Using the High Resolution Mode
Of the DSO-101 Oscilloscope
To Display Video Waveforms

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Introduction

Many video systems, such as commercial television and CCTV (closed circuit television), use the *RS-170* or *NTSC* video standard to create a video image. There are some challenges in viewing these waveforms on an oscilloscope. In this application note, we describe some techniques for using the DSO-101 oscilloscope to view an RS-170 video signal.

Similar techniques may be useful in capturing and displaying a lengthy string of digital data.

A Brief Description of RS-170 Video

The RS-170 video signal causes a video camera or display to be scanned line by line from the top to to the bottom of the screen. The entire screen is scanned approximately 30 times per second[1].

There are a total of 525 scan lines per frame of which 484 are used for the image and the remainder for vertical synchronization and retrace. The horizontal scan rate is then $30 \times 525 = 15.75$kHz. That is, the duration of each scan horizontal scan line is 63.4μsec.
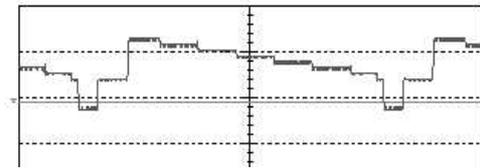

Figure 1: Horizontal Scan Line, Monochrome

Scan Line and Horizontal Sync

The waveform of a typical horizontal scan line is shown in figure 1. The negative-going pulses at the start and finish of the line are the horizontal sync pulses[2].

For a monochrome (black and white) image, the brightness (*luminance*) is determined simply by the amplitude of the signal during the line scan interval. The luminance information in figure 1 is the staircase section. Repeated over many lines, this waveform would display as a series of vertical bars, brightest at the screen left, progressively darker toward the right edge of the screen.

The scan lines may be *interlaced*, in which case the frame is scanned 60 times per second in an even-odd sequence: *even* frame scan lines are interleaved with *odd* frame scan lines.
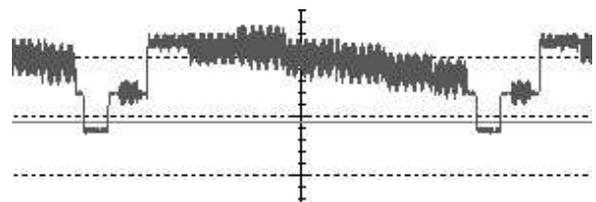

Figure 2: Horizontal Scan Line, Colour

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[1]This rate was originally chosen because it is frequent enough to avoid flicker and synchronous with the power line frequency. Consequently, ripple on a power supply does not 'beat' with the video display. Subsequently, for reasons that are given in the Wikipedia NTSC reference, the vertical frequency was change to 59.94Hz, so it's only approximately equal to the AC line frequency.

[2]These waveforms were obtained with the *screen capture* facility of the DSO-101 oscilloscope, and then cropped using the xv image manipulation program.

For a colour image, there is a burst of a 3.58MHz sine wave at the end of the horizontal sync interval. This sine wave acts as a reference for a *colour subcarrier* riding on top of the luminance signal. The phase and amplitude of this colour subcarrier determine the hue and saturation of the displayed colour.

Figure 2 shows the signal for one horizontal line, with colour information. Notice the colour burst immediately after the horizontal sync pulse. This is located on the so-called *back porch* of the waveform. The staircase luminance information is still present, but now there is an AC colour subcarrier (*chroma*) riding on the luminance.

Repeated over many lines with the proper chroma signals, this waveform would show as a series of vertical coloured bars on a video display.
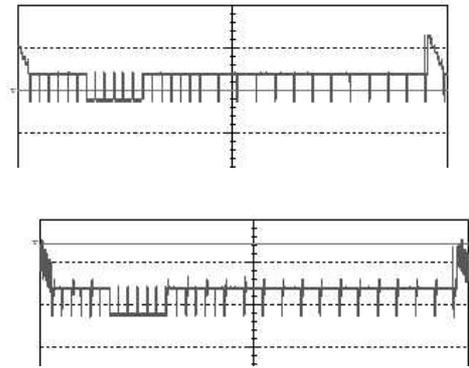

Figure 3: Vertical Sync, Monochrome and Colour

Vertical Sync

Figure 3 shows the RS-170 vertical sync and retrace interval waveform in a monochrome system (top) and colour system (bottom).

The duration of the vertical sync interval is $525 - 484 = 41$ horizontal lines, that is, a duration of 41 lines $\times$ 63.4μsec ≈ 2.6 millisec.

The display is blanked during vertical sync, so it is common to place other data such as closed-caption data between the sync pulses in this interval. Notice the fragment of the last horizontal line at the left, and the first horizontal line at the right.

Notice that the colour bursts continue throughout the vertical sync and retrace.

The Oscilloscope Sync Problem

Consider a circuit that overlays characters information on a standard television screen. This requires that the character information be generated at precise intervals with respect to the horizontal and vertical sync signals. When debugging such a design, it can be useful to view the resultant signal with an oscilloscope. However, every RS-170 sync pulse is exactly the same amplitude as every other sync pulse. An oscilloscope trigger signal recognizes a trigger signal as one that that passes through the trigger level, so this technique will not work. Each trace of the oscilloscope shows a different horizontal interval.

Some oscilloscopes include trigger circuitry that will detect the horizontal or vertical sync in an RS-170 signal. These trigger circuits are typically labelled as `TV Line` and `TV Frame`. This is a specialized requirement
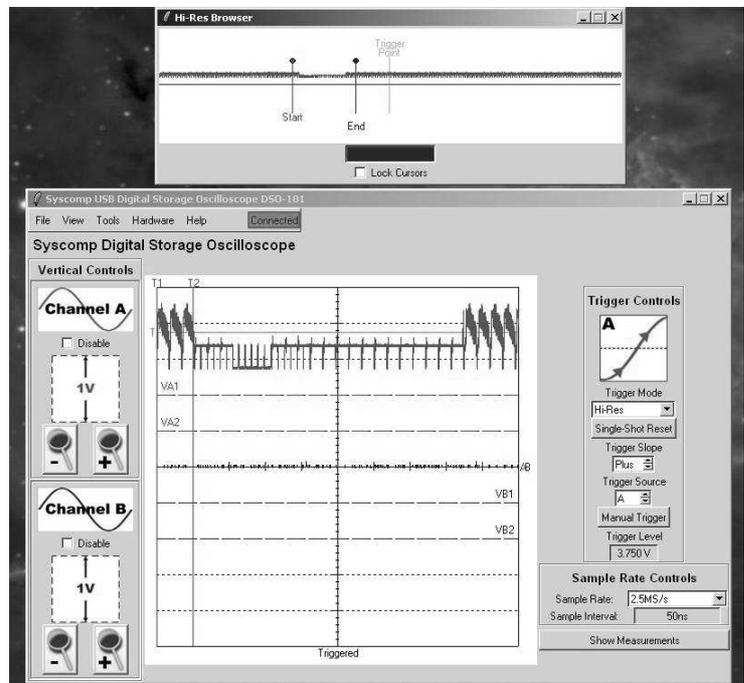

Figure 4: Hi-Res Capture Mode

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and not included with the DSO-101 oscilloscope. However, there are two techniques which support viewing RS-170 on the DSO-101: random capture using `Hi-Res` trigger mode, and sync separation using an external circuit.

Random Capture

The *high res (resolution)* trigger mode captures a full 32k samples, 16k before and 16k after the trigger event, at a selectable *sampling rate*. As shown in 4, these samples are shown in their entirety in a separate *browser window* (above the main window in this screen shot).

The operator may then adjust browser window cursors to shown some subsection of the 32k samples in the main window. In figure 4, the main window displays the horizontal sync interval.

If the duration of the full 32k sample interval exceeds one frame interval, then the captured waveform must include one horizontal sync interval. If the full 32k samples is less than one frame interval, then the displayed section of waveform is some random section of video waveform.

For a quick look at a video waveform, this may be sufficient. The operator can repeatedly click the trigger reset button and obtain new views of the waveform until the section of interest appears.

There is a tradeoff here: a longer section of waveform is displayed at a lower sampling rate. However, a lower sampling rate eliminates some detail in the waveform. For example, any frequency components in the video waveform that exceed twice the sampling rate will be aliased.

In practice, this is not a major limitation and as figure 4 indicates, it's quite possible to obtain much useful information about the waveform.

Sync Separation

The RS-170 video differentiates between horizontal and vertical sync on the basis of the pulse *widths* rather than amplitudes. Consequently, some type of timing circuit is required to reliably detect the horizontal and vertical sync signals.

The circuit of figure 5 is ideal for this purpose. It uses the National Semiconductor LM1881 and a few passive components
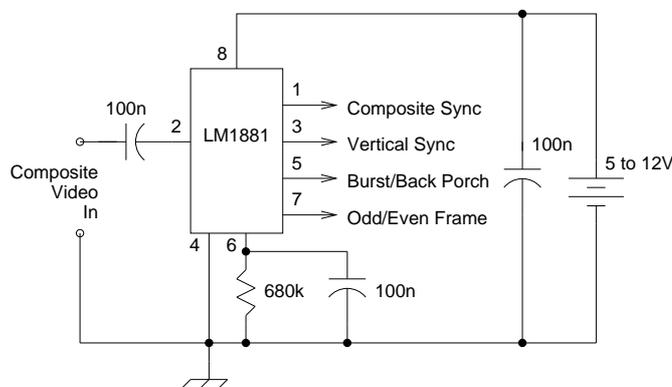
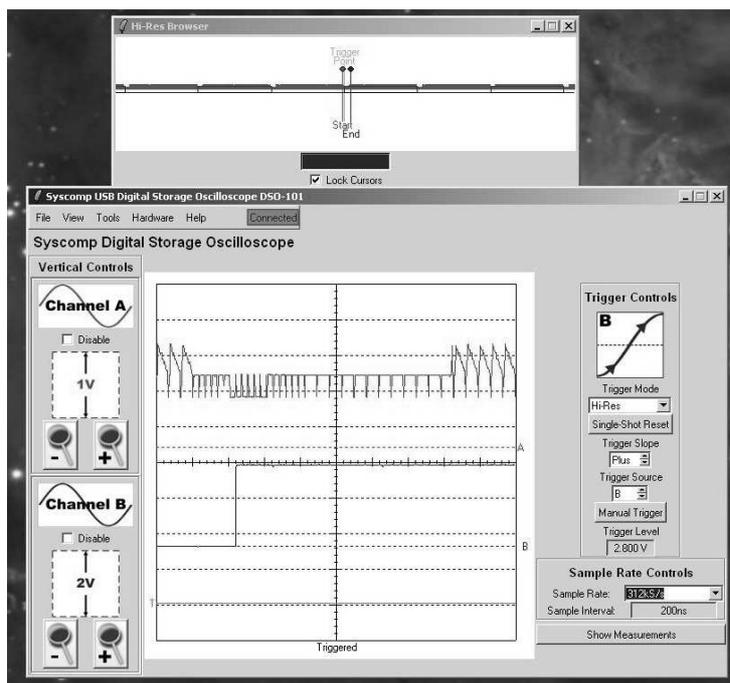

Figure 5: Video Sync Separator

Figure 6: Odd/Even Synchronized Capture

to separate the synchronization signals.

For our purposes, the Odd/Even output is most useful. If the video signal is interlaced, then this signal is low during the Odd frame and high during an even frame. The transition occurs at the vertical sync interval.

This signal may be used to trigger Channel B of the oscilloscope while Channel A shows waveforms in the vicinity of the vertical sync interval.

In high-res mode, triggering from the Odd/Even transition ensures that the vertical sync occurs at the mid point of the 32k samples.

An example is shown in figure 6. The lower trace shows the odd/even low-to-high transition that is used as a trigger signal. The high-res window shows data that was captured at a sample rate of 312KSamples/sec. The upper trace of the main window shows a magnified version of the waveform between the high-res cursors.

Several vertical retrace intervals are visible in the high-res window trace. It would be quite feasible to move the cursors to select these intervals and compare the odd-even retrace with an even-odd retrace.

Equipment Setup

The equipment setup is shown in figure 7.

The video signal generator is in the aluminum box at bottom left. It is a VG-1 unit from Gekco Labs (see resources), a very cost-effective unit for testing video systems. The generator has been modified so that the colour burst can be disabled. The generator then produces gray-scale bars.

The LM1881 is on the small protoboard, obscured by mini-grabber clips.

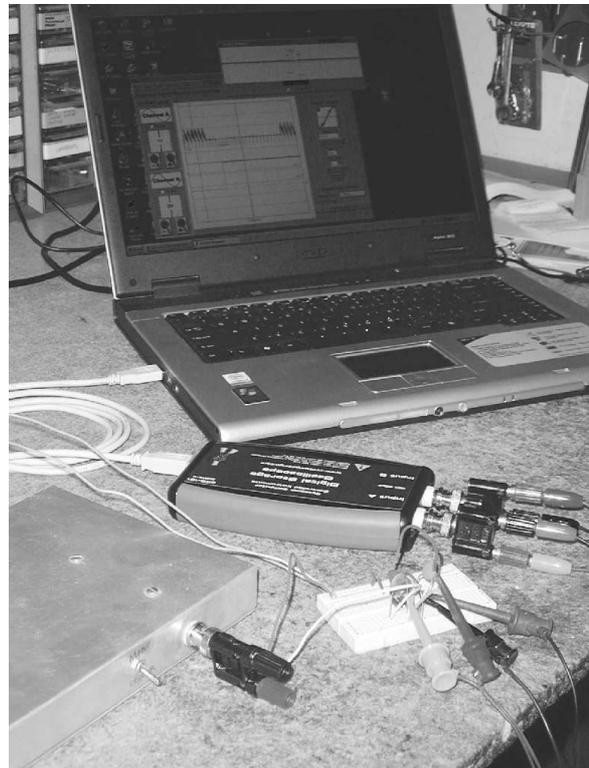The DSO-101 oscilloscope hardware unit is adjacent to the computer, which displays a video waveform.

Figure 7: Equipment Setup

Resources

Wikipedia RS-170 (NTSC) reference:
http://en.wikipedia.org/wiki/NTSC

LM1881 Video Sync Separator, Data Sheet:
http://www.national.com/search/search.cgi/main?keywords=lm1881

Colour Bar Video Generator:
http://www.gekco.com/vg1.htm