AN-1603
APPLICATION NOTE

# DC Restoration Circuit for an AC-Coupled Video Driver
by Christopher John Gozon

INTRODUCTION

Rear view cameras provide an unobstructed view of the area behind a car. These cameras are often used in automotive applications for driver safety while reversing. When installing rear view cameras, the video source and the video driver are typically ac-coupled to provide dc blocking to the device. The dc level of a video signal represents the black level, which must be constant to suit the video processing circuit.

This application note describes a method of restoring the proper dc level of a composite video signal.
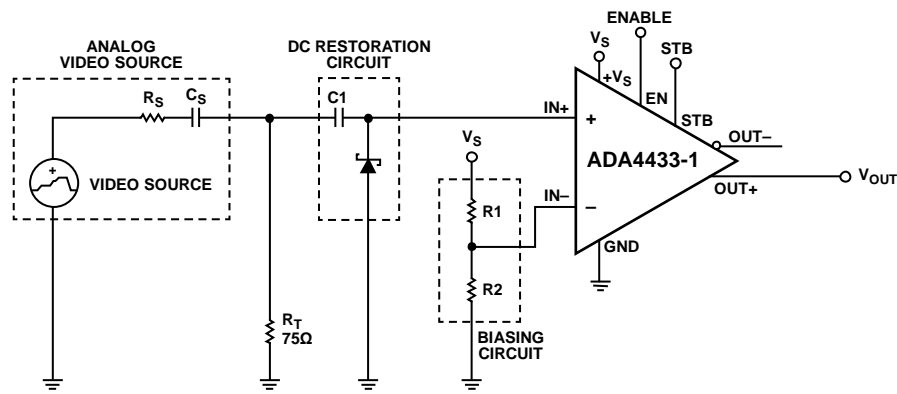
NOTES
1. R_S IS THE SOURCE RESISTANCE, C_S IS THE SOURCE CAPACITANCE, AND R_T IS THE TERMINATION RESISTOR.

Figure 1. DC Restoration Circuit Schematic Using the ADA4433-1

DESCRIPTION OF A COMPOSITE VIDEO SIGNAL

A composite video signal, also known as color, video, blanking, and synchronization (CVBS), is one of the most complex waveforms in electronics. Brightness information, color information, and synchronizing signals combine to form a composite video signal. Figure 2 shows a typical waveform of an all white National Television System Committee (NTSC) composite video signal.
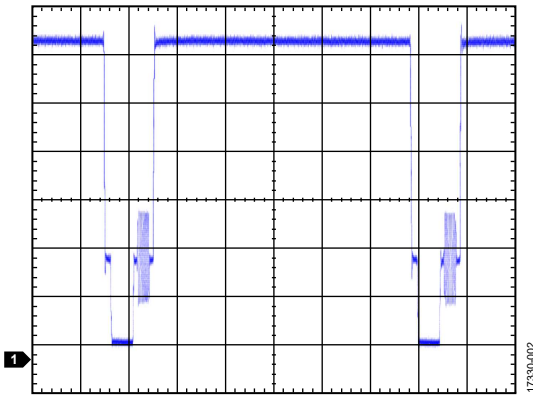

Figure 2. All White NTSC Composite Video Waveform

In Figure 2, the video signal is equivalent to one horizontal scan line. One scan line is made up of an active video section and a horizontal blanking section. The active video part contains the picture brightness information (luma) and the color information (chroma). Luma is the instantaneous amplitude of the signal and chroma is the sine wave. To identify the colors of the picture (yellow, cyan, green, magenta, red, and blue), the difference between the phase of the sine wave and phase of the color bursts are compared. Chroma is imposed onto the luma signal. This composite signal is shown in Figure 3, which shows a scan line for TV color bars.
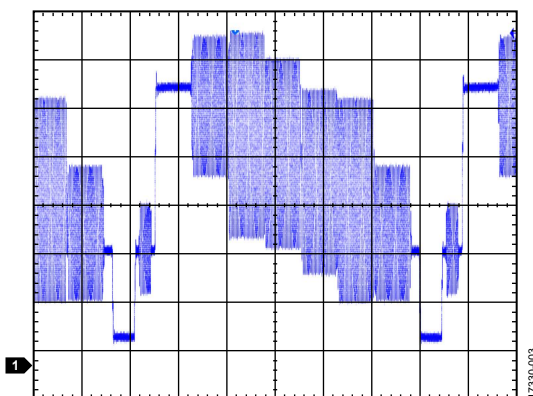

Figure 3. Scan Line for TV Color Bars

The amplitude on the active video portion corresponds to the amount of color (saturation), and the phase difference between the chroma and the color bursts signifies the tint (hue) of the color. The horizontal blanking portion contains the horizontal synchronizing pulse as well as the color burst located after the rising edge of the synchronization pulse, which is called the back porch.

AC COUPLING

Video sources are ac-coupled through the output capacitance (C_S). This method protects the device from potential damage, such as an accidental short to the battery or the power supply connection, derived from a dc current.

C_S stores the average value of the voltage signal. Video content affects the average voltage signal of the video waveform, for example, the black level varies with scene brightness. Depending on the video content, such as NTSC or phase alternating line (PAL), a time constant must be considered because the combination of C_S and the high input impedance of the amplifier result in a filter with a time constant of $\tau = R \times C_S$ and a cut-off frequency (f_C) that is calculated as follows:

$$f_C = \left(\frac{1}{2 \times \pi \times R \times C_S} \right)$$

where R is the input impedance of the amplifier.

The C_S and R values are variables that can cause the signal to droop.

Droop is a change in brightness from the left edge to the right edge of the video, which causes a temporary flicker or fading in and out that is visible on a display. The droop must be below human perception. To minimize droop, the time constant of the ac coupling circuit must be as short as possible. To compensate for a short time constant, one or many capacitors are added to the circuit. Thus, the value of the capacitor(s) must be sized properly. In choosing the right capacitor, low leakage is more important than effective series resistance (ESR).

To set the input common-mode level correctly, the filter or driver input requires a clamp and bias circuit.

DC RESTORATION WITH A SCHOTTKY DIODE

When ac coupling the output of a video device, the dc content is lost. To recover the dc bias level, the ac-coupled output of the video source must be clamped to a reference dc voltage using dc restoration or a clamp circuit. One method to minimize supply requirements when using ac coupling is to use a Schottky diode for dc clamping, as shown in Figure 1. A Schottky diode is used in this application for notable advantages over normal silicon or germanium diodes. A Schottky diode has a low forward voltage and fast recovery or switching time. The turn-on voltage of a radio frequency (RF) Schottky diode is low. Diodes with a 30 mV turn-on voltage provide satisfactory results in single-supply applications.

When the load on the coupling capacitor is high, such as the ADA4432-1 input impedance buffer, the average voltage on the coupling capacitor trickles up in the positive direction. A low on voltage Schottky diode provides a synchronizing tip clamping function, as shown in Figure 4. When the voltage at the cathode of the diode is above zero, the diode acts as a one way switch. Therefore, the lowest part of the signal is forced to a reference, which is the voltage level at the anode of the Schottky diode. The value of the coupling capacitor also depends on the termination resistor. If a 75 Ω termination resistor is parallel to the Schottky diode, the coupling capacitor must be large (~100 μF or larger). If the termination resistor is high, 1 μF or lower, the coupling capacitor is suitable. A downside to this circuit is a slight loss on the synchronization tip due to the diode conduction current. Therefore, low leakage is more favorable than high ESR.

The ADA4432-1 operates at 3.3 V, and the amplifier output is at gain of 2. Therefore, a typical 1 V p-p NTSC composite signal has a design margin of the following:

$$0.55 \text{ V } (V_{MIN} = 2 \text{ V p-p} + V_{OH} + V_{OL})$$

where:
V_{OH} is the high voltage output.
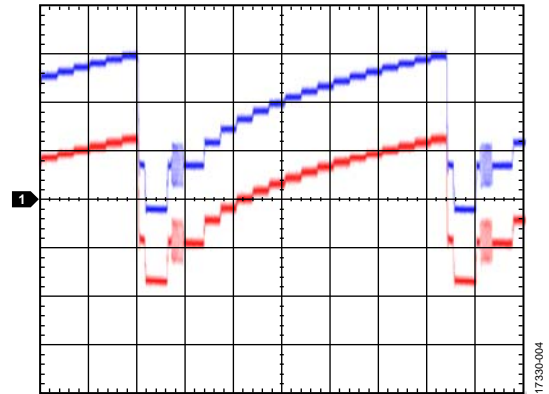V_{OL} is the low voltage output.

Figure 4. Clamping the Composite Signal

CONCLUSION

When ac coupling a video source to a receiver, restoring the proper dc level of the composite signal is essential in providing the correct brightness of the transmitted video signal. In doing so, it is important to consider the proper value of the capacitor to avoid droop and to use a low on voltage Schottky diode to reduce the synchronizing tip loss. DC clamping also prevents the synchronization signal to drift when changing scenes as the diode provides a constant reference for the synchronization tip.

ANALOG DEVICES

www.analog.com