Agilent
Physical-Layer Test Systems

N1947/8A 80 ps (9 GHz)
N1951A 35 ps (20 GHz)

Product Overview

- **Unprecedented accuracy**
- **Advanced analysis tools**

Agilent Technologies

Characterize high-speed physical-layer components with a powerful frequency domain-based test system

High accuracy coupled with advanced analysis tools

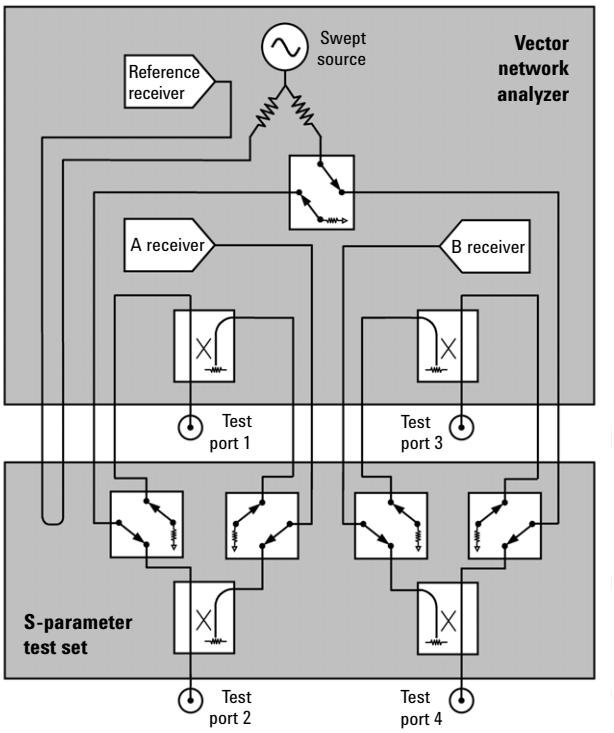
Agilent's N1947A, N1948A, and N1951A physical-layer test systems combine a vector network analyzer (VNA), an external test set, and software with advanced analysis tools to provide the highest accuracy possible for measuring inactive, single-ended or differential physical-layer components such as

- back-planes
- high-speed serial cables
- interconnects
- packages

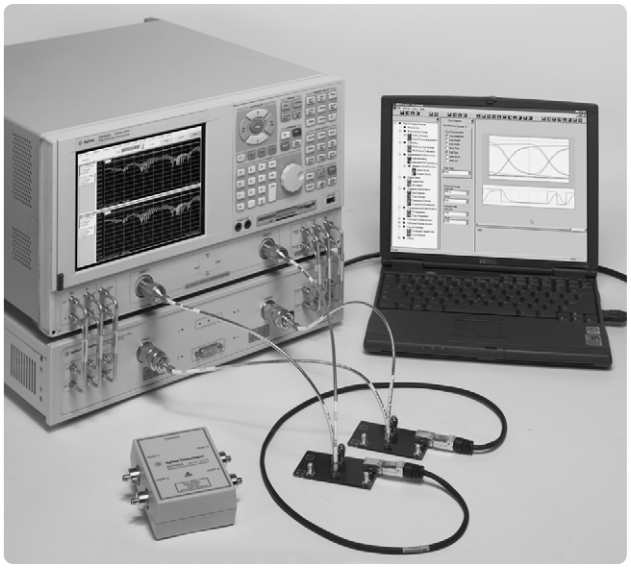
VNAs gather reflection and transmission (S-parameter) information in the frequency domain using a swept-sinusoidal stimulus, but with the measurement software, you can view your device's performance versus frequency or time. Time-domain tools include time-domain reflectometry (TDR) and time-domain transmission (TDT), as well as eye diagrams.

Measure non-50-ohm devices

Although the nominal impedance of the physical-layer test system is 50 ohms, you can easily test non-50-ohm devices by re-normalizing and displaying the test data using any arbitrary reference impedance that you define. This makes it easy to characterize devices like 150-ohm differential cables or 28-ohm differential clock traces.



Simplified block diagram for three-receiver systems (N1947A and N1951A)



A complete physical-layer test system with a user-provided PC. The test system's four test ports are equivalent to having two dual-channel plug-ins in a TDR analyzer.

Minimize risk and maximize confidence in your designs

High accuracy, high frequency measurements for verification models you can trust

Successful system verification requires accurate models of all the physical layer components. Agilent's VNA-based test solutions provide highly accurate component measurements to help you derive verification models you can trust. Accurate verification models will help you maximize your timing margins, and give you the confidence that your designs will work in the real world.

VNAs use advanced error-correction techniques to eliminate systematic measurement errors caused by the instrument itself, plus those from interconnect cables, adapters, probes, and test fixtures. The network analyzer's inherent high dynamic range coupled with a rigorous approach to error correction produces results with accuracy that far exceeds that of oscilloscope-based TDR analyzers.

You can use the test data generated with Agilent's physical-layer test systems directly with verification tools that support S-parameters, such as Agilent's Advanced Design System (ADS) electronic-design-automation software, or you can use it to extract accurate, high frequency models for SPICE simulations.

Tools to test your design margins and perform "what if" experiments

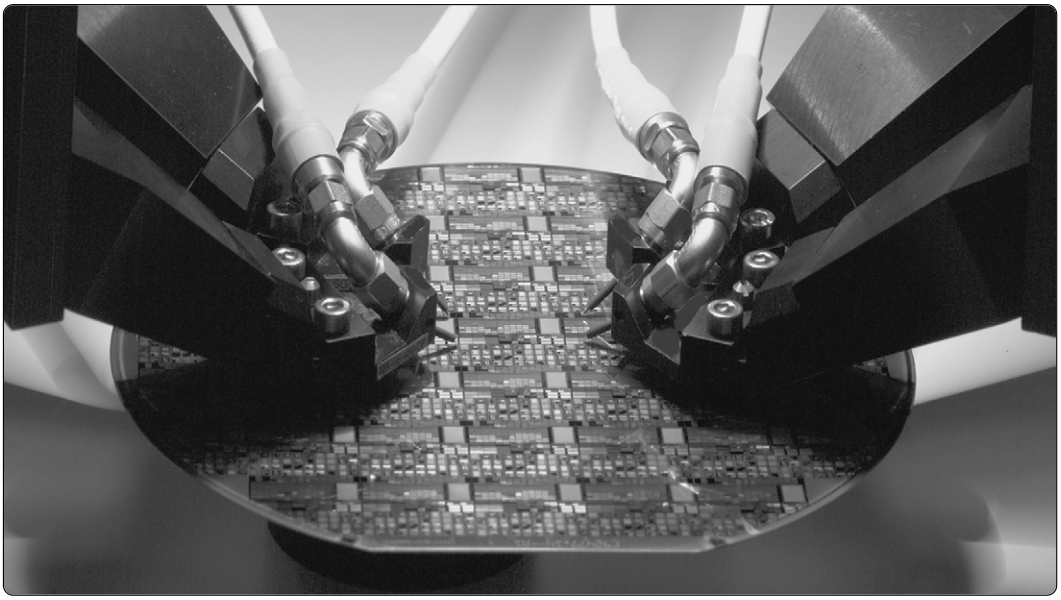
Agilent's physical-layer test systems provide you with a signal-integrity "expert in a box" that displays data in ways that make sense to digital-design and signal-integrity engineers. You can easily analyze your device-under-test (DUT) in the time or frequency domain:

- use eye diagrams to evaluate eye closure and deterministic jitter due to your device's performance
- easily extract RLCG parameters to accurately verify transmission line designs

You can also perform "what if" analysis to test the limits of your design:

- perform skew analysis to help understand mode conversions and their impact on your system's electromagnetic interference (EMI) performance
- gate out unwanted responses in the time domain, giving you a clear picture of your device's performance versus frequency

With Agilent's VNA-based test solutions, you work smarter, not longer. Let Agilent help you get the job done and go home on time.



A combination of coaxial calibration plus probe and fixture de-embedding provides high measurement accuracy

Go beyond characterization – gain insight into your device's behavior

Time domain analysis as easy as using a TDR

Agilent's physical-layer test systems provide an intuitive user interface for TDR and TDT measurements. Once the underlying reflection and transmission (S-parameter) data is obtained, well-established techniques involving Fourier transforms allow you to analyze your DUT using familiar TDR and TDT displays. The system software lets you set up your measurement just as you would using a TDR analyzer, such as specifying start and stop times and number of points.

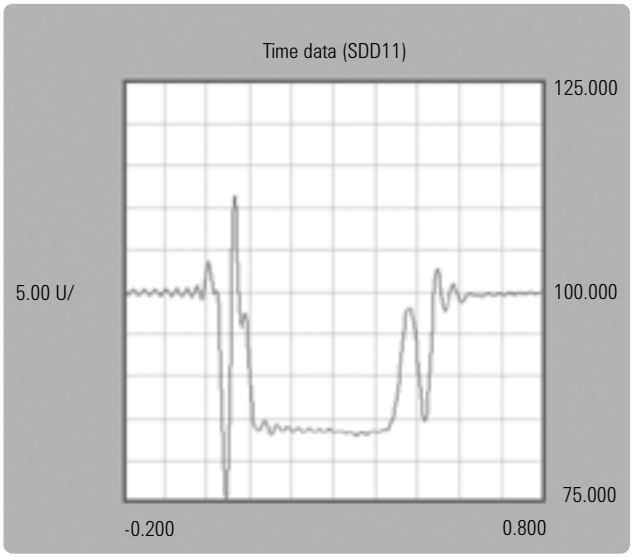
Analyze all modes of operation with a single set of connections

Real-world differential devices often have undesirable common-mode responses, or exhibit unwanted differential-to-common-mode or common-to-differential-mode conversions. It is important to quantify these mode conversions to evaluate your system's generation of or susceptibility to EMI:

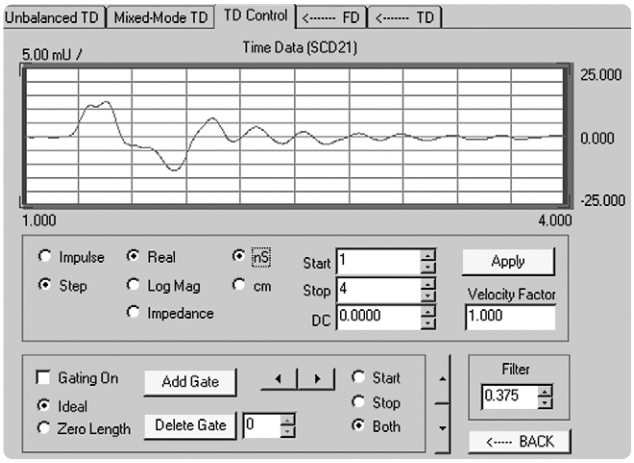
- differential-to-common-mode conversion means your DUT may radiate interference signals or create unwanted ground currents that can couple to other circuitry
- common-to-differential-mode conversion means your system may be susceptible to bit errors caused by external electromagnetic fields

Agilent's high-dynamic-range physical-layer test systems let you see elusive EMI problems that previously might have gone undetected.

With a single set of connections, you can measure the single-ended, differential-mode, common-mode, and mode-conversion behavior of your DUT. When characterizing devices such as a pair of printed-circuit traces, you can analyze each trace by itself to measure total delay and skew, or analyze them together as a balanced pair.



A TDR plot showing two SMA-to-microstrip transitions and a short length of 84-ohm differential transmission line



Differential-to-common-mode conversion caused by a metallic object situated too close to one side of a differential printed-circuit trace

View eye diagrams without an external pattern generator

Eye diagrams are one of the best tools to assess the quality of a physical-layer device. Combining eye diagrams with simulated compensation networks lets you optimize your systems for maximum eye opening and minimum jitter. These accurate predictions of your device's performance result in fewer hardware prototypes and a faster time to market.

Using frequency-domain data, Agilent's physical-layer test systems calculate your DUT's impulse response, which is then convolved with an arbitrary digital input waveform.

You can then use an eye diagram to view the resulting output waveform:

- easily observe eye-diagram degradation without requiring an expensive external pattern generator
- vary input waveform parameters such as rise time, bit rate, and the data sequence
- use markers on the output waveform to determine signal parameters such as rise time, deterministic jitter, overshoot, and droop

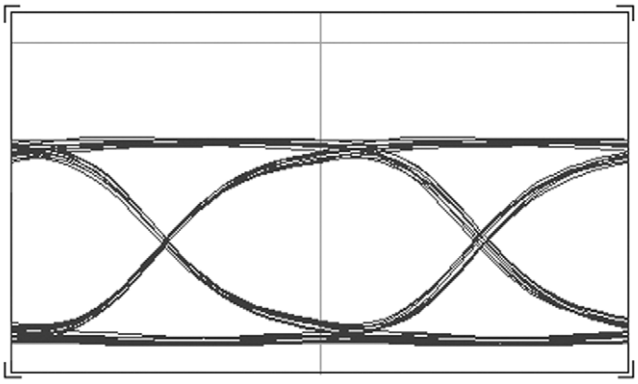
Extract RLCG parameters for design verification

Verifying system operation often requires accurate transmission-line models of high-speed interconnects. Agilent's physical-layer test solution extracts RLCG parameters for use in simulation programs such as HSPICE. You can extract both static and frequency-dependent variables.

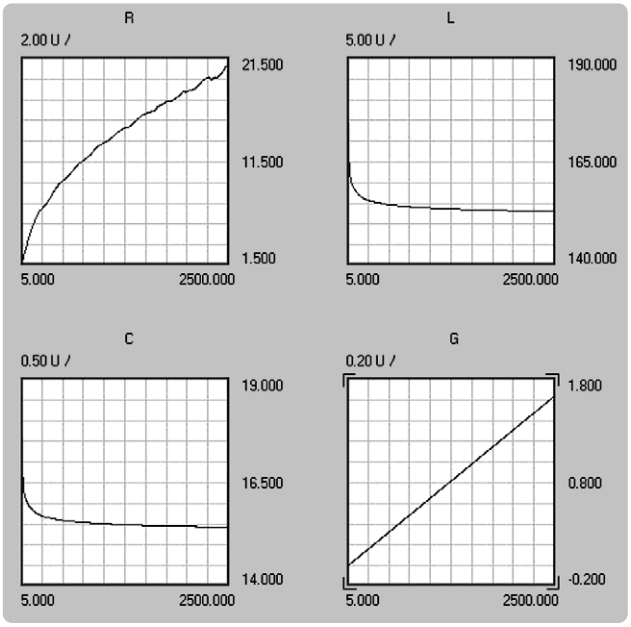
Frequency domain augments understanding of device performance

When working with physical layers designed to carry high-bit-rate information, many non-ideal effects are better understood when viewed in the frequency domain. For example, it is often easier to pinpoint mode-conversion problems in the frequency domain, and dispersion is best characterized by examining delay versus frequency.

With Agilent's physical-layer test systems, you can view transmission loss, dispersion, cross-talk, return loss, and impedance versus frequency.



Simulated eye diagram of an Infiniband interconnect cable



A plot of RLCG parameters of a 4-ft 1X Infiniband cable

Accessories to ease calibration and measure non-connectorized devices

Four-port electronic calibration module dramatically reduces calibration times

The optional four-port N4430A/B electronic calibration module (ECal) enables you to quickly and easily calibrate the entire test system up to the ends of the coaxial test cables. With a single set of connections and the click of the mouse, ECal cycles through all the impedance states required for a full, four-port calibration in well under a minute. This saves you considerable time compared to calibrating with mechanical standards.

The effect of any adapters needed to convert from ECal's female 3.5-mm connectors to the connector type of the test cables can easily be removed from the calibration data. The system software provides an adapter-characterization tool to measure the electrical length and loss of the adapters. This information is used in de-embedding calculations to remove the effects of the adapters during the calibration process.

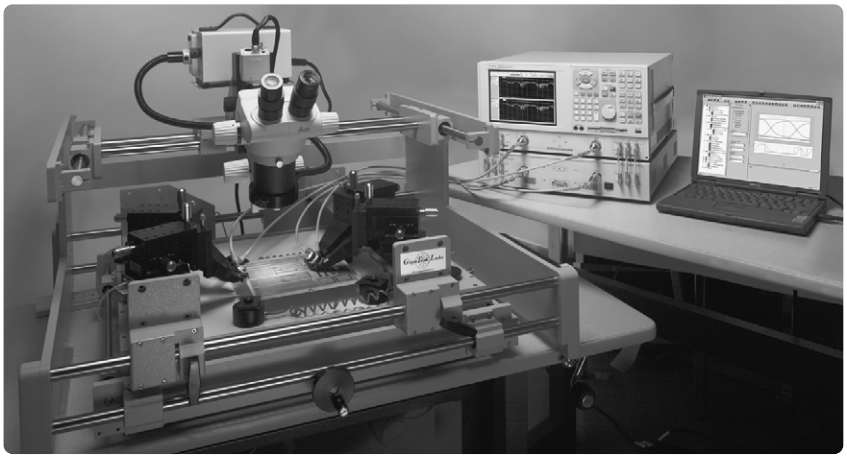
Four-port ECal module simplifies system calibrations

Probing solutions from GigaTest Labs make it easy to contact printed-circuit traces

To test devices like back-planes or packages, Agilent recommends probing solutions from GigaTest Labs. GigaTest Labs probe stations have the flexibility to probe almost any geometry, with outstanding precision. For high-bandwidth, accurate, and repeatable measurements on challenging geometries, these probe stations are an indispensable tool.

GigaTest Labs probe station features

- accommodates large 3-D structures like back-planes and motherboards
- offers precise control with positioning resolution to 1 µm
- simple to operate
- customizable with many accessories for almost any application



Measuring an FR-4 test card using a GigaTest Labs probe station and an Agilent physical-layer test system

Performance summaries

N1947/8A physical layer test systems and N4417A S-parameter test set

System performance summary

The following specifications are applicable for a system in the following configurations:

Network analyzers	Agilent E8358A Option 015
	Agilent E8803A Option 014
Test set	Agilent N4417A
Calibration kit	Agilent 85052C precision 3.5 mm
Test port cables	Agilent N4417A Option B20

System dynamic range

The test port transmission measurements are valid at 10 Hz IF bandwidth with four-port error correction and 10-dBm maximum output power. The dynamic range is the difference between the rms noise floor and maximum output power.

300 kHz to 1.3 GHz	120 dB*
1.3 GHz to 3 GHz	120 dB
3 GHz to 6 GHz	108 dB
6 GHz to 9 GHz	103 dB

Measurement port characteristics

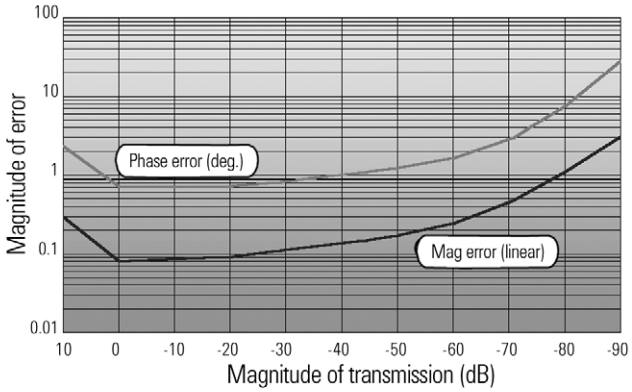
Residual uncertainties for corrected data using four-port error correction. These apply for 25°C with less than 1°C variation from calibration.

Freq. Range	300 kHz-1.3 GHz	1.3-3 GHz	3-6 GHz	6-9 GHz
Directivity	50 dB	47 dB	42 dB	40 dB
Source match	42 dB	42 dB	38 dB	35 dB
Load match	50 dB	47 dB	42 dB	40 dB
Refl. tracking (±)	0.006 dB	0.007 dB	0.009 dB	0.015 dB
Trans. tracking (±)	0.012 dB	0.015 dB	0.040 dB	0.060 dB

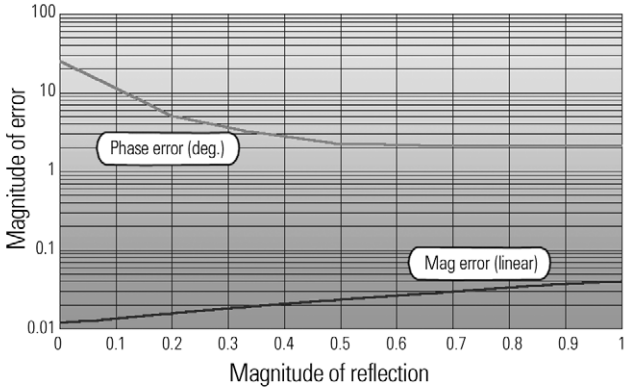
Test set typical performance

Frequency range	300 kHz - 9 GHz
Impedance	50 ohms
Insertion loss, source out to coupler in	4.5 dB max.
Insertion loss, ports 2 or 4 to A or B in	8.5 dB max.
Insertion loss, A and B in to A and B out	8.0 dB max.
Isolation, port to port and A to B	≥105 dB
Maximum operating level	+20 dBm
Damage level	+30 dBm
Test port connectors	50 ohm type-N
VNA connectors	50 ohm SMA (f)
Weight	9 kg

Measurement uncertainties



Worst case 3.5 mm transmission magnitude and phase uncertianty



Worst case 3.5 mm reflection magnitude and phase uncertianty

* May be limited to 100 dB at particular frequencies below 750 MHz due to spurious receiver residuals.

N1951A physical layer test system and N4418A S-parameter test set

System performance summary

The following specifications are applicable for a system in the following configuration

Network analyzer	Agilent 8720ES Option H32
Test set	Agilent N4418A
Calibration kit	Agilent 85052C precision 3.5 mm
Test port cables	Agilent N4417A Option B20

System dynamic range

The test port transmission measurements are valid at 10 Hz IF bandwidth with four-port error correction and +5 dBm maximum output power. The dynamic range is the difference between the rms noise floor and maximum output power.

50 MHz to 840 MHz	77 dB
840 MHz to 20 GHz	90 dB

Measurement port characteristics

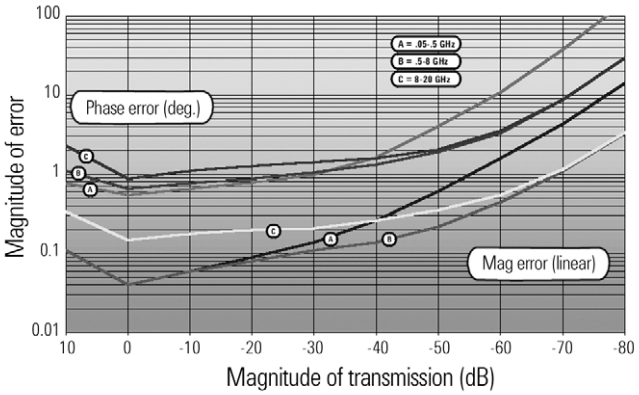
Residual uncertainties for corrected data using four-port error correction. These apply for 25°C with less than 1°C variation from calibration.

Freq. Range	.05-2 GHz	2-8 GHz	8-20 GHz
Directivity	48 dB	48 dB	43 dB
Source match	41 dB	41 dB	33 dB
Load match	48 dB	48 dB	43 dB
Refl. tracking (±)	.005 dB	.005 dB	.008 dB
Trans. tracking (±)	.014 dB	.014 dB	.035 dB

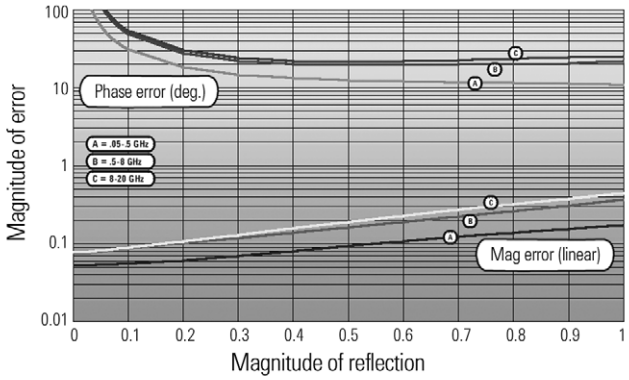
Test set typical performance

Frequency range	50 MHz - 20 GHz
Impedance	50 ohms
Insertion loss, nominal	8 - 10 dB
Isolation, port to port	≥85 dB
Maximum operating level	+20 dBm
Damage level	+30 dBm
DC bias range (Option UNK)	40 VDC, 500mA
Test port connectors	3.5 mm (m)
VNA connectors	50 ohm SMA (f)
Weight	9 kg

Measurement uncertainties



Worst case 3.5 mm transmission magnitude and phase uncertianty



Worst case 3.5 mm reflection magnitude and phase uncertianty

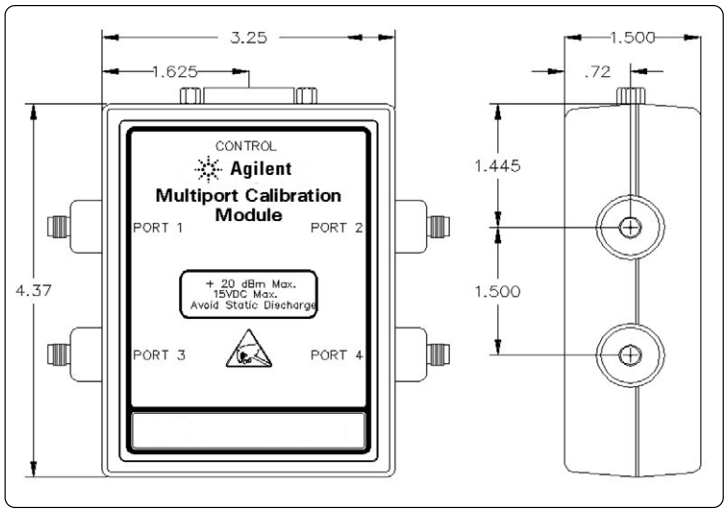
N4430B ECal module

- fast, single-connection electronic calibration
- 9 GHz frequency coverage
- accurate transfer standard with excellent repeatability

The N4430B four-port ECal module is the perfect companion for Agilent's physical-layer test systems. Fast, and easy-to-use, the N4430B ECal module replaces a standard short-open-load-through-based mechanical calibration kit with a solid-state transfer standard.

With a single set of connections, the ECal module cycles through all of the impedance states required for a full, four-port, vector error-corrected calibration in under a minute. This saves you considerable time compared to calibrating with mechanical standards. Not only is ECal fast, it is also extremely repeatable and accurate.

Control of the ECal module is built into the physical-layer-test application software – the same software that controls the measurement and provides all of the time and frequency domain analysis. Ease of use is provided through an intuitive graphical user interface. The N4430B is compatible with the N1947/8A physical-layer test systems.



Product configuration

A complete system includes an Agilent PNA series or 8720 series vector network analyzer, an Agilent S-parameter test set, N1930A physical-layer test system software, a Windows-based PC with IEEE-488 control, and the N4430B electronic calibration module.

Performance summary

These specifications show the residual uncertainties for corrected data using four-port error correction. They apply for 25°C with less than 1°C variation from calibration, and are applicable for a system in the following configuration:

Network analyzer	PNA series (E8803A with Option 014 or E8358A with Option 015)
Test set	N4417A four-port test set
Test port cables	N4417A Option B20

Measurement port specifications

Frequency range	300 kHz-1.3 GHz	1.3-3 GHz	3-6 GHz	6-9 GHz
Directivity	49 dB	50 dB	48 dB	42 dB
Source match	47 dB	40 dB	39 dB	39 dB
Load match	46 dB	45 dB	40 dB	34 dB
Reflection tracking (±)	0.040 dB	0.025 dB	0.060 dB	0.062 dB
Transmission tracking (±)	0.063 dB	0.037 dB	0.087 dB	0.100 dB

Typical performance

Frequency range	30 kHz - 9.0 GHz
Impedance	50 ohms
Maximum operating level	+20 dBm
Damage level	+30 dBm
RF port connectors	3.5 mm (f)
Control connector	DB-15
Weight	.34 kg

Supported system components

S-parameter test sets	N4413/4/5/6/7A

Ordering information

Complete systems

N1947A Physical-layer test system, 80 ps (9 GHz)
Includes:
- E8803A PNA Series network analyzer with Opt. 014
- N4417A 9 GHz S-parameter test set with Opt. 103
- N1930A physical-layer test-system software
- System installation and start-up assistance (1 day)

N1948A Physical-layer test system, 80 ps (9 GHz)
Includes:
- E8358A PNA Series network analyzer with Opt. 015
- N4417A 9 GHz S-parameter test set with Opt. 104
- N1930A physical-layer test-system software
- System installation and start-up assistance (1 day)

Note: with this system, through-reflect-line (TRL) calibration is supported for standalone operation of the PNA Series network analyzer, but not with the physical-layer test system

N1951A Physical-layer test system, 35 ps (20 GHz)
Includes:
- 8720ES network analyzer with Opt. H32
- N4418A 20 GHz S-parameter test set with Opt. UNK
- N1930A physical-layer test-system software
- System installation and start-up assistance (1 day)

System options

Option 1CP	Rack-mount and handle kit
Option B20	Add four precision 50 ohm cables

For N1947/8A systems only:

Option 060	Add four-port electronic calibration module (N4430B)

System components

These items can be ordered separately if you already own a PNA Series or 8720 Series network analyzer. You may need to upgrade your network analyzer to add the configurable test set option.

N1930A	Physical-layer test-system software
N4417A	9 GHz S-parameter test set
Option 1CP	Rack-mount and handle kit
Option B20	Add precision 50 ohm cables (four)
Option 103	For use with E8803A Option 014 PNA Series network analyzer
Option 104	For use with E8358A Option 015 PNA Series network analyzer
N4418A	20 GHz S-parameter test
Option 1CP	Rack-mount and handle kit
Option B20	Add precision 50 ohm cables (four)
Option UNK	Add bias tees
Option 302	Add adapters for use with 8722ES

Network analyzer upgrade kits

E8803AU 014	Installs configurable test set Option 014 to E8803A PNA Series analyzer
E8358AU 015	Installs configurable test set Option 015 to E8358A PNA Series analyzer
Z5622A G32	Installs configurable test set Option H32 to 8719/20/22/D/ES analyzers
Z5622A G42	Installs configurable test set Option H42 to 8719/20/D/ES analyzers
Z5622A G44	Installs configurable test set Option H44 to 8722/D/ES analyzers

Accessories

N4430B	Four-port electronic calibration module, 30 kHz to 9 GHz
85033E	9 GHz 3.5mm calibration kit

Add Options 100, 200, and 300 for a complete set of 3.5 mm adapters

85052B/C/D	26.5 GHz 3.5mm calibration kit

Includes a complete set of 3.5 mm adapters

Note: other mechanical calibration kits can be found in the PNA Series or 8720ES configuration guides (see last page for literature numbers or view them online at www.agilent.com) or at ***www.agilent.com/find/mta***

System requirements

A user-supplied computer is required with the following specifications:

CPU / RAM	Pentium® II or better / ≥64 MB
Operating system	Windows® 98/NT/2000
Monitor	1024 x 768 minimum resolution
GPIB card	Agilent 82340/41/50A or National Instruments (any model)

Signal integrity engineering services

In the constantly changing environment of high speed digital design, Agilent's ability to quickly provide applications-engineering consulting for your specific signal integrity needs gives you the certainty and confidence to accelerate the development and deployment of winning technologies for your customers. Agilent Technologies' knowledge-services engineers will work with you to help solve your design problems and maximize the capabilities of your physical layer test system, thereby improving your competitive advantage. For a quote and scheduling, send an e-mail message to **kso_services@agilent.com**, or in the US, call the Agilent Test & Measurement Call Center at 1-800-452-4844, and ask about professional engineering services for the physical layer test system.

Channel partners

GigaTest Labs

GigaTest Labs is a signal integrity and RF engineering resource, providing hardware design, test and development consulting to the computing and communications industries. GigaTest has the resources and expertise to solve the most difficult high speed digital and high frequency design problems. Visit them at www.gigatest.com

Cascade Microtech

Cascade Microtech provides a full range of probing solutions for on-wafer test. Visit them at www.cmicro.com

Related literature

PNA series

Brochure	5968-8472E
Configuration guide	5980-1235E
Data sheet	5980-1236E

8720ES

Brochure	5968-5161E
Configuration guide	5968-5162E
Data sheet	5968-5163E

For more information about Agilent's signal integrity products, application notes, and services, please visit – **www.agilent.com/find/SI**.

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Agilent Technologies' Test and Measurement Support, Services, and Assistance

Agilent Technologies aims to maximize the value you receive, while minimizing your risk and problems. We strive to ensure that you get the test and measurement capabilities you paid for and obtain the support you need. Our extensive support resources and services can help you choose the right Agilent products for your applications and apply them successfully. Every instrument and system we sell has a global warranty. Support is available for at least five years beyond the production life of the product. Two concepts underlie Agilent's overall support policy: "Our Promise" and "Your Advantage."

Our Promise

Our Promise means your Agilent test and measurement equipment will meet its advertised performance and functionality. When you are choosing new equipment, we will help you with product information, including realistic performance specifications and practical recommendations from experienced test engineers. When you use Agilent equipment, we can verify that it works properly, help with product operation, and provide basic measurement assistance for the use of specified capabilities, at no extra cost upon request. Many self-help tools are available.

Your Advantage

Your Advantage means that Agilent offers a wide range of additional expert test and measurement services, which you can purchase according to your unique technical and business needs. Solve problems efficiently and gain a competitive edge by contracting with us for calibration, extra-cost upgrades, out-of-warranty repairs, and on-site education and training, as well as design, system integration, project management, and other professional engineering services. Experienced Agilent engineers and technicians worldwide can help you maximize your productivity, optimize the return on investment of your Agilent instruments and systems, and obtain dependable measurement accuracy for the life of those products.

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