Technical Brief

Tektronix
Test and Measurement

TDS 400 Video Measurements

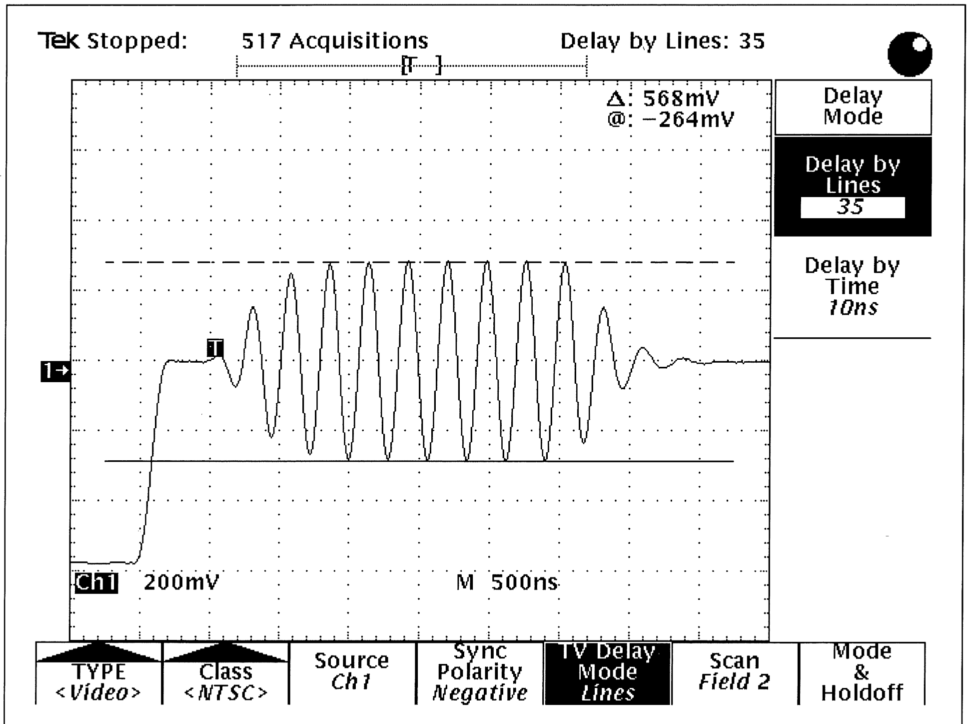


Figure 1. Video applications challenge the abilities of oscilloscopes because they contain many timing events and multiple frequencies, such as this

Video applications are characterized by very complex waveforms comprising multiple signal frequencies and timing events. To capture and measure them, you need powerful instruments with features tailored for video signals. At the same time, video applications use a variety of standards and architectures. Therefore, you also need a general-purpose instrument that can provide accurate information, quickly, regardless of what variation of video signal you are using.

Wide variety of TV standards. For broadcast and cable TV applications, you are most concerned with meeting specific signal standards. In the U.S. and Japan, the NTSC defines the way that color, luminescence, and video timing information are encoded on the carrier signal. In Europe, the PAL standards provide the same function. Video applications may also need to adhere to other, less widespread formats, such as SECAM within France.

Each of these standards has specific waveforms and signals of interest. For example, sync pulses define the beginning of fields and lines, useful for finding specific information on the TV signal. A general-purpose instrument needs to be able to recognize and act upon these signals to be useful for designing, debugging, and servicing video equipment.

Custom video applications. Other video applications have nothing to do with broadcast standards. The most prominent examples are computer system displays for personal computers and work stations, and for other systems that display information on video screens, like retail terminals.

Since the signals do not need to be transmitted long distances, these applications usually use less complex encoding than the broadcast applications. The intensity and color of the video image signals remain in the three component colors of the monitors: red, green, and blue. For custom video applications, the challenge is to correlate the simultaneous information on the three component signals with one another, and with other signals in the system.

Complicating this challenge is the range of resolution of custom video monitors, unlike the standards in broadcast video. For example, lower-priced PCs may display information on a display in a grid of 640 pixels on 350 lines, refreshed at 60 Hz. High-resolution monitors for image processing, on the other hand, may display 1024 pixels on 1280 lines, with potentially higher refresh rates. This range of resolution results in a wide range of line frequencies which you may have to work with.

Similarly, custom video applications have the option of determining how lines are written to the video screen interlaced or non-interlaced. This becomes another factor in trying to get information out of the signals.

General-purpose scope provides flexibility for design, debug, service. With this range of signal rates and formats, a general-purpose instrument can cover all types of video work that you may do: designing video applications to make sure that circuits are meeting design specifications; debugging video applications, to pinpoint anomalies in signal amplitude, phase, and reproduction; and servicing, to respond to any problems with an instrument that can capture and display a range of signal types.

This technical brief will demonstrate how the TDS 400 Series of digital oscilloscopes can satisfy most measurements for video design, debug, and servicing. In particular, its advanced triggering capabilities help you get stable, meaningful waveforms. High signal fidelity gives you confidence in what you measure. And its ease of use helps you quickly locate and measure the information you need on almost any video signal.

Making basic video measurements.

First, the TDS 400 Series makes it easy to get standard waveform displays. From these displays and measurements, more advanced measurements naturally follow. This section covers the basic measurements, using the NTSC standards as an example.

Wide spectrum of video signals. A typical TV spectrum includes the following frequencies (Figure 1): 30 Hz frame rate, 60 Hz field rate, 15 kHz line rate, chroma frequency at 3.579545 MHz for NTSC, and luminance frequencies and noise up to 8 MHz.

In many digital scopes, the TV signal's wide spectrum results in aliasing as a normal part of many measurement displays. For example, a video waveform display suitable for measuring line period doesn't contain enough points to accurately resolve the chroma signal. On the other hand, a sweep speed fast enough for sufficient resolution of chroma levels can only present a short portion of a line. Fortunately, the selectable record length and 100-MS/sec digitizing rate of the TDS 400 make it simple to get either type of display at the push of a few buttons (Figure 2).

What's more, some digital scopes have difficulty displaying at reasonable repetition rates the chroma-signal phase difference between both odd fields or both even fields. With its sophisticated video triggering circuitry, the TDS 400 can give you a stable display for distinguishing any portion of a video signal.

Getting a stable waveform. The first step toward measuring video waveforms is capturing the portion of interest. To enable the TDS 400's video triggering feature, you select "Video" from the on-screen trigger menu. This selection automatically sets up the scope to trigger on 525-line, 60-Hz video signals like NTSC. It also directs the instrument to lock on the odd interlaced color fields using negative sync pulse polarity. Using the "Class" option, you can also direct the scope to trigger on PAL, SECAM, and custom video signals.

To alter these default settings, you also use the menus and screen-side controls. Select "Scan" on the main menu and choose the odd or even fields on the side menu. Or select "Sync" and change to positive sync if the portion of the circuit you are debugging has inverted the video signal.

To provide a stable waveform, the TDS Series incorporates a fast DC restoration circuit in the trigger path. This circuit ensures that the scope triggers on the same portion of the video waveform at every repetition. At the same time, the scope's wide dynamic range and long record lengths also improve accuracy and resolution.

Much of the information of interest in a video signal is on the specific video lines. To find a particular line within a field, you can select the "Delay By Line" option in the side menu. You then turn the general-purpose knob above the side menus to display any particular line from the 2600 subsequent lines – or at least one color frame – that this feature can distinguish. The specific line number appears on the screen to help you keep track.

Identifying individual color fields. For many measurements, the information you need is in a specific color field. NTSC color TV requires four sequentially numbered fields to encode color information (Figure 3). Pulses at the beginning of each field identify if the field is even or odd; the input circuitry of the TDS 400 can decode this information. To distinguish between color fields 1 and 3, or between 2 and 4, requires looking at the color field's chroma burst. The signal is 180° apart between fields 1 and 3, and between fields 2 and 4.

The default hold-off of the TDS 400 ensures that you have a stable image of one of the four color fields (Figure 4a and 4b). Using the chart in (Figure 4c), you can easily determine which field the TDS 400 is displaying.

The TDS 400 Series has an extremely long record length, user-selectable up to 5000 points standard or 30,000 points using the Option 1M. You can capture up to five complete lines and make measurements across them, including selecting any line for looking at the color burst. The ability to scroll extensively around your trigger point can reduce the number of times you need to re-orient the scope to new portions of the video waveform.

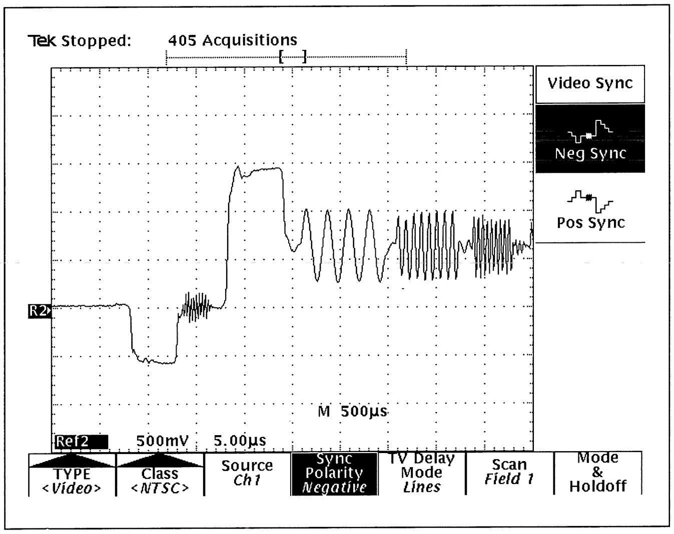


Figure 2. The 100-MS/sec digitizing rate and built-in video triggering of the TDS 400 captures and displays a waveform, such as this live video waveform, at the push of a few buttons.

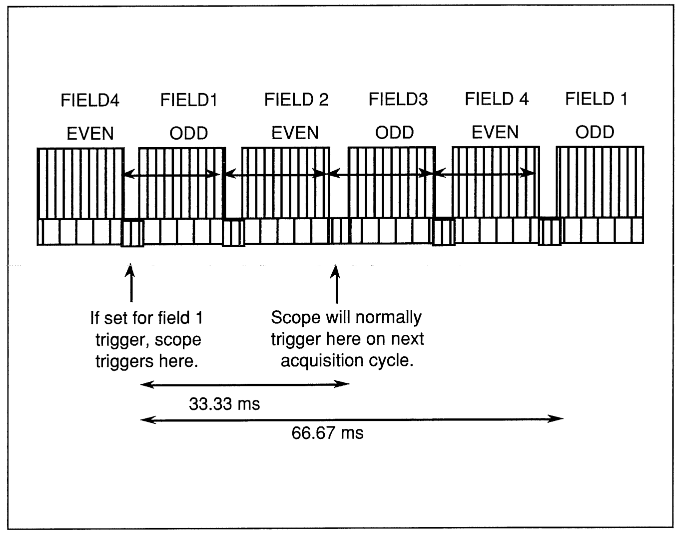
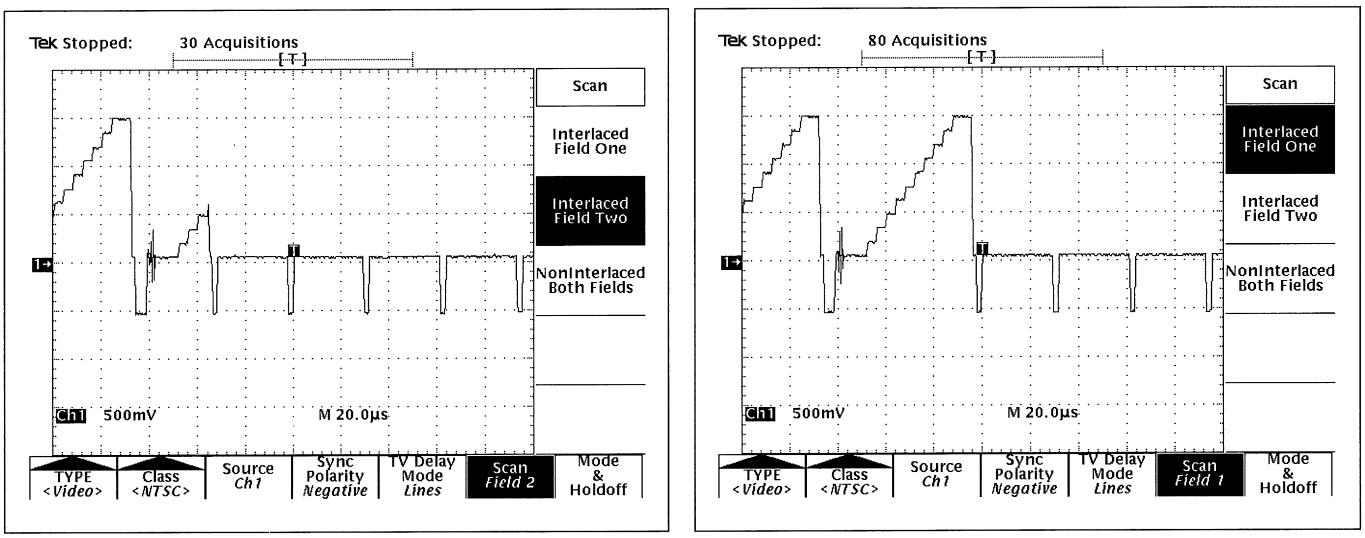


Figure 3. NTSC color TV requires four sequentially numbered fields to encode color information.

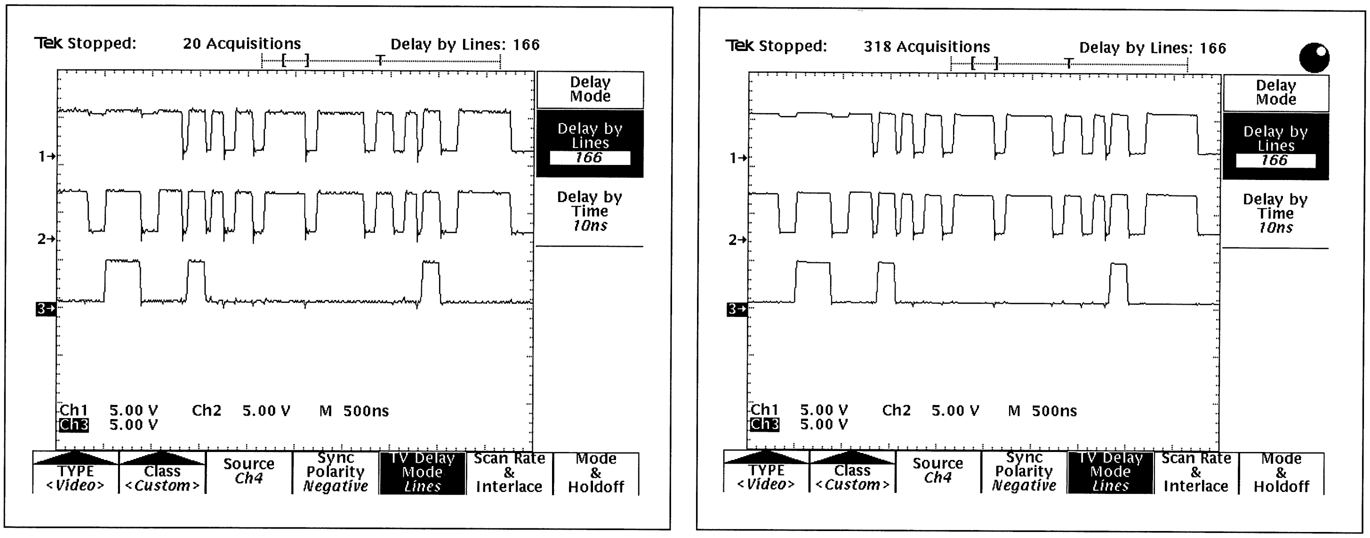


(A) (B)

Figure 4. The TDS 400 series locks on to either even or odd fields (A) and (B). You can then use the chart in (C) to determine which color field you are observing.

If the first zero crossing is ...	And the line number is ...	And the selected field is ...	Then the color field is ...
Positive	Even	1	1
		2	4
	Odd	1	3
		2	2
Negative	Even	1	3
		2	2
	Odd	1	1
		2	4

(4C)



(A) (B)

Figure 5. The TDS 400 averaging function removes much of the noise in a signal (A) to create a display that is easier to measure (B).

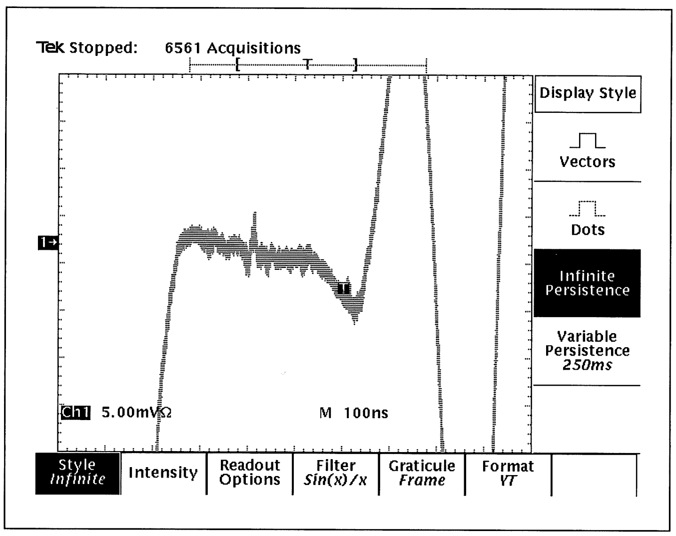


Figure 6. The Infinite Persistence mode captures long-term variations to simplify measurement of varying voltage values, like the noise on this live video chroma signal.

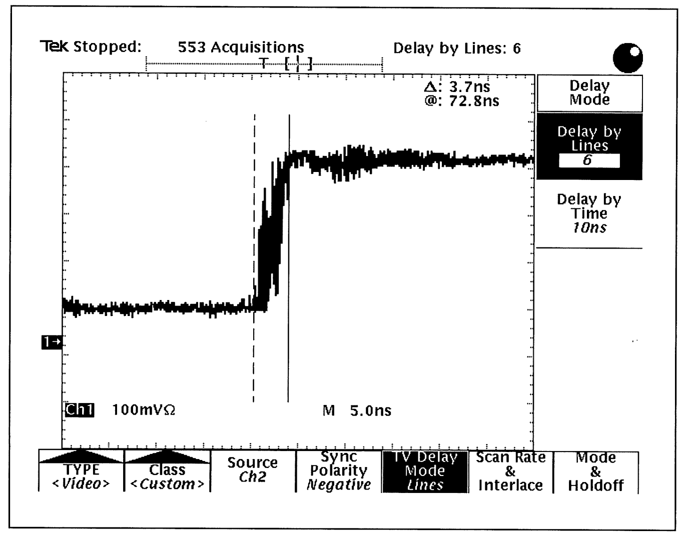


Figure 7. The envelope function displays the maximum and minimum values of a waveform over a period of time. In this case, you can easily measure the jitter on the sync pulse.

Making accurate measurements. Measuring any video signal amplitude is now straightforward. With a standard test signal inserted into the system, you can measure the signal as it travels through the system. You can determine any deviations from the standard waveform that may be caused by the system.

The useful storage bandwidth and measurement features of the TDS 400 Series make it easier to make accurate measurements.

For example, using the standard video test signal, you can use the scope's averaging and cursors to make accurate measurements of video signal amplitude. A typical video signal may have enough noise to make precise voltage levels difficult to determine. The averaging function – a feature under the "Acquisition" menu – considerably smooths the waveform for this measurement (Figure 5). Then you can instantly bring up horizontal cursors to measure the voltage steps within the waveform.

On the other hand, sometimes noise on the video waveform is exactly what you want to see and measure. The difficulty in noise measurement is often the small size of the noise component relative to the video signal. For such problems, the TDS Zoom preview mode allows detailed signal examination and waveform expansion. You can expand, compress, and position the waveform in both the x and y directions for precise comparison of fine waveform detail without affecting ongoing acquisitions.

In one example, the noise on the leading edge of a chroma burst, which is much smaller in amplitude than the burst, can be made much larger on the screen using Zoom than it can with vertical scale adjustments. All you need to do is hit the "Zoom" button on the TDS 400; the scope increases the display sensitivity – increasing the waveform's vertical displacement – without affecting the attenuation of the signal in the scope's input circuitry. You can also measure long-term noise variations more easily through the Infinite Persistence mode (Figure 6).

A similar function makes it easier to measure noise anywhere in the video waveform. Choosing the "Envelope" function from the "Acq Modes" side menu causes the scope to display the minimum and maximum values of the waveform across a number of records that you define (Figure 7). This gives you a representation of the minimum and maximum excursions of the waveform over a period of time. You can measure the jitter on a line's chroma burst, for example, using the Envelope function and vertical cursors placed at either side of one voltage value of the color burst.

The features of the TDS also assist measuring the Vertical Interval Test Signals (VITS) and Vertical Interval Reference Signals (VIRS). VITS and VIRS waveforms place one, two, or three test signals onto one line in one field. Observing part of one line and making measurements is difficult on a conventional real-time analog oscilloscope, unless it is in a darkened room. The digital TDS Series displays these waveforms brightly in any room light.

All functions easily accessible. To simplify use of all its triggering modes and measurement functions, the TDS Series user interface uses on-screen menus and icons. Each function is described and differentiated by a graphical representation of the task selected. Setup conditions, acquisition modes, and other functions are immediately recognizable under this system of icons. The scope's VGA quality display resolution makes all waveform, icon, and text information sharp and clear.

Custom and advanced video applications

For video applications not intended for broadcast, many of the preceding instructions still apply. The triggering features of the TDS help you quickly display the signal of interest. And its measurement features ensure fast, accurate measurements. The primary differences are the line rates and composition of the signals.

Range of line frequencies. The first difference is capturing specific waveforms at different line frequencies. The line rate depends on the number of lines displayed on the monitor. This number is set by the applications as follows:

- TV monitors – 15-20 kHz
- Personal computer monitors – 20-45 kHz
- High-resolution monitors – 45-64 kHz

The TDS 400 trigger can work with line rates up to 64 kHz. Selecting "Custom" under the "Class" main menu automatically configures the scope to trigger on non-standard video signals. Choosing "Option" in the main menu brings several ranges of line frequencies available for your selection. Simply select one of the ranges to set the scope for triggering on the appropriate fields and lines within your custom video application.

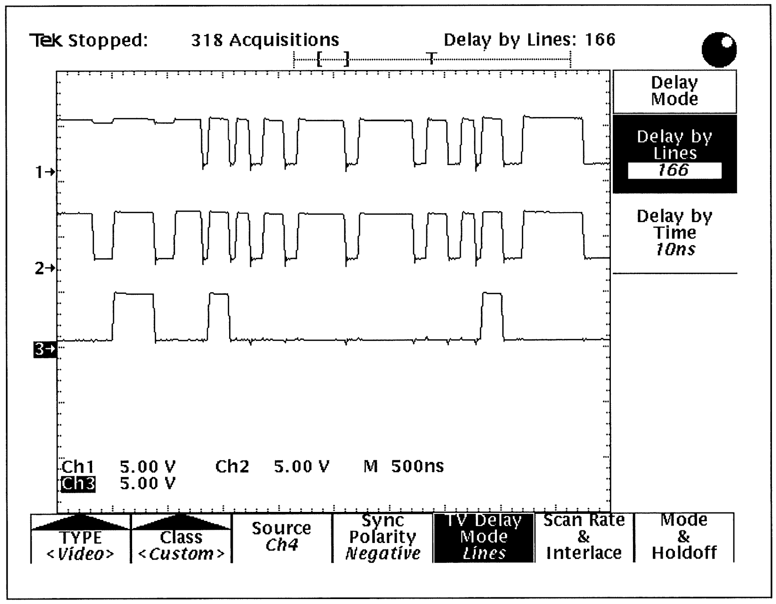


Figure 8. For RGB applications, four-channel operation can display all three video signals while triggering off a fourth, such as a video timing signal.

You also can use the TDS for interlaced and non-interlaced signal analysis. You can select interlaced or non-interlaced field configuration under the frequency-range menu.

Working with RGB systems. The second difference between standard and custom video applications is that the custom systems may not have to encode all information onto a single signal. Each primary color – red, green, and blue – comes from a separate source, and requires no color burst. The challenge to the engineer is to observe and measure all three channels at the same time, usually with a reference to some fourth signal like a clock.

The four-channel operation of the TDS provides ample capabilities for debugging the RGB system. You can hook up the RGB lines to three channels, and the fourth channel to a clock or reference signal (Figure 8).

This operation is also appropriate for monitoring the demodulation within a video system. You can inject a test signal into the demodulator circuit and attach the TDS scope to the RGB signals running to the monitor. By displaying all three components superimposed, you can detect differences in amplitude between the components, or variations from expected amplitudes, which indicate problems in demodulation.

The TDS 400 can trigger on positive or negative sync pulses, to help with subsequent measurements anywhere in the video application.

This general-purpose scope also debugs digital control circuits. So if RGB system problems are caused by control circuitry within the application, the TDS 400 can look directly at that circuitry as well.

Summary. Although video signals exhibit complexity in both the time and frequency domains, the TDS 400 Series demonstrates how a general-purpose instrument can still assist your video system designing, debugging, and servicing tasks. The TDS 400's sophisticated video triggering and high-speed digitizing make sure you can capture and display any part of the video waveform you need. And its accurate measurement features, all easily accessible through on-screen menus, help you pinpoint anomalies quickly. With the TDS 400, you can work with applications spanning a variety of signal standards and architectures.

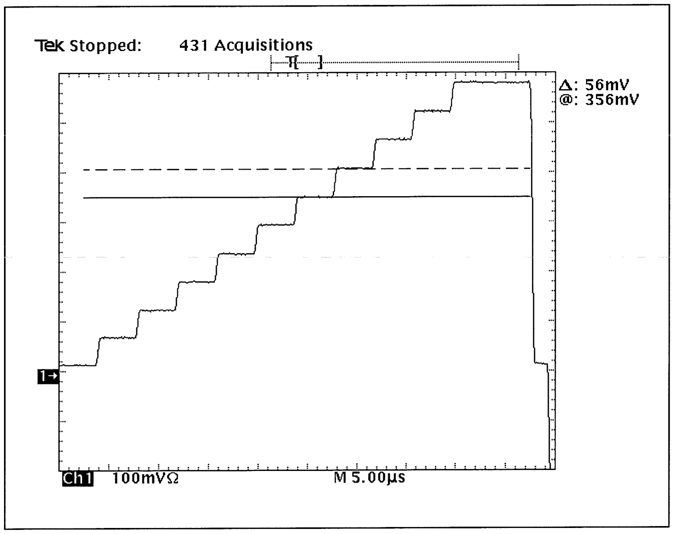


Figure 10. Cursors help you characterize your video amplifier accuracy and monotonicity when used with a gray bar (stairstep) pattern.

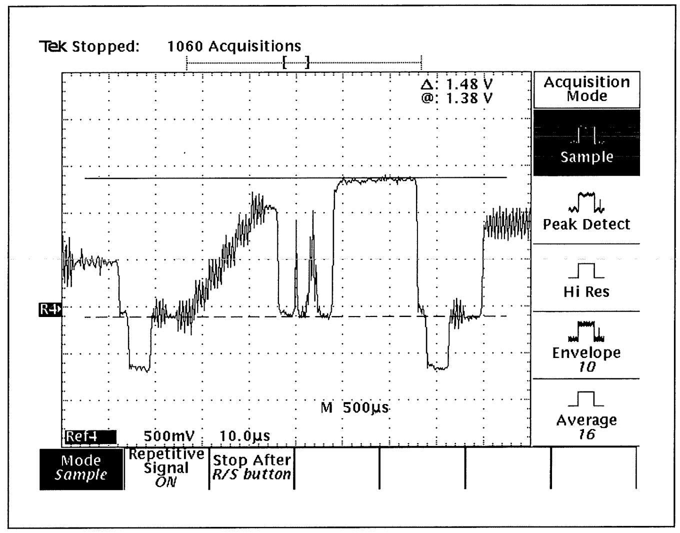


Figure 9. Use the multi-burst test waveform and the scope's cursor function for accurate gain-bandwidth measurements, such as this live video waveform.

Advanced measurements

Investigating picture smear. One of the most important characteristics of a video system is the bandwidth of the video amplifiers within its stages. One visible indication of problems with video bandwidth is a loss of picture resolution along the horizontal axis, more commonly known as smearing. Smearing is the result of insufficient transition of the video waveform from one amplitude to another, resulting in a fade from one to the other instead of a sharp edge.

To find the cause of the smearing, you can investigate each video amplifier stage to find which one is limiting the bandwidth. With a standard video signal injected at the front end, you can test the output of subsequent stages. Using the video triggers and delay-by-line features, you can easily look at the same line within the video fields for the smeared waveform. The smearing is visible on the waveform as an excessive transition time between the two portions of the line.

The multi-burst test waveform provides a more comprehensive way of checking the gain-bandwidth response of the video amplifier stages. It provides six bursts of sine waves at frequencies from 0.5 to 4 MHz, and white and black reference levels. The waveform also includes the composite sync signals, for applying it to video systems.

The TDS 400 can trigger off these signals, providing a stable representation of the video subsystem frequency response (Figure 9). Using the cursors, you can make very accurate measurements of the amplitude at each frequency. And like many digital scopes, you can use the TDS 400 to save the waveform and print it out for reference.

Video DAC and amplifier debugging. While smearing is just one particular effect of video amplifier problems, you may need to more fully characterize your video amplifier stages. Fortunately, you can use common test signals and the capabilities of the TDS 400 to quickly evaluate video amplifiers.

To illustrate, a gray-bar pattern is injected into the front end of the amplifier stage. You can select either NTSC, PAL, or one of the custom triggering ranges to lock in the signal waveform. Then use the delay-by-line capabilities to find the lines within which the staircase resides (Figure 10).

The discrete levels within the pattern indicate the accuracy and of the DAC circuit. Any excessive noise in the circuit would be obvious on the waveform. Using the averaging and cursor functions helps you make accurate voltage-level measurements. You can also see missing or extraneous steps that indicate a faulty DAC or data path problem. And clipping of pattern levels would indicate a gain or offset error.

You can also use the cursors for accurate measurements of the time interval of each step. Distortion in the steps indicates a bad DAC or loading or termination problems. In addition, you can measure the transition time between levels to ensure amplifier response.

PAL color field. Debugging PAL and SECAM systems with the TDS 400 is much the same as working with NTSC systems. Subtle differences in the standards exist in the line and field rates.

PAL and SECAM systems usually have a 50 Hz field rate and 625 lines/frame. Unlike NTSC, PAL and SECAM have 8 color fields. Selecting "PAL" from the "Type" menu sets the TDS 400 to trigger on a particular color field.

The basic 50 Hz field rate establishes a field time of 20 msec. The time between repeating color fields is 160 msec, representing a 6.25 Hz repetition rate. To see and measure features of single lines in a color field, at this repetition rate, a digital scope is required.

In NTSC, line count starts at the beginning of the equalizing pulse interval (three lines prior to vertical sync). In PAL and similar 625-line systems, line count starts at the beginning of the vertical sync pulse interval. Selecting the NTSC or PAL triggering function automatically configures the TDS 400 scope to use the appropriate line numbers for the waveforms it displays.

For further information, contact:

U.S.A., Asia, Australia, Central & South America, Japan
Tektronix, Inc.
P.O. Box 500
Beaverton, Oregon 97077-0001
For additional literature, or the address and phone number of the Tektronix Sales Office nearest you, contact:
(800) 426-2200
(503) 627-7111

Canada
Tektronix Canada
50 Alliance Blvd.
P.O. Box 6500
Barrie, Ontario L4M 4V3
Canada
Phone: (705) 737-2700
FAX: (705) 737-5588

Germany
Tektronix GmbH
Colonia Allee 11
D-5000 Koeln 80
Germany
Phone: 49 (221) 96969-0
Telex: (841) 8886601
FAX: 49 (221) 96969-362

France and Africa
Tektronix S.A.
ZAC Courtaboeuf, 4 Av du Canada
B.P.13
91941 Les Ulis Cedex
France
Phone: 33 (1) 69 86 81 81
Telex: (842) 604332 TEKOR A
FAX: 33 (1) 69 07 09 37

Belgium, Denmark, Finland, Holland, Norway, Sweden and Switzerland
Tektronix Holland N.V.
P.O. Box 226
2130 AE Hoofddorp
Holland
Phone: 31(2503) 13300
Telex: (844) 74898 TEKSO NL
FAX: 31 (2503) 37271

South Europe Area, Eastern Europe and Middle East
Tektronix Espanola S.A.
Calle Condesa de Venadito,
1-5 Planta
28027 Madrid
Spain
Phone: 34 (1) 404.1011
Telex: (831) 46014 TKME E
FAX: 34 (1) 404.0997

United Kingdom
Tektronix U.K. Limited
Fourth Avenue
Globe Park
Marlow
Bucks SL7 1YD
England
Phone: 44 (0628) 486000
Telex: (851) 847277, 847378
TEKMAR G
FAX: 44 (0628) 47 4799

Tektronix sales and service offices around the world:

Algeria, Argentina, Australia, Austria, Bahrain, Bangladesh, Belgium, Bolivia, Brazil, Bulgaria, Canada, Chile, People's Republic of China, Colombia, Costa Rica, Cyprus, Czechoslovakia, Denmark, Ecuador, Egypt, Finland, France, Germany, Greece, Hong Kong, Iceland, India, Indonesia, Ireland, Israel, Italy, Ivory Coast, Japan, Jordan, Korea, Kuwait, Lebanon, Malaysia, Mexico, The Netherlands, New Zealand, Nigeria, Norway, Oman, Pakistan, Panama, Peru, Philippines, Poland, Portugal, Saudi Arabia, South Africa, Singapore, Spain, Sri Lanka, Sweden, Switzerland, Taiwan, Thailand, Tunisia, Turkey, U.S.S.R., United Arab Emirates, United Kingdom, Uruguay, Venezuela, Yugoslavia, Zimbabwe.

2/92 TG 20M 3GW-8223-0

Tektronix
Test and Measurement