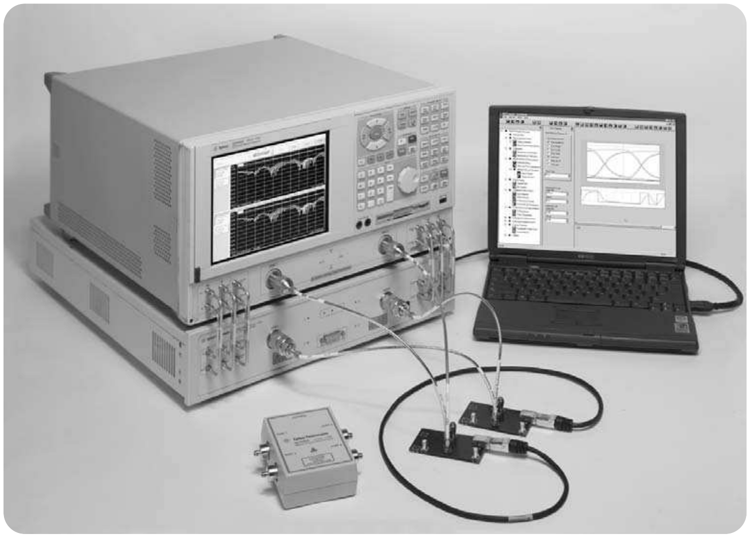
Agilent
Physical Layer Test Systems

Data Sheet



N1947A	**80 pS (300 kHz to 9 GHz)**
N1948A	**80 pS (300 kHz to 9 GHz)**
N1951A	**36 pS (50 MHz to 20 GHz)**
N1953A	**36 pS (45 MHz to 20 GHz)**
N1957A	**14 pS (45 MHz to 50 GHz)**

NOTE:
Some specifications contained herein are preliminary and subject to change.

Agilent Technologies

Physical Layer Test Systems

Product	Description	Frequency Range	Rise Time
N1957A	E8364B PNA and N4421A Test Set 4-Port / 4-Receiver	45 MHz to 50 GHz	14 pS
N1953A	E8362B PNA and N4419A Test Set 4-Port / 4-Receiver	45 MHz to 20 GHz	36 pS
N1951A	8720ES VNA and N4418A Test Set 4-Port / 3 or 4-Receiver	50 MHz to 20 GHz	36 pS
N1948A	E8358A PNA and N4417A Test Set 4-Port / 4-Receiver	300 kHz to 9 GHz	80 pS
N1947A	E8803A PNA and N4417A Test Set 4-Port / 3-Receiver	300 kHz to 9 GHz	80 pS
N1930A	Physical Layer Test System software that controls the system and provides advanced data analysis tools	-----	----
N4430B	Fast, single-connection electronic SOLT calibration	300 kHz to 9 GHz	----

Design Confidence Through Complete Characterization

Physical-layer structures have increasingly become the bottleneck in high-speed digital system performance. As bus speeds, clock speeds, and link speeds all push past the gigabit-per-second mark, digital data no longer looks like simple ones and zeros. In fact, digital data begins to exhibit analog behavior such as reflections from discontinuities, dispersive loss, crosstalk, and EMI radiation and susceptibility. Analog analysis can be the key to solving such digital problems as overshoot, undershoot, ringing, rise-time degradation, pulse droop, dropouts, ground bounce, and eye closure.

Of course, Time-Domain Reflectometry (TDR) and Time-Domain Transmission (TDT) measurements are also important, as are familiar time domain views such as eye diagrams. These analyses are critical for complete understanding of device performance.

Another challenge for today's digital designers is the trend to differential topologies. The benefits of differential signaling include lower voltage swings, immunity from power supply noise, a reduced dependency on a RF ground, and improved EMI performance (reduced generation and susceptibility). The extent to which a device can take advantage of these benefits is directly related to device symmetry. Therefore, mode-conversion analysis becomes yet another requirement.

These factors make it clear that physical-layer structures – passive linear components such as interconnects, backplanes, IC packages, cables, and the like – are significant elements affecting signal propagation and have become the focal point for the emerging discipline of signal integrity.

Comprehensive analysis has become necessary

As this combination of digital and analog analysis in several modes of operation becomes more important, the need for multiple test solutions becomes difficult to manage.

A single test solution that can fully characterize differential high-speed devices while leaving domain and format of the analysis up to the designer becomes the tool of choice. The four-port network analyzer-based Physical Layer Test System (PLTS) does just that.

PLTS has been designed specifically for signal integrity analysis and provides the best of both worlds. Both frequency and time domains in single-ended, differential-mode, common-mode, and mode-conversion terms are immediately available. A digital-pattern generator feature allows a user-defined bit sequence to be applied to the measured data to convolve eye diagrams. Next, accurate RLCG transmission line parameter models can be extracted and used to enhance the accuracy of your models and simulations.

The need for mode-conversion analysis

Mode-conversion analysis is an important tool for understanding and resolving device asymmetry, which is an additional challenge in high-speed differential interconnect design.

Ideal (symmetrical) differential devices only respond to, and only generate, differential signals (two anti-phase signals of equal amplitude). These ideal devices do not respond to or generate common-mode (in-phase) signals, and they reject radiated external signals (i.e. power supply noise, harmonics of digital clocks or data, and EMI from other RF circuitry).

Non-ideal devices, however, do not exhibit these benefits. When stimulated differentially, an asymmetrical device will produce a common mode response in addition to the intended differential response, and cause EMI radiation. Conversely, with a common-mode stimulus, an asymmetrical device will produce an unintended differential response. This mode conversion is a source of EMI.

Mode-conversion analysis provides the designer with early insight so that EMI problems can be identified and resolved at the design stage.

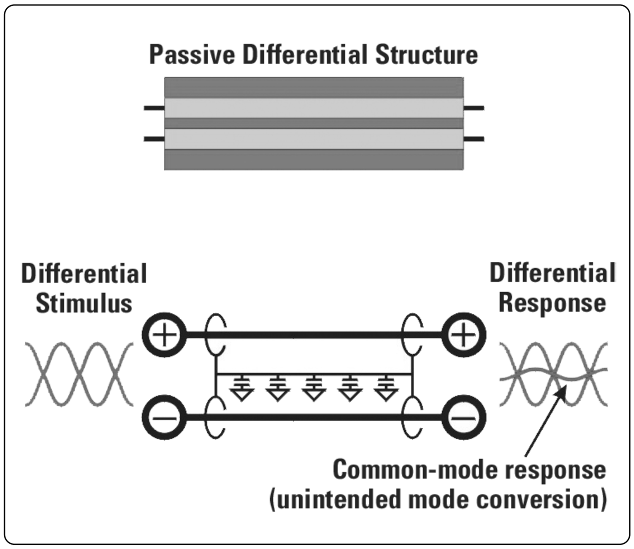


Figure 1. Non-ideal (asymmetrical) devices cause mode conversions, which are indicators of EMI generation and susceptibility.

The Agilent Signal Integrity Portfolio

Agilent offers a wide range of signal integrity solutions. Figure 2 shows where PLTS is positioned within the signal integrity market space. On the right side of this chart, several common products are shown. These include bit-error-rate testers, logic and protocol analyzers, and the like. It is important to note that these solutions are intended for live signal analysis and validation.

TDR or VNA system?

On the left-side of the chart, PLTS and TDR-based solutions are shown. These tools are more specific to the characterization of passive linear devices, rather than the signals on the device. Within this product area, the TDR-based system has traditionally been used. With the introduction of PLTS, a common question is “Which one do I need?”

Both of these systems have advantages and, in some cases where maximum versatility is required, the use of both systems may be appropriate. However, for signal integrity (SI) engineers who need quick, first-order measurements (and appreciate the ease-of-use and familiarity), the TDR-based system is the best choice.

PLTS adds enhanced accuracy and dynamic range (signal-to-noise ratio), greater ability to remove unwanted effects (non-device-under-test structures such as test fixtures), and a much more comprehensive analysis.

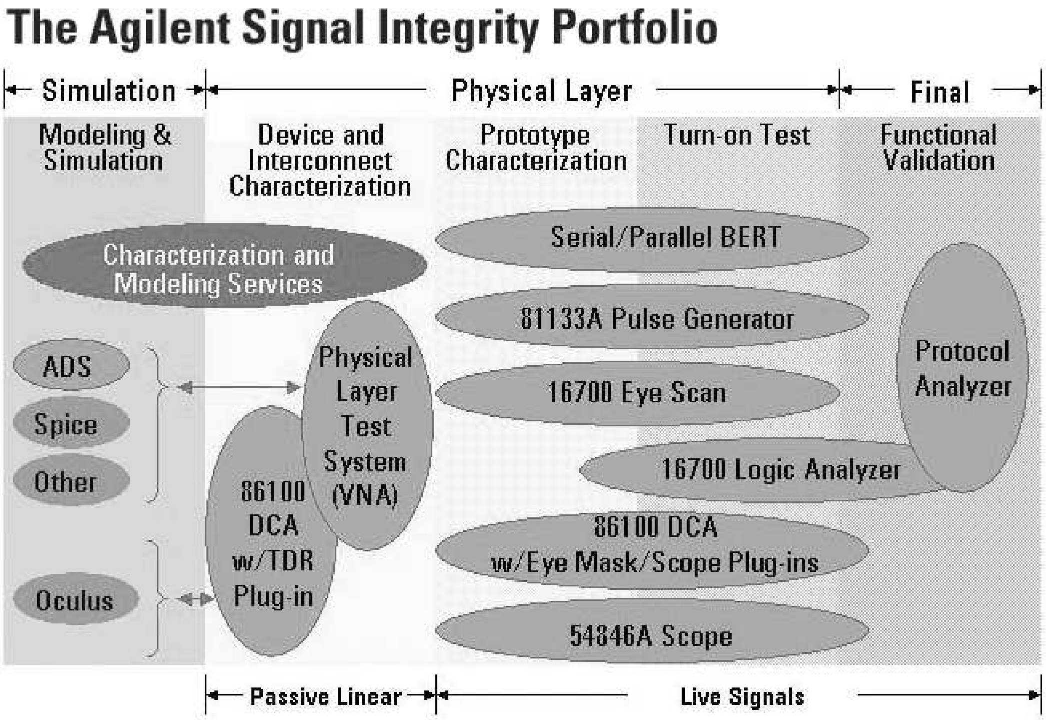


Figure 2. Agilent offers a wide range of test equipment to solve your most demanding signal integrity issues throughout the design cycle.

The Advantages of PLTS

Accuracy

Accuracy is made possible with:

- low-noise RF source
- phase-locked receiver (like a tracking filter, the receiver rejects noise outside of the immediate frequency of interest)
- systematic error-correction

Systematic errors are the predictable errors associated with all test equipment. In network analyzers, these are directivity and crosstalk related to signal leakage, source and load match related to reflections, and transmission and reflection tracking related to the frequency response of the receivers.

The full four-port error model includes all six of these terms for the forward direction and the same six (with different data) in the reverse direction, equaling twelve error terms over six signal paths (port 1-2, 1-3, 1-4, 2-3, 2-4, 3-4). A total of seventy-two error terms are measured during calibration. The correction is applied to the measured data.

Dynamic range

High-dynamic range is important for a number of reasons. Certainly measurement of very low levels of crosstalk is possible, but today's crosstalk specifications are typically within the range of traditional tools like the TDR (approximately –40 dB). Crosstalk is only one parameter where dynamic range is important.

More importantly is the ability to overcome masking effects of multiple discontinuities, which in systems with lower dynamic range would attenuate the stimulus such that deep structures would become invisible.

Most importantly for differential devices, high-dynamic range allows for identification of very low levels of mode-conversion, which are the direct result of device asymmetry. This allows early resolution of potential EMI issues.

Removing Unwanted Effects From The Measurement

Measurement results often include unwanted effects of test fixtures, signal launches, adapters, or other non-DUT structures. PLTS offers four methods for removing these unwanted effects.

- **Time-Domain Gating** is very easy and fast. The user simply defines a start and stop point, and the software mathematically replaces the measured data in that section with an "ideal" transmission line. With the enhanced dynamic range of the net work analyzer, multiple gates are possible, but accuracy diminishes in proportion to the number of gates.

- **Port Extension** (also known as Phase Rotation) mathematically extends the calibration reference plane to the DUT, and is usually implemented after a coaxial calibration has been performed at the end of the test cables. This technique is also easy to use, but assumes the fixture – (the unwanted structure) looks like a perfect transmission line: a flat magnitude response, a linear phase response, and constant impedance. If the fixture is very well designed, this technique can provide excellent results.

- **De-embedding** uses an accurate linear model of the fixture, or measured S-parameter data of the fixture. This fixture data can then be removed mathematically from the DUT measurement data in post-processing. This is a very powerful technique and accurate, but is more difficult to employ as it requires fixture characterization.

- **Calibration** at the DUT Reference Plane has the advantage that the precise characteristics of the fixture don't need to be known beforehand, as they are measured during the calibration process. This technique is commonly used in wafer probe applications.

Comprehensive analysis

The last major advantage is the comprehensive nature of the measurement and analysis. With a single setup and measurement, an incredible amount of device data is available. Forward and reverse time-domain transmission (TDT) and time-domain reflectometry (TDR), in all possible modes of operation, in both frequency and time domains.

The same data can be used to convolve eye diagrams using the Digital Pattern Generator feature, and RLCG parameters can be extracted and used to improve the accuracy of models and simulations.

PLTS provides complete confidence in your design, through complete, comprehensive, and accurate characterization. This confidence is extremely powerful, especially with today's ever changing device requirements.

Digital Device Characterization with PLTS

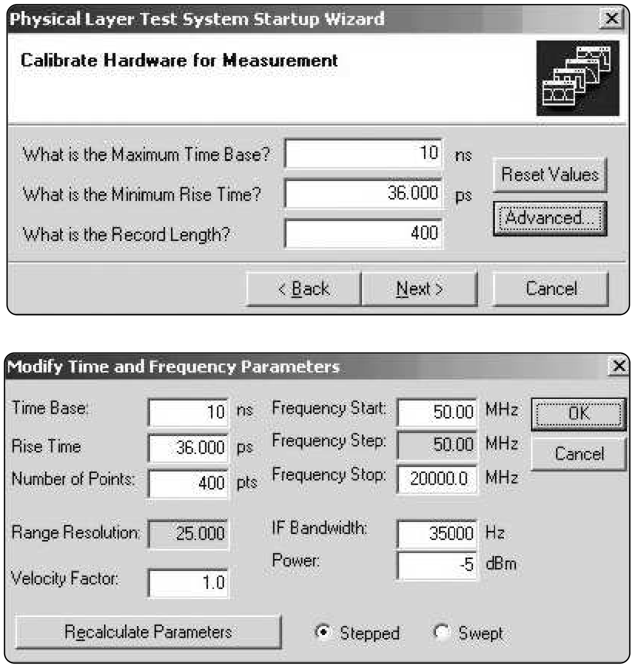
Measurement flow

Device characterization with PLTS is a straightforward process. The user interface has been designed to make setup, calibration, and measurement intuitive, even for users unfamiliar with frequency domain based tools. A Startup Wizard guides the user through all of the required steps. The last prompt is to connect the device-under-test and initiate the measurement.

Setup

Upon startup, and after automatically polling the GPIB, the Startup Wizard prompts the user to accept or modify the default parameters based on hardware capabilities.

Optionally, the "Advanced" screen can be used for entering the parameters in frequency domain terms. In this interactive screen, user input will automatically change other related parameters. This provides some insight into the correlation between the time domain and the frequency domain.



Physical Layer Test System Startup Wizard

Calibrate Hardware for Measurement

What is the Maximum Time Base? 10 ns

What is the Minimum Rise Time? 36.000 ps

What is the Record Length? 400

Modify Time and Frequency Parameters

Time Base: 10 ns

Rise Time 36.000 ps

Number of Points: 400 pts

Range Resolution: 25.000

Velocity Factor: 1.0

Frequency Start: 50.00 MHz

Frequency Step: 50.00 MHz

Frequency Stop: 20000.0 MHz

IF Bandwidth: 35000 Hz

Power: -5 dBm

● Stepped ○ Swept

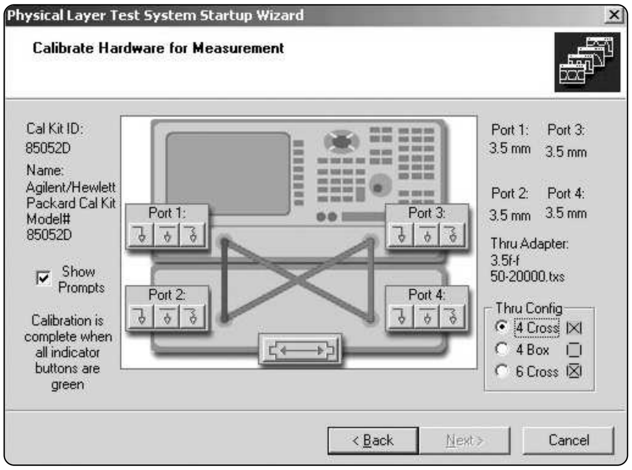
Figure 3. The Startup Wizard automatically identifies the hardware and suggests stimulus parameters. The "Advanced" screen allows more control.

Calibration[1]

After the setup, the calibration method is selected. Depending on the network analyzer hardware configuration, one or more methods are available:

- Four-port electronic calibration (ECal)
- Short/Open/Load/Thru (SOLT)
- Thru/Reflect/Line (TRL)

The Startup Wizard simplifies the process and provides the greatest flexibility to the user.



Physical Layer Test System Startup Wizard

Calibrate Hardware for Measurement

Cal Kit ID: 85052D

Name: Agilent/Hewlett Packard Cal Kit Model# 85052D

☑ Show Prompts

Calibration is complete when all indicator buttons are green

Port 1: 3.5 mm

Port 3: 3.5 mm

Port 2: 3.5 mm

Port 4: 3.5 mm

Thru Adapter: 3.5f-f 50-20000.txs

Thru Config

● 4 Cross

○ 4 Box

○ 6 Cross

Figure 4. For SOLT and TRL calibrations, the interface shows the required calibration standards as icons, which are initially represented in red. As the user connects the standards and mouse-clicks the corresponding icon, the system makes the measurement, and the icon color changes to green (indicating completion). When all of the icons are green, the calibration is complete.

---

[1] See Data Accuracy Enhancement on page 12 for more detail.

Measurement

The Startup Wizard prompts the user to connect the device-under-test, and select an initial analysis type. Then, with a single mouse-click, the system makes all of the measurements. All supported analysis types and formats are immediately available. This allows you to begin where you are most familiar.

With one setup and no additional user input, calibration measurement, and sixty-four time domain and frequency domain device parameters are available for analysis over the entire bandwidth of the instrument.

After defining just a few additional user-selected parameters, eye diagrams, and RLCG model extraction are available.

Analysis

Time domain analysis

The mixed-mode time domain is a common starting point.

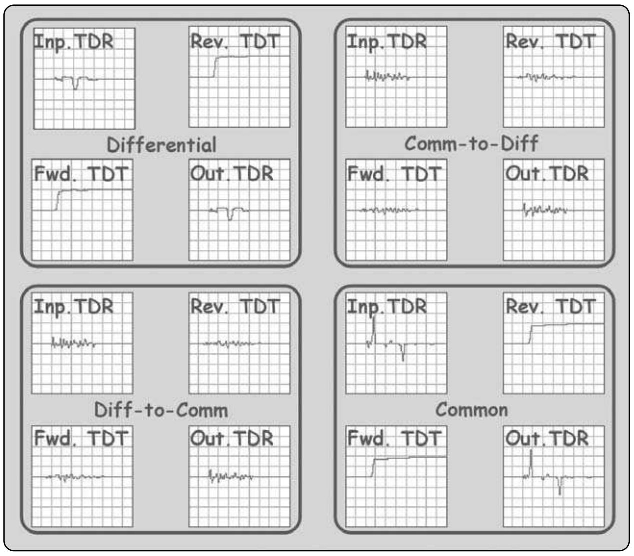


Figure 5. The Mixed-mode Time Domain Matrix

Initially, sixteen parameters are displayed in thumbnail view. These thumbnails represent four modes of device operation: differential-mode, common-mode, and the two mode-conversion types (common-mode stimulus with differential response, and differential stimulus with common-mode response). A double mouse-click on any of these thumbnails will expand the selected parameter to full screen for closer analysis.

Not shown in Figure 5 are the additional sixteen single-ended time-domain parameters, which are simply a mouse-click away.

Frequency domain analysis

The mixed-mode frequency domain is another common starting point.

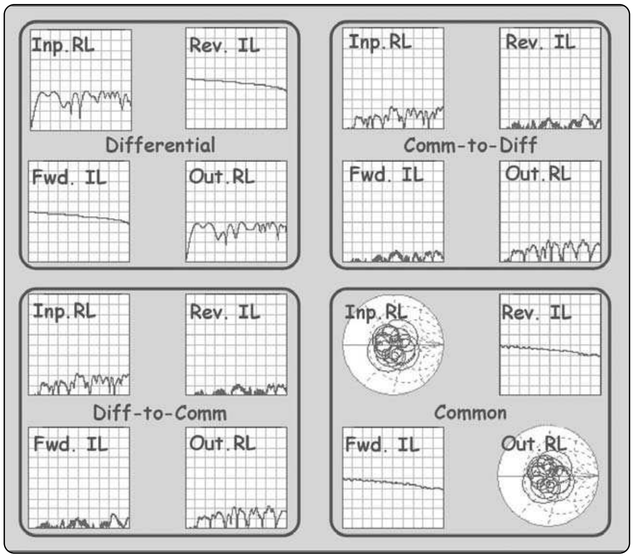


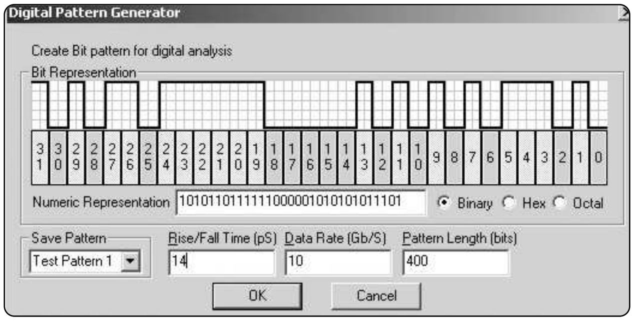
Figure 6. The Mixed-mode Frequency Domain Matrix

Initially, sixteen parameters are displayed in thumbnail view. These thumbnails also represent the four modes of device operation: differential-mode, common-mode, and the two mode-conversion types (common-mode stimulus with differential response, and differential stimulus with common-mode response). A double mouse-click on any of these thumbnails will expand the selected parameter to full screen for closer analysis.

Not shown in Figure 6 are the additional sixteen single-ended frequency-domain parameters, which are simply a mouse-click away.

Measurement-based eye diagrams

Using the digital pattern generator, the user is able to define a bit sequence[1,2] to be applied to the acquired data. PLTS then uses the selected bit pattern to convolve an accurate measurement-based eye diagram. When the eye diagram is generated, marker functions can be used to make typical measurements like deterministic jitter, eye opening, rise and fall times, and more. The digital pattern generator eliminates the need for a hardware pulse/pattern generator, and its flexibility allows for “What if...” analysis.



Numeric Representation: 1010110111111000001010101011101

● Binary ○ Hex ○ Octal

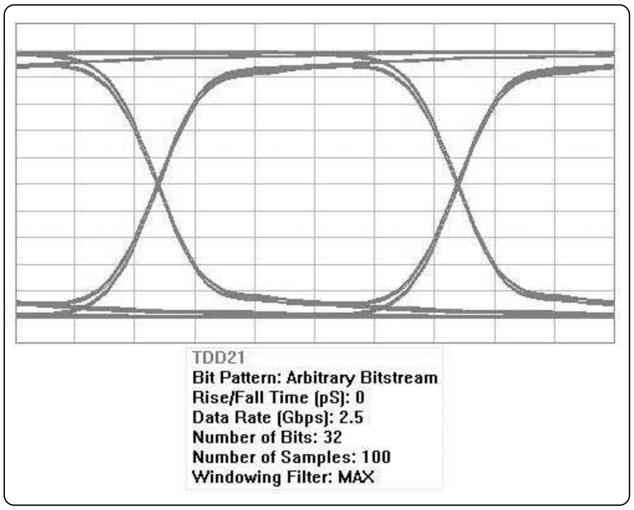
Save Pattern: Test Pattern 1

Rise/Fall Time (pS): 14

Data Rate (Gb/S): 10

Pattern Length (bits): 400

Figure 7. The Digital Pattern Generator



TDD21
Bit Pattern: Arbitrary Bitstream
Rise/Fall Time (pS): 0
Data Rate (Gbps): 2.5
Number of Bits: 32
Number of Samples: 100
Windowing Filter: MAX

Figure 8. Eye Diagram

RLCG model extraction

RLCG (resistance, inductance, capacitance, and dielectric loss) models describe the electrical behavior of passive transmission lines in an equivalent circuit model. From the measured frequency domain data, PLTS calculates the complex propagation constant and complex characteristic impedance for a differential transmission line. This provides an accurate, measurement-based transmission line model for export into modeling and simulation software such as Agilent Advanced Design Systems (ADS), Synopsis HSPICE®, and others.

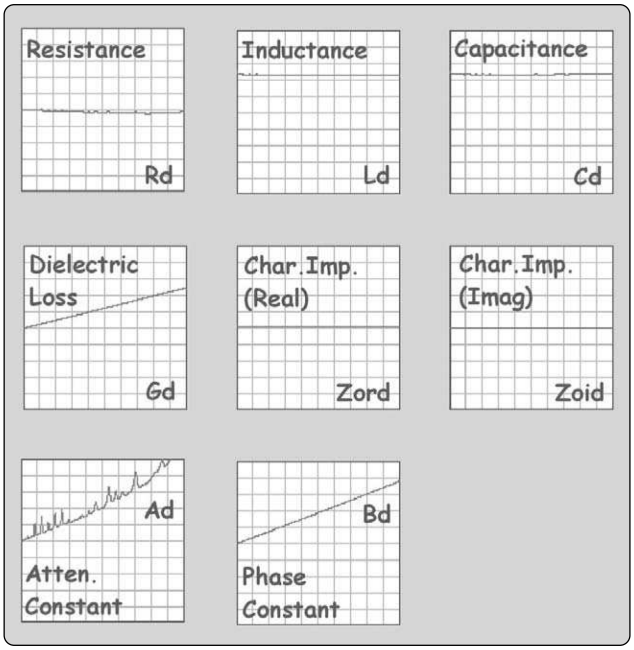


Figure 9. RLCG Model Extraction

---

1. With the Arbitrary Bitstream (ABS) function, the bit stream can be as long as 2^32-1 bits.
2. User-defined patterns may be saved and re-used.

Measurement Capabilities

Parameters and formats

Time domain

Sixteen single-ended and sixteen mixed-mode time-domain parameters are available. These parameters correspond to forward and reverse TDR and TDT in single-ended, differential-mode, common-mode, and mode-conversion.

Formats for impulse or step function are volts, real part of complex parameter, log magnitude, and impedance. Each format may be displayed in time (nS) or distance (cm).

	Stimulus			
Response	T_{11} FWD TDR	T_{12} REV TDT	T_{13} FWD TDT	T_{14} REV TDT
	T_{21} FWD TDT	T_{22} REV TDR	T_{23} FWD TDT	T_{24} REV TDT
	T_{31} FWD TDT	T_{32} REV TDT	T_{33} FWD TDR	T_{34} REV TDT
	T_{41} FWD TDT	T_{42} REV TDT	T_{43} FWD TDT	T_{44} REV TDR

Figure 10. Single-ended time-domain formats

		Stimulus			
		Differential		Common	
Response	Differential	T_{DD11} FWD TDR	T_{DD12} REV TDT	T_{DC11} FWD TDR	T_{DC12} REV TDT
		T_{DD21} FWD TDT	T_{DD22} REV TDR	T_{DC21} FWD TDT	T_{DC22} REV TDR
	Common	T_{CD11} FWD TDR	T_{CD12} REV TDT	T_{CC11} FWD TDR	T_{CC12} REV TDT
		T_{CD21} FWD TDT	T_{CD22} REV TDR	T_{CC21} FWD TDT	T_{CC22} REV TDR

Figure 11. Mixed-mode time-domain formats

Frequency domain

Sixteen single-ended and sixteen mixed-mode frequency-domain parameters are available. These parameters correspond to forward and reverse transmission and reflection in single-ended, differential-mode, common-mode, and mode-conversion.

Formats are log or linear magnitude, phase, group delay, Smith, Polar, real part of complex parameter, and imaginary part of complex parameter.

	Stimulus			
Response	S_{11} FWD REFL	S_{12} REV TRANS	S_{13} FWD TRANS	S_{14} REV TRANS
	S_{21} FWD TRANS	S_{22} REV REFL	S_{23} FWD TRANS	S_{24} REV TRANS
	S_{31} FWD TRANS	S_{32} REV TRANS	S_{33} FWD REFL	S_{34} REV TRANS
	S_{41} FWD TRANS	S_{42} REV TRANS	S_{43} FWD TRANS	S_{44} REV REFL

Figure 12. Single-ended frequency-domain formats

		Stimulus			
		Differential		Common	
Response	Differential	S_{DD11} FWD REFL	S_{DD12} REV TRANS	S_{DC11} FWD REFL	S_{DC12} REV TRANS
		S_{DD21} FWD REFL	S_{DD22} REV TRANS	S_{DC21} FWD REFL	S_{DC22} REV TRANS
	Common	S_{CD11} FWD REFL	S_{CD12} REV TRANS	S_{CC11} FWD REFL	S_{CC12} REV TRANS
		S_{CD21} FWD REFL	S_{CD22} REV TRANS	S_{CC21} FWD REFL	S_{CC22} REV TRANS

Figure 13. Mixed-mode frequency-domain formats

Eye diagram

Twelve single-ended and eight mixed-mode parameters are available. These parameters correspond to forward and reverse transmission in single-ended, differential-mode, common-mode, and mode-conversion.

	Stimulus			
Response	--	T_{12} REV TRANS	T_{13} FWD TRANS	T_{14} REV TRANS
	T_{21} FWD TRANS	--	T_{23} FWD TRANS	T_{24} REV TRANS
	T_{31} FWD TRANS	T_{32} REV TRANS	--	T_{34} REV TRANS
	T_{41} FWD TRANS	T_{42} REV TRANS	T_{43} FWD TRANS	--

Figure 14. Single-ended eye-diagram formats

		Stimulus			
		Differential		Common	
Response	Differential	T_{DD21} TDT	T_{DD12} TDT	T_{DC21} TDT	T_{DC12} TDT
	Common	T_{CD21} TDT	T_{CD12} TDT	T_{CC21} TDT	T_{CC12} TDT

Figure 15. Mixed-mode eye-diagram formats

RLCG model extraction

Thirty-two transmission line parameters are available. These correspond to resistive loss, inductance, capacitance, dielectric loss, characteristic impedance (real and imaginary), attenuation constant, and phase constant, in differential-mode, common-mode, W-element, and self and mutual terms.

R_D DIFF. RESISTANCE	L_D DIFF. INDUCTANCE	C_D DIFF. CAPACITANCE	G_D DIFF. DIELEC. LOSS
Z_{ORD} CHAR. IMP. REAL	Z_{OID} CHAR. IMP. IMAG.	A_D ATTEN. CONSTANT	B_D PHASE CONSTANT

Figure 16. Differential RLCG formats

R_C COMM. MODE RESISTANCE	L_C COMM. MODE INDUCTANCE	C_C COMM. MODE CAPACITANCE	G_C COMM. MODE DIELEC. LOSS
Z_{ORC} CHAR. IMP. REAL	Z_{OIC} CHAR. IMP. IMAG.	A_C ATTEN. CONSTANT	B_C PHASE CONSTANT

Figure 17. Common-mode RLCG formats

R_{11} REFL. RESISTANCE	L_{11} REFL. INDUCTANCE	C_{11} REFL. CAPACITANCE	G_{11} REFL. DIELEC. LOSS
R_{12} TRANS. RESISTANCE	L_{12} TRANS. INDUCTANCE	C_{12} TRANS. CAPACITANCE	G_{12} TRANS. DIELEC. LOSS
R_S SELF RESISTANCE	L_S SELF INDUCTANCE	C_S SELF CAPACITANCE	G_S SELF DIELEC. LOSS
R_M MUTUAL RESISTANCE	L_M MUTUAL INDUCTANCE	C_M MUTUAL CAPACITANCE	G_M MUTUAL DIELEC. LOSS

Figure 18. W-element, self, and mutual RLCG formats

Data Accuracy Enhancement

Measurement calibration

Accuracy enhancement involves the use of several methods by which sources of error may be resolved or minimized. There are three major sources of measurement error, and the techniques for managing each are different.

- **Drift errors -** the change in system performance over time - are primarily related to environmental issues such as temperature and/or humidity change. Drift errors can be minimized through control of the test environment, or removed through re-calibration.
- **Random errors** are caused by unpredictable factors such as instrument noise. While these can not be corrected in advance, the low-noise signal source and the tuned, phase-locked receiver of the network analyzer greatly minimizes these random errors.
- **Systematic errors** are predominantly related to issues of system directivity, source and load match, tracking, and crosstalk. These errors are fully removed by measurement calibration (error-correction).

Calibration types available

Four-port electronic calibration (ECal)

For electronic calibration, the Agilent N4430B ECal Module is used. With one set of connections, this solid-state tuner simulates all of the impedance states required for full four-port, SOLT type error correction, typically in less than one minute.

The N4430B is compatible with the N1947A and N1948A configurations only.

Four-port SOLT (Short/Open/Load/Thru) calibration

Compensates for directivity, transmission and reflection tracking (frequency response), source match, load match, and crosstalk in both forward and reverse directions.

Four-port TRL (Thru/Reflect/Line) calibration

Compensates for directivity, reflection frequency response, transmission frequency response, and crosstalk.

Definitions

To specify the performance of a PLTS, this data sheet lists the dynamic range, measurement uncertainty, and measurement port characteristics for each system configuration. Two types of numbers are offered: specifications and characteristics. These terms are further defined below.

Specifications describe the instrument's warranted performance over the temperature range of 23 °C ± 3 °C.

Characteristics are typical but non-warranted performance parameters. These are further denoted as "typical" or "nominal."

- **Typical (typ.):** Expected performance of an average unit, not including guardbands.

- **Nominal (nom.):** A general, descriptive term that does not imply a level of performance.

Measurement port characteristics indicate the RF performance of network analyzer and test set port leakages, mismatches, and frequency response. The specification for the test set's crosstalk does not include noise.

Dynamic range (signal-to-noise ratio) is further defined as or $P_{ref} - P_{min}$, where P_{ref} is the nominal or reference power out of a source test port and P_{min} is the minimum power into a receiver test port that can be measured above the peaks of the system's noise floor (10 dB above the average noise floor). System dynamic range is the amount of attenuation that can be measured from a 0 dB reference.

Calibration is the process of measuring standards that have fully defined models (and are thus called "known" standards) in order to quantify a network analyzer's systematic errors based on an error model. Calibration must be performed within the operating temperature specified for the calibration kit. For all calibration kits the operating temperature is 23 °C ±3 °C. For a calibration to remain fully verifiable, the temperature of the network analyzer must remain within ±1 °C around the initial measurement calibration temperature.

Error-correction is the process of mathematically removing from the measurement systematic errors determined by measurement calibration.

Measurement uncertainty curves show the worst-case uncertainty in reflection and transmission measurements using full error correction with the specified calibration kit. This includes residual systematic errors, as well as system dynamic accuracy, connector repeatability, noise, and detector errors. Cable stability and system drift are not included. Furthermore, the graphs for reflection measurement uncertainty apply to a one-port device. The graphs for transmission measurement uncertainty assume a well-matched device ($S_{11}= S_{22} = 0$). In the phase uncertainty curves, the phase detector accuracy is better than 0.02 degrees, useful for measurements where only phase changes.

System Performance Summary

N1947A and N1948A
Physical Layer Test System

80 pS (300 kHz to 9 GHz)

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

Network analyzer (3-receiver):	Agilent E8803A, Opt. 014
test set	Agilent N4417A, Opt. 103
--or--	
Network analyzer (4-receiver):	Agilent E8358A, Opt. 015
Test set	Agilent N4417A, Opt. 104
Test cables:	Agilent N4417A, Opt. B20
Calibration kit:	Agilent 85052C, 3.5 mm
Calibration technique:	Four-port SOLT

Dynamic range (signal-to-noise ratio)

Transmission measurements at 10 Hz IF bandwidth, with full four-port error-correction, and 10 dBm maximum output power.

	300 kHz to 1.3 GHz	1.3 to 3 GHz	3 to 6 GHz	6 to 9 GHz
Dynamic range	120 dB[1]	120 dB	108 dB	103 dB

Measurement port characteristics

Residual uncertainties for corrected data. These apply for 25 °C with less than 1°C variation from calibration.

	300 kHz to 1.3 GHz	1.3 to 3 GHz	3 to 6 GHz	6 to 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 to 9 GHz
Transition time (10 to 90%, TR=.72/BW)		80 pS
Impedance		50 ohms nom.
Insertion loss	Source Out to Coupler In	4.5 dB max.
	Port 2 to A In, and Port 4 to B In	8.5 dB max
	A In to A Out, and B In to B Out	8.0 dB max.
Isolation, port-to-port and A to B		105 dB min.
Maximum operating level		+20 dBm
Damage level		+30 dBm typ.
Test port connectors		50 ohm type-N
RF connectors		50 ohm SMA(f)
Weight (test set)		9 kg

Measurement uncertainties

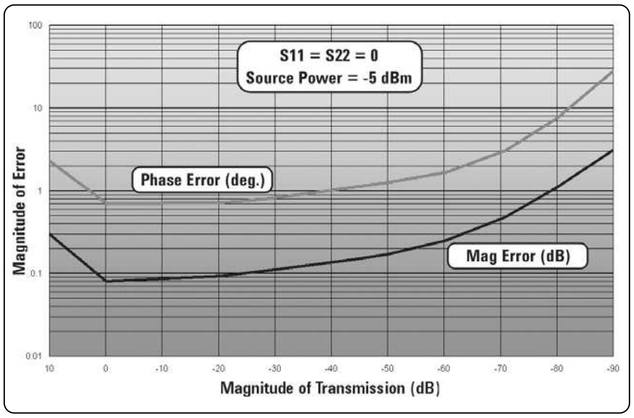


Figure 19. Worst case 3.5 mm transmission magnitude and phase uncertainty

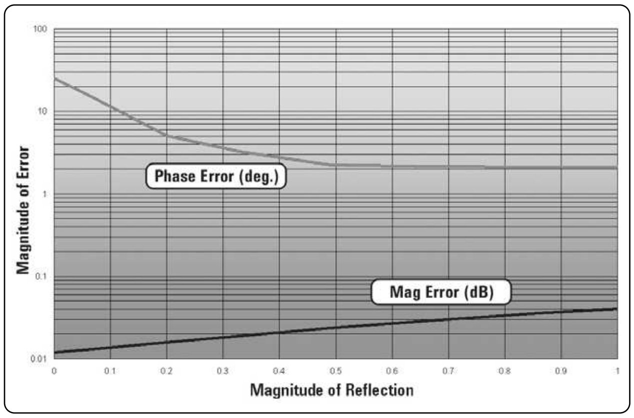


Figure 20. Worst case 3.5 mm reflection magnitude and phase uncertainty

---

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

System Performance Summary

N1951A Physical Layer Test System

36 pS (50 MHz to 20 GHz)

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

Network analyzer (3-receiver):	Agilent 8720ES, Opt. H32
Test set	Agilent N4418A
Test cables:	Agilent N4418A, Option B20
Calibration kit:	Agilent 85052C, 3.5 mm
Calibration technique:	Four-port SOLT

Dynamic range (signal-to-noise ratio)

Transmission measurements at 10 Hz IF bandwidth, with full four-port error-correction, and +5 dBm maximum output power.

	.05 to .84 GHz	.84 to 20 GHz
Dynamic range	77 dB	90 dB

Measurement port characteristics

Residual uncertainties for corrected data. These apply for 25 °C with less than 1°C variation from calibration.

	.05 to 8 GHz	8 to 20 GHz
Directivity	48 dB	43 dB
Source match	41 dB	38 dB
Load match	48 dB	43 dB
Refl. tracking	± 0.005 dB	± 0.008 dB
Trans. tracking	± 0.014 dB	± 0.035 dB

Test set typical performance

Frequency range	.05 to 20 GHz
Transition Time (10 to 90%, TR=.72/BW)	36 pS
Impedance	50 ohms nom.
Insertion loss	8 – 10 dB nom.
Isolation, port-to-port	85 dB min.
Maximum operating level	+20 dBm
Damage level	+30 dBm typ.
Test port connectors	3.5 mm (m)
RF connectors	50 ohm SMA (f)
Weight	9 kg

Measurement Uncertainties

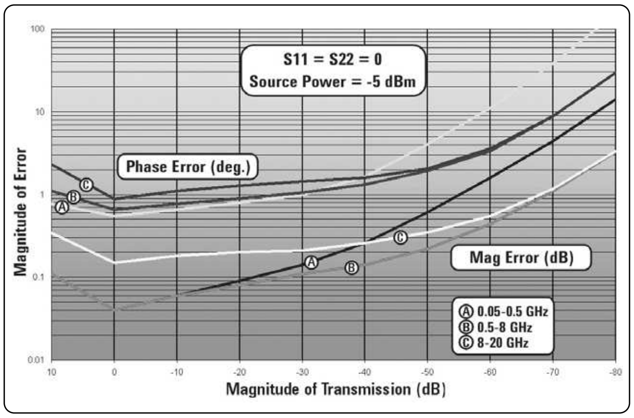


Figure 21. Worst case 3.5 mm transmission magnitude and phase uncertainty

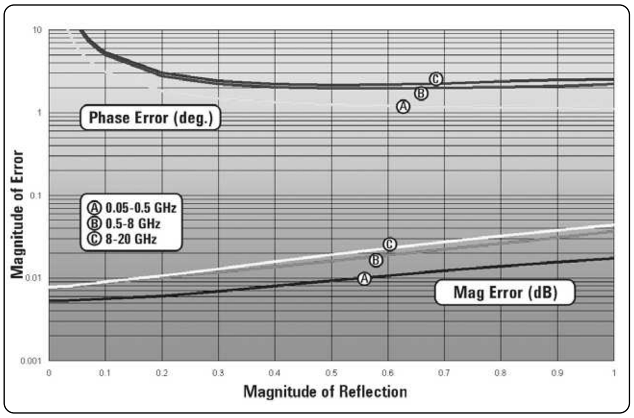


Figure 22. Worst case 3.5 mm reflection magnitude and phase uncertainty

System Performance Summary

N1953A Physical Layer Test System

36 pS (45 MHz to 20 GHz)

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

Network analyzer:	Agilent E8362A, Opt. 014/711
Test set:	Agilent N4419A
Test cables:	Agilent N4419A, Option B20
Calibration kit:	Agilent 85052D 3.5 mm
Calibration technique:	Four-port SOLT

Dynamic range (signal-to-noise ratio)

Transmission measurements at 10 Hz IF bandwidth, with full four-port error-correction, and -5 dBm maximum output power.

	.045 to .5 GHz	.5 to 10 GHz	10 to 20 GHz
Dynamic range	70 dB	100 dB	85 dB

Measurement port characteristics

Residual uncertainties for corrected data. These apply for 25 °C with less than 1°C variation from calibration.

	.045 to 2 GHz	2 to 10 GHz	10 to 20 GHz
Directivity	56 dB	42 dB	40 dB
Source match	42 dB	36 dB	33 dB
Load match	56 dB	42 dB	40 dB
Refl. tracking	± 0.0015 dB	± 0.009 dB	± 0.013 dB
Tran. tracking	± 0.020 dB	± 0.032 dB	± 0.050 dB

Test set typical performance

Frequency range		.045 to 20.0 GHz
Transition time (10 to 90%, TR=.72/BW)		36 pS
Impedance		50 Ohms nom.
Insertion loss		
Source Out to Coupler Thru		5.0 dB max.
Port 2 to A In, and Port 4 to B In, .045 to 1 GHz		18-45 dB typ.
Port 2 to A In, and Port 4 to B In, 1.0 to 20.0 GHz		18-25 dB typ.
Rcvr A In to Cplr Arm, and Rcvr B In to Cplr Arm		8.0 dB max.
Isolation, port-to-port	.045 to 1 GHz	≥70 dB
	1.0 to 20.0 GHz	≥90 dB
Maximum operating level		+20 dBm
Damage level		+30 dBm typ.
Test port connectors		3.5 mm (m)
RF connectors		50 ohm SMA(f)
Weight		9 kg

Characteristic measurement uncertainties

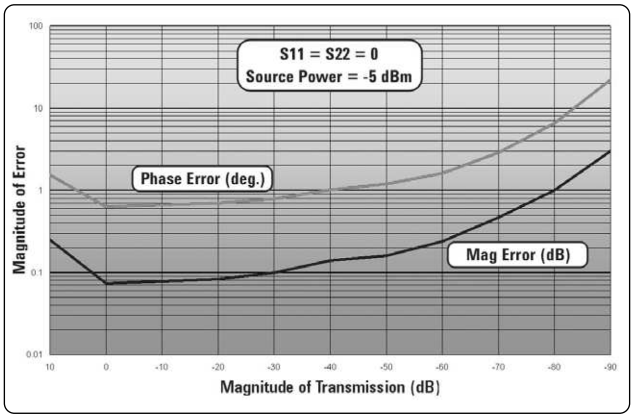


Figure 23. Worst case 3.5 mm transmission magnitude and phase uncertainty

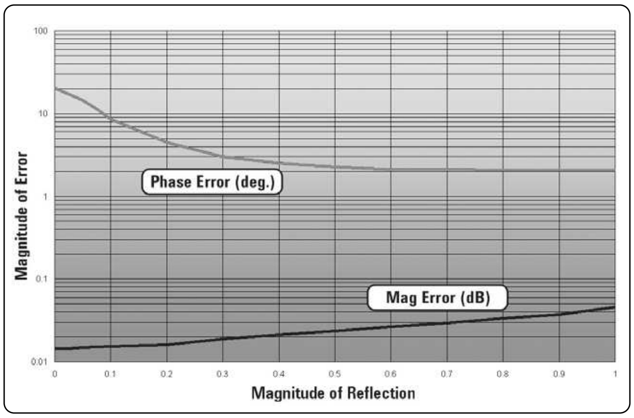


Figure 24. Worst case 3.5 mm reflection magnitude and phase uncertainty

System Performance Summary

N1957A Physical Layer Test System

14 pS (45 MHz to 50 GHz)

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

Network analyzer:	Agilent E8364A, Opt. 014/711
Test set:	Agilent N4421A
Test cables:	Agilent N4421A-B20
Calibration kit:	Agilent 85056A, 2.4 mm
Calibration technique:	Four-port SOLT

Dynamic range

Transmission measurements at 10 Hz IF bandwidth, with four-port error correction and -17 dBm maximum output power.

	45 to 500 MHz	.5 to 10 GHz	10 to 20 GHz	20 to 50 GHz
Dynamic range	55 dB	70 dB	70 dB	55 dB

Measurement port characteristics

Residual uncertainties for corrected data. These apply for 25 °C with less than 1°C variation from calibration.

	45 to 500 MHz	.5 to 10 GHz	10 to 20 GHz	20 to 50 GHz
Directivity	43 dB	39.5 dB	39 dB	33 dB
Source match	38 dB	34 dB	34 dB	27 dB
Load match	43 dB	39.5 dB	39 dB	33 dB
Refl. tracking	± .001 dB	± .002 dB	± .008 dB	± .026 dB
Tran. tracking	± .015 dB	± .020 dB	± .040 dB	± .20 dB

Test set typical performance

Frequency range		.045 to 50.0 GHz
Transition time (10 to 90%, TR=.72/BW)		14 pS
Impedance		50 Ohms
Insertion loss		
Source Out to Coupler Thru		12.0 dB max.
Port 2 to Rcvr A In, and Port 4 to Rcvr B In		
	45 MHz to 1 GHz	18-45 dB typ.
	1.0 to 50.0 GHz	16-26 dB typ.
Rcvr A In to Cplr Arm, and Rcvr B In to Cplr Arm		15 dB max.
Isolation, port-to-port	45 to 200 MHz	≥70 dB
	200 MHz to 50.0 GHz	≥90 dB
Maximum operating level		+20 dBm
Damage level		+30 dBm typ.
Test port connectors		2.4 mm (m)
Weight		9 kg

Characteristic measurement uncertainties

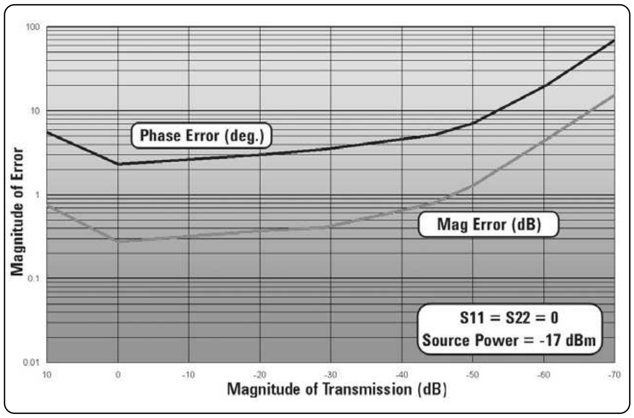


Figure 25. Worst case 2.4 mm transmission magnitude and phase uncertainty

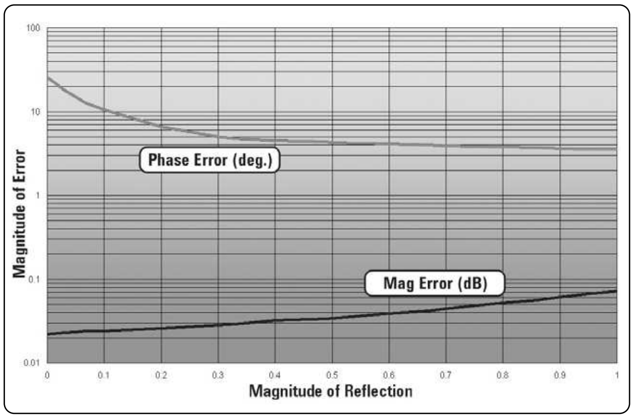


Figure 26. Worst case 2.4 mm reflection magnitude and phase uncertainty

System Configurations

A Physical Layer Test System includes network analyzer hardware and application software running on an external PC.

Each PLTS system bundle includes the following:

- Four-port network analyzer system (vector network analyzer and external two-port S-parameter test set)
- CD-ROM containing the Physical Layer Test System software
- Node-locked license certificate
- Sample DUT board (balanced transmission line)
- User documentation

Test-port cables and rack mount kits with handles are available as options. Calibration kits and ECal modules can be ordered separately, or as part of a bundled system.

Start-up assistance is available.

System controller (user-supplied PC) requirements:

- 700 MHz Pentium III minimum, ≥1 GHz recommended
- Windows NT®, Windows® 2000, or Windows XP (Windows XP is recommended)
- 256 megabytes of RAM minimum, ≥512 MB recommended
- CD-ROM drive
- Supported GPIB card:
  - Agilent 82340, 82341, 82350 GPIB Interface Card
  - Agilent 82357A USB/GPIB Interface for Windows
  - any National Instruments GPIB card

Physical Layer Test System Configurations[1]

PLTS Bundled Systems	Test Set Model Number	System Frequency Range	Supported Network Analyzer			
			Model Number	Network Analyzer Options[1]		
				Required	Compatible	Incompatible
N/A[2]	N4415A	30 kHz to 6.0 GHz	8753ES	006[3], 014	002, 004, 010, 1D5	011, 075, H16
N/A[2]	N4416A	300 kHz to 6.0 GHz	E8356A[4]/7A/8A[5]	015	010, 1D5	
N1947A	N4417A[6]	300 kHz to 9.0 GHz	E8803A	014	010	
N1948A	N4417A[6]	300 kHz to 9.0 GHz	E8358A	015	010, 1E1, 1E5	
N1951A	N4418A	50 MHz to 20 GHz	8720ES	H32 or H42	010, 012, 400	007, 085, 089
N/A[2]	N4418A[7]	50 MHz to 20 GHz	8722ES[7]	H32 or H42	010, 012, 400	007, 085, 089
N1953A	N4419A	45 MHz to 20 GHz	E8362A/B	014	010, 022, 711, UNL	
N1957A	N4421A	45 MHz to 50 GHz	E8364A/B	014	010, 022, 711, UNL	

1. This table lists only the most specifically relevant options. For compatibility with options not listed here, contact the factory.
2. PLTS software, N1930A, must be ordered to create complete PLTS system.
3. Option 006 required only for operation above 3 GHz.
4. Using this network analyzer, the maximum operating frequency is limited to 3 GHz.
5. Using this network analyzer, the maximum operating frequency is limited to 6 GHz.
6. E8356A family requires N4417A Option 104; E8801A family requires N4417A Option 103.
7. When an 8722ES is used with an N4418A, the N4418A requires Option 302. The system’s maximum operating frequency is limited to 20.0 GHz.

System Ordering Guide

N1947A Physical Layer Test System

80 pS (300 kHz to 9 GHz)

Includes:

E8803A	PNA network analyzer, 300 kHz to 9 GHz, 3-rcvr
E8803A-014	Configurable test set
N4417A	S-parameter test set, 300 kHz to 9 GHz
N4417A-103	E8803A compatibility
N1930A	Physical Layer Test System software

Recommended options and accessories:

N4417A-B20	Test cables, 3 ft., Type-N (m) to 3.5 mm (m), qty. 4
N4417A-1CP	Rack mount kit, test set
N4430B	Four-port ECal module, 300 kHz to 9 GHz, 3.5 mm (f)

N1948A Physical Layer Test System

80 pS (300 kHz to 9 GHz)

Includes:

E8358A	PNA network analyzer, 300 kHz to 9 GHz, 4-rcvr
E8358A-015	Configurable test set
N4417A	S-parameter test set, 300 kHz to 9 GHz
N4417A-104	E8358A compatibility
N1930A	Physical Layer Test System software

Recommended options and accessories:

N4417A-B20	Test cables, 3 ft., Type N (m) to 3.5 mm (m), qty. 4
N4417A-1CP	Rack mount kit, test set
N4430B	Four-port ECal module, 300 kHz to 9 GHz, 3.5 mm (f)

N1951A Physical Layer Test System

36 pS (50 MHz to 20 GHz)

Includes:

8720ES	Vector network analyzer, 50 MHz to 20 GHz, 3-rcvr
8720ES H32	Configurable test set
N4418A	S-parameter test set, 50 MHz to 20 GHz
N1930A	Physical Layer Test System software

Recommended options and accessories:

N4418A-B20	Test-port cables, 3 ft., 3.5 mm (m-f), quantity 4
N4418A-1CP	Rack mount kit, test set
85052D	Calibration kit, 3.5 mm

N1953A Physical Layer Test System

36 pS (45 MHz to 20 GHz)

Includes:

E8362B*	PNA network analyzer, 45 MHz to 20 GHz, 4-rcvr
E8362B-014	Configurable test set
E8362A-711	Standard power configuration
N4419A	S-parameter test set, 45 MHz to 20 GHz
N1930A	Physical Layer Test System software

* This system is not tested or specified with network analyzer options 016/080/081/083

Recommended options and accessories:

N4419A-B20	Test-port cables, 3 ft., 3.5 mm (m-f), quantity 4
N4419A-1CP	Rack mount kit, test set
85052D	Calibration kit, 3.5 mm

N1957A Physical Layer Test System

14 pS (45 MHz to 50 GHz)

Includes:

E8364B*	PNA network analyzer, 45 MHz to 50 GHz, 4-rcvr
E8364B-014	Configurable test set
E8364A-711	Standard power configuration
N4421A	S-parameter test set, 45 MHz to 50 GHz
N1930A	Physical Layer Test System software

* This system is not tested or specified with network analyzer options 016/080/081/083

Recommended options and accessories:

N4421A-B20	Test-port cables, 3 ft., 2.4 mm (m-f), quantity 4
N4421A-1CP	Rack mount kit, test set
85056A	Calibration kit, 2.4 mm

Web Resource

For more information regarding PLTS systems
visit our Physical Layer Test System web site:
www.agilent.com/find/plts

Agilent Email Updates

www.agilent.com/find/emailupdates
Get the latest information on the products and applications you select.

Agilent Direct

www.agilent.com/find/agilentdirect
Quickly choose and use your test equipment solutions with confidence.

Agilent
Open

www.agilent.com/find/open
Agilent Open simplifies the process of connecting and programming test systems to help engineers design, validate and manufacture electronic products. Agilent offers open connectivity for a broad range of system-ready instruments, open industry software, PC-standard I/O and global support, which are combined to more easily integrate test system development.

www.agilent.com

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. 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 receive your new Agilent equipment, we can help verify that it works properly and help with initial product operation.

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 onsite 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.

United States:
(tel) 800 829 4444
(fax) 800 829 4433
Canada:
(tel) 877 894 4414
(fax) 800 746 4866
China:
(tel) 800 810 0189
(fax) 800 820 2816
Europe:
(tel) 31 20 547 2111
Japan:
(tel) (81) 426 56 7832
(fax) (81) 426 56 7840

Korea:
(tel) (080) 769 0800
(fax) (080) 769 0900
Latin America:
(tel) (305) 269 7500
Taiwan:
(tel) 0800 047 866
(fax) 0800 286 331
Other Asia Pacific Countries:
(tel) (65) 6375 8100
(fax) (65) 6755 0042
Email: tm_ap@agilent.com
Contacts revised: 09/26/05

For more information on Agilent Technologies' products, applications or services, please contact your local Agilent office. The complete list is available at:

www.agilent.com/find/contactus

Printed in USA, July 13, 2006
5988-5288EN

Agilent Technologies