Basic Video Measurements Using a TDS5000 Series Digital Phosphor Oscilloscope

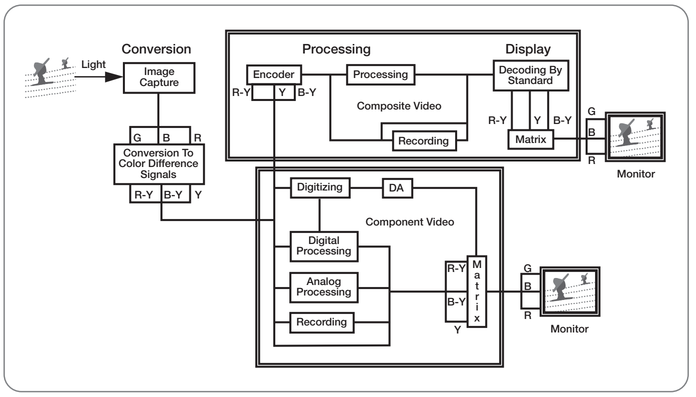
Introduction

Whether you're troubleshooting a video installation or designing a new set top box, making video measurements can be a major challenge. The TDS5000 Series oscilloscope's fast waveform capture rate, live analog-like display, dedicated video triggers, and long record length make it an ideal solution for video design and development.

Video waveforms are complex and frequently combine the signals that represent the video picture with the timing information necessary to display the picture. The signals can be in a variety of different standards and formats, each with its own characteristics.

Some video measurements require specialized instruments, such as industry-standard Tektronix waveform monitors, video measurement sets and vectorscopes. Many, however, can be made quickly and easily with a general-purpose oscilloscope—providing that the instrument has the right acquisition and measurement capabilities.

In this application note, we will examine critical video measurement issues and show how they relate to the capabilities of different kinds of oscilloscopes. We will also demonstrate how to make common video measurements using a TDS5000 Series digital phosphor oscilloscope.



► ***Figure 1.** Typical block diagram of a standard definition video system.*

A Video Primer

There are many different video standards and formats. Some systems, such as NTSC, PAL and SECAM, have been in use for decades and are commonly referred to as "standard definition" television. Newer systems, such as High Definition Television (HDTV), offer higher resolution by increasing the number of lines and pixels within the picture.

Video signals can originate from many sources, including cameras, scanners, and graphics terminals. Signals that have not been modulated on an RF carrier for transmission are called baseband video signals. These include most video signals used in analog terrestrial or cable transmission systems. Typically, baseband video signals begin as three component analog or digital signals representing the three primary color elements – the Red, Green, and Blue (RGB) components. These signals often go through many transformations before they reach the television monitor.

Figure 1 shows a typical video system block diagram. The steps will be similar whether the system is standard or high definition. Notice that the video signal changes formats several times between its source and its destination. To design and debug such systems, test equipment must be able to examine signals in each of the formats.

Conversion

The first format change occurs in the very first step, **conversion**. To make processing easier, the original RGB signal is usually converted into three component signals: the Luma signal or Y, and two color-difference signals derived from Y, usually B-Y and R-Y.

The color-difference signals may be modified, depending on the standard or format used. For SMPTE analog component systems, for example, they are scaled to become Pb and Pr. In NTSC composite systems, the color-difference signals are scaled to I and Q. For PAL systems they become U and V, and so forth. Once converted, the three component signals can be distributed for processing.

Processing

The controls we tweak on television monitors simply change how the image is displayed. In video **processing**, the video signals are edited, mixed or otherwise altered and prepared for transmission and viewing. The video component signals can be combined to form a single composite video signal (as in NTSC, PAL, or SECAM systems). They can be maintained separately as discrete component signals (as in RGB graphics and HDTV systems). They can be divided into separate luminance and chrominance signals (as in Y/C systems, such as in S-VHS or Hi-8). They may even be upconverted to HDTV signals.

Composite Video

Composite video signals are most common in traditional broadcast and cable TV applications. They are called "composite" because they contain multiple signal components combined into a single signal. In North America and Japan the NTSC standard defines the way that Luma (black and white information), chrominance (color information), and synchronization (timing information) are encoded into the composite video signal. In most other countries, the PAL and SECAM standards provide the same function. In these standards, the chrominance signals are modulated on a pair of color subcarriers. The modulated chrominance signal is then added to the luminance signal to form the active portion of the video signal. Finally, the synchronization information is added. Although complex, this composite signal has the advantage of being carried on a single coaxial cable.

Component Video

Component video signals, however, are preferred within television studios. They are simpler to generate, record, and process where many combinations of switching, mixing, special effects, color correction, noise reduction, and other functions may be applied to the signals. Since there is no encoding/decoding process, as in composite video, it is easier to maintain signal integrity in component video systems and equipment. This results in a higher quality image. The drawback to component video is that the signals must be carried on separate cables. This limits the distances over which the signals can be transmitted and requires careful matching of signal paths.

Y/C Video

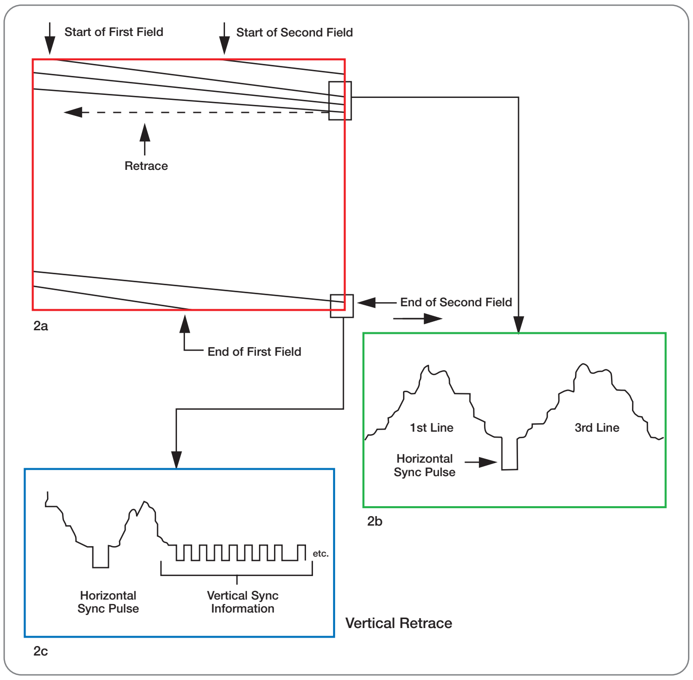
Y/C video is a compromise solution used in S-VHS and Betacam systems. Y/C is a component format that modulates the chrominance signals on a pair of color subcarriers, but keeps the chrominance signal separate from the luminance signal. This minimizes the luminance/chrominance artifacts of composite systems while simplifying the inter-channel timing issues of component systems. Y/C signals can be carried on a single special cable.

High Definition Television

The baseband signal can be processed into (or even originate as) **high definition television** signals. Obviously, upconverted standard definition signals cannot have the same quality and resolution as native high definition signals. We will take a closer look at HDTV a little later.

Display

After transmission, the objective of the **display** step is to accurately reproduce the processed image. In composite systems, the signal has to be decoded to component form and then translated to RGB format for display on the monitor. Component video signals go through less processing since they can be converted directly to an RGB signal for display.



▶ ***Figure 2.*** *The synchronization signals in an analog composite baseband video signal provide the timing signals necessary to reproduce a video signal on a display.*

Video Synchronization

To reproduce an image, both the camera and the video display are scanned horizontally and vertically (see Figure 2a). The horizontal lines on the screen might be scanned alternately – odd numbered lines first, then even numbered lines – as in interlaced scanning systems, or they might be scanned sequentially as in progressive scanning systems.

Both the camera and display must be synchronized to scan the same part of the image at the same time. This synchronization is handled by the horizontal sync pulse, which is part of the baseband video signal. The horizontal sync pulse starts a horizontal trace. During the horizontal blanking interval, the beam returns to the left side of the screen and waits for the horizontal sync pulse before tracing another line. This is called "horizontal retrace" (see Figure 2b).

When the beam reaches the bottom of the screen, it must return to the top to begin the next field or frame. This is called the "vertical retrace" and is signaled by the vertical sync pulse (see Figure 2c). The vertical retrace takes much longer than the horizontal retrace, so a longer synchronizing interval – the "vertical blanking interval" – is employed. No information is written on the video screen during the horizontal or vertical blanking intervals.

Each video standard defines a series of synchronization signals that control how the video signal is displayed. PAL signals display a video frame 25 times a second and a frame contains 625 video lines. NTSC signals display a video frame 30 times a second, but with only 525 lines. Some high-resolution computer monitors display more than 1000 lines with a frame rate of 72 times a second.

Component signals need timing signals too. The synchronization is often combined with one of the components (such as the green channel).

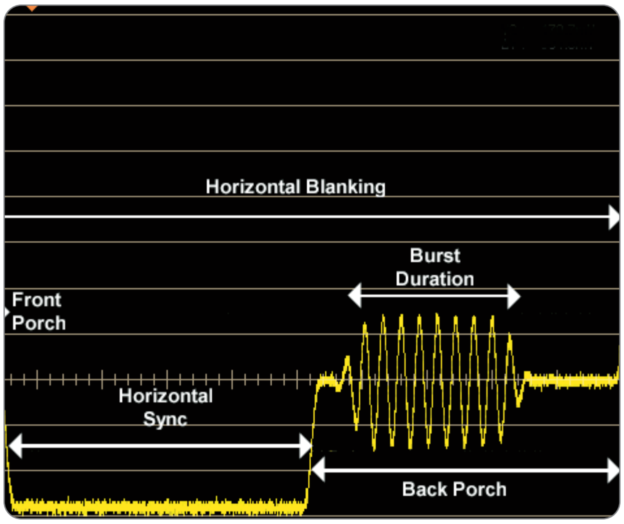


Figure 3a. *The horizontal blanking portion of an NTSC baseband video waveform.*

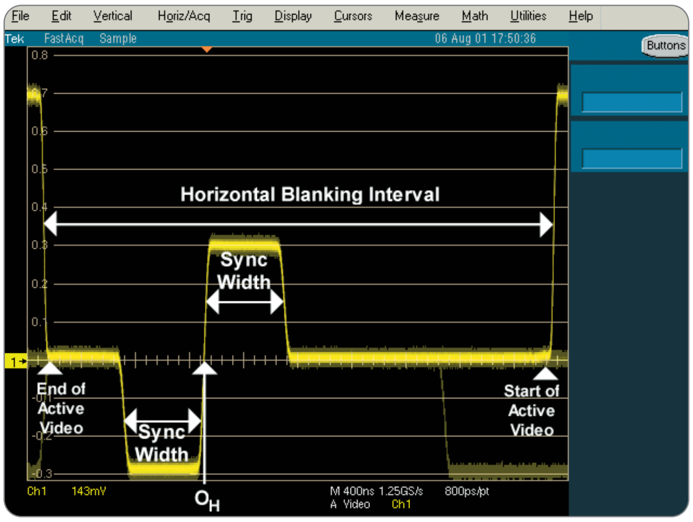


Figure 3b. *An HDTV baseband video waveform showing a tri-level synchronization pulse.*

HDTV

So far, we have concentrated on classic standard definition systems such as NTSC and PAL. High Definition Television offers higher resolution by increasing the number of lines and pixels within the picture. There are numerous HDTV standards. These standards are referred to by their characteristics. The first part states the number of active lines present in the signal. The second part specifies whether the picture is interlaced (I) progressive (P), or a combination referred to as segmented frame (sF). The final part refers to the field (for interlaced signals) or frame rate (for progressive signals) of the format, which defines the number of pictures displayed in one second.

HDTV Synchronization

A standard definition signal uses a bi-level synchronization signal that allows circuits to lock to the line and field rate of the television signal. Figure 3a shows the horizontal blanking portion of an NTSC baseband video signal with its bi-level horizontal sync pulse.

In HDTV, however, a tri-level sync signal is used as shown in Figure 3b. The pulse contains three levels –300mv, 0mv and +300mv with a timing interval dependent on the clock rate of the appropriate HDTV format. The timing and voltage cursors of the TDS5000 make it easy to measure these parameters.

Test Setup Requirements

Before we look at how to measure video signals, let's consider what measurement tools will serve us best to efficiently test a variety of applications.

Choosing the Right Oscilloscope

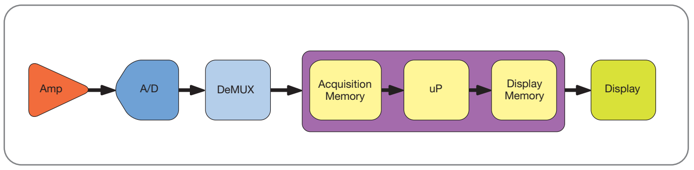
Oscilloscopes are universal test instruments. They create two-dimensional representations of the signal that allow us to "see" the waveform in the time domain. Not all oscilloscopes are created alike, however, and some are better suited for video applications than others.

Analog Versus Digital Storage

Until recently, designers and engineers had to choose between two types of oscilloscopes, analog real-time and digital storage (DSO). Since each had distinct advantages, many users tried to keep both types at hand.

Analog oscilloscopes provide fast capture rates and intensity-graded displays to bring a real-time "statistical" dimension to the waveform. Varying brightness levels clearly show the frequency of occurrence of different parts of the signal. Experienced users can quickly characterize the quality of the signal, spot anomalies, and get real-time feedback as they adjust their systems.

Digital storage oscilloscopes have their own advantages. DSOs offer automated measurements, sophisticated triggering, waveform storage, and hard copy capabilities that analog instruments cannot. DSOs, however, also have drawbacks. DSOs rely on a serial-processing architecture that requires microprocessor intervention in every step of the signal acquisition process (see Figure 4). DSO capture rates are too slow to accurately portray complex video signals and they lack the intensity-graded information so necessary for troubleshooting.



▶ ***Figure 4.*** *Serial-processing architecture of a digital storage oscilloscope (DSO).*

The Digital Phosphor Alternative

There is a third choice. Digital phosphor oscilloscopes (DPOs) combine the best of analog and digital storage oscilloscopes. DPOs offer all the traditional benefits of a DSO, from data storage to sophisticated triggers. In addition, they capture and display waveform information in three dimensions—amplitude, time, and distribution of amplitude over time—much like an analog oscilloscope. DPOs digitally emulate the chemical phosphorescence process that creates the intensity-grading in an analog oscilloscope's CRT.

The result is a live-time display that duplicates the feature-rich nature of the signal. DPOs provide unmatched insight into subtle patterns of behavior and dynamic characteristics of video signals.

The power of a DPO lies in its parallel-processing architecture (see Figure 5). The DPO rasterizes the digitized waveform data into a database called the digital phosphor. About every 1/30th of a second, a snapshot of the signal image stored in the digital phosphor is sent directly to the display system. Meanwhile waveform math, measurements, and front panel control are executed by the microprocessor in parallel to the integrated acquisition/display system. This direct rasterization of waveform data, and direct copy-to-display memory, removes the bottleneck in data processing common to DSOs.

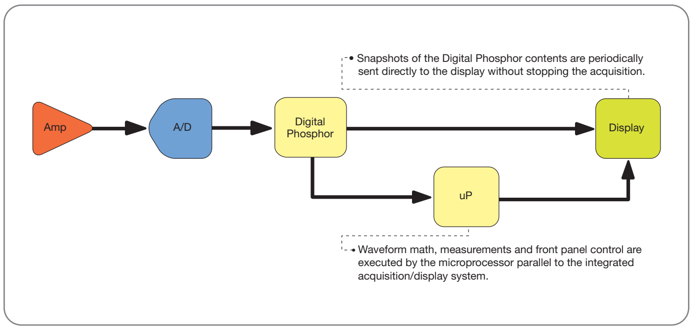


Figure 5. *Parallel-processing architecture of a digital phosphor oscilloscope (DPO).*

Some advanced DPOs feature a DPX™ waveform imaging processor. This proprietary ASIC enables the oscilloscope to capture waveforms far faster than DSOs. This fast waveform capture rate gives users maximum insight into signal activity. They gain a higher probability of witnessing transient problems such as runt pulses, glitches and transition errors. The TDS5000 Series achieves capture rates up to 100,000 waveforms per second.

Most DSOs, however, can manage only 100 to 5,000 waveform capture cycles per second. Some DSOs do 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 DPOs.

Analog oscilloscopes share the characteristics of fast waveform captures rates and intensity-graded displays with DPOs. Analog oscilloscopes, unfortunately, lack many basic features offered by DSOs and DPOs, such as automatic measurements, advanced triggering, waveform math, and waveform storage. In effect, DPOs combine the strengths of analog and DSO architectures, while avoiding their weaknesses.

Basic Oscilloscope Specifications

In addition to their architecture, oscilloscopes can also be described by their specifications. The first is usually **bandwidth**. A good rule of thumb is to use an oscilloscope with an analog bandwidth at least five times the bandwidth of the signal to ensure accurate representation of the signal. (A way to estimate the bandwidth of your signal is to divide the number 0.35 by the 10 to 90% risetime of the fastest signal component.) The bandwidth of an HDTV signal, for example, is typically 30 MHz. Therefore, an oscilloscope for HDTV applications should have bandwidth of at least 150 MHz. TDS5000 Series oscilloscopes offer bandwidths up to 1 GHz.

The **sample rate** dictates how fast the signal is sampled. For accurate reconstruction using sin (x)/x interpolation, your oscilloscope should have a sample rate at least 2.5 times the highest frequency component of your signal. If you are using linear interpolation, the sample rate should be at least 10 times the highest frequency signal component. TDS5000 Series oscilloscopes sample up to 5 GS/s, accurately representing even the most complex video standards.

An oscilloscope's **waveform capture rate** specifies the rate at which signals are acquired (in waveforms/second). As we mentioned, traditional DSOs capture signals at a much lower rate than analog oscilloscopes or DPOs. Slower rates can hide signal anomalies and cast doubt on your analysis. For example, to have a lively display of NTSC or PAL signals you need to see more than 15,000 waveforms a second. The TDS5000 Series features a maximum waveform capture rate of 100,000 waveforms a second, to enable a lively, information-rich display of your video signal.

The **record length** of a digital oscilloscope, expressed as the number of points that comprise a complete waveform record, determines the amount of data that can be captured with each channel. Since an oscilloscope can store only a limited number of samples, the waveform duration (time) will be inversely proportional to the oscilloscope's sample rate. Oscilloscopes with short record lengths force you to make a trade-off between signal detail and record length, or between sample rate and time duration acquired. You can acquire either a detailed picture of a signal for a short period of time or a less detailed picture for a longer period of time. Fortunately, the TDS5000 Series offers record lengths up to 8 MB, allowing you to capture long periods of signal activity without sacrificing signal detail.

Acquisition and Display Modes

As we discussed, the most critical display issue for many video engineers is to have an **intensity-graded display** mode. This familiar characteristic of analog oscilloscopes and waveform monitors shows the signal's statistical behavior by varying the intensities of the displayed samples. TDS5000 Series DPOs provide this intensity-graded display. The insight they give through qualitative intensity information enables users to visually assimilate subtle details and variations of the signal. Since most DSOs cannot acquire enough data to accurately represent the complex video signal, their users have to rely on special acquisition and display modes to attempt to compensate.

The basic acquisition mode of a digitizing oscilloscope is the **Sample** mode, where the waveform is sampled in time and the amplitude of each sample is digitized and displayed. With the use of interpolation, these samples can be connected to create a continuous waveform display. A DSO or DPO can also digitally process the signal before it is displayed, making complex measurements much easier.

For example, you can use the oscilloscope's **Average** mode to remove the effects of random noise and enable you to make precise amplitude measurements. The averaging function, usually found in the HORIZ/ACQ MENU, smooths the waveform by averaging multiple waveforms together.

HiRes mode filters the samples taken during an acquisition to create a higher-resolution, lower-bandwidth signal. On the other hand, you may want to see and measure a relatively small noise riding on a relatively large video signal. For such problems, a **Zoom** mode allows detailed signal examination and waveform expansion. You can expand and position the waveform in both the horizontal and vertical direction for precise comparison of fine waveform detail without affecting on-going acquisitions.

Other acquisition functions can make it easy to see noise anywhere in the video waveform. **Peak Detect** mode captures and displays the minimum and maximum values of a waveform, which shows its worst-case amplitude excursions. Choosing **Envelope** mode causes the oscilloscope to accumulate and display the minimum and maximum values of a series of waveforms over time.

Measurement Features

Well-designed measurement features can be very helpful for video measurement. **Video graticules**, for example, display the signal in a familiar format that helps you quickly characterize the signal. TDS5000 Series DPOs let you select a software graticule from the DISPLAY MENU. When you choose IRE or mV graticules, the oscilloscope automatically scales the video signal to the graticule you've chosen, making it easier to assess the captured signal.

Cursors make manual on-screen measurements faster and more accurate. The TDS5000 Series has controls for the cursors in the CURSORS MENU. **Horizontal** cursors allow you to measure signal amplitudes while **Vertical** cursors make it easier to measure signal timing. **Paired** cursors allow simultaneous measurement of relative amplitude and timing parameters on the same channel, while **Split** cursors allow you to make these measurements with the cursors on different waveforms.

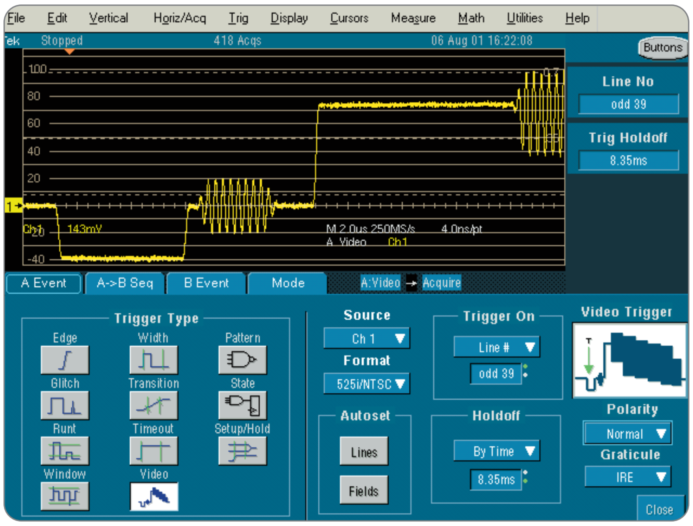
The processing power of a TDS5000 Series DPO allows you to automatically measure multiple signal parameters. For example, you can set the oscilloscope to check peak-to-peak amplitude, sync-pulse width, and inter-channel timing. To select and control **automated measurements** use the MEASURE MENU.

▶ ***Figure 6.*** *The Tektronix AMT75 (shown here with AFTDS adapters) provides precision termination for video applications.*

Signal Conditioning

Termination

Most video systems are designed to deliver a known amplitude signal into a specified impedance. Improper termination can degrade frequency response. At low frequencies, video measurement accuracy depends on terminating the signal into a precise resistance, usually 75 Ohms. At higher frequencies, the termination must match the impedance of the transmission line (usually coaxial cable). The termination impedance must have a precise resistance with negligible reactance (also known as maximizing the return loss and minimizing the voltage standing wave ratio). The AMT75, shown in Figure 6, is specified to 1 GHz and provides precision termination for video applications.



▶ ***Figure 7.*** *The TDS5000 Series' video trigger allows convenient selection of video standard, trigger source, holdoff, graticule type, and sync polarity. In this example, the oscilloscope has triggered on line 39 of the Odd Field of an NTSC signal.*

Video Clamping

A common signal anomaly in analog video measurements is the low-frequency hum produced by AC line voltage. If this hum is not removed, it causes the signal to drift up and down in the display and can cause the trigger point to vary. A video clamp (part number 013-0278-00) is available from Tektronix that effectively removes AC hum, as well as any DC offset on the signal. If the signal has been AC-coupled, the clamp also removes low-frequency variations which result as the average picture level changes. The clamp pod attaches to the input BNC connector and serves as a pre-processor of the video signal. It provides "back-porch" clamping on all standard video signals.

Triggering

The key to measuring video waveforms is getting a stable waveform. Before you can capture and analyze a signal, you must first trigger the oscilloscope on the signal. TDS5000 Series oscilloscopes feature advanced trigger modes to make this task much easier.

Analog Composite Video Triggering

To select the TDS5000 Series' **video trigger**, press the ADVANCED TRIGGER button on the front panel and choose "Video" from the on-screen trigger type menu. The default is to trigger on ALL FIELDS for 525-line, 60 Hz NTSC video. Use the drop down selection boxes to configure the settings to work with your video signal (See Figure 7). First, select the standard you are working with from the FORMAT drop down box. Choices include NTSC, PAL, SECAM, several analog HDTV standards, and "Custom" for non-standard video formats. Next, choose which component of the video signal to trigger on by selecting either Field, Line #, or All Lines from the TRIGGER ON selection box. Alternately, you can quickly configure the vertical, horizontal and trigger settings of the oscilloscope to view lines or fields by simply selecting the appropriate AUTOSET button.

HDTV Triggering

Different analog HDTV formats require different HDTV trigger settings. Formats are identified by the number of active lines, the type of scan, and the frame or field rate. The table on page 11 summarizes the HDTV formats supported by the TDS5000 Series.

Analog HDTV formats supported by the TDS5000 Series.

HDTV Format	Number of Active Lines	Number of Active Pixels per Line	Progressive, Interlaced, or Segmented	Frame/Field Rate	Total Number of Lines
1080i60	1080	1920	I	60	1125
1080i50	1080	1920	I	50	1125
1080p24	1080	1920	P	24	1125
1080p25	1080	1920	P	25	1125
1080/24sF	1080	1920	sF	48	1125
720p60	720	1280	P	60	750
480p60	480	720	P	60	525

Custom Trigger

Not every video system conforms to NTSC, PAL, SECAM or HDTV formats. As a rule, computer video monitors, medical displays, security cameras, and other self-contained systems are not designed to interface directly with broadcast video equipment and may not adhere to the normal 525- or 625-line standards. Consequently, it is sometimes necessary to use an oscilloscope to determine the line rate and a custom video trigger to trigger on that line rate.

The TDS5000 Series offers an easy solution. The first step is to capture a stable video waveform on the screen using the oscilloscope's Edge trigger (not Video trigger, since that function is designed for standard line rates). Second, using the Vertical Bars cursors, place one cursor on the leading edge of the first sync pulse and the other cursor on the leading edge of the second sync pulse. Observe the frequency listed in the cursor readouts. Third, press the ADVANCED TRIGGER button on the front panel, select Video, and then select Format>Custom. When you make this selection, Scan Type and Scan Rate appear as menu options. Select either progressive or interlaced Scan Type and select the Scan Rate range that includes the frequency you measured in the first step. You can select scan rates up to 65 kHz.

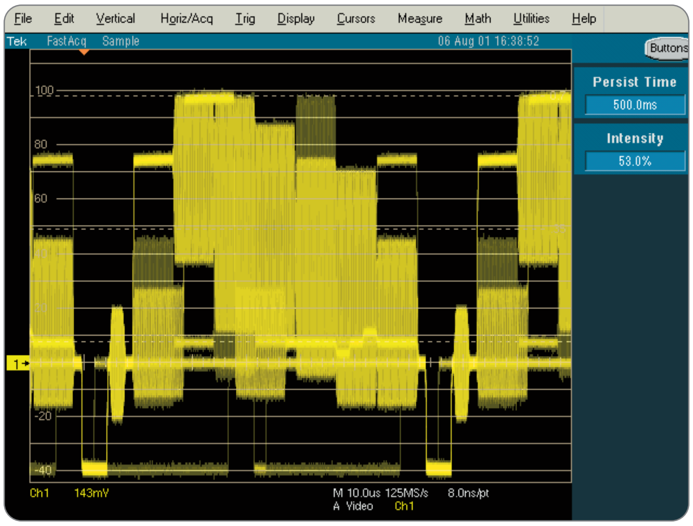


Figure 8. *A familiar video line rate display of signal amplitude vs. time on a digital phosphor oscilloscope illustrating the waveform monitor-like appearance of its intensity-graded display.*

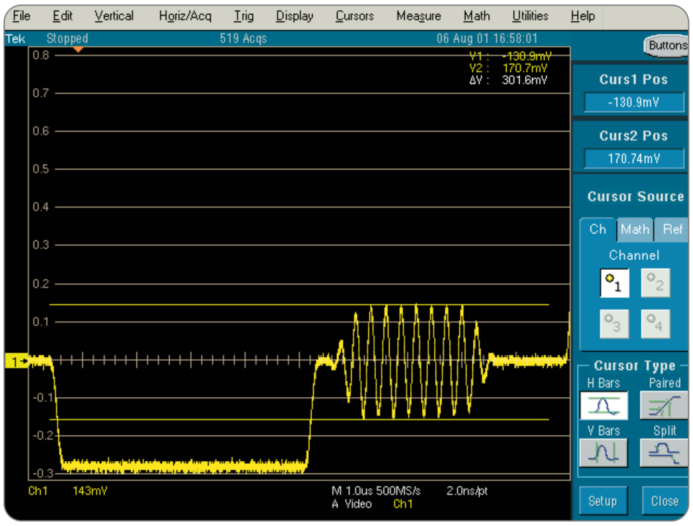
Common Video Signal Measurements

Video Signal Monitoring

When you are monitoring analog video signals, an oscilloscope with an intensity-graded display can be your most valuable debug tool. Subtle variations in the signal, which are not visible on a DSO display, can spell the difference between a video system that works and one that doesn't.

Line Rate Intensity-graded Displays of Live Video

The most basic analog video display is that of line signal amplitude vs. time. This display is easily accomplished by triggering on the leading edge of sync using an All Lines trigger mode. A digital phosphor oscilloscope with an intensity-graded display (and a waveform capture rate high enough to capture every line) provides a familiar line rate display similar to a waveform monitor (see Figure 8).



▶ ***Figure 9.*** *An example of amplitude measurements on an NTSC signal. The peak-to-peak amplitude of the burst packet can be measured visually with the graticule, with the horizontal cursors (note cursor readout in upper right corner), or with an automatic measurement.*

XY Displays of Chrominance

The oscilloscope's XY display mode allows you to display one signal against another in a manner similar to a vectorscope. For example, if you connect a B-Y signal to Channel 1 and an R-Y signal to Channel 2, you will see a radial display much like a vectorscope's display. The advantage to using a DPO is that its intensity-graded display shows details in the signal that are not visible on ordinary DSOs.

Standard Definition Analog Measurements

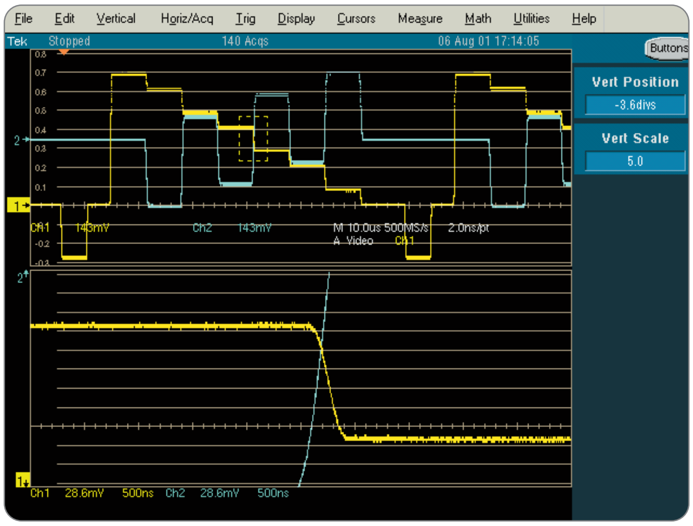
Amplitude Measurements

Amplitude measurements can be made a number of ways with an oscilloscope. For example, to measure the peak-to-peak amplitude of the NTSC burst signal, you can simply compare the signal to the TDS5000 oscilloscope's IRE video graticule (see Figure 9). You can also use the oscilloscope's horizontal cursors to make the same measurement. Finally, if you want to analyze variations over time, the oscilloscope can make a number of measurements automatically, and accumulate measurement statistics.

Timing Measurements

Timing measurements are especially critical for component analog systems. Small differences in timing between channels can cause fringing effects on the picture monitor. Displaying the relative timing differences between channels can be the most important use of a multi-channel oscilloscope. Figure 10 shows the relative timing of the luminance and one of the color-difference signals.

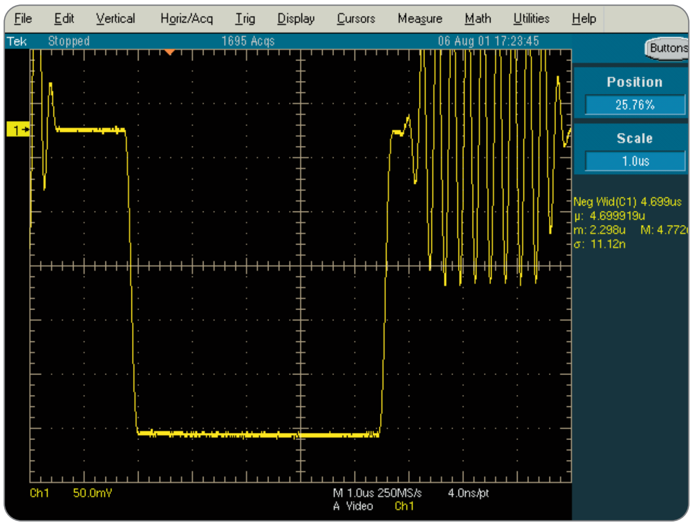
Unlike an analog oscilloscope, a DPO can also make timing measurements automatically and accumulate statistics on those measurements. For example, to measure sync width, trigger on the leading edge of sync, turn on HiRes acquisition mode, and adjust the horizontal and vertical controls so that the sync pulse fills most of the display. This optimizes the accuracy of the measurement system. Now turn on the negative pulse width measurement in the MEASURE MENU. Then enable the measurement statistics (see Figure 11) to monitor the mean (μ) and standard deviation (_) of the pulse width measurement.



▶ ***Figure 10.*** *Inter-channel timing is critical for component analog video systems. This example depicts the relative timing of the luminance and one of the color-difference signals. The upper half of the display shows the main acquisition while the lower half is zoomed in on the signal transition of interest.*

Analog HDTV Measurements

The same measurement techniques that we used on standard definition component signals apply to High Definition analog component signals as well. The wide variety of HDTV formats, however, does complicate some tasks. Engineers and designers may have to ensure that their products meet some or all of the specifications of the many analog HDTV formats. This makes the flexibility of the TDS5000 Series' HDTV triggers especially useful.

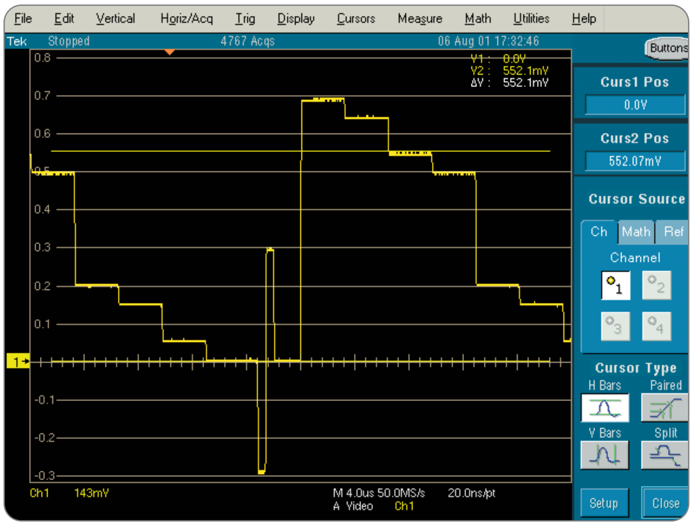


▶ ***Figure 11.*** *Automatic timing measurements provide an easy and accurate method of measuring basic signal parameters.*

HDTV Amplitude Measurements

Because the colorimetry used for high definition signals is different than in standard definition, the amplitude levels of the component signal will be different as well. To ensure that the signal levels are correct, apply a color bar test signal to the system that has defined values within each of the three component signals (YPbPr). Then measure the output of the system to make sure it complies with the standard by using horizontal cursors to measure the amplitude of each part of the color bar signal (see Figure 12).

Begin with the ADVANCED TRIGGER MENU. Select the proper HDTV format for the system under test. Then select "Trigger On All Lines." Go to the CURSOR MENU. Select "Horizontal Bars." Then position the cursors at the top and bottom of that portion of the signal. The exact measurement appears on the screen.



▶ ***Figure 12.*** *HDTV amplitude measurements can be quickly performed using horizontal cursors.*

▶ ***Figure 13.*** *Critical timing information of HDTV signals can be easily gained by using a TDS5000 Series' HDTV triggers and timing cursors.*

HDTV Timing Measurements

Timing information is also critical for correct operation of an HDTV system. To measure the horizontal-blanking interval, select a white field test signal that is active for the full sample of the line. Make your timing measurements at the 50% point of the amplitude of the blanking pulse. Place the TDS5000 Series' timing cursors to give direct readouts of blanking interval as in Figure 13.

Video Frequency Response

The 30MHz bandwidth of HDTV analog signals is significantly higher than standard definition bandwidth. You may need to make sure that the circuits used within your video system process the full bandwidth of the HDTV signal.

To test frequency response, apply a line sweep signal as a test signal to your system. This produces a sweep from 1-30MHz across the line of the signal. You will be looking for a 100% or 60% amplitude signal depending on the signal you applied. Ideally, you should observe a flat response at the output of the system as in Figure 14a. Processing equipment, however, can sometimes produce a roll off of the signal such as shown in Figure 14b. Perform amplitude measurements at the maximum and minimum amplitude of the signal using cursors. Then calculate the frequency response distortion using the following calculation.

$$20 \log_{10} |Min/Max| = \text{Frequency Response Distortion}$$

Figure 14a.

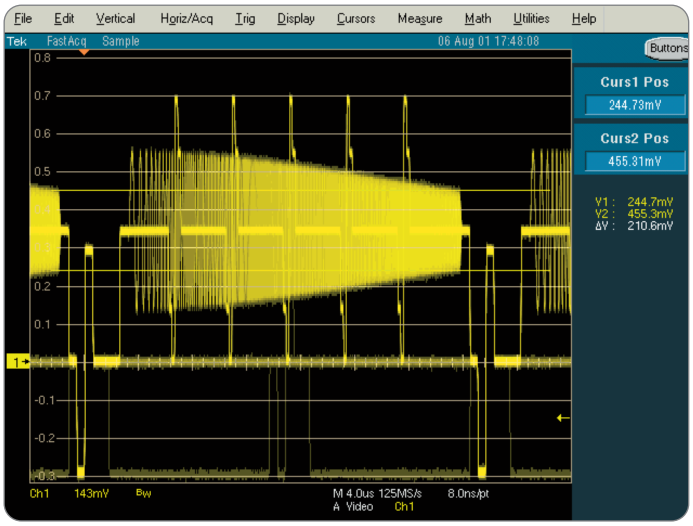


Figure 14b.

Figures 14a & b. *Video frequency response measurements compare the maximum and minimum amplitude of a line sweep test signal to calculate system distortion. Figure 14a shows a 60% line sweep of an analog HDTV signal with no frequency roll off—a pure signal. Figure 14b shows the effects of a roll off above 20 MHz.*

Conclusion

In this application note, we demonstrated the use of a TDS5000 Series digital phosphor oscilloscope to make a variety of video measurements that are common in standard and high definition systems. We illustrated how important an intensity-graded display, high waveform capture rate, and modern digital oscilloscope features can be to making those measurements. These capabilities make the TDS5000 Series the tool of choice to debug, characterize, and verify video circuits and systems.

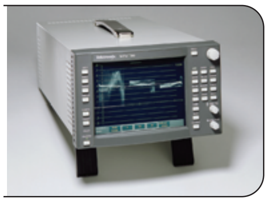
Superior Video Design, Measurement and Monitoring Solutions

TDS5000 Series DPO

The TDS5000 Series oscilloscope's fast waveform capture rate, live analog-like display, dedicated video triggers, and long record length make it the ideal solution for video design and development.

TDS3000B Series DPO

The TDS3000B Series oscilloscope offers automatic anomaly detection and two video application-specific modules in a lightweight, battery-capable design at an affordable price - ideal for video testing and troubleshooting.



WFM700 Waveform Monitor

The WFM700 is a modular, multi-format, in-depth measurement tool for HD/SD signals. This reliable, easy-to-use instrument offers a configurable, modular architecture that allows it to grow with your needs, and delivers both proprietary, industry-standard displays and eye pattern and jitter measurements.

VM700T Video Measurement Set

The VM700T is a total solution for your baseband video and audio measurement needs. Its fully automated measurement capabilities create the standards for video transmitter measurements and provide virtual real-time graphic displays of results, making it a superior solution for equipment manufacturing and research and design.

For Further Information

Tektronix maintains a comprehensive, constantly expanding collection of application notes, technical briefs and other resources to help engineers working on the cutting edge of technology.

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