Designing Video Signal Circuits using PI5V33x Family of Video Switches

By Paul Li

Introduction

Pericom's PI5V33x family of products are wide-bandwidth Video Switches specifically designed and characterized for analog video signal applications including the component video signals of Ypbpr, YUV, YIQ, Y/R-Y/B-Y, RGB, and composite video signals such as NTSC, PAL, SECAM etc. Due to the low R-on and C-on, the bandwidth for these products can be as high as 570 MHz. This family also has good R-on flatness, which is an excellent analog characteristic suitable for video signals that request minimum attenuation and distortion due to the critical color and picture quality.

PI5V33x are 5V devices with ultra-low quiescent power supply current (less than 3uA). These devices also have wide input signal range which ensures that the peaks of the video signal can be passed through the switch without clipping. PI5V330 and The devices are NMOS switches, therefore when the power applied is off, the input channel will be high impedance. Thus, the video switches are hot-swappable and fit the TV video signal switching application which is often required to be in hot-swap condition.

Because of the excellent performance and suitability for video signal applications, the PI5V33x family is used by many major projection and LCD TV manufacturers. The devices provide an optimum cost-performance solution to high volume video applications such as projection TV, LCD TV, FPD, PDP and HDTV.

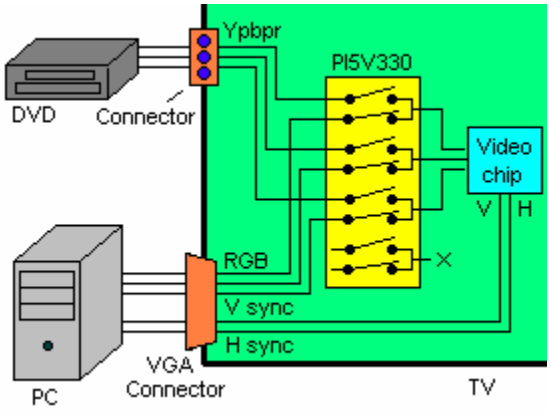

Figure 1: Typical application

Recent models of projection and LCD Televisions have two connectors interfacing to PC and DVD or other video signal sources sharing the same video chip as shown in Figure 1.

The video signals from the DVD could be the component video signals as Ypbpr, YUV, YIQ, Y/R-Y/B-Y signals, or the composite video signal in a single channel, such as NTSC, PAL, SECAM etc. The VGA signals from the PC include the RGB (red, green, blue) analog signal portion and the separated horizontal and vertical synchronous signals, which are directly connected to the video chip without going though the switch.

Termination, DC isolation and DC offset circuits

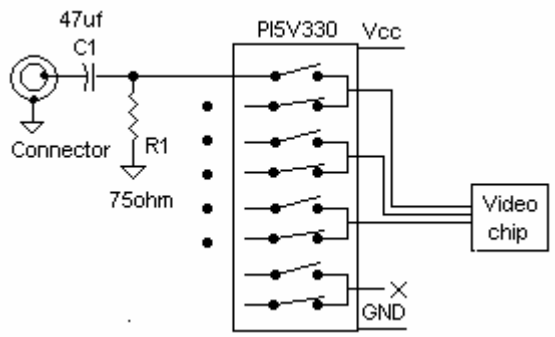

Figure 2: Basic video DC isolation and termination circuit

The circuit in figure 2 is a basic interface circuit for the video switch application. It is important to have C1 as the DC isolation in order to help prevent the damage from the EOS (Electrical over stress) surge current which is often caused by the ground voltage difference between the video signal source (DVD) and the receiver (the TV). C1 is also the AC coupling interface to offset the DC level at its output. The capacitance of C1 can be in the range of 0.1uf to 100uf and depends on the signal bandwidth (normally 47uf). The smaller capacitance of C1 will help to reduce the EOS surge current, but in a trade-off of limiting the low frequency bandwidth. R1 is to terminate the 75-ohm impedance of the video signal cable.

The circuit in figure 2 is not good enough for the PI5V33x family of switches because the signal at the output of C1 is riding on the 0V offset, and the signals negative portion below 0.7V will turn "on" the switch when it is set "off" thereby causing interference. The solution is to generate a DC offset

voltage using a voltage divider consisting of R1 and R2 as shown in figure 3.

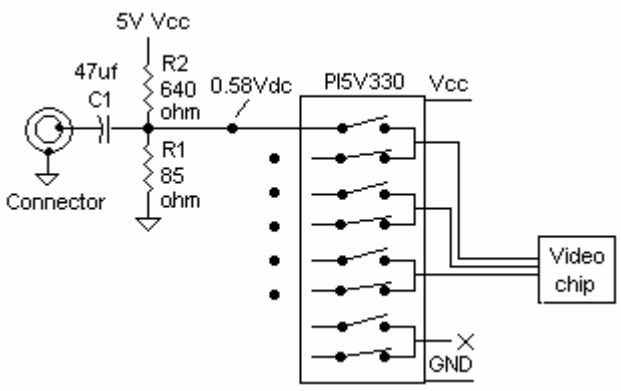

Figure 3: DC offset circuit

The signal from C1 will ride on the 0.58V DC offset voltage from the voltage divider and the negative portion of the signal will not be able to reach below –0.7V, thereby preventing the switch to be turned "on" when it is set "off".

R1 and R2 are also the termination resistors for the 75-ohm cable since R1//R2=85//640=75-ohm. The current flowing through R1 and R2 is 6.89ma.

Another resistance ratio of R1 and R2 could be 90-ohm and 450-ohm, which will generate a 0.833V DC offset voltage in case that the peak-to-peak voltage of the video signal is larger than normal nominal. At this ratio, R1//R2=90//450=75-ohm and the current flowing through R1 an R2 will be 9.25ma.

Why the video switches need the special EOS protection circuits?

The TV hot-insertion condition for the video switch is much more critical than the industry's system hot-swap condition for bus switches. When the banana plugs of DVD video cable are connected to RCA connectors on the TV while the DVD and the TV are power-on, the signal pins of the banana plugs and the RCA connectors will contact before the ground pins. Thus, the ground voltage difference between the two devices will cause an EOS surge current through the switch signal pins and may damage the switch. As a comparison, industry hot-swap application standards specify that the ground pins of the hot-swap connectors must contact before the other signal and power pins during the hot-swap. This approach ensures that the ground voltage difference between the two devices will be released through the ground pins instead of thru the signal pins, therefore protecting the switches.

The external protection circuits in figure 4 will help prevent the EOS damage. The D1 and D2 are normal diodes with 0.7V forwarding voltage drop for EOS protections. This external ESD protection diodes circuit is commonly used at each input pins of the video switch. These diodes will clip the EOS voltage above 5.7V, or below –0.7V, by clamping the excessive EOS voltage either to the 5V Vcc or the 0V ground in the forwarding direction. These diodes can tolerate the forwarding current up to 1A to 2A, thus will protect the switch from the EOS damage.

The R3, R4, C2 and C3 in figure 4 will provide further EOS protection. The R3 and R4 will limit the EOS current caused by the parasitic diodes inside the switch. The C2 and C3 are the bypass capacitors to filter out the Vcc ripples. The resistance value of R3 and R4 can be from 35-ohm to 50-ohm. The DC power voltage drop on R3 and R4 should be less than 1mv, since the quiescent power supply DC current Icc is 3uA maximum. The AC voltage variation on the Vcc and GND pins will be de-coupled by C2 and C3.

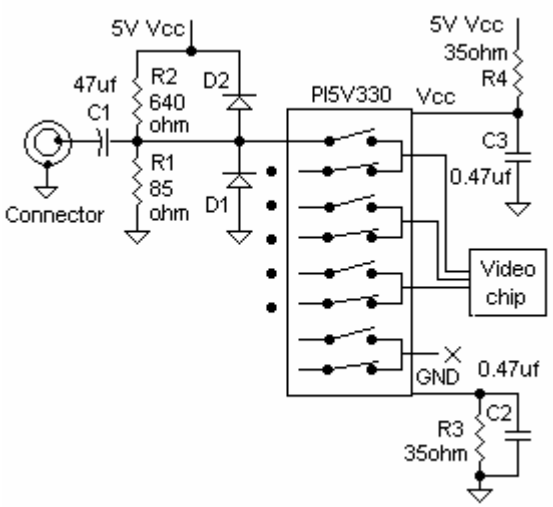

Figure 4: EOS protection circuit

The low-pass-filter circuit preventing the interference

A typical application using the PI5V33x family is to switch between the Yprpb and the RGB signals as in Figure-1. When both the Ypbpr and the RGB signals are active, they may interfere with each other through the parasitic capacitance between the input-output pins of the channel that is "off", or through the parasitic capacitance between the switch channels. A typical interference could be the horizontal lines, or the screen "ghost", from the active signal at the channel that is "off" to the channel that its signal is playing on the TV.

Pericom's PI5V33x products have excellent crosstalk and isolation parameters because of their minimal parasitic capacitance, but the parasitic capacitance can not be completely canceled due to the technology limitation. In addition, the human eye is very sensitive to any fine glitches or ripples on a high quality picture, which requests to avoid any level of interference.

In order to prevent this annoying interference, an external low-pass-filter circuit consisted of L1, C4 and C5 is commonly used in video circuit designs using a switch as shown in figure-5. This low-pass-filter will filter out the high frequency component in the fast rising and falling edges of the horizontal synchronous signal, which is in the Y signal of the Ypbpr signals. These high frequency components are estimated higher than 100 MHz and will cause much higher interference than the lower analog video frequency through the "off" capacitance between the in/out pins of the switch. Adjust the value of C4, C5 and L1 will optimize the low-pass-filter's frequency response, therefore the low-pass-filter will filter out only the high frequency components while still remain the useful contents in the analog video signal below 30 MHz. This low-pass-filter will also help to prevent the screen "ghost" interference since it will limit the bandwidth of the analog video signal. This low-pass-filter is suitable for component video signals such as Ypbpr, YUV, YIQ, Y/R-Y/B-Y and the composite video signals such as NTSC, PAL, SECAM, since their bandwidth are below 30 MHz. But this low-pass-filter may not be suited for the VGA type RGB signals if their bandwidth is higher than 30 MHz.

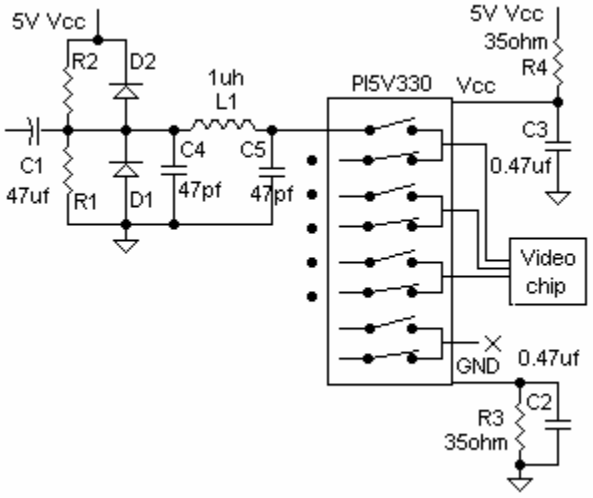

Figure 5: low pass filter to prevent interference

The follower circuit

The reference circuits in Figure-6 are commonly used in many existing TV video circuit designs. It is a transistor follower circuit translating the higher input impedance to the lower output impedance with an almost 0db gain. The R6 and R7 will generate a DC offset at the output of C1, change the proportion of R6 and R7 will change the DC offset level at the input of T1.

The signal voltage at the emitter of T1 follows the signal voltage at the input of T1 with a -0.45V offset. Slightly adjusting the ratio of R8 and R9 will fine-tune the gain to slightly compensate the signal loss. This follower circuit will reduce the signal bandwidth and add extra distortion since it is not an Op-Amp circuit. This has better characteristics than a simple transistor.

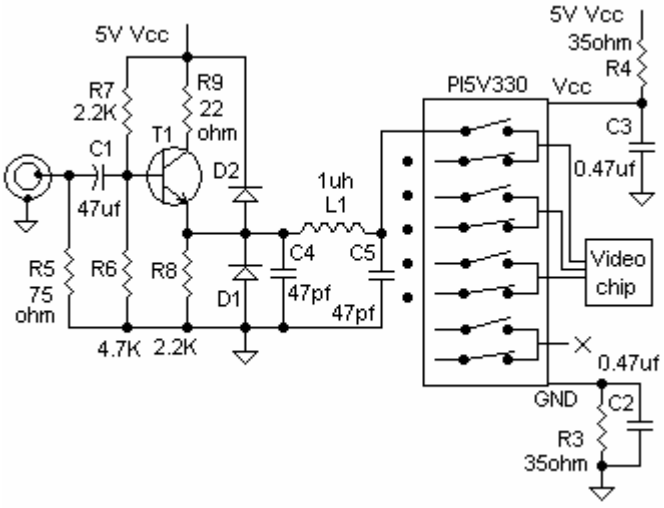

Figure 6: the transistor follower circuit

Conclusion

Pericom provides a full line of analog switches with low R-on, C-on, high performance, low crosstalk and fast switching time. PI5V33x devices are suitable for all types of analog video signal applications, with a compatible price for TV applications. These solutions help make Pericom the leader in the video signal application markets. The application circuits in this app note provide extra EOD protection and excellent crosstalk and isolation results.

Datasheets, IBIS, Samples, Tech Support, Application Notes, and more can be found on the company website www.pericom.com/video