AN2472
Application note

STMAV340 analog video switch

Introduction

STMAV340 is a 4-channel SPDT high bandwidth, low R_{on} switch which provides a simple, inexpensive means to switch high quality video signals without corrupting them. It is a versatile video switch which can be used in multiple applications such as televisions, notebooks, graphic cards and DVD players.

Contents

1 Video switch parameters

1.1 On-resistance (R_{on})

The on-resistance of the switch determines the propagation delay as well as the losses suffered by the incoming signal. The higher on-resistance of the switch increases the insertion loss making the use of a buffer/gain-stage inevitable. Since the analog voltage level for most video signals lies between 0 V and 1 V, the switch must provide a minimum R_{on} within this range. The higher value of the resistance will reduce the gain, add noise and increase the propagation delay. Thus it is desirable to have the on-resistance of the video switch only in the range of a few ohms. It is worth mentioning here that to achieve a lower R_{on}, the pass transistor has to be large which gives a higher capacitance, thus limiting the bandwidth of the device. Thus a good trade-off between the R_{on} and channel capacitance is an important consideration in the design of an analog video switch.

If the on-resistance of the switch is higher, the need to use an amplifier is larger as there is a higher voltage drop across the switch.

1.2 Bandwidth

The bandwidth of the video switch is an important parameter as it determines the signal quality at the output. The higher bandwidth of the switch allows the signal at the input of the switch to be reproduced at its output with minimum distortion on the edges and the amplitude. The amplitude distortion is due to the losses through the switch, parasitic resistances, and capacitances while the edge distortion comes mainly from the capacitance. The high bandwidth of the switch maintains the high fidelity of the analog video signal.

The higher the bandwidth in the system, the higher is the detail in the video signal. The highest frequency of the video signal depends on the rise/fall time of the signal. The bandwidth of a video signal is a complex function depending on several factors like the aspect ratio, number of vertical scan lines, frame rate or refresh rate and the ratio of total horizontal/vertical pixels to active ones. The circuit that processes the video signal needs to have more bandwidth than the actual bandwidth of the processed signal to minimize the degradation of the signal and the resulting loss in picture quality. The amount of circuit bandwidth needs to exceed the highest frequency in the signal to reproduce a high-quality signal. Depending upon the attenuation of the signal at the output, the circuit bandwidth has to be 3-6 times higher than the maximum frequency in the video signal. In addition to the bandwidth, the circuit must slew fast enough to faithfully reproduce the video signal.

1.3 Cross-talk and off-isolation

It is seen during the crosstalk measurement that the termination on other ports can significantly affect the crosstalk measured value on a port. When the unused ports are un-terminated (left open) the value of the crosstalk measured is worse than when the unused ports are terminated with proper 75 Ohm loads. Thus it is necessary to terminate the unused ports with proper loads for an accurate crosstalk measurement (similar to a real application environment). This also applies to the off-isolation parameter. The higher the off-isolation value, the better the switch separates the active data from the non-active display terminals.

1.4 Differential gain and phase

Differential gain and differential phase refer to how the video switch attenuates the signal differently for inputs biased at various DC levels.

This specification is associated with R_{on} flatness over the 1.0V range, with more flatness occurring with a smaller differential gain. A lesser variation of on capacitance of a video switch over various DC biases results in a lower differential phase.

The differential gain and phase are further defined as below:

Differential gain is the percentage error in the magnitude/amplitude change in the analog output voltage from the analog input voltage when the input is between 0 V and 0.714 V and the switch is enabled. Load at the output is 150 Ohm. 0 V and 0.714 V represents the DC offset.

Differential gain is expressed in % error and is calculated as follows:

- Reference gain (when input bias is 0 V, f=3.58 MHz) = V_{out}/V_{in} = 20 log (V_{out}/V_{in}) dB = G1 (say)
- New gain (when input bias is 0.714V, f=3.58MHz) = $V_{out}//V_{in}$ = 20 log ($V_{out}//V_{in}$) dB = G2 (say)
- Then Error = E = G2 - G1 (dB)
- % Error in Gain = Differential Gain = 100 * Antilog (E/20)

The differential phase is measured in a similar way from the AC/transient simulation plot.

1.5 Current consumption

There are two parts to the current, one comes from the current consumed by the logic control circuit and the other is by the switch itself. The supply of the device is only connected to the logic control part (switch enable and selection). The analog pulsing input video signal is the other source of voltage to the video switch.

The current consumption of the switch when it is active but not switching is only determined by the static current through the logic part of the device. When it is switching, the current is determined by the logic control elements of the switch.

The input voltage source to the switches' drain/source and the load attached at the switch output determine the current through the switch itself.

During the standby state, the current consumption of the switch drops to very low and is practically negligible.

1.6 Delay measurements

The magnitude of the R_{on} and C_{on} determine the propagation delay of the switch.

The delay measurements include the switch turn-on / turn-off times and the propagation delays. The measurement is done using the load circuit as shown in the datasheet. For the waveforms and the timing specifications, refer to the STMAV340 datasheet.

2 STMAV340 measurement set up

2.1 Calibration

This is one of the most critical parts to good measurement. The AC parameters of the switch are measured using a network analyzer which must be properly calibrated before use. The calibration is done on the equipment itself and then with the board. Through, open and short calibration are performed without the DUT placed on the board or with DUT enabled on the board and with both the input and output ports of the network analyzer connected to the switch connectors on the board. After the calibration is done, the channel output on the analyzer is stable and is not affected by any movements of the cables or the board. This also helps to ensure that the calibration is performed by taking the DUT and board into account. Initially if desired the calibration can be run by connecting the two ports together.

2.2 Termination for bias

In a typical video application the bias is needed to provide the DC offset required for the video signal. The decoupling capacitor filters the negative part of the video signal before it reaches the switch. The inputs and outputs of the switch have to be terminated with 75 Ohm resistors to eliminate any reflections due to impedance mismatches between the source and the sink.

The parameters are measured with 150 Ohm load as the series resistor of 75 Ohm of the cable is in series with the far-end termination resistor of 75 Ohm, adding them up to 150 Ohm.

2.3 Measurement techniques

Proper measurement methods and stable test set-up ensure that the real device parameters are measured during the characterization of the device. Good contacts of the cable assemblies to the SMA connectors on the board must be present. Care is taken to ensure that the probes of the equipment are tightly screwed to the equipment and the device under test (D.U.T.). Soldering with a good shining solder dot without any dry solder gives a robust low resistance contact for the signals on the board.

3 Advantages

The low on-resistance and capacitance of the switch make it very suitable for high-bandwidth signal switching like video signals.

The high off-isolation provides excellent isolation at high frequencies when the video switch is open.

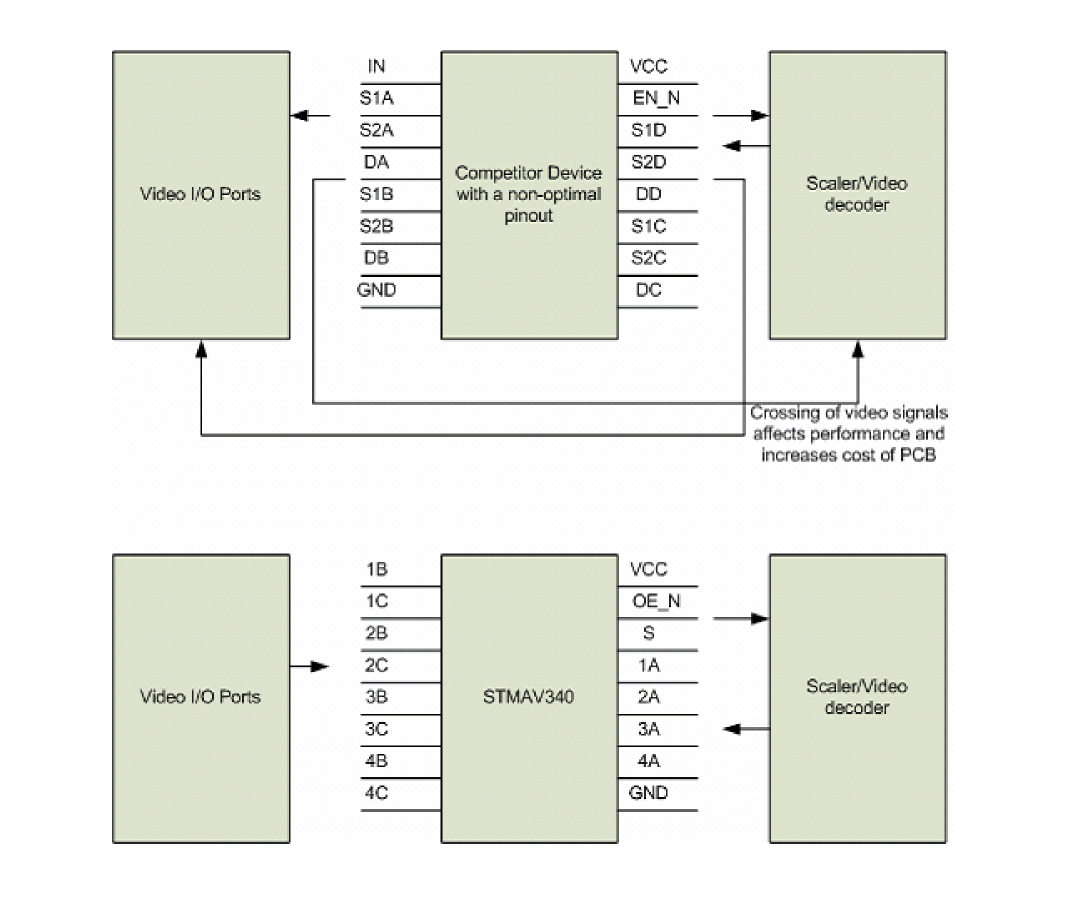
The low crosstalk gives excellent isolation between channels to prevent unwanted interference.

The low differential gain/phase of the switch means very low signal distortion and excellent R_{on} matching.

The TSSOP16 package with a pitch of 0.65mm allows easy mounting and assembly on the PCB board.

A major advantage of this product over the competitors' product is that the inputs and outputs of the switch are on either sides which allow easy PCB routing that leads to saving a layer on PCB, thus reducing cost and improving performance at the same time. This is highlighted in the *Figure 1.*

Figure 1. Simple PCB design using STMAV340



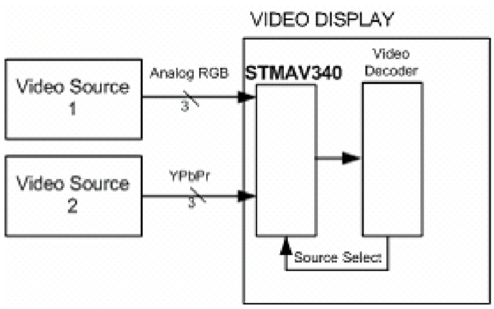
4 Application information

The switch can be used in a wide array of applications as shown in the below section. The only difference is the way the switching is accomplished (mux or de-mux) and the type of signals which are needed by different applications.

4.1 Video display (TV)

The main application of the switch is in the displays like the CRT TV, LCD TV and Monitor.

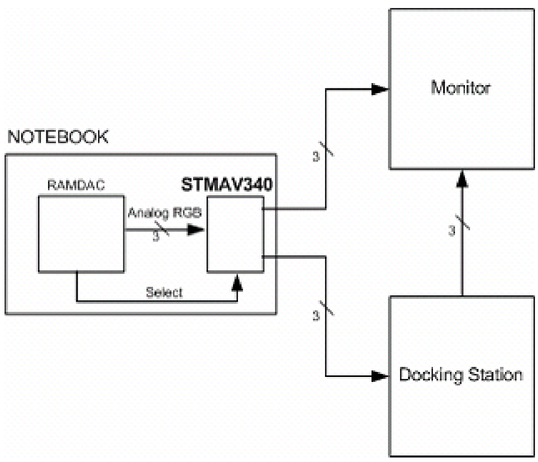
Figure 2. Application of STMAV340 in a video display



4.2 Notebook

In a PC application, the video switch can be used to multiplex RGB signals between a notebook and its docking station. Use of a 3-bit/3-channel SPDT analog video switch in this application eliminates a redundant graphics chip in the docking station, thus reducing cost, component count and complexity.

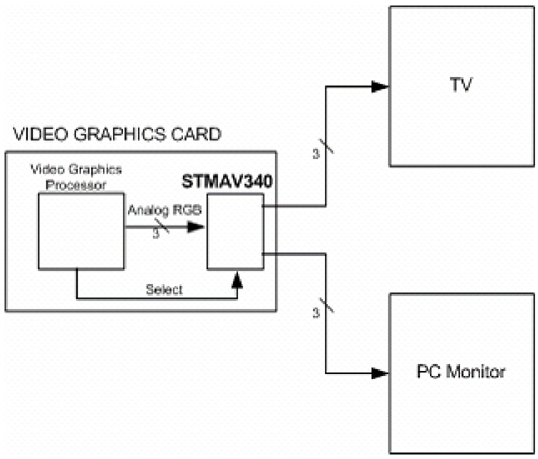
Figure 3. Application of STMAV340 in a notebook



4.3 Graphic cards

Sometimes graphic cards in PCs can be used to drive multiple displays. In such cases, the display loading of the RAMDAC output is increased. This increased load will not only degrade the signal quality as voltage levels will be reduced, but also may require buffer/amplifier which increases the cost and complexity. One way to accommodate multiple, simultaneously connected displays to a single graphics chip is through the use of STMAV340 as depicted in *Figure 4.*

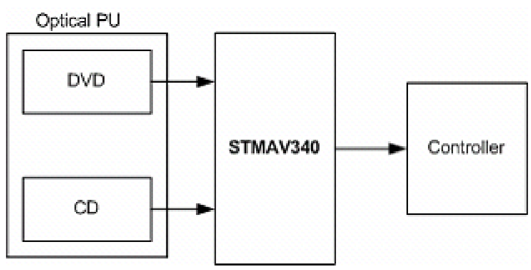
Figure 4. Application of STMAV340 in graphic cards



4.4 DVD R/W

The STMAV340 can also be used in DVD R/W applications to multiplex the DVD R/W signals and the CD signals between the Optical pick up unit and the main controller.

Figure 5. Application of STMAV340 in multiplexing DVD R/W and CD signals



5 PCB layout considerations

The decoupling capacitors should be placed as close as possible to the supply pins of the device as it helps to minimize the noise due to switching and other sources. It is important to ensure that the PCB tracks have resistances of 75 Ohm and are well matched for all the inputs and outputs. This minimizes the impedance discontinuities between the analyzer probes and measurement points on the board and thus reduces the reflections. From an application perspective, image ghosting may occur if there is an impedance mismatch. The 75 Ohm termination on both the sides of the switch is provided by the network analyzer itself. Load capacitance is placed close to the output pins of the device when required for respective measurements.

5.1 Supply and ground effects

Placing decoupling capacitors close to the V_{DD} and GND pins of the device help in good noise isolation and decoupling. For both high and low frequency noise filtering, a 10 µF electrolytic capacitor is placed in parallel with a 100 nF ceramic capacitor. The ground plane and good solid connections to it significantly improve the performance of the device. It is a good practice to place as many vias from the top layer to the ground plane as possible to lower the resistance between the contact and the ground plane, thereby reducing noise.

5.2 PCB demo board

This board is manufactured to do real video signal application level tests. A typical configuration of the switch is shown below (to be added) for the tests. The BOM and the board schematics + layout files (Gerber files) are available upon request and will be placed in the Appendix section of the application note. The PCB demo board allows switching between RGB, YPbPr inputs and also two composite (CVBS) inputs. The inputs come from the video sources and the output of the switch is connected to the display device like a TV or PC monitor.

6 Conclusion

In this way a single product finds use in a wide range of applications to serve various needs. ST's STMAV340 is a perfect low-cost, high-performance solution which provides system developers with simple and effective ways to do video signal switching without impacting the quality of the image.

7 Revision history

Table 1. Revision history

Date	Revision	Changes
14-Mar-2007	1	First issue