

Circuit Protection Solutions for DisplayPort Interface

The DisplayPort interface is designed for broad application in PCs, monitors, TV displays, projectors, as well as other sources of display content. DisplayPort enables a common interface signaling approach for both internal and external display connections to help reduce overall design complexity. It is also expected to make digital displays easier to use and more affordable.

The new display interface addresses low-voltage operation, supports protected high-definition content, and is designed to accommodate the higher display resolutions and color depths enabled by Microsoft's next-generation operating system, Windows® Vista.

To conform to current and emerging communications requirements and provide safe, reliable operation, display interfaces must be protected from circuit damage caused by power variations and harsh environmental conditions. The challenge in any high data rate circuit protection scheme is that excess capacitance presented by protection devices will cause some signal attenuation and degradation in display quality.



Circuit Protection Considerations

Two major design considerations in display applications are overcurrent protection and ESD (electrostatic discharge) protection. The DisplayPort specification requires that end user-accessible powered connectors implement overcurrent protection for safety and regulatory reasons. The overcurrent protection device must be resettable without user mechanical intervention and its preset trip limit must be above allowable current transients in order to avoid false trips. Polymeric positive temperature coefficient (PPTC) devices are typically used to help protect powered ports in a wide range of computer, telecom and datacom applications, and are suitable for DisplayPort interface applications.

The DisplayPort specification also requires that systems include ESD protection. Adding ESD protection to high-speed interfaces raises many complex and confusing issues that can increase the manufacturer's cost and time to market. The major source of complexity is operating speed.

The DisplayPort standard specifies two operating speeds, 1.62GHz and 2.7GHz. Depending on usage scenarios and cost issues, designers may choose the lower operating speed. Others may design equipment to run at the higher speed to achieve faster refresh rates, higher resolution, and more color depth. In some cases, a design that runs at both speeds may be implemented. In all of these scenarios, however, optimizing the design generally requires that the designer make tradeoffs between device size, ESD protection performance, and ease of implementation.

Tyco Electronics' PolySwitch devices and PESD devices have demonstrated their effectiveness in a variety of high-speed interface applications, including the 3.4GHz maximum speed of HDMI 1.3. Reference designs are available to help designers provide adequate overcurrent and ESD protection for next-generation displays. Because they provide low capacitance, have minimal impact on bandwidth and exceed both of the DisplayPort operating speeds, these reference designs can help designers make trade-offs in other areas, including board layout, connector choices, or interoperability with a variety of cables.

ESD Protection

ESD suppression devices that demonstrate low capacitance, low insertion loss, and stable capacitance across a broad frequency range make a significant contribution to the design goals of adequate protection, low cost, and minimal signal attenuation. Selection of an ESD suppression device must be predicated on the dynamics of the signal frequency, the presented capacitance and consistent performance of the shunt capabilities of the device.

The DisplayPort specification mandates protection on all potentially exposed interface signals and power pins to meet or exceed the EOS (electrical over stress) specification of IEC 61000-4-2, Level 4 (8kV contact) without damage. For repeatability of the contact test the exposed input/output or power line must withstand a direct strike to each connector pin without contacting the ESD test gun to the connector shield. The designer must carefully select clamping devices and clamping rail voltages such that ESD devices will not cause clipping of normal signals.

When adding ESD protection to DisplayPort systems, it is critical to consider the added impact of additional capacitance and inductance on timing of the chosen device on the high-speed differential lanes. When operating at up to 2.7GHz, any additional impedance on the line can distort the signal, leading to greater difficulty in meeting the required eye diagrams for rise times and signal levels.

Timing performance is typically measured with eye diagrams, a timing analysis tool used to provide an accurate visual display of timing and level errors. The grey space in the middle of the eye diagrams shown in Figures 1 and 2 represents high-speed differential pair specifications.

As the lines encroach on the grey space, the less margin of error there is. The eye width is a good measure of the amount of time the data lines are stable and if any errors are present. The eye height measures the level, or amplitude, of the signal. Since DisplayPorts' pairs are differential signals, it is important to minimize both differential and signal-to-ground capacitance to ensure the rise and fall times of the signals are within specification. Optimally, the capacitance should be as low as possible to give designers as much margin as possible.

Figures 1 and 2 compare the eye diagram performance of Tyco Electronics' 0.25pF PESD device operating at 3.4GHz (with HDMI 1.3) with that of a silicon ESD protection device at 2.25GHz. As shown in Figure 2, silicon solutions have much higher capacitance. Although their eye diagrams are commonly shown at 2.25GHz or 1.48GHz to demonstrate compliance with 1080p 36- and 24-bit color depths, their eye diagrams appear to have marginal tolerance on the specification. This can lead to increased board design constraints.

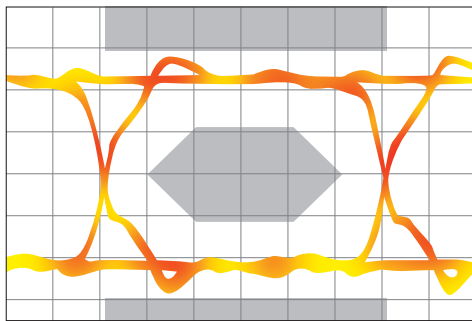


Figure 1. Eye diagram of Tyco Electronics' 0.25pF PESD device operating at 3.4GHz.

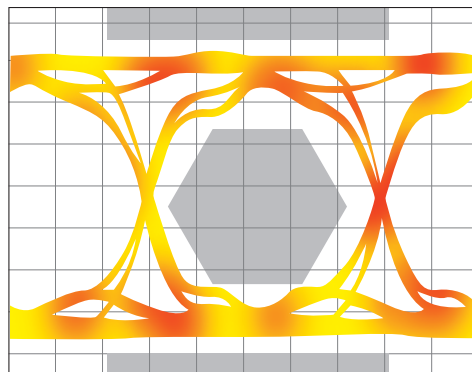


Figure 2. Silicon ESD protection device eye diagram at 2.25GHz.

Tyco Electronics' PESD devices reduce ESD transients to a level that helps prevent damage to electronic components in the circuit. They provide exceptionally low capacitance (less than 0.25pF), are capable of handling numerous ESD transients without performance degradation, and offer a lower trigger voltage and a lower clamping voltage than typical ESD devices. PESD devices offer the following advantages in DisplayPort applications:

- Minimize signal attenuation
- Improve eye diagram margins versus higher capacitance devices, enabling easier design
- Help designers comply with DisplayPort specification requirements
- In most cases, can be added without additional agency testing
- Help reduce total system cost

In addition to protecting the eight high-speed differential pairs, or lanes, designers must also use ESD protection on the lower speed control lines and power lines per the DisplayPort specification.

DisplayPort designs have implemented an auxiliary channel (AUX CH) that provides flexible delivery of control and status information between the source and display devices. This auxiliary channel runs at a much slower speed than the high-speed lanes, and can thus utilize higher capacitance ESD protection (1 Mbps for the AUX CH vs. up to 2.7Gbps for the main lanes).

Low-voltage DC lines also need ESD protection. A DisplayPort source, sink, or locally powered device must provide power on the DP_PWR pin of the connector (and corresponding ground referred to as the DP_PWR_RETURN) per the specification. Also, a HPD (hot plug detect) signal is used to detect a sink device by the source. Since these lines are static DC power lines, higher capacitance ESD protection devices are commonly used.

Tyco Electronics' Multi Layer Varistors (MLVs) are commonly used in the previously mentioned low-speed/low-voltage DC applications as they are cost-efficient and provide low clamping voltages and high transient capability. MLVs offer the following advantages in the AUX CH, DP_PWR, and HPD DisplayPort applications:

- Provide cost-effective ESD protection
- Help designers comply with DisplayPort specification requirements
- In most cases, can be added without additional agency testing

Tyco Electronics recommends that customers consider the following part numbers:

- MLV0402-120-E120
- MLV0402-080M-C221
- MLV0603-130M-C201

Figure 3 illustrates a typical DisplayPort circuit protection design utilizing PESD suppressor devices, MLV suppressor devices, and a PolySwitch overcurrent protection device.

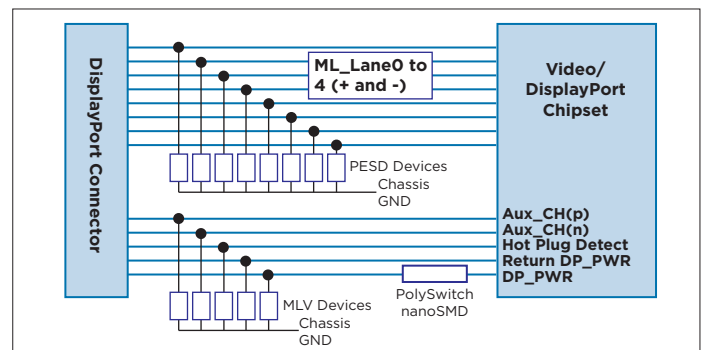


Figure 3. Typical DisplayPort circuit protection design.

Overcurrent Protection

The DisplayPort standard specifies resettable overcurrent protection on source devices such as computers, TV tuners, DVD players, etc. The low resistance, fast time-to-trip, and small form factor of Tyco Electronics' PolySwitch surface mount devices have made them the preferred method of overcurrent protection in these mass market, powered bus architectures.

PolySwitch devices are used to help protect against harmful overcurrent surges. Like traditional fuses, they limit current after specified limits are exceeded. However, unlike a fuse, the PolySwitch device has the ability to reset after the fault is cleared and the power is cycled.

Unlike the USB specification, DisplayPort source voltages can vary from system to system (3V to 16V typical) and the spec is limited by wattage and voltage drop. When selecting a PolySwitch device for these applications the device's voltage rating must match or exceed system bus voltage.

Page 137 of the DisplayPort V1.1 specification states: "The voltage on the DP_PWR pin of the source connector must be in the range of 3.0V to 16.0V and the DP_PWR pin of the sink connector must be in the range of 3.15V to 3.45V. The minimum power available at the DP_PWR pin must be 1.5W, regardless of the power supply voltage. A device that consumes more than 1.5W of power must have a means of getting power from an alternate power source. The DP_PWR and RETURN pins of the box-to-box connectors must support the maximum current rating of 500mA."

In our testing, the PolySwitch devices referred to (ie: 0.75-1.5A) meet all hold current, trip current, voltage drop, and self-reset requirements of the DisplayPort specification. To assure the voltage specification is met, Tyco Electronics recommends that customers consider the following part numbers:

- PolySwitch miniSMDC075F/24
- PolySwitch miniSMDC110F/16
- PolySwitch miniSMDC125F/16
- PolySwitch miniSMDC150F/24

Lower current devices or lower voltage rated devices can also be used in some situations. Specifically, if the customers' source voltages are lower than 16V, overcurrent protection can be implemented with smaller, lower voltage rated devices. However, these devices should be rated at or above the customer designed DisplayPort bus voltage, and also above the minimum current defined by the 1.5W power delivery spec requirement. For example, on a 3.3V bus, the PolySwitch device would need to be rated above 3.3V and have a hold current above 500mA ($1.5W/3.3V = 0.45A$). Under these conditions, and taking into consideration the thermal derating of the PolySwitch device, Tyco Electronics would recommend a PolySwitch nanoSMD075 device (6V rating, 0.75A hold current) be considered for size-constrained applications.

Ganged protection may also be possible using PolySwitch devices. The key constraint to consider is the requirement that the preset trip limit must not exceed 3A at the source connector DP_PWR pin. Considering their 2:1 trip-to-hold ratio, PolySwitch devices with hold currents greater than 1.5A are not appropriate in this application.

Summary

Designing an ESD protection solution that can operate at bandwidths above DisplayPort's 2.7GHz speed minimizes design challenges, increases system margin, and facilitates next-generation designs by obviating the need for a full redesign of the ESD protection scheme down the road.

Tyco Electronics' ESD and overcurrent protection reference layouts can help designers comply with the DisplayPort specification at 2.7GHz, by helping to provide IEC 61000-4-2 ESD protection, optimize board space, and reduce design risk.

PolySwitch overcurrent protection devices provide a low-cost protection solution to help meet the DisplayPort specification requirements. They offer field reliability and can help manufacturers meet the DisplayPort requirements for resettability, voltage drop, and trip limits.

DisplayPort standards are available for download at <http://www.vesa.org/>.

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