WHITE PAPER

Agilent 54620/54640 Series Oscilloscope Display Mechanisms

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Background

Digital oscilloscopes have been evolving to address user's concerns of trust and confidence. These concerns pertain to aliasing, little Z-axis information, deadtime and dot rendering of waveforms. Various techniques and methods have been used to address these concerns, generally by emulating characteristics and behaviors of an analog vector oscilloscope. Innovations from Agilent Labs include variable persistence (54100A, 1984), color-graded variable persistence (54700 Series, 1991), high throughput plotting system (54620/54640A, 1991), near-zero deadtime acquisition system and interactive deep memory system (54645A/D, 1996). These are a few of the more visible leaps forward. Yet no product has taken a systemic approach to emulate a fuller breadth of analog scope mechanisms, until the new 54620/54640 Series oscilloscopes from Agilent Technologies was introduced. This white paper outlines some of the methods, both previous and new, deployed to emulate these analog scope mechanisms.

Goals

- Provide all of the positive capabilities and characteristics of analog vector oscilloscopes without the drawbacks of traditional analog oscilloscopes
- Maintain the positive aspects of the digitizing systems of the digital storage oscilloscope (DSO)
- Take the 'USABLE Deep Memory' system of the Agilent 54645s to a 'VIEWABLE Deep Memory' system

Analog Mechanisms

Statistical nature of the phosphor-vector CRT

- Z-axis Intensity dependence as a function of frequency of excitation — either from multiple waveforms or from one waveform.

  An additive display memory is realized by implementing a counter behind every pixel to track the relative number of times a raster pixel is 'excited' by waveform rendering operations. This mimics the build up of intensity, unlike many earlier digital-decay persistence methods. The 54620/54640 Series deep memory and high update rate results in a large dynamic range of intensities.
- Z-axis Intensity dependence as a function of the speed of the CRT beam (slew rate)

  In an analog oscilloscope, the beam is brighter when the trace is moving slower. For example, this can manifest as edges being dimmer than flat portions of signals or being able to discern the statistical nature of amplitude-modulated signals. The 54620/54640 Series oscilloscopes have an emulation technique for this mechanism. This is a critical mechanism needed to fully emulate an analog oscilloscope's display.
- Z-axis Intensity dependence as a function of time since last excitation (decay persistence)

  The 54620/54640 Series oscilloscopes use a phosphor CRT and has a very natural decay persistence.

Vector rendering

- An analog oscilloscope really displays waveform traces as vectors. Whereas most digital scopes render waveforms in an unnatural dot mode in order to provide some statistical content. Though many have vectors mode, there always seems to have been tradeoffs — in reduced update rate and loss of statistical density. The 54620/54640 Series is designed to allow its best rendering mode to be with vectors, with no sacrifice of waveform throughput or of waveform statistical image quality.

Inherent high BW at all sweep speeds

- An analog oscilloscope has essentially its full bandwidth regardless of sweep speed. For there is no alaising in an analog oscilloscope. But regardless of maximum sample rate, DSO waveform fidelity is reduced, meaning distortions and aliasing occur, at many sweep speeds due to fixed, relatively-short, record lengths. The new 54620/54640 Series scopes have very deep memory (up to 8 Megabytes/channel). They also have special algorithms that optimize the displayed record length, and hence signal bandwidth, at all sweep speeds to provide the maximum signal fidelity and bandwidth — without sacrificing waveform update rate or increasing inter-acquisition deadtime. The very-fast render engine — up to 25-Megavectors/second/channel — keeps this record length much longer than many fixed record length architectures.

Low deadtime

- The dead time, the time between triggered waveform traces, of an analog scope is minimized by its vector CRT retrace time, which is very low at just a few microseconds per waveform. In typical DSOs this time is the waveform rendering time, which can be quite substantial. While the waveform is being rendered, the acquisition memory cannot be used to acquire new data until the rendering is done. The 54620/54640 Series in essence has dual acquisition systems so one can be acquiring the next waveform while the current waveform is being rendered. This leads to a near-zero deadtime system at a great deal of sweep speeds. In addition, the plotted record length is optimized to be efficient and to utilize as much of the plot bandwidth as possible.

High-resolution trace placement

- An analog scope allows infinite placement of the trace. This allows for very smooth traces and the ability to resolve very fine signal details. DSOs have typically mapped traces onto 500 raster points of horizontal resolution. The 54620/54640 Series has taken advantage of the Raster CRT to provide 1000-point horizontal resolution. This resolution has markedly improved the ability to resolve signal details and reduce the rasterization side affects of spatial aliasing (jaggies). Simply by comparing a simple sine wave at a variety of sweep speeds, the benefits of the finer resolution become apparent.

Z-axis gray scale

- Analog scopes have literally infinite z-axis (intensity) resolution, and a wide dynamic range. This has been used advantageously by engineers for decades to reveal more signal information and details that help speed acquiring insight into the systems and circuits they are analyzing. Typical DSOs have one or only a few intensity levels. The new 54620/54640 Series utilize 32 visible levels of gray scale that are mapped onto a phosphor CRT. An internal intermediate rendering has a 12-bit dynamic range to enable detail capture for a wide variety of different signal-composition and trigger-rate scenarios.

Lively and interactive display

- An analog scope responds instantaneously to any user or signal change. The 54620/54640 Series continues to improve Agilent's innovative multiple processor architecture. In addition to the near-zero deadtime, 2-Megavector/sec acquisition and plot system, there is a more powerful processor dedicated to monitoring user changes and to responding quickly to these changes.

Summary

The above techniques are all brought together synergistically in the 54620/54640 Series oscilloscopes. They are all utilized in the normal, mainstream operating mode, as opposed to being available only in some special operating modes, with many tradeoffs. While we have other specialized modes and controls, we truly believe they will be seldom used due to the innovations and the systemic design of the waveform rendering described.

At Agilent Technologies we view this oscilloscope series as the most advanced and comprehensive oscilloscope rendering system on the market — certainly at its price points.