

# Keysight Technologies

## N5412D Serial Attached SCSI-3 (SAS-3) Compliance Test Software for Infiniium 90000 and Z-Series Oscilloscopes

Data Sheet



## Introduction

N5421A SAS IT/IR Test Fixtures for SFF-8482 SAS-2 x2 Internal Plug/Receptacle Interfaces

Wilder Technologies SAS IT/IR Test Fixtures for SFF-8482 SAS-3 x2 Internal Plug/Receptacle Interfaces

Wilder Technologies Mini-SAS HD Test Fixtures for SAS-3 Plug/Receptacle Interfaces

### The SAS-3 electrical test software simplifies the validation of SAS designs:

- Test definitions based on T10 SAS-3 specification and UNH-IOL SAS 3.0 Physical Layer Test Suite
- Support SAS 1.5, 3.0, 6.0 and 12.0 Gbps data rates
- Support transmitter tests that require SAS3\_EYEOPENING and WDP scripts
- Easily select tests and configure IT/CT interfaces for compliance testing
- Automated setup and programming of scope measurements
- Graphical HTML test results report format for documentation and sharing
- Trials test reporting capability to allow quick comparison of test results with multiple test patterns or device configurations

### Verify and debug your SAS devices faster and more easily

Keysight Technologies, Inc. Serial Attached SCSI-3 (SAS-3) compliance test software for Infiniium Series oscilloscopes provides you with a fast and easy way to validate and debug your SAS 1.5, 3.0, 6.0 and 12.0 Gbps silicon, host bus adapter, initiator, high-density disk drive or enclosure backplane. It also supports automated SAS out-of-band (OOB) and loop back signal tests with the 81134A pattern generator and N4903B BERT with Option 002. The SAS compliance test software allows you to automatically execute SAS electrical checklist tests at each of the IT and CT interface points 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 measurements with the SAS-3 compliance test software, you also will need a method of connecting to the SAS compliance interface on the electrical mating surfaces of your SAS connector.

Keysight currently provides a full set of compliance test fixtures for the SFF-8482, SAS x2 internal drive/backplane connector interfaces for SAS 1.5 Gbps, 3.0 Gbps and 6.0 Gbps. The fixtures do meet the zero-length test load requirement for testing transmitter device compliance per section 5.9.2 of the SAS-3 specification<sup>1</sup>. The N5421A SAS SFF-8482 compliance test fixture kit offers connectivity from the SFF-8482

primary and secondary transmitter and receiver differential ports to SMA for connection to Keysight Infiniium Series ultra-high-performance oscilloscopes. The N5421A kit also includes the necessary TX and RX transient circuit test loads.

Wilder Technologies ([www.wilder-tech.com](http://www.wilder-tech.com)) provides compliance test fixtures for SFF-8482, SAS x2 internal drive/backplane connector interfaces for SAS 1.5, 3.0, 6.0 and 12.0 Gbps. In addition, the Mini-SAS HD test fixtures for SAS-3 plug and receptacle interfaces are available from Wilder Technologies.

The SAS-3 compliance test software performs a wide range of tests required to meet the physical layer requirements per section 5.9, Tables 32-51 of the SAS-3 specification. The SAS-3 compliance test software helps you execute the most difficult physical layer tests for transmitters (TX tests only), at the near-end (IT/CT interfaces) of a SAS link, that can be measured with a combination of a 20-GHz or higher real-time oscilloscope and the 81134A or N4903B programmable pulse/pattern generator. The SCSI Trade Association currently sponsors at least one compliance and interoperability plugfests annually for member companies to test their products' operational capability and margins with other member companies' products.

With the SAS-3 compliance test software, you can use the same oscilloscope you use for everyday debugging to perform automated testing and margin analysis based on the requirements in the SAS-3 specification.

1. The test circuits and parameters are defined in the Project TID/2212-D: Serial Attached SCSI-3 (SAS-3) working draft, hereinafter referred to as "the SAS-3 specification."

## SAS-3 software saves you time

The SAS-3 compliance test software saves you time by setting the stage for automatic execution of SAS electrical tests. Part of the difficulty of performing electrical tests for SAS is connecting the oscilloscope to the target device, configuring the scope's measurement system for compliance testing, issuing the proper commands to perform the tests and then analyzing the measured results by comparing them to limits published in the specification. The SAS electrical test software does much of this work for you. In addition, if you discover a problem with your device, debug tools in the scope are available to aid in root-cause analysis.

The SAS-3 compliance test software offers the required tests to verify compliance with the physical layer parameters defined per section 5.9, Tables 32-51 of the SAS-3 specification. The 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 SAS-3 compliance test software.

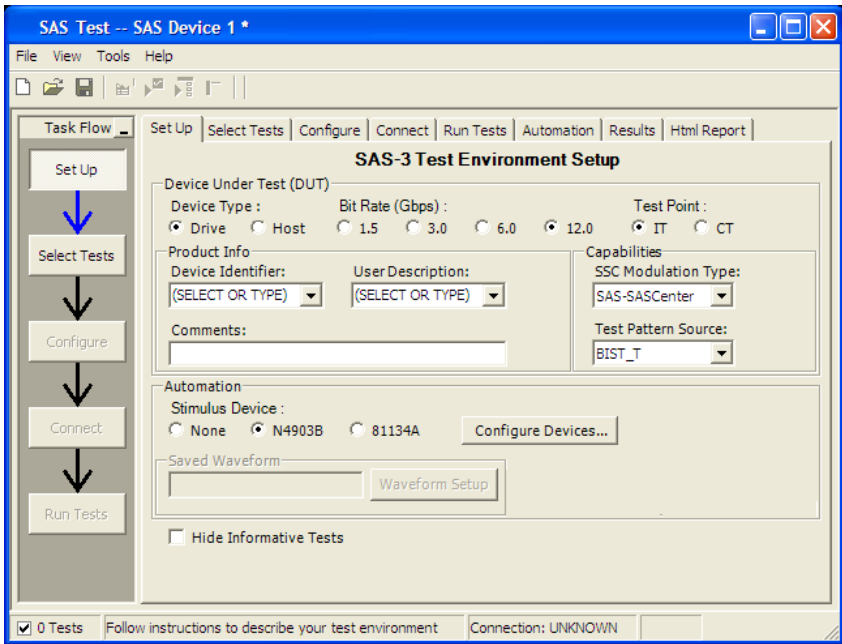


Figure 1. The Keysight automated test engine guides you quickly through selecting and configuring tests, setting up the connection, running the tests, and viewing the results. You can easily select individual tests or groups of test with a mouse-click and customize your output report based on the test results you want to see.

## Easy test definition

The SAS-3 compliance test software extends the ease-of-use advantages of Keysight's Infiniium Series oscilloscopes to testing SAS designs. The Keysight automated test engine walks you quickly through the steps required to define the tests, set up the tests, perform the tests, and view the test results. You can select a category of tests all at once, or

specify individual tests. The user interface is oriented to minimize unnecessary reconnections, which saves time and minimizes the potential for operator error. 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 of mouse clicks.

## Configurability and guided connections

The SAS-3 compliance test software provides flexibility in your test setup. When the tests you select require it, the software guides you to make connection changes with hookup diagrams. The SAS electrical test software provides you with user-defined controls for critical test parameters, such as interface, line baud rate and number of unit intervals (UI) desired for the test group.

After configuring the tests according to your needs, the user interface displays the connection screen that is specific to the configuration data you have selected. This includes the oscilloscope channels used for the test and the routing of any necessary SMA cabling, power dividers and test fixtures needed to perform the tests.

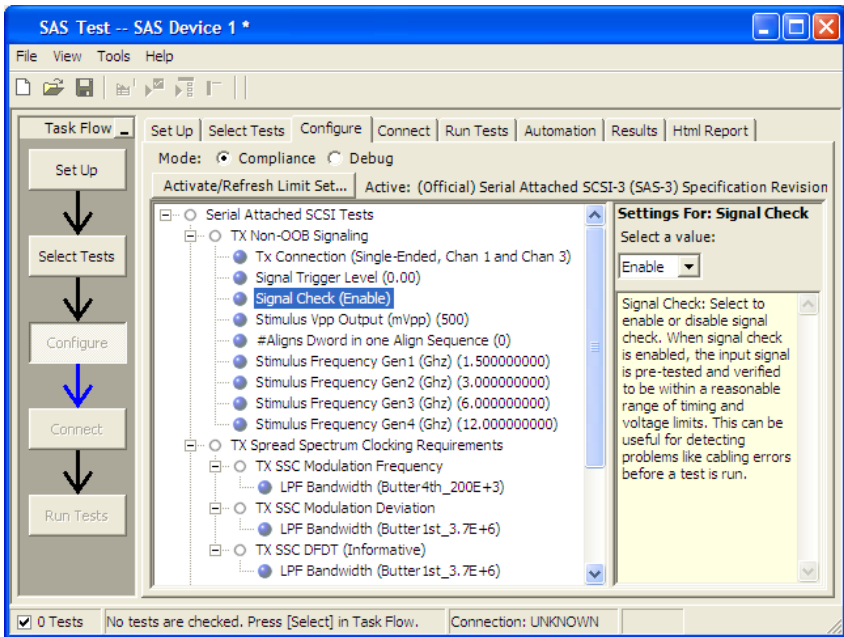


Figure 2. In configuring the tests, you define the number of UI to test, whether or not a TCTF load is being used and how the differential inputs and transient test probe are connected to the oscilloscope.

## Reports with margin analysis

In addition to providing you with measurement results, the SAS-3 compliance test software provides a report format that shows you not only where your product passes or fails, but also reports how close you are to the limits specified for a particular test assertion. You select the margin test report parameter, which means you can specify the level at which warnings are issued to alert you to the electrical tests where your product is operation close to the official test limit defined by the specification for a given test assertion.

## Thorough performance reporting

The SAS-3 compliance test software generates thorough reports that not only capture the performance and status of the device under test, but capture the screen shots of your most significant measurements for your documentation and evaluation.

## Measurement requirements

To use the SAS-3 compliance test software you will need a Keysight Infiniium Series oscilloscope with at least 12-GHz of analog, real-time bandwidth. MATLAB license is required to run the WDP tests. In order to use the SAS-3 compliance test software for compliance validation, your SAS chipset will need to be able to source the required compliance jitter tolerance pattern (CJTPAT or jitter tolerance pattern (JTPAT), SCRAMBLE\_0 pattern and long random pattern (e.g. IDLE Dwords, PRBS 15, etc.). The SCSI software command language provides a method for enabling these PHY test patterns in most chipsets by sending a "send diagnostic" command through a protocol-specific diagnostic page (see "Section 4.2 Phy test functions" of the SAS-3 Specification for details).

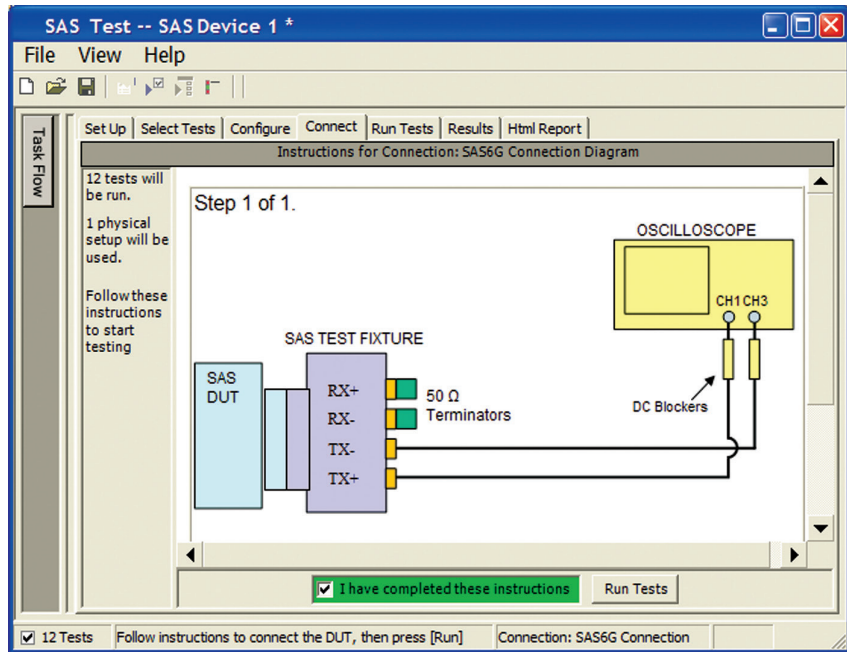


Figure 3. When you make multiple tests where the connections must be changed, the software prompts you with connection diagrams.

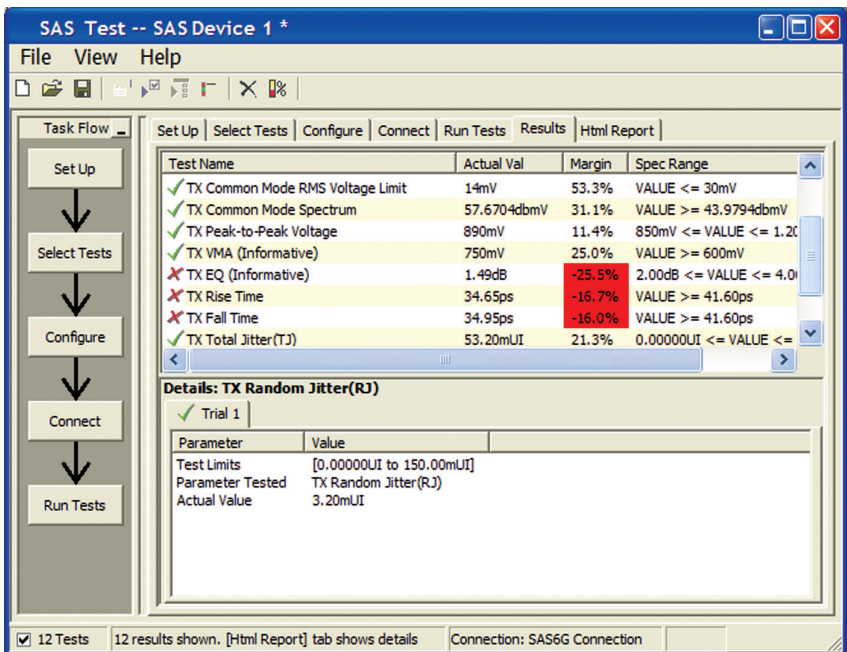


Figure 4. The SAS electrical test software results report documents you test, indicates the pass/fail status, the test specification range, the measured values and the margin.

## Extensibility

You may add additional custom tests or steps to your application using the User Defined Application (UDA) development tool ([www.Keysight.com/find/uda](http://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

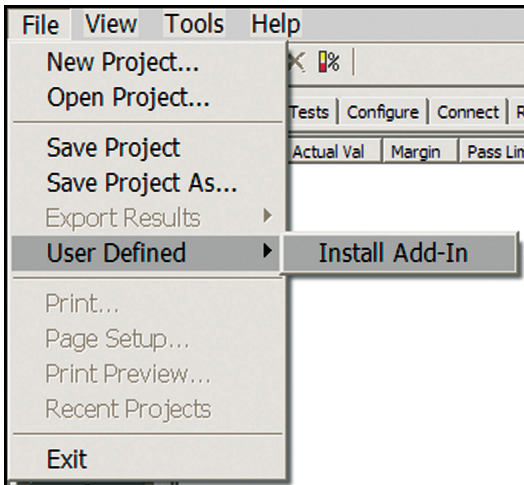


Figure 5. Importing a UDA Add-In into your test application.

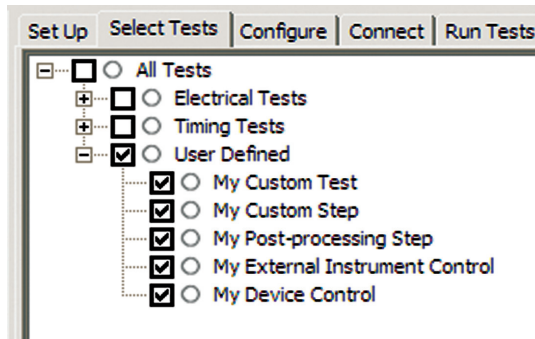


Figure 6. UDA Add-In tests and utilities in your test application.

## 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](http://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.

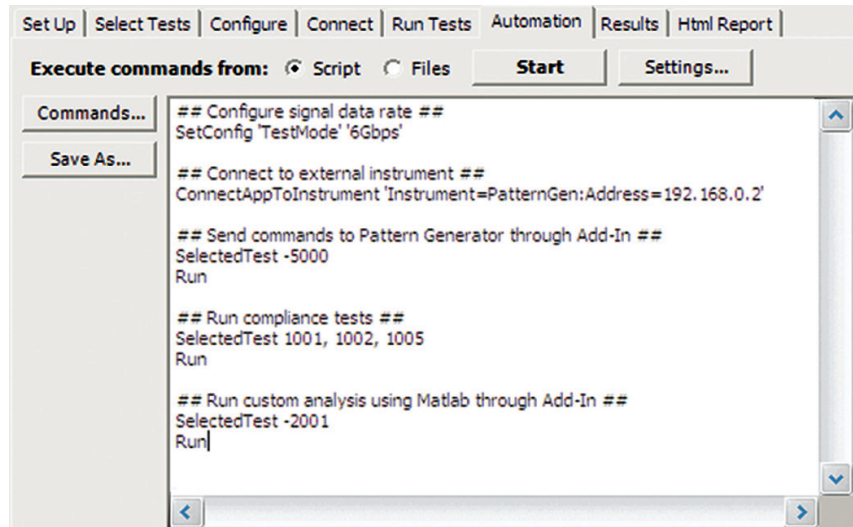


Figure 7. Remote Programming script in the Automation tab.

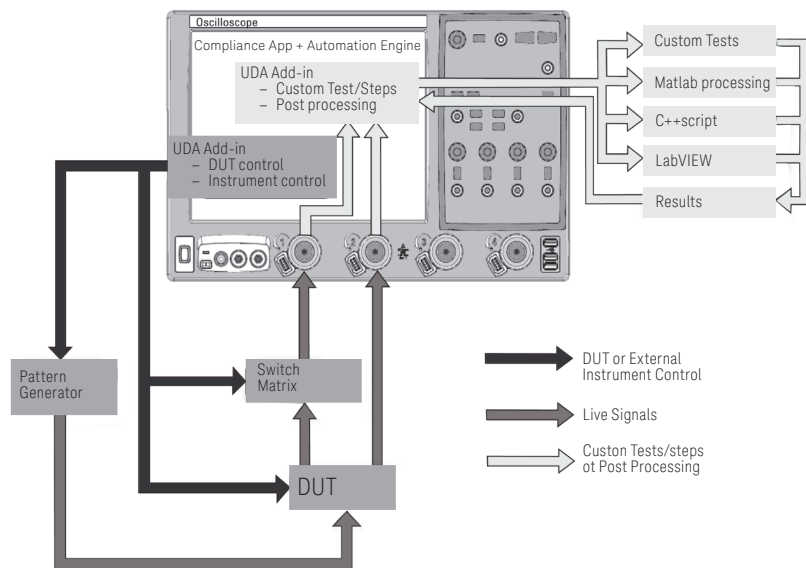


Figure 8. Combine the power of built-in automation and extensibility to transform your application into a complete test suite executive.

## Recommended oscilloscopes

The SAS-3 compliance software is compatible with Keysight Infiniium Series oscilloscopes with operating software revision 4.30 or higher. For oscilloscopes with earlier revisions, free upgrade software is available at [www.keysight.com/find/scope-apps-sw](http://www.keysight.com/find/scope-apps-sw).

Data rate	Minimum bandwidth	Minimum channels	Description
6 Gbps	12 GHz	2	Infiniium 90000 and Z-Series oscilloscopes
12 Gbps	20 GHz	2	Infiniium 90000 and Z-Series oscilloscopes

## Ordering information

### Software options

To purchase the SAS-3 software with a new or existing Infiniium Series oscilloscope, order the following options.

Application	License type		Infiniium Z-Series	Infiniium 90000 Series
SAS-3 compliance	Fixed	Factory-installed	N5412D-1FP	Option 076
		User-installed	N5412D-1FP	N5412D-1NL
	Floating	Transportable	N5412D-1TP	N5412D-1TP <sup>1,2</sup>
		Server-based	N5435A-073	N5435A-073
SAS-2 to SAS-3 compliance upgrade	Fixed	Factory-installed	–	–
		User-installed	N5412D-2FP	N5412D-2NL
	Floating	Transportable	–	–
		Server-based	–	–
SAS-2 compliance	Fixed	Factory-installed	N5412D-3FP	Option 043
		User-installed	N5412D-3FP	N5412D-3NL
	Floating	Transportable	N5412D-3TP	N5412D-3TP <sup>1,2</sup>
		Server-based	N5435A-039	N5435A-039
Serial data analysis with clock recovery (included in DSA model)	Fixed	Factory-installed	E2688A-1FP	Option 003
		User-installed	E2688A-1FP	E2688A-1NL
	Floating	Transportable	E2688A-1TP	E2688A-1TP <sup>1,2</sup>
		Server-based	N5435A-003	N5435A-003
EZJIT Plus jitter analysis (included in DSA model)	Fixed	Factory-installed	N5400A-1FP	Option 004
		User-installed	N5400A-1FP	N5400A-1NL
	Floating	Transportable	N5400A-1TP	N5400A-1TP <sup>1,2</sup>
		Server-based	N5435A-001	N5435A-001
InfiniiSim (optional)	Fixed	Factory-installed	N5465A-1FP	Option 014
		User-installed	N5465A-1FP	N5465A-1NL
	Floating	Transportable	N5465A-1TP	N5465A-1TP <sup>1,2</sup>
		Server-based	N5435A-027	N5435A-027
PrecisionProbe (optional)	Fixed	Factory-installed	N2809A-1FP	Option 001
		User-installed	N2809A-1FP	N2809A-1NL
	Floating	Transportable	N2809A-1TP	N2809A-1TP <sup>1,2</sup>
		Server-based	N5435A-044	N5435A-044
Matlab <sup>3</sup>	Fixed	Factory-installed	–	Option 061
		User-installed	N6174A	N6174A

1. Requires software 5.00 and above.

2. Software 4.30 or above requires Windows 7. N2753A Infiniium Windows XP to 7 OS upgrade kit (oscilloscope already has M890 motherboard). N2754A Infiniium Windows XP to 7 OS and M890 motherboard upgrade kit (oscilloscope without M890 motherboard). Verify the M890 motherboard using the procedure found in the Windows 7 upgrade kit data sheet with the publication number 5990-8569EN.

3. Matlab basic software package for running WDP tests - WDP script is not provided; The user is responsible for obtaining the script from the SAS standards.



## Ordering information continued

### Other hardware, probes and accessories

Model number	Description	Quantity
N5421A	Keysight IT/CT test fixtures for SFF-8482 SAS-2 x2 internal plug/receptacle interface	1
SAS-TPA	Wilder Technologies SAS IT/IR test fixtures for SFF-8482 SAS-3 x2 internal plug/receptacle interfaces (www.wilder-tech.com)	1
MSASHD-TPA	Wilder Technologies Mini-SAS HD test fixtures for SAS-3 plug/receptacle interfaces (www.wilder-tech.com)	1
11742A	DC blocking capacitor, 0.045 to 26.5 GHz, 3.5-mm (m-f) connectors	2
15443A	Matched cable pair, two 90-cm (36-in) SMA (m-m) cables, propagation delay within 25 ps (or equivalent)	3
81134A or N4903B	3.35 Gbps pulse/pattern generator J-BERT high-performance serial BERT 7 Gb/s or 12.5 Gb/s (with Option 002)	1
11636B	Power divider, DC to 26.5 GHz, 3.5-mm (f) connectors	2
5062-6681	Cable assembly 6-in SMA (m-m) cables or equivalent	4

### Recommended test accessories

To complete your test setup, Keysight provides a wide range of cables, adapters, terminations, etc. Please note that the required equipment is listed in the Ordering Information summary. This list is provided for your convenience to accommodate necessary mating switches or additional debug capability.

Model number	Description
11667B	Power splitter, DC to 26.5 GHz, 3.5-mm (f) connectors
11636B	Power divider, DC to 26.5 GHz, 3.5-mm (f) connectors
1250-1158	SMA (f-f) adapter, DC to 18 GHz
1250-1159	SMA (m-m) adapter, DC to 18 GHz
1250-1694	SMA (m) to SMA (f) adapter
15442A	Cable kit, four 90-cm (36-in) SMA (m-m) cables
15443A	Matched cable pair, two 90-cm (36-in) SMA (m-m) cables, propagation delay within 25 ps
1810-0118	SMA (m) 50 ohm termination
11742A	DC blocking capacitor, 0.045 to 26.5 GHz, 3.5-mm (m-f) connectors
N5421A	Serial attached SCSI IT/IR test fixtures for SFF-8482 SAS x2 internal plug/receptacle interfaces
SAS-TPA	Wilder Technologies SAS IT/IR test fixtures for SFF-8482 SAS-3 x2 internal plug/receptacle interfaces (www.wilder-tech.com)
MSASHD-TPA	Wilder Technologies Mini-SAS HD test fixtures for SAS-3 plug/receptacle interfaces (www.wilder-tech.com)

## Tests performed

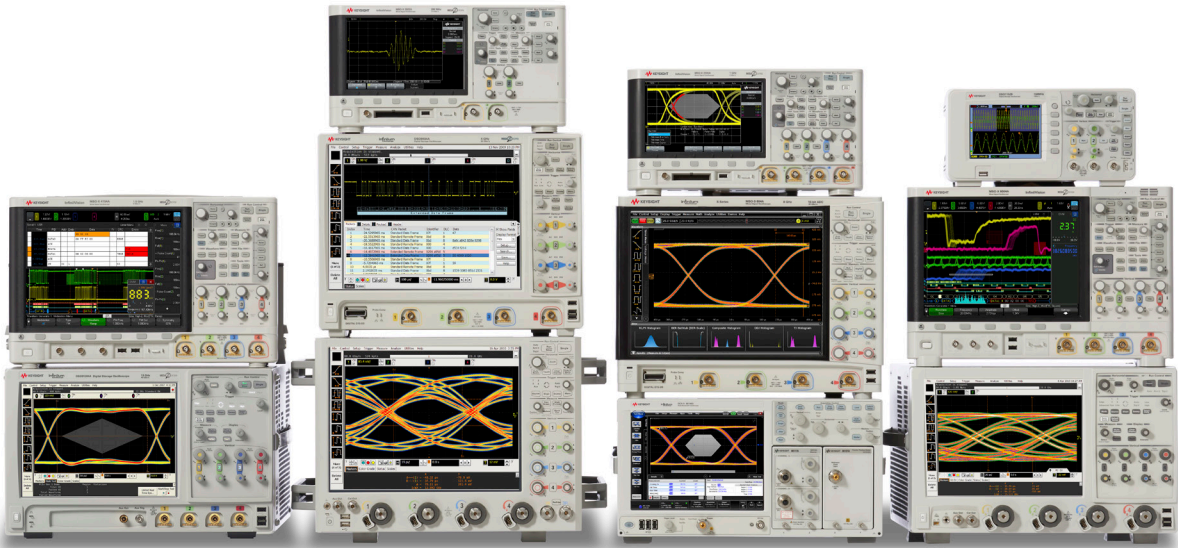
The SAS-3 compliance test software performs the following tests as per section 5.9, Tables 32-51 of the SAS-3 specification, by the T10/2212-D.

Test parameters	Test interfaces	
	IT	CT
<b>Data signaling tests</b>		
Physical link rate long-term stability	Table 32	Table 32
Common mode voltage limit (rms)	Table 38/43	Table 38/43
Common mode spectrum	Table 39/44	Table 39/44
Peak-to-peak voltage	Table 38/43	Table 38/43
Differential voltage swing (mode) (VMA)	Table 41/43	Table 41/43
Transmitter equalization (EQ)	Table 41/43	Table 41/43
Rise/fall time	Table 38/43	Table 38/43
Total jitter (TJ)	Table 38/43	Table 38/43
Random jitter (RJ)	Table 38/43	Table 38/43
<b>TX equalization tests</b>		
Pre and post cursors equalization ratio (Rpre, Rpost)	Table 43	Table 43
TX coefficients requests and circuit response	Table 45	Table 45
TX circuit coefficient presets at ET	Table 46	Table 46
TX device characteristics for trained 12 Gbps at ET/ER	Table 49	Table 49
<b>SSC signaling tests</b>		
SSC modulation frequency	Table 68	Table 68
SSC modulation deviation and balance	Table 68	Table 68
SSC DFDT (Informative)	Table 68	Table 68
<b>OOB signaling tests</b>		
Maximum noise during OOB idle	Table 32	Table 32
Minimum OOB burst amplitude	Table 51	Table 51
OOB offset delta	Table 51	Table 51
OOB common mode delta	Table 51	Table 51
Receive COMINIT idle time	Table 78	Table 78
Receive COMSAS idle time	Table 78	Table 78

Table 1. SAS transmitted signal electrical characterization tests performed by the N5412D software

## Related Literature

Publication title	Publication type	Publication number
<i>Infiniium 90000 Series Oscilloscopes</i>	Data sheet	5989-7819EN
<i>Infiniium 90000 X-Series Oscilloscopes</i>	Data sheet	5990-5271EN
<i>Infiniium 90000 Q-Series Oscilloscopes</i>	Data sheet	5990-9712EN
<i>Infiniium S-Series Oscilloscopes</i>	Data sheet	5991-3904EN
<i>Infiniium Z-Series Oscilloscopes</i>	Data sheet	5991-3868EN
<i>N5400A EZJIT Plus and EZJIT Jitter Analysis Software for Infiniium Series Oscilloscopes</i>	Data sheet	5989-0109EN
<i>E2688A, N5384A High-Speed Serial Data Analysis and Clock Recovery Software for Infiniium Oscilloscopes</i>	Data sheet	5989-0108EN
<i>N2809A PrecisionProbe for Bandwidths up to 33 GHz</i>	Data sheet	5990-7940EN
<i>N5465A: InfiniiSim Waveform Transformation Toolset for the Infiniium Series Oscilloscopes</i>	Data sheet	5990-4059EN
<i>J-BERT N4903B High-Performance Serial BERT</i>	Data sheet	5990-3217EN
<i>81133A and 81134A 3.35 GHz Pulse Pattern Generators</i>	Data sheet	5988-5549EN



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