ESD Protection for HDMI 1.3

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Two essential functions that customers look for in HD video systems are fast data processing and high-speed interface. Advances in data process technology are shrinking trace geometries and allowing for more performance and functionality to be included on ever-smaller integrated circuits (ICs). As for high speed interface, High-Definition Multimedia Interface (HDMI) is the latest standard for devices that handle high-bandwidth, real time data, such as HDTV.

However, the higher the data speed and the more advanced the process technology are, the harder it is to protect the IC adequately from over-voltage stresses caused by ESD (electrostatic discharge) or CDE (cable discharge events). This is because the designated IC becomes more sensitive to the transient threats as the technology advances. As a result, HDMI designs often include additional transient protection to ensure the IC's reliability. Adding external transient protection for HDMI is difficult, however, due to HDMI's sensitivity to signal integrity. Each additional device added to the signal line implies extra parasitic elements that can affect signal transmission.

Introduction to HDMI

HDMI is an uncompressed, all-digital audio/video interface that provides a high-speed link between audio/video source devices such as DVD players, and sink devices such as HDTVs. Since its introduction in 2002, the HDMI standard has undergone various revisions to increase its capabilities. Currently, the most up-to-date HDMI specification is HDMI 1.3, which supersedes its predecessor HDMI 1.2 by doubling the bandwidth and increasing its speed from 1.65 Gbps per differential pair to 3.4 Gbps. HDMI 1.3 also includes unique, new features such as Deep Color, broader color space and the use of the mini connector. These added features enable HDMI 1.3 to present video images with even more color details and to be used with portable electronics.

HDMI compliance test specification

In order for a product to claim compliance to the HDMI standard, it must receive HDMI certification. HDMI certification requires that both the sink and the source device comply with their respective test requirements set forth by the HDMI Compliance Test Specification (CTS). Although HDMI CTS includes many types of tests, due to the fast signal data speed, it is crucial to meet the eye pattern requirement for the source devices and the TDR requirement for the sink devices. In order to meet the eye pattern requirement, the opening of the eye must have a minimum size as specified by the HDMI eye mask for the source device. To meet the TDR requirement, the differential impedance of the HDMI signal line pairs for the sink device must be 100 ohm ±15% with the rise time of the test pulse less than or equal to 200ps. Meeting these requirements is not a trivial task since the opening of the eye and the differential impedance can be easily affected by introduction of even a small amount of capacitance or inductance.

In addition to signal integrity requirements, the externally accessible HDMI ports are becoming more susceptible to transients threats. The threats can come from any charged entity; for example from either a user's direct touch or from hot plugging a charged cable. The internal onchip ESD protection does not provide sufficient protection needed to keep the sensitive HDMI chip from becoming damaged. Thus, most consumer electronics manufacturers require HDMI ports to meet ESD standard of IEC 61000-4-2. To protect against the over-voltage stress induced by users and ESD testing, external protection is required. With this added concern, HDMI designers need to meet ESD immunity requirement of IEC61000-4-2 while maintaining signal integrity and impedance requirements per the HDMI CTS.

Protecting HDMI from transient threats

In order to meet both the signal integrity and the ESD immunity requirements, the chosen protection device should have as small of a capacitance value as possible, preferably less than 0.5pF. This is because the lower the protection device's capacitance, the less the device will affect the differential line impedance when it is added to the HDMI layout. To further facilitate the high-speed design, the protection device should also offer flow-through, symmetrical layout capability. Symmetrical and uninterrupted signal layout will help maintain the signal integrity by streamlining high-speed signal line design and maintain impedance requirements.

In addition to the electrical characteristics requirement, to ensure maximum reliability for the HDMI IC, the same protection device should provide repeatable ESD immunity to and beyond level 4, IEC 61000-4-2 ESD to each of the exposed signal pins. In other words, when testing the I/O or power pin of the HDMI connector, each pin should have a minimum of ±8kV contact ESD and ±15kV air ESD handling capability when surged directly with ESD and without the ESD gun touching the connector shield. In conjunction with ESD voltage protection level, another important parameter to consider is ESD clamping voltage. With the increasing sensitivity to over-voltage stress in today's ICs, lowering the ESD clamping voltage will reduce the risk of being damaged further. Thus, it is important that the chosen protection device offers the lowest ESD clamping voltage possible.

An example of a protection device that meets the aforementioned requirements is Semtech's RClamp0524PA. With a maximum differential capacitance value of 0.3pF, RClamp0524PA is a 5V, 10-pin device that can be used directly on two pairs of 100-Ohm differential impedance signal lines regardless of board characteristics, such as the number of layers or the board thickness.

In other words, designers can design the 100-Ohm differential impedance per their board parameters, and the RClamp0524PA will not cause any change to the already calculated and controlled impedance. *Figure 1* shows an example of high-speed differential trace routing with the Semtech RClamp0524PA.

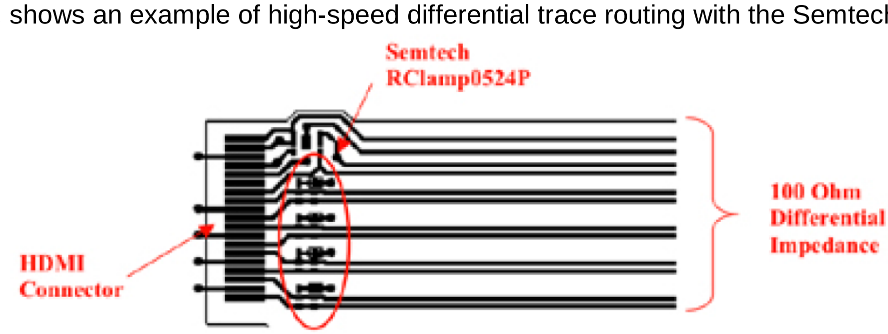
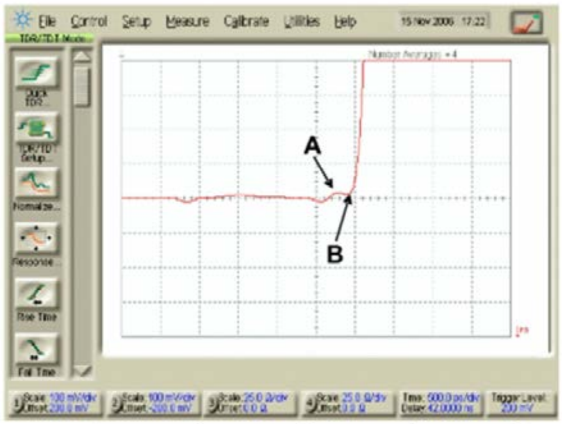


Figure 1: Flow-through layout of Semtech RClamp0524PA for HDMI applications

As can be seen in the layout example, by having 0.5mm pitch to match with the connector pins, the device package helps maintain the coupling between the differential lines of the same pair. By having a flow-through design, the protection device also does not appear as an interruption to the signal routing. This illustrates that the package design is important because a large package with wide pin pads and pitch can create stubs and signal discontinuities and introduce noise, and therefore, corrupt the signal integrity. The result is that a small protection device optimized for high-speed designs is often desired because it can help reduce discontinuities and increase common noise rejection through tight-pitch coupling.

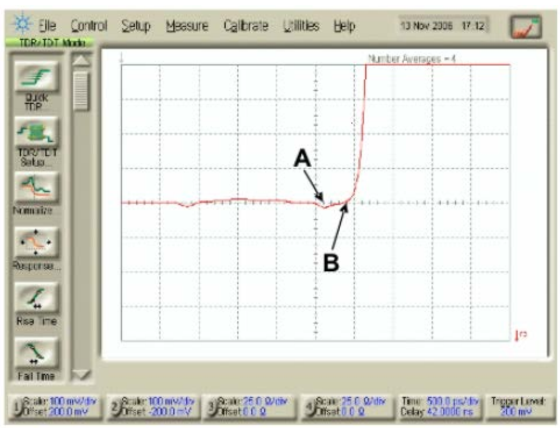
Test results and recommendations

Low capacitance and a package designed with signal integrity maintenance in mind are desired for an ideal protection device for HDMI applications. *Figure 2* and *Figure 3* show respectively the TDR results of Semtech RClamp0524PA on 4-layer and 2-layer HDMI evaluation boards. Both results show that the TDR has met and is well within the HDMI CTS requirement (100 Ohm ±15% for differential impedance) for the sink devices.



	A	B	
X-axis	2.097	2.214	(nsec)
Y-axis	104.0	103.0	(Ohm)

Figure 2: Semtech RClamp0524PA 4-Layer HDMI TDR result



	A	B	
X-axis	1.923	2.216	(nsec)
Y-axis	96.0	101.0	(Ohm)

Figure 3: Semtech RClamp0524PA 2-Layer HDMI TDR result

Semtech RClamp0524PA comparison with TSSOP package

Figure 4 shows the passing eye pattern result using Semtech RClamp0524PA at 1.48Gbps for the source devices.

In contrast, *Figure 5* shows when a TSSOP 38-pin packaged protection device is used on the same traces with 100 Ohm differential impedance, it can affect the impedance by dropping the impedance to as low as 68 Ohm.

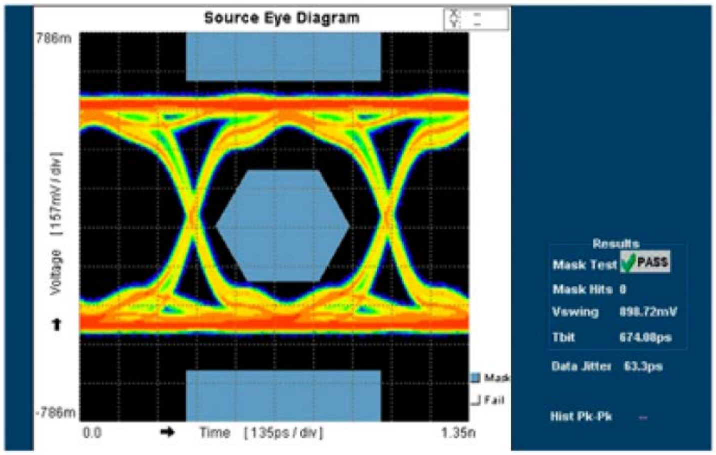
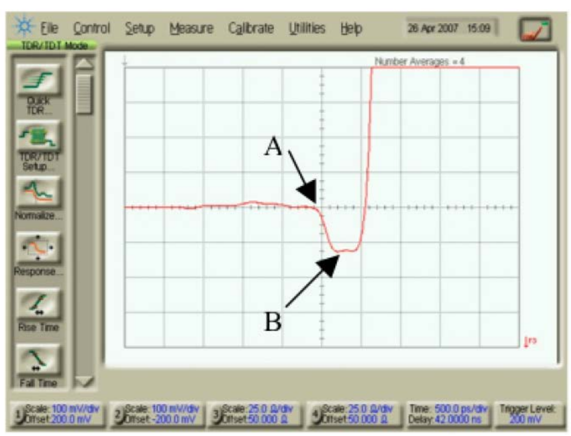


Figure 4: Semtech RClamp0524PA HDMI eye pattern result (1.48Gbps)

This result (*Figure 5 - below*) does not comply with HDMI CTS requirement for the sink devices, and because the package is large with wide pins, these can introduce signal discontinuity at high frequency.



	A	B	
X-axis	1.739	1.988	(nsec)
Y-axis	100	68	(Ohm)

Figure 5: TDR measurement of TSSOP 38-Pin on 4-Layer, 100Ohm differential impedance lines

Figure 6 compares the package size difference between Semtech RClamp0524PA and the TSSOP package.

Significant board compensation would be required in order for this TSSOP package to meet the HDMI CTS differential impedance requirement. Thus, the use of this package can require several board design iterations to achieve an acceptable result.

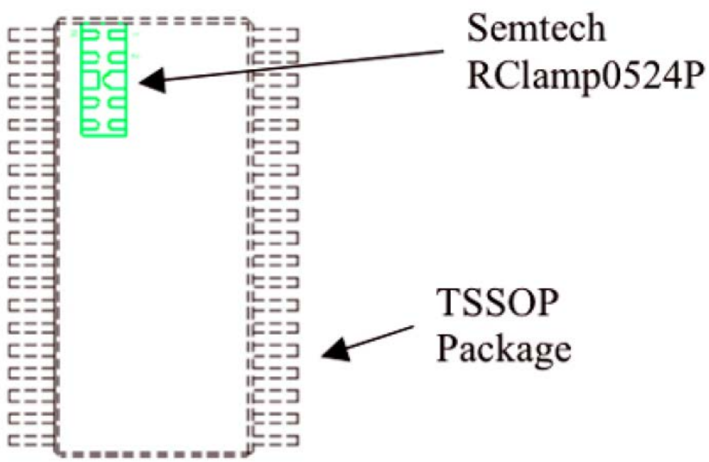


Figure 6: Package size comparison between RClamp0524PA and TSSOP package

Conclusion

Designers of HDMI systems are faced with the difficult challenge of providing reliable ESD protection while meeting signal integrity requirement per HDMI CTS. Proper selection of external ESD protection devices is imperative. The chosen protection device must exhibit very low capacitance and high transient threat handling capability while keeping the ESD clamping voltage at a minimum to maintain the quality and reliability of the protected IC. Package design of the protection device is also important for signal integrity. These factors will ensure that the HDMI chip will not experience catastrophic or latent failure during a transient threat. Solutions such as the Semtech RClamp0524PA meet these requirements and provide designers with a reliable and easy to implement solution.

About the author

Sophie Hou *is an Application Engineer with the Protection Products Division of Semtech Corporation. In this capacity, she focuses on protection solutions for portable and video electronics, participates in new product definition, and provides global customer support. Sophie's expertise is in cellular phone and high-speed application layouts as well as tear-down and analysis of current electronics; she frequently conducts ESD protection seminars, including topics such as board layout techniques and optimization, proper ESD protection component selection, and ESD solutions for portable and video electronics, for electronics designers and manufacturers worldwide. In 2003, she presented a paper at The JEDEX Conference on ESD devices and ESD testing methods. She received a BSEE degree from the University of California at Los Angeles and has been an Application Engineer for more than 6 years. She can be reached at* shou@semtech.com.

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