Video Basics

Video Format Overview

Video Measurements

Video is a broad term, which encompasses many applications. Some applications include, but are not limited to: Commercial Broadcast, Medical Imaging, Military Chemical Detection & Targeting Surveillance, Industrial Imaging, Consumer/Commercial Service, and Training Simulators.

There are many video formats currently in use. The most common formats are: NTSC, PAL, SECAM and HDTV is an emerging technology.

Each of these general formats has sub-categories of specifications. Each video format shares some general characteristics in composite form and the associated recommended test procedures, make use of the features of an analog oscilloscope. The analog oscilloscope is a versatile and cost effective tool and over the years analog scopes have been used as general-purpose test equipment. The ability of the analog scope to display mixed signal relative frequency content is useful when viewing complex video waveforms. In addition to their crisp and familiar analog display, the following LeCroy analog scope features can be exploited when viewing:

Composite video: TV Triggering (Line or TV Horizontal); channel output for another test instrument (e.g. vector scope or waveform monitor); calibrated variable time increment to optimize display vertical and horizontal size; pedestal clamp locks back porch to ground.

RF head switch-point adjustments: dual delayed trace "zoom"; bright display; 2+2 channels for trigger source.

Transmitter inter-modulation distortion: X-Y mode real time update; Z Axis input.

Data transfer constellation patterns: DC Offset bias, remains DC coupled and maintains dynamic range.

Serial data video: Skew compensation adjustment; Front panel active probe connections; 50Ohm/1MOhm inputs; Percent display control.

Camera Setup: Fast re-trigger rate; real time display; composite video triggers; bright display with Grey scaling and persistence.

Post Production Sub-carrier to Horizontal Synch Phase Adjustment: Delayed trace; bright display; stable trigger; fast display update rate.

A Brief Video Overview:

Video is designed for the human eye and brain to be perceived as seamless motion. Though visual acuity may vary from person to person, the biological peculiarities of the human eye and brain are exploited to create the illusions of motion and color in video. Frame rates, color levels and gamut, hue, persistence of vision, resolution are essential to all visual display technologies. The basic idea is quite simple, single still frames are presented at a high enough rate so that persistence of vision integrates these still frames into motion.

Interlaced Lines

In a fashion analogous to movie film, video creates the illusion of motion by successively overwriting a sequence of complete pictures for one entire screen image. Each individual “still picture” screen image (commonly referred to as FRAME) is comprised of interlaced, raster scan lines.

Slow frame re-fresh rates cause “flicker” in moving images. This is because human vision has a shorter persistence of vision when presented a bright still image. If the space between frames is longer than the duration of persistence of vision, then the image appears to flicker. As a result, bright pictures require more frequent repetition.

Movie film is typically presented at the rate of 24 Frames/Second. The rate is slow enough to cause "flicker". Theater projectors avoid the "flicker" problem by placing rotating shutters in front of the image in order to increase the repetition rate by a factor of 2x (to 48 frames/second) or 3x (to 72 frames/second) without increasing the actual number of images.

Television electronically accomplishes the same effect as described above by presenting each frame in two interlaced fields. The first scan includes only the odd lines, the next scan includes only the even lines. This doubles the number of "flashes" per frame as the field rate is double the frame rate. NTSC systems have a field rate of 59.94 Hz and PAL/SECAM systems a field rate of 50 Hz. The line values were chosen to ensure the picture does not flicker under normal lighting conditions. Historically, the synchronizing rates were selected by relating them to the power-line frequency (e.g. 50Hz or 60Hz) but today they are derived from a stable oscillator.

Each video frame consists of an odd number of lines (e.g. PAL=625 or NTSC=525). The number of "pictures per second" is directly related to the line rate.

For each frame the number of displayed raster lines is less than the number of total number of transmitted raster lines. Some of the raster lines are typically used to ensure

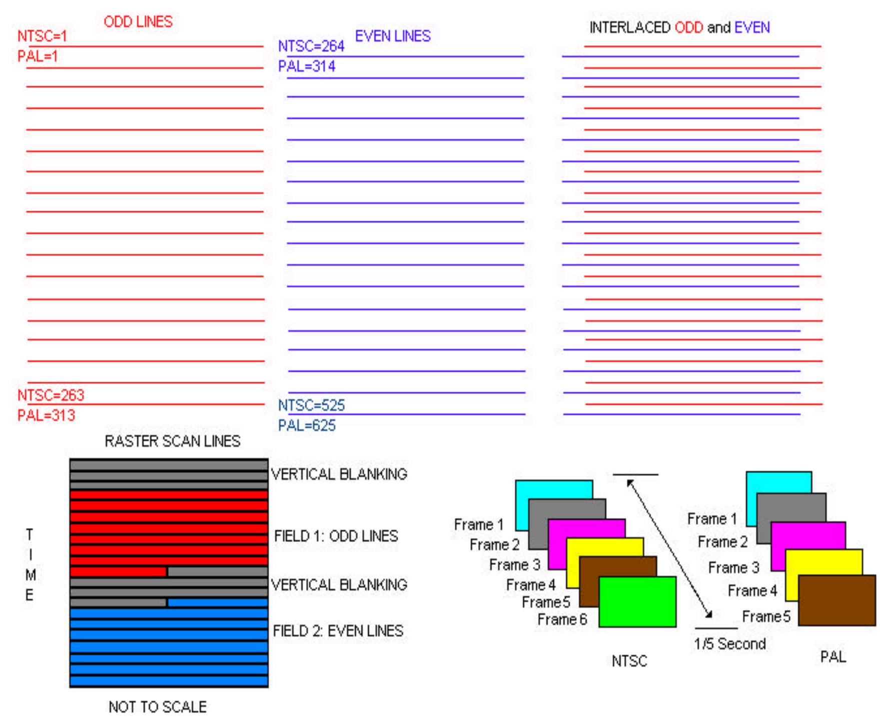

Figure 1: Frame composition

vertical blanking interval and others are for test, or special purposes. The electron beam(s) writing to the screen make two trips per frame. The first trip down the beam(s) "draw" all the odd-numbered lines of the frame, the second time down the even-numbered lines are drawn.

For example an NTSC frame consists of 525 Interlaced Raster Lines. Only 485 lines are active lines in the frame. The remaining 40 lines represent the Vertical blanking interval, containing the pre-equalizing serration pulses.

Interlaced means two sets of raster scans (commonly referred to as FIELDS) are drawn for each frame. The fields are alternately drawn on the screen, Field 1 first then field 2.

The first half (Field 1) of the frame is composed of raster scan lines 1-264 sequentially drawn on the screen. The second half (Field 2) of the raster lines is fit between the first set of lines ("interlaced") and is composed of lines 265-525. In Field 1, Lines 21 through 263.5 (242.5 lines) are active video. In Field 2, Lines 282.5 through 525 (242.5 lines) are active. The total number of active lines in a frame raster scan is 242.5+242.5 = 485.

Interlacing resolves some problems but introduces new ones. For example, vertically adjacent picture elements are sequentially drawn

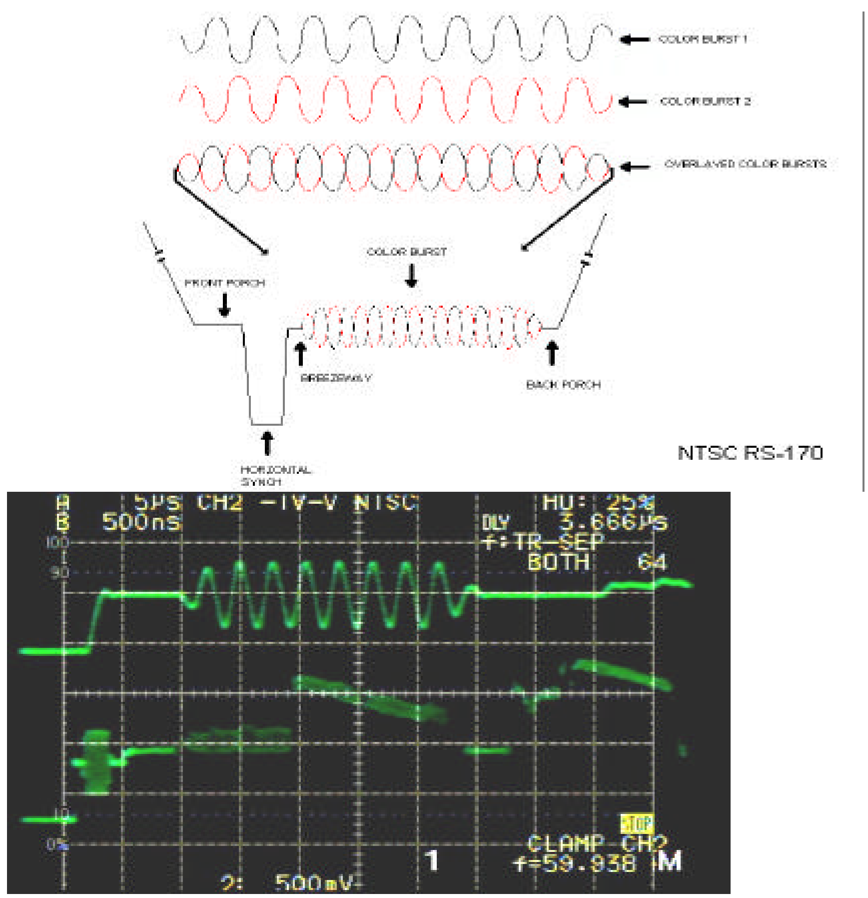

Figure 2: Color Burst and Composite Video Line (Single Shot, triggered on Both Fields, Line Number 64, zoom on burst)

and are not displayed at the same time. In moving scenes, this creates a series of serrations on the edge of the moving objects. Other aberrations include such things as misalignment (where the horizontal edges of stationary objects on one scan do not match with the next), and interline flicker (where slight mismatches between subsequent lines cause a "ghosting" effect). Another situation that must be considered is rapid motion. If the still frame images are presented at too low a rate, rapid motion becomes disjointed.

Some Background

In order to provide a clearer understanding of video, consider how the NTSC times and frequencies were derived. The Line Frequency (f line) and Field Frequencies (f field) for NTSC were defined in the original monochrome systems with respect to power line frequency. Historically, 525 Lines were displayed at a 30Hz rate (1/2 AC line frequency) or horizontal line frequency (f line) was 15.7kHz.

Each TV frequency band is mandated as 6MHz wide to conserve the spectrum. The monochrome picture carrier is 1.25MHz. The audio carrier is separated from the monochrome carrier by 4.5MHz and is 5.75MHz. The introduction of color required a monochrome compatible system while preventing interference between audio and video carriers and maintain 6MHz bandwidth. To accomplish this and maintain 4.5Mhz audio, and 525 lines, the line frequency was changed to an odd multiple of half line rate to ensure: 1) a color burst phase reversal between alternate lines and, b) the beat frequency between color sub-carrier and average audio level is approximately 920kHz.

To accomplish this the following definitions were adopted.

a) Line frequency is defined as:

f line = 4.5MHz/286 = 15.73426kHz

b) Field frequency is defined as:

f line/(525/2)= 59.94Hz.

c) Color burst frequency (fsc) is defined as:

fsc = (455/2)*(4.5MHz/286) = 3.579545MHz

Color Overview

The field lines are always displayed from left to right. After each line is written, while the beam returns back to the left, the signal is blanked (retrace blanking). When the beam reaches the bottom of the screen, it is blanked until it returns to the top to write the next line (vertical blanking).

The electron beam is analog modulated while drawing the horizontal line. In Black and White, the modulation signal, called luminance, translates into intensity changes in electron beam and thus gray scale levels on the picture screen.

Color television was developed to be compatible with existing black and white television receivers. Color TV added the color information on the monochrome signal. For color signals, a color synchronization signal called the color burst is inserted into the horizontal blanking signal back porch. Additionally, chroma modulation was added to carry color level information.

Analog Advantage

The analog oscilloscope has inherent fast update rate and rearm time allow viewing a complex waveform in real time. Effects of adjustments on the device under test are immediately visible on the bright analog display. The ease of use and "alias free" display afforded by the analog scope make them the ideal choice when making critical measurements, especially when setup time is limited.

This series of application notes will provide the reader with a basic overview of LeCroy analog scope operation to make the above-described measurements.

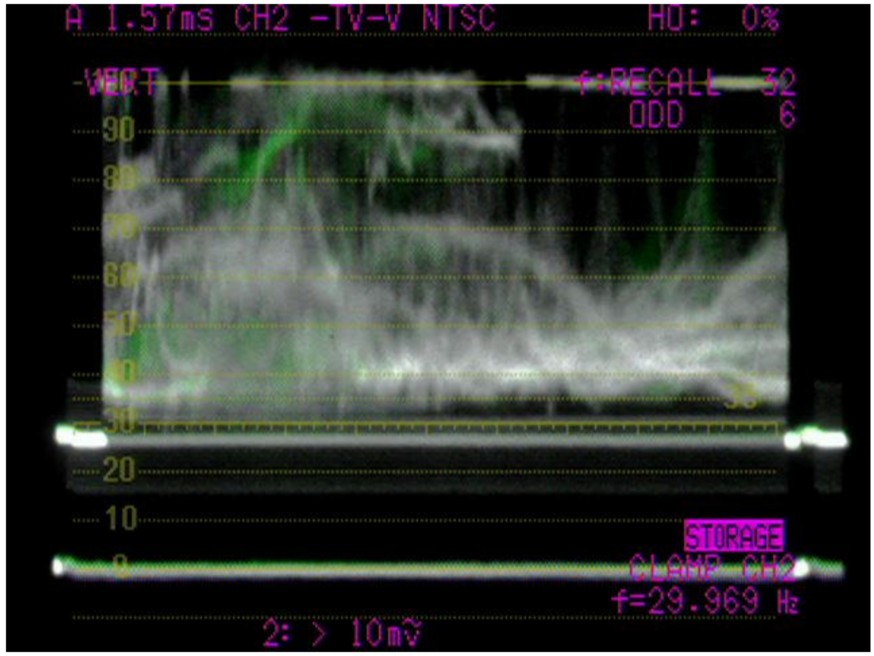

Figure 3: Composite Video; TV Line Trigger (Odd Field Line Number 6) displaying one full video Frame. Dynamic changes in white, persistence fade in green.

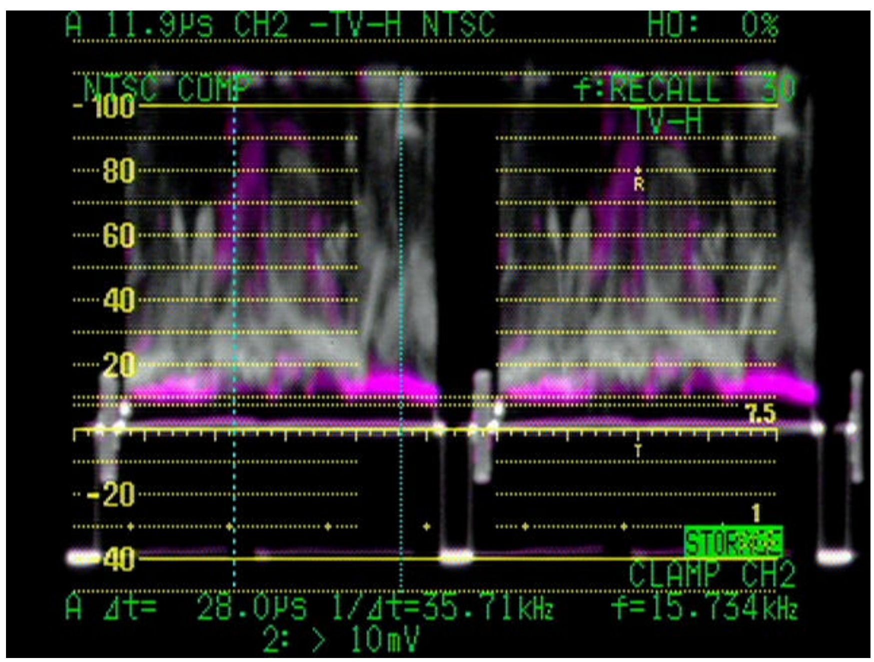

Figure 4: Composite Video 2H with EIA scales displayed on LA354 with Storage enabled (violet is stored trace, white is live feed).

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