Five Applications to Help You Decide: A Comparision between Tektronix TDS and Agilent Infiniium Oscilloscopes

Application Note 1489

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Bandwidth, sample rate, and memory depth: it really used to be just that simple when considering an oscilloscope purchase. When oscilloscopes transitioned from analog to digital, it opened wide the door for advanced measurements, math features, customized signal processing algorithms, and documentation capability in the scope you use for everyday troubleshooting and debug. As a result, there are a number of other factors engineers now consider before deciding which oscilloscope to use for their applications.

When investigating oscilloscopes, you may have heard references to Agilent's "MegaZoom" and "DPO" from Tektronix, Inc. Vendors often justify critical scope technologies like these to their customers with demo board images designed to show the technologies in the best light. Is this really the best basis for making a scope purchase?

Instead of showing flashy demo board signals, this application note takes a more in-depth look into the world of the engineer. It discusses a few key, commonplace applications and technology blocks and shows how Agilent and Tektronix oscilloscopes stack up in the real world.

Agilent Technologies

1 Application

Embedded Designs with SDRAM

You'd be hard-pressed in today's digital world to find an embedded design that does not incorporate SDRAM. Memory has evolved over the years from having just a few key control lines to many control lines. Basic read and write cycles are now much more complex. In the past, a four-channel oscilloscope provided enough channels to trigger on an event using the control lines and evaluate signal integrity with the remaining scope channels. Today, to trigger on a simple write cycle, you would need to trigger on four control lines—RAS, CAS, WE, and CS—as well as the clock. If you try to use a four-channel oscilloscope for this application, you don't even have enough channels to set up your trigger, let alone evaluate signal integrity! Obviously, this can be a problem. It can get quite complex, not to mention time consuming, to build external triggering hardware or write special software to isolate write cycles.

This is where a mixed-signal oscilloscope (MSO) comes into play. An MSO gives you all the features of a conventional oscilloscope—2 or 4 scope channels, measurement capability, and math functions—along with 16 logic timing channels and deep memory. For a typical SDRAM application, you can use the 16 logic timing channels to set the trigger event.

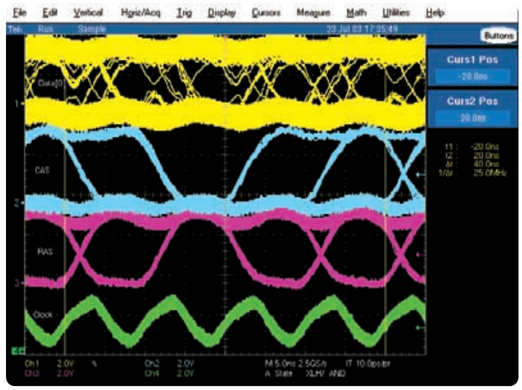


Figure 1. A traditional oscilloscope, such as this 1 GHz Tektronix TDS5104, cannot trigger on the data "read." Four-channel oscilloscopes simply do not provide the channel count and triggering capability necessary for debugging today's embedded designs. The persistence of the scope can be used to see many strange anomalies on the data line (yellow trace). But, do any of these anomalies represent a timing violation? Without proper triggering, it is impossible to tell.

Figure 2. This six-channel measurement wouldn't be possible on a traditional DSO. A mixed-signal oscilloscope, however, enables the scope to trigger on a data "write" with RAS, CAS, WE, CS, and CLK using the 16 logic timing channels. The 4 scope channels are then freed up to evaluate signal integrity. The MSO used for this measurement is the 1 GHz Agilent 54832D.

An MSO's tight time-correlation between analog and digital also enables full-width triggering across a pattern of both analog and digital signals—something that is not supported by any oscilloscope/logic analyzer time-correlation solutions on the market today. Because an MSO is first and foremost an oscilloscope, the MSO provides the fast, real-time updating you would expect from a scope with no compromises.

Deep memory plays a critical role in the MSO as well. In typical embedded designs, the data and clock signals occur much faster than other signals in the system. When trying to correlate the digital control activity with other signals, you run into a classic problem—you can view multiple cycles of the data and clock lines, but can't see the "big" picture that includes the slower signals. Deep memory mitigates this problem by allowing you to see the "big" picture without compromising acquisition resolution. The deep memory oscilloscope can maintain a higher sample rate across all timebase settings longer than its shallow-memory counterpart. To illustrate the need for deep memory in an embedded system, consider the following example. In a video camera, processing happens at a certain frame rate—normally between 50 and 60 Hz. So, you may want to capture 20 ms of video information. The processor in the system will probably be running at a minimum of 20 MHz. Therefore, you would want to sample at a minimum rate of 200 MS/s. In order to acquire at 200 MS/s for 20 ms, you need a 4-million sample (4 Mpts) memory on your scope.

Why doesn't everybody use a deep memory scope? Deep memory can be frustrating, and even a barrier, if it does not update real-time and respond quickly to user controls. If you've ever worked with a first-generation deep memory scope, you are probably very familiar with the long delays deep memory acquisition can cause.

Agilent has solved the sluggish deep memory issue with the development of MegaZoom deep memory. In all Agilent MegaZoom oscilloscopes, the deep memory is always on. In this scope architecture, a custom MegaZoom ASIC manages the acquired data. This frees up the CPU to perform other critical tasks. As a result, the deep memory records can be acquired without any nagging delays or tradeoffs in the scope's capability.

When evaluating an oscilloscope prior to purchase, test the scope to measure its responsiveness when deep memory is on. You don't want deep memory to be a mode you avoid because it can't keep up with you.

Application 2

Modulated Signals

For years, the ultimate display challenge for digitizing oscilloscopes has been in faithfully reproducing complex modulated signals. Engineers still speak fondly of analog oscilloscopes because their intensity-graded displays provided them a view into the statistical nature of their signals.

Tektronix has attempted to tackle the digital scope display problem through the development of its Digital Phosphor Oscilloscopes (DPO). To replicate the look and feel of an analog scope requires intensity grading along with a fast update rate. DPO is a phosphor imitation display technology that attempts to mimic an analog scope display by providing intensity grading in the scope's default operating mode. However, the update rate in Tektronix' oscilloscopes is limited. To get a faster update rate, you must place the scope in FastAcq mode. FastAcq mode is an equivalent-time sampling mode that has a very high waveform capture speed (100,000 wfms/sec in the Tektronix TDS5000 Series). As you can see, DPO, coupled with the high waveform capture rate delivered by FastAcq mode, does a nice job of simulating the intensity grading found on traditional analog scope displays. However, when this special mode is in operation, you sacrifice memory depth, sample rate, math functions, and zoom capability.

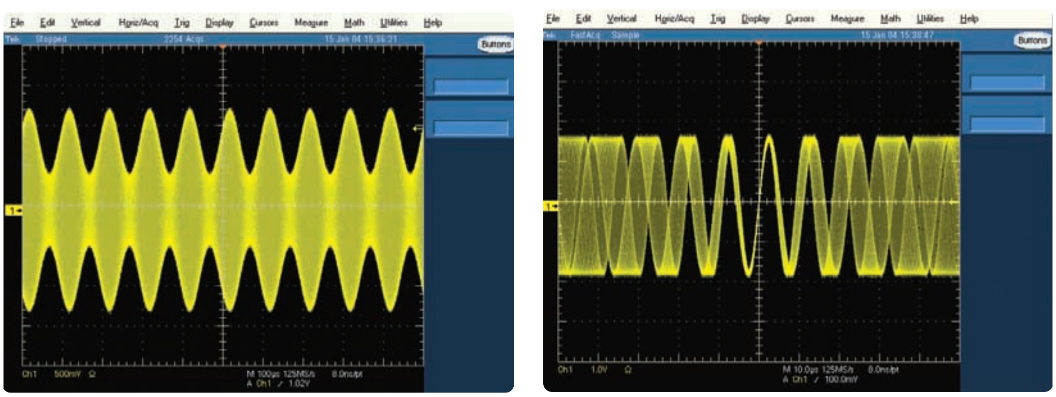
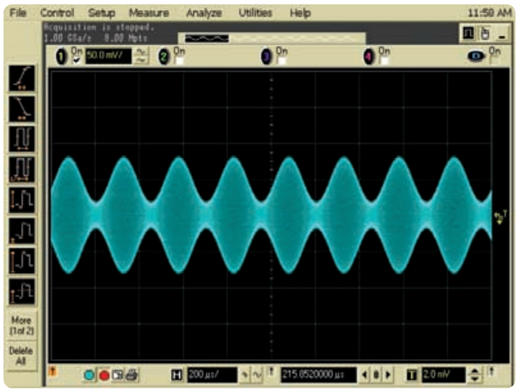


Figure 3. DPO color-grading in action on modulated signals. DPO is only effective on the Tektronix TDS5000 and TDS7000 Series when it is in the FastAcq operating mode. FastAcq is a shallow-memory, equivalent-time acquisition mode. In FastAcq mode, the sample rate is limited to $1/4$ the maximum sample rate of the scope. In the image on the left, the memory depth is limited to 125 kpts, so the sample rate is limited to 125 MSa/s.

Modulated Signals



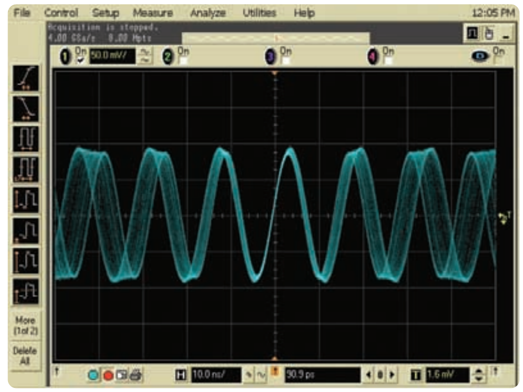


Figure 4. The Agilent Infiniium 54832D shows the intensity-graded persistence mode. Unlike FastAcq, MegaZoom allows you to capture full-memory, full-sample-rate acquisitions. Each of the images above is an 8 Mpts acquisition, of which there is more memory acquired off-screen.

Agilent Infiniium oscilloscopes now ship standard with a special intensity-graded persistence mode. The intensity-graded persistence mode also provides a display very close to that of an analog oscilloscope.

Figure 4 shows Agilent's intensity-graded persistence mode faithfully reproduces both AM and FM modulated signals. Along with providing an intensity-graded display, the Agilent 54832D is also capturing 8 Mpts deep memory records.

Intensity grading is clearly valuable for bringing out detail in complex signals. However, viewing the problem is only the first step. And—let's admit it—today's modulated signals are much more complex than the modulated sine waves shown above. For complex signals, advanced triggering, deep memory, and measurement and math capability shorten the path between symptom and root cause. Unfortunately, FastAcq stops at the first step, as it has a suite of limitations:

- Math functions are not allowed.
- You cannot zoom in on a FastAcq acquisition after the scope is stopped.
- Maximum real-time sample rate in FastAcq mode on Tektronix TDS5000 Series is 1.25 GSa/s (for 5 kpts of memory or less).
- Maximum memory depth in FastAcq mode is 1 Mpts (for sample rates of 50 MSa/s and slower).
- Peak detect acquisition mode is not allowed.
- Equivalent-time acquisition mode only (no sin(x)/x interpolation).

FastAcq is a display mode that can only be used to identify problems—once the problems are identified, you are forced to go into the scope's slower acquisition modes to proceed down the debug path. Agilent's MegaZoom deep memory gives you access to the full functionality of the scope, including the intensity-graded display persistence mode, while providing full memory, full sample rate acquisitions.

3 Application

Jitter Detection and Analysis in High-Speed Digital Circuits

Increases in data rates of modern digital designs have opened the door to a new class of problems, in which maintaining adequate timing margins is paramount. Jitter, the deviation of a transition from its ideal time, is the subject of hot new application software running inside digitizing oscilloscopes.

The multifaceted subject of jitter forces a level of complexity on common jitter measurement tools and packages. Agilent and Tektronix have already simplified the jitter analysis process by incorporating jitter analysis packages that run directly inside the oscilloscope, with no external PC post-processing required.

Even with this software integrated into oscilloscopes, jitter measurements can still be tricky to setup. The Agilent E2681A EZJIT jitter analysis package is the only jitter solution on the market in which a wizard guides the user through the setup of complex jitter measurements. The wizard ensures that the oscilloscope is configured properly for the most accurate jitter measurement.

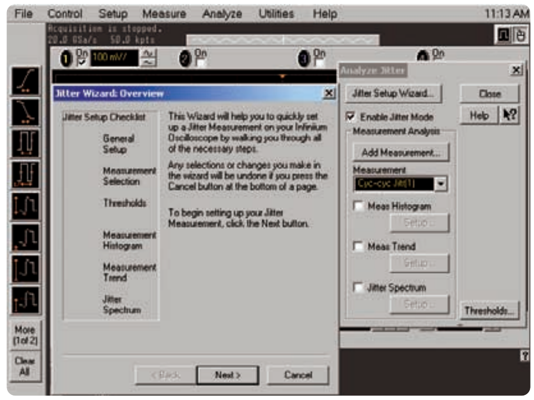


Figure 5. The Infiniium 54855A 6 GHz oscilloscope is shown running the EZJIT jitter analysis package. The EZJIT package greatly simplifies measurement setup by providing a wizard to walk the user through the setup. EZJIT is optional on all Infiniium 54800 Series models running Windows® XP Pro.

The EZJIT package is not just a jitter analysis tool—it is also a powerful jitter debug tool. In Figure 6, the purple jitter trend trace shows the timing error (i.e. jitter) for every edge in the yellow signal. This allows you to easily identify the worst-case jitter in your signal. The spikes in the purple trace indicate the worst-case jitter in Figure 6.

The debug power is extended with the ability to correlate jitter to other signals. By correlating jitter with other signals, you can more readily identify suspected sources of jitter. In Figure 6, the green trace represents another signal in the system. You can clearly see that the worst-case jitter spikes in the jitter trend (purple trace) are correlated to the edges of the suspected jitter source (green trace).

Shown at the bottom of the oscilloscope display is the spectrum (red trace) of the jitter. The jitter spectrum can also provide clues to other sources of jitter in the system. The histogram (shown in blue) is useful for estimating the composition of deterministic and random jitter.

Figure 6. The EZJIT jitter analysis package serves as a powerful jitter debug tool by providing users an integrated and time-correlated view of the signals under test and the jitter measurements.

Tektronix also offers an in-the-box jitter analysis solution with the TDSJIT3 package. As opposed to the Agilent EZJIT solution, which runs as part of the oscilloscope application, the Tektronix TDSJIT3 package runs as a separate Java™ analysis tool from the scope. The jitter trend is displayed in a window, separate from the signal acquired on the scope. The lack of correlation between the actual trace and the jitter measurement makes the TDSJIT3 package poorly suited for jitter debug applications. Because the TDSJIT3 package is not integrated into the oscilloscope application, like the Agilent EZJIT solution is, measurement throughput is severely hindered.

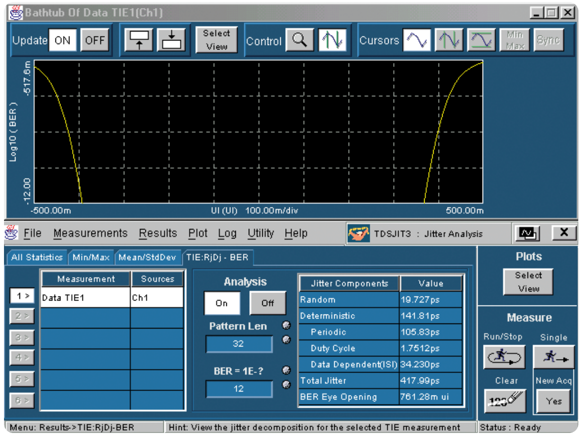


Figure 7. The Tektronix TDSJIT3 package, shown here on a Tektronix TDS6604, runs on the oscilloscope, but separate from the oscilloscope application. The lack of integration between the oscilloscope application and TDS JIT3 slows down measurement speed.

Application 4

High-Speed Serial Data Transmission

There is a direct relation between the increase in data rates and increase in data errors. When working with high-speed serial standards, it is vital to check the standards against known parameters, which are visually represented on oscilloscopes in the form of an eye diagram. Agilent and Tektronix both offer serial data analysis solutions–the E2688A serial data analysis package and the TDSRT-Eye, respectively.

Similar to the Agilent EZJIT solution, the Agilent E2688A serial data analysis package offers a wizard to help guide you through the setup of the clock recovery and real-time eye display.

In Figure 9, the recovered clock is displayed overlapping the signal. A zoom to max function allows you to jump to the signal edge with the worst-case jitter. The Tektronix TDSRT-Eye does not provide this capability.

The E2688A serial data analysis tool provides versatile clock recovery and real-time eye display for serial signal standards such as PCI Express, Serial ATA, XAUI, FibreChannel, and SAS. Only the E2688A offers a second-order PLL clock recovery, which is important for looking at jitter and the eye display on signals with spread spectrum clocking. The Tektronix TDSRT-Eye does not offer second-order clock recovery.

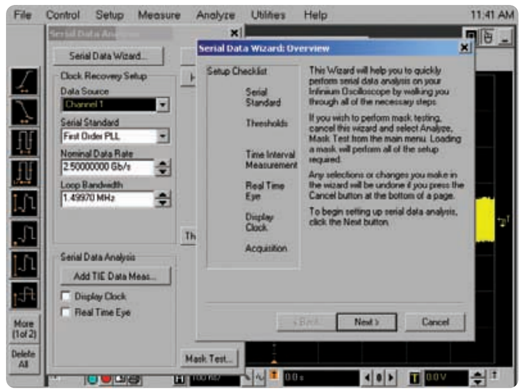


Figure 8. The Infiniium 54855A 6 GHz oscilloscope is shown running the E2688A serial data analysis package. The serial data analysis package comes with a wizard to guide you through measurement setup. The E2688A serial data analysis package is available on Infiniium 54850 Series scopes.

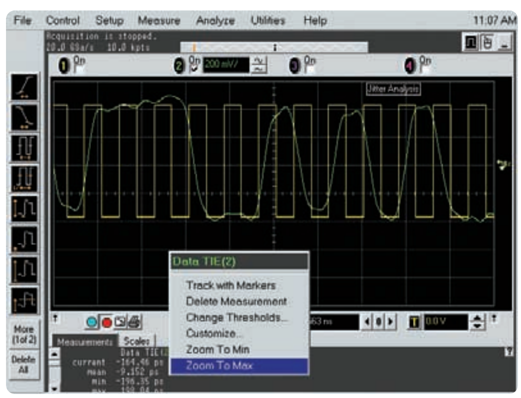


Figure 9. The Zoom to Max and Zoom to Min functions on the Agilent serial data analysis package allow you to jump to the signal edge with the worst-case jitter.

Figure 10 shows the real-time eye mask test for a XAUI signal. The real-time eye provides an accumulated, color graded picture. The color grading provides insight into the nature and distribution of jitter in the signal. And the E2688A is fast–it can analyze 1 million UI (unit intervals) in less than one minute! This speed advantage means you spend less time waiting for measurement to stabilize, and you have more confidence in your measurements.

Mask testing with the E2688A is easy. Simply load the desired mask, and the instrument is completely and automatically configured for test. Also, Agilent mask files are easily customizable to your specific signal.

The Tektronix TDSRT-Eye only shows solid-colored eye diagrams, which do not accumulate over multiple acquisitions. More importantly, the TDSRT-Eye only processes about 20,000 UI (unit intervals) per minute–meaning you need to wait longer for the measurements to stabilize.

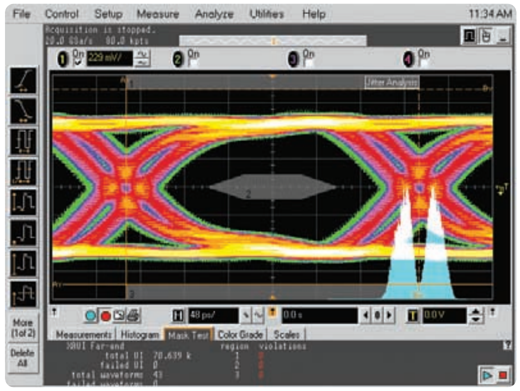


Figure 10. The Agilent Serial Data Analysis package produces an accumulated, color-graded image. Shown is an eye mask test for a XAUI signal. An astounding analysis speed of 1 million unit intervals per minute provides fast, real-time measurement capability.

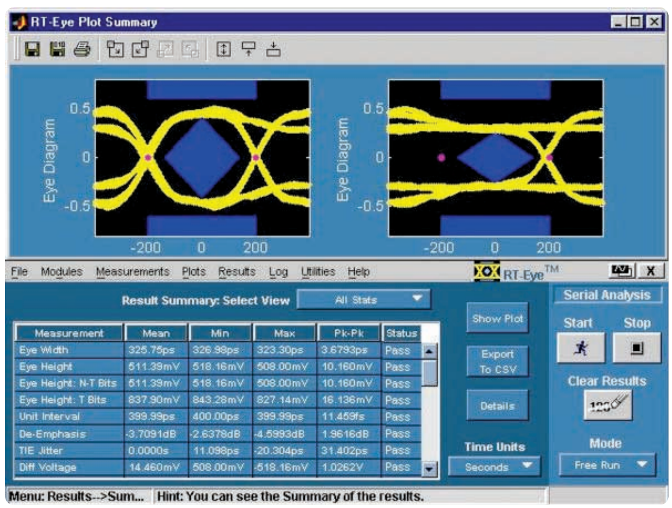


Figure 11. The Tektronix TDSRT-Eye lacks the color-graded display information provided by the Agilent serial data analysis solution. With a measurement speed of only 20,000 unit intervals per minute, the Tektronix solution takes longer to provide stable measurements.

5 Application
Digital Communications

Digital content is exploding in the area of wireless communications. In the past, when engineers looked at wireless signals, they typically used analog oscilloscopes to view constellation diagrams. They used XY mode of the scope for viewing I vs. Q. They used XY with Z-axis blanking if they could generate a gate that emulated the symbol clock. The intensity-graded display of an analog scope gave designers a first-level view of the quality of their demodulation and symbol clock recovery. Most modern digital scopes can emulate analog phosphor and produce adequate constellation diagrams. Figure 12 shows a TDS5104 in FastAcq mode displaying a constellation diagram.

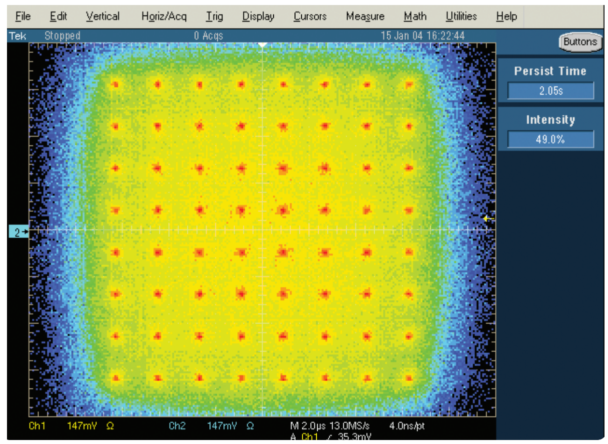


Figure 12. Tektronix TDS5104 with FastAcq mode displays a constellation diagram for a 64QAM signal.

In today's more complex modulation schemes, such as OFDM, it is much more difficult to isolate the I, Q and symbol clock of an individual carrier with analog circuitry. The picture above on the Tektronix TDS5104 oscilloscope can only be generated for simpler communication protocols. Much more processing is necessary to obtain useful information from modern digital communication systems. All this processing–and more–is available using Agilent's 89601A vector signal analysis (VSA) software. This VSA software can use a variety of Agilent hardware as its analog front end–including Agilent Infiniium oscilloscopes. Now, directly from the intermediate frequency (if), you can get all the information shown in Figure 13, and more.

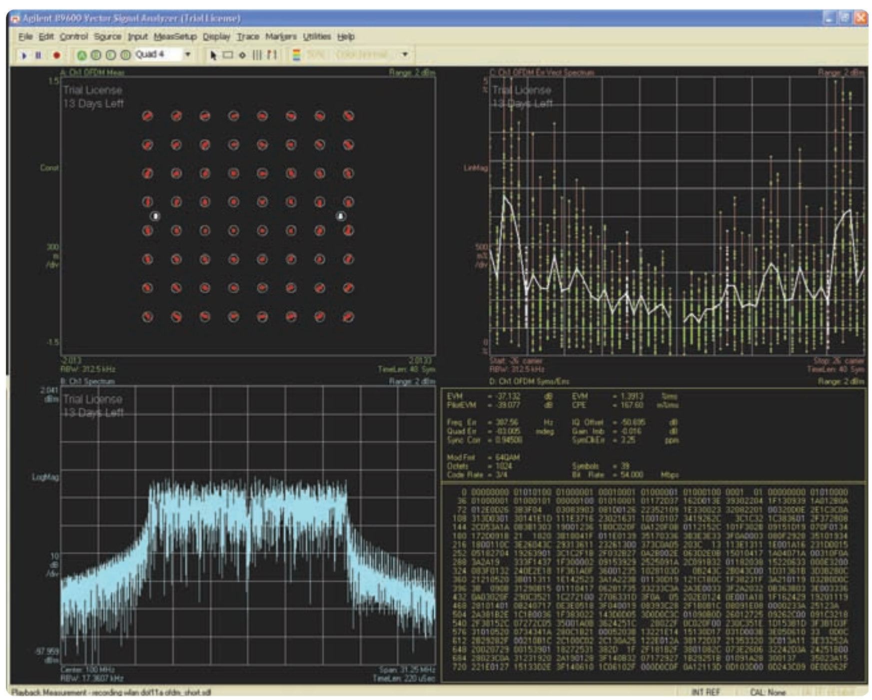


Figure 13. Agilent VSA Software running on an Agilent Infiniium 54832D Oscilloscope. Upper Left: The constellation diagram (with symbol clock recovery) of the preamble (BFSK—white trace) and all 52 64 QAM subcarriers (red traces) of an 802.11a WLAN packet. Lower Left: The FFT of the packet. Upper Right: EVM (error vector magnitude) of each symbol and RMS error separated by carrier. Lower Right: The baseband data in this packet.

Conclusion

The choice of a good oscilloscope can ultimately save you both time and money when it comes to viewing, debugging, and analyzing today's complex designs. Advanced triggering, deep memory, and measurement and math capability shorten the path between symptom and root cause. Special modes, such as Tektronix' FastAcq, limit the functionality of the scope. Ideally, an oscilloscope would provide you access to all the tools and capability you need, right when you need it. Agilent oscilloscopes with MegaZoom deep memory do just that.

Next time you are considering a scope purchase, don't just trust the pretty scope display generated by demo board signals! Hook the scope up to your own design—and make sure the scope gives you what you need to get your product to market faster.

Note: Infiniium 54832D operated with software revision A.03.10. Tektronix TDS6604 operated with software revision 2.4.0

Related Literature

Publication Title	Publication Type	Publication Number
Agilent Technologies Infiniium 54830 Series Oscilloscopes	Brochure	5988-3788EN
Infiniium 54830 Series Oscilloscope Probes, Accessories, and Options	Selection Guide Data Sheet	5968-7141EN
Agilent Technologies 54600 Series Oscilloscopes	Data Sheet	5968-8152EN
Agilent Technologies 54600 Series Oscilloscope Probes, and Accessories	Selection Guide Data Sheet	5968-8153EN
Ten Things to Consider When Selecting Your Next Oscilloscope	Application Note	5989-0552EN

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