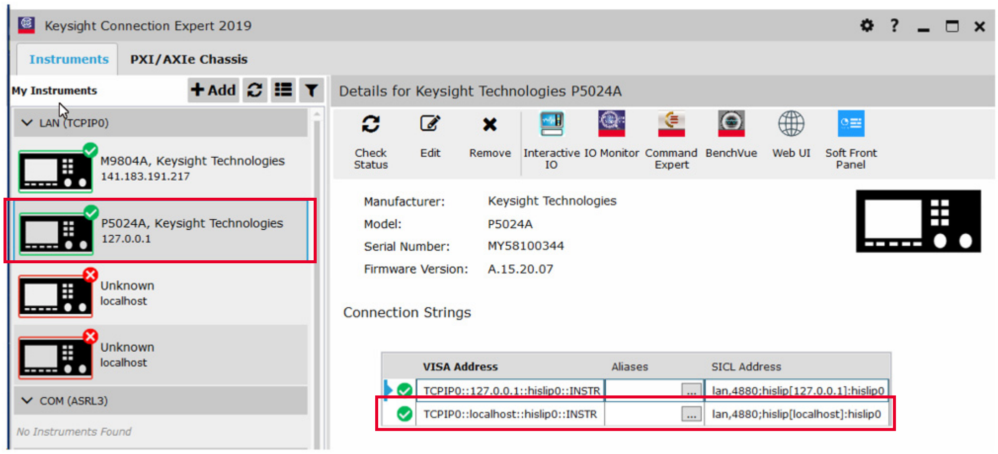


Figure 11-10 Instrument added

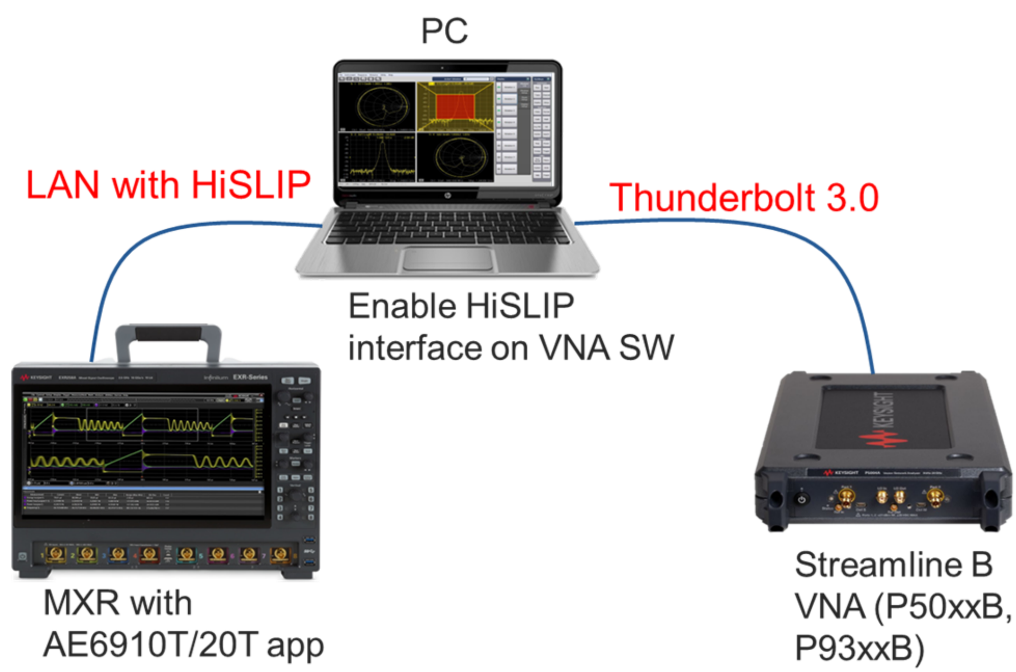


Figure 11-11 PC with Thunderbolt interface to connect the scope and VNA

AE6941A Automotive Ethernet Fixture

This test fixture is designed to work for 100Base-T1 and 1000Base-T1 compliance tests.

The test fixture board is divided into three sections.

Compliance Test Board Section	Description
1	PSD (Power Spectral Density Test)
2	Transmitter/ Distortion
3	Protocol Decode or Receiver Test

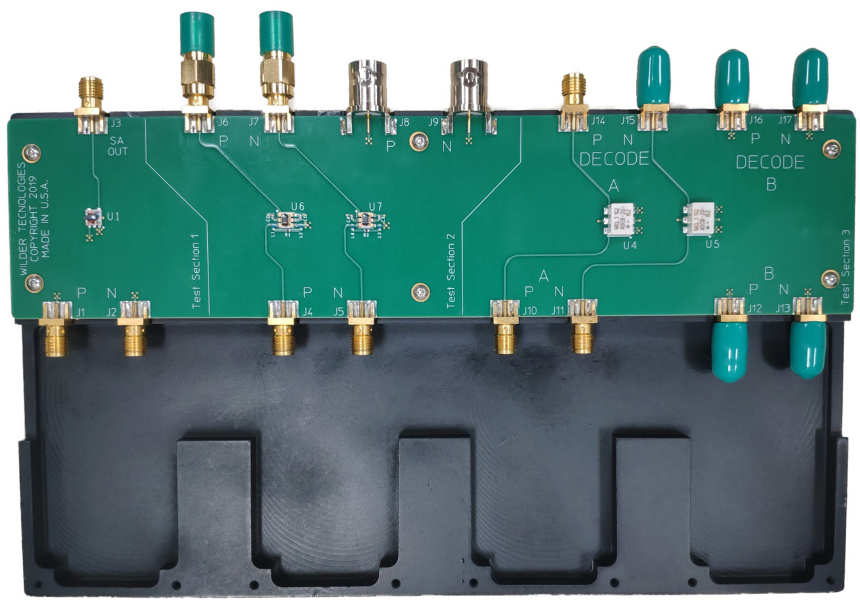


Figure 11-12 AE6941A Automotive Ethernet Fixture

The test fixture can be used with two adapters that are available to purchase separately; the SMA to MATEnet adapter and SMA to Mini-50 adapter as shown below. Optionally, this can be used with AE6965A H-MTD to SMA adapter.

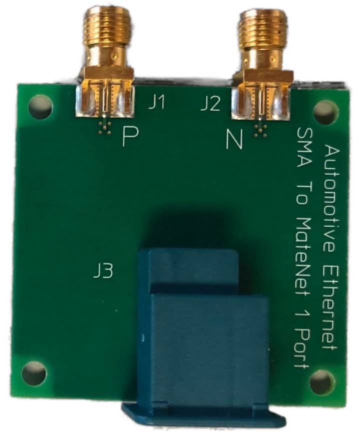


Figure 11-13 SMA to MATEnet adapter

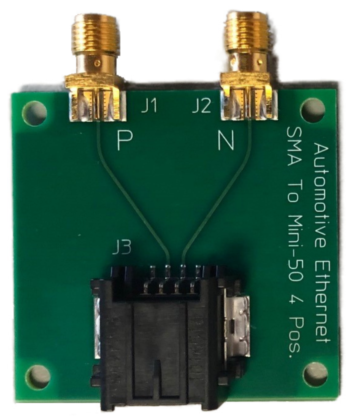


Figure 11-14 SMA to Mini-50 adapter

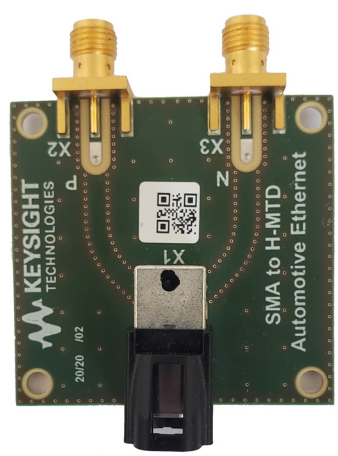


Figure 11-15 SMA to H-MTD adapter

The adapters attach to the AE6941A Automotive Ethernet Fixture are as shown in Figure 11-16. The AE6943A attached to the AE6941A Automotive Ethernet Fixture using the SMA screws provided as shown in Figure 11-16. The AE6943A can be interchanged depending on the DUT interface.

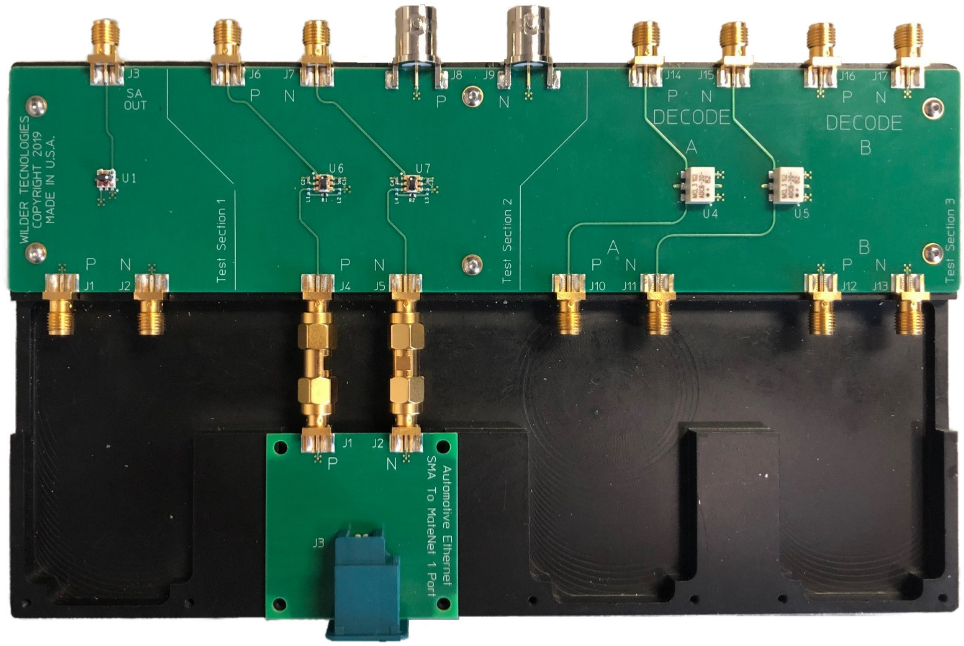


Figure 11-16 AE6941A Automotive Ethernet Fixture with AE6943A adapter

N5395C Ethernet Transmitter Test Fixture

Keysight's N5395C Ethernet 10/100/1G Transmitter Electrical Test Fixture includes a main test fixture board (N5392-66402), a short RJ45 interconnect cable (N5392-61601), and a small Return Loss impedance calibration board (N5392-66401).

Keysight recommends the N5395C Ethernet Test Fixture for the compliance of Test Mode 4. You may use a different, comparable fixture, but is not guaranteed to produce the same result.

Notice that the main Test Fixture board is divided into eight sections plus an area to store jumpers. You do not use all the sections in this demo/evaluation. Refer to Figure 11-17.

Compliance Test Board Section	Description	Compliance Test Mode
1	Differential Return Loss used for RJ45 devices	Conversion from RJ45 to SMA
2	Load & Probes	Not Used
3	100BT Jitter	Not Used
4	Common Mode Output Voltage	Not Used
6	10BT w/o TP Model	Not Used
7	10BT with TP Model	Not Used
10	Balun	Power Spectrum Density Test
11	Disturbance/Distortion	Transmitter Distortion Test

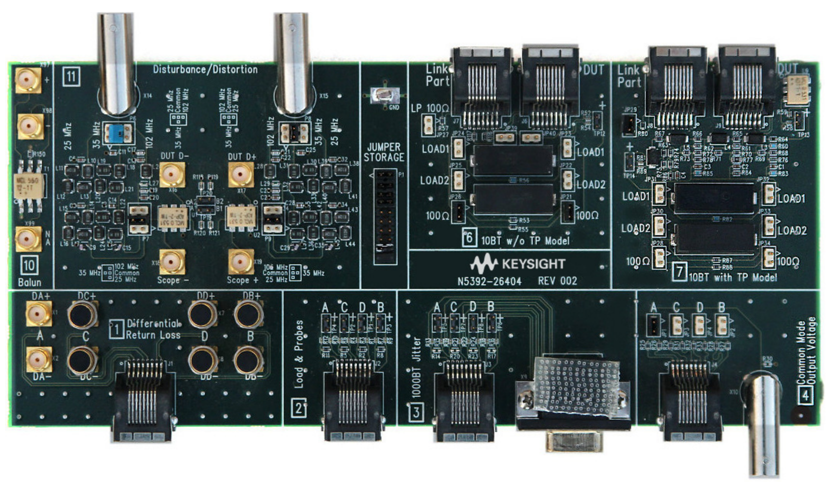


Figure 11-17 N5395C Ethernet Electrical Transmitter Test Fixture

Distortion Test Jumper Settings

Figure 11-18 shows the jumper positions for the Ethernet Test Fixture Section 11 applicable for various frequencies.

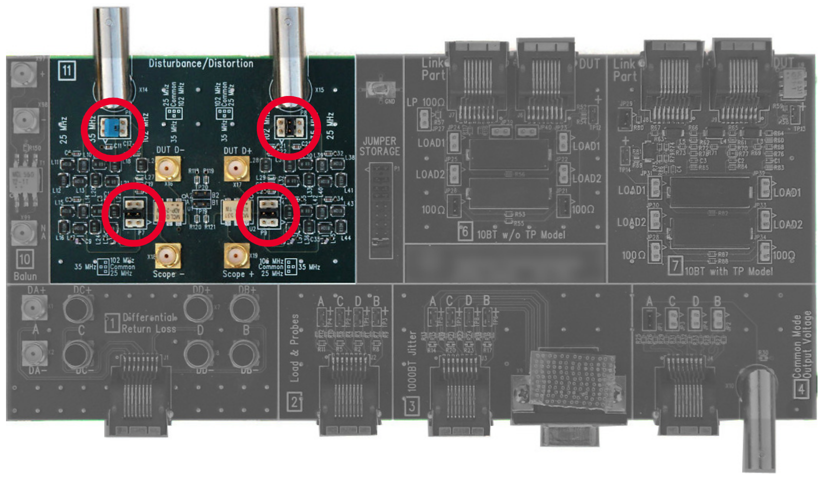


Figure 11-18 Section 11 on the Ethernet Test Fixture

For 100M and ECU:

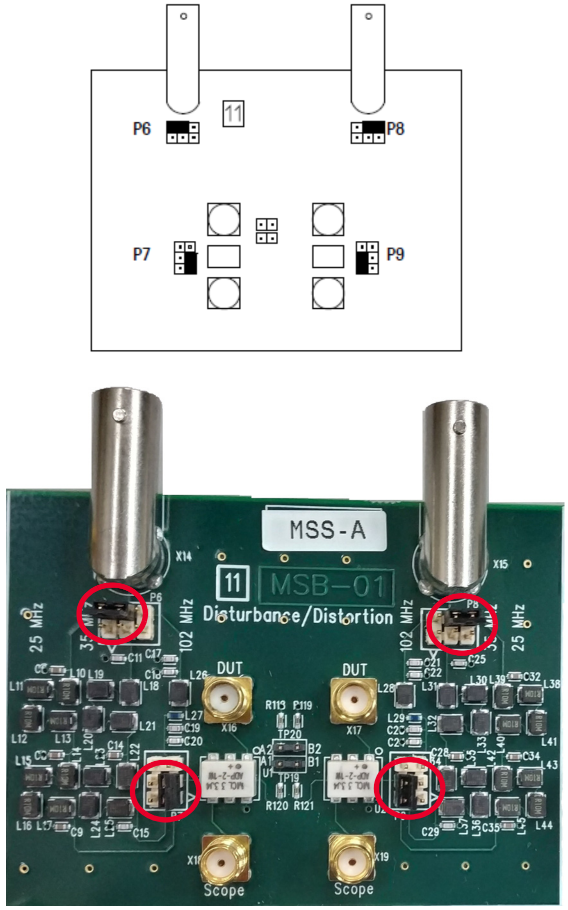


Figure 11-19 Jumper Location for 100M and ECU

For 1000M:

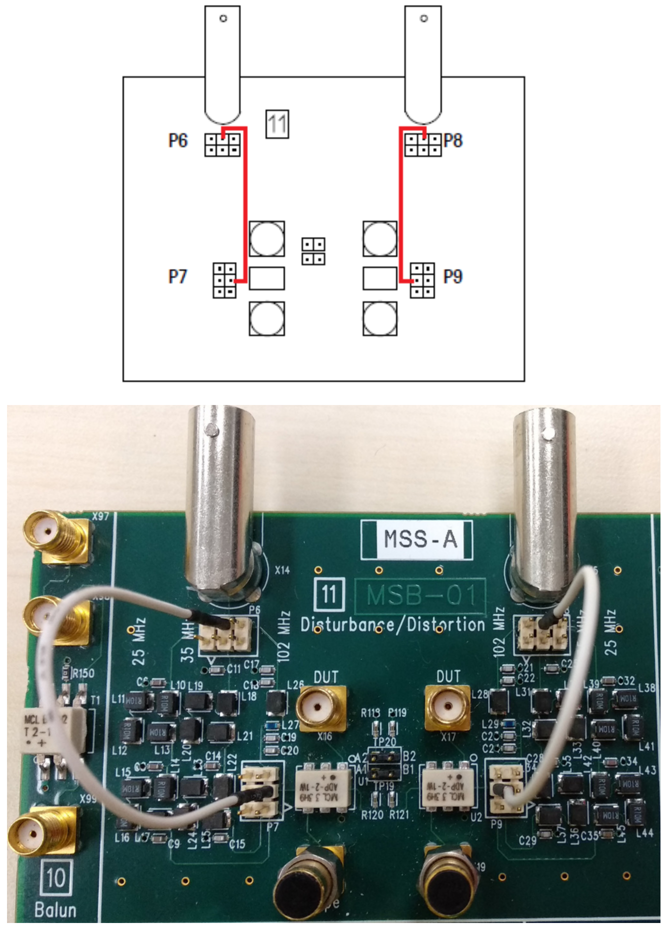


Figure 11-20 Jumper Location for 1000M

Configuring External Instruments

For each test, the Infiniium oscilloscope automatically configures any external instruments (AWG, E5080B Vector Network Analyzer, and N9010B EXA Signal Analyzer) as required for the test. To do this, however, the oscilloscope must know the SICL address of each instrument. The External Instruments **Status** indicator is red if the instruments are not properly configured.

NOTE

Connect the instruments to the oscilloscope before configuring them. The connection is generally through a USB connection.

Note that the 33250A AWGs require an 82357B USB/GPIB interface. You must configure the Master and Slave 33250A AWGs separately.

1 On the AE6910T/AE6920T Compliance Test Application's **Set Up** tab, click the **Signal Source Configure** button.

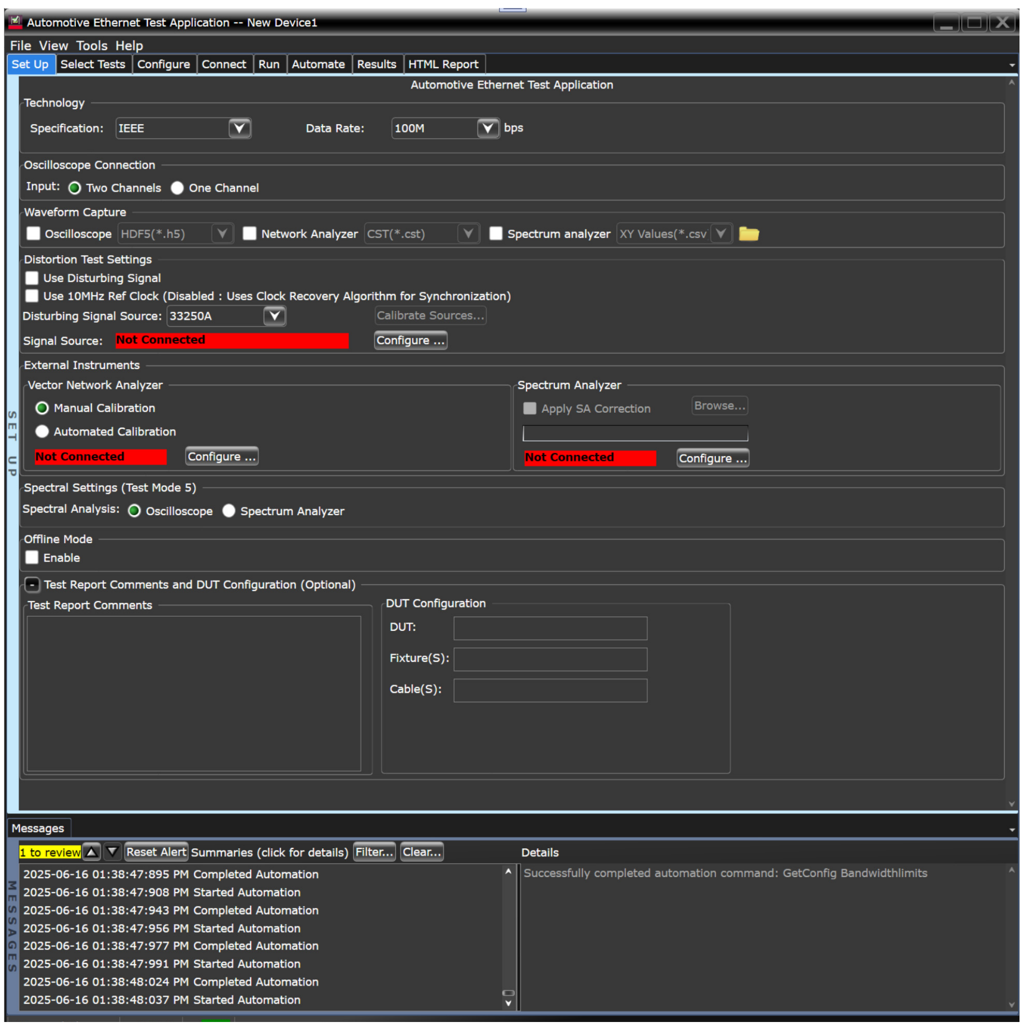


Figure 11-21 ECU Compliance Test Application Set Up Tab

There are three available external instrument configurations; Vector Network Analyzer, Spectrum Analyzer, and Signal Source (AWG).

1 Clicking the **Configure** button opens the **External Instruments List** dialog box. Kindly take note that the **find** and **clear** functions are available under the Action column.

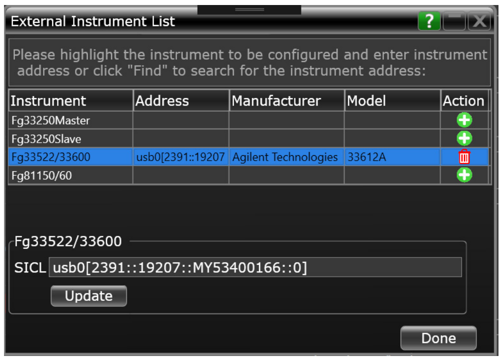


Figure 11-22 External Instrument List

2 Add instruments or interfaces to Keysight connection expert by following the steps listed as follows. Refer to Keysight Connection Expert help file for connection steps for other interfaces.
- "Keysight Connection Expert - Adding Instrument Using Remote Interface" on page 181
- "Keysight Connection Expert - Adding Instrument using LAN Instrument" on page 184
- "Keysight Connection Expert - Adding Instrument using HiSlip Interface" on page 187

3 Select the AWG to use in your system. For the AE6900T Solution, you can select any of the AWG. For example, **Fg33522/33600**.

4 Provide the SICL address:
- If you know the SICL address (you can use K*eysight IO Libraries Suite Connection Expert* utility to obtain the SICL address), enter it in the **SICL Address** field.
- If you do not know the SICL address, click the button (under the **Action** Column), and the Compliance Test Application will attempt to locate and identify the AWG.
- To clear the selected instrument details, click the button.

5 Clicking on the ⊕ button, pops up a new window, "Detected Instrument" displaying values captured from the connected instrument.

Figure 11-23 Detected Instrument

6 Click the "Refresh" button for application to attempt to locate and identify the AWG.

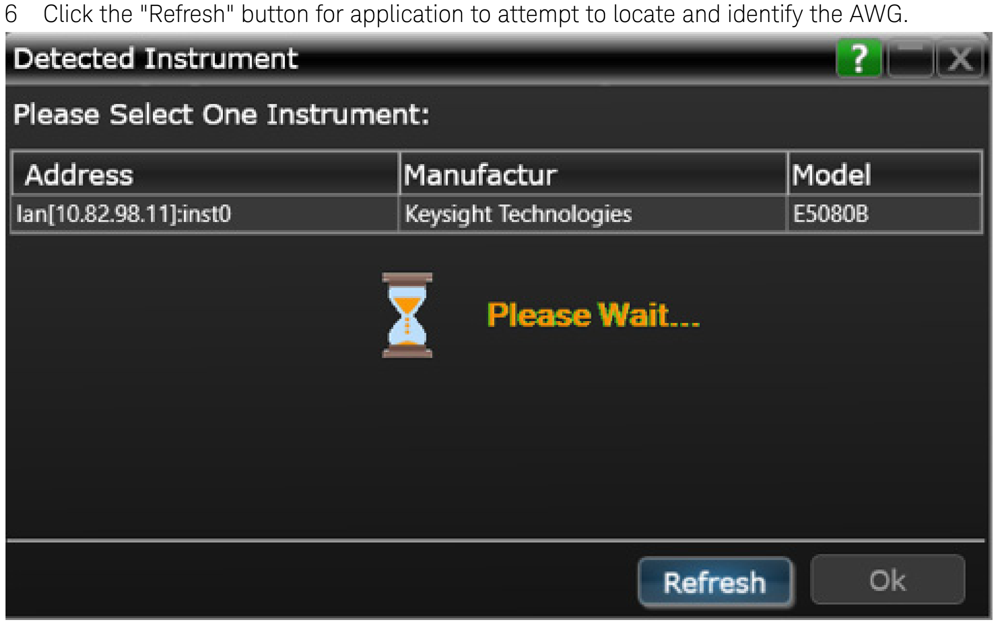


Figure 11-24 Detected Instrument

7 Highlight the instrument in Detected Instrument dialog box and click the OK button for adding the instrument to External instrument window.

Figure 11-25 Adding the instrument to External instrument window.

8 When adding instrument from "Detected Instrument" to "External Instrument List" window based on the Model, if a wrong model is selected for the corresponding instrument, error window will pop up.

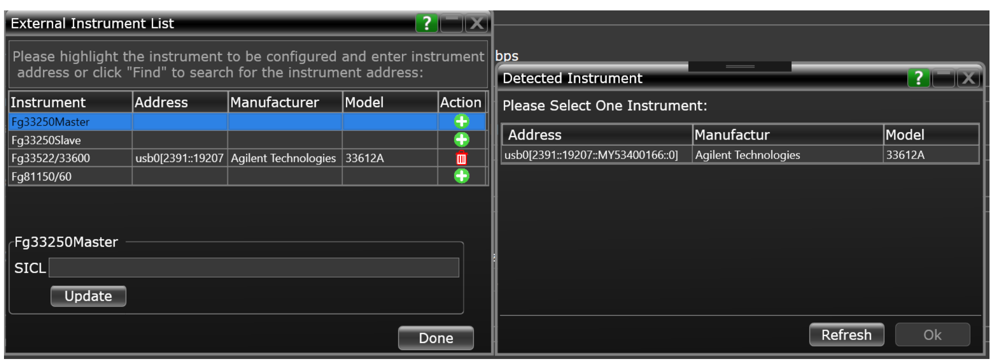


Figure 11-26

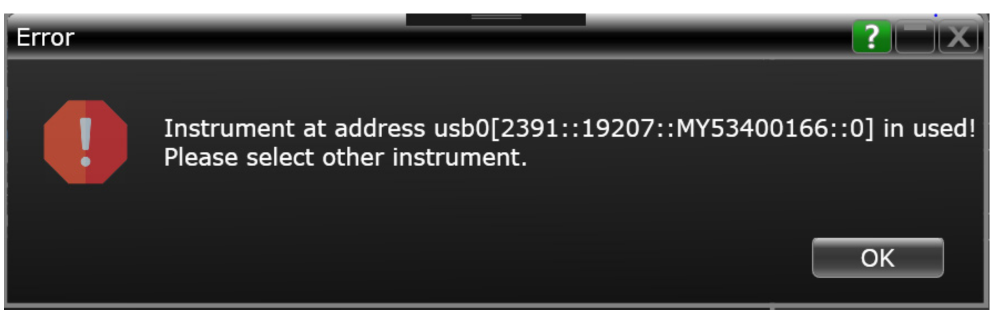


Figure 11-27

9 Click the **Update** button, which enables the **Identify** button.

10 Click the **Identify** button. Then, you will need to wait for a few seconds for the instrument's **Manufacturer** and **Model** to be populated.

11 Repeat step 2 to step 10 for the E5080B Vector Network Analyzer and the N9010B EXA Spectrum (or Signal) Analyzer by selecting the configure buttons on the Vector Network Analyzer and Spectrum Analyzer external instruments section.

12 Upon completion, click the **Done** button to return to the **Set Up** tab. An information window will pop up on the bottom right side corner of the application with message "Model is connected".

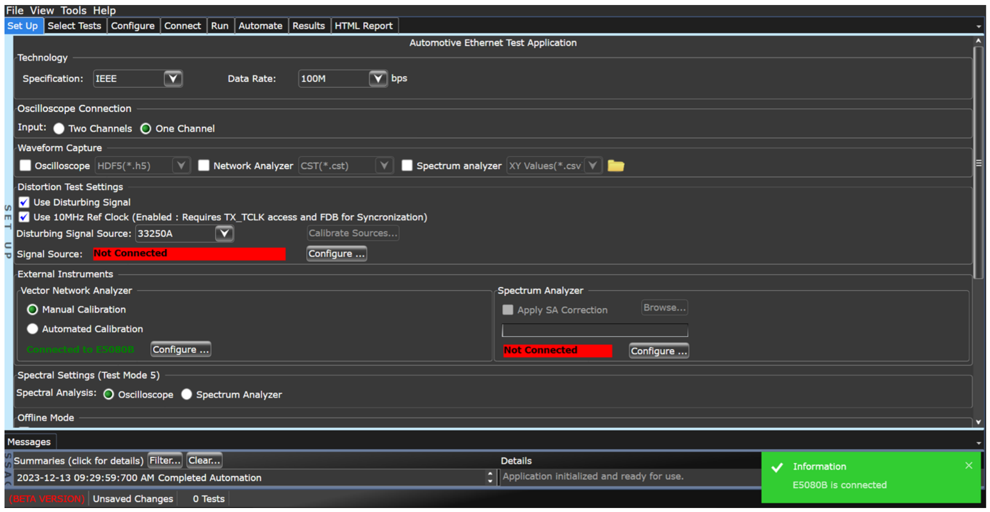


Figure 11-28 Model Connected Information pops up

13 The Signal Source **Status** indicator turns green to indicate that all external instruments are configured properly, as shown as follows.

Figure 11-29 Signal Source connected

NOTE

If the DUT is designed based on the IEEE standard for either 10BASE-T1S, 100BASE-T1, 1000BASE-T1, 2.5GBASE-T1, 5GBASE-T1, or 10GBASE-T1, then it supports Data Rate of 10 Mbps, 100 Mbps, 1000 Mbps, 2.5 Gbps, 5 Gbps, or 10 Gbps. By default, the 100 Mbps is selected.

If the DUT is designed based on the Open Alliance standard for TC8 ECU, then it only supports Data Rate of 100 Mbps.

AWG selection varies depending on the standard and the data rate selected.

Calibrating External Instruments

Calibrate all instruments before running the compliance tests. The Compliance Test Application guides you in calibrating the AWG and the VNA.

Calibrating the AWG

Before running disturbing signal tests, calibrate the AWG(s). Once calibrated, connect the equipment depending on the AWG used.

For AE6941A:

- When using a 33622A AWG, see Figure 3-7 on page 63.
- When using two 33250A AWGs, see Figure 3-8 on page 64.
- When using an 81150A/81160A ANG, see Figure 3-9 on page 64.

For N5395C:

- When using a 33622A AWG, see Figure 3-10 on page 65.
- When using two 33250A AWGs, see Figure 3-11 on page 65.
- When using an 81150A/81160A ANG, see Figure 3-12 on page 66.

NOTE You must configure The AWG Disturbing Signal Source before attempting to calibrate it. If the system is not physically configured to perform the calibration, you will not be able to click the Calibrate Sources button. Refer to "Configuring External Instruments" on page 197.

NOTE Instead of connecting SMA to SMA cables on the N5395C Evaluation Board, connect 50 Ω terminators to the two scope SMA connectors on the Evaluation Board. Figure 11-33 shows this connection.

AE6941A Fixture Connection Setup

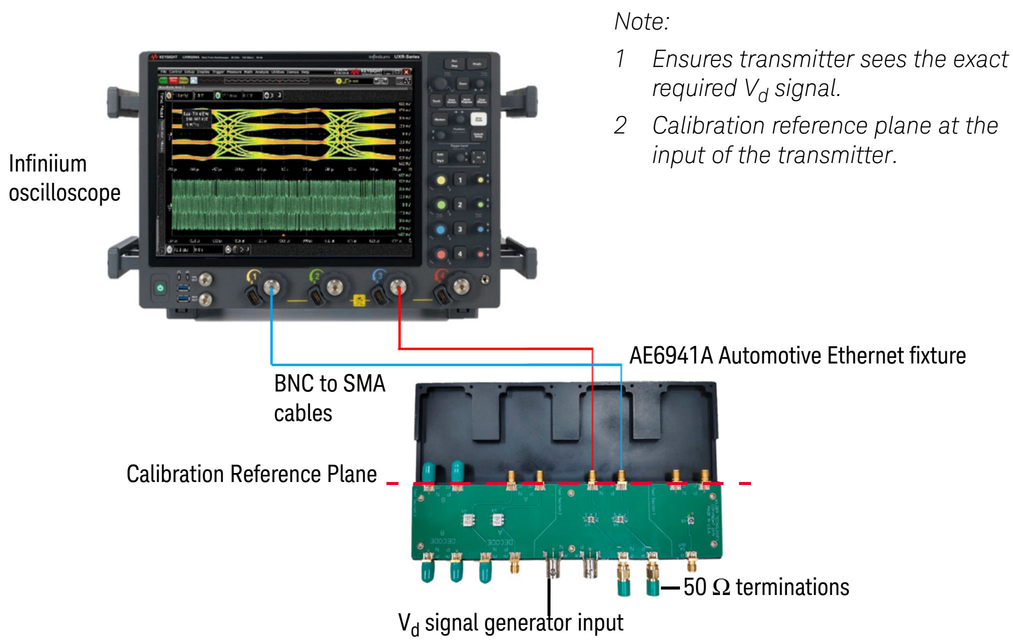


Figure 11-30 AWG Calibration Setup for the Disturbing Signal Source with AE6941A

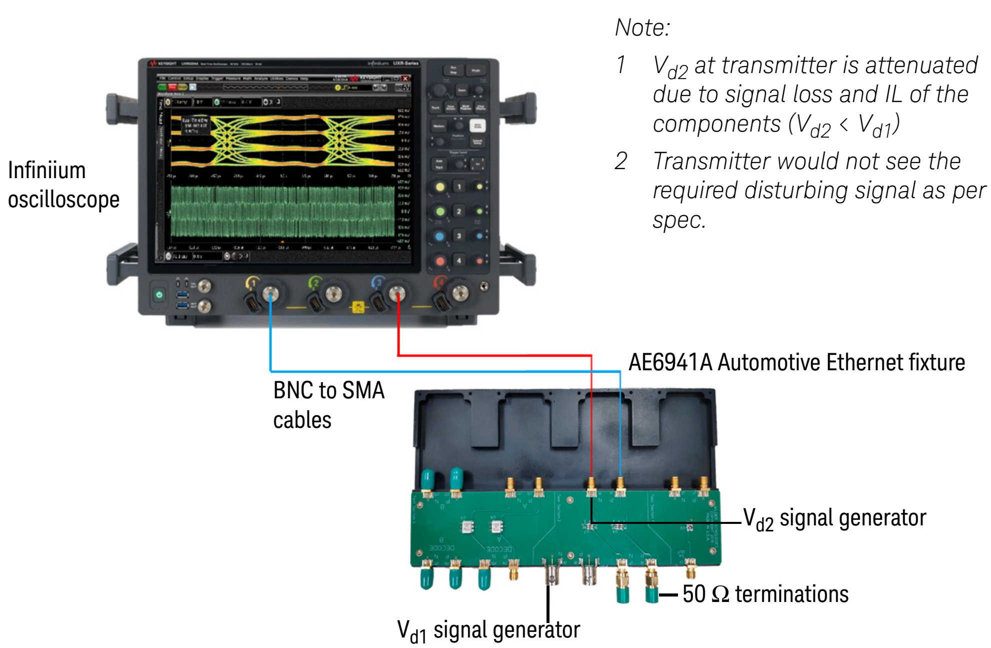


Figure 11-31 AWG Calibration Setup for the Disturbing Signal Source with AE6941A

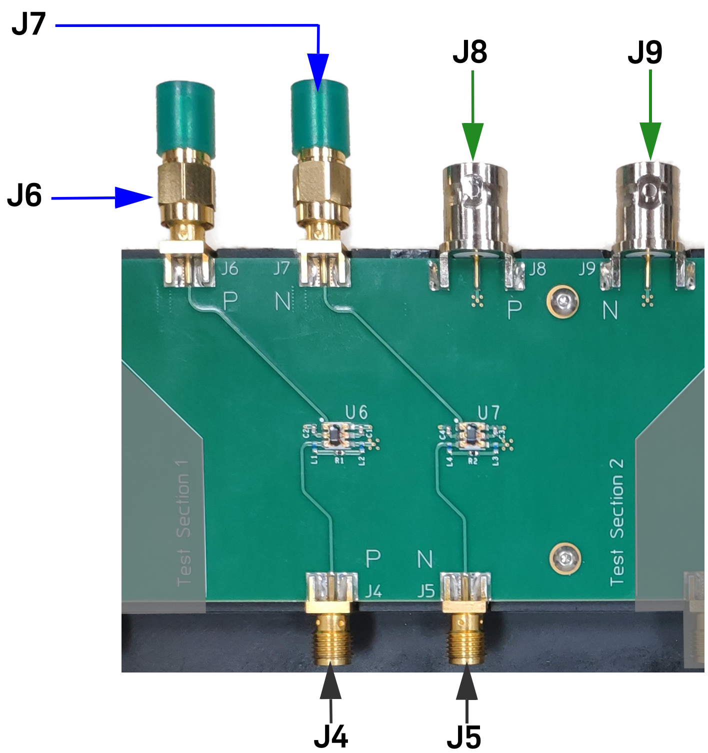


Figure 11-32 AE6941A Connection Setup

Follow the following steps to set up the connection.

1. Connect AWG Channel 1 to J8(P).
2. Connect AWG Channel 2 to J9(N).
3. Connect 50Ω Terminators to J6(P) and J7(N).
4. Connect J4(P) to Oscilloscope CHAN 1*.
5. Connect J5(N) to Oscilloscope CHAN 4*.

NOTE

* User selection determines the Oscilloscope channel in use.

N5395C Fixture Connection Setup

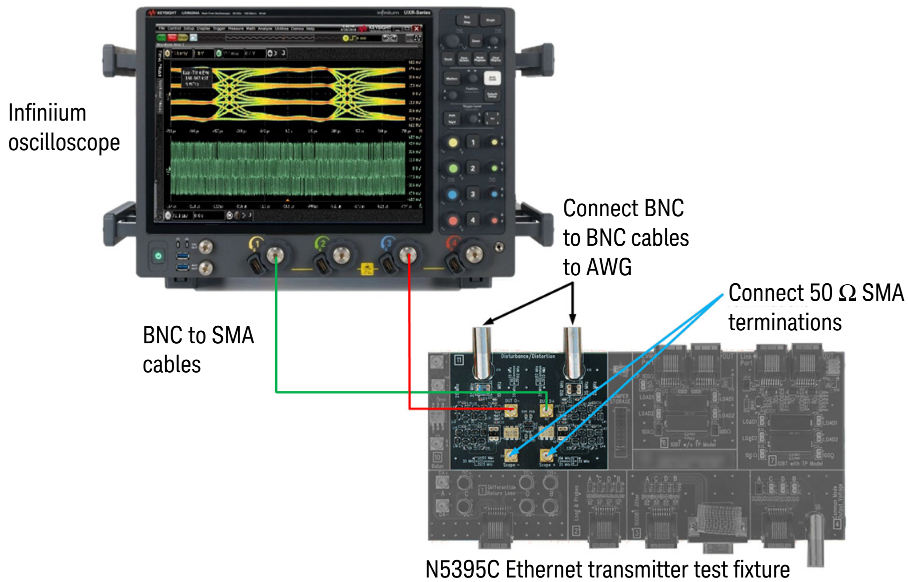


Figure 11-33 AWG Calibration Setup for the Disturbing Signal Source with N5395C

N5395C Connection Setup

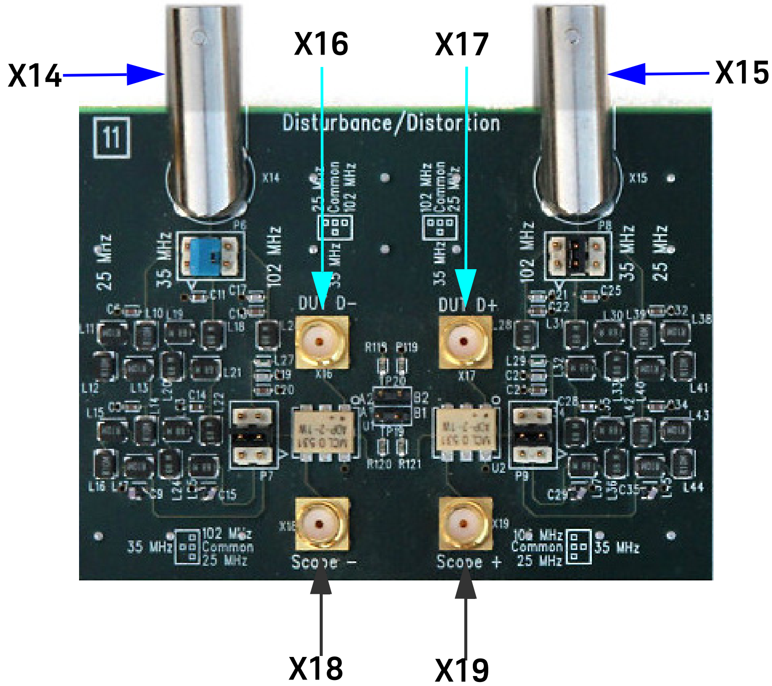


Figure 11-34 AE6941A Connection Setup

Follow the following steps to set up the connection.

1 Connect AWG channel 1 to X14.
2 Connect AWG channel 2 to X15.
3 Connect 50Ω terminators to X18 and X19.
4 Connect X16 to Oscilloscope CHAN1*.
5 Connect X17 to Oscilloscope CHAN4*.

NOTE * User selection determines the Oscilloscope channel in use.

Performing the AWG Calibration for the Disturbing Signal Source

1 On the AE6910T/AE6920T Compliance Test Application's **Distortion Test Settings** section tab, click the drop down menu and choose the appropriate source.

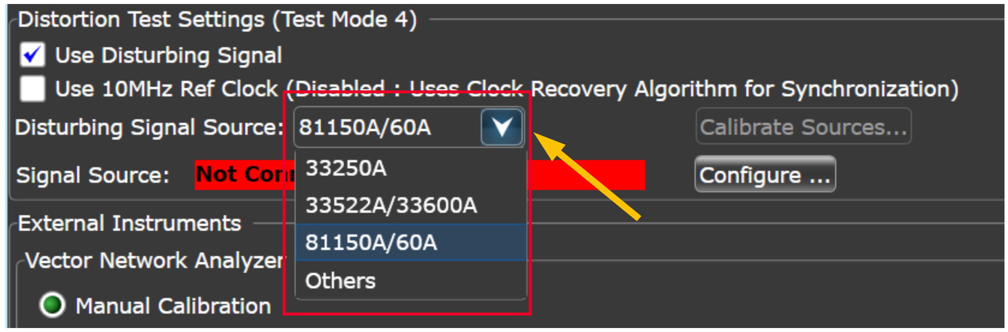


Figure 11-35 Disturbing Signal Source

2 Configure the **Signal Source**. Refer to "Configuring External Instruments" on page 197.

3 Click the **Calibrate Sources** button. This opens the **Calibrate Disturbing Signal** dialog box for the selected AWG.

Figure 11-36 AWG Calibration Setup for the Disturbing Signal Source

4 With the appropriate AWG Address set and the correct oscilloscope channels selected, click the **Calibrate** button to start the calibration process.

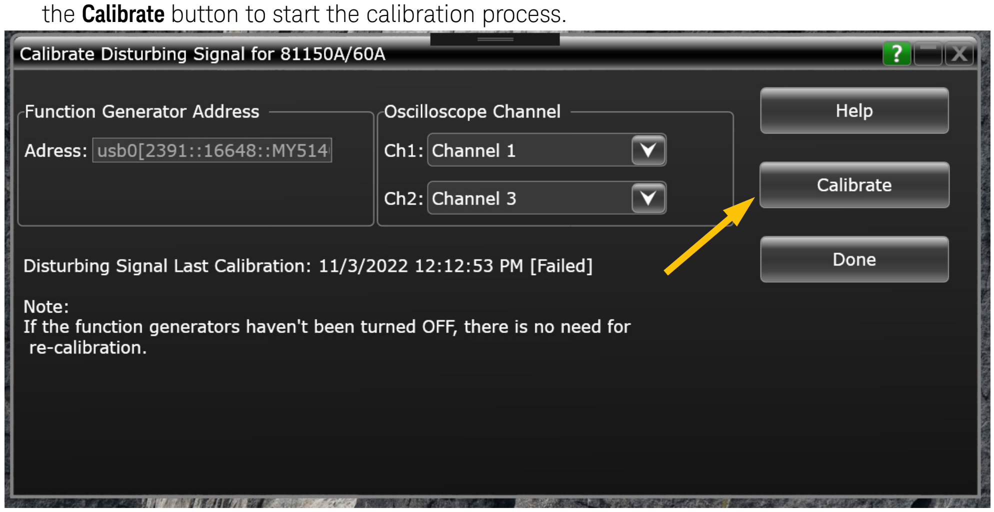


Figure 11-37 Calibrate Disturbing Signal Source for 81150A/60A

5 When the software finishes the calibration, click the **Done** button to return to the Set Up tab. Refer to the AE6910T/AE6920T online help for a more detailed explanation.

Calibrating the VNA

You have an option to either perform a manual calibration or an automated calibration. By default, manual calibration is selected.

Manual Calibration

Before using the VNA, you must calibrate it using the N4431B Ecal Kit (or similar Ecal Kit). See Figure 11-38 for the connection diagram. Calibrate the VNA using the instructions in the VNA's user guide.

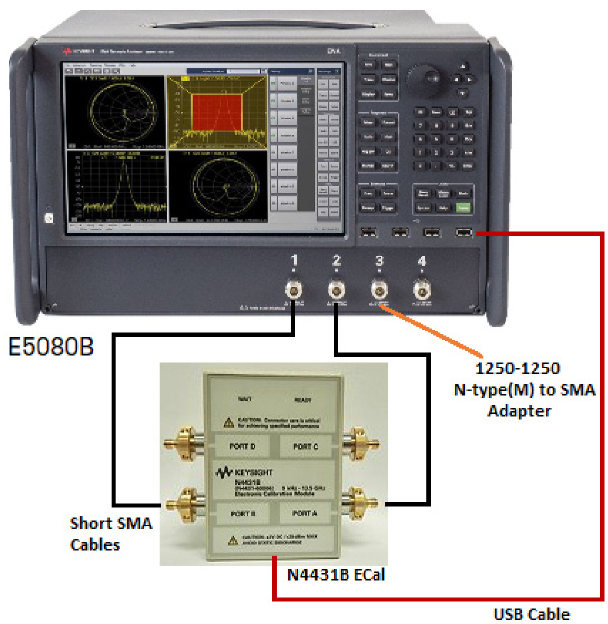


Figure 11-38 VNA Calibration Setup Connection

1. Connect the USB port on the Ecal module with the USB port on the E5080B via a USB cable. You may perform this connection while the E5080B's power is on.
2. Allow the Ecal module to warm up for 15 minutes until the module indicator changes from **WAIT** to **READY**.
3. Connect port A and port B on the Ecal module to the VNA's test ports (using SMA cables) to be calibrated. Use the N-type (M) to SMA Adapter to easily connect to the SMA cables.
4. Press **Channel Next**/**Channel Prev** keys to select the channel for which you want to perform the calibration.
5. Click **Ecal**.
6. Click **2 Port Ecal**.
   - When using a 2-port E5080B, pressing this key performs a 2-port Ecal.
   - When using a 3-port or 4-port E5080B, click one of the softkeys to start a full 2-port calibration.

7 The following is a list of setup requirements before running the calibration routine.
- Set **Measurement** to either **Sdd11** or **Sdc11** depending on test.
- Set **Start** to **0.3 MHz**. (Frequency may vary depending on the tests. Refer to the individual test information).
- Set **Stop** to **1 GHz**. (Frequency may vary depending on the tests. Refer to the individual test information).
- Set **Format** to **Log Mag**.
- Set **Sweep Type** to **Logarithmic**.
- Set **Points** to **1600**.
- Set **Output Power** to **0 dBm**.
- Set **Measurement Bandwidth** to **100 Hz**.

NOTE

If you are using the E5080B in Manual Calibration mode, you will need to set the E5071C Code Emulator. Refer to “Code Emulator for E5071C” on page 213.

When using a E5080B, as a first choice, use the automated calibration and test instead of the code emulator whenever possible.

Automated Calibration

The following steps detail how to perform an Automated Calibration. Refer to Figure 11-39 for the VNA calibration setup.

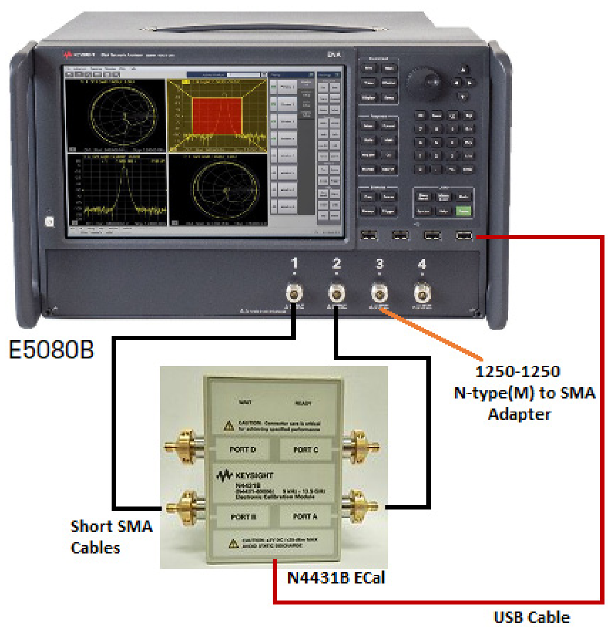


Figure 11-39 VNA Calibration Setup Connection

1 Configure the VNA. Refer to “Configuring External Instruments” on page 197.
2 Ensure that the status shows that it is connected to the E5080B (or supported models).
3 Select **Automated Calibration** and the **Calibrate** button appears.

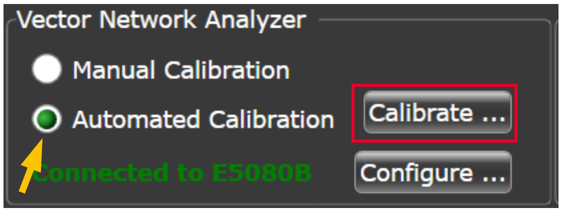


Figure 11-40 Select Automated Calibration

4 Click **Calibrate** to launch the **VNA Calibration Setup** window. By default, it populates the recommended parameter settings. However, you have the option to edit the parameters as you see fit.

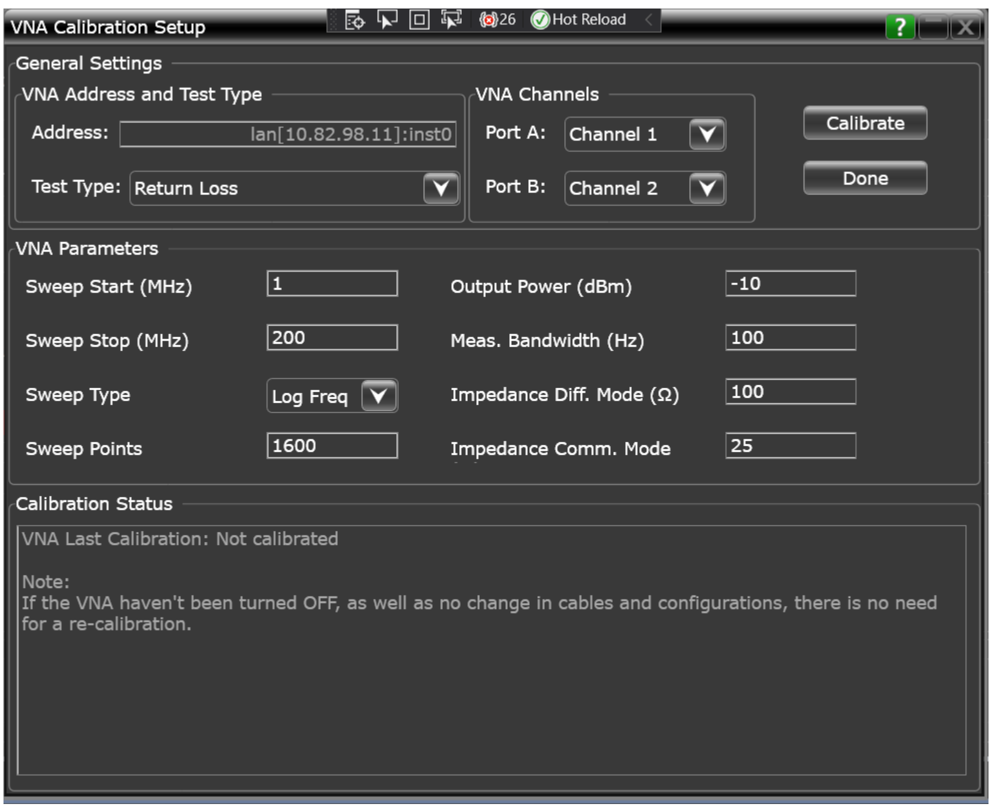


Figure 11-41 VNA Calibration Setup parameter settings

5 Once you finalize the parameters, click the **Calibrate** button to start the calibration process.

Figure 11-42 VNA Channels

6 This action starts the calibration process. The connection prompt appears for you to make connections as well as to confirm the connections made. Once done, select **I have completed these instructions**. The selection will change from Orange to Green. Click **Next** to initiate the process.

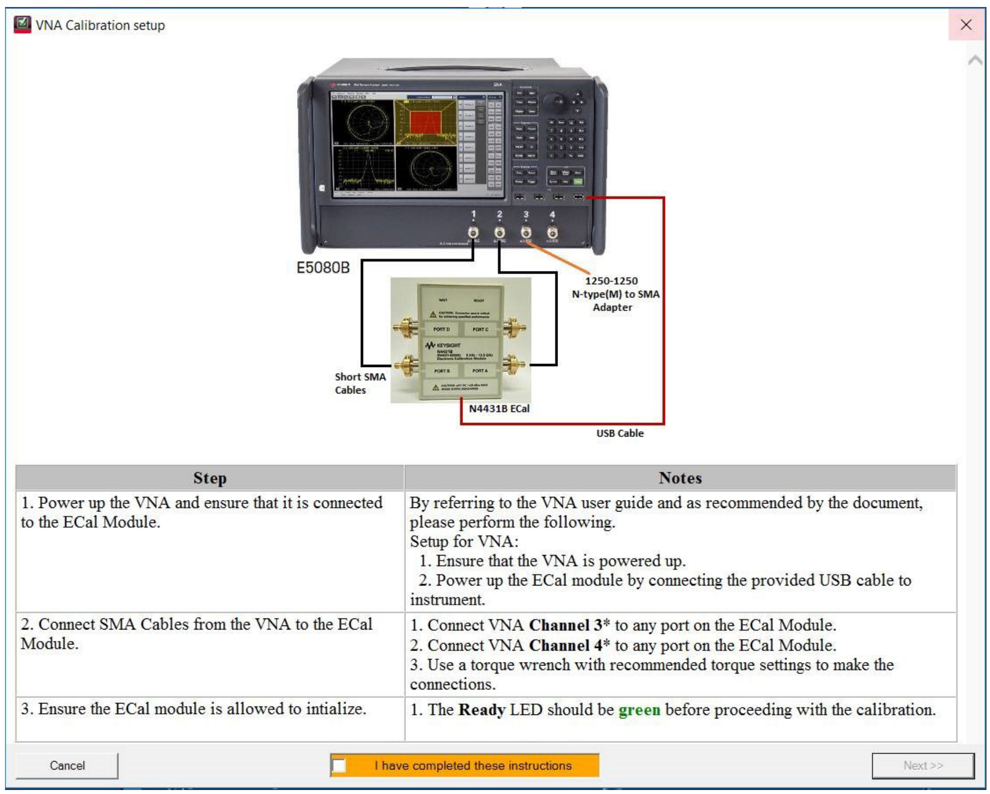


Figure 11-43 VNA Calibration Setup

7 Depending on the selected parameters, the calibration time may vary. Once the calibration is done and completed, the **Calibration Status** box will reflect the date and time, as well as the calibrated test and parameters.

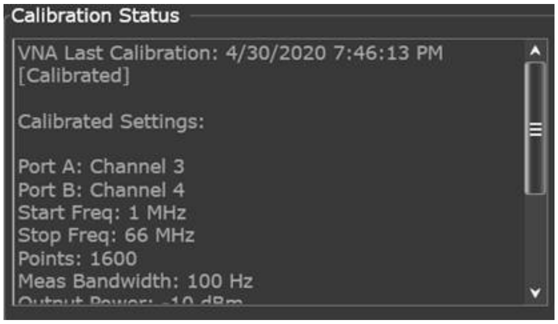


Figure 11-44 Calibration Status Box

8 The calibration is now complete, and you can proceed to select the test and run it accordingly.

Aborting Calibration

If an automated calibration has started, and you would like to cancel or abort it, follow the following steps.

1 Click the **Stop Calibration** button.

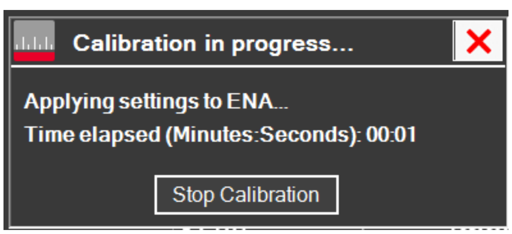


Figure 11-45 Calibration in progress - Stop Calibration

2 Click the **Abort** button on the VNA Graphical User Interface.

Figure 11-46 Abort Sweep

These actions cancel the initiated user calibration.

Code Emulator for E5071C

The E5071C code emulation mode is for remote controlling the VNA with test programs written for the E5071C ENA Series network analyzer. In the E5071C command emulation mode, the VNA firmware translates the incoming E5071C SCPI commands and executes the VNA's equivalent command(s).

How to use the code emulator

The following steps describes how you can use the code emulator.

1 Select **System** > **System Setting** > **Code Emulation** > **5071** to display the following dialog box.

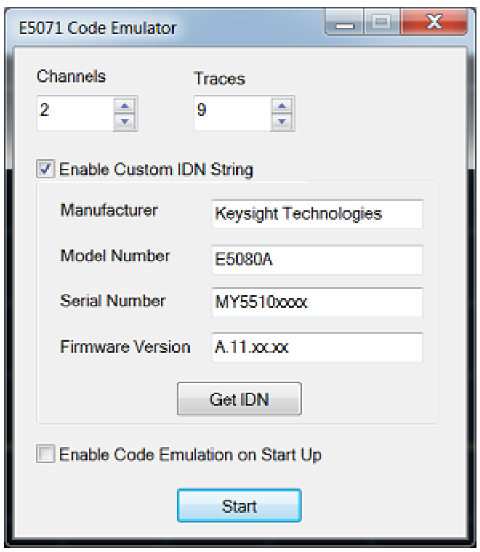


Figure 11-47 E5071 Code Emulator

2 Select the required number of **Channels** and **Traces** for your measurement.

3 Specify the IDN string if you want to modify it. The *IDN? returns the value you set.

4 If you want to start with the Code Emulator at the next VNA application start-up, check the **Enable Code Emulation on Start Up** checkbox.

5 Click the **Start** button. Upon clicking it, the **Start** button changes to **Exit**.

6 The dialog box “To quit the emulation mode requires you to exit the VNA application. Do you want to continue?” is displayed. Click **Ok**.

7 The E5080A/B is preset, but you can set the number of traces and channels.

8 Execute your program in the E5071C commands thorough GPIB, USB, or LAN.

9 To quit the emulation mode, press **Exit** on the dialog box in Figure 11-47.

NOTE When using a E5080B, as a first choice, use the automated calibration and test instead of the code emulator whenever possible.

Equation Editor

For models like the E5061B that do not support differential measurements like S_{dd11} or S_{dc11}, the application automatically configures the VNA and sets up the equation editor to effectively make the required measurements.

However, you will still need to calibrate the equivalent single-ended measurements manually prior to running tests.

You can look up the equation editor content of the VNA for more details. By clicking on the following link then searching for “Equation Editor” will display all the relevant content for the E5061B.

www.keysight.com/find/E5061B

For Automotive Ethernet, the equivalent S_{dd11} and S_{dc11} equations are as follows:

$S_{dd11} = 0.5 \times (S_{11}-S_{21}-S_{12}+S_{22})$

$S_{dc11} = 0.5 \times (S_{11}-S_{21}+S_{12}-S_{22})$

Offline Mode

The **Offline Mode** allows you to use a saved waveform file to run the tests. The following are the steps to run the tests in offline mode:

1 Enable the Offline Mode.

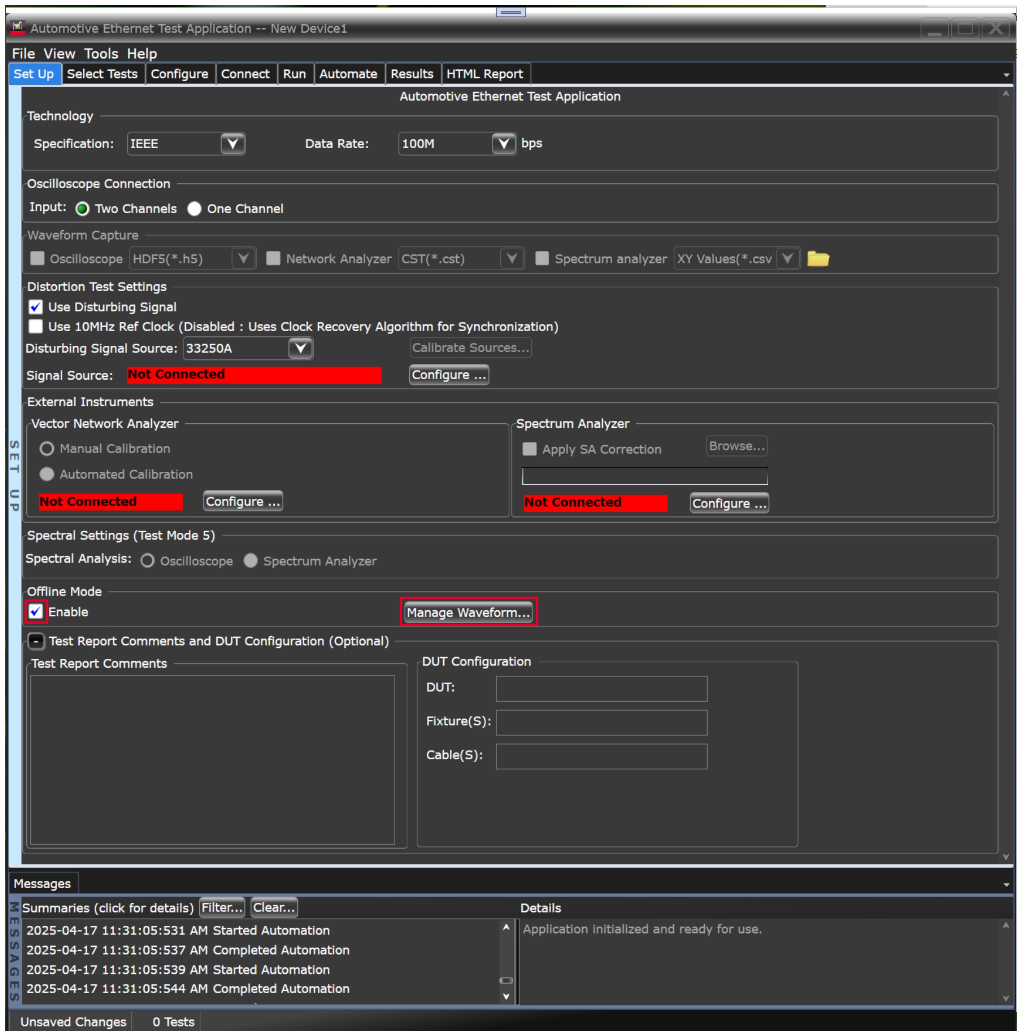


Figure 11-48 Enable the Offline Mode

2 Click **Manage Waveform...** button.

3 Refer to the following to acquire, load, or clear waveforms:

- "Acquiring waveforms" on page 216
- "Loading waveforms" on page 219
- "Clearing waveforms" on page 222

Acquiring waveforms

1 Click **Manage Waveform...** as shown in Figure 11-48. The **Offline Waveform** dialog box appears.

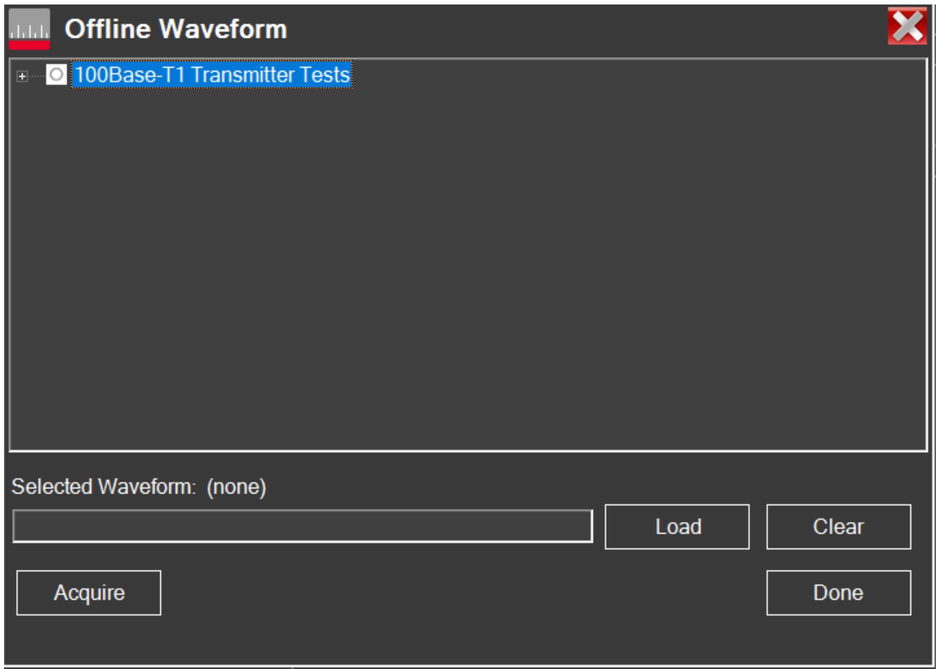


Figure 11-49 Offline Waveform dialog box

2 Click **+** to expand and view the available waveform types for each test mode.

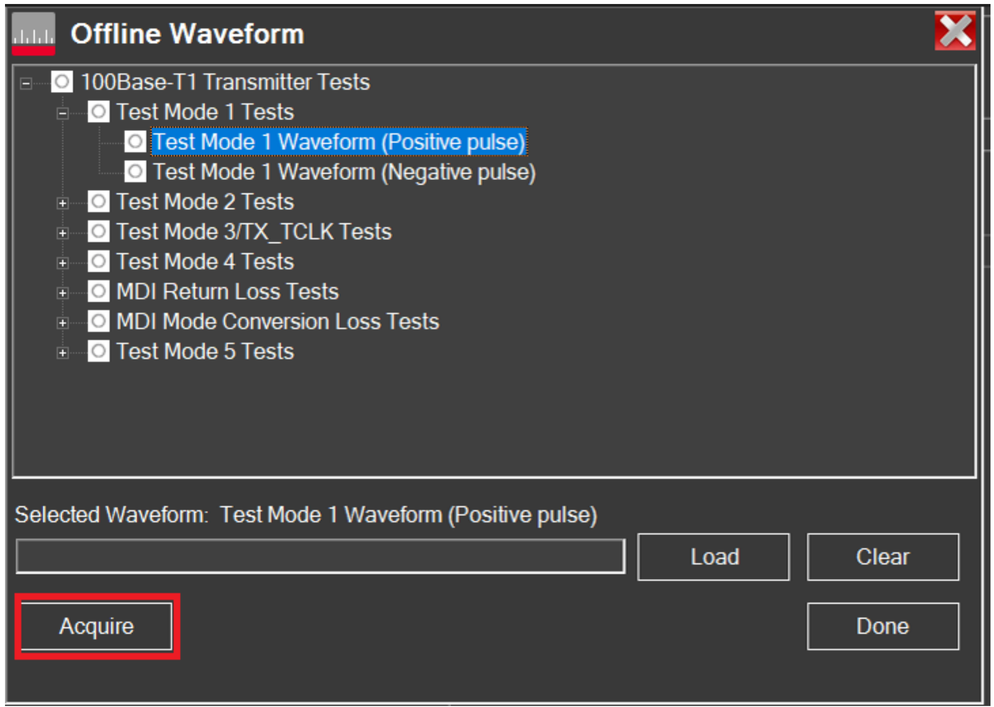


Figure 11-50 Test mode expanded view to Acquire

3 Select a Test Mode and click the **Acquire** button to acquire the waveform associated with the selected test.

- A **Capture in progress**... dialog box appears, indicating the progress of the capture and saving of the waveform on the local disk. You may click the **Stop Capture** button if you want to abort capturing the waveform file.

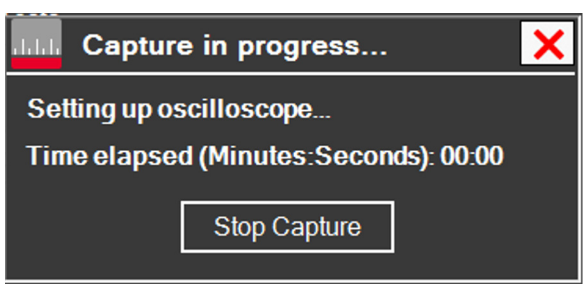


Figure 11-51 Capture in progress dialog box

- Notice the change in the status of the Test whose wave form has been captured.
- The file path and file name with ***.wfm** extension of the captured waveform is displayed. The default path where these files are captured is: C:\ProgramData\Keysight\Infiniium\Apps\AutomotiveEthernetTest\Project\app\

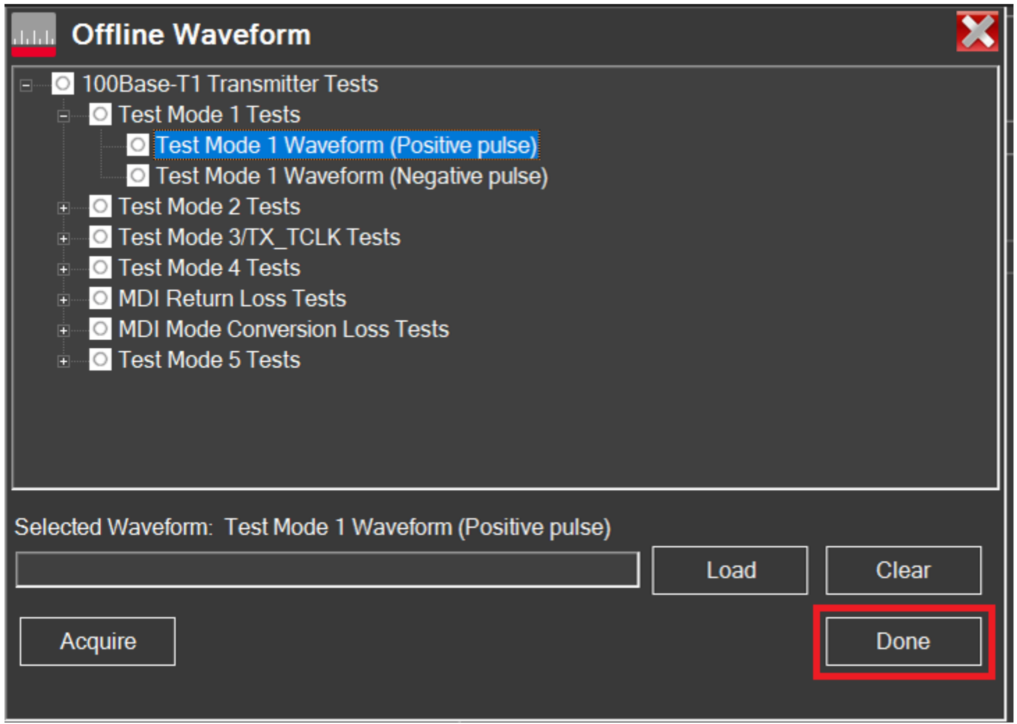


Figure 11-52 File path and file name with *.wfm extension of the captured waveform

4 Repeat step 3 to acquire more waveforms for the remaining tests.

5 Once you have finished capturing the waveforms, click the **Done** button to return to the **Set Up** tab.

Loading waveforms

1 Click **Manage Waveform...** as shown in Figure 11-48. The **Offline Waveform** dialog box appears.

2 Click **+** to expand and view the available waveform types for each test mode as shown in Figure 11-49.

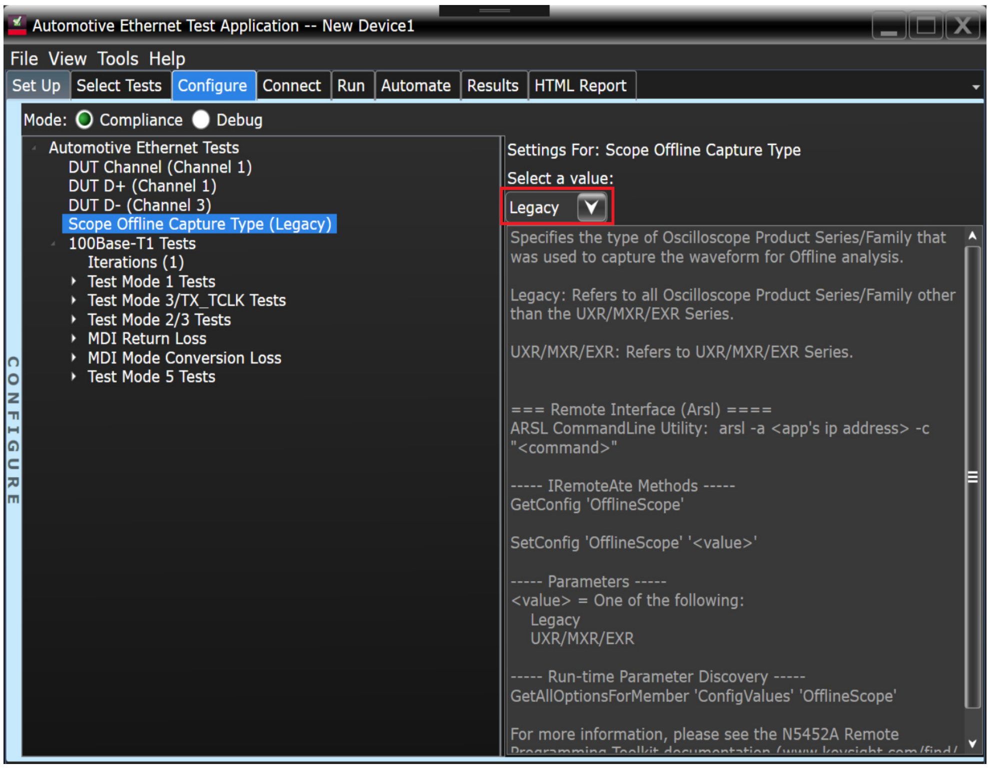


Figure 11-53 Test mode expanded view to Load

3 Select a test and click the **Load** button. The **Select wfm file** window appears.

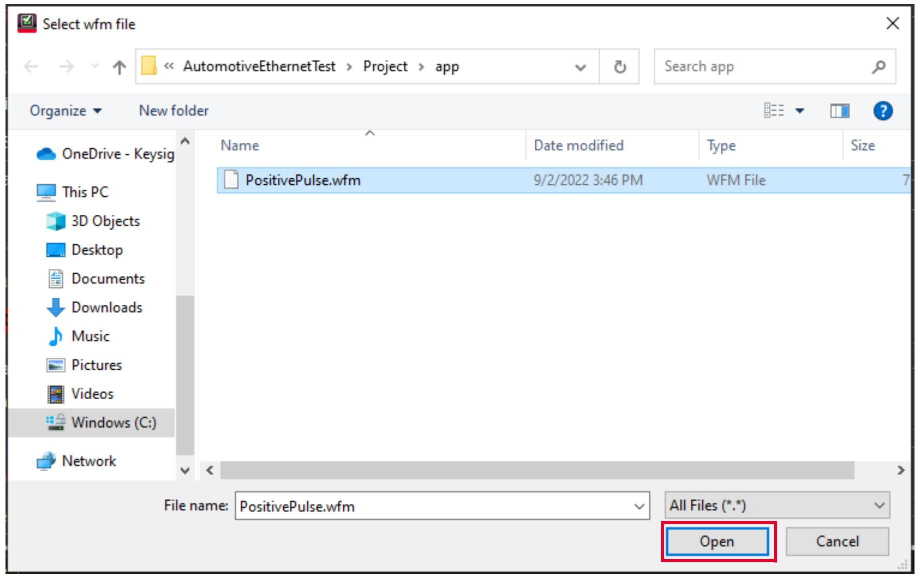


Figure 11-54 Select wfm file window

4 Select the waveform file associated with the test mode selected, and click **Open**.

- The file path and file name with ***wfm** extension of the loaded waveform is displayed.
- Notice the change in the status of the test whose waveform has been loaded.

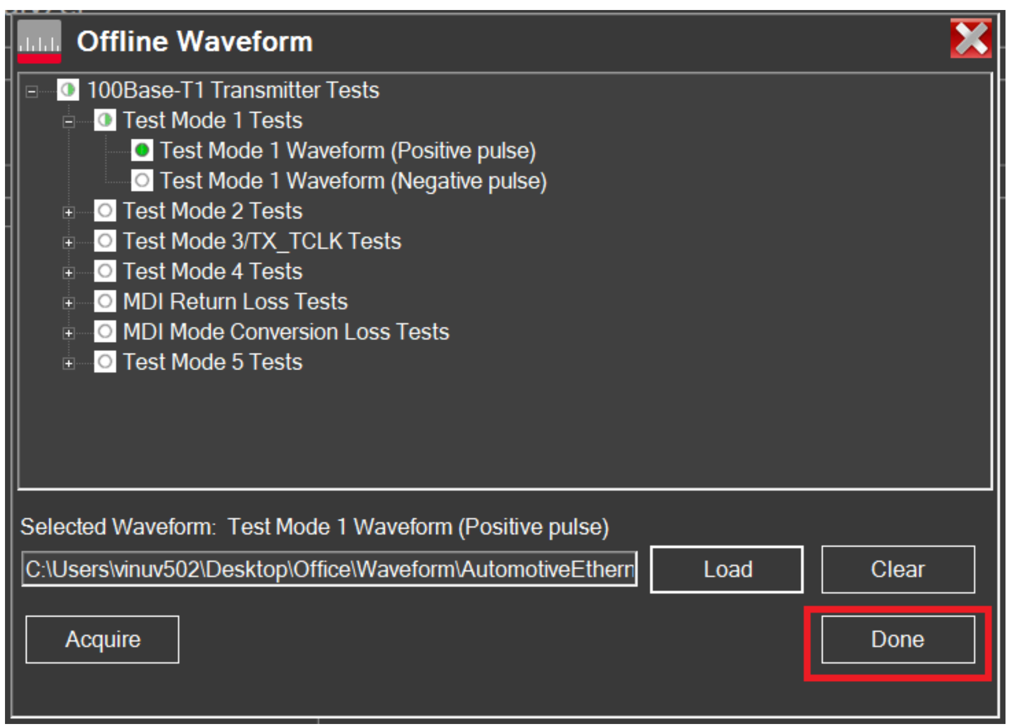


Figure 11-55 File path and file name with *.wfm extension of the loaded waveform

5 Repeat step 3 and step 4 to load more waveforms associated with the various tests as required.

6 Once you have finished loading the waveforms, click the **Done** button.

7 Go to the **Configure** tab and select a value for the **Scope Offline Capture Type**. This specifies the type of scope that was used to capture the waveform for offline analysis.

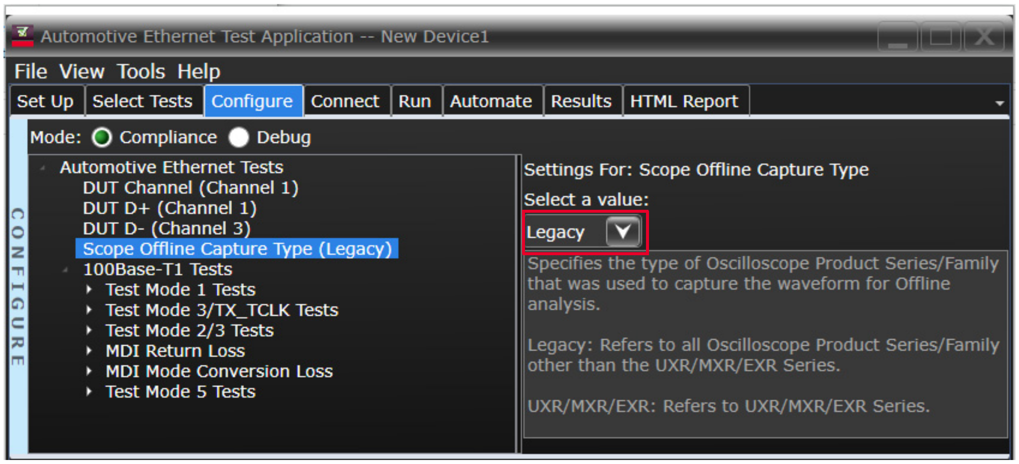


Figure 11-56 Select a value for the Scope Offline Capture Type

8 Return to the **Set Up** tab.

Clearing waveforms

1 Click **Manage Waveform...** as shown in Figure 11-48. The **Offline Waveform** dialog box appears.

2 Click **+** to expand and view the available waveform types for each test mode as shown in Figure 11-49.

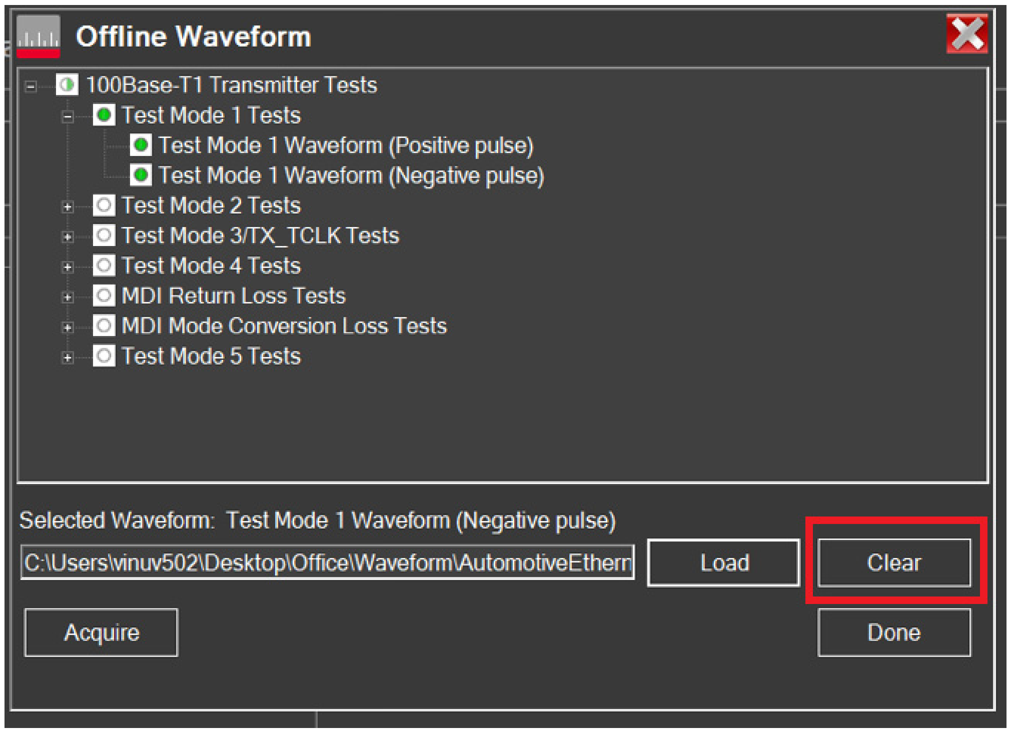


Figure 11-57 Select a test mode and click Clear

3 Select a test mode and click **Clear**. This removes the file path and the file name displayed in the adjacent text field.

- Notice the change in the status of the test whose waveform has been cleared.

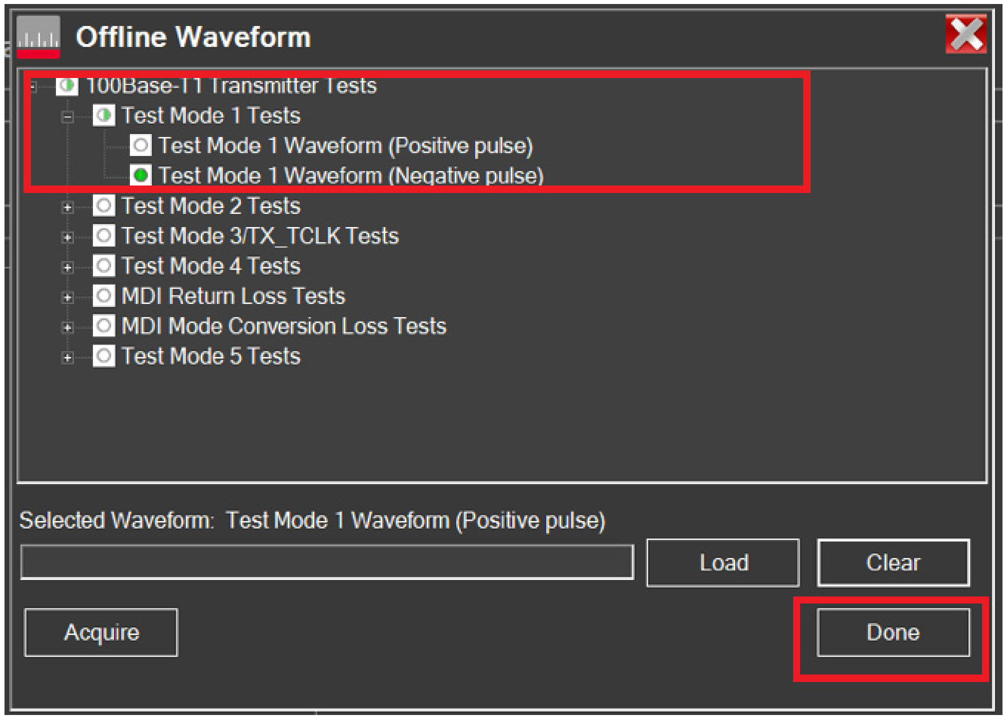


Figure 11-58 Change in the status of the cleared waveform

4 Repeat step 3 to clear waveforms for the remaining tests.

5 Once you have finished clearing the waveforms, click the **Done** button to return to the **Set Up** tab.

Using the AE6950A Frequency Divider Board

Keysight's AE6950A Frequency Divider Board produces two identical clock signal outputs (10 MHz) that are phase-locked to the input clock. Keysight recommends this Frequency Divider Board for the Transmitter Distortion Test.

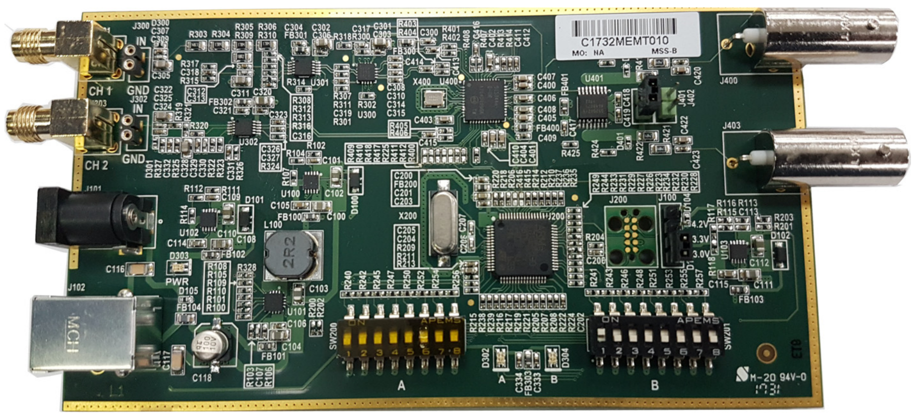
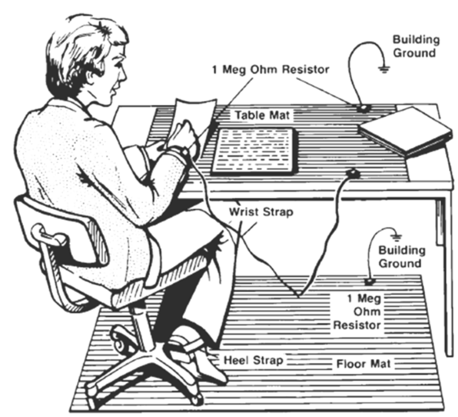


Figure 11-59 Keysight AE6950A Frequency Divider Board

Static-safe Handling Procedures



Electrostatic discharge (ESD) can damage or destroy electronic components. Use a static-safe work station to work on electronic assemblies. This figure shows a static-safe work station using two types of ESD protection:

- Conductive table-mat and wrist-strap combination
- Conductive floor-mat and heel-strap combination

Both types, when used together, provide a significant level of ESD protection. Of the two, only the table-mat and the wrist-strap combination provide adequate ESD protection when used alone. The static-safe accessories must provide at least 1 MΩ of isolation from the ground.

Observe appropriate ESD precautions before connecting and disconnecting cables as well as changing the positions of jumpers and switches.

To use the divider board, check the **Use 10MHz Ref Clock** on the ECU Compliance Test Application **Set Up** tab.

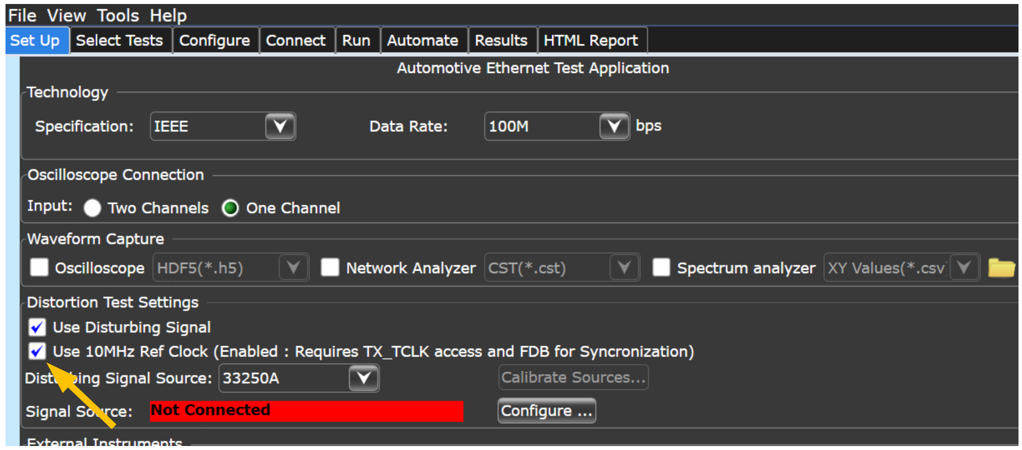


Figure 11-60 Select **Use 10MHz Ref Clock** on Set Up tab

Configure the test setup shown as follows.

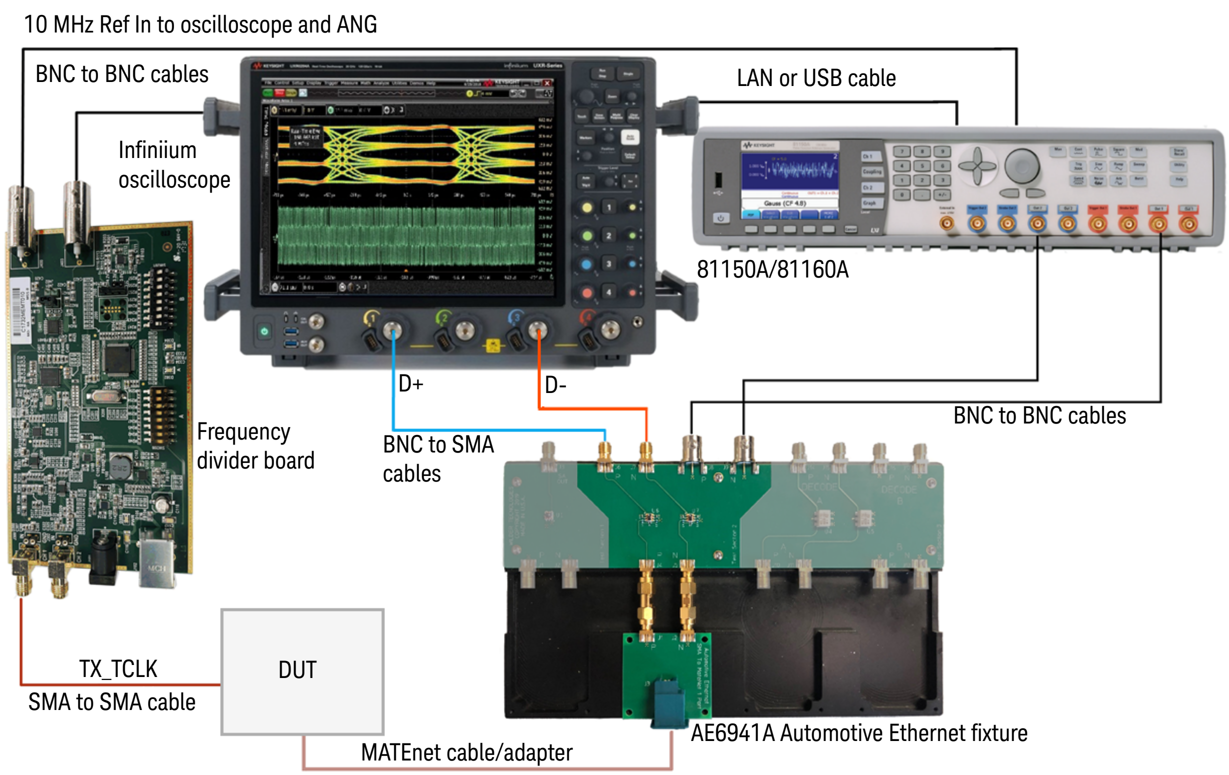


Figure 11-61 Test Setup for 10 MHz Frequency Reference with AE6941A

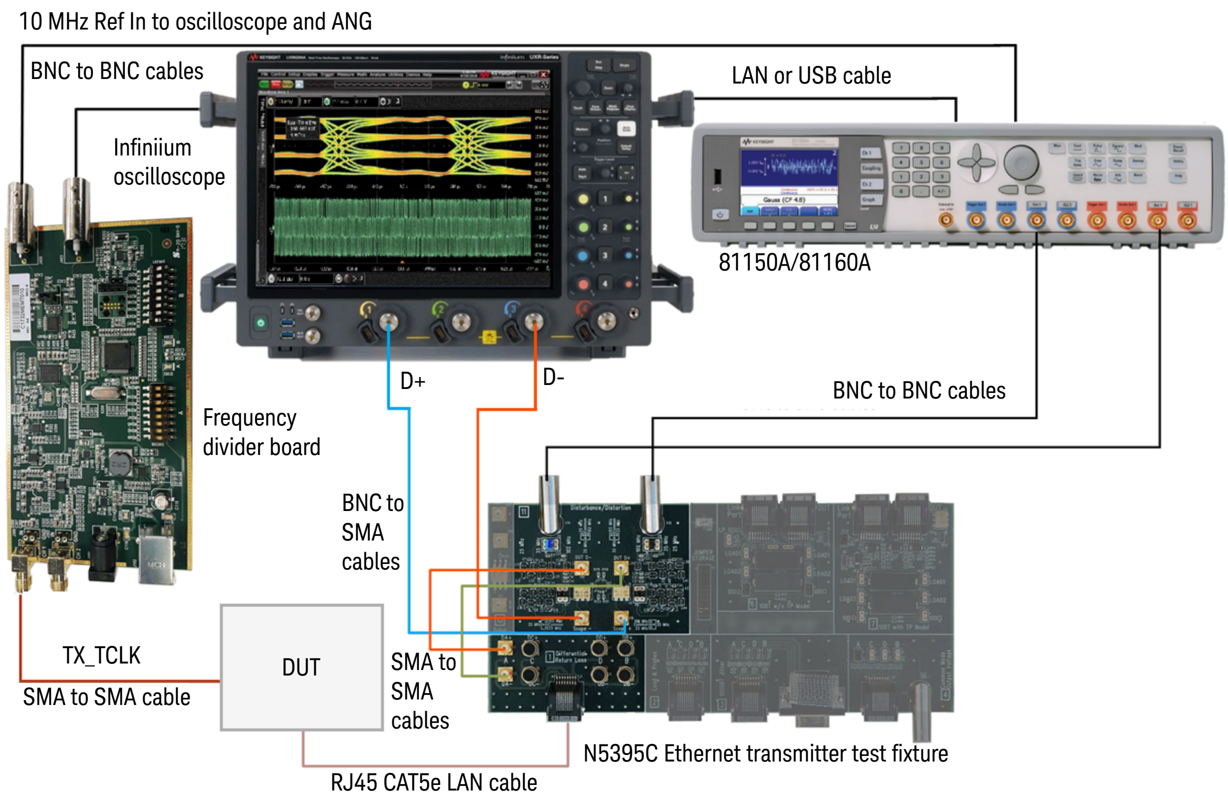


Figure 11-62 Test Setup for 10 MHz Frequency Reference with N5395C

Frequency Divider Board Test Setup

1 Connect CH1 SMA connector to the Device Under Test (DUT).
2 Use BNC to BNC cables to connect both J400 and J403 BNC connectors to the oscilloscope and the AWG 10 MHz In.
3 Select 4.2 Vpp output voltage by shorting Pin1 and Pin2 of J100 with jumper.
4 Select Normal Running mode by switching switch A1 to OFF.
5 Select Frequency Tracking mode by switching switch A2 to OFF.
6 Select CH1 as input by switching switch A6 to OFF.
7 Select Targeted 25 MHz input by switching switch B2 to ON.
8 Power on the board by connecting a power source to the USB connector or the DC power jack. (4.5 V to 5.5 V @450 mA).
9 At power on, the LEDs should light up as follows:
   - the Power LED PWR (D303) should light up as GREEN
   - the LED A (D302) should light up as GREEN
   - the LED B (D304) should light up as GREEN

Connector Description

This section describes the various user components on the AE6950A.

Component	Description
USB type-B / DC Jack	It provides power to the fixture. You may use either the USB port or the 2.5 mm, center positive DC Power input jack may be used. The USB jack is not used for any other purpose. Input voltage is required to be within +4.5 V to +5.5 V @500 mA. Any voltage that is out of specification will trigger a warning on the Power LED.
SMA	It provides an interface to feed the input signal into the test fixture. CH1 connector is 50 Ω terminated, and CH2 connector is 10 kΩ terminated.
BNC	Both J400 and J403 produce a separate output clock signal. The signals are back-terminated by 50 Ω.
Jumpers	They provide you with the option to modify the test fixture circuitry.
J100	This jumper controls the output signal amplitude: 4.2Vpp: Connect pin 1 and pin 2 3.3Vpp: Connect pin 2 and pin 3 3.0Vpp: Connect pin 3 and pin 4
J300 & J302	This jumper allows you to probe the channel 1 and channel 2 inputs respectively.
J401	This jumper shorts both outputs together.
J402	Parking location for unused jumpers.

DIP Switch Description

Switch A

Switch A sets the Fixture operating mode.

Switches	Position	Operating mode	Comment
A1	off	Normal running mode	Normal operating mode
	on	Sleep mode	Changes made to any of the switches are ignored
A2	off	Frequency Tracking Mode	Output frequency track to input frequency
	on	Lock Frequency Mode	Output clock is phase lock to input clock
A3	off	NA	NA
	on	NA	NA
A4	off	NA	NA
	on	NA	NA
A5	off	NA	NA
	on	NA	NA
A6	off	Select CH1 as input	NA
	on	Select CH2 as input	NA
A7	off	NA	NA
	on	NA	NA
A8	off	NA	NA
	on	NA	NA

Switch B

Switch B sets the frequency divider to the relevant setting.

								Divider	Comment
B8	B7	B6	B5	B4	B3	B2	B1		To obtain 10 MHz output
off	off	off	off	off	off	off	off	Not valid (def)	Free Run Mode
off	off	off	off	off	off	off	on	Div 1	Targeted 10 MHz input clock
off	off	off	off	off	off	on	off	Div 5/2	Targeted 25 MHz input clock
off	off	off	off	off	on	off	off	Div 20/3	Targeted 66.67 MHz input clock
off	off	off	off	on	off	off	off	Div 25/2	Targeted 125 MHz input clock
off	off	off	on	off	off	off	off	Div 75	Targeted 750 MHz input clock

NOTE

Other combinations are not valid, and if no valid switch setting is detected, the LED will flash, indicating invalid switch B configuration. After reset, if no valid position is detected, the board uses the "Free Run Mode" which generates an accurate 10 MHz signal.

LED Description

Table 11-1 Power LED

	Green	Red
Input voltage below 4.5V	ON	Flash 1 Hz
Input voltage below 3.6V	ON	Flash 2 Hz
Input voltage above 5.5V	ON	ON

Table 11-2 LED A

	Green	Red
Input signal locked (Normal condition)	ON	OFF
Lost of Lock	Flash 1 Hz	OFF
Lost of Signal	OFF	Flash 1 Hz
Lost of 48 MHz reference	OFF	ON

Table 11-3 LED B

	Green	Red
Valid switch B configuration (Normal condition)	ON	OFF
Invalid switch B configuration	Flash 1 Hz	OFF
Missing input signal/ input signal out of range/ Warning. See LED A for list of warnings.	N/A	ON

List of Abbreviations

Table 11-4 Abbreviation and Definition

Abbreviation	Definition
A	
ANG	Arbitrary Noise Generator
AWG	Arbitrary Waveform Generator
B	
BNC	Bayonet Neill-Concelman
C	
CH1	Channel 1
CME	Common-mode Emission
D	
DA+	Differential Pair A+
DA-	Differential Pair A-
DUT	Device Under Test
E	
ECU	Electronic/Engine Control Unit
H	
H-MTD	High-Speed Modular Twisted-Pair Data
M	
MDI	Media/Medium Dependent Interface
O	
OABR	Open Alliance BroadR-Reach
P	
PHY	Physical layer
PSD	Power Spectral Density
R	
RBW	Resolution Bandwidth
RMS	Root Mean Square
S	
SICL	Standard Instrument Control Library
SMA	SubMiniature version A
T	
TX_TCLK	Transmit System Clock

Table 11-4 Abbreviation and Definition

Abbreviation	Definition
V	
VBW	Video Bandwidth
Vd	The magnitude of the droop
Vpk	The initial peak after the zero-crossing

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KEYSIGHT TECHNOLOGIES

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