Technical Brief

The DPO Breakthrough

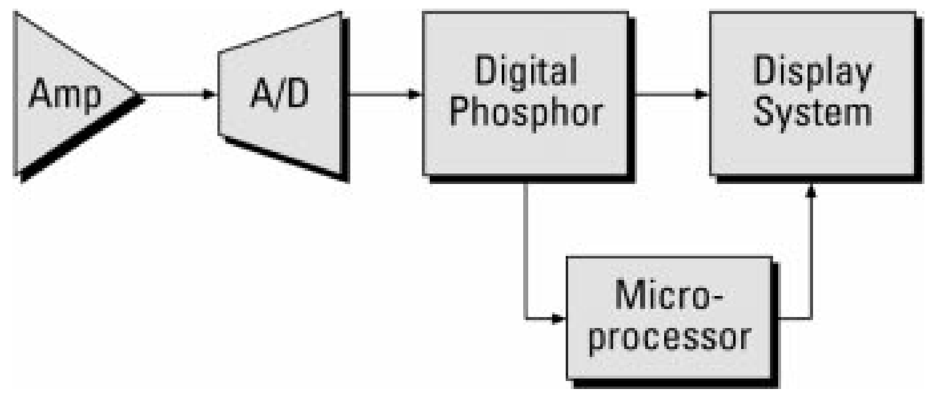


Figure 1. In a digital phosphor oscilloscope (DPO), the waveform is first digitized similar to a standard digital storage oscilloscope (DSO). The DPO then rasterizes the waveform in a dynamic, three-dimensional database called digital phosphor and the information is periodically sent to the display system. At the same time, and in parallel, the microprocessor performs automatic measurements and math functions.

A 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) oscilloscopes. Why? Because the two platforms have mutually exclusive strengths.

The DSO provides simultaneous multi-channel operation, as well as measurement automation and waveform storage. The analog oscilloscope's intensity-graded display, with its varying brightness and fast waveform capture rate, innately brings a real-time "statistical" dimension to the viewed waveform. It indicates the frequency of occurrence of different parts of the signal. But the analog oscilloscope lacks the DSO's storage capabilities and other features. Consequently, engineers have been unable to depend entirely upon either oscilloscope architecture for all their signal characterization needs.

DPO: An Architectural Breakthrough

A new oscilloscope platform from Tektronix, the DPO combines the best of the analog and digital worlds while going beyond both technologies. With one instrument, it's now possible to capture all of the salient information about a waveform in three dimensions: amplitude, time, and the intensity axis that reveals amplitude distribution over time.

The DPO is nothing less than a defining measurement breakthrough. It offers all the traditional benefits of the DSO, from data storage to sophisticated triggering. It answers, as well, the need for analog-like characteristics, such as intensity-graded display and real-time behavior, by digitally emulating the chemical phosphorescence process that creates the intensity grading in an analog oscilloscope's CRT. It makes the digitizing oscilloscope into a universal waveform acquisition instrument. Figure 1 shows a simplified block diagram of a DPO system.

The DPO is able to continuously acquire and display three-dimensions of information because of its parallel processing architecture that integrates the display and acquisition systems. Note that the DPO's system microprocessor 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 every bit of data going to the display must pass through the processor, which is also carrying out computations, managing the oscilloscope's user interface, etc.

This parallel processing enables the DPO to support an exceptional waveform capture rate that provides a real-time display of signal activity. Conventional DSOs acquire signals only a small fraction of the time – less than 1 percent. The rest of the time is spent processing the acquired waveform data and creating the display, and, incidentally, ignoring all the signal activity occurring while that is being done. In contrast, the DPO creates the waveform image directly in the acquisition system as fast as the signal can be triggered. 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 create intensity-graded displays. But persistence displays are created by post-processing normally acquired waveforms, and are not in real time. Persistence relies on many accumulated "screens" of data in the display memory, but the time it takes to create the display is limited by the slow waveform capture rate of the DSO. 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 like an analog oscilloscope.

Using the DPO in the Real World

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, while also going beyond both. The best way to prove this is to look at some real-world measurement examples.

A Solution for Video Signal Capture. Packetized signals made up of multiple components with relatively long time periods are especially difficult to capture faithfully with a DSO. This is especially true for the composite video signal in Figure 2a. 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.

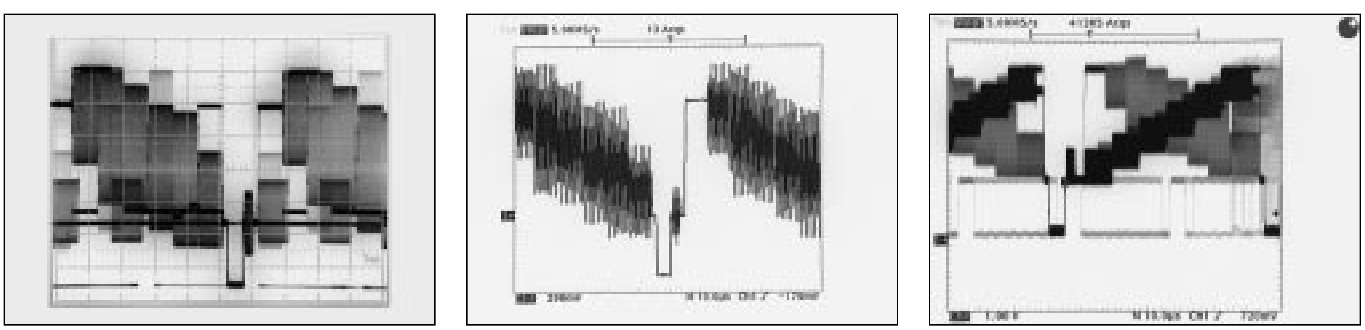
The normal procedure is to set the DSO's timebase (and therefore its sample rate) to a horizontal rate slow enough to acquire the whole signal envelope. On a DSO, however, the slow sample rate produces aliasing because of the lack of waveform data. The result is a waveform that is distorted and inaccurately represented as shown in Figure 2b. 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 oscilloscope for viewing these types of signals. The analog display in Figure 2a 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 solves the aliasing problem. The resulting waveform (Figure 2c) is clear and comprehensible, even though it was acquired at the slow time base setting.

Aliasing is a major deficiency of DSOs. Besides video measurements, aliasing has been a concern when measuring disk-drive read channels, wireless communication signals, and others that require capturing long "packets" made up of faster pulses, giving engineers cause to hold on to their ART oscilloscopes. With the advent of Tektronix' DPOs, the aliasing effects of a digitizing oscilloscope are finally conquered.

At Last: A Digitizing Oscilloscope with a No-Compromise XY Mode. For some applications, the XY display in an oscilloscope is essential. In the XY display 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 oscilloscope, 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 3 depicts a QAM constellation diagram captured by a Tektronix DPO. The lobes describing the 90-degree phase shift points are clear and stable.

The DPO continuously draws samples into the digital phosphor and scans that informa-



(A) (B) (C)

Figure 2. (A) The analog oscilloscope 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.

The Power of DPX

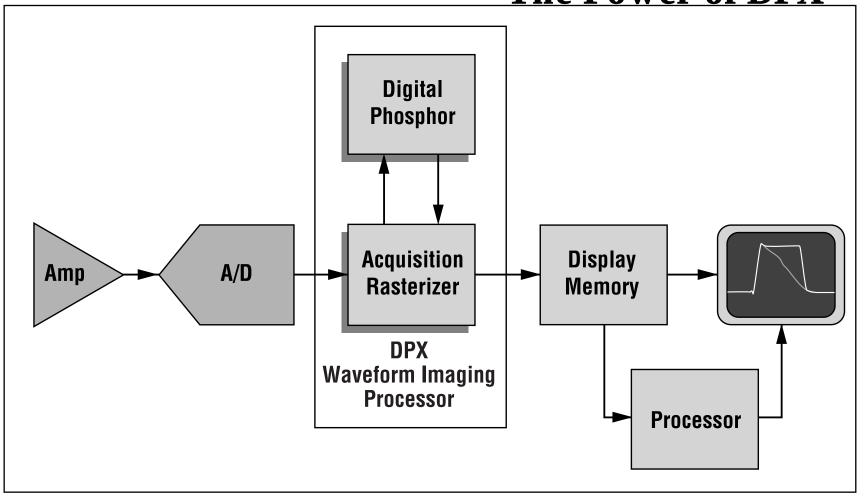


Figure A. Simplified block diagram of a DPX-based system.

At the heart of the high-performance DPOs from Tektronix is the DPX waveform imaging processor; a proprietary ASIC that provides waveform capture rates comparable to those of the fastest ARTs. The DPX combines rasterization with a deep, 3-D database and fast waveform capture rates, making for a DPO with exceptional display data density.

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 that incorporates a full 21 bits of gradation information. If the signal traverses one point again and again, its array location will be updated repeatedly to highlight that fact. Over the time span 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 oscilloscope.

But unlike an ART, the DPX allows gray scale levels to be expressed in color. Figure B uses a waveform from a metastable logic 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 acquisition engine continuously samples at the maximum rate, triggering and building image after image with minimal dead time between acquisitions. The DPX can record up to 200,000 waveforms per second – 1000 times more signal data than an ordinary DSO – and 500,000 samples in an acquisition. A new snapshot of the digital phosphor is sent to the display every 1/30th of a second without interrupting the acquisition process.

The DPX waveform data in the dynamic 3-D database can be accessed to provide statistical information about the signal. In histogram mode, the DPX engine extends each point in the digital phosphor to be 32- or 64-bits deep. This enables the oscilloscope to build a statistically significant database in just a few minutes instead of hours or even days. The internal histogram function gathers quantitative information on the distribution of the signal on the fly or on a stored waveform.

The DPX also allows for XYZ display, where the Z input is used to enable the display of XY information when creating, for example, constellation diagrams of symbols in wireless communication signals.

The 3-D database can be exported via the oscilloscope's GPIB port, floppy drive, or Zip drive to an external PC for analysis including 3-D plots. This data presents a 3-D view wherein frequency of occurrence shows up as the Z-axis of the graph. Like the screen display itself, color can be used to enhance legibility. Figure C shows the resulting graph.

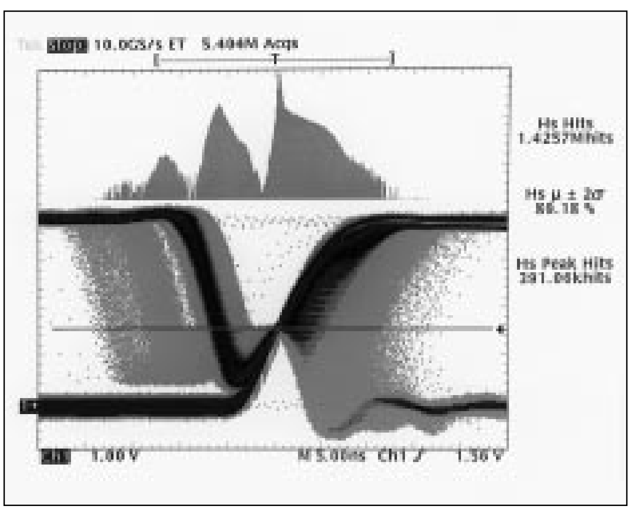


Figure B. DPO waveform image created with the DPX technology shows how trace intensity reveals frequency of occurrence.

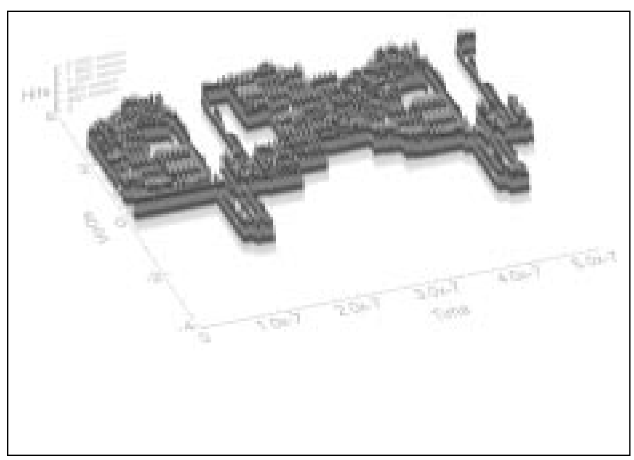


Figure C. A 3-D view of waveform data from the digital phosphor array in an oscilloscope enabled by DPX. Frequency of occurrence shows up as the Z-axis of the graph.

tion out serially to the display at 1 Mpixels/s. 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.

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 waveform capture rate means the oscilloscope spends much more time actively acquiring data than processing it for display. That means 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 on-screen.

Figure 4 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.

Conclusion

The new Tektronix digital phosphor oscilloscope surpasses the strengths of analog and digital oscilloscopes. Its integrated acquisition and display architecture gives the DPO the real-time intensity-graded, alias-free display expected from an analog oscilloscope, plus the storage and analysis capabilities of a DSO. The resulting measurement tool is greater than the sum of its parts, providing never-before-seen insights into signal behavior.

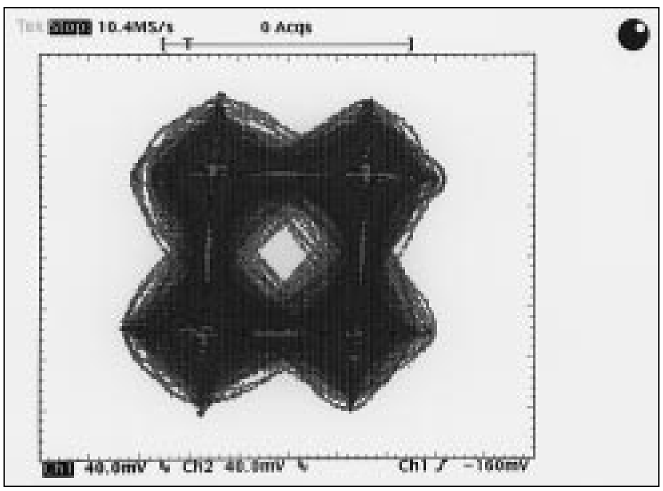


Figure 3. A QAM constellation diagram as seen on a Tektronix DPO screen. The DPO's continuous untriggered acquisition provides a dynamic and accurate XY display.

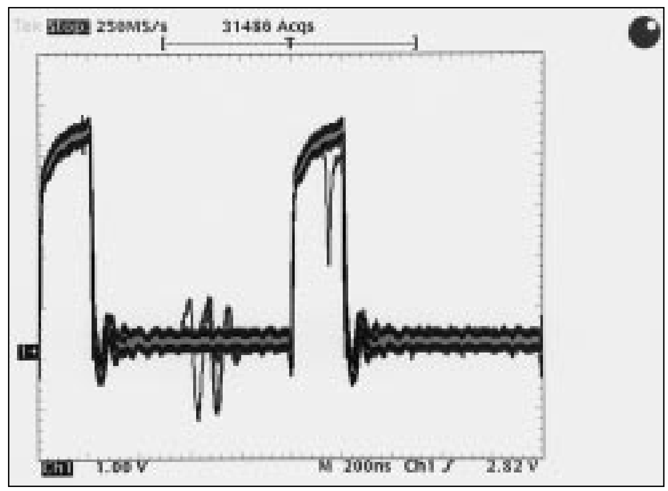


Figure 4. The dim aberration in the pulse at the center of the display is occurring less frequently than the normal pulse shape. This visual clue reveals irregular transients quickly.

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