Automotive Ethernet Channel Testing

10 Mbps to 10 Gbps

Harness, Connector, and Cable Testing for Automotive Ethernet Devices

Introduction

Next-generation ADAS systems require camera and radar systems with increasingly high resolution. That means new requirements for speed and bandwidth. Automotive Ethernet enables faster data communication to meet the demands of today's vehicles and the connected vehicles of the future.

Unlike other serial technologies in the car, CAN, LIN or MOST, Automotive Ethernet demands rigorous compliance verification. The requirements include complex measurements that, until recently, have been uncommon in the auto industry: vector network analysis measuring and monitoring cross talk, insertion loss, mode conversion between all, and any cables bundled together in an Automotive Ethernet network. The channel or link in any system can create a point of failure and must be thoroughly tested.

To help you save time and effort, Keysight offers solutions that automate the testing and validation of Automotive Ethernet designs. These proven applications help ensure proper test configuration and valid, repeatable measurement results. The net result: you'll have greater confidence that your device complies with the IEEE standard, a faster development cycle, repeatability of testing, and less human error.

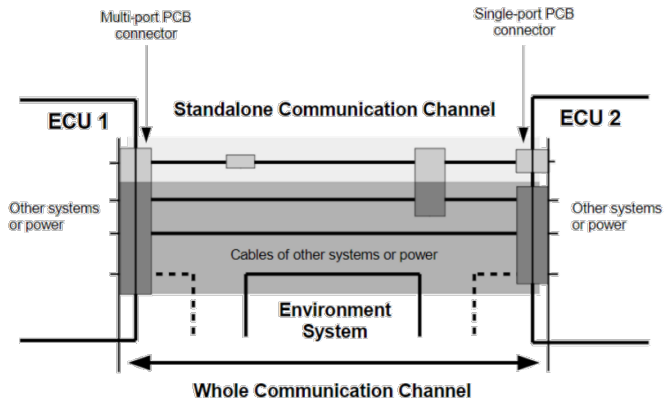
KEYSIGHT

Harness and Connector Validation

The AE6000L Automotive Ethernet channel compliance solution provides an easy and accurate way to verify and debug Automotive Ethernet harness assemblies, cables, and connectors. The channel, in this case, represents the complete wired connection between two transmit/receive modules with an Automotive Ethernet interface using a two-wire twisted pair cable. The AE6000L Automotive Ethernet channel compliance solution, verifies that information is carried, without loss or cross-talk, to its intended destination. Performing these tests is required and will give you confidence in your design/s. The Keysight AE6000L link segment solution will save you hours of valuable time with configuration, instrument setup, calculations, and report generation.

Link segment = Cabling + Inline connectors + Mating connectors

The Connector type is not standardized and will be specific to each connector vendor. The Keysight AE6000L channel compliance solution greatly simplifies automotive ethernet harness and connector compliance testing for 10M,100M, 1000M, and 2.5/5/10GBASE-T1.



Test Specifications

The AE6910L Automotive Ethernet channel compliance software covers the specifications for open alliance and IEEE as follows.

OPEN Alliance	IEEE
TC9 Channel and components requirements for 10BASE-T1S link segment, draft version 0.4	802.3cg 2019
TC2 100BASE-T1 EMC definitions for communication channel 1.0	802.3bw 2015
TC9 Channel and components requirements for 1000BASE-T1 link segment type A (UTP), Final, Version 2.3	802.3bp 2021
TC9 Channel and components requirements for 1000BASE-T1 link segment type A (STP), Final, Version 2.0	802.3bp 2021
TC9 Channel and component requirements for fully shielded 1000BASE-T1 and 2.5G/5G/10GBASE-T1 link segment v1.0 (interim)	802.3ch 2020

For additional information on each test case, please see the supported test specifications in Chapter 5 of the user guide.

Save Time and Take Advantage of VNA Automation

The AE6000L is an automotive Ethernet channel testing solution that includes hardware, accessories, and software. The software requires three licenses to run.

- The KS8400B is the base GUI test automation software from Keysight.
- The AE6800C is the core software for channel testing.
- The AE6910L contains all the specific test cases for Automotive Ethernet standards.

All three licenses are available under the AE6000L for purchase. The AE6910L channel compliance software saves you time by setting the stage for the automatic execution of required cable, connector, and harness tests. Some difficulties in performing these tests include correctly understanding the specification, configuring/ running the instrument/s, and then analyzing the measured results by comparing them to limits published in the specification. The AE6910L channel compliance software does much of this work for you.

The AE6910L channel compliance software is installed directly onto a vector network analyzer or the PC controlling the network analyzer. The AE6910L software automatically configures the VNA for the test. It provides an informative results report that includes insertion loss, crosstalk, mode conversion, and a pass/fail limit. See the Tables under test specifications for a list of the measurements and specifications tested in the AE6910L.

The software offers several features to simplify the validation of Automotive Ethernet designs:

The AE6910L software:

- Contains step-by-step guide walks through the test selection and execution.
- Supports parallel mode execution on PXI/PXIe series VNA.
- Automatically detects the number of available ports.
- Create a test plan for those lanes selected with all the required tests.
- The test plan created will include all the required tests for the specification selected.
- Automatically sets up the network analyzer for each measurement and applies the limit lines.
- Expandable to cover proprietary limits and quickly adapt to new standards.
- Provides detailed information about each test run.
- Creates an HTML test report.
- AE6910L v1.7 or later supports E5071C ENA.

Step-by-Step

The software contains a step-by-step guide that walks through the test selection and execution, enabling you to quickly see where you are in the process with links to compatible instruments, calibration modules, setup connection diagram selections.

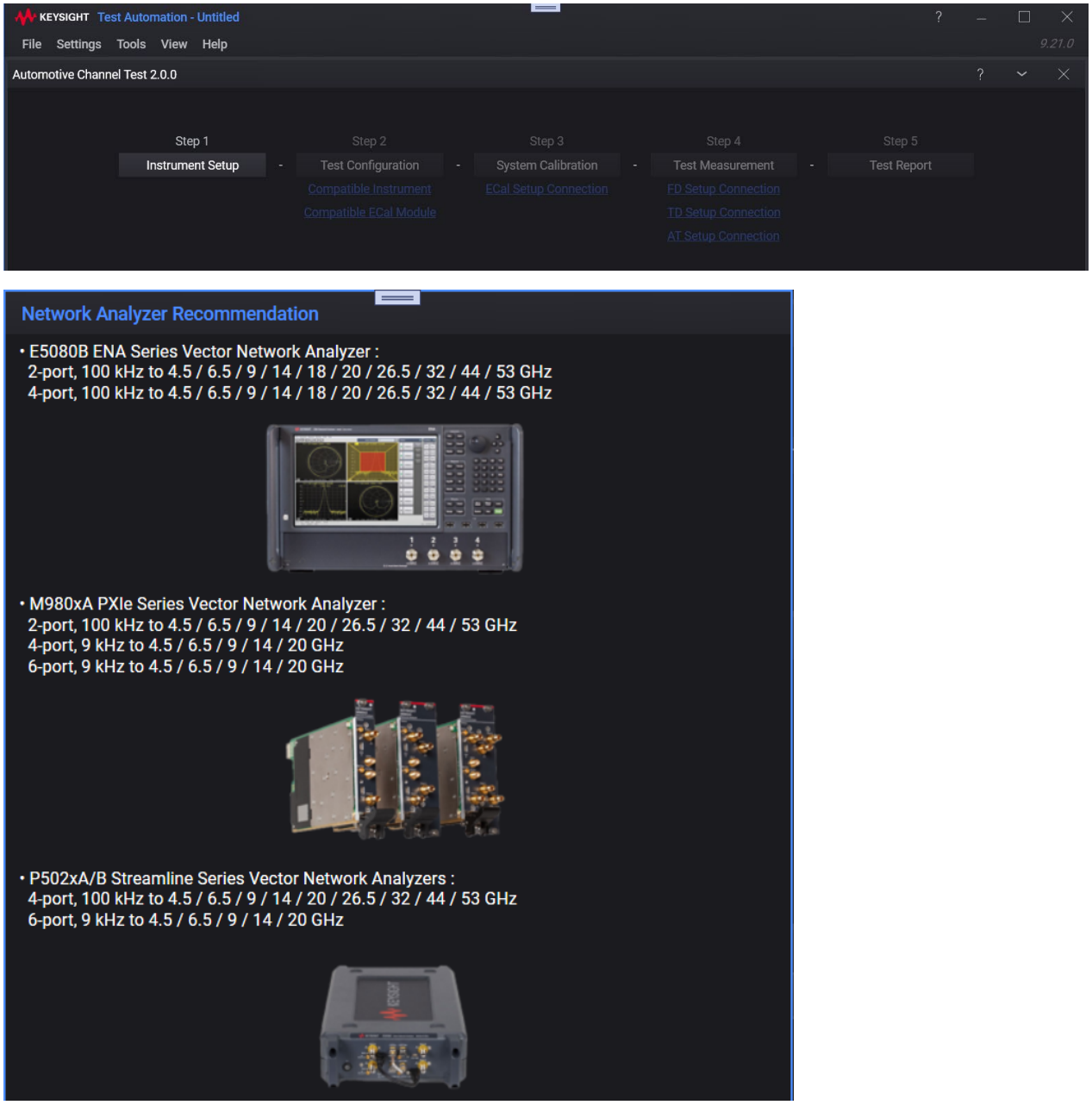


Figure 1-2. Steps are available at launch with links to configuration information, including compatible instruments based on user-configured test settings.

Test Selection

The test automation software platform lets you select which standard you would like to test to with a pull-down menu. Once selected all the relevant and correct tests and limits will be selected.

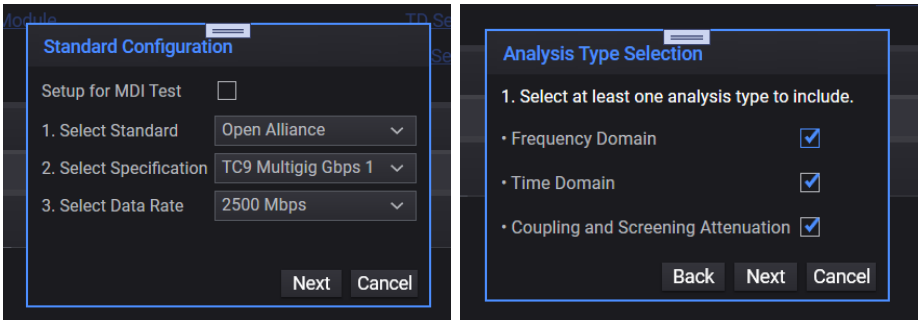


Figure 3-4. The test setup screens have specifications and analysis type selection.

Expandable

The software is expandable to the number of ports used. For example, a 3-cable bundle will need 4 ports for each cable, measuring each differential end, so a 3-cable example uses 12 lanes.

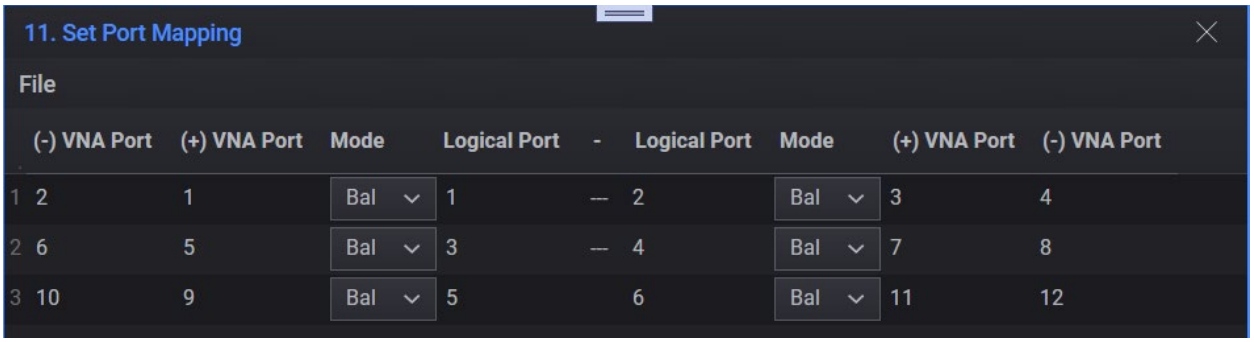


Figure 5. Port definition for 12 physical ports, shown in dark mode

System calibration

The software lists compatible instruments and ECal modules based on user-configured test settings. Step 3 is system calibration. Made more accessible, with quick reference on compatible ECals and easy-to-follow steps for calibration.

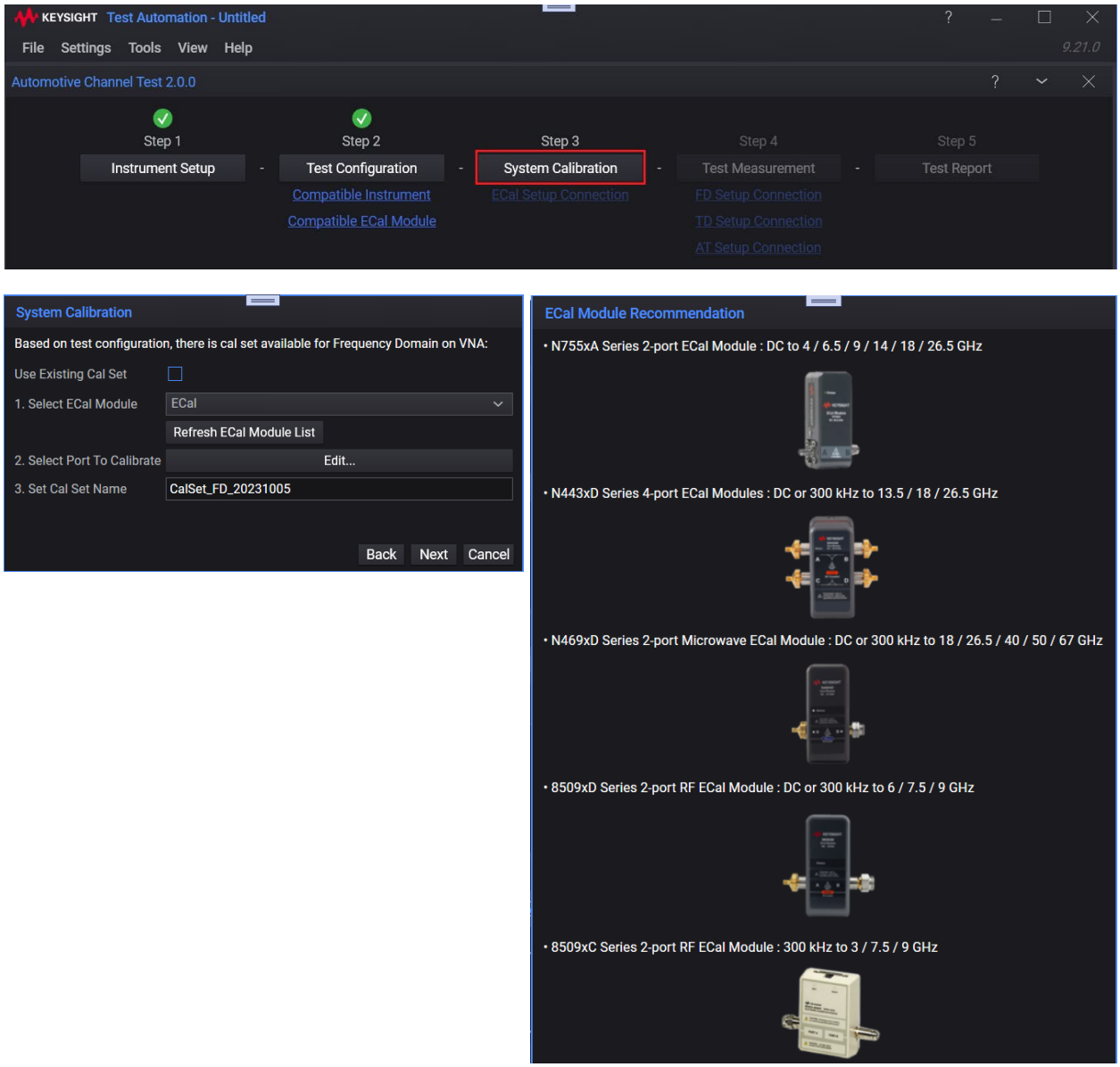


Figure 6-8. Compatible Ecals are listed based on user-configured test settings.

The test automation software can also be expanded to cover customized limits using the configuration file. Within the AE6910L, a configuration file generator and editor show all the limits and enable edits to those limits.

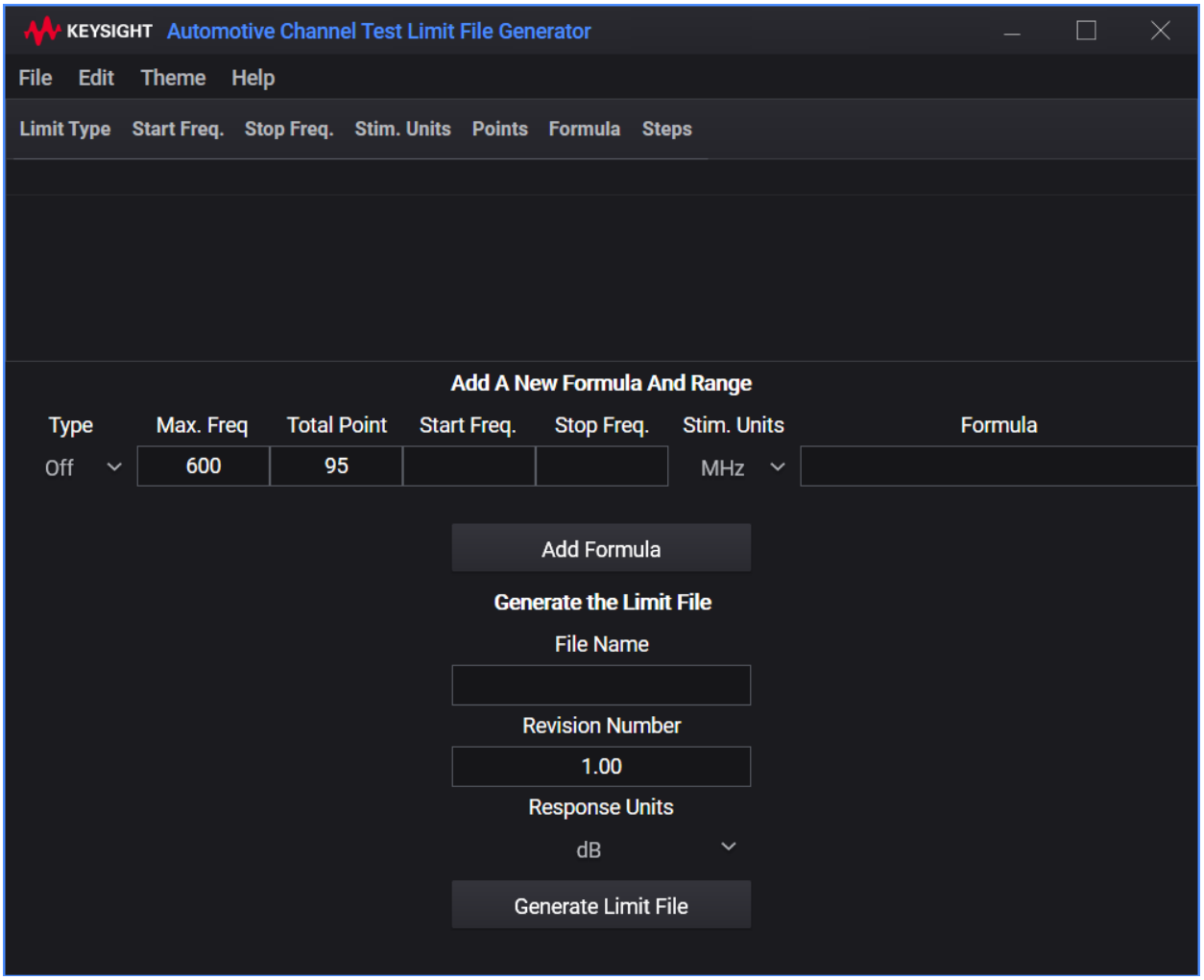


Figure 9. A limit file generator tool also allows users to create a limit file.

Test Plan Per Limit Lines

The test plan will include all the required tests per the specification, including crosstalk, insertion loss, mode conversion, and more.

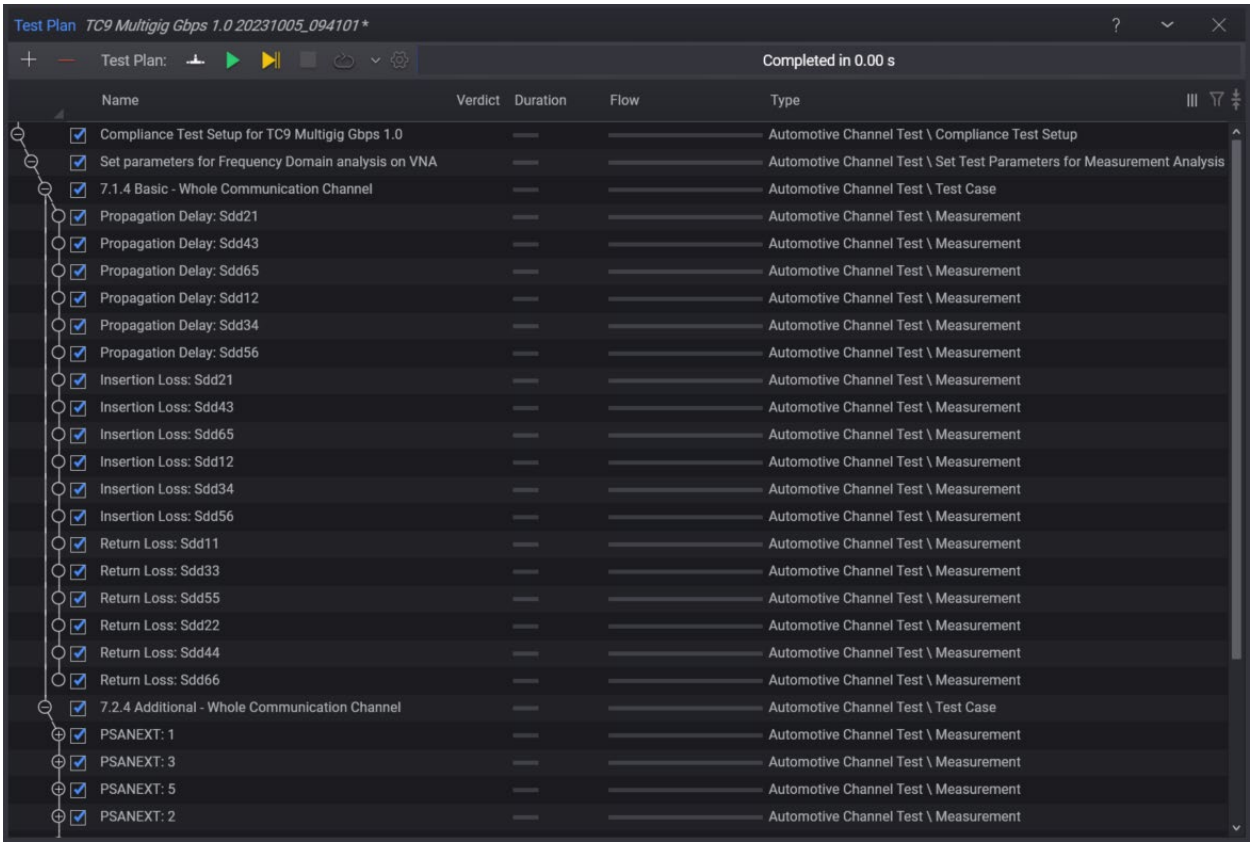
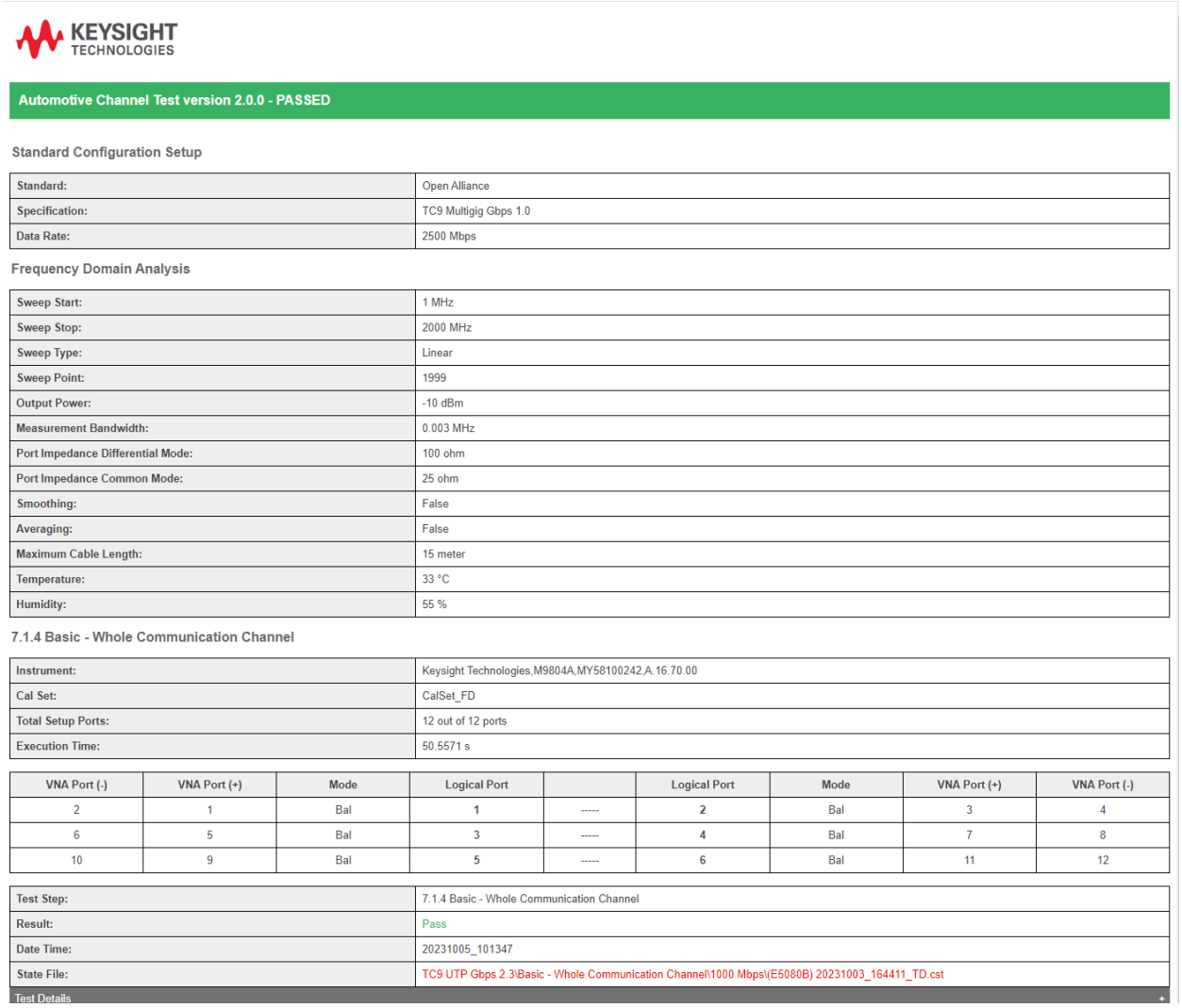


Figure 10. Test plan creation in a list mode, select only the test you want to run.

Test Report

In addition to giving measurement results, the AE6910L Automotive Ethernet Lx Compliance Software provides a report format showing whether your product passes or fails. The test automation software platform provides test results in HTML. The AE6910L displays and updates all the results online. After stopping or pausing the test, you can access any result for analysis at your convenience.



KEYSIGHT TECHNOLOGIES

Automotive Channel Test version 2.0.0 - PASSED

Standard Configuration Setup

Standard:	Open Alliance
Specification:	TC9 Multigig Gbps 1.0
Data Rate:	2500 Mbps

Frequency Domain Analysis

Sweep Start:	1 MHz
Sweep Stop:	2000 MHz
Sweep Type:	Linear
Sweep Point:	1999
Output Power:	-10 dBm
Measurement Bandwidth:	0.003 MHz
Port Impedance Differential Mode:	100 ohm
Port Impedance Common Mode:	25 ohm
Smoothing:	False
Averaging:	False
Maximum Cable Length:	15 meter
Temperature:	33 °C
Humidity:	55 %

7.1.4 Basic - Whole Communication Channel

Instrument:	Keysight Technologies,M9804A,MY58100242,A.16.70.00
Cal Set:	CalSet_FD
Total Setup Ports:	12 out of 12 ports
Execution Time:	50.5571 s

VNA Port (-)	VNA Port (+)	Mode	Logical Port		Logical Port	Mode	VNA Port (+)	VNA Port (-)
2	1	Bal	1	-----	2	Bal	3	4
6	5	Bal	3	-----	4	Bal	7	8
10	9	Bal	5	-----	6	Bal	11	12

Test Step:	7.1.4 Basic - Whole Communication Channel
Result:	Pass
Date Time:	20231005_101347
State File:	TC9 UTP Gbps 2.3\Basic - Whole Communication Channel\1000 Mbps\(E5080B) 20231003_164411_TD.cst

Test Details +

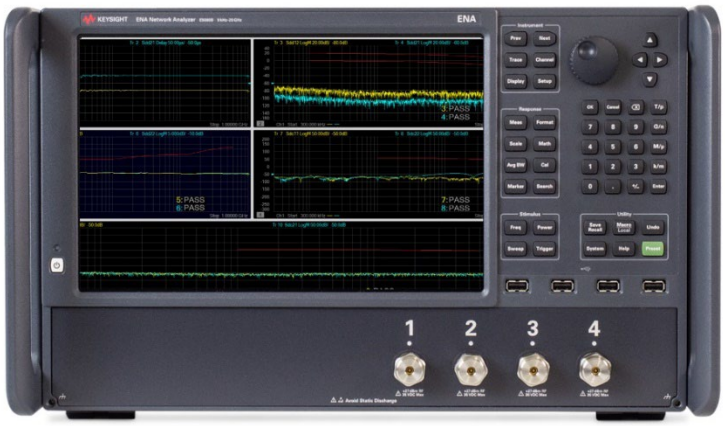
Figure 7. Test results

Requirements: Instruments and Accessories

Instruments

The AE6910L software runs on a separate computer and controls the instruments. The primary hardware on which the solution is built can be any of the following 3 different VNA options.

M9019A 18-slot PXIe chassis with up to 50 ports, M9010A 10-slot PXIe chassis; with any combination of 6-port M9804A (option 600), 4-port M9804A (option 400) or 2-port M9804A (Option 200)



E5080B 4-port 9 kHz to 53 GHz VNA

P502xA/B or P9382B Streamline series 4-port 100kHz to 53 GHz or 6-port 9 kHz to 20 GHz VNA

Minimum Requirements

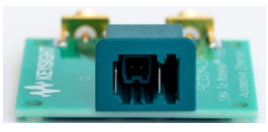
The AE6910L software installed on a computer controls a Keysight vector network analyzer (VNA). Additional hardware is required depending on the specification. The table below captures the specifications' minimum requirements and lists the equipment Keysight offers for that measurement type.

Minimum Instrument Requirement	Supported Keysight Models
Network analyzer (VNA) with a start and stop frequency range 300 kHz – 1 GHz (100 and 1000BASE-T1), 4-port configuration, and a calibration kit.	M980xA series, P5022A/B series, P9382B, E5080B
Network analyzer (VNA) with a start and stop frequency range of 1 MHz – 5.6 GHz (2.5/5/10GBASE-T1), 4-port configuration, and a calibration kit with a start and stop frequency range.	

Accessories

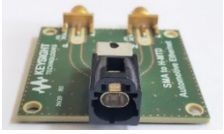
Adapters and fixtures help convert SMA to some of the more standard interfaces for Automotive Ethernet since IEEE or OABR does not specify a standard connector type. Choose from multiple Ecals options, including 2- and 4-port models.

Model Number	Description	Used for What Purpose
AE6942A	SMA to Molex/Mini-50 adapter board AE6942A	Conversion from SMA to automotive interface
AE6943A	SMA to MATEnet adapter board AE6943A	
AE6960A	SMA to H-MTD adapter board AE6960A	
AE6944A	SMA to Solderable Open Automotive Adapter	
N755xA	RF Electronic calibration module, 2-Port DC to 4 / 6.5/ 9/ 14/ 18/ 26.5 GHz	Compatible Ecal modules
N443xD	RF Electronic calibration module, 4-Port 300 kHz to 13.5/ 18/ 26.5 GHz	
N469xD	Microwave Electronic calibration module, 2-Port DC to 18/ 26.5/ 40/ 50/ 67 GHz	
8509xD	RF Electronic calibration module, 2-Port DC to 6/ 7.5/ 9 GHz	
8509xC	RF Electronic calibration module, 2-Port 300 kHZ to 3/ 7.5/ 9 GHz	

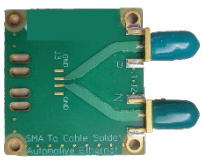


AE6943A MATEnet

AE6942A Mini-50



AE6960A H-MTD



AE6944A solderable open

Ordering Information

Notes	Description	Part number
Software		
Required	Test Automation Platform, Developer's System	KS8400B
Required	Channel compliance core software	AE6800C
Required	Automotive Ethernet Channel Compliance Test Software	AE6910L
Software is Required but Specific to the VNA Selected Order Stand-Alone or Through the Hardware		
Required with PXIe VNA	Time domain analysis for PXI M980xA VNA	S95010B
Required with Bench VNA	Time domain analysis for Bench E5080B VNA	S96010B
Required with Portable VNA	Time domain analysis for Portable P5022B/P9382B VNA	S97010B
Required with more than one PXI	Multiport calibrated measurements software for M980xA VNA	S95551B
Required with more than one portable	Multiport calibrated measurements software for P5022B/P9382B VNA	S97551B
Hardware Selections [1] **Choose Either Bench, PXIe, or Portable VNA**		
Bench VNA	E5080B 9 kHz to 9 GHz Opts 490, 181, 182, S96010B (TD)	E5080B
Portable VNA	USB 9GHz, 4-port P5022B Opt 400, S97010B (TD)	P5022B
	Thunderbolt 9GHz, 4-port P9382B Opt 400, S97010B (TD)	P9382B
Required for more than one USB/Thunderbolt VNA, Qty 1	Jumper cables for multiport configuration of USB or Thunderbolt	Y1701A-002
PXIe - high channel 9 or 20 GHz	PXIe chassis and filler panels; 18-slot [2] PXIe chassis and filler panels; 10-slot	M9019A M9010A
Required for mainframe	PXIe embedded controller with memory, windows OS	M9038A
VNA modules mix and match for the required number of ports	PXIe Vector Network Analyzer, 6-port, 9 kHz to 9 GHz	M9802A-600
	PXIe Vector Network Analyzer, 4-port, 9 kHz to 9 GHz	M9802A-400
	PXIe Vector Network Analyzer, 2-port, 9 kHz to 9 GHz	M9802A-200
Required Order one less than the number of PXI modules	Jumper cables for multiport configuration of M9080XA	Y1730A-002
ECal [3]	Ecal 9 GHz, N7552A 2-port Option 3FF	N7552A
Required x the number of ports tested	Coax cable, 3.5 mm (m) to 3.5 mm (f), 26.5GHz, 1 m use with E5080B Option 490 [4]	N9910X-708
	Coax cable, 3.5mm (m) to 3.5 mm (m), 26.5 GHz, 1 m use with portable VNA P5022B/P9382B and M980xA	
	Adapter, N(m) to 3.5 mm(m) adapter – use with E5080B Option 490	
Optional one or more depending on DUT connectivity	SMA to MATEnet adapter boards	
	SMA to Molex/Mini-50 adapter board	
	SMA to H-MTD adapter board	
	SMA to open solderable adapter board	

1 A VNA is required to run the software and for these tests, you can choose any VNA that meets the min configuration on page 12 – those listed here are available for ordering convenience.
2 The 18-slot mainframe can fit six 2-slot modules or 14 single-slot modules, a max of 24 ports.
3 An Ecal is required for the VNA this is a suggestion.Other options are available for higher bandwidth or number of ports.
4 E5080B option 490 will also need a N9910X-849 adapter

For example,

Below are two examples: one for a low-cost, single cable, portable option, and another for a single cable benchtop.

A Configured Order for Automated Compliance of 4-Ports at 9 Ghz Portable VNA	A Configured Order for Automated Compliance 4-Port 9 Ghz Benchtop VNA (To Measure 1 Cable)
Qty (1) AE6800C	Qty (1) AE6800C
Qty (1) AE6910L	Qty (1) AE6910L
Qty (1) KS8400B	Qty (1) KS8400B
Qty (1) P9382B option 400	Qty (1) E5080B option 490
Qty (1) S97010B	Qty (1) N755A option 3FF
Qty (4) Y1740A-100	Qty (4) N9910X-849
Qty (1) N7552A option 3FF	Qty (1) S96010B

Conclusion

Learning or remembering how to use a VNA can be frustrating and take time. With the AE6910L, Keysight has done much of the work for you. The software can be used with three different platforms of VNA depending on what kind of cable, bundle of cables, connectors, or harness assemblies you are testing.

Keysight's AE6910L automotive Ethernet software ensures signal quality requirements with conformance testing for the channel. Built on functional and multipurpose hardware – E5080B, PXI M980xA, or Streamline Series USB Vector Network Analyzers – which are also invaluable tools in the lab for design verification and validation beyond Automotive Ethernet.

Learn more at www.keysight.com/find/AE6000L