Third-Generation Digital Phosphor Oscilloscopes Deliver Unprecedented Waveform Visualization

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A New Level of Confidence

The DPOs provide increased confidence in capturing significantly better information about complex signal behavior.

Since their invention, oscilloscopes have been the eyes of the designer in the electrical domain. Today's sophisticated digital designs and complex modulation schemes require advanced performance to accurately represent signal behavior – performance that in many cases exceeds the limits of traditional digital storage oscilloscopes (DSOs).

Digital oscilloscopes brought advantages of permanent signal storage and extensive waveform processing when compared with their analog predecessors. However, they have lagged substantially in two key areas: waveform capture rate (live-time) and effective representation of dynamic complex signals. Oscilloscope live-time is a critical element for both detecting infrequent events, such as asynchronous faults in digital systems, and capturing feature-rich dynamic signals.

Digital Phosphor Technology Addresses Fundamental Issue

When Tektronix introduced the Digital Phosphor Oscilloscope (DPO) in June 1998, it immediately acquainted the design community with a new approach to signal acquisition. Fundamentally different, the DPO architecture dedicates unique ASIC hardware to the task of acquiring waveform images.

In the TDS7000 Series the result is an unmatched level of signal visualization. With capture rates greater than 400,000 waveforms per second, engineers can be confident they have maximum insight into signal activity. This performance results in the highest probability of witnessing transient problems that occur in digital systems, including runt pulses, glitches and transition errors.

By comparison, most DSOs operate on the order of 100 to 5,000 waveform capture cycles per second. Some DSOs provide a special mode that alternates between bursting multiple captures into long memory and following up with a display cycle. This can temporarily deliver rates of about 40,000 waveforms per second, but with substantial dead-time while the waveform data is processed and displayed. These performance levels do not compare to the unprecedented live-time afforded by the proprietary DPX™ technology implementation in the TDS7000 Series.

A New Level of Confidence

The DPO is a digitizing scope that provides increased confidence in capturing all the information about waveform behavior. This increased confidence is achieved by accelerating waveform capture rates well beyond those of even the most advanced DSOs, thereby increasing the probability of capture of rare events. It is equally suitable for viewing high frequencies, low repetition waveforms, transients, and signal variations in real-time.

For any scope – analog, DSO or DPO – there is always a holdoff time during which the instrument processes the most recently acquired data, resets the system, and waits for the next trigger event. During this time, the scope is blind to all signal activity. The probability of seeing an infrequent or low rep-rate event decreases as the holdoff time increases.

The probability of capture can be calculated as follows:

$$\text{Probability of Capture} = \frac{\text{Acquisition Time}}{\text{Acquisition Time} + \text{System Holdoff Time}}$$

Figure 1.

It should be noted that it is impossible to determine the probability of capture by simply looking at the display update rate. If you rely solely on the update rate, it is easy to make the mistake of believing that the oscilloscope is capturing all pertinent information about the waveform when, in fact, it is not.

Digital Storage Oscilloscopes process captured waveforms serially. The speed of the DSO microprocessor is a bottleneck in this process because it limits the waveform capture rate. As a result, DSOs can miss infrequent events and lack real-time response to signal changes.

The DPO rasterizes the digitized waveform data into a database called the Digital Phosphor. Every 1/30th of a second, about as fast as the eye can perceive it, a snapshot of the signal image stored in the Digital Phosphor is pipelined directly to the display system. This direct rasterization of waveform data, and direct copy to display memory from the digital phosphor, removes the data processing bottleneck inherent in the DSO architecture. The result is enhanced “live-time” and lively display update. Signal details, intermittent events, and dynamic characteristics of the signal are captured in real-time, with a verisimilitude that cannot be achieved by a DSO. The DPO’s microprocessor works in parallel with this integrated acquisition system for automatic measurements, waveform math, and instrument control.

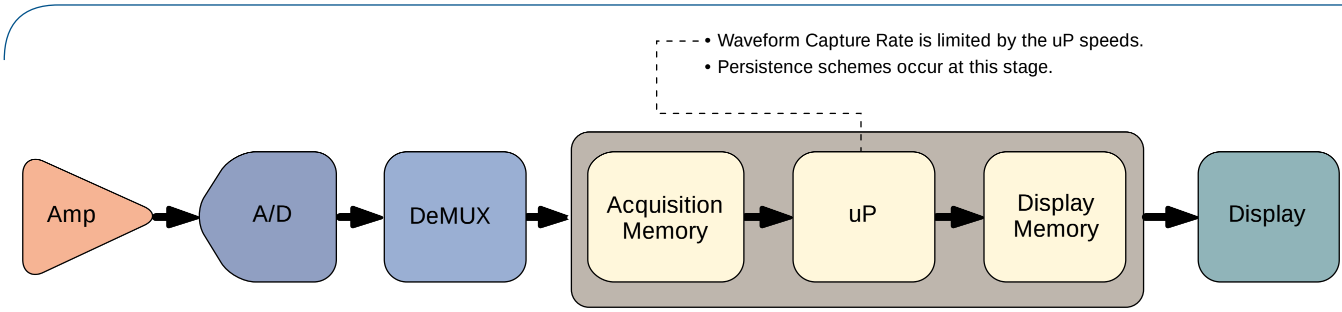
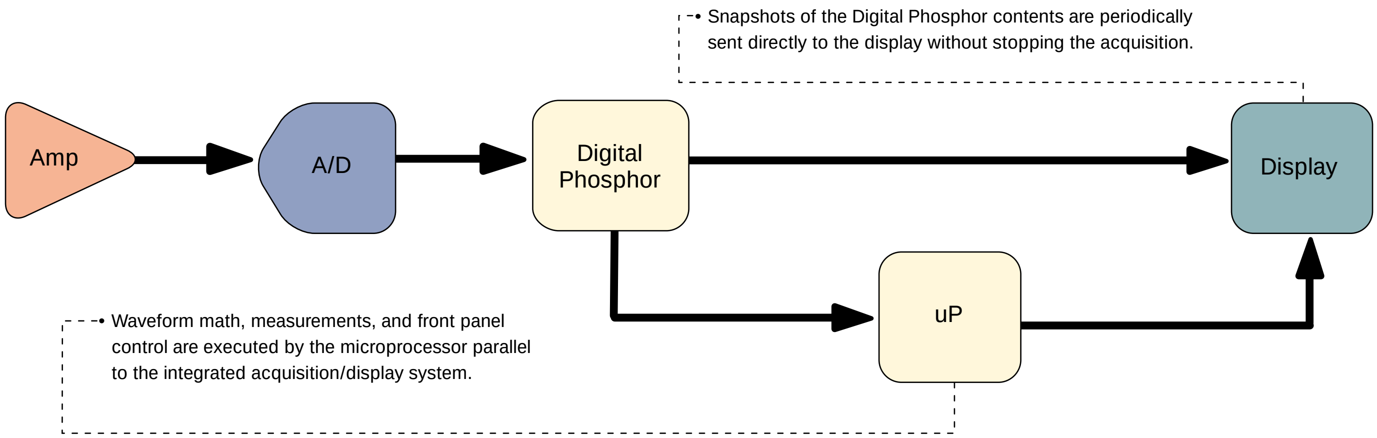


Figure 2. *Digital Storage Oscilloscope, Serial Processing Technology 1982.*



▶ ***Figure 3.*** *Parallel Processing.*

Accurate Signal Representation – DSOs vs. DPOs

Before the advent of the Digital Phosphor Oscilloscope, many designers kept an analog oscilloscope around to verify signal acquisitions made by their DSOs. This need for analog verification – or, mistrust of DSOs, if you will – grew out of the DSOs propensity to misrepresent, or alias, high-speed signals due to a lack of digitized signal data.

In addition, designers like analog scopes because they provide an “information rich” display that combines intensity information with “real-time” waveform capture. DSOs, with software-based persistence modes and slower capture rates, simply cannot duplicate the amount of information provided in the “real-time” analog display.

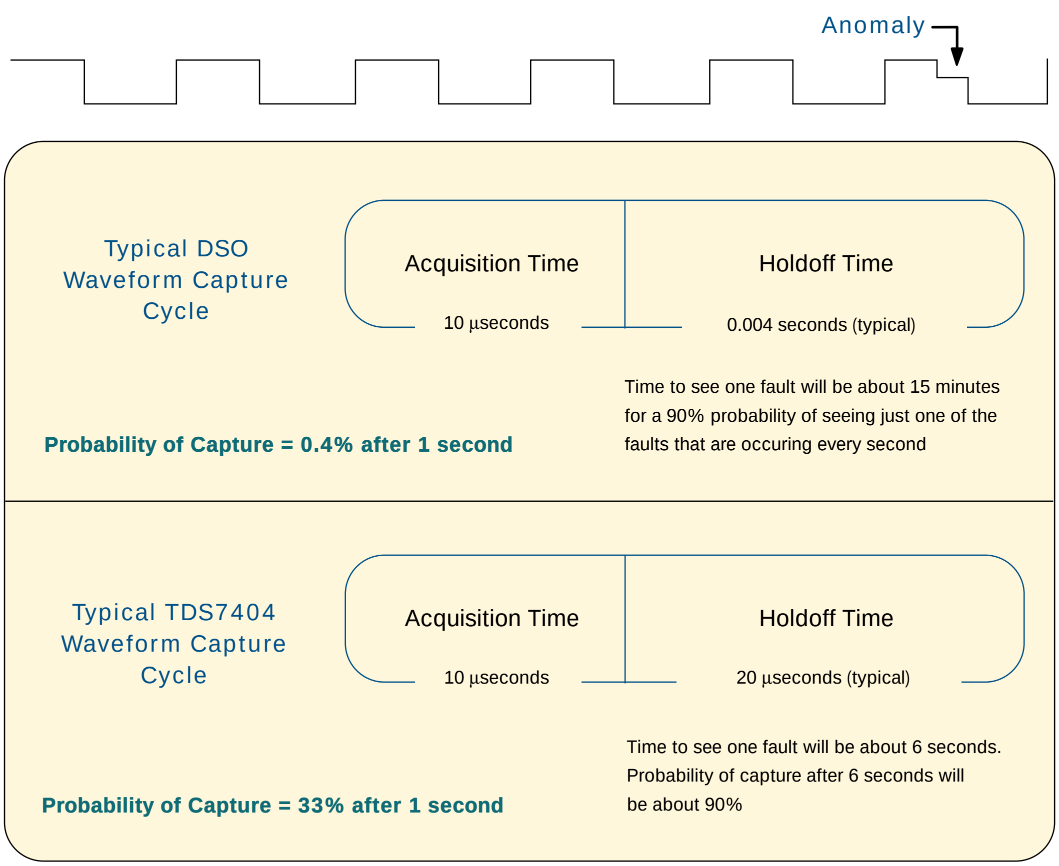
DSOs that can temporarily burst multiple captures at high rates always follow up with long processing dead times to provide only limited live-time. The settings for this burst mode must be carefully adjusted by the user in order to coax the instrument into displaying adequate signal content. These modes find applications in certain repetitive single-shot situations but are error prone during set-up and still provide “information poor” displays.

What the DPO Does for You

To truly appreciate the importance of the DPO's waveform capture rate and signal processing capabilities, consider for a moment the way design engineers use a scope when trying to capture infrequent events. Typically, the probe is moved from circuit location to circuit location in the suspected area of the fault, while waveform behavior is observed on the scope display. The time that the probe remains at any one circuit location varies somewhat, but is rarely more than a few seconds.

Certainly, if a fault is expected at a specific circuit node, sophisticated trigger techniques can be applied to "sit and wait" for it. Realistically though, these capabilities are only applied in the "proof" stage after evidence of a fault has been visually identified. Without visual clues, it is difficult to know whether to set the trigger system to discriminate on pulse width (glitches), amplitude thresholds (runts), transition times (metastable edges) or other conditions. Though trigger systems may detect such anomalies, the key is to quickly determine where to look and classify the type of error present.

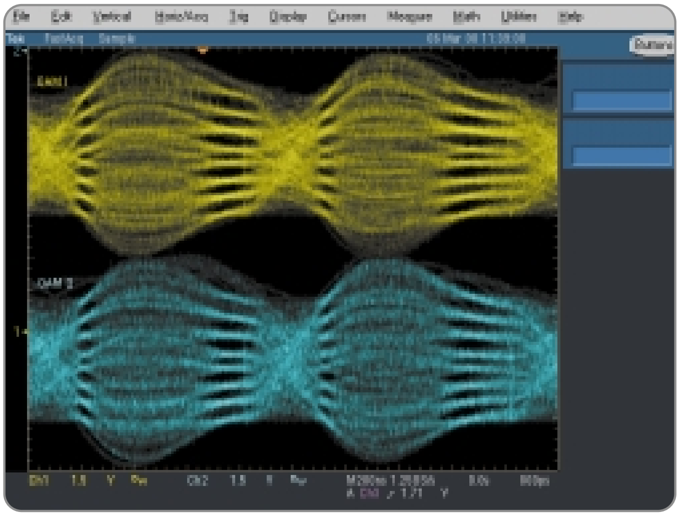
DPOs speed this process by effortlessly showing the user millions of waveforms in just seconds. In the example below, we compare the probabilities of capturing an anomaly in a 1 MHz square wave signal using a DSO and a DPO.



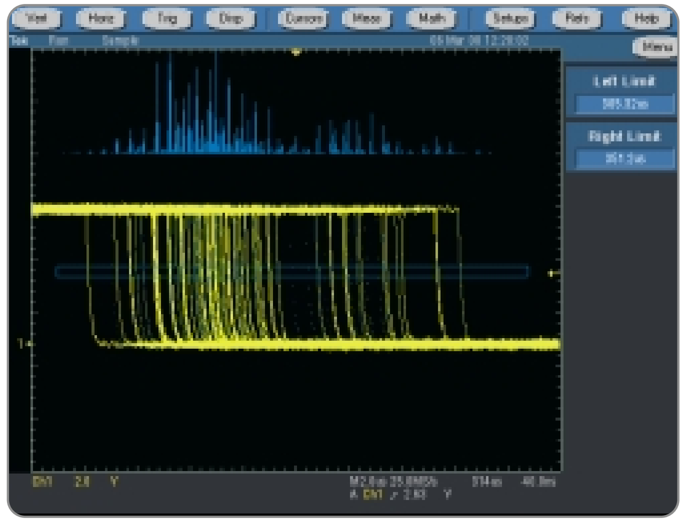
Example:

- 1 MHz Square Wave Signal
- 1 µsecond/division oscilloscope time-base setting
- Anomaly occurs about once per second or once every million cycles

Figure 4.



▶ ***Figure 5.*** *The extraordinary live time achieved by DPX technology allows dynamic signals to be accurately analyzed.*



▶ `***Figure 6.*** *DPX technology coupled with histogram analysis provides rapid insight into timing and amplitude distributions.*

Capturing Dynamic Complex Signals – Many of the measurement challenges facing engineers today are centered on the need to characterize dynamic complex signals – quadrature amplitude modulated (QAM) signals, asynchronous packetized data, and analog video signals, to name a few. These signals present the toughest challenges to traditional DSOs.

Digital Phosphor Oscilloscopes were designed to address the need to capture and analyze such signals. Because DPOs acquire hundreds of thousands of waveforms a second they can, in 1/30 of a second, develop detailed information about dynamic complex signals that could take minutes or even hours to collect with a traditional DSO. The result is a live-time display that duplicates the feature rich nature of the signal. Plus, it enables designers to reveal the subtle modulation and dynamic characteristics of the signal with eye diagrams, I-Q patterns, vector and constellation diagrams.

Jitter Evaluation – DPOs allow design engineers to gain visual and statistical insight, in real-time, into the distribution of edge jitter. In communication signal applications it is possible to "see" jitter in the picosecond range, allowing engineers to view real-time updates of jitter while adjusting the circuit.

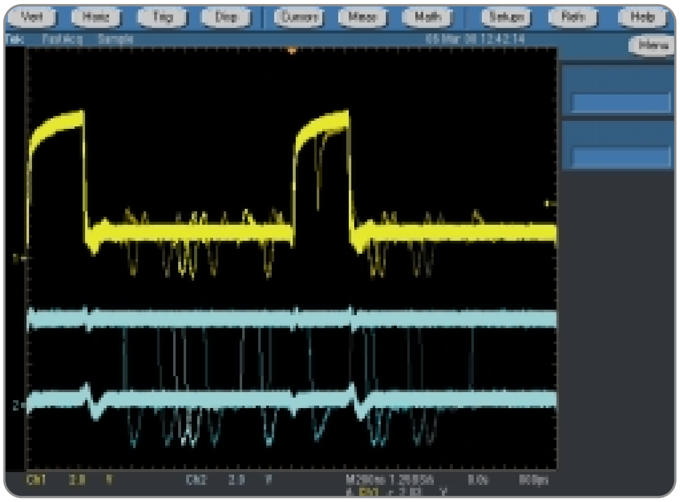


Figure 7. *In debug applications, DPOs provide confidence that critical events are detected.*

Infrequent Glitch Capture – The DPO's fast waveform capture rate finds even the rarest glitches, allowing engineers to detect and analyze aberrant events in logic circuits. Frequency-of-occurrence information provides relative information about how often aberrant events occur.

Long Time Interval Capture – The abundance of data provided by the DPO allows engineers to detect subtle patterns of signal behavior over long time intervals. Nanosecond signal variations within a 1 ms window can be viewed in disk drive applications, providing a window into signal details, down to the bit-level, for entire sectors of a disk track.

Noise Distribution Analysis – The DPO helps solve noise problems by providing qualitative and quantitative feedback on signal noise distribution. Histograms can be used in real-time to analyze video signal noise characteristics.

Constellation Diagrams – DPOs make Inphase (I) and Quadrature (Q) alignment easier, allowing quick detection of phase and offset in I and Q signals. The DPO also permits acquisition of qualitative and quantitative information on signal distribution in the XY-mode. In addition, the XYZ-mode allows the engineer to focus on the symbols that are essential for quadrature alignment of wireless communication signals.

Amplitude Modulation – The DPO accurately displays amplitude modulated signals in a familiar, analog scope, format. Intensity grading and an abundance of waveform data show the details within the signal envelope.

Conclusion

For over fifty years, Tektronix has pioneered many major advances in oscilloscope technology. Today, we're proud to usher in the next era of electronic test and measurement with the next generation of Digital Phosphor Oscilloscopes – the TDS7000 Series.

The benefits of using the TDS7000 Series DPOs in electronic design, debug and test, are dramatic. Equipped with the proprietary DPX Waveform Imaging Processor, these oscilloscopes provide unprecedented waveform capture rates that enable design engineers to accurately interpret signal dynamics. Now, the true nature of signal changes, as well as the frequency of occurrence of anomalous signal phenomena, is available in seconds rather than minutes or hours. In addition, this advanced DPX technology is fully integrated into the TDS7000 Series Digital Phosphor Oscilloscopes, so gaining insight is virtually effortless.

DPOs enable design engineers to see a world others don't.

▶ *TDS7054*

▶ *TDS7104*

▶ *TDS7404*

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