Optimizing Video Crosspoint Switch Design

Introduction

The recent unrest around the world creates unprecedented demands on video security systems. One of the key components in a security system is a crosspoint switch which directs video signal from multiple input sources to any output. Choosing the correct crosspoint switch component requires more consideration than functionality, the designer must be aware of the bandwidth trade-offs and linear operating region to ensure the best video quality. This article steps through an example to demonstrate these design considerations.

Start by Choosing Functionality

The ISL59532, shown in Figure 1, is a 32x32 integrated video crosspoint switch matrix designed for routing video signals in security and video-on-demand systems. Any input can be broadcast to all 32 outputs. Also, each output can be switched to any of the 32 input video signal sources with a gain of +1 or +2 or can be tri-stated. The switch matrix configuration and output buffer gain are programmed through an SPI/QSPI™-compatible three-wire serial interface.

Bandwidth Concerns

Wide frequency response (high bandwidth) in a video system means better video resolution. Four sets of frequency response curves are shown in Figure 2. Depending on the switch configurations, one can get between 250MHz to 350MHz bandwidth. A short discussion of the trade-offs follows—including matrix configuration, output buffer gain selection, channel selection, and loading.

In multiplexer mode, the input only drives one output channel, while in broadcast mode the same input drives all 32 outputs. The parasitic capacitance of all 32 channels loads down the input and reduces bandwidth in broadcast mode. In addition, output buffer gain of +2 has higher bandwidth than gain of +1 due to internal device compensation. Therefore, the highest bandwidth set-up is multiplexer mode and output buffer gain of +2.

The relative location of the input and output channels also has significant impact on the device bandwidth. Again this is due to the layout of the device. When the input and output channels are further away, there are additional parasitics as a result of the distance and lower bandwidth results.

The bandwidth does not change significantly with resistive loading (Figure 3). However, it does change greatly with capacitance loading (Figure 4). This is most significant when laying out the PCB. If the PCB trace between the output of the crosspoint switch and the back termination resistor is not minimized, additional parasitic capacitance severely distorts the frequency response.

To emphasize how critical the PCB layout is to performance, let's compare the two boards presented in Figure 6. The one on the left is a larger engineering evalution board where the termination resistor is far away from the device because of the use of a socket. The one on the right is a demoboard without the socket. The parasitic capacitance of the demoboard is about 2.7pF less.

To prove that the parasitic capacitance is the largest contributor to the difference in bandwidth of the two boards, we added 2.7pF at the output of the demoboard. Figure 5 shows the similarity in frequency response of the engineering evaluation board alongside the demoboard piggybacked with 2.7pF.
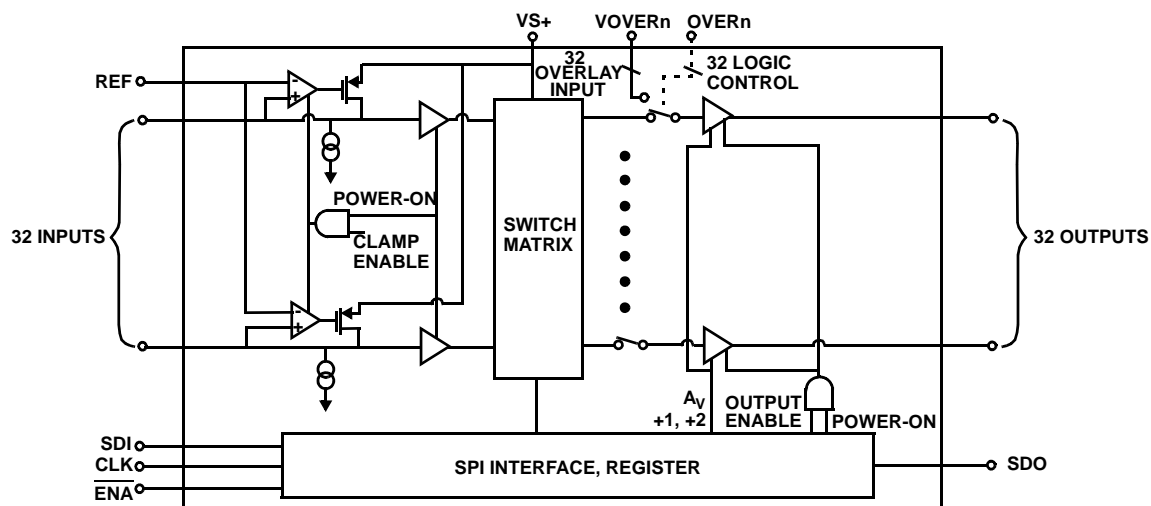

FIGURE 1. BLOCK DIAGRAM OF THE ISL59532, A 32x32 INTEGRATED VIDEO CROSSPOINT SWITCH MATRIX

Linear Operating Region

In addition to bandwidth, one must also be very careful with operating the device at its linear operating region. Figure 7 shows differential gain curve. The ISL59532 is a single supply 5V device with its linear region between 0.1V and 2V. The signal range is fine for most video signals whose nominal signal amplitude is 1V. However, since video signals are often AC coupled, their DC levels are not well defined. A DC restore circuit is required to put the video signal within the linear operating region of the crosspoint switch.

The high quality differential gain performance is provided by a DC restore clamp circuit at the input of the device. A discussion of the benefits of the DC-restored system begins by understanding the block diagram of a DC-restore (Figure 8). It consists of 4 simple sections: an input RC network, an op amp configured as a buffer, a FET switch, and a current source. In the absence of an input signal, R_{IN} drains the input node to ground. The discharge current drains the input capacitance of charge to restore the output of the block to ground in preparation for when the FET switch is turned on. This action eliminates any intensity abnormalities.

Now, the input time constant is generated as a function of the input capacitance and the bias current of the clamp current source, $I_{CLAMP\_DISCHARGE}$. Since the output impedance of current sources is designed to be large, the value of C_{IN} is smaller than in traditional AC coupling techniques (with bias resistors) for similar bandwidth performance.

Because the value of the current source is set by design parameters, C_{IN} must be chosen appropriately. If the value of C_{IN} is too small, the intensity of the video signal will be compromised by offsets (as seen in Figure 9). Raising the input capacitance increases its associated time constant and adds to the set-up time of the DC-restore circuit. An optimum C_{IN} must be selected, 100nF in this case for each crosspoint switch input.

Conclusion

In the process of designing with a crosspoint switch, selecting a device with the right number of input and output channel is just the beginning. One must consider frequency response trade-offs and operating the device at its most linear operating region to get the most performance out of the device.
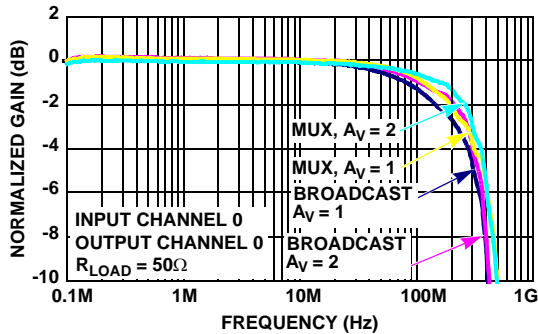

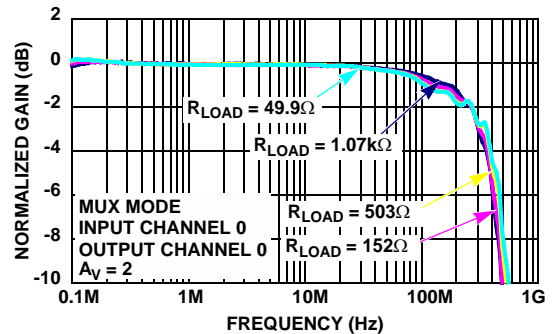FIGURE 2. FREQUENCY RESPONSE FOR TWO SWITCH SETTINGS AND TWO OUTPUT BUFFER GAIN SETTINGS

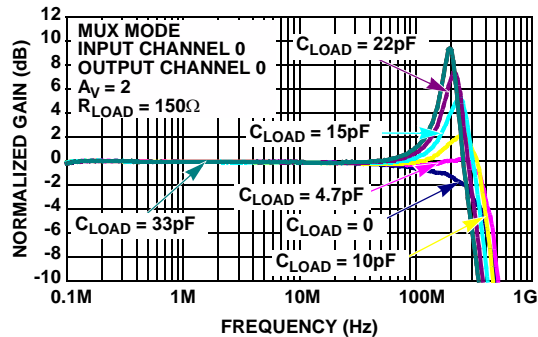FIGURE 3. FREQUENCY RESPONSE FOR VARIOUS RESISTIVE LOADS

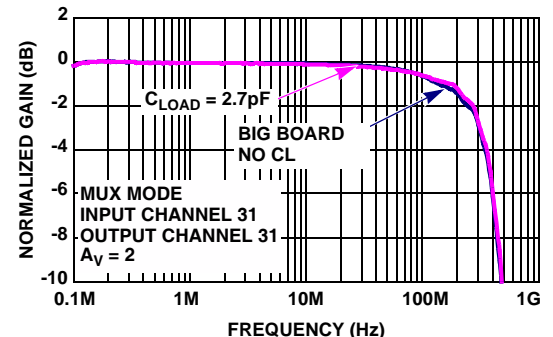FIGURE 4. FREQUENCY RESPONSE FOR VARIOUS CAPACITIVE LOADS

FIGURE 5. FREQUENCY RESPONSE OF TWO EVALUATION BOARDS. DEMONSTRATION BOARD HAS AN ADDITIONAL 2.7pF TO MATCH THE RESPONSE OF THE ENGINEERING EVALUATION BOARD
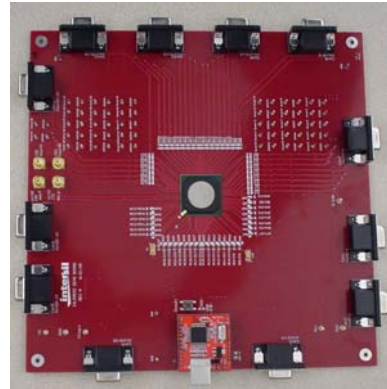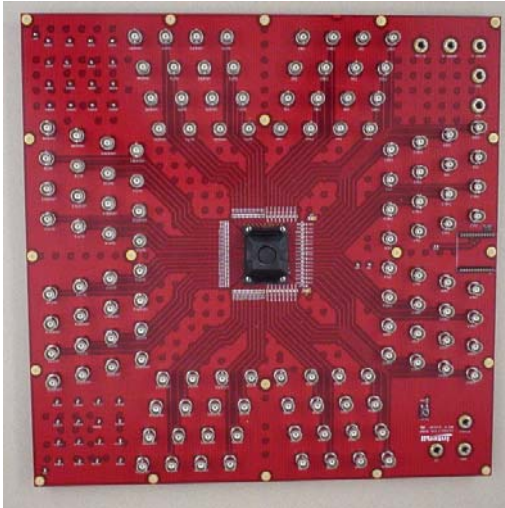
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FIGURE 6. TWO EVALUATION BOARDS. LEFT IS AN ENGINEERING EVALUATION BOARD USING A SOCKET. RIGHT IS A SMALLER DEMONSTRATION BOARD IN WHICH THE PART WILL BE SOLDERED IN PLACE
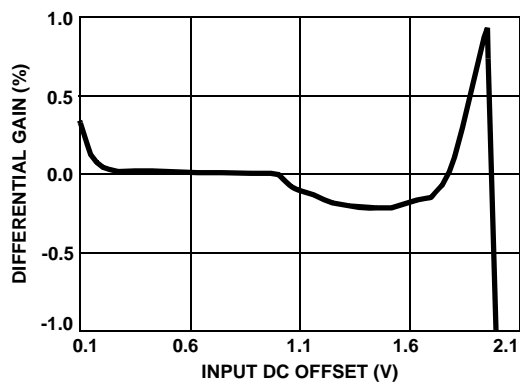

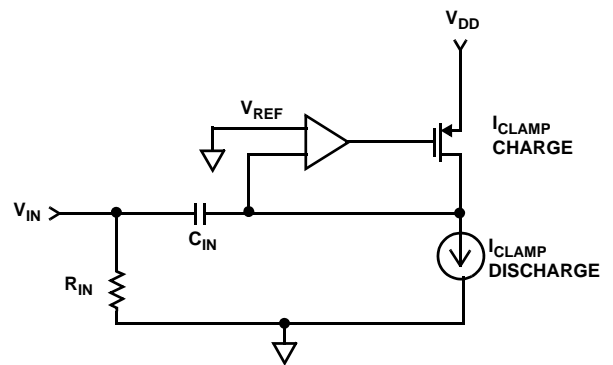**FIGURE 7. DIFFERENTIAL GAIN FOR VIDEO CROSSPOINT SWITCH**
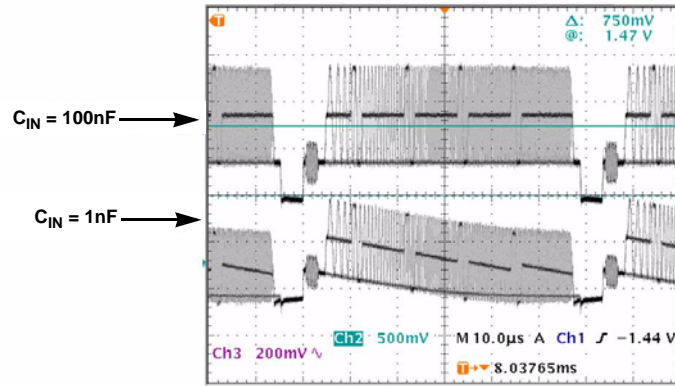

FIGURE 8. BLOCK DIAGRAM OF DC-RESTORE CIRCUIT

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FIGURE 9. VIDEO OUTPUT FROM DC RESTORE WITH C$_{IN}$ PROPERLY SIZED AND C$_{IN}$ TOO SMALL

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