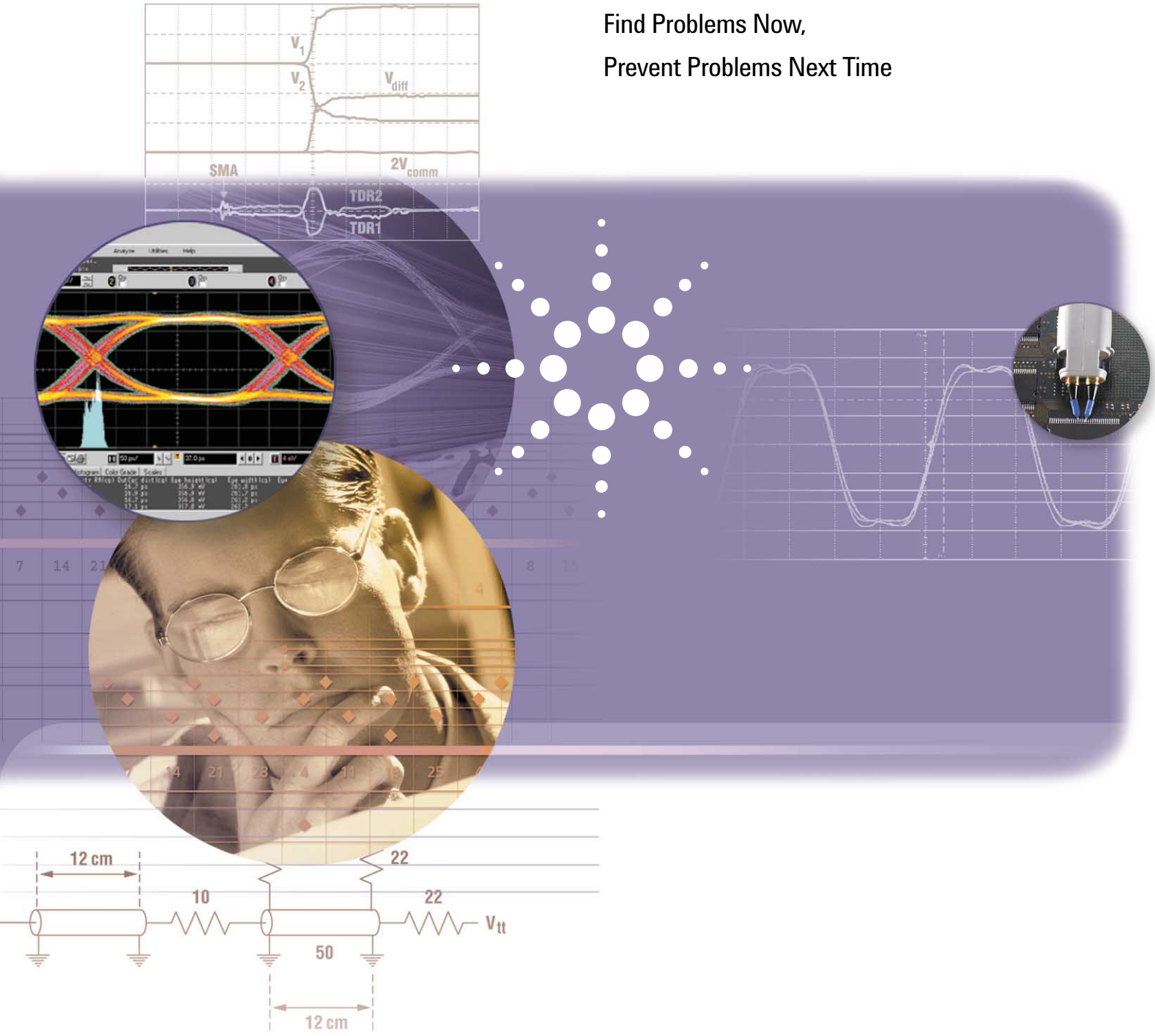
Signal Integrity Solutions

Find Problems Now,

Prevent Problems Next Time



Agilent Technologies

A New Perspective on the Design Process

In all evolving technologies, you eventually reach a point where you must change your way of thinking to go past a certain level. The methods and rules of thumb you have used in the past are no longer adequate. To move forward, you must step back and look at the design process from a new perspective.

To move to the next level in high-speed digital design, with sub-nanosecond edge rates and slim design margins, you must add additional problem solving tools to your trusty toolbox. The ubiquitous oscilloscope, though important, requires complementary software and/or instrumentation to adequately address today's difficult signal integrity and jitter issues.

Agilent is constantly researching new ways to assist design engineers and has developed a comprehensive set of tools that will keep signal integrity problems under control as you move into higher-speed designs. Instead of relying on guessing and the old rules of thumb, you can measure critical components and create accurate models to simulate and verify your new designs before committing them to hardware. Once the hardware is built, you can accurately measure the physical layer to validate the signal paths prior to installing components.

When the components are first installed, you can use pulse pattern generators to test your system with live signals. High-speed scopes and active probes enable you to see what is going on. Once the system is running, you can monitor the signal integrity of hundreds of channels simultaneously with a logic analyzer and new eye diagram feature, eye scan. An oscilloscope or bit error ratio tester (BERT) help characterize jitter.

Signal integrity is no longer something to be looked at just once at the beginning of a project when laying out the device or board. Everyone must be aware of signal integrity and evaluate it throughout the project, and must have the proper tools to accomplish this sometimes daunting task. The challenging high-speed digital designs of today's data rates require careful use of a wide variety of engineering tools. It is important for designers to learn these new tools effectively to avoid multiple re-design efforts.

The breadth of tools available from Agilent Technologies enables signal integrity evaluation throughout the entire design process. You can use a vector network analyzer (VNA) or time domain reflectometer (TDR) for device and interconnect characterization. The measurement data is used to enhance your model database so that design simulation will produce accurate results. For those who do not want to invest in the equipment and expertise for characterization, Agilent can provide device characterization and modeling services.

Once the device or board is created, a wide variety of tools from Agilent enable you to characterize the physical layer of your design. After you are satisfied with the results, you can install components and bring the system up. Capable pulse/pattern generators can provide live signals to stimulate portions of the system as you bring it up. For jitter characterization, use the jitter analysis tools of the oscilloscope or the bathtub curve from a BERT.

When the system is running, you can use eye diagrams to validate signal quality. The eye diagram can be acquired with a scope when you want to see a few signals, or with a unique, signal integrity-aware logic analyzer if you want to check hundreds of signals in a short time. BERTs can also be used to ensure that errors are within the required range.

Finally, when all of the signals have been checked, the entire system can be tested with Agilent's protocol analyzers and bus exercisers. You can stress your design with very specific and controllable worst-case scenarios to give you the confidence that your system is ready to ship.

Agilent has the knowledge, tools, and methods to help you move to the next level in system performance by addressing all of the signal integrity issues. You may have to look at the signal integrity problem from a different perspective, but with Agilent's help, you will not be looking at it alone.

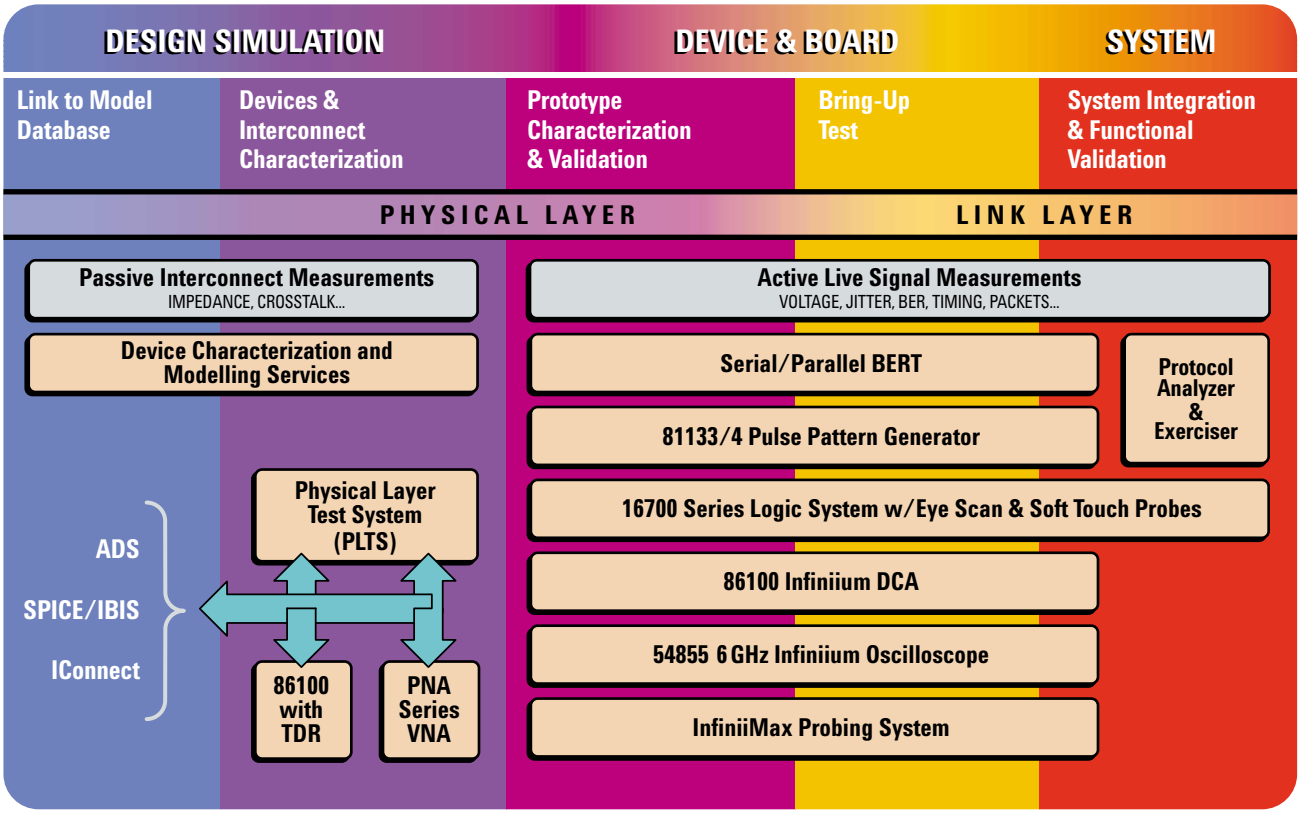


Figure 1. Agilent Technologies helps you address signal integrity and jitter issues throughout the entire design process.

When you suspect a signal integrity-related problem, the first instrument you grab is an oscilloscope. The scope is the best instrument for finding out what a signal looks like. It will continue to be an important tool for understanding signal integrity problems, but it is only one of many tools that are now required.

You will need a scope that can accurately measure sub-nanosecond edge rates. The Infiniium 54850 Series provides up to 6 GHz bandwidth and an intuitive Windows® interface that makes it easy to analyze signals and get the information you need. It can characterize critical signal parameters, such as setup and hold time violations, edge rates, overshoot, and jitter.

As an experienced scope user, you know that your measurements are only as good as your probing system. And as bandwidth increases, it's increasingly important to ask the question: am I measuring my circuit or my scope probe? Nothing is more frustrating than chasing down an apparent design problem, only to find that it was caused by an inferior scope probe.

Together, the newest Infiniium scopes and the innovative InfiniiMax high-performance probing systems offer an end-to-end measurement system with unmatched performance, accuracy and connectivity. InfiniiMax probes, with up to 7 GHz bandwidth, can measure differential and single-ended signals. Their flexibility supports even the most demanding mechanical access requirements without sacrificing performance. The result is measurements you can trust and better insight into circuit behavior.

When you are developing even faster systems that have edge rates less than 100 ps, you will need a scope with significant bandwidth. The 86100B Infiniium DCA accepts modules that provide up to 80-GHz of electrical bandwidth. A new remote sampling head for the 86100B allows the user to minimize bandwidth loss due to long cables.

Testing today's high-speed serial buses is simplified with the E2668A Serial Data Analysis Software for the Infiniium 54850 Series oscilloscopes. Perform mask testing and characterize serial data streams that employ embedded clocks. Verify compliance to standards such as PCI Express, Serial ATA, Fibre Channel, and Gigabit Ethernet.

Characterizing jitter is easy using the Infiniium 54850 Series with the optional jitter analysis software, providing histogram, measurement vs. time, spectrum, and RJ/DJ separation. When your data rates are greater than 3.2 Gb/s, the 86100B Infiniium DCA is the scope to use.

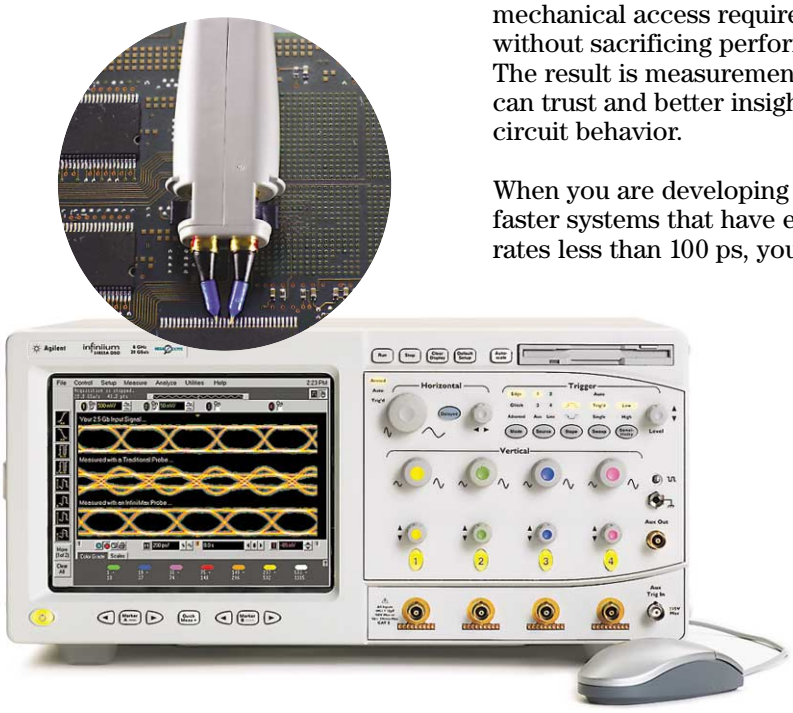


Figure 2. The Agilent 54850 Series Oscilloscopes and InfiniiMax 1130 Series probes deliver a high-performance 6 GHz end-to-end measurement system.

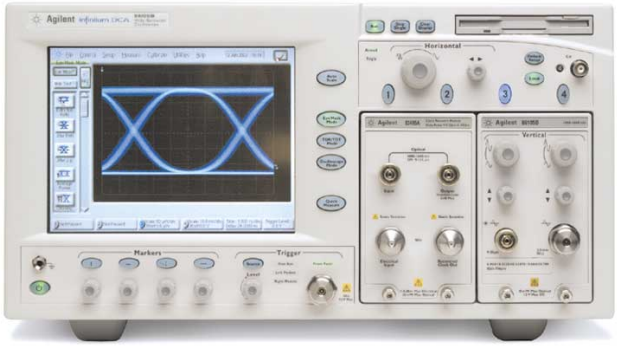


Figure 3. The Agilent 86100 DCA is a digital communications analyzer, a wide-bandwidth oscilloscope, and a time-domain reflectometer.

Logic Analysis System

Prototype Characterization

Bring-Up Test

System Integration & Functional Validation

Hundreds of signal traces moving data along wide data paths at high speeds can present quite a challenge to the high-speed digital designer. The interaction of these hundreds of signal lines keeps signal integrity in the forefront. You must validate the signal integrity of each signal path in order to be fully confident of your design.

The typical method for validating all of the signals is to use a 2- or 4-channel scope and measure eye diagrams. This can take a considerable amount of time and is often deleted from the project as many back-end tests fall victim to sliding schedules. The ideal alternative to making hundreds of eye-diagram measurements with a scope is a novel measurement technique called eye scan.

With eye scan, you can have the same eye-diagram capability in a logic analyzer that you have in your scope, *and* cover up to 340 channels at a time. Eye scan gives you a rapid, comprehensive overview across hundreds of signals simultaneously. Eye scan is a standard feature in the Agilent 16760A, 16753A, 16754A, 16755A, and 16756A state/timing modules for the 16700 series logic analysis systems. If eye scan finds a bad signal and you need more detail, you can take a closer look with your scope.

The Agilent 16760A provides a 1.5-Gb/s state acquisition rate and 128-M sample memory depth. It can acquire differential signals with a probing system that presents only 1.5-pF capacitive loading to preserve your system's signal integrity. It has an equivalent bandwidth of 2.33 GHz when using eye scan.

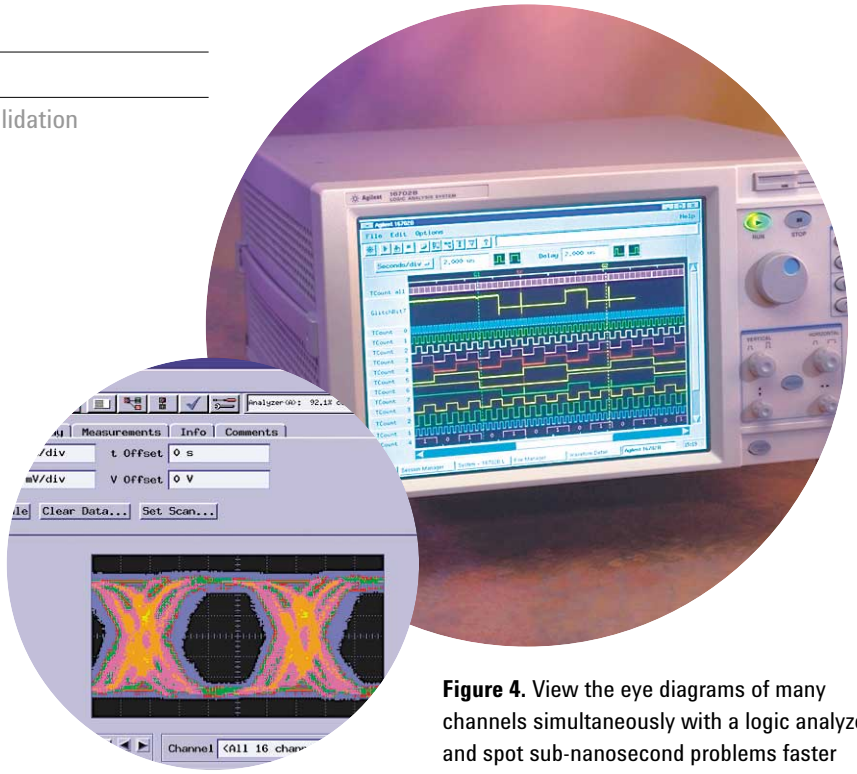


Figure 4. View the eye diagrams of many channels simultaneously with a logic analyzer and spot sub-nanosecond problems faster than conventional methods.

On your next project, use Agilent's innovative, time-saving "eye scan" technology for a comprehensive overview of the system's signal integrity. Immediately spot problems and identify the offending signals. Use the time you gain to check out signal integrity under all conditions.

Quality measurements start at the probe tips. Agilent's soft touch probes provide accurate, reliable connectorless contact with your device. Available in single-ended and differential versions, soft touch probing provides quick, easy signal access and minimal loading on the target. With less than 0.7 pF capacitive loading, you can maintain tight timing margins with the soft touch probe attached to your board.

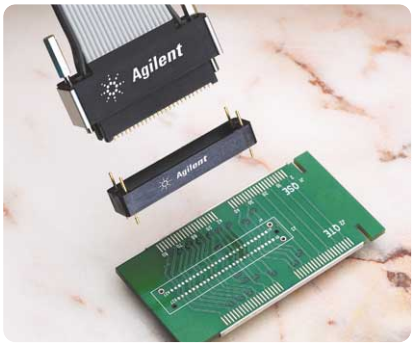


Figure 5. Agilent's soft touch probes combine high-density, low loading and differential capability into a reliable space-saving package.

TDR, VNA, Physical Layer Test System (PLTS)

High-speed system design starts with the physical structure. The extreme data rates on the latest high-speed, differential buses are equivalent to sending microwave signals through copper structures. First-pass success demands a systematic approach to design and validation. Microwave engineers have addressed similar design challenges by breaking down the system to model each component separately, then together as a complete channel. This successful approach is now applied to high-speed digital design.

Accurate simulations require accurate component models. You can modify existing models or rely on supplied libraries but the most accurate method is to measure actual components. Measurement-based models increase your confidence by providing real-world data to your time domain or frequency domain simulator.

Process variations, connector wear and silicon aging erode signal integrity margins. The more accurately you know the transmission and reflection properties of your channel, the less design margin is required.

Two choices are available to design and extract measurement-based models with either a Time Domain Reflectometer (TDR) or a 4-port Vector Network Analyzer (VNA). Each have unique advantages and both produce similar results. TDRs are more affordable and familiar while VNAs produce more accurate and traceable results.

TDR/TDT

A TDR combines a sampling oscilloscope with a step generator capable of launching a fast edge into the Device Under Test (DUT). The time, location and magnitude of the reflected wave (TDR) provide an easy to interpret display of impedance discountinuities vs. distance. The transmitted wave (TDT) enables you to measure propagation delay and signal deterioration due to system loss and reflections.

Measurement errors due to cables, fixtures and probes can be removed through a calibration technique unique to the Agilent 86100 DCA/TDR, called Normalization.

The Agilent 86100B Infiniium DCA and 54754A Differential TDR module provide an intuitive tool for debug, analysis and model extraction. Excess inductance and capacitance measurements determine the location and magnitude of discontinuities. When not in TDR mode, the 86100 DCA operates as a wide-bandwidth oscilloscope with over 80 GHz coverage, depending upon the module used.

4-Port Vector Network Analyzer (VNA)

A VNA uses stimulus/response to characterize the DUT. A sine wave is transmitted into the DUT while tuned receivers are swept in lockstep, providing both reflection and transmission properties. VNAs offer greater measurement resolution and accuracy than a TDR through calibration and fixture removal techniques that have been refined through years of demanding microwave applications. VNA results are calibrated using frequency domain artifacts—each measurement is accurate, repeatable and traceable to industry standards.

VNA measurements are often expressed as Scattering Parameters (or S-Parameters) that can be translated into time-domain views. S-Parameters are well established as the best technique to characterize the manner in which a component modifies a digital signal.

Figure 6. Gather accurate measurements for model extractions and comprehensive physical-layer test with the Agilent 86100B DCA/TDR, PNA Series VNA, and PLTS system.

Physical Layer Test System (PLTS)

The Agilent PLTS provides confidence in your design through complete characterization and model extraction of your DUT. PLTS supports both the TDR and VNA measurement platforms, providing instrument control including setup, error correction, acquisition and data transfer—thus reducing the difficult and time-consuming process of measuring differential structures to a few keystrokes with minimal chance of error.

Many high data rate standards require characterizing input differential insertion loss, return loss, impedance and near/far end crosstalk. PLTS provides direct measurement of these parameters, as well as mode conversion analysis, which is used to understand EMI.

Guided setup and calibration methodologies ensure that the data you capture accurately reflects your DUT. Export VNA or TDR data to simulators that accept S-Parameters such as Agilent's Advanced Design System (ADS), or to TDA Systems IConnect model extraction and analysis software.

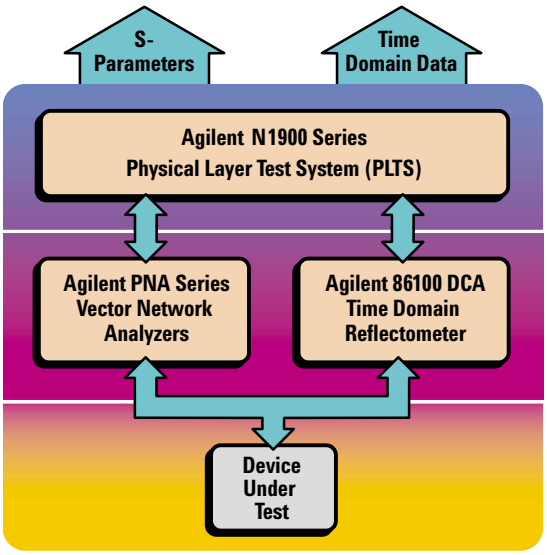


Figure 7. The Agilent PLTS system enables you to control, measure and compare data from both TDR and VNAs.

Prototype Characterization

Bring-Up Test

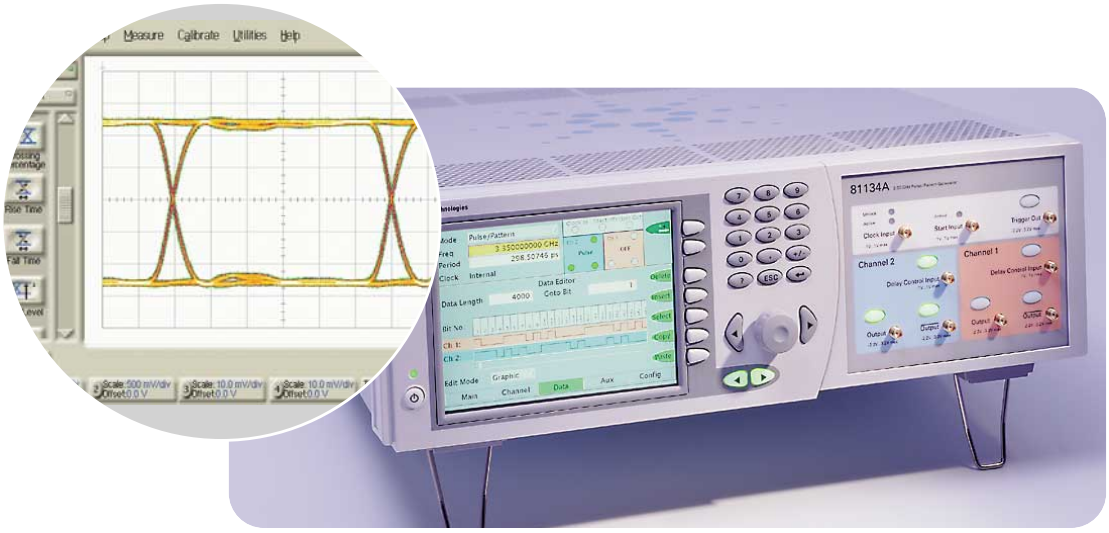


Figure 8. The Agilent 81133/4 pulse pattern generator enables the precise characterization of devices and minimizes the influence of jitter injection by the source with superior signal performance up to 3.35 GHz.

While bringing a system up, it is often necessary to stimulate a portion of the system before the entire system is running. A pulse/pattern generator can provide the stimulus signals used by a scope to make eye diagrams. The generator must also allow you to stress the system by adding controllable jitter to the stimulus signal.

The 81134A pulse pattern generator is a high-performance and easy-to-use pulse and data-pattern source for characterizing the physical layer as well as verifying and validating high-speed clock systems. The graphical user interface enables you to easily set up very complex signals. From generating PRBS to adding jitter to your clock or data, the 81134A gives you the required signals.

With the capability of easily uploading any data pattern up to 12 Mbit, a real life data pattern is easily created.

The fast rise times, low jitter, and full parameter flexibility provide just the signal you need, especially in high-speed systems where timing is critical. Performance can be evaluated with eye-diagram measurements with PRBS from 2^5-1 to 2^{31}-1. The delay control input allows you to add jitter to the clock or data signals. The eye can be distorted with the variable crossover function.

Other features include LVDS levels and a remote graphical user interface and SCPI commands for remote handling and programming.

ADS, Serial/Parallel BERT, Protocol Analyzers

Link to Model Database

Devices and Interconnect Characterization

Prototype Characterization

Bring-Up Test

System Integration & Functional Validation

Other tools that supplement Agilent's broad coverage of signal integrity include ADS software for simulation, BERTs for determining data error ratios, and protocol analyzers and bus exercisers for full system stress and test.

The Advanced Design System (ADS) software from Agilent EEsof EDA provides the design environment, models, and simulation technologies you need to design sub-nanosecond circuits and interconnects. ADS has a wide range of simulation tools and libraries, including a multilayer interconnect library that enables you to accurately model and analyze high-speed interconnect problems before your design is fabricated. This can be accomplished with the built-in libraries, an electromagnetic planar simulator, or measured data supplied by the PLTS, VNA or a TDR.

This tool also allows you to simulate differential S-parameters, eye patterns, noise, jitter, group delay, skew, ground bounce, via inductance, and coupling effects.

Bit error ratio testers (BERTs) enable you to accurately measure the data quality of your system. By generating a known pattern of data, sending it through your system, and then comparing it to the data leaving the system, you can verify that your system has an error ratio that is low enough to meet your design goals. For jitter analysis, the BERT provides a bathtub curve measurement to separate jitter into random and deterministic components.

Once you know that the system transfers data properly, you can use protocol analyzers and exercisers to verify the entire system. These instruments enable you not only to debug and validate your system, but also to stress the system with worst-case traffic in a controlled and repeatable fashion in a realistic system-level environment.

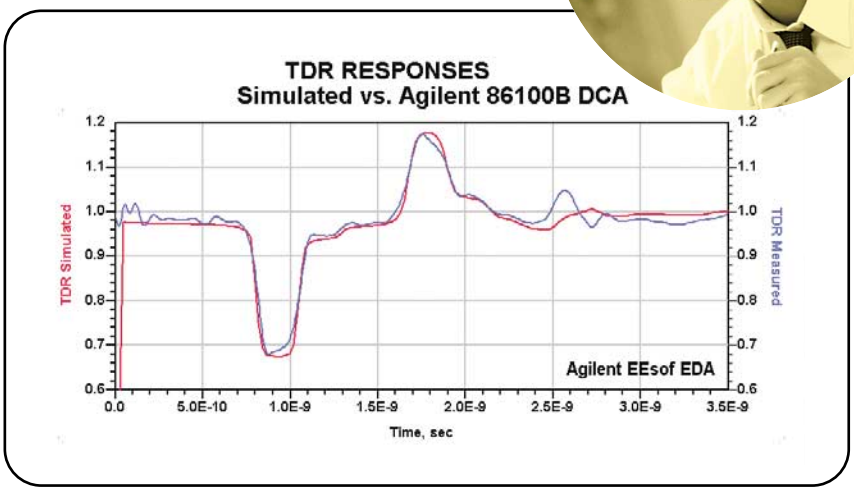


Figure 9. Quality simulations from ADS EDA software accurately track real-world measurements.

Signal Integrity Channel Partners

Partner for Success

Agilent Channel Partners are industry experts with world-renowned expertise in Signal Integrity. Their experience combined with Agilent measurement tools can enable you to address both your technical and business constraints, providing what is needed to keep your high-speed digital products on the competitive "leading edge".

See table on the right for more detail about Agilent's Channel Partners.

Channel Partner	Offering(s) / Capabilities								
	Model Extraction & Verification	Electronic Design	Enclosure/Mechanical Design	Modeling /Simulation Tools	Jitter Characterization	Operational Characterization / Simulation	Probing Products	Fixtures / Fixturing	SI Education & Training
Cascade Microtech, Inc. www.cascademicrotech.com						x			
GigaTest Labs www.gigatest.com	x			x			x	x	x
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MicroTest www.microtest.com								x	
Northeast Systems Associates www.nesa.com	x	x	x		x	x			x
TDA Systems, Inc. www.tdasystems.com	x			x		x			x

Related Literature

86100 Agilent Infiniium DCA	Color Brochure	5988-5235EN
Infiniium 54800 Series Oscilloscopes	Color Brochure	5988-3788EN
16700 Series Logic Analysis Systems	Color Brochure	5988-8435EN
16760 Logic Analyzer Module	Photo Card	5988-1665EN
600 MHz Logic Analyzer Modules for the Agilent Technologies 16700 Series	Photo Card	5988-7711EN
Soft Touch Connectorless Logic Analyzer Probes	Photo Card	5988-8128EN
81133 and 81134 3.35 GHz Pulse Pattern Generators	Data Sheet	5988-5549EN
Physical Layer Test Systems (PLTS)	Product Overview	5988-5288EN
EEsof EDA	Color Brochure	5988-3326EN
Infiniium 54850 Series Oscilloscope and InfiniiMax 1130 Series Probes	Data Sheet	5988-7976EN
Serial/Parallel BERTs	Color Brochure	5988-9514EN
Jitter Solutions for Telecom, Enterprise, and Digital Designs	Color Brochure	5988-9592EN

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