Keysight Technologies

N6467A/B Automotive Ethernet Electrical Compliance Application

Data Sheet

Easy and accurate
Automotive Ethernet design validation
and debug

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TECHNOLOGIES

The Keysight Technologies, Inc. N6467A/B 802.3bw and automotive electrical performance validation and conformance software for Infiniium oscilloscopes provides you with an easy and accurate way to verify and debug your automotive Ethernet designs. The Ethernet electrical test software lets you automatically execute Ethernet physical-layer (PHY) electrical tests and displays the results in a flexible report format. In addition to the measurement data, the report provides a margin analysis that shows how closely your device passed or failed each test.

To make automotive Ethernet measurements with the N6467A/B Ethernet electrical test software, you may also need the Keysight N5395C Ethernet electrical conformance test fixture. The optional fixture is only needed when connecting with an RJ-45 cable from the customer's device, otherwise SMA cables are used to connect directly to the oscilloscope. IEEE 802.3bw does not specify a connector, users may have different means to connect D+ and D- signals to the oscilloscope. For DUTs that use standard RJ-45 Ethernet connections, Keysight's E5395C Ethernet compliance test fixture can be used for differential signal breakout. Alternatively, a differential probe or SMA cables can be used to access D+ and D- signals.

The N6467A/B Ethernet electrical test software performs a wide range of electrical tests required to meet the 802.3bw as well as BroadR-Reach electrical specifications. To meet signal quality requirements, your product must successfully pass conformance testing based on these specifications. Performing these tests gives you confidence in your design. The N6467A/B electrical test software helps you execute a wide subset of the conformance tests that can be measured with an oscilloscope.

Features

The N6467A/B electrical performance validation and conformance software offers several features to simplify the validation of automotive Ethernet designs:

– Setup wizard for quick and clear setup, configuration and test
– Wide range of 802.3bw tests enabling standards conformance
– Accurate and repeatable results with Keysight Infiniium oscilloscopes
– Automated reporting in a comprehensive HTML format with margin analysis

With the N6467A/B electrical test software, you can use the same oscilloscope you use for everyday debugging to perform automated testing and margin analysis based on 802.3bw and BroadR-Reach standards.

N6467A/B software saves you time

The N6467A/B electrical test software saves you time by setting the stage for automatic execution of 802.3bw and BroadR-Reach electrical tests. Some of the difficulties of performing electrical tests for 802.3bw and/or BroadR-Reach are properly connecting to the oscilloscope, loading the proper setup files, and then analyzing the measured results by comparing them to limits published in the specification. The N6467A/B electrical test software does much of this work for you.

The N6467A/B electrical test software automatically configures the oscilloscope for each test and provides an informative results report that includes margin analysis indicating how close your product is to passing or failing that specification. See Table 2 for a complete list of the measurements made by the N6467A/B test software.

Easy test definition

The N6467A/B electrical test software extends the ease-of-use advantages of Keysight's Infiniium oscilloscopes to testing 100BASE-T1 designs. The Keysight automated test engine quickly walks you through the steps required to define the tests you want to make, set up the tests, perform the tests, and view the results. A setup page lets you quickly make decisions from the outset regarding the choice of tests and perform functions that affect the testing. The test selections available in the following steps are then filtered according to the choices made in the setup page. While selecting tests, you can select a category of tests all at once or specify individual tests. You can save tests and configurations as project files and recall them later for quick testing and review of previous test results. Straightforward menus let you perform tests with a minimum amount of mouse clicks.
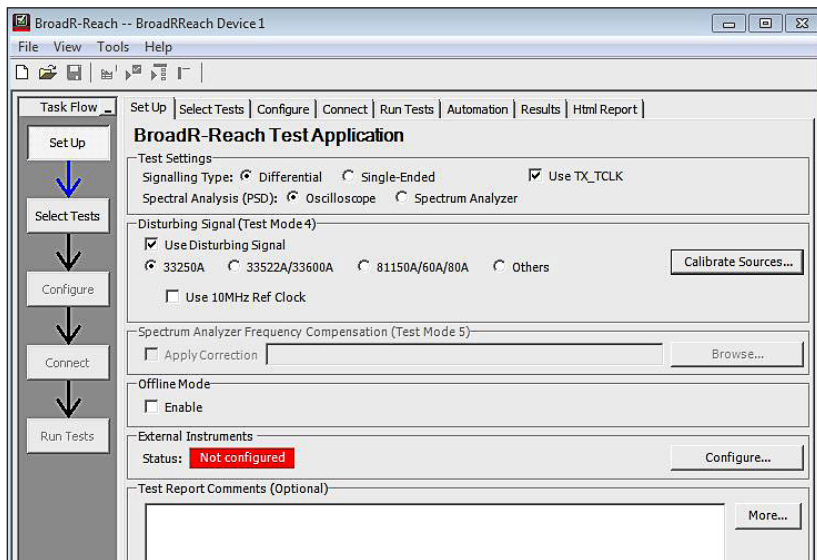

Figure 1. The clean interface allows you select which tests you want to run.

N6467A/B software saves you time

View all of the tests in the GUI under selected tests

- Setup wizard for quick and clear setup, configuration and test
- Clearly see all the available tests
- Run single or multiple tests based on your needs
- When test is highlighted, it will show description of test along with pass limits
- Accurate and repeatable results with Keysight Infiniium oscilloscopes
- Automated reporting in a comprehensive HTML format with margin analysis
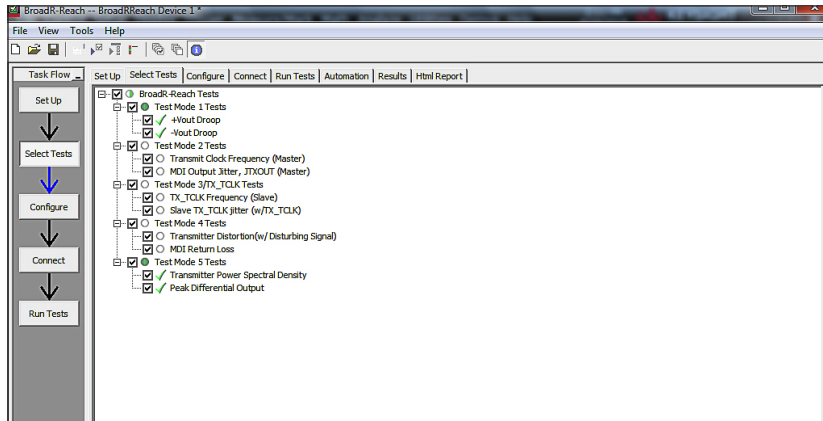

Figure 2. The Keysight automated test engine quickly guides you through selecting and configuring tests, setting up the connection, running tests, and viewing results. You can easily select individual tests or groups of tests with a mouse-click.

Configurability and guided connections

The N6467A/B electrical test software provides flexibility in your test setup. It guides you to make connection changes with hookup diagrams when the tests you select require it. In most cases, connection from device under test to the oscilloscope will be made through an SMA cable, otherwise a Keysight N5395C Ethernet test fixture can be used with an RJ-45 connector. You then connect the oscilloscope to the test fixture using SMA cables.
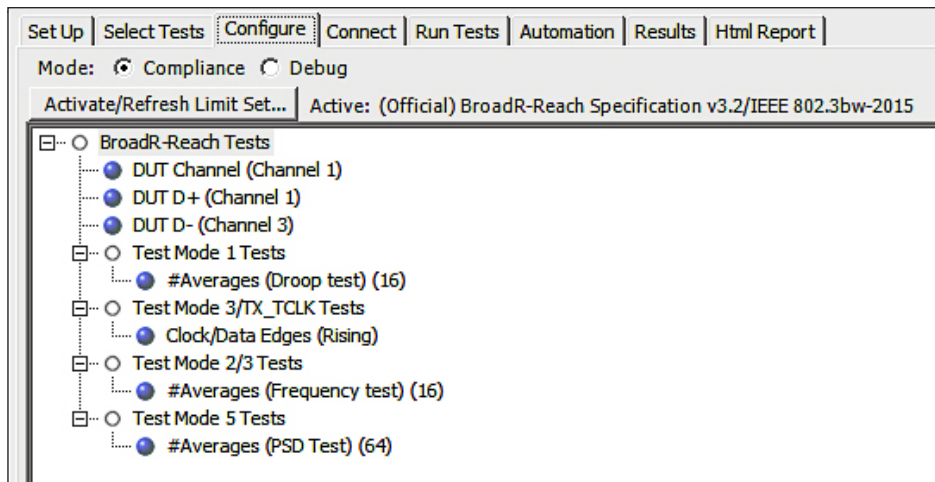

Figure 3. To set up tests, you define the device to test, its configuration, and how the oscilloscope is connected to it.
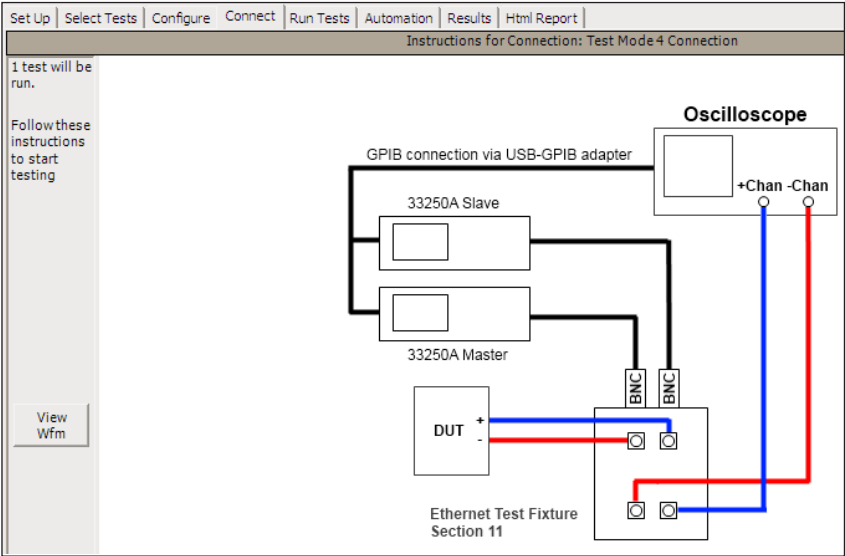
Configurability and guided connections

Figure 4. When you make multiple tests where the connections must be changed, the software prompts you with connection diagrams.

Step	Notes
1. Connect the DUT to the **Ethernet Test Fixture, Section 11** using a pair of SMA cables.	Connect the DUT to the SMA connectors labeled "DUT"
2. Connect the Function Generators to the **Ethernet Test Fixture, Section 11** using a pair of SMA cables.	Please calibrate the Function Generators before running the test.
3. Connect the Oscilloscope to the output of the **Ethernet Test Fixture, Section 11**.	Connect the oscilloscope to the SMA connectors labeled "Scope"
4. Configure the DUT to transmit in **Test Mode 4**.	Use the software supplied by your PHY manufacturer to control the DUT.

Example waveform:

Figure 5. In the connection setup, step-by-step instructions along with expected signals are displayed to help with test setup.

Configurability and guided connections

In addition to giving you measurement results, the N6467A/B electrical test software also provides a report format that shows you not only where your product passes or fails but also how close you are to the limits specified for a particular test. You can select the margin test report parameter, which means you can specify the level at which warnings are issued to alert you to electrical tests where your product is operating close to the official test limit defined by the IEEE 802.3bw specification.
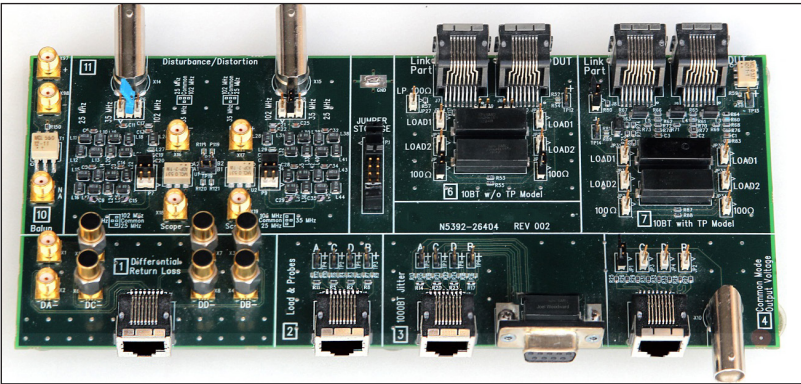

Figure 6. The Keysight N5395C fixture is optional when customers have RJ-45 cables coming from the device instead of SMA cables.

Test Name	Worst Actual	Worst Margin	Pass Limits
✗ Transmitter +Vout Droop	55.38 %	-23.1%	VALUE < 45.00 %
✗ Transmitter -Vout Droop	55.23 %	-22.7%	VALUE < 45.00 %
✓ TX_TCLK Frequency (Master)	66.669190 MHz	31.1%	66.660000 MHz <= VALUE <= 66.673333 MHz
✓ MDI Output Jitter, JTXOUT (Master)	23.293 ps	53.4%	VALUE < 50.000 ps
ⓘ TX_TCLK Frequency (Slave)	66.669150 MHz		Information Only
✓ TX_TCLK Jitter (Slave)	1.449 mUI	85.5%	VALUE < 10.000 mUI
✗ Transmitter Distortion	19.35 mV	-29.0%	VALUE <= 15.00 mV
✗ Transmitter Power Spectral Density	-46.412 dBm/Hz	-464.1%	Overall = Pass

Figure 7. The N6467A/B electrical test software results screen shows a summary of the tests performed, pass/fail status, and margin. Clicking on a specific test also shows the test specification and a measurement waveform, if appropriate.
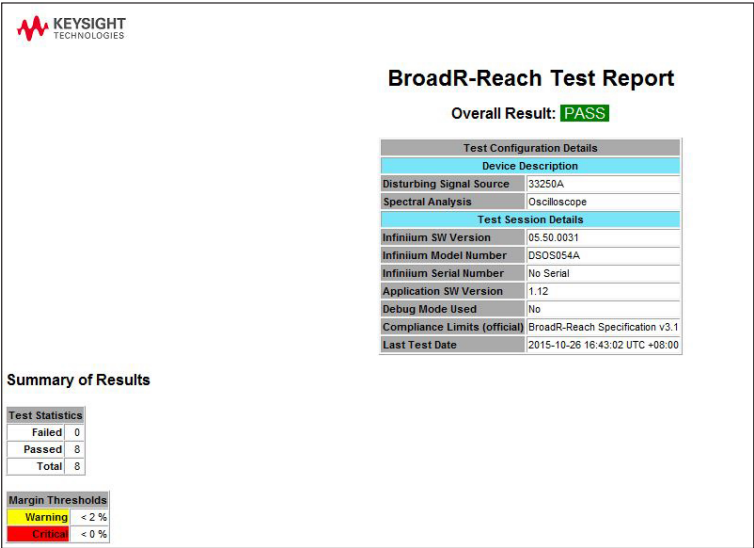
Reports with margin analysis

Figure 8. The N6467A/B electrical test software HTML report documents your test and indicates the pass/fail status, test specification range, measured values, and margin.
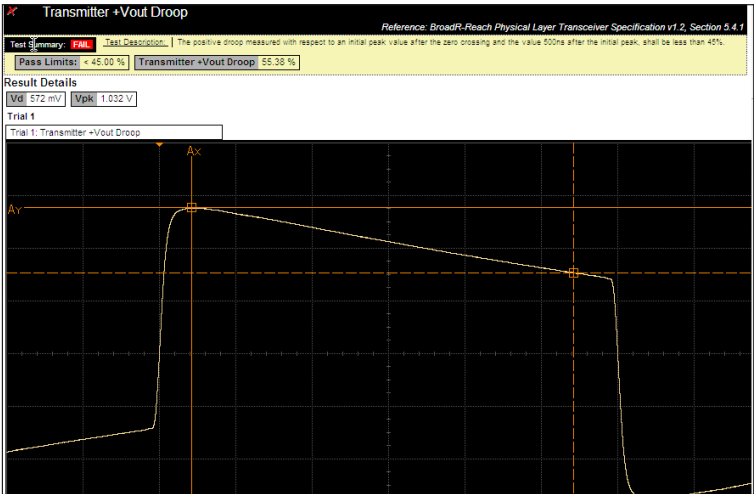

Figure 9. Additional details are available for each test, including the test limits, test description, and test results, including waveforms, if appropriate.
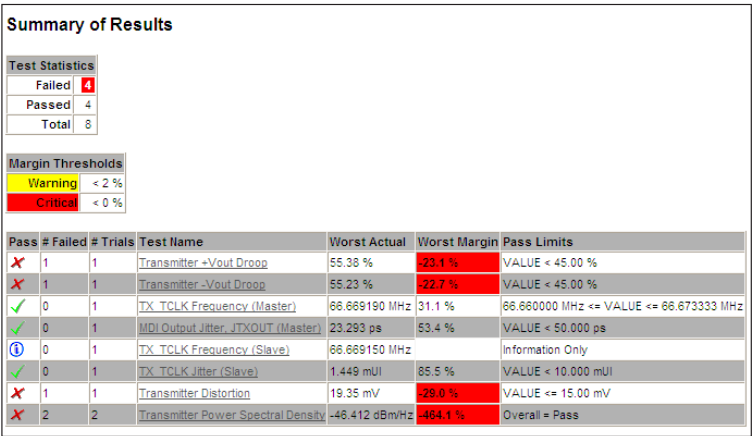

Figure 10. How close your device comes to passing or failing a test is indicated as a percentage in the margin field. A result highlighted in yellow or red indicates that your device has tripped the margin threshold level for a warning or failure.

Extensibility

You may add additional custom tests or steps to your application using the N5467B User Defined Application (UDA) development tool (www.keysight.com/find/uda). Use UDA to develop functional "Add-Ins" that you can plug into your application.:

Add-Ins may be designed as:

– Complete custom tests (with configuration variables and connection prompts)
– Any custom steps such as pre or post processing scripts, external instrument control and your own device control
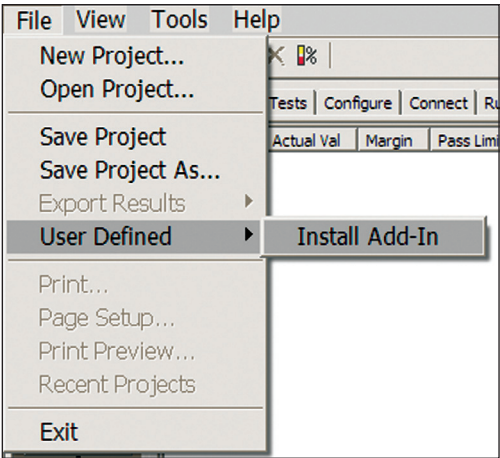

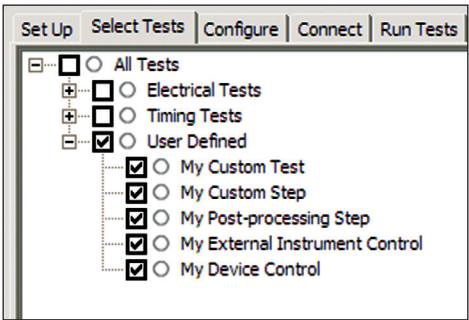Figure 11. Importing a UDA Add-In into your test application.

Figure 12. UDA Add-In tests and utilities in your test application.

Automation

You can completely automate execution of your application's tests and Add-Ins from a separate PC using the included N5452A Remote Interface feature (download free toolkit from www.keysight.com/find/scope-apps-sw). You can even create and execute automation scripts right inside the application using a convenient built-in client.

The commands required for each task may be created using a command wizard or from "remote hints" accessible throughout the user interface.

Using automation, you can accelerate complex testing scenarios and even automate manual tasks such as:

– Opening projects, executing tests and saving results
– Executing tests repeatedly while changing configurations
– Sending commands to external instruments
– Executing tests out of order

Combine the power of built-in automation and extensibility to transform your application into a complete test suite executive:

– Interact with your device controller to place it into desired states or test modes before test execution.
– Configure additional instruments used in your test suite such as a pattern generator or probe switch matrix.
– Export data generated by your tests and post-process it using your favorite environment, such as MATLAB, Python, LabVIEW, C, C++, Visual Basic, etc.
– Sequence or repeat the tests and "Add-In" custom steps execution in any order for complete test coverage of the test plan.
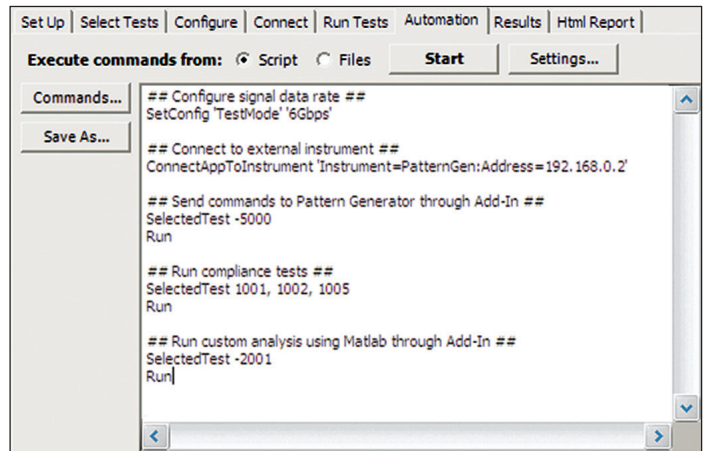

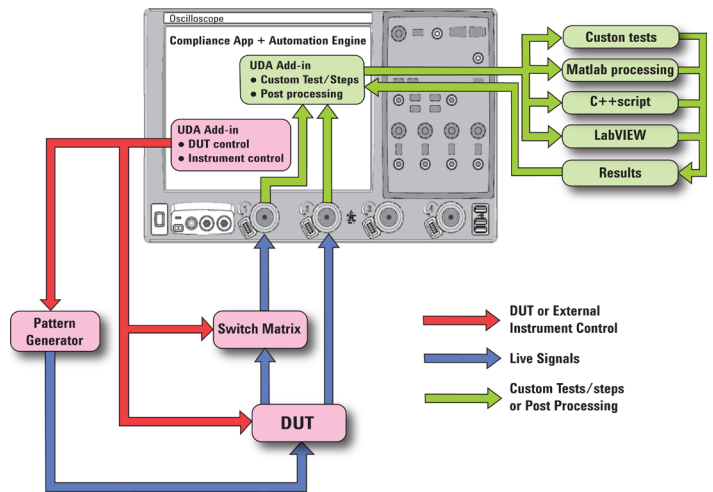Figure 13. Remote Programming script in the Automation tab.

Figure 14. Combine the power of built-in automation and extensibility to transform your application into a complete test suite executive.

The N6467A/B automotive compliance application covers all of the following physical layer transceiver specification tests.

Table 2. Electrical tests performed by the N6467A/B compliance application software as required by the OPEN alliance and IEEE 802.3bw.

Physical layer transceiver specification for automotive applications tests	Description
5.4.1	Transmitter output positive droop
5.4.1	Transmitter output negative droop
5.4.2	Transmitter distortion
5.4.3	Transmitter master timing jitter
5.4.3	Transmitter slave timing jitter
5.4.4	Transmitter Power Spectral Density (PSD) with spectrum analyzer[1]
5.4.4	Transmitter Power Spectral Density (PSD) with oscilloscope[1]
5.4.5	Transmit clock frequency (master)
5.4.5	Transmit clock frequency (slave)
96.5.6	Transmitter peak differential output

1. Only one PSD test is required but there is a choice to use a spectrum analyzer or oscilloscope.

Ordering information

Recommended hardware

	Minimum instrument requirements	Available Keysight models
Basic compliance	1 GHz oscilloscope, 2-channel	9000, Infiniium S-Series, 90000, V-Series or Z-Series
Transmitter distortion	2-channel function generator min bandwidth 12 MHz	33510/20B, 33512/22B, 33612A, 81150/60A/80A
MDI return loss	Network Analyzer; Start and Stop frequency range 1MHz - 66 MHz Only 1 port ENA is required	E5063A,E5061B,E5071C, E5072A, E5080A
Power spectral density (SA)[1]	Spectrum analyzer, min 1 GHz bandwidth	Any X-Series analyzer

Recommended accessories

Listed here are many options, please note some of these accessories are optional to the standard configuration.

Description	Keysight model number/s	Comments
Probe	113xA/B or 116XA/B or N275xA Series[2]	Min of 1.5 GHz bandwidth
Probe head	E2678A InfiniiMax socketed differential probe head E2677A InfiniiMax solder-in differential probe head N5381A InfiniiMax solder-in differential probe head E2669A InfiniiMax connectivity kit for differential/single-ended measurements[2]	Only one probe head is required. An alternative to purchasing the E2677A and E2678A is the E2669A which contains, one E2575A differential browser probe head, four E2677A solder-in differential probe heads, and two E2678A socketed differential probe heads.
Ethernet compliance test fixture	N5395C[2]	
SMA cable SMA (m) – SMA (m)	E6961-SMA	Quantity 2 needed
BNC (m) to SMA(f) adapter	54855-67604	Quantity 2 needed
Additional items needed for required transmitter distortion and MDI return loss test (test mode 4)		
Frequency Divider card	E6961A-FDB	
ECal 4 ports	N4431B with option 010	Used to calibrate the ENA (can also be calibrated with 2 port Ecal)
N-type(m)- APC-3.5 (f) adapter	E6961A-ADC	For connection to the ENA, quantity 4 needed.

1. The power spectral density test can also be done with an oscilloscope, the Spectrum Analyzer is a secondary and optional method
2. IEEE 802.3bw does not specify a connector, users may have different means to connect D+ and D- signals to the oscilloscope. For DUTs that use standard RJ-45 Ethernet connections, Keysight's E5395C Ethernet compliance test fixture can be used for differential signal breakout. Alternatively, a differential probe or SMA cables can be used to access D+ and D- signals.

Ordering Guidelines

N6467A should be ordered with the Infiniium 90000, V-Series and Z-Series
N6467B should be ordered with the 9000 and Infiniium S-Series

Single part number inclusive of all applicable hardware and software

Required for compliance	Description	Option number through E6961A		Stand alone
Required	100Base-T1 Tx Compliance test software	N6467B-1FP		N6467B-1FP
Required	Frequency divider board	These items are available in a bundle E6961A-AEB	E6961A-FDB	
Optional	Ethernet compliance test fixture		E6961A-ETF	N5395C
Required	SMA cable x 2 SMA(m) – SMA(m)		E6961A-SMA	E6961A-SMA
Required	SMA adapter x2 (BNC to SMA)		E6961A-ADP	54855-67604
Optional	InfiniiMax Differential probe and socketed differential probe head, 3.5 GHz or greater[1]	E6961A-PRO		1131B and E2678B
Required	Infiniium S-Series High-Definition Oscilloscope 2.5 GHz, 4 Analog channels[1]	E6961A-OSC		DSOS254A
The following are additional requirements when executing test mode 4				
Required	Frequency divider board	E6961A-FDB		E6961A-FDB
Optional	USB/GPIB adapter – can be used to control ENA or function generator from the oscilloscope[2]	E6961A-USB		82357B
Required	RF Electronic Calibration Module (ECal), 9 kHz to 13.5 GHz, 4-port and connectors used to calibrate the ENA	E6961A-ECL		N4431B with Option 010
Required	N-type(m)- APC-3.5 (f) adapter used for connection to the ENA	E6961A-ADC		1250-1744
Required	Pulse Function Arbitrary Noise Generator, 2 channels[1]	E6961A-AWG		81150A Option 002
Required	ENA Vector Network Analyzer	E6961A-ENA		E5071C options 440,810, 820
Optional (for alternative method of power spectral density test)				
Optional	EXA Signal Analyzer, Multi-touch, 10 Hz to 3.6 GHz and step attenuator	E6961A-EXA		N9010A, and Options 503 and FSA

1. These items exceed the min requirements for 100BASE-T1 but contain enough bandwidth to also cover 1000BASE-T1 requirements.
2. Direct LAN connection can also be used to connect the instruments together.

For example, a completely configured order for full compliance with one part number

Qty(1) E6961A
   opt Qty(1) N6467B-1FP **Automotive Ethernet compliance software for Infiniium oscilloscopes**
Qty(1) E6961A-AEB[1] **Bundle of cables and fixtures**
Qty(1) E6961A-OSC **2.5 GHz S-Series oscilloscope**

Additional items needs for required MDI return loss and transmitter distortion test
Qty(1) E6961A-ECL **4-port Ecal**
Qty(2) E6961A-ADC **Ntype to APC adapter**
Qty(1) E6961A-AWG **81150A 2 channel AWG**
Qty(1) E6961A-ENA **E5071C Vector Network Analyzer 4.5 GHz**

1. Qty(1) E6961A-AEB includes the following
         Qty(1) E6961A-FDB **Frequency divider board**
         Qty(1) E6961A-ETF **Ethernet test fixture**
         Qty(2) E6961A-SMA **SMA cables**
         Qty(2) E6961A-ADP **BNC to SMA adapters**

Ordering Guidelines (continued)

For example, a completely configured order for full compliance with standalone part numbers

Qty(1) DSOS204A **1GHz S-Series Infiniium oscilloscope**
Qty(1) N6467B-1FP **100BASE-T1 Automotive Ethernet compliance application**
Qty(1) N5395C **Ethernet test fixture**
Qty(2) E6961A-SMA **SMA Cable SMA(m) -SMA(m)**
Qty(2) 54855-67604 **BNC(m) to SMA(f) adapter**
Qty(1) E6961A-FDB **Clock Frequency Divider Test Fixture**

Additional items needs for required MDI return loss and transmitter distortion test
Qty(1) 33522B **2-channel Waveform Generator**
Qty(1) E5071C **Vector Network Analyzer** – used for MDI return loss
  opt Qty(1) 240
  opt Qty(1) 810
  opt Qty(1) 820
Qty(2) 1250-1744 **Type-N(m) to SMA(f) adapter**
Qty(2) E6961A-SMA **SMA Cable SMA(m) -SMA(m)**
Qty(1) N4431B **Ecal module for VNA**
  opt Qty(1) 010 4 port

Hardware firmware requirements	
Keysight Infiniium Series oscilloscopes with operating software revision 6.10 or higher.	For oscilloscopes with earlier revisions, free upgrade software is available here: www.keysight.com/find/scope-apps-sw
Keysight N9010B EXA analyzer with instrument software version A.19.05 or higher.	For N9010B with earlier revisions, free upgrade software is available here: www.keysight.com/find/exa_software
Keysight E5071C ENA analyzer with firmware revision B.13.30 or higher.	For E5071C with earlier revisions, free upgrade software is available here: www.keysight.com/find/ena_firmware

Ordering information (continued)

To purchase the software with a new or existing Infiniium Series oscilloscope, order the following options.

Software options

Application	License type		Infiniium Z-Series	Infiniium S-Series /Infiniium V-Series[1]
Automotive Ethernet	Fixed	Factory-installed	N6467A/B-1FP	N6467B-1FP
		User-installed	N6467A/B-1FP	N6467B-1FP
	Floating	Transportable	N6467A/B-1TP	N6467B-1TP
		Server-based	N5435A-062	

1. Infiniium V and Z series require a 10 dB attenuator when connecting to the clock frequency divider board.

Related Keysight literature

Publication title	Pub number
Infiniium 90000 Series Oscilloscopes Data Sheet	5989-7819EN
N5435A Infiniium Server-Based License for Infiniium Oscilloscopes Data Sheet	5989-6937EN
E2688A, N5384A High-Speed Serial Data Analysis and Clock Recovery Software for Infiniium Oscilloscopes Data Sheet	5989-0108EN
Infiniium 90000 X-Series Oscilloscopes Data Sheet	5990-5271EN
E6960A 1000BASE-T1 Automotive Ethernet Compliance Application Data Sheet	5992-2672EN
Automotive Ethernet Solutions Brochure	5992-2561EN
N8847A Automotive Ethernet Protocol Triggering and Decode	5992-2682EN

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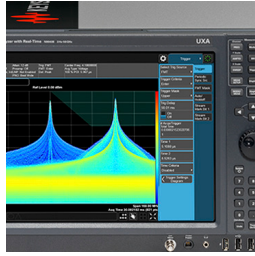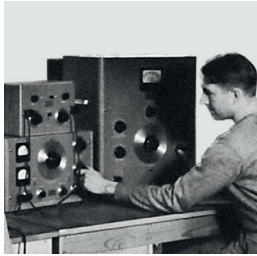
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Keysight Services can help from acquisition to renewal across your instrument's lifecycle. Our comprehensive service offerings—one-stop calibration, repair, asset management, technology refresh, consulting, training and more—helps you improve product quality and lower costs.

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