

Keysight Technologies

N5392B Energy Efficient Ethernet Electrical Performance Validation/ Conformance Software

For Infiniium Oscilloscopes

EEE Fixture from Wilder P/N: EEE-TPA-ERK fixture Kit

Data Sheet

Easy and Accurate Energy Efficient Ethernet Design Validation and Debug

The Keysight Technologies, Inc. N5392B Energy Efficient Ethernet (EEE) electrical performance validation and conformance software for Infiniium oscilloscopes provides you with an easy and accurate way to verify and debug your 1000BASE-T, 100BASE-TX and 10BASE-T 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 1000BASE-T, 100BASE-TX and 10BASE-T Energy Efficient Ethernet measurements with the N5392B Ethernet electrical test software, you also need the

Wilder Fixture Kit (P/N: EEE-TPA-ERK) Energy Efficient Ethernet electrical conformance test fixture.

The N5392B Ethernet electrical test software performs a wide range of electrical tests required to meet the Energy Efficient Ethernet electrical specifications for 1000BASE-T, 100BASE-TX and 10BASE-T systems as documented in the IEEE 802.3az-2010 standard. To meet signal quality requirements, your product must successfully pass conformance testing based on this specification. Performing these tests gives you confidence in your design. The N5392B Ethernet electrical test software helps you execute a wide subset of the conformance tests that can be measured with an oscilloscope.

N5392B Software Saves You Time

Seamless Integration into the Standard N5392A Ethernet Compliance Application

The N5392B Energy Efficient Ethernet electrical performance application can be integrated into the existing N5392A Ethernet application so that both standard and Energy Efficient Ethernet compliance tests can be run in one single interface.

For more information on N5392A Ethernet Electrical Performance Validation and Conformance Software, visit:

www.keysight.com/N5392A

Features

The N5392B Energy Efficient Ethernet electrical test software offers several features to simplify the validation of Ethernet designs:

- Setup wizard for quick and clear setup, configuration and test
- Wide range of 1000BASE-T, 100BASE-TX and 10BASE-T Energy Efficient Ethernet tests enabling standards conformance
- Accurate and repeatable results with Keysight Infiniium oscilloscopes
- Test various Low-Power Idle (LPI) conditions
- Automated reporting in a comprehensive HTML format with margin analysis

With the N5392B electrical test software, you can use the same oscilloscope you use for everyday debugging to perform automated testing and margin analysis based on the Energy Efficient Ethernet standards.

The N5392B Ethernet electrical test software saves you time by setting the stage for automatic execution of Energy Efficient Ethernet electrical tests. Part of the difficulty of performing electrical tests for Ethernet is 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 Ethernet electrical test software does much of this work for you.

The N5392B Energy Efficient Ethernet electrical test software automatically configures the oscilloscope for each test, and it 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 Energy Efficient Ethernet electrical test software.

Easy test definition

The N5392B Energy Efficient Ethernet electrical test software extends the ease-of-use advantages of Keysight's Infiniium oscilloscopes to testing Energy Efficient Ethernet 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 test results. A setup page enables you to quickly make decisions from the outset regarding the choice of tests and perform functions that affect the testing task. 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.

View all of the Energy Efficient Ethernet tests in the GUI under selected tests

- Setup wizard for quick and clear setup, configuration and test
- See clearly all the Energy Efficient Ethernet tests for 10BASE-T, 100BASE-TX and 1000BASE-T
- Run single or multiple tests based on your needs
- When a test is highlighted, it will show the description of the test along with pass limits
- Accurate and repeatable results with Keysight Infiniium oscilloscopes
- Automated reporting in a comprehensive HTML format with margin analysis

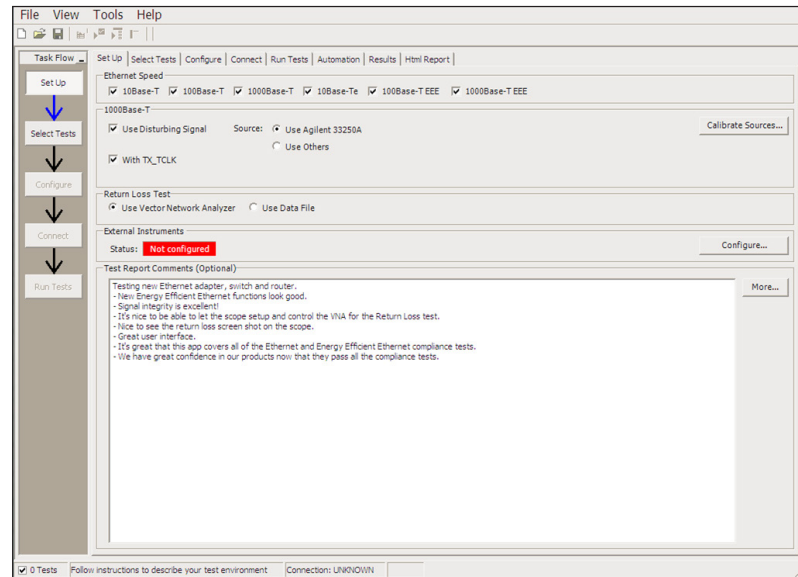


Figure 1. The clean interface lets you select any Ethernet speed or speeds and/or associated Energy Efficient Ethernet standard.

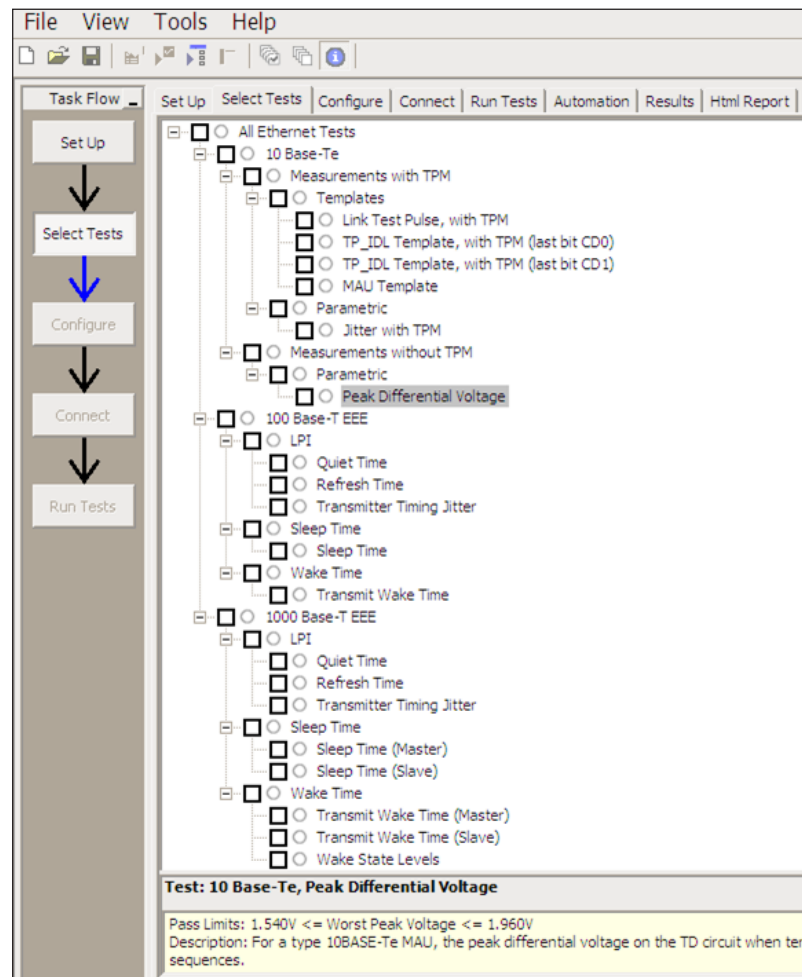


Figure 2. The Keysight automated test engine quickly guides you through selecting and configuring tests, setting up the connection, running the tests, and viewing the results. You can easily select individual tests or groups of tests with a mouse-click.

Configurability and guided connections

The N5392B Ethernet 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. All Ethernet electrical conformance tests you perform are based on the Wilder EEE-TPA-ERK Energy Efficient Ethernet electrical conformance test fixture. You connect the oscilloscope to the conformance test fixture using Keysight InfiniiMax active differential probes and SMA cables.

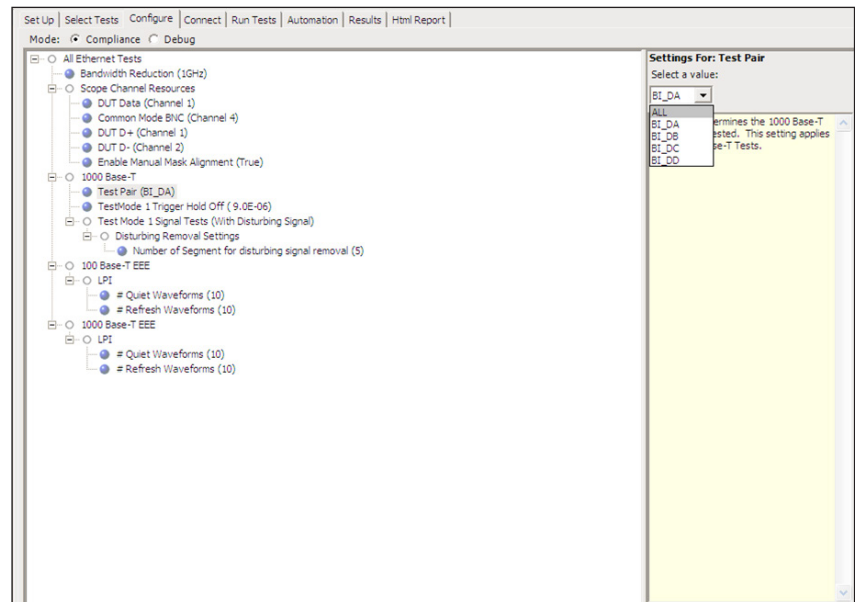


Figure 3. To set up tests, you define the device to test, its configuration, and how the oscilloscope is connected to it.

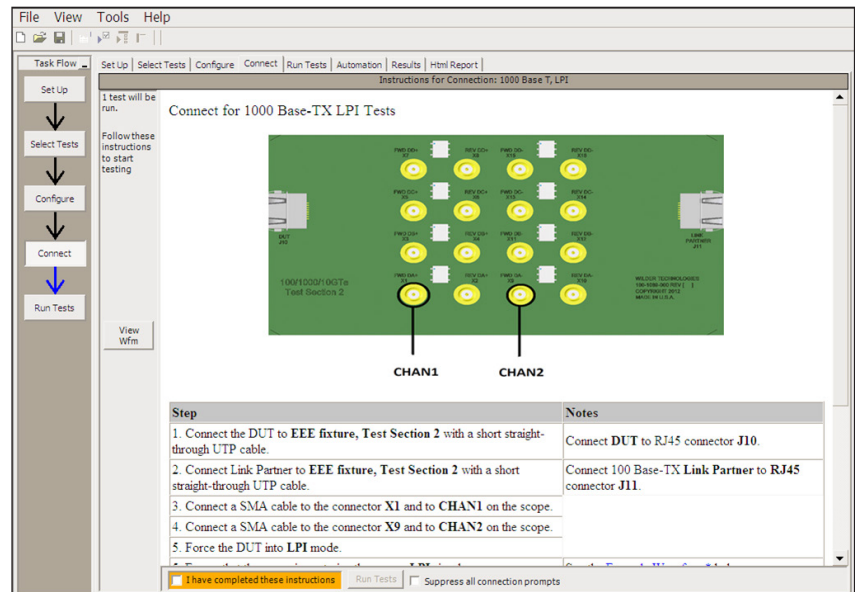


Figure 4. When you make multiple tests where the connections must be changed, the software prompts you with connection diagrams.

Configurability and guided connections (Continued)

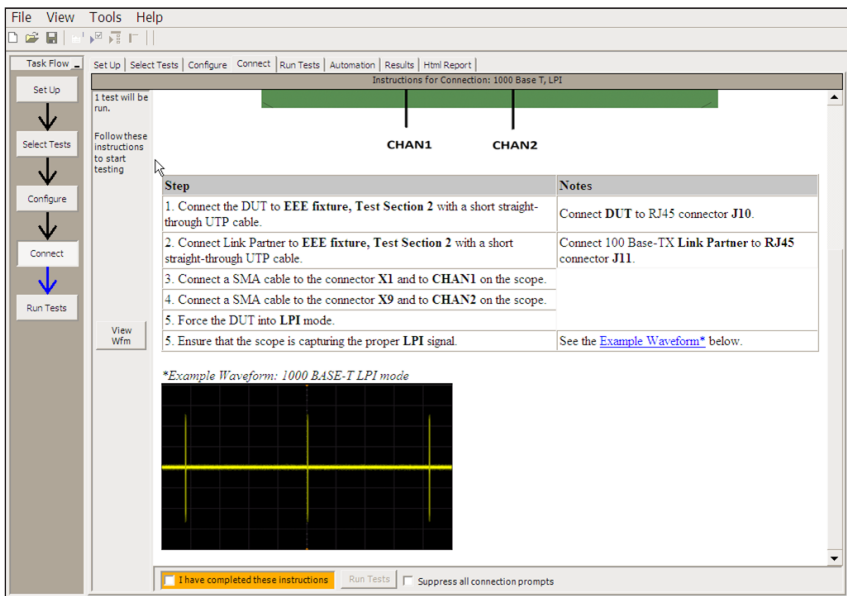


Figure 5. In the connection setup, step-by-step instructions along with expected signals are displayed to help with test setup.

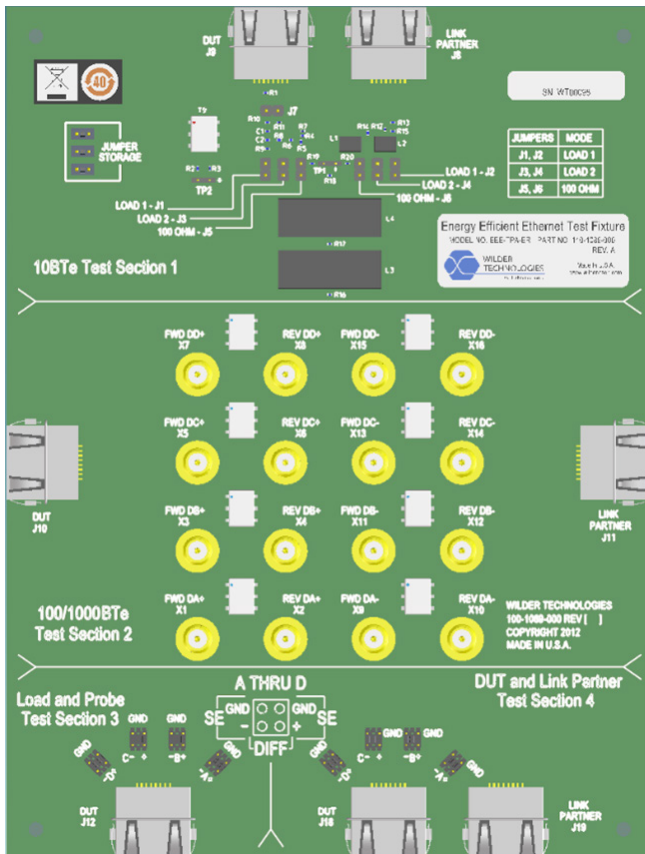


Figure 6. The Energy Efficient Ethernet fixture from Wilder Technologies, P/N: EEE-TPA-ERK, is used for all EEE tests.

Configurability and guided connections (Continued)

In addition to providing you with measurement results, the N5392B Energy Efficient Ethernet electrical test software provides a report format that not only shows you where your product passes or fails, but also reports 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 Energy Efficient Ethernet specification.

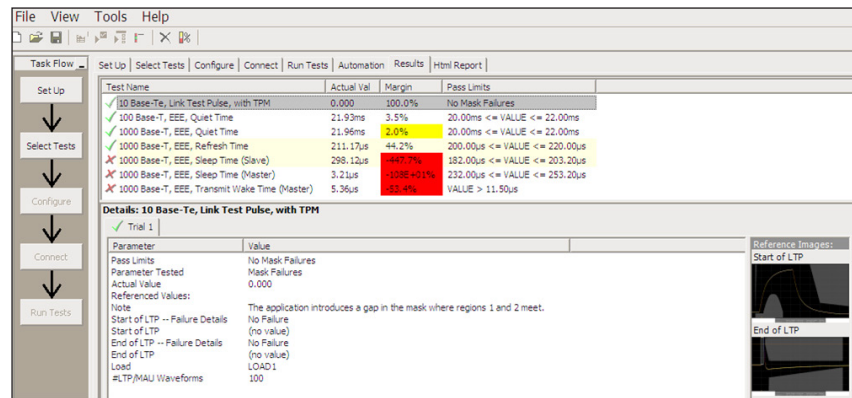


Figure 7. The Ethernet electrical test software results screen shows a summary of the tests performed, pass/fail status, and margin. Clicking on a specific test also shows the test specification and a measurement waveform, if appropriate.

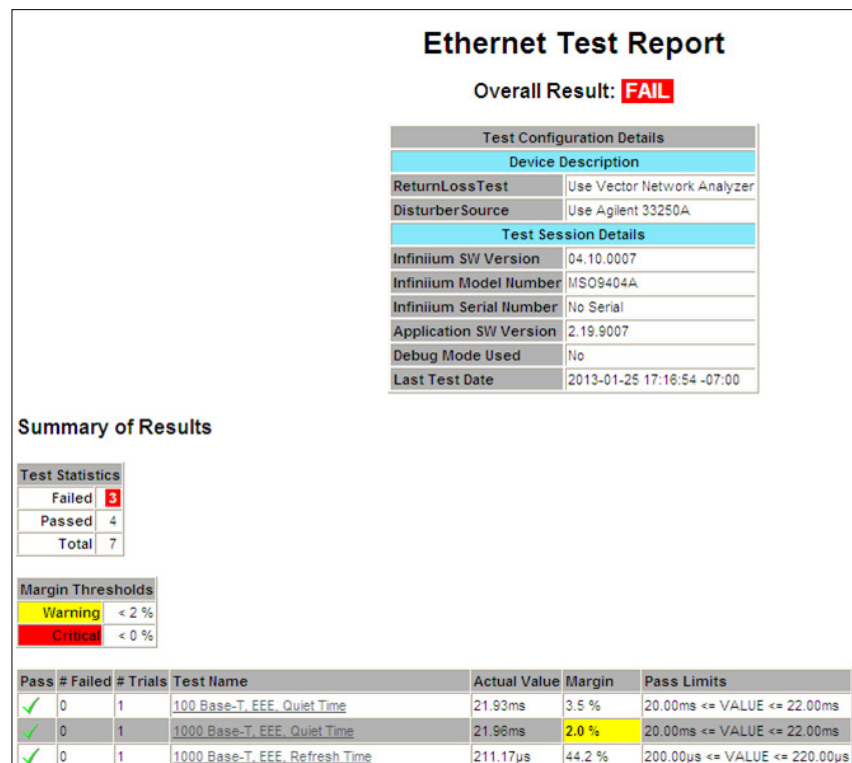


Figure 8. The Energy Efficient Ethernet electrical test software HTML report documents your test, and indicates the pass/fail status, test specification range, measured values, and margin.

Reports with Margin Analysis

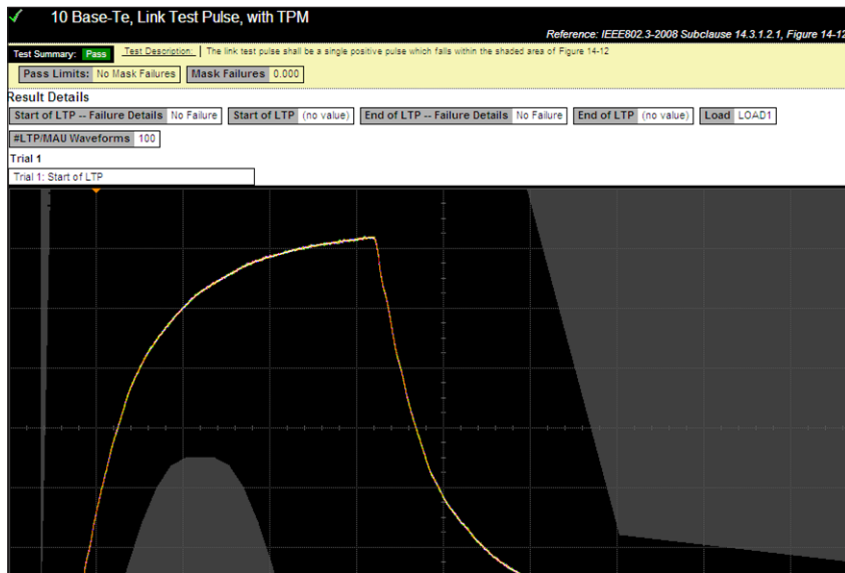


Figure 9. Additional details are available for each test, including the test limits, test description, and test results, including waveforms, if appropriate.

Summary of Results

| Test Statistics | |
|-----------------|---|
| Failed | 3 |
| Passed | 4 |
| Total | 7 |

| Margin Thresholds | |
|-------------------|-------|
| Warning | < 2 % |
| Critical | < 0 % |

| Pass | # Failed | # Trials | Test Name | Actual Value | Margin | Pass Limits |
|------|----------|----------|---|--------------|------------|-------------------------------|
| ✓ | 0 | 1 | 100 Base-T, EEE, Quiet Time | 21.93ms | 3.5 % | 20.00ms <= VALUE <= 22.00ms |
| ✓ | 0 | 1 | 1000 Base-T, EEE, Quiet Time | 21.96ms | 2.0 % | 20.00ms <= VALUE <= 22.00ms |
| ✓ | 0 | 1 | 1000 Base-T, EEE, Refresh Time | 211.17µs | 44.2 % | 200.00µs <= VALUE <= 220.00µs |
| ✗ | 1 | 1 | 1000 Base-T, EEE, Sleep Time (Master) | 3.21µs | -108E+01 % | 232.00µs <= VALUE <= 253.20µs |
| ✗ | 1 | 1 | 1000 Base-T, EEE, Sleep Time (Slave) | 298.12µs | -447.7 % | 182.00µs <= VALUE <= 203.20µs |
| ✗ | 1 | 1 | 1000 Base-T, EEE, Transmit Wake Time (Master) | 5.36µs | -63.4 % | VALUE > 11.50µs |
| ✓ | 0 | 1 | 10 Base-Tc, Link Test Pulse, with TPM | 0.000 | 100.0 % | No Mask Failures |

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 N5467A 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

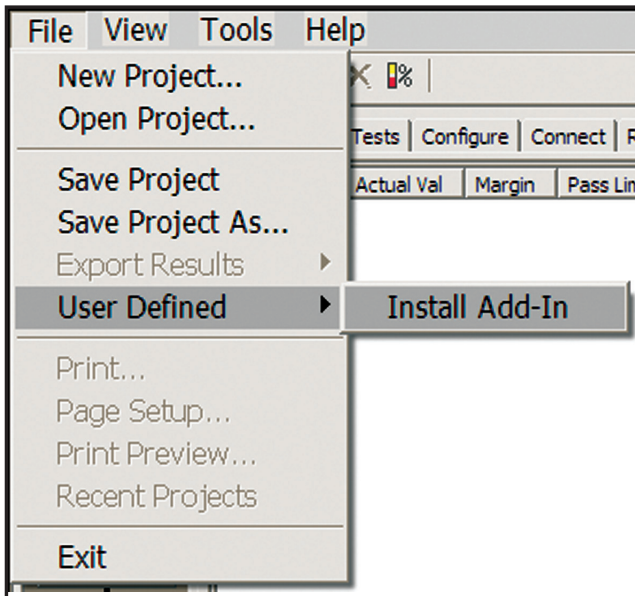


Figure 11. Importing a UDA Add-In into your test application.

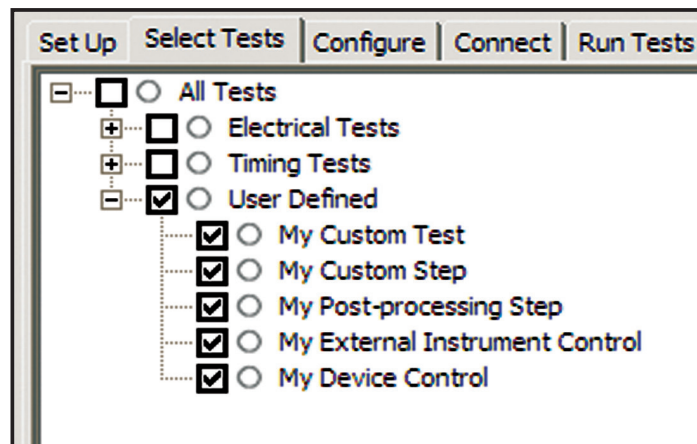


Figure 12. UDA Add-In tests and utilities in your test application.

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 and 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.

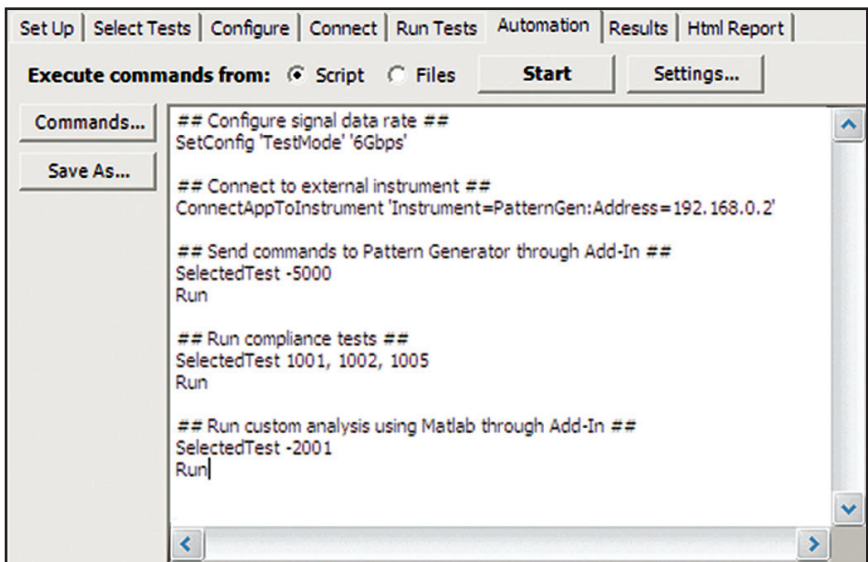


Figure 13. Remote Programming script in the Automation tab.

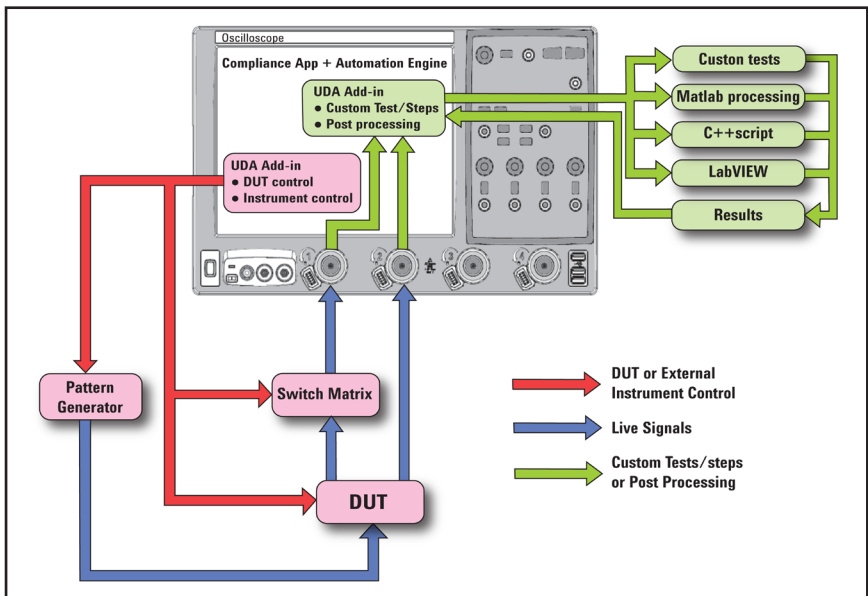


Figure 14. Combine the power of built-in automation and extensibility to transform your application into a complete test suite executive.

Oscilloscope compatibility

The N5392B Ethernet Conformance software will run on:

- 9000 Series, version 4.20 or higher
- 90000 Series, version 4.20 or higher
- 90000 X-Series, version 4.20 or higher

These are shown in Table 1 below with minimum recommended bandwidth model and probes shown.

For oscilloscopes with earlier software revisions, upgrade software is available at:

www.keysight.com/find/infiniium_software

| Data rate | Standard | Recommended oscilloscope | Bandwidth of recommended oscilloscope | Recommended probe | Bandwidth of recommended probe |
|----------------------------------|-------------------------|--------------------------|---------------------------------------|-------------------|--------------------------------|
| 10 Mb/s, 100 Mb/s | 10BASE-T, 100BASE-TX | DSO/MSO9064A | 600 MHz | 1130A | 1.5 GHz |
| | | DSO/MSO9104A | 1 GHz | 1130A | 1.5 GHz |
| | | DSO/DSA90254A | 2.5 GHz | 1131A | 3.5 GHz |
| | | DSO/DSA90404A | 4 GHz | 1132A | 5 GHz |
| | | DSO/DSA90604A | 6 GHz | 1134A | 7 GHz |
| | | DSO/DSA90804A | 8 GHz | 1168A | 10 GHz |
| | | DSO/DSA91204A | 12 GHz | 1169A | 12 GHz |
| | | DSO/DSA91304A | 13 GHz | 1169A | 12 GHz |
| | | DSO/DSAX91604A | 16 GHz | N2800A | 16 GHz |
| | | DSO/DSAX92004A | 20 GHz | N2801A | 20 GHz |
| | | DSO/DSAX92504A | 25 GHz | N2802A | 25 GHz |
| | | DSO/DSAX92804A | 28 GHz | N2802A | 28 GHz |
| | | DSO/DSAX93204A | 32 GHz | N2803A | 30 GHz |
| | | | | | |
| Gigabit Ethernet (4x250 Mb/s) | 1000BASE-T | DSO/MSO9254A | 2.5 GHz | 1131A | 3.5 GHz |
| | | DSO/DSA90254A | 2.5 GHz | 1131A | 3.5 GHz |
| | | DSO/MSO9404A | 4 GHz | 1132A | 5 GHz |
| | | DSO/DSA90404A | 4 GHz | 1132A | 5 GHz |
| | | DSO/DSA90604A | 6 GHz | 1134A | 7 GHz |
| | | DSO/DSA90804A | 8 GHz | 1168A | 10 GHz |
| | | DSO/DSA91204A | 12 GHz | 1169A | 12 GHz |
| | | DSO/DSA91304A | 13 GHz | 1169A | 12 GHz |
| | | DSO/DSAX91604A | 16 GHz | N2800A | 16 GHz |
| | | DSO/DSAX92004A | 20 GHz | N2801A | 20 GHz |
| | | DSO/DSAX92504A | 25 GHz | N2802A | 25 GHz |
| | | DSO/DSAX92804A | 28 GHz | N2802A | 28 GHz |
| | | DSO/DSAX93204A | 32 GHz | N2803A | 30 GHz |
| | | | | | |

Table 1. Recommended oscilloscopes and active probes

This is the first Energy Efficient Ethernet compliance application to support 10/100/1000BASE-T tests based on the IEEE 802.3az-2010 specification.

| Standard reference | | Description |
|---------------------------------|---|---------------------------|
| 10Base-T | IEEE 802.3az, 14.3.1.2.1, Figure 14-12 | LTP, w/TPM |
| Energy Efficient Ethernet tests | IEEE 802.3az, 14.3.1.2.1, Figure 14-10 | TP_IDL, w/TPM |
| | IEEE 802.3az, 14.3.1.2.1, Figure 14-9, Table 14-1 | MAU template |
| | IEEE 802.3az, 14.3.1.2.1, and Annex B.4.1, B.4.3.3 | Jitter w/TPM |
| | IEEE 802.3az, 14.3.1.2.1 | Peak differential voltage |
| 100Base-TX | IEEE 802.3az, Sub clause 78.2, Table 78-2, Sub clause 24.8.3.5 | Quiet time |
| Energy Efficient Ethernet tests | IEEE 802.3az, Sub clause 78.2, Table 78-2, Sub clause 24.8.3.5 | Refresh time |
| | IEEE 802.3az, Sub clause 25.4.6 | Transmitter timing jitter |
| | IEEE 802.3az, Sub clause 78.2, Table 78-2, Sub clause 24.2.2.1.1, Sub clause 24.8.3.5 | Sleep time |
| | IEEE 802.3az, Sub clause 78.3, Figure 78-4, Sub clause 78.5, Table 78-4 | Wake time |
| 1000Base-T | IEEE 802.3az, Sub clause 78.2, Table 78-2, Sub clause 40.4.5.2 | Quiet time |
| Energy Efficient Ethernet tests | IEEE 802.3az, Sub clause 40.4.6.1, Figure 40-15b, Sub clause 40.4.5.2 | Refresh time |
| | IEEE 802.3az, Sub clause 40.6.1.2.5 | Transmitter timing jitter |
| | IEEE 802.3az, Sub clause 40.4.5.2 | Sleep time |
| | IEEE 802.3az, Sub clause 78.3, Figure 78-4, Sub clause 78.5, Table 78-4 | Wake time |
| | IEEE 802.3az, Sub clause 40.6.1.2.7 | Wake state levels |

Table 2. Energy Efficient Ethernet electrical tests performed by the N5392B software

Measurement Requirements

To use the N5392B Energy Efficient Ethernet electrical performance validation and conformance software on your Infiniium oscilloscope, you will need oscilloscope probes, probe heads, Wilder Technologies Energy Efficient Ethernet electrical conformance test fixture and other test accessories depending on the Ethernet standard and test suites you want to perform. For 10BASE-T and 100BASE-TX Ethernet testing, the test configurations are similar. For 1000BASE-T, the testing requirements include SMA cables. The following section describes the fixtures and tests.

Wilder Technologies EEE-TPA-ERK Energy Efficient Ethernet electrical conformance test fixture kit

The Wilder Technologies EEE-TPA-ERK Energy Efficient Ethernet electrical conformance test fixture kit includes a main test fixture board, two short RJ-45 interconnect cable, and fourteen 50 ohm termination plugs. The main test fixture board is subdivided into four sections that are configured specifically for the requirements of different tests. Ethernet device connection is accomplished through the short RJ 45 interconnect cable.

Some measurements require a direct SMA cable connection to channels on the oscilloscope, however, most commonly the connection is via a Keysight InfiniiMax active differential probe (1130A, 1131A, 1132A, 1134A, 1168A, or 1169A) with an E2678A socketed differential probe head.

Ordering information

The following products are used in the total solution for Energy Efficient Ethernet testing with the N5392B:

| Model number | Description |
|--|--|
| N5392B | User-installed license |
| Option 060 | Factory-installed license on 9000 and 90000 Series oscilloscopes |
| N5435A Option 060 | Server-based license for 9000 and 90000 Series oscilloscopes |
| EEE-TPA-ERK | Wilder Technologies Energy Efficient Ethernet conformance test fixture kit |
| 113XA or 116XA | InfiniiMax active differential probe |
| E2678A | InfiniiMax socketed differential probe head |
| E2677A or N5381A | InfiniiMax solder-in differential probe head |
| An alternative to purchasing the E2677A and E2678A is the E2669A: | |
| E2669A | InfiniiMax connectivity kit for differential/single-ended measurements (contains one E2575A differential browser probe head, four E2677A solder-in differential probe heads, and two E2678A socketed differential probe heads) |
| Accessories | |
| SMA cables | 2 maximum needed. Recommend two long (36") cables. Suggested vendor, part number: Farnell, 8558566 (36" length) |
| SMA push-on connectors | Aids productivity by not requiring threaded SMA connections. Order 33SMA-Q50-0-4 from S.M Electronics |

Table 3. Ordering information.

Related Literature

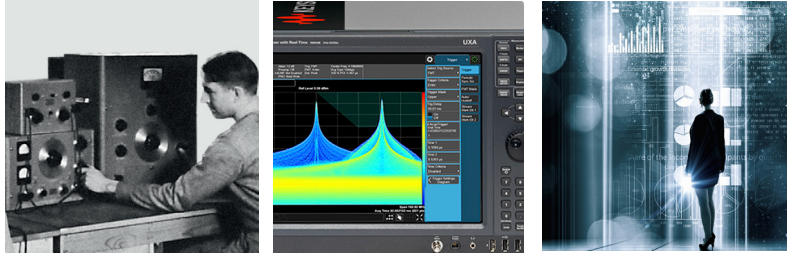
| Publication title | Publication number |
|--|--------------------|
| <i>Infiniium DSO/DSA90000A Series – Data Sheet</i> | 5989-7819EN |
| <i>Infiniium Application Server License for Infiniium Oscilloscopes – Data Sheet</i> | 5989-6937EN |
| <i>E2688A High-Speed Serial Data Analysis and Clock Recovery Software – Data Sheet</i> | 5989-0108EN |
| <i>Infiniium 9000A Series Oscilloscopes – Data Sheet</i> | 5990-3746EN |
| <i>Infiniium 90000 X-Series Oscilloscopes – Data Sheet</i> | 5990-5271EN |

Table 4. Related literature.

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Published in USA, December 2, 2017
5991-1901EN
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