Technical Brief

InstaVu™ Acquisition – Setting the Benchmark for DSO Performance

The TDS 784A with InstaVu acquisition catches rare glitches that other scopes can miss.

Digital technology has brought a steady stream of increased functionality to digitizing storage oscilloscopes (DSOs) over the years. Capture and storage of large amounts of waveform data, color displays, documentation, measurements, and Fast Fourier Transform (FFT) analysis are now common DSO features. Still, users want more from their DSOs, especially the high-speed acquisition capabilities that were previously available only in analog scopes.

A major shortcoming of DSOs has been the small fraction of time they actually spend capturing waveforms. The human eye gets the impression of rapid waveform capture when the DSO display is updated 60 times per second. For example, if the DSO is set at a sweep speed appropriate for displaying a 10 MHz clock, each display refresh shows about five cycles of the clock, or 500 ns. Observing 500 ns at 60 times per second requires the acquisition of only 30 microseconds out of every second, or 30 parts per million of real-time.

In contrast, the best analog oscilloscopes can refresh the screen several hundred thousand times per second, but still may have trouble displaying rare events – the writing rate of the CRT phosphor is too slow for a single "glitch" to be observed, even with the use of a viewing hood. The only way to see rare events with an analog scope is to use a specialized CRT that includes an electron multiplying plate (micro-channel plate or MCP) between the deflection system and the screen phosphor. The Tektronix 2467B and 7104 MCP oscilloscopes can capture single-shot events at high sweep speeds and make them visible to the user; infrequent events buried in the midst of a repetitive signal can be seen. As a result, these scopes have gained a reputation as the instruments-of-choice when it comes to difficult debugging and signal integrity verification.

In Search of Live, Digital Acquisition

A DSO display system capable of receiving several hundred thousand full-screen acquisitions per second would be needed to achieve the waveform capture rates of the fastest analog oscilloscopes. However, today's DSOs only display a maximum of a few hundred waveforms per second, and the conventional DSO architecture is a major hurdle to such a phenomenal leap in waveform capture rate. In fact, the instrument display controller would have to rasterize these acquisitions at nearly 200 million pixels per second, and the data bandwidth between the acquisition system and the display system would need to be 200 Mbytes per second to achieve this performance.

A different, but more practical, method of achieving the same result is to make major revisions to conventional DSO architecture. First, the rasterization capability of the display system must be

NOTE: InstaVu™ acquisition technology is patent pending.

duplicated in the acquisition system. Next, the rasterizer must be allowed to use a portion of the high-speed acquisition memory to build display images. The acquisition hardware itself is allowed to start acquisitions without instrument firmware intervention and calculate its own trigger positions. Finally, the instrument firmware and user interfaces have to be adapted to this new form of data produced by the acquisition system, while still supporting conventional DSO functions. With these changes, a DSO can offer acquisition rates that are faster than those of analog oscilloscopes.

InstaVu™ – A New Acquisition Benchmark

The Tektronix TDS 500B and TDS 700A InstaVu™ DSOs make all of the power of this new DSO architecture available in a new mode called InstaVu acquisition. When this mode is enabled, the data moved from the acquisition system is a complete, rasterized image of multiple triggered acquisitions of the captured signals. Transferring this pixel map requires more data to be moved between the two systems, but the raster is only moved at the refresh rate of the scope's display and contains information from tens-of-thousands of acquisitions. Alternatively, ten thousand 500-byte acquisitions would have to be moved to the display every 30 ms requiring a data rate of 167 Mbytes/s. By comparison, a 500 x 200 one-bit per pixel raster moved to the display every 30 ms equals a data rate of only 417 Kbytes/s.

Besides displaying many acquisitions as a single raster image, InstaVu acquisition achieves its rapid acquisition rates by allowing the system to rearm itself and acquire as soon as it has completed one acquisition rather than having the instrument firmware intervene on an acquisition-by-acquisition basis. The instrument firmware only shuts down the acquisition system occasionally – once every 30 ms to copy out the raster that shows the behavior of the signal over the last 12,000 acquisitions.

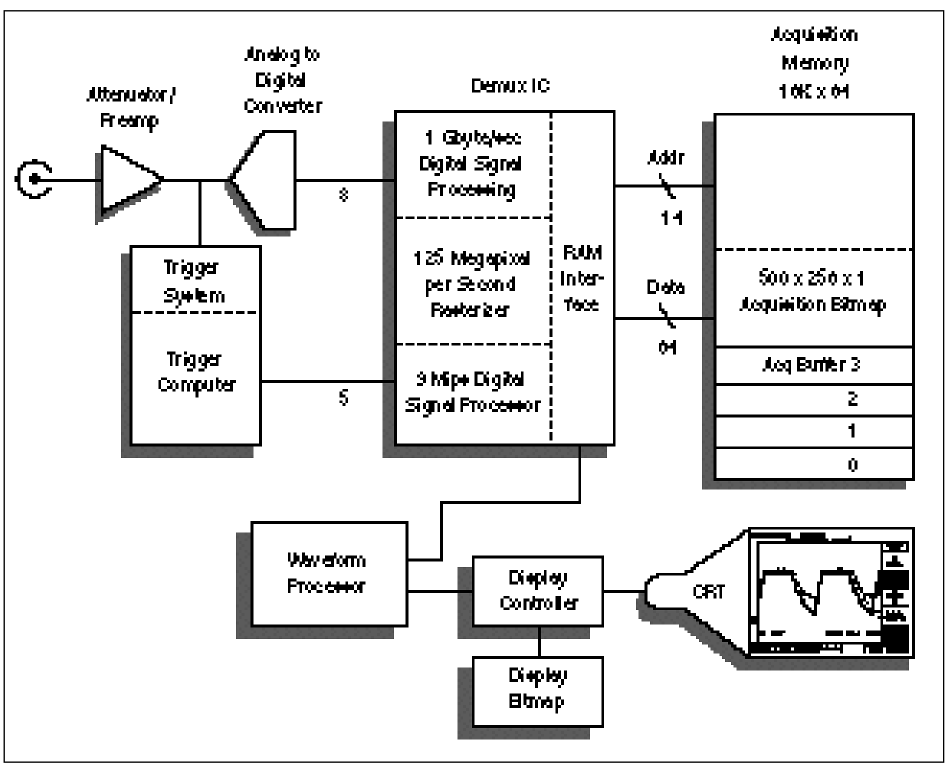

Figure 1. InstaVu acquisition block diagram.

Common DSO trigger rates (how quickly an oscilloscope can recognize trigger events), are much faster than their waveform capture rates. However, with InstaVu acquisition, the trigger rate is actually the limiting factor.

A New Kind of Demultiplexer

Much of the hardware necessary to implement InstaVu acquisition is integrated into the TDS 500B/TDS 700A demultiplexing IC. This "Demux IC" is a 360,000 transistor, 0.8 micron CMOS IC with 304 pins. It dissipates about 2.5 W when running at full speed.

Ordinarily, the only function of the Demux IC would be to demultiplex data from the analog-to-digital converter and store that data in high-speed SRAM. One third of the Demux IC is devoted to this purpose (see Figure 1). The remainder is split evenly between a high-speed rasterizer and a digital signal processor (DSP). The DSP is included for local programmability, mathematical algorithms, and trigger position computations. The rasterizer is the primary enabler of the high live-time DSO.

The rasterizer was designed to make efficient use of available memory bandwidth while operating on a 16 ns clock. This rasterizer is able to draw four acquisitions at once into a 500 x 256 x 1 bitmap. The bitmap is organized as vertical lines of 256 pixels so that adjacent bits in the memory correspond to vertically adjacent bits. Thus, drawing is done in a top-to-bottom, then left-to-right fashion so that each data point in an acquisition need be fetched only once. On the first pass through the bitmap, the rasterizer clears the contents of memory while turning on pixels that correspond to voltage levels of each of the four acquisitions it is rasterizing. On subsequent passes through the bit map, it reads the previous contents of the bit map, ORs in new

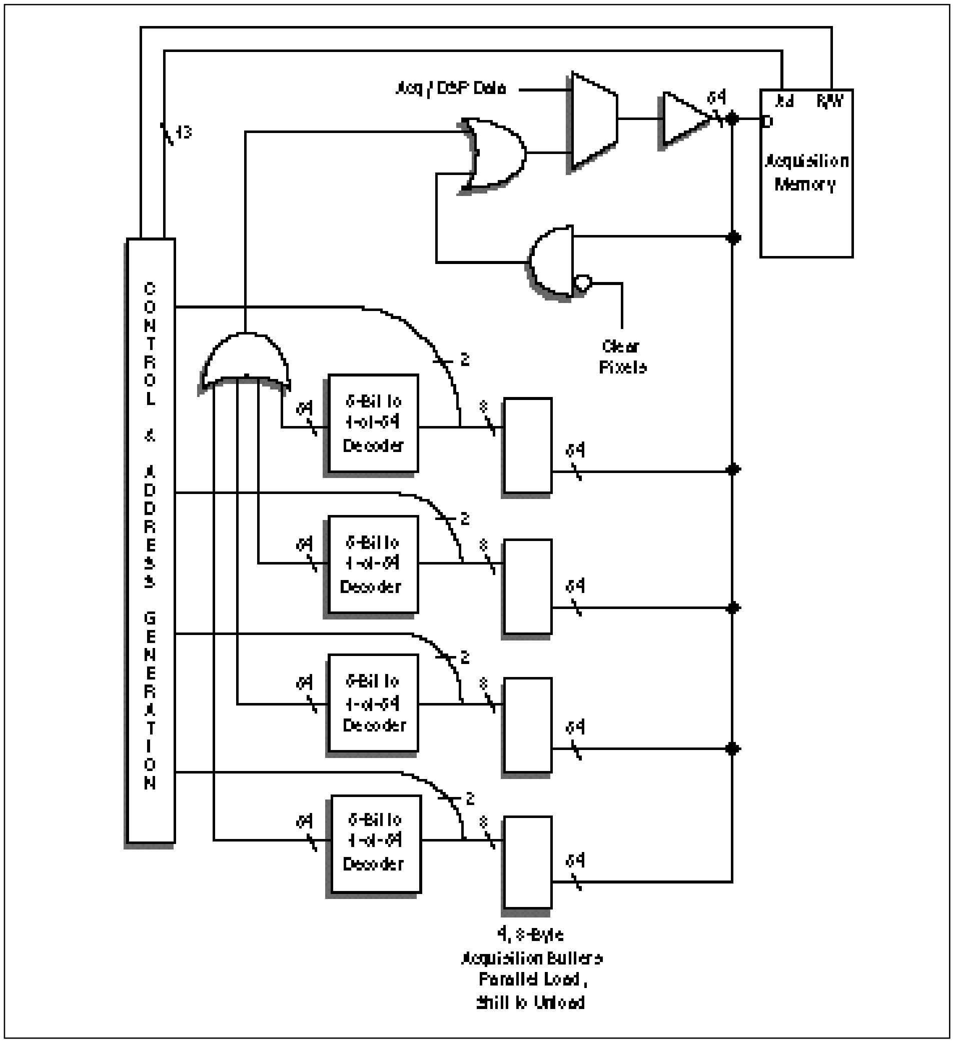

Figure 2. InstaVu Acquisition rasterizer block diagram.

pixels, and writes the result back into the same section of memory (see Figure 2).

The read-modify-write (RMW) cycles operate on 64 pixels at a time and each cycle is 32 ns long. Data for each acquisition that is being rasterized is fetched 8 bytes at a time as needed. These data reads are allowed 16 ns and are interspersed among the RMW cycles at times sufficiently prior to when the corresponding columns are modified so that the data can propagate through several pipeline stages. Each waveform is drawn into the raster in either dot or vector mode: In dot mode, a single pixel is turned on at the time and voltage level corresponding to a single point in an acquired waveform. In vector mode, all of the pixels between a lower and upper limit in a single column of the raster are turned on. This does not slow down the waveform capture rate.

If the four acquisitions lie in the same quadrant of the screen for a given sample time, 32 ns is required to update that time's raster column. On the other hand, if each of the four samples is in a different quadrant, or the rasterizer is operating in vector mode and a signal edge is being rasterized, four RMW cycles may be necessary and it would take 128 ns to update that particular column. If a user is looking at a logic signal, few of the time columns will require more than a single RMW. Presuming ten percent of the time slots require four RMW cycles, the RMW time for four 500-point acquisitions is 20.8 µs. The time required to read the data is 500/8 * 4 * 16 ns, or 4 µs and the total time for a single rasterization is 24.8 µs. This corresponds to 6.2 µs per acquisition.

This rasterization rate allows only about 100,000 acquisitions per second, which is still short of the maximum rate attainable by the best analog scopes. However, an analog scope's maximum waveform capture rate is only attainable when a single channel is used. When an InstaVu DSO acquires a single channel, greater "live" time is achieved by allowing each of the four channels to take turns acquiring a single input. Now, three rasterizations can be run while the input continues to be monitored. What's more, three channels can continue to take turns acquiring a single input while firmware is unloading the raster in the fourth channel. The TDS 500B/TDS 700A can perform over 400,000 full-screen (500-point) acquisition-rasterization cycles per second on a single channel (see Figure 3). This rate works out to 220 million pixels per second and is limited as much by the trigger system rearm speed as by acquisition system graphics performance.

Once the acquisition system is producing pixel maps, the instrument firmware can collect them and provide infinite and variable persistence displays. Thus, the scope can be left on overnight if a few tens of billions of acquisitions are needed, or it can be operated interactively to produce color-graded displays.

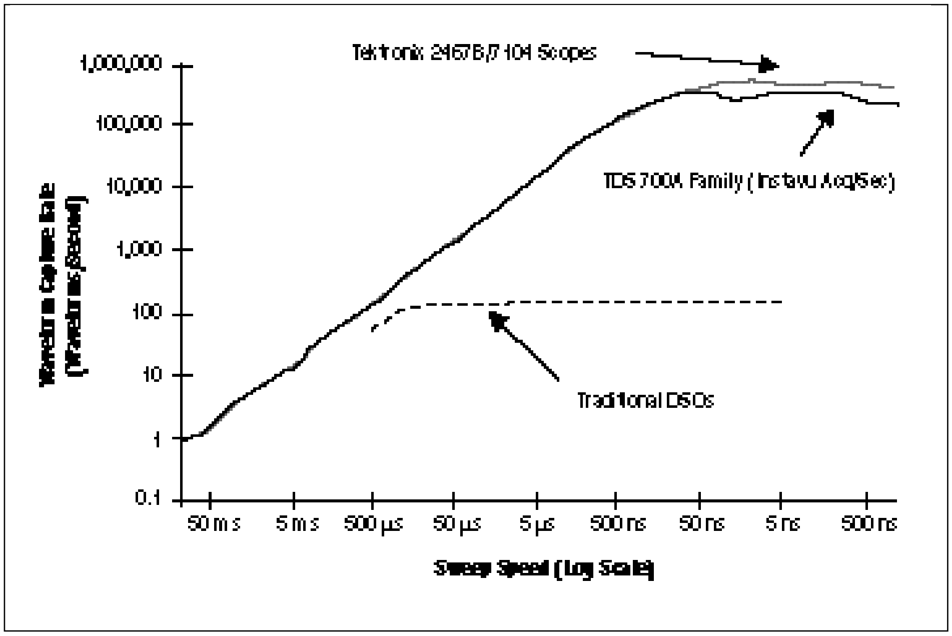

Figure 3. Waveform capture rate comparison between InstaVu acquisition, traditional DSOs, and the fastest analog scopes.

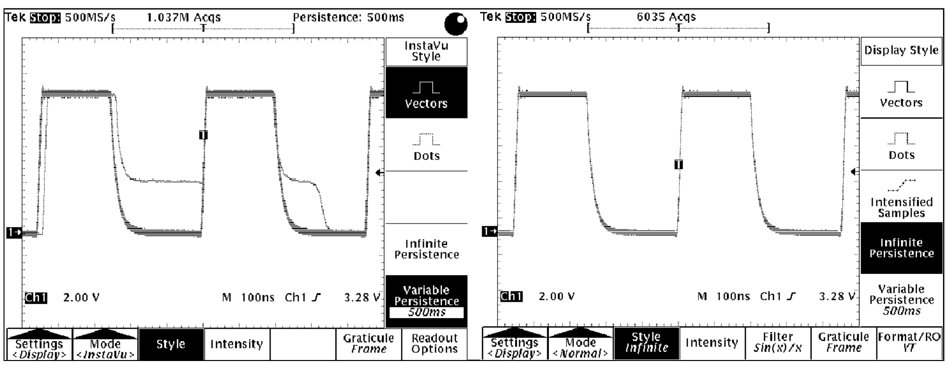

Figure 4. Signal acquired using the InstaVu Mode (left) displays waveform components not visible in the Normal Mode (right).

The Same Applications… Only Better

InstaVu acquisition gives the Tektronix TDS 500B and TDS 700A InstaVu DSOs better fault-finding capability than the best analog scopes. When used to verify clock and signal integrity, a TDS 500B/TDS 700A acquires and displays rare events and jitter without blooming, and shows aberrant signals with fine detail without the need of a viewing hood. The TDS 500B/TDS700A acquisition can be stopped when a glitch appears on its display and a hardcopy can be generated. Or, its advanced triggers can be set to trigger on the event once its presence and shape have been determined.

To debug high-speed digital systems, InstaVu acquisition instantly shows a true picture of crosstalk, jitter, and signal interference that previously could be obtained only with MCP-based analog oscilloscopes. The accessibility of InstaVu acquisition through a single front-panel button allows quick clarification of confusing displays often presented by previous DSOs.

Aliasing and modulation instantly appear in their true form with InstaVu acquisition, and complex waveforms such as video and radar signals can be visually assessed. This was previously possible only with an analog scope. InstaVu acquisition is the clear choice in any situation where enveloping or color-graded displays of timing or amplitude jitter are necessary. In system design or manufacturing, InstaVu acquisition scopes can rapidly display everything present in a signal, providing the user with an expedient and powerful means to analyze and optimize system operation.

The Proof's In The Viewing!

Does InstaVu acquisition provide improved display for difficult signals? The best proof is to see the actual results. Figure 4 shows the display improvement in a typical signal acquired in the Normal Mode and in the InstaVu Mode. To see the difference InstaVu acquisition can provide for your signals, contact your local Tektronix representative.

For further information, contact Tektronix:

World Wide Web: http://www.tek.com; **ASEAN Countries** (65) 356-3900; **Australia & New Zealand** 61 (2) 888-7066; **Austria** 43 (1) 7 0177-261; **Belgium** 32 (2) 725-96-10; **Brazil and South America** 55 (11) 3741 8360; **Canada** 1 (800) 661-5625; **Denmark** 45 (44) 850700; **Finland** 358 (9) 4783 400; **France & North Africa** 33 (1) 69 86 81 81; **Germany, Eastern Europe, & Middle East** 49 (221) 94 77-0; **Hong Kong** (852) 2585-6688; **India** 91 (80) 2275577; **Italy** 39 (2) 250861; **Japan** (Sony/Tektronix Corporation) 81 (3) 3448-4611; **Mexico, Central America, & Caribbean** 52 (5) 666-6333; **The Netherlands** 3 12 35 6 95555; **Norway** 47 (22)070700; **People's Republic of China** (86) 10-62351230; **Republic of Korea** 82 (2) 528-5299; **Spain & Portugal** 34 (1) 372 6000; **Sweden** 46 (8) 629 6500; **Switzerland** 41 (42) 219192; **Taiwan** 886 (2) 765-6362; **United Kingdom & Eire** 44 (1628) 403300; **USA** 1 (800)426-2200

From other areas, contact: Tektronix, Inc. Export Sales, P.O. Box 500, M/S 50-255, Beaverton, Oregon 97077-0001, USA (503)627-1916

ISO 9001

11/96 TD/XBS 55W-10341-1

Tektronix