Subject: Video Transmission and Receiving Systems
Topic: CVBS (Color, Video, Blanking, Sync) Receiver

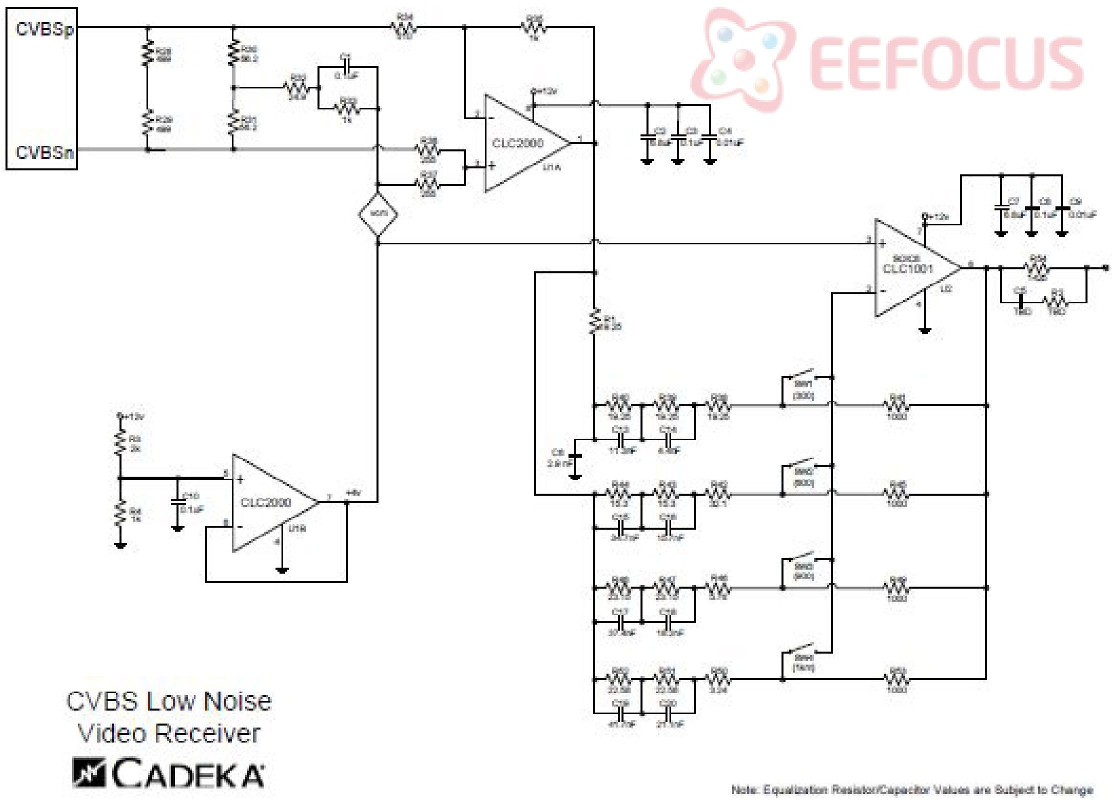

Figure 1 CVBS Low Noise Video Receiver

Let’s now move to designing a low noise CVBS (Color, Video, Blanking, Sync) video receiver as shown in Figure 1. As we have said in the past, a CVBS (composite video) signal is a highly complex signal with multiple levels of analog voltages, time intervals, edge rates, and differential gain and phase relationships (see Figures 2 and 3 below). Composite signals are the most commonly used analog video interface simply because they require only a single transmission line due to the fact that all the video data is embedded in one signal. CVBS combines the brightness information (luma), the color information (chroma), and the synchronizing levels in one signal transmitted by just one cable (usually a single CAT 5e twisted pair). Of course contained within these signals (in Figures 2 and 3) are multiple frequency components that must be transmitted and received properly without adding additional noise and distortion components. Portions of the waveform, particularly during the horizontal blanking interval demand exact voltage levels that are flat over the required time interval(s) as well as transition edges that must slew various voltage levels within given time limits. Color information is also added on top of the luma signal and is a sine wave with the colors identified by a specific phase difference between it and the color-burst reference phase. This can also be seen in Figure 3, which shows a horizontal scan line of color bars.

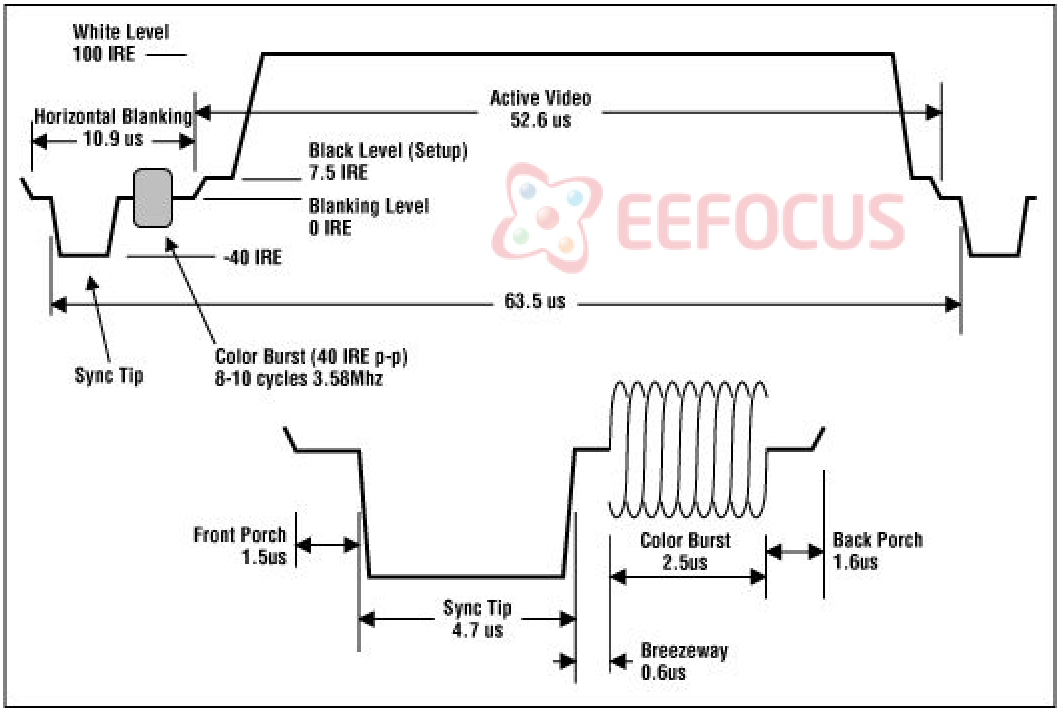

Figure 2 Composite Video Signal (CVBS) Voltage and Time

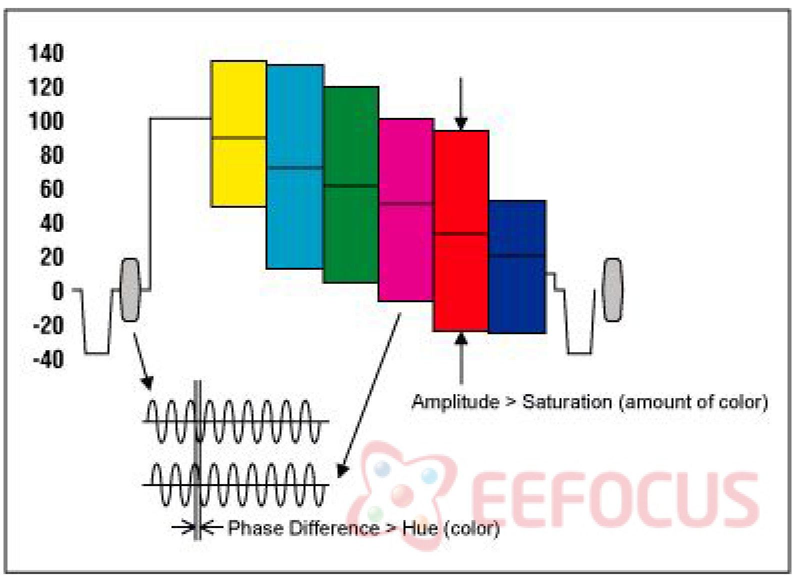

Figure 3 A Single Line Composite Video Signal (CVBS) With Color Bar

Of course when transmitting and receiving the signals of Figures 2 and 3 through a single transmission line, the usual choice is to use a low cost CAT5e twisted pair. Twisted pair requires a differential transmitter (see last week's article) as well as a differential receiver (see Figure 1). The differential receiver must "equalize" the signal in such a way as to restore the original transmission at the receiver end. This equalization process is difficult given the fact of the various insertion loss characteristics exhibited by a CAT5e cable (see Figure 4).

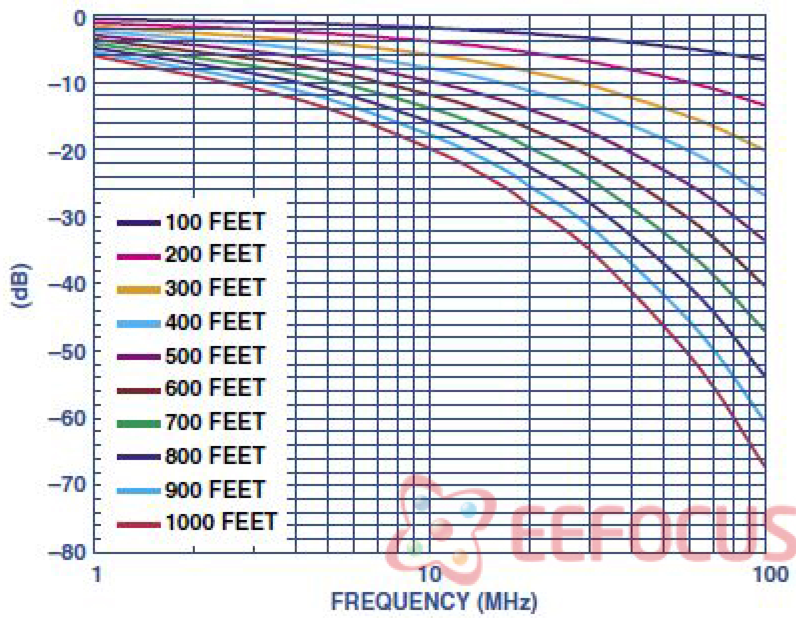

Figure 4 CAT5e Cable Insertion Loss Over Frequency (for various cable lengths)

Contained within the single CVBS video transmission of Figures 2 and 3 are the color burst and color bar signals that must be "equalized" and restored that are at frequencies of 3.58 Mhz (in which the amplifier must have sufficient bandwidth beyond this frequency in order to gain up and pass this frequency without distortion and attenuation). In additional to equalizing the higher color frequencies, low frequency signals such as the horizontal blanking interval are also included and contain frequency components that are well below 100 KHz. Therefore the equalizer must be able to restore both low and high frequency components contained within the CVBS signal. For instance, standard CAT5e cable has a typical DC conductor resistance of about 10 ohms/100 meters. This means at cable lengths nearing 750 meters (depending on the type of cable used), the DC attenuation of the CVBS signal can begin to approach -6 dB (which must be accounted for and restored by multiplying the received signal by 6 db through the equalizing amplifier circuit). If for example you use a 300 meter CAT5e cable which may have about -2 dB of DC attenuation, according to Figure 4, an additional -10 dB attenuation occurs at 3.58 MHz for an overall attenuation of -12 dB! The trick to equalizing and restoring this higher frequency attenuation is to locate the -3 dB attenuation point of the cable at the frequency of interest and nullify that pole with a zero in the equalizing amplifier. In the case for a 300 meter CAT 5e cable, the zero corresponding to the cable's attenuation 1st pole, in order to pass the color burst signal, is best set at approximately 932 KHz. Also, remember, the CAT5e cable does not exhibit a single pole roll-off, and therefore more zeros are necessary for the equalizing amplifier to nullify the extra poles that are contained within the cables response (we will go over this next week).

The CVBS receiver of Figure 1 receives the differentially transmitted signals of Figures 2 and 3 through an equivalent 100 ohm load (which is the characteristic impedance of CAT 5e cable). The differential signal is then converted into a single-ended signal through a CLC2000 amplifier that is set into a differential to single-ended gain of two. This gain of two is necessary in order to transmit the received signal through the 75 ohm load and reverse termination entering into the CVBS video input jack at the monitor and thereby nullifying the (factor of two) attenuation through the monitor's termination load resistor. The CLC2000 differential to single ended convertor configuration is also centered at a +4.0 offset voltage using the other high frequency unity gain stable CLC2000 (this offset allows the amplifier (and receiver) to operate using only a single +12V supply with the minus supply being ground).

The key to this CVBS low noise video receiver design is using the CLC1001 ultra low noise high bandwidth amplifier as the equalizing amplifier. The CLC1001 is a high performance, voltage feedback amplifier with ultra-low input voltage noise, .6 nV/√Hz. One key element here is that the CLC1001 provides a 2.1 GHz gain bandwidth product and a 410 V/µsec slew rate making it well suited for this kind of high speed video acquisition system requiring high levels of sensitivity and signal integrity. This high gain bandwidth product and sensitivity makes the device an ideal receiver for picking out highly attenuated CVBS frequency components over long CAT 5e cable transmissions. At 1 Km cable lengths, the color signal (3.58 MHz) can be attenuated by nearly -50 dB (which is a factor of $1/300^{th}$ of the signal). Whether the design requires this kind of severe recovery/equalization or not, the equalizing amplifier would need a gain bandwidth product (in this case it would require 3.58 MHz X 300= 1 GHz) of greater than 1 GHz and more appropriately approaching 2 GHz which is the significant design feature of the CLC1001. Of course designed into the CLC1001, in order to realize the ultimate in low noise and high gain bandwidth product is an internal DC gain of 10. This gain of 10 requires the system to also receive low frequency CVBS signals (through short length cables with minimal attenuation) of nearly 1 Vpp and multiply them by 10 therefore requiring a +12V power supply system in order to handle the voltage levels developed with this high of gain. Another significant performance feature of the CLC1001 when equalizing the received CVBS signal, is a common mode rejection ratio (CMRR) of typically 90 dB. This specification is essential in gaining up the received differential mode signal and equalizing and amplifying the signal without introducing common mode DC distortion and corrupting the CVBS video signal (we will go over the equalizing portion of the CLC1001 receiver amplifier next week). Overall, the receiver utilizing the CLC1001 is simple, elegant, and has the drive and flexibility to be used in any CVBS receiver application (at any cable length) with minimal cost, power, and distortion within the overall system.

When designing a high performance video transmission and receiving system, it is important to simply break down the system into the various functional blocks that make up the system and address each performance limiting factor. Depending on the overall system specification, such as the video data transmission rate and resolution, these numbers will determine many of the required analog performance specifications of the system including simple layout geometries, amplifier bandwidths, slew rates, and required gains. The number one passive component within a high performance video transmission and receiving system is the cable and understanding the positive and adverse effects of this single component will greatly enhance your ability to design the system.

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