Evaluating Logic Analyzers Objectively

Application Note 1589

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Introduction

Selecting the right logic analyzer to meet your current and future measurement needs is an important task. Comparing specifications and features of logic analyzers made by different manufacturers can be time-consuming and confusing. The considerations outlined in this application note are intended to speed your selection process and help you avoid common pitfalls. No matter who makes the logic analyzers you are considering, carefully analyzing each one in relation to the concepts discussed here will help you evaluate the instruments objectively and choose the best possible logic analyzer for your application.

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Logic Analyzer Considerations: A Quick Overview

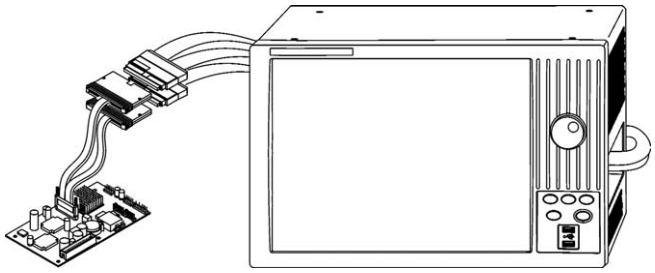
When you select a logic analyzer, start by evaluating the three main components of a logic analyzer to ensure you get the capabilities that match your application needs. The three main components are the probing system (connect), logic analyzer (acquire), and display and analysis tools (view and analyze). Making an incorrect decision in one area can significantly compromise the results you obtain in another. *For example: Did you know that the single most important decision you can make about your logic analyzer isn't the logic analyzer's acquisition capabilities? It's the logic analyzer's probing connection.* If your probing connection is intermittent or if the probing accessories you use limit the signal bandwidth, the acquisition system may not be getting the information it needs to properly represent signal activity.

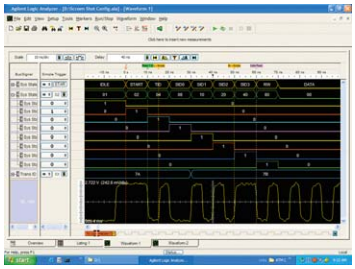
The following table provides an overview of the three main components and the key items to consider for each. More detail on what to consider and what to avoid is provided in the following pages.

In addition, we'll also cover

Maximizing productivity: What helps increase your design team's efficiency?

Budget considerations: What should you consider to optimize your investment?





Connect Probing system	**Acquire** Logic analyzer	**View and analyze** Display and analysis tools
Purpose: Provides reliable physical and electrical connection between the logic analyzer and your device under test	Purpose: Delivers accurate and reliable measurements, with the power to cover future technology trends	Purpose: Consolidates large amounts of data rapidly into displays that provide insight into your system's behavior in a format you understand
What is the best way to probe your signals, given their unique characteristics?	What is the right combination of acquisition capabilities required to address your measurement needs?	What is the most efficient way to analyze the captured data?
Considerations include: • Design-in probing connections or connect to individual signals after the design is complete • Impact of probe loading on the target device and measurement accuracy • Reliable connectivity • Probe bandwidth to match your signal speeds • Access to signals and probing flexibility	Considerations include: • Signal types: differential and single-ended • Sampling modes: timing, state, transitional timing, timing zoom • Sample rate in relation to target system speeds • Memory depth selection • Channel count • Triggering • Integrating and time correlating other measurements with your logic analyzer acquisition	Considerations include: • Display and analysis tools to gain the most insight into your specific application • How to analyze your data • Keeping up with technology changes and the latest innovations

Connect
What Is the Best Way to Probe Your Signals, Given Their Unique Characteristics?

The importance of probing

As we mentioned earlier, the single most important decision you make about your logic analyzer purchase isn't the logic analyzer's acquisition capabilities – it's the logic analyzer's probing. The logic analyzer needs to see the signals in your system the same way your hardware does. Your logic analyzer measurement is only as accurate and reliable as your probing. Be sure to consider the following characteristics when determining your probing solution.

Probing methods – Designed-in and after thought

There are two types of probing methods – designed-in and after thought. In an ideal world, during the board design phase you will route certain signals to pads or connectors because you expect they'll be critical for debug (designed-in probing). However, if you knew every problem you were going to have in your device, you would have fixed them in the first place, so some "after-thought" probing is inevitable. Remember to purchase a few flying lead probes to allow you to access those widely dispersed problem signals that inevitably pop up during debug.

Logic analyzer probe characteristics to evaluate

- **Accuracy:** A probe with low capacitive loading ensures minimum intrusion on your circuit, which is important to the proper operation of your system and to providing an accurate representation of your signals to the logic analyzer. Most probe solutions are acceptable for lower frequencies, however a probe with low capacitive loading is crucial at higher frequencies. Avoid probing solutions that require an additional adapter between the probe and the target device. Additional adapters increase loading and cost, compromise performance and introduce another possible failure point. Connectorless probes provide the lowest-capacitance solution by removing the loading of a physical connector from the signal path. Agilent's probes are specifically designed with the lowest loading available for a given probing application.

- **Reliability and connectivity:** Intermittent or faulty probe connections only compound your debug problems, causing you to spend your time debugging your probes instead of your circuit. Avoid costly and complex solutions that require gold plating or special board processes and handling, stiffeners, keep-out area on the back of the board, multi-step cleaning processes or complex setups to hold your probes in place. Agilent uses the latest innovations in probing technology to create a mechanical design that provides strain relief and ensures rugged, reliable connections without requiring any of these constraints.

- **Performance:** If your probe has less bandwidth than the acquisition system behind it, your measurement is limited to the bandwidth of the probe. Select a probe that has greater performance capability than the logic analyzer to which you are connecting the probe. Also it is very important to make sure the probe's accessories don't limit the overall bandwidth of the probe. Agilent's flying lead accessories, which are based on the high-performance, award-winning InfiniiMax scope probes, provide performance that is matched to the bandwidth of the probe.

- **Access and flexibility:** You may need to measure signals that are physically far apart or that are located where a probe connector hasn't been designed in. Make sure you have probes and accessories available that allow you to probe a signal no matter where it resides on the board – at an IC pin, trace, pad, via...even internally in an FPGA. Agilent's wide probe selection minimizes the keep-out area while maximizing the number of signals you can probe in a small area. Agilent gives you flexibility by offering a wide variety of probing options, each designed to ensure the best measurement possible for any given measurement need. Review the different probing options that follow to ensure you choose the right probe for the job.

Connect
What Is the Best Way to Probe Your Signals, Given Their Unique Characteristics?

Available Probing Options for All Agilent Logic Analyzers

	Connectorless 	**Connector Samtec** 
Connection to the target system	Requires appropriate pro series soft touch or original soft touch footprint designed into the target system. Retention module is used for alignment and mechanical retention only	Requires 100-pin Samtec connector designed into the target system
Advantages	• Reduces cost and shortens the design cycle by eliminating a connector • Eliminates the capacitive loading of a connector, which gives you the lowest-loading (less than 0.7 pF), highest-performance (> 2.5 Gbits/s rate) logic analyzer probing option available • Pliable micro spring-pin design with four-point crown tip allows you to easily attach and get a reliable, repeatable contact even for contaminated or uneven board surfaces • Flow through signal routing streamlines design flow and maintains differential pair spacing to ensure constant differential-mode impedance and virtually eliminate stubs • Acquire high-speed single-ended or differential signals without impacting the performance of your circuit, while providing an accurate representation to the logic analyzer • Provides ability to attach retention module to probe and browse multiple signals by pressing the probe against the target device • Compatible with all board finishes, including lead free	• High-performance connector solution (1.5 pF loading, 1.5 Gb/s data rate) • Supports single-ended and differential signals • 3 times the performance and half the loading of Mictor solution
Disadvantages	• Requires up-front design of probe footprint on PCB	• Added cost to include connector • Requires up-front design of connector on PCB
When evaluating alternative vendor solutions, keep in mind...	• Probe technology traps contaminants, thereby requiring special cleaning and handling process for each use • Requires gold plating	• Requires adapter between probe and target device. Increases loading and cost, lowers performance and introduces another possible failure point.

Connect
What Is the Best Way to Probe Your Signals, Given Their Unique Characteristics?

Available Probing Options for All Agilent Logic Analyzers (continued)

	Connector Mictor	**Flying leads**
		
Connection to the target system	Requires 38-pin Mictor connector designed into the target system	Connects to individual, widely dispersed signals at IC pins, traces, pads, vias
Advantages	• Reliable and cost-effective solution for lower data rates (600 Mb/s) • Supports single-ended signaling • 3.0 pF capacitive loading	• High-performance accessories are based on award winning, InfiniiMax scope probes • Compatible with a wide variety of accessories to connect to IC pins, traces, pads, vias • Maintains a one-to-one signal-to-ground ratio • Doesn't require up-front design effort
Disadvantages	• Added cost to include connector • Combination of through-hole and surface-mount technology can make signal routing and board component loading difficult • Requires up-front design of connector on PCB	• More time-consuming to connect
When evaluating alternative vendor solutions, keep in mind...	• Requires adapter between probe and target device. Increases loading and cost, lowers performance and introduces another possible failure point.	• Accessories can limit the bandwidth performance of the probe.

Additional probing considerations

Solving the probing challenges of FPGAs

Since pins on an FPGA are typically an expensive resource, there are a relatively small number available for debug. This limits internal visibility (i.e., one pin is required for each internal signal to be probed). When you need to access different internal signals, you must change your design to route these signals to pins. This can be time consuming and can affect the timing of the FPGA design. Finally, the process required to map the signal names from the FPGA design to the logic analyzer setup is manual and tedious. When new signals are routed out, the need to manually update these signal names on the logic analyzer takes additional time and is a potential source of confusing errors.

Agilent extends its innovative probing leadership with the FPGA dynamic probe. The FPGA dynamic probe gives you unprecedented visibility into your Xilinx or Altera FPGA's internal activity and design. You can automate setup with custom signal names and measure new groups of signals in seconds – without stopping your FPGA, changing your design, or impacting the timing. Agilent's FPGA solution provides faster, error-free measurement setup with auto pin-mapping, consumes fewer pins with the 2x TDM mode and delivers higher-confidence state measurements with auto-calibration.

Does a common footprint mean probing solutions from different vendors are equivalent?

Common footprint does not mean equivalent probing. Agilent's connectorless probing solution works with any board surfacing processes including lead free. It also uses the pliable micro-spring technology for reliable connectivity for uneven or contaminated board surfaces. Other solutions work only with gold plating, require complex attachment and cleaning processes for each use of the probe, and need external strain relief to maintain connection. Again, a common footprint does not mean that the probes provide equivalent measurements.

Acquire
What Are the Acquisition Capabilities Required for Your Measurement Needs?

Sampling modes – timing and state
Logic analyzers have two distinct sampling modes, timing and state. The way you want to evaluate the data determines which sampling mode you use. Use timing mode if you want to see the timing relationships between signals over a long period of time, typically in a waveform display. Select state mode if you want to monitor the functional operation of the system as a sequence of events, just as the device sees it, typically in a listing display.

With Agilent's logic analyzers, you have the added benefit of not having to purchase an additional measurement module to acquire data from multiple buses. Only Agilent allows you to split each logic analyzer into two separate time bases, meaning you can run the analyzer as a single timing analyzer, single state analyzer, two state analyzers or a state and timing analyzer.

Channel count – Determine how many signals you want/need to see.
Typically the number of signals you want to see equals the number of logic analyzer channels you'll need. If you're sampling in state mode, you need to consider channels for the clock signal(s). You will also want to have additional channels available to probe signals you didn't originally anticipate. In some cases, you will need extra channels to use higher state speed modes. Agilent only requires reserving 34 channels for higher state speeds, unlike other solutions that reduce your available channel count by half.

Threshold – Verify the logic analyzer and probes support your device's signal levels (single-ended and differential)
A logic analyzer reacts the same way as your logic circuit does when a threshold is crossed by a signal in your system. It will recognize the signal to be either low or high. It is very important that you specify a threshold voltage that matches what your device under test is using. Incorrectly specified threshold voltages result in incorrect data. Be sure to verify that the logic analyzer and probes you choose support your device's signal levels, whether they're single-ended or differential.

Agilent automates the threshold and sample position adjustment to provide the most reliable sampling on each signal, thereby saving you time and giving you the highest confidence in your measurement. You also obtain diagnostic clues when signals are not at their expected voltage levels.

Timing mode – Select a timing analyzer with a sampling rate of 4 to 10 times your bus data rate
In timing mode, a clock internal to the logic analyzer is used to sample data into logic analyzer memory asynchronously to the target system. The faster the timing sample rate, the higher the measurement resolution. Additional timing speed is valuable because it gives you a more precise measurement of the timing relationship between signals. Timing mode is sometimes referred to as deep-memory timing, as all of the logic analyzer memory can be used.

Today's logic analyzers also offer an additional high-speed timing mode, which is typically four to eight times the maximum speed of the standard timing mode. Agilent's timing zoom simultaneously samples the target system in parallel to either deep-memory timing or state mode through the same probe, without double probing. The added benefit of Agilent's timing zoom is the 64 K deep memory that allows you to see more system operation time at high resolution.

State mode – Select a state analyzer with a maximum state speed that is at least as high as your bus data rate
In state mode, a target's signals are sampled into logic analyzer memory using a signal from the system under test as the clock for the logic analyzer. The signal is referred to as the external clock. The data you sample must be stable relative to the signal you use to clock the data into the logic analyzer. What occurs between clock events is not of interest, only the state of the system at the time of the clock.

Look for tools that make accurate state capture easier. Agilent's state analyzers come with automated threshold and sample position setup, which can scan your signal's data-stable windows. This feature gives you confidence that you're sampling states at the optimal acquisition points and it gives an overview of the signal quality on all of your channels at once.

Acquire
What Are the Acquisition Capabilities Required for Your Measurement Needs?

Memory depth – Multiply the amount of time you need to see by the timing or state sampling rate

A logic analyzer's memory depth determines how much system operation time is covered during an acquisition. In choosing a memory depth, multiply the amount of time you need to see by the timing or state sample rate. More memory increases your chances of finding elusive problems where the symptom and root cause are widely separated in time or where you need to see all of the events leading up to an elusive crash.

You can see even more time by using your acquisition memory efficiently. Features like advanced triggering and store qualification allow you to specify what gets stored in memory, preventing memory from being filled with unwanted activity such as wait loops.

You can't always anticipate how much memory depth you will need. Be sure to get a logic analyzer that allows you to purchase what you need today and upgrade as your needs evolve. Agilent offers the deepest memory in the industry with 256 M behind every channel.

Triggering – Look for interface that allows you to easily specify any trigger event

You can't fix what you can't find. A logic analyzer trigger allows you to specify the sequence of events you want to see, the actions you want the logic analyzer to take when they're found, and what it should store in acquisition memory. The number of sequence levels available, resources available on each level, and the speed with which the analyzer can move from one sequence level to the next define the power of the trigger. Most of today's logic analyzers provide very advanced triggering functionality. But a powerful trigger is useless if you can't set it up easily and correctly in terms of your system's operation. Agilent's intuitive triggering modes allow you to trigger the way you think about your devices' signals so you can narrow in on the root cause of a problem.

Triggers available in Agilent logic analyzers:

Simple trigger – Define a trigger event according to how you think about your target signals. Use standard events, such as rising edge, falling edge, level, glitch or pattern. You can specify the trigger event on the basis of activity on one or more buses or signals. Simply select the patterns, edge or levels for the signals that apply.

Quick trigger – See something you didn't expect in the current trace? Simply draw a box around the questionable event and select **Set Quick Trigger** to see if it occurs again. You don't have to spend time defining the trigger. The instrument does the work for you.

With the **Advanced trigger**, you can customize a trigger for your specific situation. You can use trigger functions as individual trigger events or as building blocks for complex scenarios. Icons provide a graphical representation for each trigger function. Simply drag-and-drop an icon into the trigger sequence. To fully define the trace event, fill in the blanks with values or select standard options from the pull-down menus.

Acquire
What Are the Acquisition Capabilities Required for Your Measurement Needs?

Additional capabilities in Agilent logic analyzers allow you to:

- Specify the trigger position within the acquisition. In this manner you can position the trigger on a symptom at the end of the trace and look backward in time to see what caused the problem.

- Save and name each trigger to create a series of favorites. Recall a previous trigger to test your latest defect fix. Have the confidence of knowing you can make the same measurement later without having to spend time setting up the instrument.

- Tell the analyzer to send you an e-mail when it finds a trigger condition and acquires a snapshot of your system when you're working remotely.

- Storage qualification lets you filter out specific types of data as the acquisition is running, saving memory.

- Display where you are in the trigger sequence during an acquisition to identify when an expected event doesn't occur.

Take advantage of the ability to integrate all of your measurement needs with your logic analyzer. Wouldn't it be nice if your critical debug tools were time-correlated and easy to integrate into a single measurement with your logic analyzer? Agilent offers these capabilities to help you get the most out of your logic analyzer and other measurement tools.

Tracking down problems across a device's functional and parametric boundaries requires a combination of logic analysis and scope measurements. View Scope provides seamless integration of scope waveforms into the logic analyzer's waveform display for easy viewing and analysis. Connection is simple – LAN for data transfer and two BNCs for cross-triggering. Time-correlated, tracking markers and voltage markers let you quickly validate signal integrity and timing relationships between the measurement domains. You can also synchronize the sampling clocks to keep the logic analyzer and oscilloscope measurements tightly time-correlated across deep acquisitions. View Scope works with all Agilent 16900, 16800, 1690 and 1680 Series logic analyzers and DSO80000, 8000, 54800 and 6000 Series oscilloscopes.

Use a pattern generator to start testing before your system is complete. Customize the stimulus your system receives. Emulate missing components or inject faults to see how your system responds. An integrated pattern generator lets you reduce project risk and verify operation across a variety of test conditions.

View and Analyze
What is the Most Efficient Way to Analyze the Captured Data?

How can you get the most effective insight into your specific application and find the cause of your problem?

Several key technology changes in digital designs are changing the way logic analyzers are traditionally used.

1. Design teams are using bigger and faster FPGAs to differentiate their products, get greater design flexibility, reduce development risk, and enable field upgrades.

2. Use of serial buses is increasing. The drive is fueled by the pin reduction, cost savings, and increased performance. As the technology matures, serial buses, like PCI Express, are moving into the embedded space. One of the big enablers for adoption in the embedded space is the support for PCI Express on FPGAs.

3. Although serial links are quickly becoming very common, there are many parallel buses that are continuing to increase in speed and create design challenges – these include buses like DDR2 and 3, FBD 1 and 2 and high speed A to D and D to A converters.

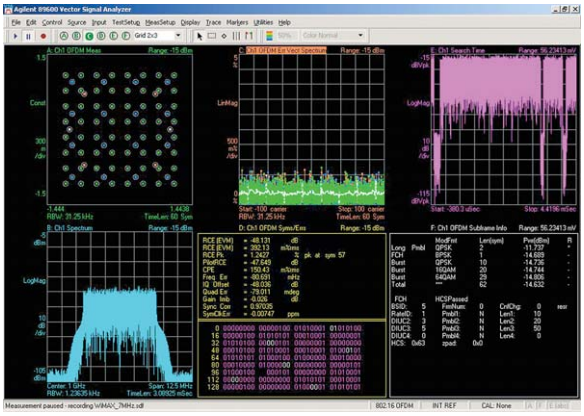
4. Analog RF signals are moving to digital, driven by the need for more bandwidth, lower costs and design flexibility.

Once your signals are accurately and reliably captured, it's important to be able to perform in-depth analysis quickly. Design teams often spend hours turning low-level measurement data into meaningful insight related to their systems. In some cases, they write their own application software to perform these tasks. When you are evaluating logic analyzers, be sure to look for tools that help you capture and analyze your data efficiently.

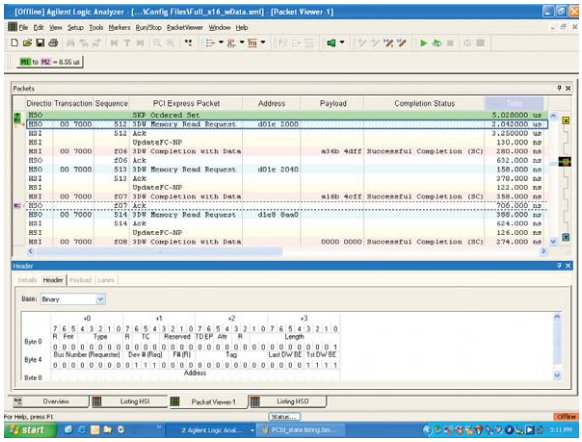
Agilent and its partners have addressed this need with a wide range of application software and device-specific analysis tools, which can save weeks of development time and eliminate errors caused by manual data interpretation. Capabilities include displays that allow you to view the same data in multiple formats that are familiar to you, all time-correlated with up to 1024 global tracking markers. From basic waveform and listing displays, up to source code, protocol packets, and frequency graphs for digital baseband and IQ signals.

View and Analyze
What is the Most Efficient Way to Analyze the Captured Data?

FPGA
Gain visibility into your Xilinx and Altera FPGA's internal activity and get "x-ray vision" into your design. You can automate setup with custom signal names, and measure new groups of signals in seconds – without stopping your FPGA, changing your design, or impacting the timing.



Digital VSA
Perform in-depth time, frequency, and modulation domain analysis on your digital baseband and IF signals. Agilent's 89600 vector signal analysis software provides flexible tools for making quality RF and modulation measurements on digital communication signals.



Packet Viewer
Trigger, search, view and analyze at the packet level in a familiar protocol format, whether you use industry-standard protocols or use Agilent's customization tool to create a solution for your proprietary bus.

Maximize Your Productivity

How can a logic analyzer improve your work efficiency?
Look for tools that save you time and work the way you do. Whether you work alone at a bench or with team members distributed around the world, your test equipment needs to easily integrate into your debug environment. It also needs to be easy to use. Unfortunately, there isn't a data sheet specification for usability. Specifications that may look good on paper are useless if you can't figure out how to make the measurement.

Usability has two components, time to learn and time to relearn. A good test in evaluating a logic analyzer is to determine several events that you normally need to capture. Time how long it takes you to make these measurements on each logic analyzer you are evaluating.

Efficiency improvements can also be realized through a variety of use models that are compatible with your wide range of work styles.

- Increase your analyzer's usage and team's productivity by using any Windows-based computer on the network to host the logic analyzer application software and remotely control the logic analyzer.
- View and analyze captured data on an offline PC while the logic analyzer makes additional measurements. You can also create setups for your next round of measurements.
- Expand the desktop across multiple monitors to get the most comprehensive view of your acquisition.
- Run automated tests via Microsoft DCOM programmability.
- Share results and setups easily, anywhere in the world by transferring files over high-speed LAN, shared drives, or USB flash drives.
- Use modular frames individually, then connect them together when you need to analyze complex, multi-bus problems.

Selecting the best logic analyzer form factor for your needs
With capabilities normally found exclusively in higher-priced modular systems, the Agilent 16800 Series provide unmatched performance in a portable logic analyzer, all with prices designed to fit your budget. With the largest portable display in the industry, the 16800 series 15 inch (38.1 cm) display with available touch screen offers twice the viewing area of other portables. Select models include the only pattern generator in a portable logic analyzer. Portable logic analyzers are smaller and come in a variety of fixed-channel configurations ranging from 34 to 204 channels. You also have the ability to purchase the memory depth or state speed you need now and upgrade later as your needs change.

If you like the capabilities provided by a portable logic analyzer but you need more flexibility, consider Agilent's 16900 Series modular logic analyzers. In addition to the capabilities of the 16800 Series you get:

- Modularity to configure a system the way you want
- Higher timing/state speeds
- Increased number of channels
- Deeper memory depths
- Differential as well as single-ended signal support
- The ability to use frames individually or connect multiple frames together for complex, multiple-bus applications

Budget Considerations

How can you best optimize your investment?

Budget plays an important role in selecting the right logic analyzer for the design team, however if you shop for a logic analyzer on price alone, you may not get the performance you need for your specific application. Instead, look for equipment with configuration flexibility and upgrade options that give you the performance you need now with the ability to upgrade as your needs evolve.

Financial alternatives

A number of financial alternatives are available to help your design team get the measurement performance they need. If you have an existing logic analyzer, you can trade it in and receive credit toward the purchase of the latest logic analyzer technology from Agilent. Renting provides a short term solution over adding a capital expense. Leasing or buying Agilent CertiPrime used equipment are other viable options.

Conclusion

After you have reviewed each consideration in relation to your target device, you should have a good idea of what logic analyzer capabilities address your measurement needs. If you're still unsure, you may want to discuss the choices with other logic analyzer users or call the manufacturer's technical support staff.

Web site

For the most up-to-date and complete application and product information, please visit our product Web site at:
www.agilent.com/find/logic

Related literature

Publication title	Publication type	Publication number
Agilent 16800 Series Portable Logic Analyzers	Color brochure	5989-5062EN
Agilent 16800 Series Portable Logic Analyzers	Data sheet	5989-5063EN
Agilent 16900 Series Logic Analysis Systems	Color brochure	5989-0420EN
Agilent 16900 Series Logic Analysis System Mainframes	Data sheet	5989-0421EN
Agilent Measurement Modules for the 16900 Series	Data Sheet	5989-0422EN
Agilent B4655A FPGA Dynamic Probe for Xilinx	Data Sheet	5989-0423EN
Frequently Asked Questions, B4655A FPGA Dynamic Probe for Xilinx	Data Sheet	5989-1170EN
Agilent B4656A FPGA Dynamic Probe for Altera	Data Sheet	5989-5595EN
Frequently Asked Questions, B4656A FPGA Dynamic Probe for Altera	Data Sheet	5989-5716EN
Agilent Logic Analyzers and 89601A Vector Signal Analysis Software	Technical overview	5989-3359EN
How to Measure Digital Baseband and IF Signals Using Agilent Logic Analyzers with 89600 Vector Signal Analysis Software	Application note	5989-2384EN
Probing Solutions for Agilent Logic Analyzers	Catalog	5968-4632E
Application Support for Agilent Logic Analyzers	Catalog	5966-4365E

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