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Introduction to Analog Video

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APPLICATION NOTE

Introduction

Eventually all video signals being broadcasted or transmitted will be digital, but until then analog video signals will still be used to broadcast video images (moving images) over the airwaves and/or cable. Analog video designs today are implemented with either high speed voltage feedback operational amplifiers or high speed current feedback operational amplifiers replacing most if not all discrete components. The characteristic parameter data of the high speed op amp must be carefully interpreted to match the needs of the video application to the correct high speed op amp. This document will address the basics of the analog video signals with emphasis on video line driver implementation as a typical video application.

Video Signals

Graphics and broadcast are two main forms of analog video signals. Graphics refer to computer video signals and broadcast refer to TV signals. This article will focus on broadcast video signals / TV signals.

Broadcast Formats

There are three main analog video broadcast standards: NTSC, PAL, and SECAM. Table 1 shows the typical characteristics of these formats.

−NTSC (National Television Systems Committee) – Composite TV signal standard for North America and Japan

− PAL (Phase Alternating Line) − Improved NTSC format (wider channel bandwidth to obtain better picture quality) for most of Europe, Asia, and South America

− SECAM (Sequential Couleur Avec Mémoire) − A variation of PAL format with color information transmitted sequentially for France

Table 1. Common Analog Video Signal Characteristics*

	NTSC M	PAL B	SECAM B	Units
Lines / Field	525/60	625/50	625/50	
Horizontal Frequency	15.734	15.625	15.625	kHz
Vertical Frequency	60	50	50	Hz
Color Sub−Carrier Frequency	3.579545	4.433618	−	MHz
Video Bandwidth	4.2	5.0	5.0	MHz
Sound Carrier	4.5	5.5	5.5	MHz

*There are about 15 different sub−formats within these three general formats

Video Hierarchy

The general structure of an analog broadcast video is complex, because of the analog encoding it needs to combine all information (video, color, etc.) into a single composite signal for transmitting to the TV sets. Figure 1 shows the video signal hierarchy of an analog video signal.

The primary video signal with the highest video quality is made up of three basic color signals (Red, Blue, and Green). The RGB signal is processed or combined to produce a video signal according to NTSC, PAL or SECAM for the TV set. This processing reduces the video quality as some information is lost during encoding.

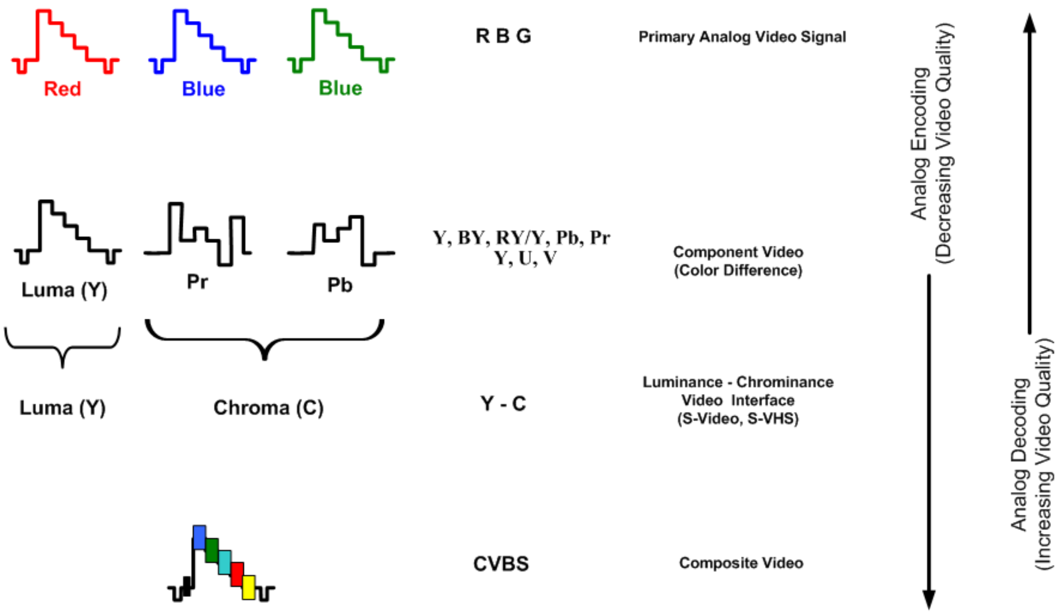

Figure 1. Video Signal Hierarchy

Component Video

The component video signal is the first derivative and the highest quality analog video signal available. YPbPr, YUV are usually called the color difference component video signal. Color difference component video is provided by three different signals (one luminance signal and two color difference signal). Luminance (Y) signal contains the brightness information and the color difference (PbPr or UV) contains the color information derived from the three primary signals. The luminance and the color difference are produced by linear addition and scaling of the three primary video signals.

Y−C Interface

The Y−C interface is another encoding scheme with two video signals, which further degrades the video quality. This signal is usually referred to S−VHS or S−Video. The Y signal or luminance (brightness) contains the same information as the Y signal for component video. The C signal or chrominance (color) combines the two color difference information in component video into a single filtered modulated signal on a sub−carrier.

Once the Y and C signals are combined, it cannot be separated again as it will produce unwanted artifacts (i.e. distortion).

Composite Video

The composite video (CVBS) is the most common analog signal and the lowest quality video signal. NTSC, PAL, and SECAM are all composite signals. Composite video combines color, video, blanking, and sync information into one signal referred to as CVBS. Sound is also integrated into the signal and it is frequency modulated at the high end of the bandwidth. A typical waveform for an NTSC analog video signal is shown in Figure 2.

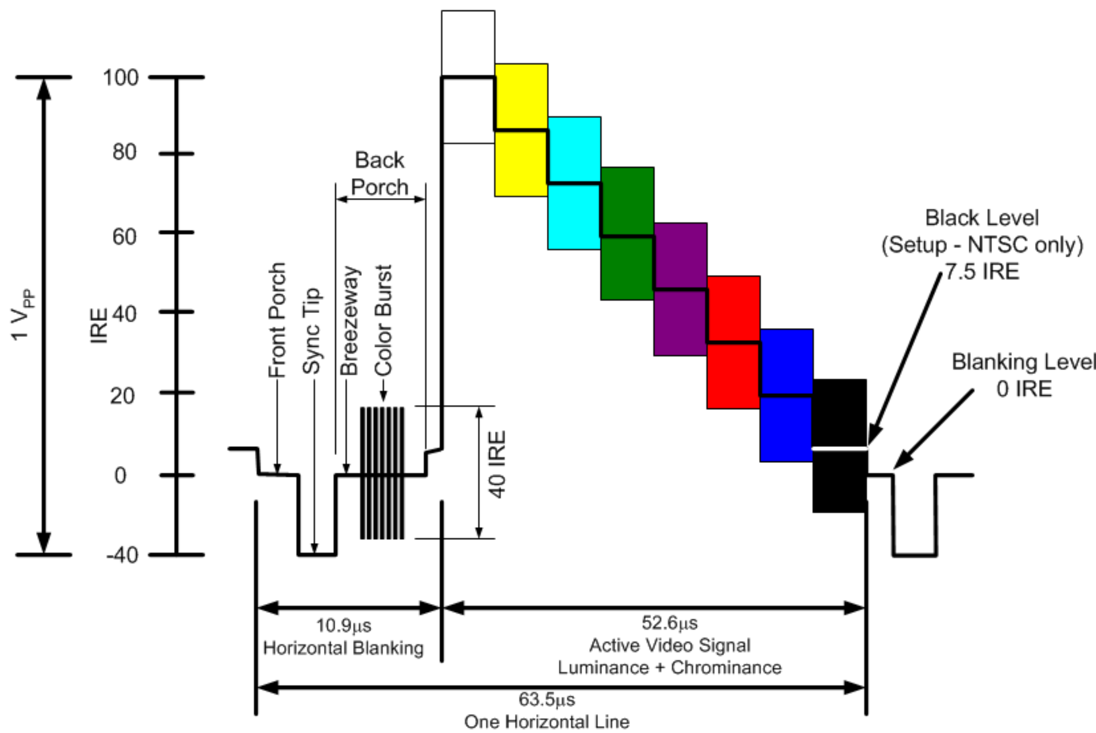

Figure 2. NTSC Composite Video Signal

Figure 2 represent one horizontal scan line of the video signal. The amplitude of the video signal is 1 V_{PP}. The unit of measure for amplitude is in IRE unit, where 1 IRE = 7.143 mV_{PP} (140 IRE = 1 V_{PP}). Each scan line is made up of horizontal blanking area and active video signal area.

The major components of the horizontal blanking area are the sync tip and color burst. The sync tip tells the TV set to go to the next horizontal line. The color burst represents the reference frequency of color sub−carrier (i.e. NTSC has 3.58 MHz color sub−carrier frequency). Since the entire horizontal blanking area is below 0 IRE, the display will be black and will not be seen. For NTSC signal, there is a setup area where the reference black voltage is offset by 7.5 IRE or ~54 mV_{PP} above blanking level.

The active region provides the luminance (brightness) and chrominance (color) information of the picture. The instantaneous amplitude of the signal contains brightness information as shown on the top part of Figure 2. The color information is added on top of the brightness signal as a sine wave. The colors are identified as a specific phase difference between the signal and the color burst reference phase. The amplitude of the modulation represents the amount of color or saturation and the phase information represents the tint or hue of the color.

Displaying the Composite Video Signal

A Picture is displayed on a TV screen by sweeping an electrical signal horizontally across the screen one line at a time from left to right. At the end of the active region of the video signal, the horizontal blanking region tells the scanning circuit to retrace back to left and begin scanning the next horizontal line. Starting from the top of the screen, the lines are scanned all the way to the bottom of the screen, until a vertical blanking region is reached where it instructs the scanning circuitry to go to top of the screen. A frame is one complete set of horizontal line displayed on the TV screen. This procedure is repeated fast enough so the images are perceived to be in continuous motion.

There are two different types of scanning system: interlaced and progressive scan. They are incompatible with each other. TV signals are typically interlaced, where the frame is divided into two separate sub−pictures (fields) and to view the frame, two fields have to scan onto the screen. One field consists of every other horizontal line scan and the second field consists of the remaining horizontal line scan. A progressive (non−interlaced) method scans all horizontal lines of the picture in one pass from top to bottom.

Video Application for High Speed Op Amps

Several characteristic parameter of a high speed op amp must be considered for composite video applications. Since human visual perception is very sensitive, fuzzy or distorted pictures produced by inadequate high speed op amp in the video circuit design can be very disappointing to the viewer. Bandwidth, phase, noise margin, differential gain, and differential phase are some of the critical parameters to consider when choosing an op amp.

Bandwidth

The high speed op amp must possess adequate bandwidth for video application. The performance at high AC frequency must be good as the performance at DC in order to retain the high resolution pictures. Figure 3 shows the comparison of a high speed op amp with adequate bandwidth and inadequate bandwidth. If the op amp does not contain adequate bandwidth, the amplitude rolls off as the frequency is increased. With inadequate bandwidth, the picture becomes progressively grayer and loses most of the fine details of the picture. This also affects color saturation (chrominance), in that a red color will appear pink, because of insufficient amplitude of the video signal.

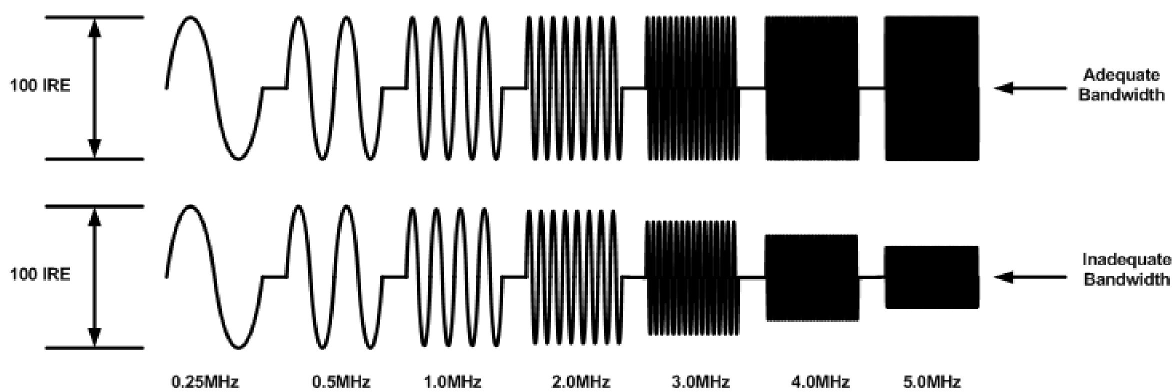

Figure 3. Op Amp Bandwidth Comparison

Phase

The phase difference between the color burst and the active region of the video signal presents the color of the picture. If the op amp has inferior phase performance, the picture will be displayed with incorrect colors.

Noise

The dynamic range of the video signal is 1 V_{PP} or 140 IRE. Only 0.714 V for NTSC is used for luminance between black (7.5 IRE) to white (100 IRE). PAL uses 0.7 V. When it is digitized, each voltage step is in the sub mili−volt range. If the noise of the op amp is high, the picture will be corrupted or distorted.

Differential Gain and Phase

Differential gain and phase is another important parameter to be considered, as they effect the color saturation and the hue of the picture. Differential gain errors refer to AC amplitude variation at different DC levels. Differential gain errors differs from bandwidth limitation in that the color saturation will be different at another DC (luminance) level, unlike bandwidth limitation where it will have one saturation level. Likewise, differential phase error will affect the hue of the picture at different DC levels.

Video Application Circuit

Figure 4 shows a typical video cable driver circuit with either current feedback op amp or voltage feedback op amp. The input typically terminates the 75 Ω coax cable. The op amp is usually in non−inverting configuration with a fixed gain of 2 (6 dB). The driver will also drive a 75 Ω coax cable, but because of the series resistor and the load resistor, the driver output will see a 150 Ω back terminated load. Of course, PCB layout for high speed application must be observed to insure the integrity of the high speed signal.

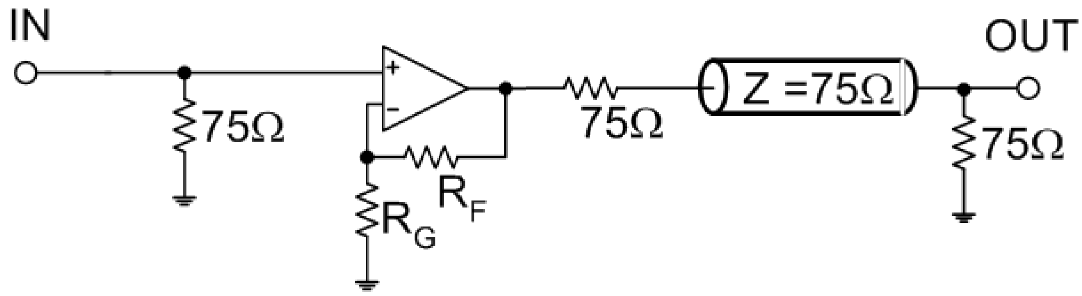

Figure 4. Typical Video Cable Driver Circuit

ON Semiconductor is introducing a family of high speed op amps in both current feedback and voltage feedback topology. The bandwidth of these op amps vary from 100 MHz to well over 1 GHz and are optimized for various video application. Please refer to our website for more information.

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