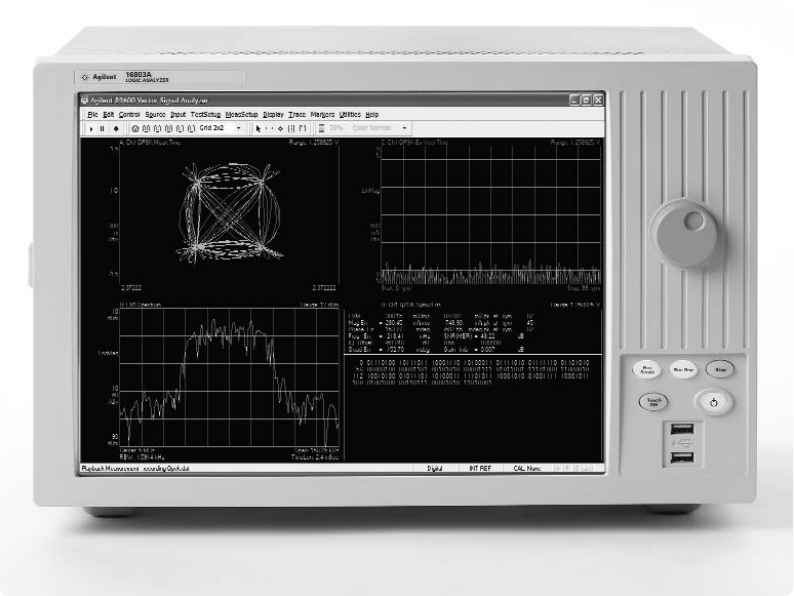
Agilent Logic Analyzers and 89601A Vector Signal Analysis Software (Digital VSA)

Technical Overview



Digital baseband, IF and RF (up to 1.5 GSa/sec) vector signal analysis and modulation analysis tools for applications involving digital signal processing for wireless, satellite communications and radar.

The popularity of DSP techniques, combined with ever-tighter size and power restrictions, are driving more and more segments of digital RF transceiver design into the digital domain. If you're an RF or digital baseband design engineer, you can apply in-depth signal analysis techniques to every portion of your digital transceiver design with a new team of Agilent solutions. The combination of an Agilent digital logic analyzer and 89601A VSA (vector signal analysis) software – is the only solution in the industry to deliver precise, accurate measurements and analysis for digital baseband, IF and even RF signals up to 1.5 GSa/sec. This digital VSA results from Agilent's unparalleled experience and sustained leadership in signal analysis, combined with Agilent's industry-leading logic analyzers.

Features and Benefits

- Digital input control allows you to analyze the baseband signal in the VSA software in a variety of different formats, including: Scalar baseband, Scalar IF, complex I & Q (separate or interleaved), Magnitude & Phase, and Phase Only.
- Flexible demodulation lets you measure constellation diagrams, carrier offset, and frequency error for QPSK, QAM, and much more.
- Display formats including phase vs. time, frequency vs. time, and spectrogram provide rapid insight into complex signal behavior.
- Error vector magnitude measurements (89601A Option AYA).
- Markers facilitate making frequency, amplitude, offset, power, phase, and other measurements.
- Time gating allows you to select specific portions of a signal for analysis.
- Variable frequency resolution, depending on the length of a gated signal.
- Probe digital signals of up to 1.5 GHz with soft touch connectorless probes.
- Probe multiple internal FPGA signals quickly and easily with the Agilent B4655A FPGA dynamic probe.

Agilent Technologies

How it Works

Using a simplified transmitter block diagram in Figure 1, we see many different parts of a digital circuit where vector signal analysis is useful (symbol encoders, baseband filters, IF modulation stages). More advanced functions like digital predistortion make analysis in the digital domain even more important.

Referring to Figure 1, we'll examine how the digital VSA works. First, the digital signals (baseband, IF, or RF) are probed with the logic analyzer.
In an FPGA, the B4655A FPGA dynamic probe is a great way to connect to various parts of the design. In an ASIC or commercial digital RF processing chip, a digital MUX can route baseband and IF signals to chip pads dedicated for debug, which are then connected to the logic analyzer probes. Next, the logic analyzer is configured to capture the signals using synchronous (or "state mode") sampling. Once configured, the VSA software receives digital samples and takes live measurements as a single dedicated instrument. The VSA software can run on the logic analyzer itself (using the built-in Windows® XP system) or on a remote PC connected to the logic analyzer via LAN.

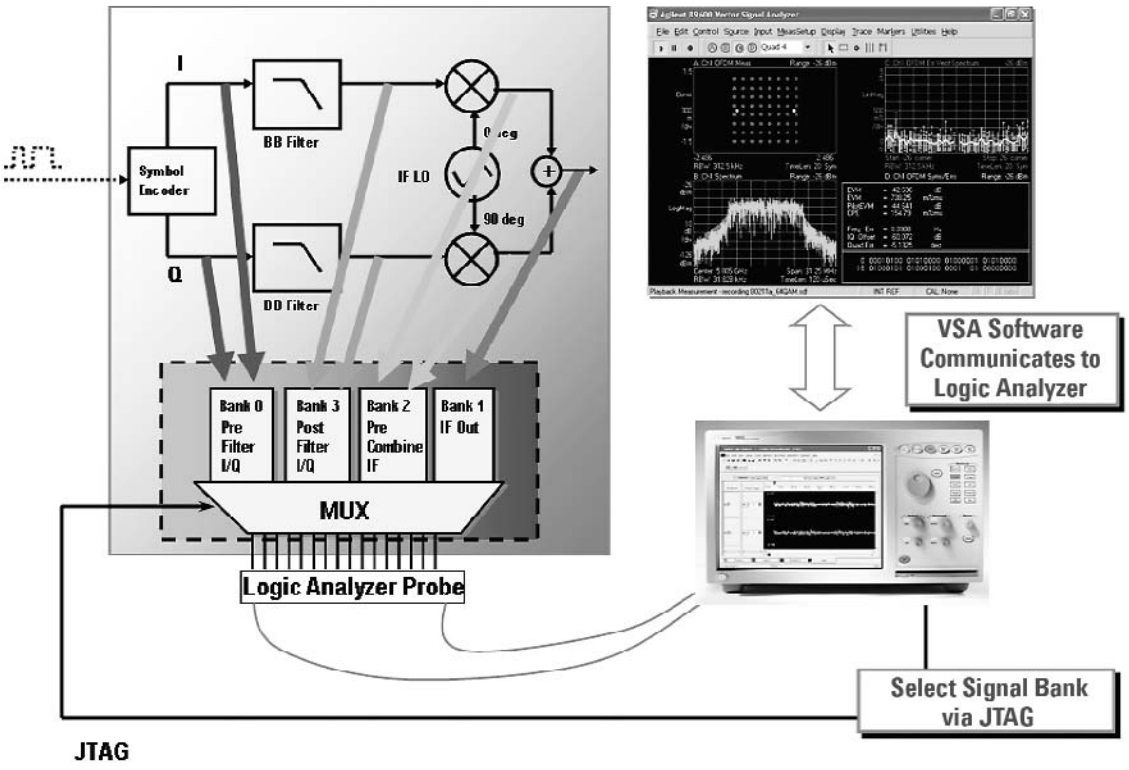


Figure 1. Digital radio transmitter block diagram with digital signals output through a choose-bank multiplexer

Case Study: Root-Raised Cosine FIR Filter

Here is an example of using the Agilent digital VSA to run an analysis of a digital root raised cosine filter, implemented in a Xilinx FPGA. The filter is processing QAM16 symbol data, which enters the filter at a rate of 25 Msymbols/sec. Using the FPGA dynamic probe, we can actively select signals before and after the digital filter, and use Digital VSA to perform signal analysis on each to examine the effects of the filter.

Figure 2 shows the logic analyzer display, with a few symbols of QAM16 IQ captured. Notice how the I_Symbol bus is displayed two ways – first, as a "bus" style display (the traditional logic analyzer digital bus waveform), and second as a "chart" style display. The chart display shows how the digital signal is actually a representation of a waveform, something like you would see in an oscilloscope when capturing analog signals.

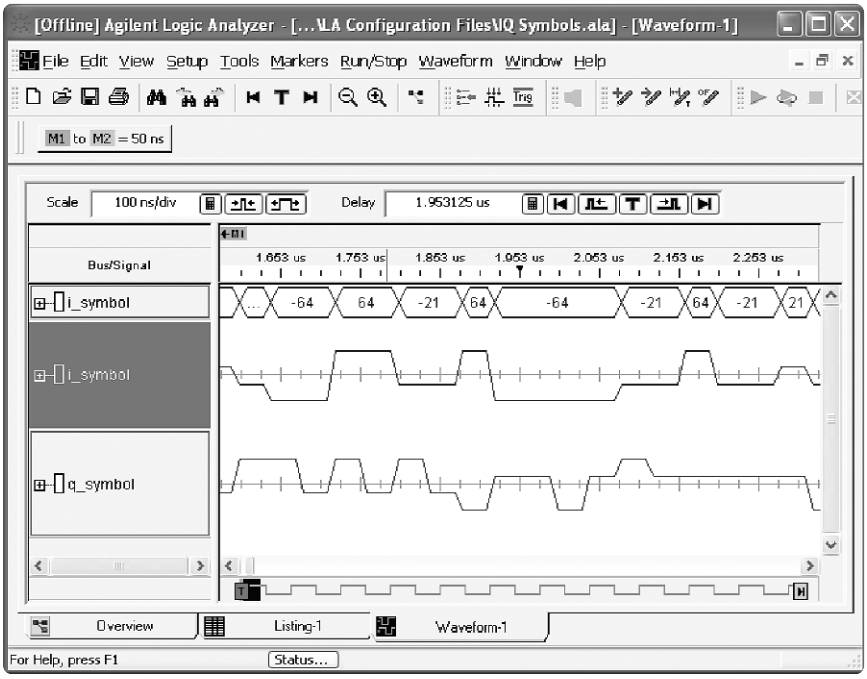


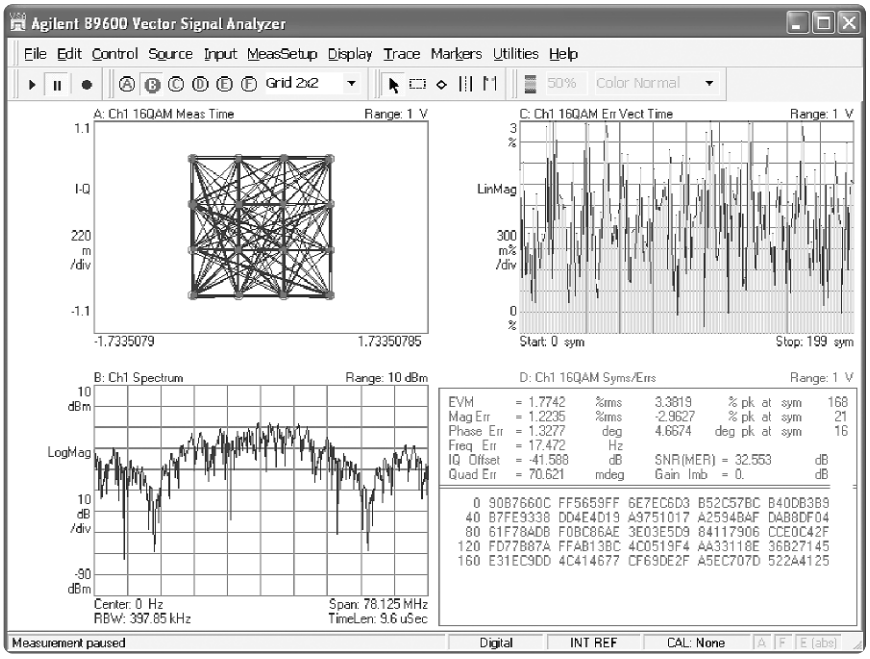
Figure 2. I and Q digital buses probed by a logic analyzer

Case Study: Root-Raised Cosine FIR Filter (continued)

Figure 3 is a VSA analysis of the unfiltered IQ symbols, which are examined from the device in real-time, using the logic analyzer as the hardware front end of the 89601A VSA package. Looking at the unfiltered symbol stream, we can see a 16-point QAM constellation in the IQ diagram (upper left quadrant). The measurements (lower right quadrant) show an EVM (Error Vector Magnitude) of 1.7%. On the lower left quadrant, the spectrum of the signal shows power in adjacent frequency channels. Because the IQ signals are unfiltered, the sharp edges create harmonics (power in unwanted frequency ranges), which appear as adjacent channel power in the spectrum. The root raised cosine lowpass filter will eliminate the signal's high-frequency content, limiting the signal to the desired bandwidth.

I/Q Constellation plot

Magnitude Spectrum



Error vector versus time

Comprehensive Measurements

Figure 3. The Agilent 89601A VSA running with digital input from a logic analyzer

Figure 4 is a logic analyzer display of the QAM16 IQ stream after the root raised cosine filter. These signals are still digital, and still captured by the logic analyzer. We've selected them by sending a control message through the FPGA's JTAG control port, without recompiling the FPGA design. Changing our probe point inside the FPGA took no more than three mouse clicks; no re-synthesis, no place & route were required. Note how the chart displays of I and Q are smooth now. The filter has rounded the sharp edges in the original symbol stream.

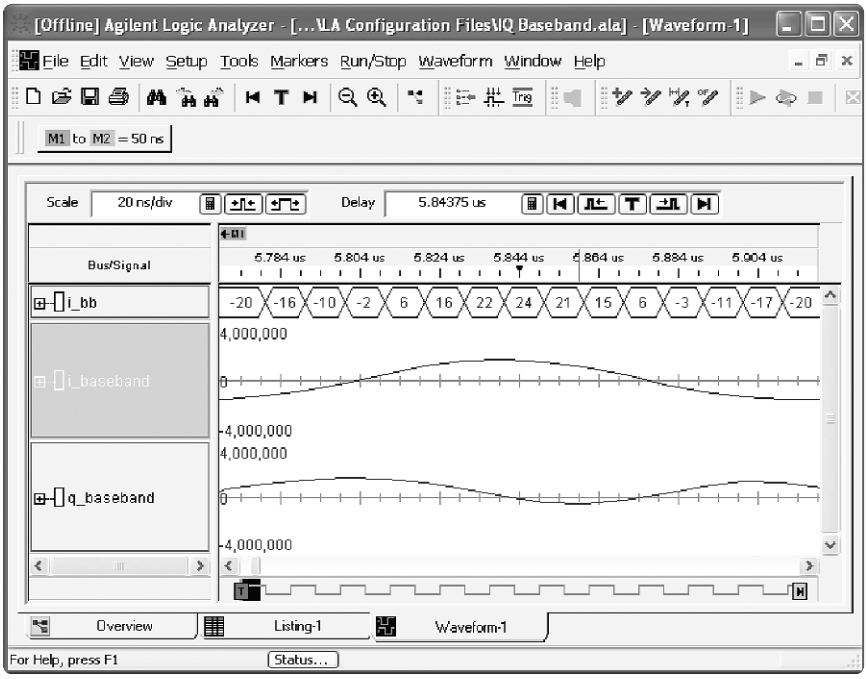


Figure 4. I and Q buses after lowpass filtering

Looking at the VSA analysis of the filtered signals, we now see the adjacent channel power in the spectrum display (lower left) has been removed. The EVM shown in the lower right quadrant is now 0.6%. So our digital filter has done a good job of filtering out unwanted frequencies without damaging the modulated signal quality.

Summary

Vector signal analysis is becoming as important to digital signal processing engineers as it is to RF circuit designers. The combination of Agilent's logic analyzers and 89600 VSA software makes it easy to perform digital VSA, saving time to market and reducing project schedule risk. It also provides a unified software interface for baseband and RF teams to work from, making it easier for them to work together and solve cross-domain problems more easily.

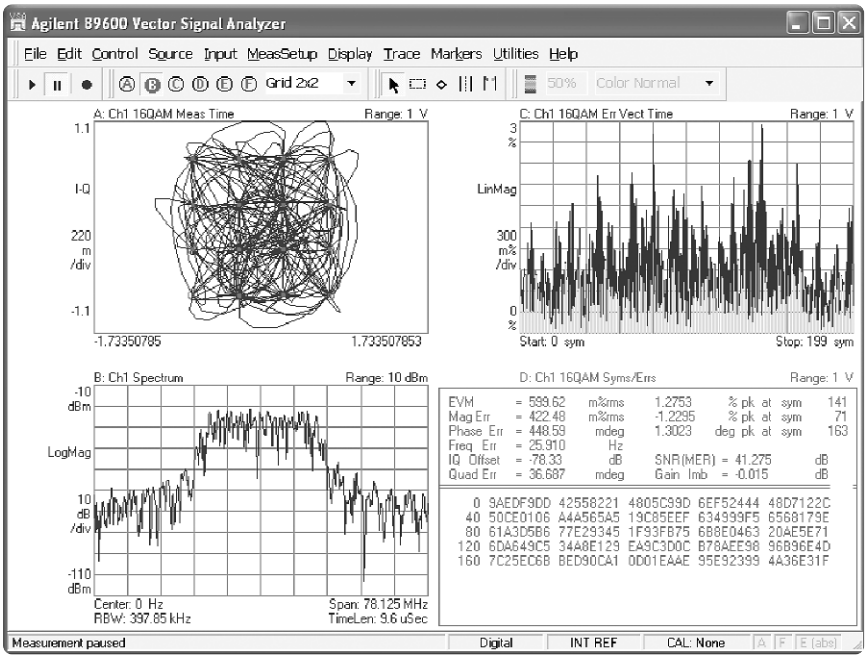


Figure 5. VSA analysis of lowpass filtered baseband signal

Appendix A: 1680, 1690, 16800 and 16900 Series Logic Analyzer Capabilities and Configuration Information

Logic analyzer capabilities

Agilent logic analysis systems help you solve tough debug problems, minimize your project risk, and get your leading-edge products to market faster. These systems provide the performance you need for making accurate, reliable measurements. All Agilent logic analyzers offer the familiarity of Windows® XP Pro, an intuitive graphical user interface and straightforward triggering capability – so you spend more time on design and debug and less time learning how to use them.

With Agilent 1680, 1690, 16800 and 16900 Series logic analyzers you can:

- Reliably capture digital buses with clock rates up to 1.5 Gb/s, sampling synchronously with the target device's clock, or asynchronously for bus timing analysis.
- Automatically configure accurate synchronous sampling by measuring data valid eyes on all bus channels simultaneously.
- Use a wide variety of triggering utilities from simple (e.g., a rising edge) to complex (e.g., a 16-step sequence of if/then events).
- Quickly render graphical waveforms of data captures up to 64 M in sample depth using on-board hardware acceleration.
- Perform fast digital pattern searches on captured data using the same acceleration hardware.

Agilent logic analyzers are designed to minimize the time required to configure your measurements and give you more time to debug your system. For example, you can easily set up triggers using several convenient methods:

- Set triggers directly from the waveform and listing displays by selecting an edge or a pattern.
- Draw a box around a particular set of signals you see in the waveform, and automatically set the trigger to that set of patterns.
- Drag and drop from a palette of programmable trigger macros to create an in-depth trigger sequence in the Advanced Trigger menu.

You can also display digital data in bus- or analog-like chart-style displays, for digital signal processing applications.

And, because you can't measure what you can't probe, we've used innovative probing technologies so you can access critical signals in your designs. You can use Agilent connector-less probes that are easy to route in printed circuit boards, support single-ended and differential signals, and create less than 0.7 pF of capacitive load. Or use Agilent's high-performance flying lead probes to debug systems where logic analyzer probing was not incorporated in the original board design.

Agilent logic analyzers also make it easy for you to share your instrument. When you install the Windows-based logic analyzer application software on your remote PC, you can view captured data offline. Or use your PC to remotely control the logic analyzer, then share the instrument with your colleagues easily by working offline.

Appendix A: 1680, 1690, 16800 and 16900 Series Logic Analyzer Capabilities and Configuration Information (continued)

Logic analyzer configuration information

The 89600 VSA software is compatible with any of the Agilent 1680, 1690, 16800 and 16900 Series logic analyzers. In general, there are three key items to consider when selecting a logic analyzer:

1. Form Factor: Modular System mainframe (16900 Series), standalone (1680 or 16800 Series), or PC-hosted logic (1690 Series) analyzer

2. Acquisition modules (modular system only)

3. Probes

Modular systems are the most flexible, with more choices for measurement performance, and are upgradeable in the future as new acquisition technologies are developed. There are three modular mainframe models:

1. 16900A, a 6-slot mainframe with no built-in display

2. 16902A, a 6-slot mainframe with built-in touch screen display and control knobs

3. 16903A, a 3-slot mainframe with built-in display and control knobs

The 16903A provides a low-cost entry point into modular systems. The two 6-slot options provide maximum configurability.

The acquisition modules available for the 16900 Series logic analyzers range from 250 MHz synchronous capture speed to 1.5 Gb/sec, with variable numbers of channels per module. Typical modules have 68 or 102 channels. Acquisition cards have two types of cables. The traditional 40-pin cable is compatible with 30 years of legacy probe adapters. The higher performance modules employ a 90-pin cable for improved bandwidth. You will need to match probe options (discussed below) to the cabling type of the module. Table 1 lists the current acquisition modules with their state speeds, channel counts, and cabling type.

The 16740 Series, 16750 Series and 16753/4/5/6 modules, although now discontinued, are also supported.

Model	Max state clock rate	Channels	Depth	Cable
16910A	450 MHz	102	Up to 32 M	40-pin
16911A	450 MHz	68	Up to 32 M	40-pin
16950A	600 MHz	68	Up to 64 M	90-pin
16760A	1.5 Gb/s	34 / 17	64 M	90-pin

Table 1. Logic analyzer acquisition modules

Appendix A: 1680, 1690, 16800 and 16900 Series Logic Analyzer Capabilities and Configuration Information (continued)

The 16800 Series logic analyzers provide synchronous capture up to 500 MHz, with models ranging from 34 to 204 channels. Memory depths of up to 32 M are available.

The 1680 Series standalone logic analyzers provide synchronous capture up to 200 MHz, with models ranging from 34 to 136 channels. Memory depths of 512 K and 2 M samples are available according to Table 3.

The 1690 Series PC-hosted logic analyzers work much like the 1680 Series, with 200 MHz state speed, variable number of channels and memory depths. The main difference is that you control the logic analyzer from your own host PC running Windows 2000 and a FireWire connection, rather than using the built-in PC in the 1680, 16800 or 16900 Series. Table 4 provides the range of options for the 1690 Series.

Model	Memory depth options	Channels
16801A	1 M, 4 M, 16 M, 32 M	34
16802A	1 M, 4 M, 16 M, 32 M	68
16803A	1 M, 4 M, 16 M, 32 M	102
16804A	1 M, 4 M, 16 M, 32 M	136
16806A	1 M, 4 M, 16 M, 32 M	204
16821A	1 M, 4 M, 16 M, 32 M	34
16822A	1 M, 4 M, 16 M, 32 M	68
16823A	1 M, 4 M, 16 M, 32 M	102

Table 2. 16800 Series logic analyzers

Model	Memory depth	Channels
1680A	512 K	136
1680AD	2 M	136
1681A	512 K	102
1681AD	2 M	102
1682A	512 K	68
1682AD	2 M	68
1683A	512 K	34
1683AD	2 M	34

Table 3. Standalone logic analyzers

Model	Memory depth	Channels
1690A	512 K	136
1690AD	2 M	136
1691A	512 K	102
1691AD	2 M	102
1692A	512 K	68
1692AD	2 M	68
1693A	512 K	34
1693AD	2 M	34

Table 4. PC-hosted logic analyzers

Appendix A: 1680, 1690, 16800 and 16900 Series Logic Analyzer Capabilities and Configuration Information (continued)

Probes come in two types, matching the cabling types mentioned earlier – 40-pin and 90-pin. There are many options in connection type:

1. Mictor connector – while it has drawbacks in routability and mechanical reliability, it has been the historical standard logic analyzer connection.

2. Samtec connector – this connector is purely surface-mount, and has more ground connections for lower loading and improved cross-channel isolation.

3. Soft touch connectorless probing – no connector is needed on the circuit board; instead a pattern of pads is placed on the board, and spring-loaded pins make the signal connection.

4. Flying leads – when a circuit board was not planned ahead for debug (i.e., none of the previous choices were designed into the board), a flying lead probe can be used to make a solder connection to a signal. These leads can also connect to header pins on a board, but this is less convenient for a large number of signals.

Table 5 lists a selection of probe model numbers:

Model	Type	Channels	SE/Diff	Cable
E5383A	Flying leads	17	Single-ended	40-pin
E5404A	Pro Series soft touch	34	Single-ended	40-pin
E5396A	Soft touch	17	Single-ended	40-pin
E5394A	Soft touch	34	Single-ended	40-pin
E5385A	Samtec	34	Single-ended	40-pin
E5346A	Mictor	34	Single-ended	40-pin
E5382A	Flying leads	17	Single-ended	90-pin
E5381A	Flying leads	17	Differential	90-pin
E5406A	Pro Series soft touch	34	Single-ended	90-pin
E5405A	Pro Series soft touch	17	Differential	90-pin
E5402A	Pro Series soft touch, low profile	34	Single-ended	90-pin
E5398A	Soft touch	17	Single-ended	90-pin
E5390A	Soft touch	34	Single-ended	90-pin
E5387A	Soft touch	17	Differential	90-pin
E5378A	Samtec	34	Single-ended	90-pin
E5379A	Samtec	17	Differential	90-pin
E5380A	Mictor	34	Single-ended	90-pin

Table 5. Logic analyzer probes

Product 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
www.agilent.com/find/fpga
www.agilent.com/find/logic-sw-apps

Related Literature for logic analyzers

Publication Title	Publication Type	Publication Number
16900 Series Logic Analysis Systems	Brochure	5989-0420EN
16900 Series Logic Analysis Systems	Data sheet	5989-0421EN
Timing and State Modules for the 16900 Series	Data sheet	5989-0422EN
16800 Series Logic Analyzers	Brochure	5989-5062EN
16800 Series Logic Analyzers	Data sheet	5989-5063EN
FPGA Dynamic Probe	Data sheet	5898-0423EN
FPGA Dynamic Probe	Frequently asked questions	5989-1170EN
Probing Solutions for Logic Analyzers	Brochure	5968-4632E

Appendix B 89600 VSA Software Capabilities and Configuration Information

89600 Series VSA software capabilities

The 89600 vector signal analysis software provides flexible tools for making RF and modulation quality measurements on digital communications signals.

You can analyze a wide variety of standard and non-standard signal formats with the VSA software. Standard signal presets cover GSM, GSM (EDGE), cdmaOne, cdma2000, W-CDMA, WLAN, WLAN-HT, IEEE-802.16-2004, IEEE-802.16 OFDMA, and many more. For proprietary standards, the 89600 VSA software series offers numerous digital demodulators with variable center frequency, symbol rate, filter type, and filter alpha/BT. A user-adjustable adaptive equalizer is also provided.

The VSA software lets you:

- Quickly evaluate and troubleshoot digitally modulated signals with the modulation analysis tools.
- Use the constellation and vector diagrams for an overall indication of signal behavior and to obtain clues to the cause of a problem.
- Take advantage of the EVM, EVM spectrum, and EVM time capabilities for a more sensitive examination of signal errors.

You can perform time domain analysis using the 89601A software RF scope capability. It is easy to evaluate pulse shape with the main time display, select specific portions of a burst for analysis with the time gating feature, and use statistical tools like CCDF and CDF to characterize the noise-like behavior of your modern communications signal.

In addition, you can simplify the characterization of your signal with the FFT-based spectrum analysis tools in the 89600 VSA analysis software. Match your measurement span to your signal bandwidth, thus maximizing analysis signal-to-noise ratio (SNR), with the wide selection of spans available in the software. FFT-based resolution bandwidths provide all the resolution you need for frequency domain investigations. A power spectral density (PSD) function is useful for estimating the level of the noise floor when you calculate SNR. And, a spectrogram display is provided for monitoring the wideband behavior of hopping signals over time.

Appendix B 89600 VSA Software Capabilities and Configuration Information (continued)

89600 Series VSA software configuration information

The 89600 VSA software is available with either a node-locked license or a floating license. The node-locked version is locked to a PC, which can either be a remote PC, or the logic analyzer itself. The floating license runs on a network server, which can be the same remote PC running the VSA software. It is not recommended for use running inside the logic analyzer. For more information on these products, see the *89600 VSA Software Technical Overview*, literature number 5989-1679EN.

89601A Options	*Vector signal analysis software, including 1-year of software update subscription service. Option 200 required.*
89601A-200	Basic vector signal analysis software
89601A-300	Hardware connectivity (includes link to Logic Analyzers)
89601A-AYA	Flexible modulation analysis
89601A-B7N	3G modulation analysis bundle
89601A-B7T	cdma2000/1xEV-DV modulation analysis
89601A-B7U	W-CDMA/HSDPA modulation analysis
89601A-B7W	1xEV-DO modulation analysis
89601A-B7X	TD-SCDMA modulation analysis
89601A-B7R	WLAN modulation analysis
89601A-B7S	IEEE-802.16-2004 OFDM modulation analysis
89601A-B7Y	IEEE-802.16 OFDMA modulation analysis
89601A-B7Z	IEEE-802.11n MIMO modulation analysis
89601A-105	Dynamic link to EEsof/ADS

Related Literature for vector signal analyzers

Publication Title	Publication Type	Publication Number
89600S Vector Signal Analyzer	CD	5980-1989E
89600 Series Vector Signal Analysis Software 89601A/89601AN/89601N12	Technical overview	5989-1679EN
89600 Series Vector Signal Analysis Software 89601A/89601AN/89601N12	Data sheet	5989-1786EN
Hardware Measurement Platforms for the Agilent 89600 Series Vector Signal Analysis Software	Data sheet	5989-1753EN
89600 Series Vector Signal Analyzers	VXI configuration guide	5968-9350E
89650S Wideband Vector Signal Analyzer System with High-Performance Spectrum Analysis	Technical overview	5989-0871EN
89650S Wideband Vector Signal Analyzer System with High-Performance Spectrum Analysis	Configuration guide	5989-1435EN
89604A Distortion Test Suite Software	Technical overview	5988-7812EN

Product Web site

For the most up-to-date and complete application and product information, please visit our product Web sites at:
www.agilent.com/find/89600
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