Advantages of All-Digital Processing in DTV Waveform Monitors

How important is accuracy in your work?

There are limitations in the waveform monitor displays that engineers, technicians, and artists use to examine digital video. In this document, we will examine the primary waveform monitor architectures, explain why what users see may not be what they get, and explore the advantages of an all-digital approach.

Types of digital waveform monitoring

Different kinds of waveform monitors use different methods to process and display incoming signals. These methods affect not only the appearance, but also the accuracy of the displays. To correctly interpret what we see, we need to know how the information got on the screen. There are three basic architectures used for monitoring digital video signals.

1) Digital Analog Hybrid Monitor Using a Vector Stroke CRT

This creates the traditional “green worm” display. The electron beam that excites the phosphors on a vector stroke CRT responds directly to changes in voltage. This gives the feeling of looking directly at the original analog waveform. When you examine the Digital Analog Hybrid Monitor architecture, however you realize that this is not the case. (See Figure 1). The incoming serial digital video signal is actually a sequence of samples. These digital samples are run through a Digital to Analog (D/A) converter and a then a low pass filter. This creates the continuous, analog flow that is much easier to read and interpret. That analog signal drives the vector stroke CRT to draw the display.

Analog displays can be inaccurate. Often users accept the display on faith, and do not take into account the drift and calibration variations that the analog circuitry adds. Digital Analog Hybrid Monitors are subject to thermal drift, can be difficult to keep in calibration, and have measurement results that are not repeatable. Careful instrument design can minimize these disadvantages. For example, the Tektronix WFM601A was very carefully designed to enhance temperature stability and repeatability. Even so, it is only two percent accurate for vertical deflection. Response and gain can vary from unit to unit.

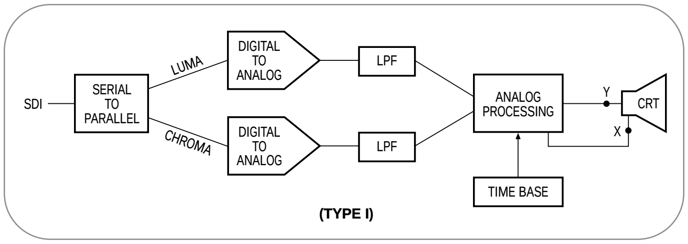

Figure 1: *The architecture of a Digital Analog Hybrid Monitor. The digital video signal is converted to analog information and interpolated through a filter. The analog information is processed into the signals that drive the vector stroke CRT display.*

2) Digital Analog Hybrid Rasterizer Using a Raster Scan Display

Digital Analog Hybrid Rasterizers further confuse the issue by adding another processing step. (See Figure 2). After constructing an analog representation, this architecture adds another opportunity for distortion by converting the signal back to digital to produce the raster scan display. There are advantages to using a raster scan display, which we will examine a little later. Nevertheless, this second sampling and conversion further removes the screen display from the original serial digital waveform and introduces new chances for error.

3) Full Digital Rasterizer Using a Raster Scan Display

The most elegant solution is to keep the signal information digital throughout the process. (See Figure 3A). In a Full Digital Rasterizer, all processing, including the rasterized display, is done in digital form. It uses a mathematical digital filter for interpolation rather than an analog filter. The process from signal to display is as direct as possible. Although there are no extra steps to induce distortion, such as creating an analog signal or to reconverting that signal back to digital, the filter will still create some artifacts, but they are smaller and repeatable. The result is closer to the goal of producing a precise, repeatable waveform trace on the display.

Displays: Raster Scan Digital Displays versus Vector Stroke CRTs

There are two basic choices of display technology for digital waveform monitors. The instrument designer can decide to rasterize the final information to enable a digital display, or the designer can rely on traditional, analog-style vector stroke CRT technology. The two methods have different effects on the quality and usability of the instrument.

Graticules and Text

Clear graticules and readable text allow users to make their observations quickly and accurately. The advantage of rasterization is that the graticule is infinitely customizable and appears in the same plane as the waveform-there are no problems with parallax. Vector Stroke CRTs typically use an etched glass graticule, which appears in a different plane than the trace. Most vector stroke CRT waveform monitors come with only a couple of graticules, limiting their use. Text is another problem for vector stroke displays. The beam is "shared," meaning that it has to drop away from portraying the waveform to physically "write" each letter. "Beam sharing" can cause dim or fuzzy text. A rasterized display, however, is essentially a high-resolution computer display. It writes the entire screen every time, eliminating the tradeoff between text and waveform. Rasterized text is sharp and easy to read, often providing a choice of fonts and sizes.

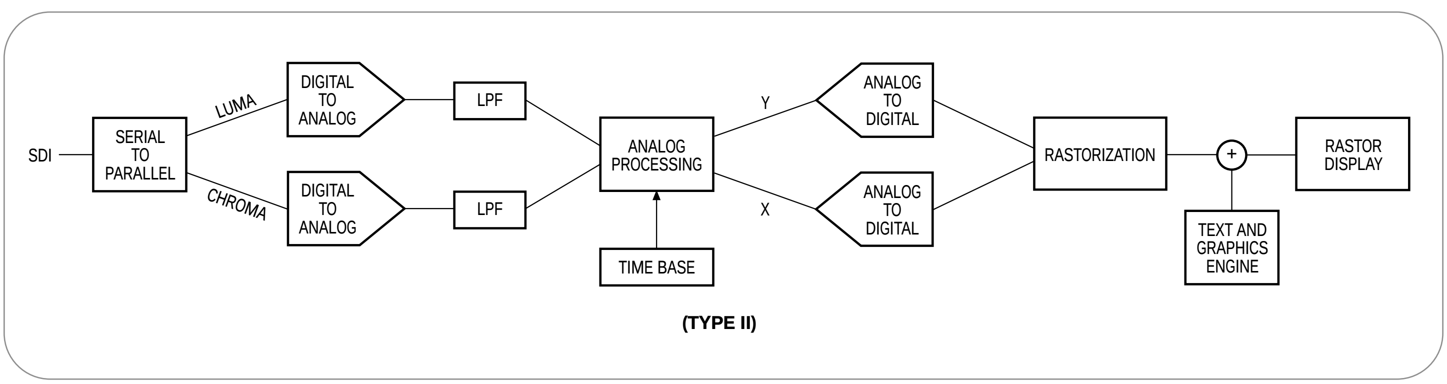

Figure 2: *The architecture of a Digital Analog Hybrid Rasterizer. The digital video signal is converted to analog information, interpolated through a filter and processed in the analog domain. It is then sampled and digitized to drive a raster display.*

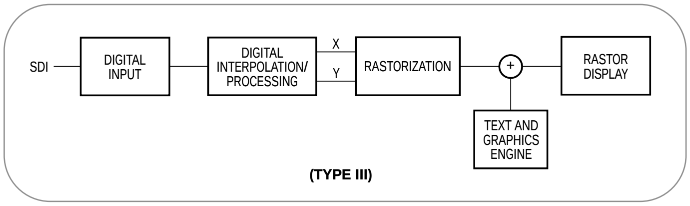

Figure 3A: *The architecture of a Full Digital Rasterizer. The digital video signal is run through a digital, mathematical filter. Precise digital processing is used to create its digital, raster scan display.*

The Advantage of Color

Color displays are simply not practical on vector stroke CRTs. Rasterized monitors, however, can draw on the full bag of tricks possible in computer graphics. They can use color to attract the operator's eye to areas of attention or to provide additional information.

Digital Storage and Remote Viewing

Since a rasterized display is already digitized, its information is readily available for digital storage and archival. The information can be transferred and processed by other digital systems or analyzed for trends over time. Users with geographic challenges, such as the need to monitor television transmitters or other facilities at widely separated points, can transfer the digital information to a centralized location for remote viewing. This can even be done over the Internet. Onsite users have the convenience of porting the display to large computer monitors for group training or for closer examinations of data. None of this can be easily done with vector stroke waveform monitors.

Size and Shapes

Convenience is another factor. Vector stroke waveform monitors are prisoners of their CRTs. Instruments have to be designed around what is necessary to keep traditional tube displays happy. Rasterization permits a revolution in size and shape. Manufacturers can choose to use a digital CRT for display or to take advantage of flat LCD screens or other technologies that reduce the size and weight of waveform monitors. In fully digital systems, manufacturers can take a "card cage" approach to add versatility and flexibility to their instruments.

Scintillation Noise

One advantage that vector stroke CRT's still enjoy is their freedom from "scintillation" noise. Scintillation describes the dots of sampled information that can appear around or in place of the expected drawn waveform on a rasterized display. This occurs when there are not enough points of reference for the rasterizing monitor's writing rate to merge into a continuous, waveform-like display. New, fully digital waveform monitors, however, have significantly improved their ability to interpolate between sampled points and have greatly reduced the scintillation effect. Some new models have plotting rates that are 10 to 15 times higher than "first" generation instruments. Many users have reported this display quality is "just as good as analog."

The Case for Full Digital Processing

Staying completely digital from input to rasterization offers significant advantages. Full digital processing technology introduces users to a variety of display options, as shown in Figure 3B. The WFM700 can generate a number of displays, such as waveform, vector, picture and eye either individually or collectively, as available in multimode.

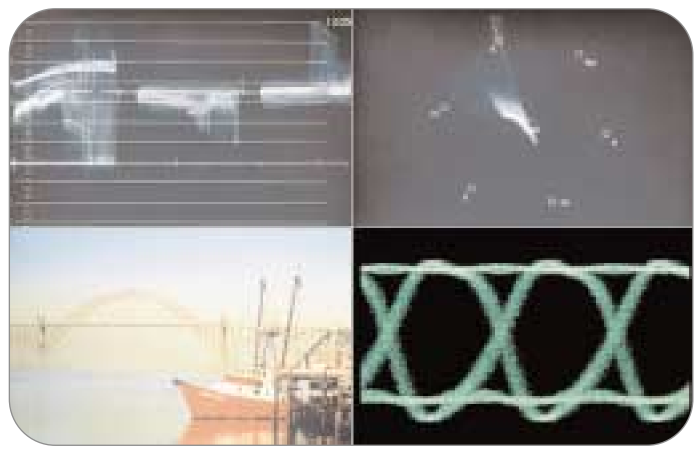

Figure 3B: *Contrast of the displays possible using a Full Digital Rasterizer as shown here in the WFM700 Series.*

Stable, Repeatable, No-Calibration Measurement

Converting sampled information into an analog representation of the digital waveform brings in an extra level of complexity-and error. Analog components are notoriously sensitive to temperature and other changes in operating conditions. Simply put, analog components drift. This reduces accuracy and reliability. Waveform monitors with analog circuitry require repeated calibrations over the life of the instrument. This is completely unnecessary in an all digital instrument. They are always "in cal." Users always know that 0mv and 700mv really are 0mv and 700mv, each and every time they use the instrument. Measurements are stable and repeatable from unit to unit.

Relative Freedom from Obsolescence

Analog instruments age physically and functionally. CRT's grow fuzzy and graticule illumination lights keep burning out. More importantly, their functionality stays the same even as the technological demands placed on their users evolve. An analog serial digital waveform monitor with limited capabilities stays an analog serial digital waveform monitor with limited capabilities – forever.

All digital instruments, however, have the potential to be upgraded and adapted as requirements change. Digital hardware can be designed to be re-targetable. Sometimes functionality can be added with nothing more than a download of new code. Other times a new function board could add depth. A fully digital waveform monitor, for example, might inexpensively adapted for HD-TV measurement or upgraded in other ways as the needs evolve. As microchip data densities and capabilities continue to grow, we can only expect an all-digital approach to get better and better. This trend can be seen in other television equipment such as fully digital studios, which have rapidly become less expensive and far more capable than fully analog studios.

Conclusion

Full Digital waveform monitors have definite advantages over Digital Analog Hybrid Monitors whether they use vector stroke or rasterized displays. While hybrid monitors are a mature technology, we can only expect fully digital waveform monitors to continue to become more powerful and less expensive. Some new models already have plotting rates that are 10 to 15 times higher than earlier instruments. These "third generation" monitors show much better trace density and grayscale, and significantly lower scintillation noise. Considering their accuracy and repeatability, the question is not whether to upgrade to all-digital waveform monitor technology, but when.

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