Tektronix

Technical Brief

Digital Phosphor Oscilloscope Architecture Surpasses Analog, Digital Scope Strengths

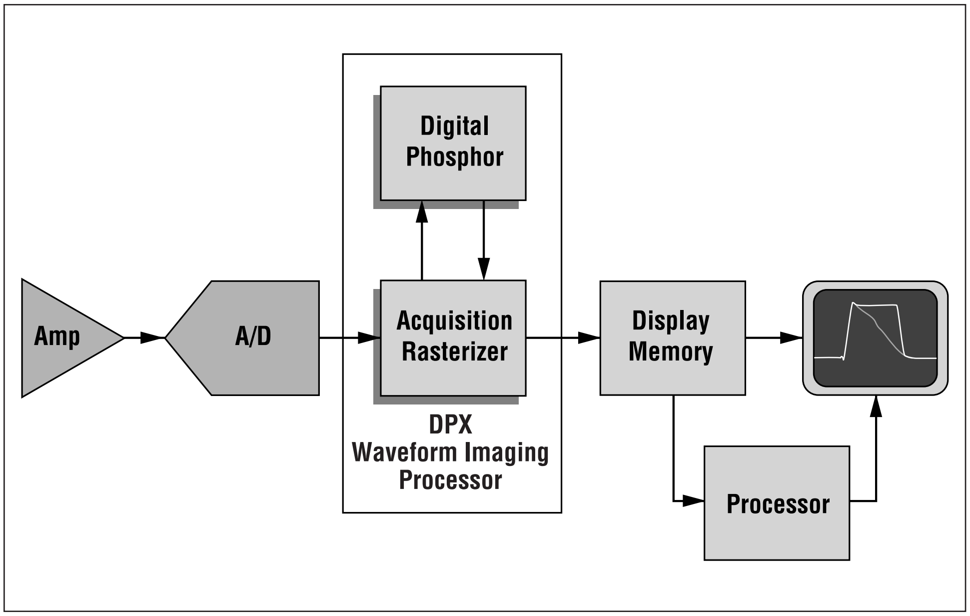

Figure 1. Simplified block diagram of a DPO system.

A Digital Storage Oscilloscope (DSO) is found on just about every engineer's bench these days. But many DSOs still share benchtop space with aging Analog Real-Time (ART) scopes. Why?

It's because of the mutually exclusive strengths of the two platforms. The DSO provides simultaneous multi-channel operation, as well as measurement automation and waveform storage.

The analog scope's gray scale display, with its varying brightness and continuous acquisition, innately brings a real-time "statistical" dimension to the viewed waveform. It highlights the portion of the signal that occurs most frequently. But the analog scope lacks the DSO's storage capabilities and other features. Engineers have been unable to depend entirely upon either scope architecture for all their signal characterization needs.

DPO: An Architectural Breakthrough

A new oscilloscope platform from Tektronix, the Digital Phosphor Oscilloscope (DPO), combines the best of the analog and digital worlds and goes beyond both of these technologies. With one instrument, it's now possible to capture all of the salient information about a waveform: amplitude, frequency, and the intensity axis that reveals amplitude distribution over time.

The Digital Phosphor Oscilloscope is nothing less than a defining measurement breakthrough. It offers all the traditional benefits of the DSO architecture, from data storage to sophisticated triggering. It answers the need for analog-like characteristics such as gray scale display and real-time behavior by digitally emulating the chemical phosphorescence process that creates the intensity grading in an analog oscilloscope's CRT. And it makes the digitizing oscilloscope into a universal waveform acquisition instrument.

Tektronix leverages its experience with such DSO advancements as Digital Real-Time and InstaVu™ acquisition to create the remarkable performance of the DPO. Figure 1 shows a simplified block diagram of a DPO system.

The Digital Phosphor is able to continuously acquire waveforms into its three-dimensional database while updating the display because of its parallel processing architecture that integrates the display and acquisition systems. Note that the DPO's system processor is not burdened by display management tasks. The processor is devoted to measurement automation and analysis. This is very different from the typical DSO, in which

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every bit of data going to the display must pass through the processor, which is also carrying out computations, managing the scope's user interface, etc.

The heart of the DPO is the DPX™ waveform imaging processor; a proprietary ASIC that rasterizes the digitized waveform into a dynamic three-dimensional database called the Digital Phosphor. The DPX accumulates signal information in a 500 x 200 integer array. Each integer in the array represents a pixel in the DPO's display. If the signal traverses one point again and again, its array location will be updated repeatedly to highlight that fact. Over the timespan of many samples, the array develops a detailed map of the signal intensity. The result is a waveform trace whose intensity varies in proportion to the signal's frequency of occurrence at each point – a type of "gray scaling" that's just like an analog real-time scope. But unlike an ART, the DPO allows gray scale levels to be expressed in color. Figure 2 uses a waveform from a metastable circuit to illustrate this effect. The intensity levels clearly express the frequency of occurrence at each point on the screen. The histogram above the main trace statistically represents the intensity information in the trace itself.

The DPO operating model relies on its exceptional display sample density to provide a real-time display of signal activity. Conventional DSOs sample only a small fraction of the time – less than 1%. The rest of the time is spent compiling the display, and incidentally, ignoring all the signal activity that occurs at that time. In contrast, the DPO draws upon Tektronix' patented and proven signal capture technology, InstaVu acquisition, which dramatically reduces dead time between acquisitions. The DPO can record up to 200,000 waveforms per second – 1000 times more signal data than an ordinary DSO. A new snapshot of the digital phosphor is sent to the display every 1/30th of a second without interrupting the acquisition process. As a result, the image responds to waveform activity in real time, and an abundance of data accurately represents the waveform.

"Persistence" modes are sometimes used in DSOs to simulate gray scaling. But persistence displays are created by post-processing the normally acquired waveforms, not in real time. Persistence relies on many accumulated "screens" of data, and it takes time to freshly acquire and calculate the display. The DPO, on the other hand, integrates the display and acquisition system to produce a real-time display of the three dimensions of signal information, which are instantly visible on the screen.

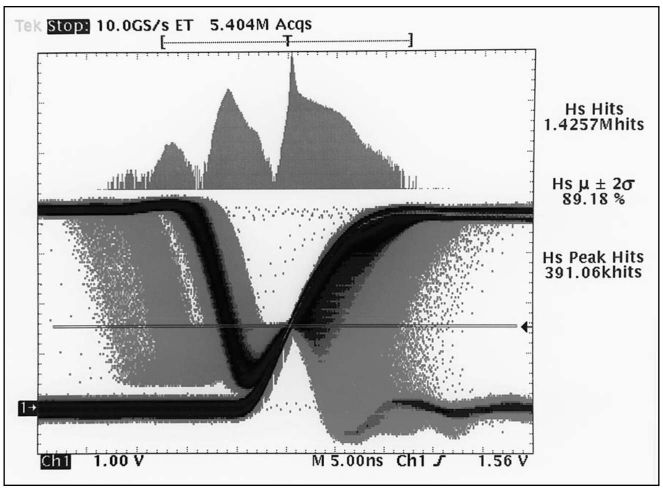
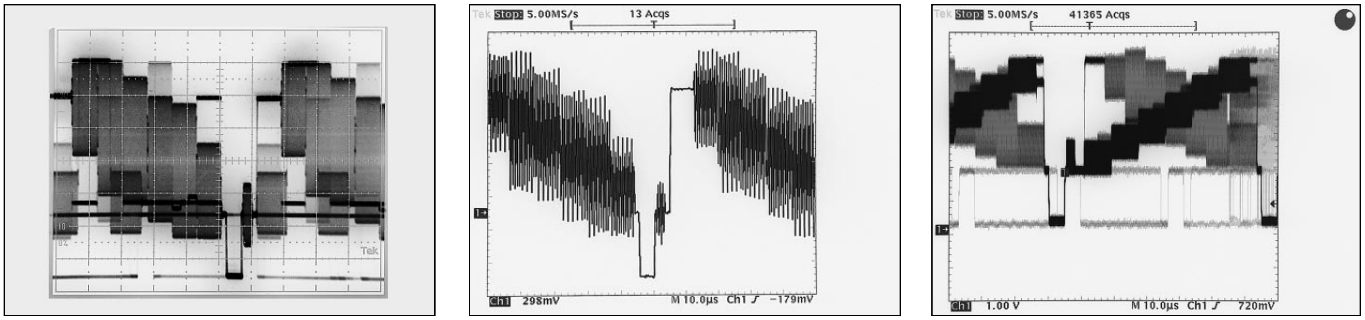


Figure 2. DPO waveform image showing how trace intensity reveals frequency of occurrence.



(A) (B) (C)

Figure 3. A) The analog scope is the accepted waveform profile; B) The DSO display of the video signal is distorted by aliasing caused by using a low sample rate needed to capture the whole signal envelope; C) The DPO displays the video waveform without aliasing; portions of the waveform are intensified, indicating that the signal spent more time at these points.

Using the DPO in the Real World

As we have seen, ARTs and DSOs have their respective strengths and weaknesses. The DPO provides, for the first time, a platform that has all of the strengths of both, and none of the weaknesses, and goes beyond.

The best way to prove this is to look at some real-world measurement examples.

A Solution for Long-Interval Signal Capture. Packetized signals made up of multiple components with relatively long time periods are especially difficult to capture faithfully with a DSO. One example is the composite video signal in Figure 3a. It requires capturing a long time interval (and thus the use of a slow time base setting) to understand the characteristics of the whole envelope. But in order to capture individual pulse detail, a fast time base setting is required.

The normal procedure is to set the DSO's time base (and therefore its sample rate) to a horizontal rate slow enough to acquire the whole signal envelope. On a DSO, the slow sample rate produces aliasing on the individual faster pulses within the signal – a by-product of using a sample rate that's too low relative to the frequencies being measured. The result is a waveform that is distorted almost beyond recognition, as shown in Figure 3b. Worse yet, it can actually appear to be a lower-frequency waveform than it really is.

The solution, until now, has been to use an analog scope for viewing these types of signals. The analog display in Figure 3a is regarded as a "correct" waveform profile. But the ART offers no way to store, automatically measure, or analyze the signal.

The DPO's abundance of waveform data, with 100 million points per second being sent to the display, solves the aliasing problem. The resulting waveform (Figure 3c) is clear and comprehensible, even though it was acquired at the slow time base setting. Note in Figure 3c that portions of the waveform are intensified, indicating that the signal spent more time at those points. This axis of information is completely absent from the DSO display in real-time.

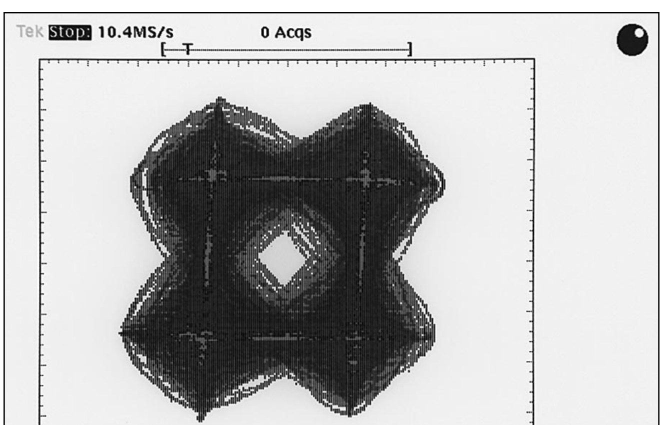


Figure 4. A QAM constellation diagram as seen on a Tektronix DPO screen. The DPO's continuous acquisition provides a dynamic and accurate XY display.

Note also that the signal shown is a stable test pattern. If it were a live video signal with dynamic variations, the DSO display would be even further from the truth.

Aliasing has plagued DSOs for years. Video measurements, disk drive read channel measurements, wireless communication signals, and others that require capturing long "packets" made up of faster pulses have given engineers cause to hold on to their ART scopes. With the advent of Tektronix DPOs, the aliasing effects of a digitizing oscilloscope are finally conquered.

At Last: A Digital Scope with a No-Compromise XY Mode. There's no substitute for a true XY measurement function in a scope. In the XY mode, the phase relationship of two signals is compared by feeding one signal to a vertical input as usual, and the other to the horizontal input. XY mode is a traditional strength of the analog scope, and because of the mode's real-time data flow requirements, a weakness of the DSO.

But today's complex digitally modulated signals for wireless telecommunications need the additional capabilities of a digitizing oscilloscope – the bandwidth, the triggering, the analysis, and more.

Figure 4 depicts a QAM constellation diagram captured by a Tektronix DPO. The lobes describing the 90-degree phase shift points are clear and stable. That's

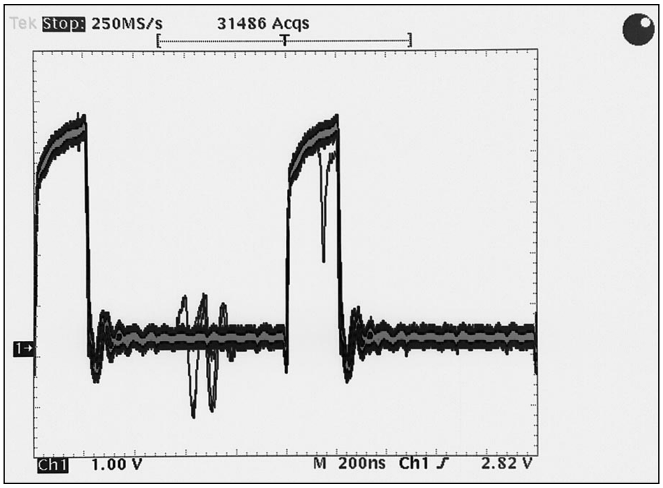


Figure 5. The dim aberration in the pulse at the center of the display is occurring less frequently than the normal pulse shape. This visual cue reveals irregular transients quickly.

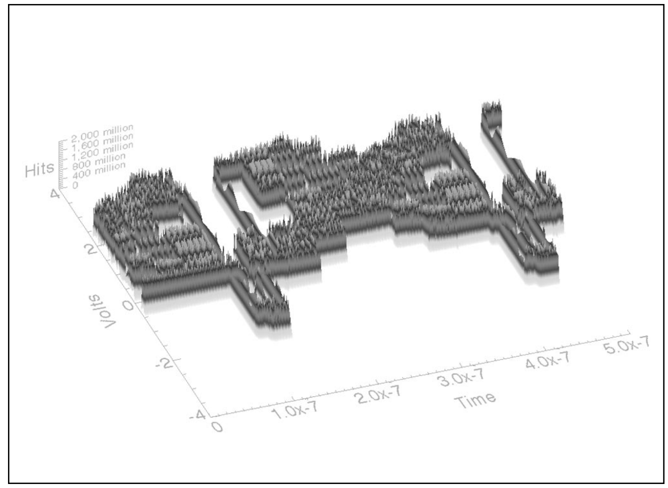


Figure 6. A 3-dimensional view of waveform data from the Digital Phosphor Array. Frequency of occurrence shows up as the Z-axis of the graph.

because the DPO continuously draws samples into the digital phosphor at a rate of 10.4 Msamples/sec and scans that information out to the display serially at 1 Mpixels/-sec. This continuous acquisition provides a dynamic and accurate XY display.

A DSO simply cannot produce such a display. The DSO doesn't provide sufficient sample density or continuous acquisition. Furthermore, the DPO's color-grading provides resolution superior to the ART's monochromatic gray scaling.

Random and Infrequent Events Revealed. The ability to capture random or infrequent events makes the DPO ideal for debugging even the most advanced electronic designs. Here again, the DPO's extraordinary display sample density means the scope spends much more time actively acquiring data, rather than processing it for display. That means that occasional transients are far less likely to pass unnoticed. In addition, the gray scaling capability emphasizes just how frequent these transients are, relative to the other signal components onscreen.

Figure 5 shows a signal made up of widely-separated pulses with intermittent noise and transients. Note the dim aberration in the pulse at the center of the display. This is a pulse variant that's occurring less frequently than the normal pulse waveform. Ability to detect such aberrations is especially helpful in troubleshooting applications.

A New Level of Data Analysis. Because the DPO stores the waveform data in the dynamic three-dimensional database, statistical information about the signal can easily be derived. The DPO's internal histogram function gathers quantitative information on the distribution of the signal on-the-fly or on a stored waveform. The three-dimensional database can also be exported via the scope's GPIB port to an external PC for analysis including 3-D plots. This data presents a three-dimensional view wherein frequency of occurrence shows up as the Z-axis of the graph. Like the DPO screen display itself, color can be used to enhance legibility. Figure 6 shows the resulting graph.

Conclusion

The new Tektronix Digital Phosphor Oscilloscope surpasses the strengths of analog and digital oscilloscopes with one powerful acquisition technology. The resulting measurement tool is greater than the sum of its parts, since it provides never-before-seen insights into signal behavior. No existing oscilloscope architecture, analog or digital, can measure up to the Digital Phosphor Oscilloscope.

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