BRD8080/D
Rev. 2A, Jul-2013

ON Semiconductor

Energy Efficient Innovations

# Circuit Protection Solutions

*Providing a comprehensive portfolio of ESD and EMI/RFI protection devices from ON Semiconductor.*

www.onsemi.com

# Introduction

Electro-Static Discharge protection and Electro-Magnetic Interference is becoming an increasingly important consideration for all electrical devices. Increased feature sets demanded by consumers, and sleek industrial designs require enhanced performance of ESD and EMI products in small outline packages.

## External Protection Requirement

Advanced system-on-chip (SOC) designs are being manufactured in the most advanced technologies. In order to optimize functionality and chip size, designers are constantly reducing the minimum feature sizes within their designs. But at what cost? The reduced dimensions of features have resulted in devices that are more susceptible to damage from ESD.

Today's integrated circuits have a reduced window for designing protection. As Figure 1 illustrates, ICs have an intended operating region of voltage and current, surrounded by a region of safe overvoltage. ESD protection must work in the region of safe overvoltage and over current. As the industry moves to more advanced ICs using smaller geometries and lower voltages, the region of safe overvoltage is shrinking.

In previous IC generations, it was sufficient for designers to pick a protection product that simply survived the IEC61000-4-2 ESD specification. As a result, most datasheets for protection products only include a survival rating (i.e. the protector survives IEC61000-4-2 8 kV contact level 4). This does not indicate how effective the product would be at protecting sensitive circuits. The key to effective ESD protection is to limit the voltage during the ESD event to a level within the safe voltage window for a given chipset. ESD protection products do this by providing a low resistance current path to ground during an ESD event. This is illustrated in Figure 1; protection products for new integrated circuits need lower dynamic resistance (Rdyn) to avoid voltages that cause damage. Adding to this challenge, ESD protection products must have lower and lower capacitance as signal speeds increase.

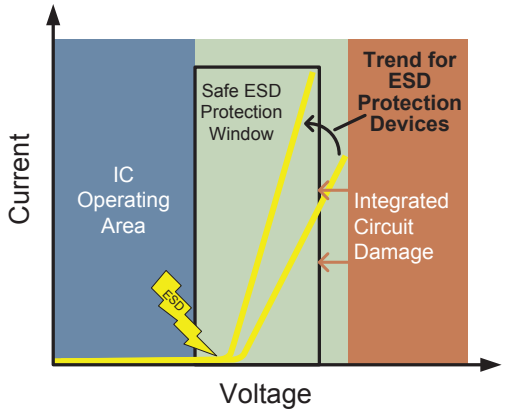



**Figure 1. The design window for ESD protection (green) shrinks as technology advances, requiring protection devices with lower dynamic resistance**

To meet these more demanding requirements, silicon based ESD protection products have evolved. As illustrated in Figure 2, 10 or 15 years ago simple Zener diodes met all the ESD protection requirements. As the need for lower voltage protection and decreased capacitance increased, simple Zener diodes could no longer meet the challenge because a Zener's capacitance increases as turn on voltage is decreased. To meet the low capacitance requirement, the three diode approach was adopted; two steering diodes and a Zener diode integrated in silicon provided low capacitance, low breakdown voltage and protection for both positive and negative stress. As the push to lower voltage and higher speed signals has continued, ON Semiconductor is introducing low turn on voltage SCR (silicon controlled rectifier) based ESD protection as shown in Figure 2. SCRs have very low dynamic resistance for their physical size and therefore can provide excellent protection at very low capacitance. With the wide range of applications in today's electronics, all three protection strategies remain important and must be carefully matched to the application. This is especially important for SCR based protection.

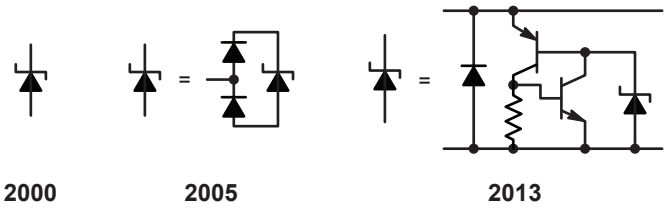



**Figure 2. Evolution of ESD Protection Design**

SCRs provide very low on state dynamic resistance through a pair of cross coupled bipolar transistors. When an SCR turns on, the voltage across it drops to a low value, often in the range of 1 to 2 V as shown in Figure 3. This low voltage makes SCR based protection products extremely effective at preventing damage to sensitive high speed circuits. Voltages of 1 to 2 V are, however, often within the working voltage range for many applications, raising the fear of latch-up. Latch-up can occur when an SCR triggered into its on state will stay in the low impedance state and draw considerable current even after the trigger stress is over. This is a legitimate concern, but high speed data lines have termination resistances between 50 and 100 ohms, limiting the current which can be delivered to the SCR. If the application's load line is below the

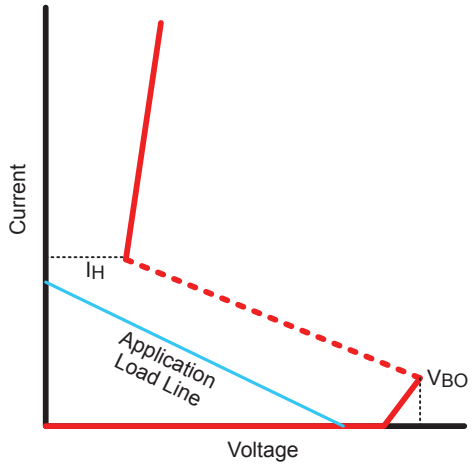



Figure 3. SCR Characteristic and Application Load Line

holding current, IH, of the SCR protection device, as shown in Figure 3, a latch-up state cannot be maintained. A more complete discussion of this is given in Application Note AND9116/D.

## Evaluating ESD Protection Effectiveness

As the design window for protection shrinks, choosing ESD protection products with low Rdyn becomes more important to ensure that clamping voltages do not exceed the safe protection window of new chipsets. Suppliers of ESD protection products must therefore provide information on the effectiveness of the product for protection, not just self-survival levels.

ON Semiconductor demonstrates ESD protection effectiveness using two methods: ESD screen shots and Transmission Line Pulse (TLP) measurements. ESD screen shots capture the voltage across the protector when an IEC 61000-4-2 ESD stress is forced through it; typically for an 8 kV contact stress. The screen shot shown in Figure 4 demonstrates how an ON Semiconductor protection device clamps the voltage to below 20 V within 10 ns for an 8 kV stress. Screen shots provide a graphic and intuitive view of a protection product's effectiveness, especially when comparing two products intended for the same application. Application Note AND8307/D describes the capture of screen shot data. Screen shots do not, however, allow the extraction of fundamental parameters describing the performance of a protection product. Transmission Line Pulse (TLP) provides a more quantitative measurement of ESD protection device effectiveness.

TLP creates I-V curves in which each data point is obtained with a square pulse that closely matches an ESD event in terms of

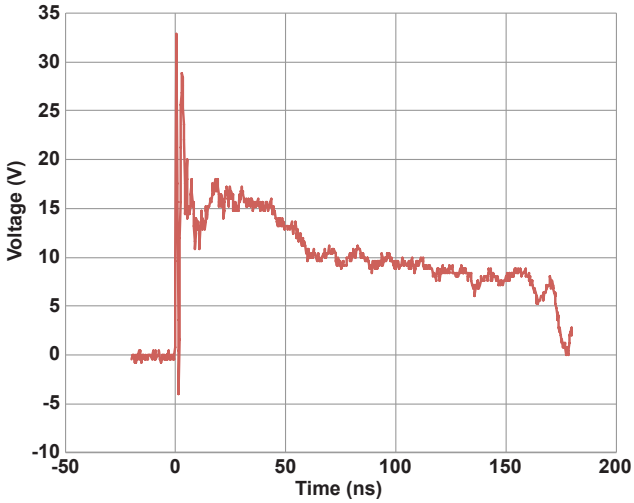



Figure 4. ESD clamping screenshot

current shape and pulse width. TLP pulse lengths are typically 100 ns, with pulse amplitudes up to 40 A. Sample TLP I-V curves are shown in Figure 5, comparing an ON Semiconductor product with a competitor's product intended for the same application. The ON Semiconductor product turns on at a lower voltage and has significantly lower dynamic resistance than the competitor's device. The TLP I-V curves and parameters extracted from them can be used to compare the properties of different ESD protection devices and can be used to predict a circuit's ESD clamping performance. Parameters that can be extracted from TLP data include clamping voltage values for specified current levels, as well as dynamic resistance and voltage intercepts. Application Note AND9006/D gives a full explanation of the TLP technique, and Application Note AND9007/D describes datasheet parameters extracted from TLP measurements.

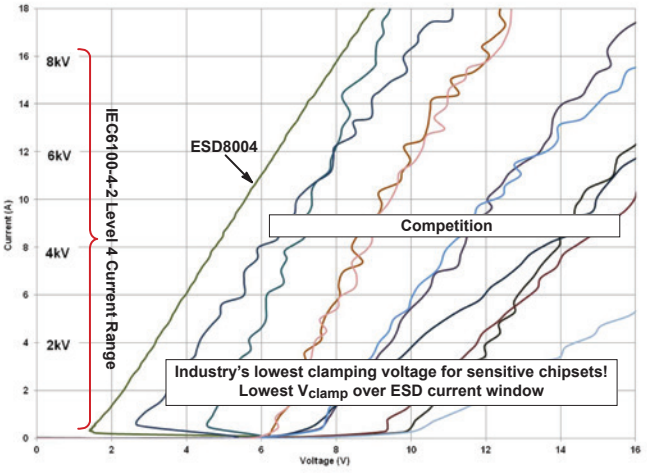



Figure 5. Typical TLP I-V curves from TLP measurements

## Silicon vs. Passive Technology

Protection and filtering solutions from ON Semiconductor are based on state of the art silicon processes. In contrast, there are other types of low cost passive solutions that use a combination of ceramic, ferrite and Multi-Layer Varistor (MLV) materials. These types of devices historically have poor ESD clamping performance. In some instances the voltages that downstream devices can be exposed to are an order of magnitude or more than in an ON Semiconductor solution. This is illustrated in the ESD screen shot in Figure 6, comparing an ON Semiconductor silicon solution with a competing technology for an 8 kV ESD stress. The turn on voltage of the competing technology was so high that it never activated and the measured voltage was purely the voltage drop over the 50 Ω measurement circuit. Some of the older technologies can even degrade after a minimal number of ESD strikes.

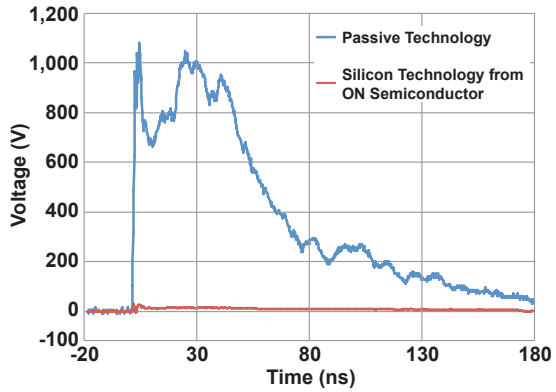



**Figure 6. Example of a competitive passive technology's ESD Clamping performance compared to an ON Semiconductor silicon device at 8 kV when measured with a 50 Ω system**

Because of their material make up, some passive devices tend to be inconsistent over temperature and therefore less reliable in harsh environments.

## Maintaining Signal Integrity

ESD and EMI solutions protect against unwanted signals that interfere with the overall system performance. During a system's normal operation, these protection devices must not degrade signal integrity, as they must be completely transparent. As the data rates on serial interfaces increase, it is important to demonstrate that protection products do not degrade signal integrity. ON Semiconductor uses several methods to demonstrate that these products do not degrade signal integrity.

One way in which to measure signal integrity effects is with the S-parameter return and insertion loss plots, such as the ones in Figure 7 and Figure 8. S11 plots measure signal power return loss over frequency, where a small amount of loss shows up as a large –dB value due to the matched impedance of the interconnect. Lower return loss translates into more of the signal, both amplitude and phase, being transferred through the interconnect which can be seen in the S21 plot where the signal power insertion loss is being measured. Both S-parameter plots below show how an ON Semiconductor ESD protection device maintains the lowest loss and best transparency among other top competitor devices. S-parameter plots also measure the frequency response of filters, as shown in Figure 11 for a Common Mode Filter.

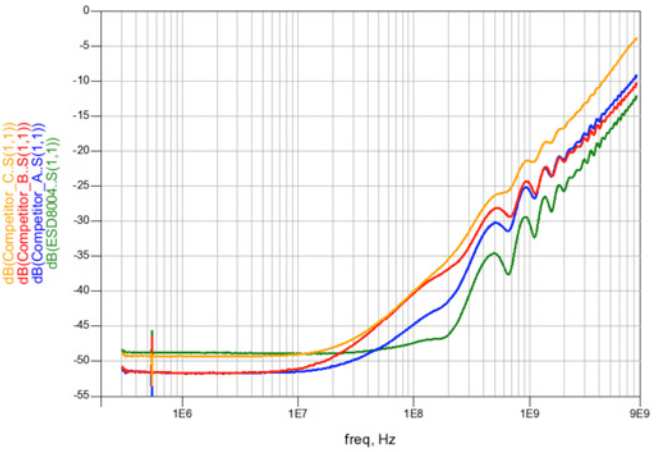



**Figure 7. Return loss (S11) characteristics of ESD protection solutions**

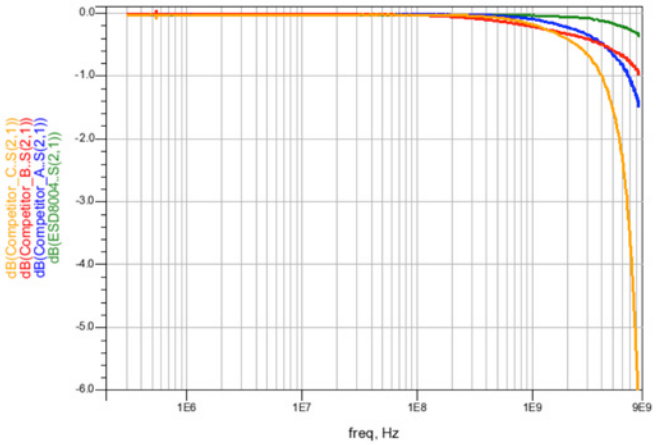



**Figure 8. Insertion loss (S21) characteristics of ESD protection solutions**

A classic way to demonstrate signal integrity of high speed digital signals is the eye diagram, as shown in Figure 9, comparing a signal with and without an ON Semiconductor ESD protection product. A pseudo-random pattern of clocked digital data is built up on a digital storage oscilloscope over time. A high quality signal will show a large open area, or eye, midway between the times of data

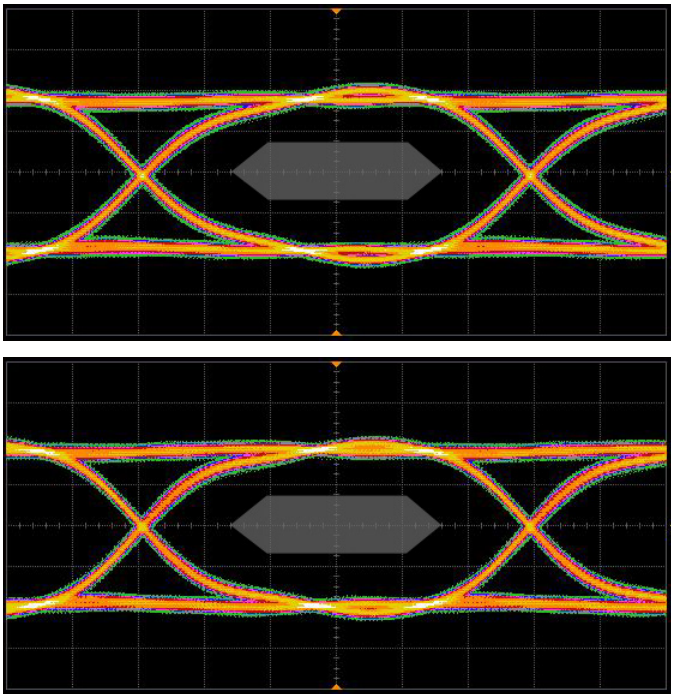


**Figure 9. Eye Diagram screenshot showing the overlay of a random clocked data stream as well as the mask in the center of the eye without (top) and with (bottom) an ON Semiconductor ESD protection device**

transition. The specifications for high speed interface standards define a mask, the hexagon in the center of the eye. The data pattern must not cross the mask, thereby ensuring that data can be read without errors. Other key parameters of the signal can be quickly visualized and measured from the eye diagram. The presence of protection products must cause minimal degradation of the eye diagram as shown in the figure for an ON Semiconductor ESD protection device.

In some cases where impedance matching is crucial to the interface standard to achieve maximum performance, Time-Domain Reflectometer (TDR) measurements can be done. TDR shows the characteristic impedance of the entire signal path including the effects of a given protection or filter solution. Most high speed standards such as USB and HDMI specify acceptable TDR measurements of the impedance across a differential pair.

## *Electromagnetic Interference (EMI)*

ON Semiconductor provides two classes of EMI filters, single ended and common mode filters. The single ended filters are made in various array configurations for parallel interfaces. These include general purpose resistor-capacitor (RC) versions for low speed signals such as audio and inductor-capacitor (LC) versions for higher speeds and power sensitive interfaces. Low pass filters are available with cut off frequencies ranging from 700 MHz to up to 6 GHz. Cut off frequency is illustrated with the S21 plot in Figure 10.

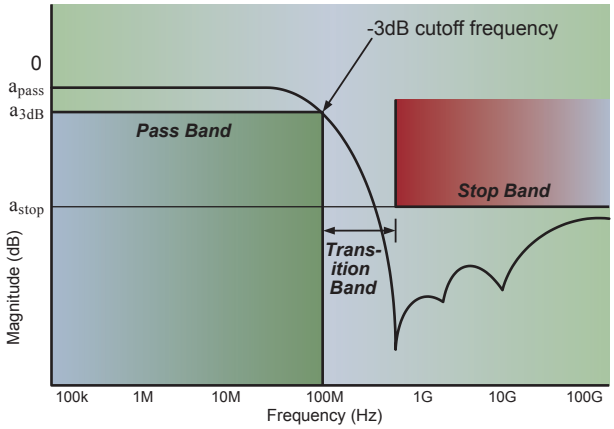



**Figure 10. Single ended low pass filter characteristics**

Single ended filters cannot meet the needs of high speed differential interfaces. Differential interfaces have inherent noise rejection, but they are not completely immune to common mode noise that may exist from an external source or prevent the interface signal from radiating to other parts of the system.

For high-speed differential signals, Common Mode Filters (CMF) can be used to remove unwanted common mode noise and also prevent high speed signals from radiating harmful common mode noise signals to other parts of the system. At the same time the CMF allows the passage of the intended high speed data virtually undisturbed. Typical CMF properties are shown in Figure 11, demonstrating the removal of common mode noise, while allowing free passage of the differential mode signal.

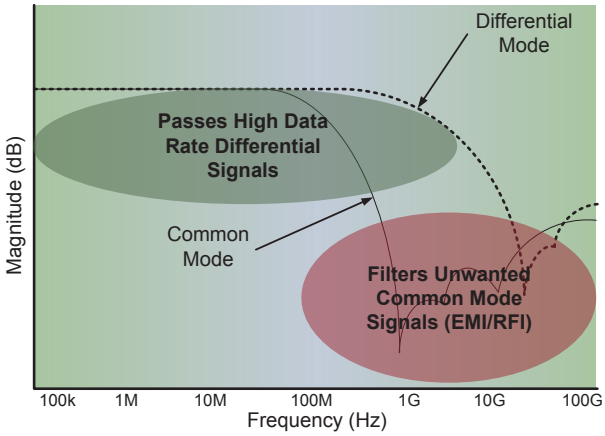



**Figure 11. Example of an S21 insertion loss plot showing two types of circuit modes**

## Surge Protection

In addition to protecting against ESD strikes, ON Semiconductor also provides solutions for protecting against surge strikes, induced by a lighting strike or power-cross fault. A common interface found in a wide variety of consumer and telecommunications/networking equipment is the RJ45 interface for the 10/100BASE-T and 1000BASE-T Ethernet protocols. It consists of four pairs of differential data lines, each carrying a maximum data-rate of 250 Mbps. The interface is often surge-rated to an intra-building standard. Protection for this interface consists of ensuring that transverse (metallic or differential) surge strikes do not damage sensitive downstream chips such as PHYs. This is achieved by connecting shunt protection elements from line-to-line (for each pair of lines) that transfer the incoming hostile surge energy back towards the source.

For lower data-rates (10/100BASE-T), ON Semiconductor offers a combination of crowbar devices known as thyristor surge protector devices (TSPD), and transient voltage suppressor (TVS) devices similar to those used in ESD protection. TSPDs offer the advantage of lower clamping voltages and possess higher surge current capability; for instance, they meet the 100 A requirement of the GR-1089 10/1000 μs standard. As a result, they are appropriate for primary side protection, also known as the "line-side."

TVS clamping devices support surge levels for the 8/20 μs pulse and are commonly used on the tertiary or PHY-side to capture and safely dissipate any residual surge pulses. Pictured in Figure 12 is a time-domain plot of the 8/20 μs surge current applied to a new TVS product from ON Semiconductor. Also shown are time-domain response voltages, clearly showing the superiority of the ON Semiconductor solution in comparison to a competing device.

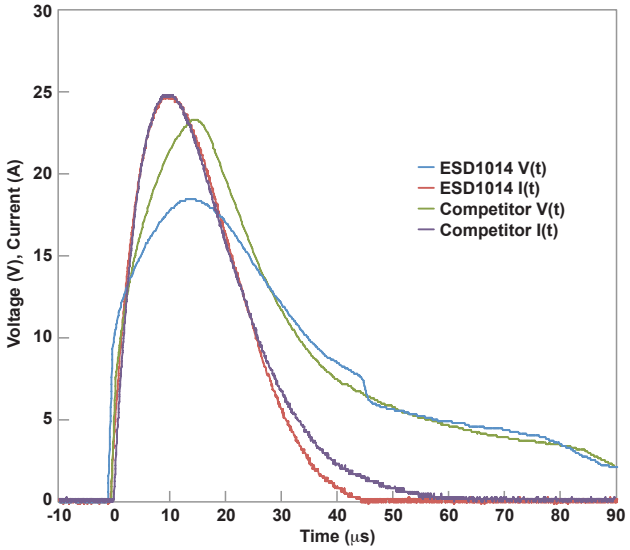



**Figure 12. Example of V & I plots in an 8/20 μs surge**

## Conclusion

This introduction has summarized the important features of protection and filter products from ON Semiconductor. The remainder of this brochure details specific products, interface by interface, along with a convenient selection guide.

# Thunderbolt

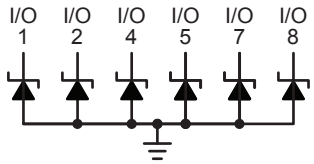
*Four High Speed Pairs, up to Six Additional Lines, Low Capacitance ESD*

## Key Requirement

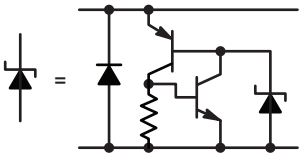
- Cap < 0.3 pF

## Features

- 0.25 pF
- Flow through routing
- Grounds between pairs for reduced cross talk
- Industry leading clamping voltage



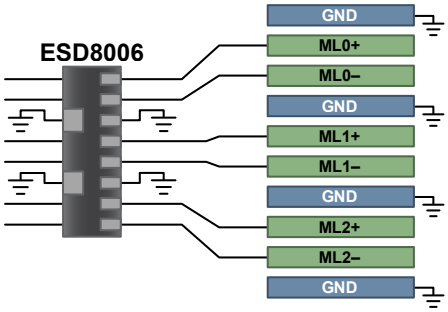

Pins 3, 6, 9, 10



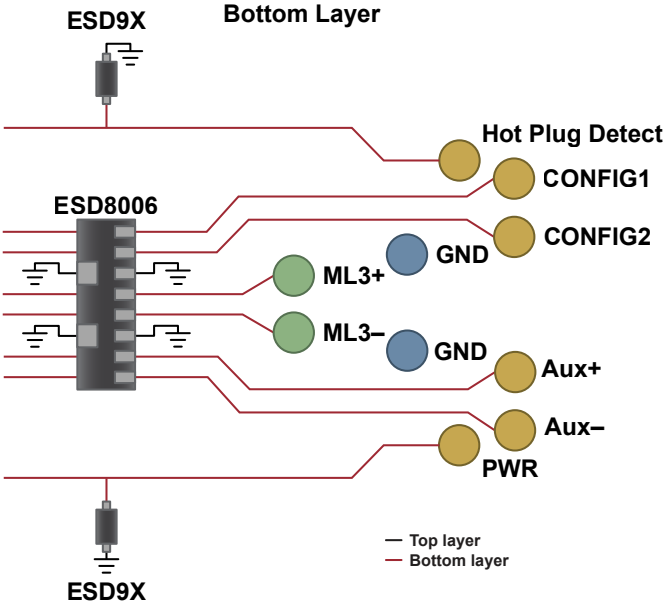
| Device | Lines | Capacitance (pF) | Package | Size (mm) |
|---|---|---|---|---|
| ESD8006* | 6 | 0.25 | UDFN-8 | 3.3 x 1.0 |

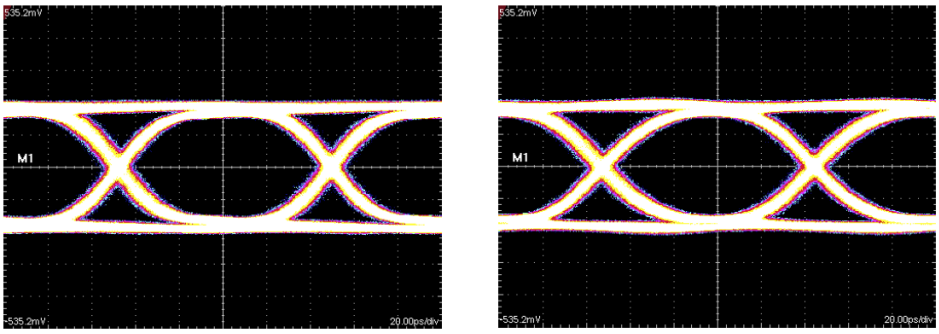
* Pending 2H13

Thunderbolt Connetctor
Top Layer




Thunderbolt Connetctor
Bottom Layer



Without ESD8006 | With ESD8006

Thunderbolt @ 10 Gb/s

# USB 2.0 for Consumer and Portables

## *One High Speed Pair, $V_{CC}$, Low Capacitance ESD Protection*

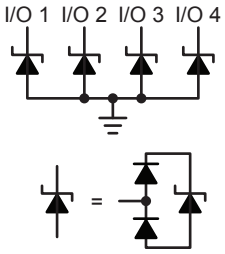
### Key Requirement

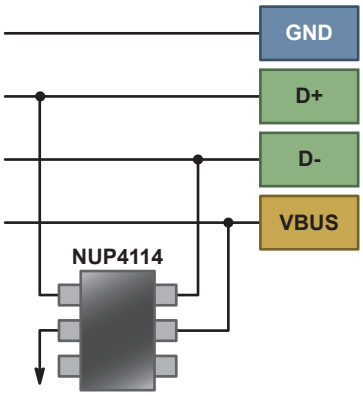
- Cap < 1.5 pF

### Features

- 0.5 - 0.8 pF
- 4 low speed + 1 VBUS integrated – can protect up to 2 USB ports
- Industry leading low clamping voltage

| Device | Lines | Capacitance (pF) | Package | Size (mm) |
|---|---|---|---|---|
| NUP4114UPX | 4 | 0.8 | SOT-563 | 1.6 x 1.6 |
| NUP4114UCL | 4 | 0.5 | SC-88 | 2.0 x 2.1 |
| NUP4114H | 4 | 0.8 | TSOP-6 | 3.0 x 2.75 |
| ESD7L5.0 | 2 | 0.5 | SOT-723 | 1.2 x 1.2 |
| ESD9L5.0 | 1 | 0.5 | SOD-923 | 1.0 x 0.6 |




## *One High Speed Pair, $V_{CC}$, Common Mode Filter + ESD Protection*

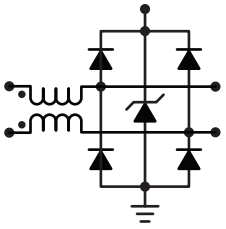
### Key Requirement

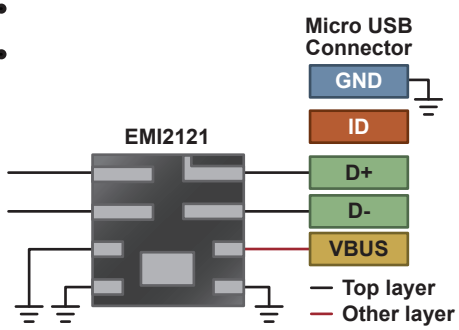
- Cap < 1.5 pF
- Common Mode Filtering

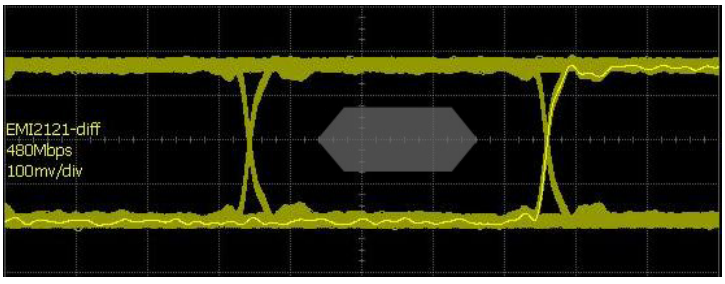
### Features

- 0.5 - 0.8 pF
- Integrated EMI suppression with ESD protection
- Industry leading low clamping voltage

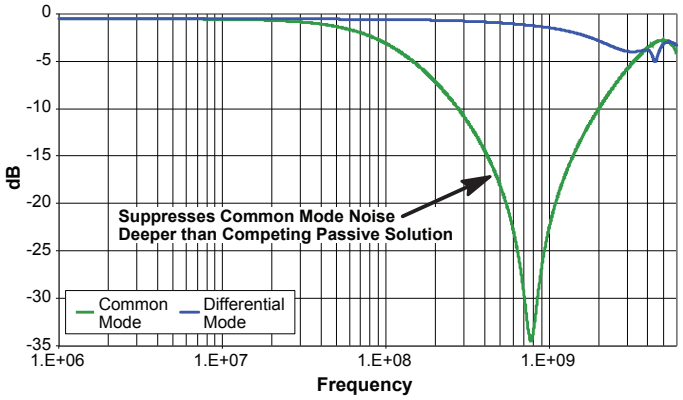
| Device | Pairs | Capacitance @ 2.5 V (pF) | CM Attenuation @ 800 MHz (-dB) | DM Bandwidth F3dB (GHz) | Package | Size (mm) |
|---|---|---|---|---|---|---|
| EMI2121 | 1 | 0.9 | -25 | 2.5 | WQFN | 2.2 x 2.0 x 0.75 |
| EMI2124 | 1 | 0.9 | -25 | 2.5 | WQFN | 2.2 x 2.0 x 0.75 |






USB 2.0 @ 480 Mb/s



# USB 3.0 for Consumer

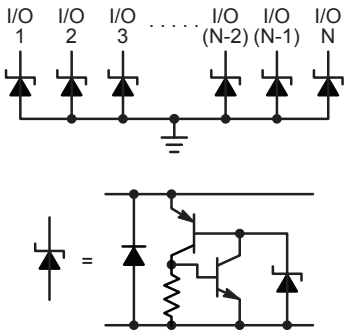
*Two SuperSpeed Pairs, One High Speed Pair, $V_{CC}$, Low Capacitance ESD Protection*

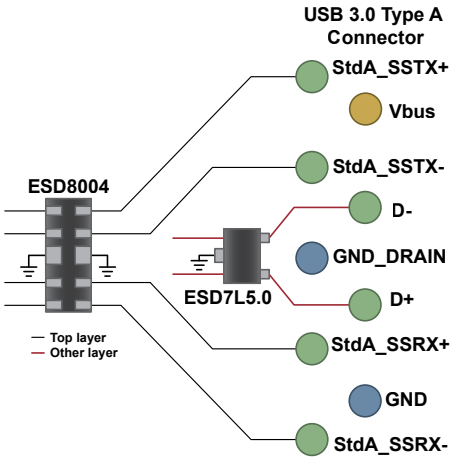
## Key Requirement

- Cap < 0.5 pF

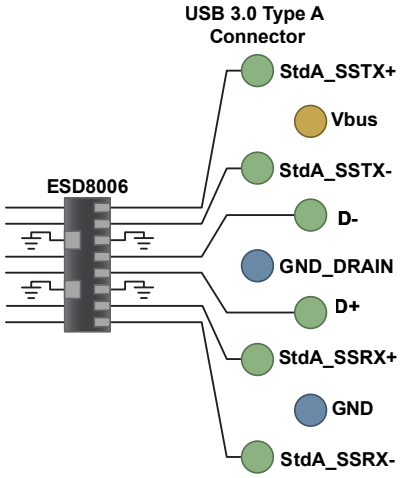
## Features

- 0.30 pF or less
- Flow through routing
- Industry leading low clamping voltage versus competitors



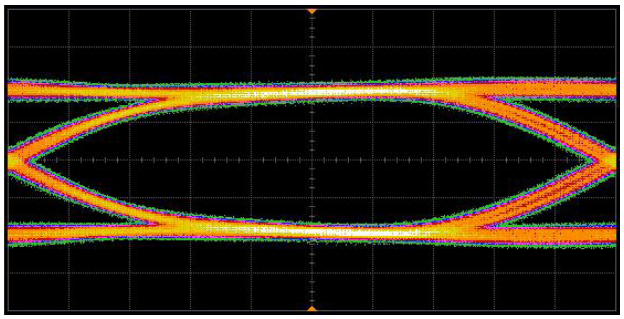

**ESD8004 – 0.32 pF, 2 Layer Routing**
(ESD8004; ESD7L5.0 for D+, D- Lines)



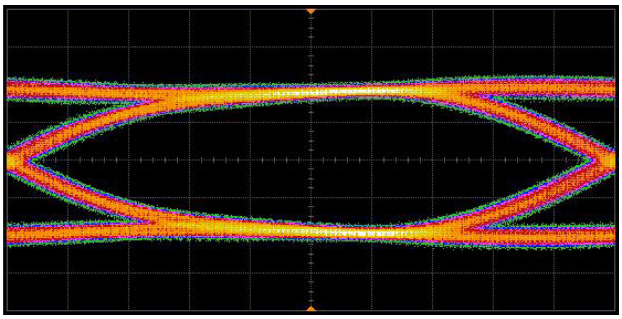

**ESD8006 – 0.25 pF, 1 Layer Routing**

| Device | Lines | Capacitance (pF) | Package | Size (mm) |
|---|---|---|---|---|
| ESD8006* | 6 | 0.25 | UDFN-8 | 3.3 x 1.0 |
| ESD8004 | 4 | 0.32 | UDFN-10 | 2.5 x 1.0 |
| ESD7L | 2 | 0.5 | SOT-723 | 1.2 x 1.2 |

* Pending 2H13.



**Without ESD**



**With ESD**

**USB 3.0 @ 5 Gb/s**

# eSATA

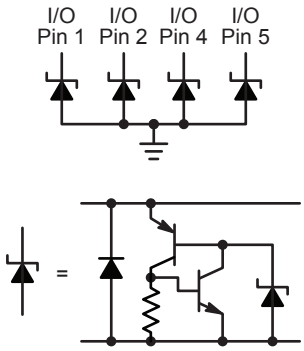
*Two High Speed Pairs, Low Capacitance ESD Protection*

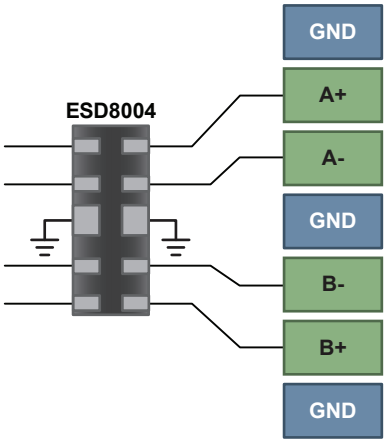
## Key Requirement

- Cap < 0.4 pF

## Features

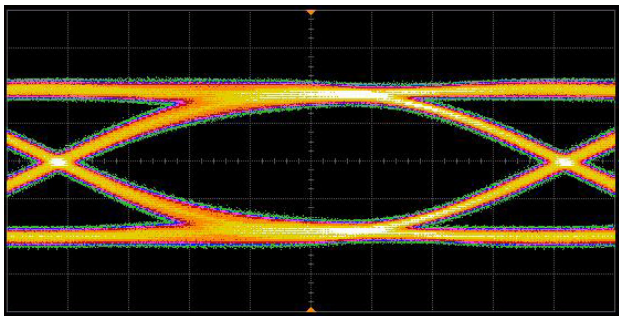
- 0.3 pF
- Flow through routing
- Industry leading low clamping voltage



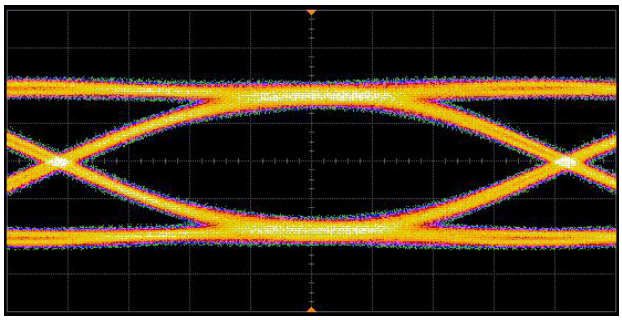




ESD8004

| Device | Lines | Capacitance (pF) | Package | Size (mm) |
|---|---|---|---|---|
| ESD8004 | 4 | 0.32 | UDFN-10 | 2.5 x 1.0 |



Without ESD



With ESD

eSATA 3.0 @ 6 Gb/s

# Parallel Interfaces for Cameras and Displays

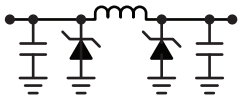
*Parallel Intefaces from 4 to 12 Lines, Low Pass LC Filters + ESD Protection*

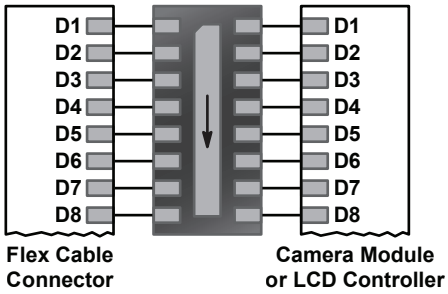
## Key Requirement

- F3dB > 250 MHz

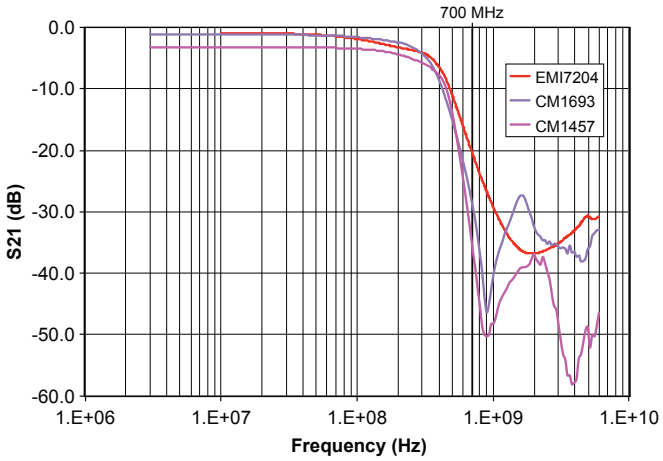
## Features

- 4/6/8 Channel LC EMI+ESD
- –35 dB Stop Band Attenuation From 700 MHz
- 700 MHz Stopband for 4G LTE
- 0.4 mm pin pitch
- 0.55 max package height






**EMI720x, CM1693, CM1457 Series Typical Interface**




**Series Insertion Loss Curves**

| Device | Channels | Resistance (Ω) | Inductance (nH) | Capacitance @ 2.5 V (pF) | Attenuation @/Freq (–dB) | Bandwidth F3dB (MHz) | Package | Size (mm) |
|---|---|---|---|---|---|---|---|---|
| EMI720x Series | 4, 6, 8 | 14 | 17 | 24 | 25/800 | 250 | UDFN | Various x 1.35 x 0.55 |
| EMI940x Series | 4, 6 , 8 | 45 | 70 | 12.5 | 35/700 | 345 | UDFN | Various x 1.35 x 0.55 |
| CM1693 Series | 4, 8 | <12 | 26 | 12 / 10 | 35/700 | 250 | UDFN | Various x 1.35 x 0.55 |
| CM1457 Series | 4, 6, 8 | 45 | 70 | 12.5 | 35/700 | 300 | CSP | Various x 1.05 x 0.62 |

# Serial Interfaces for Cameras and Displays

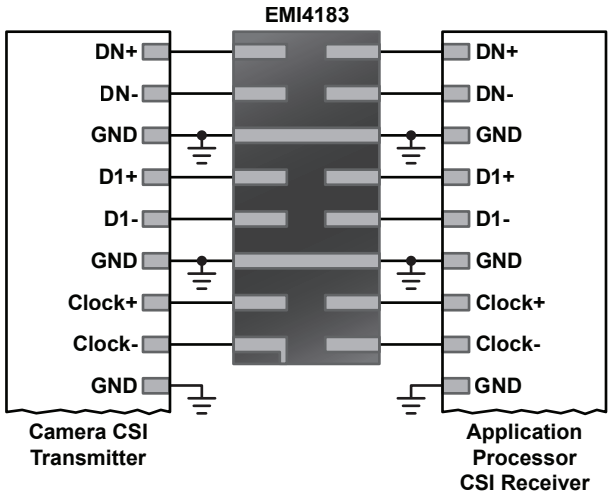
*3 to 5 Pairs of High Speed Serial Lanes, Common Mode Filters + ESD Protection*

## Key Requirement

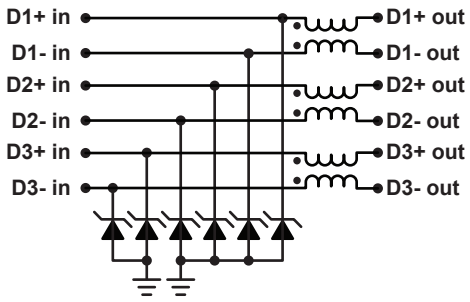
- DM F3dB > 2 GHz
- Low Cap ESD Protection

## Features

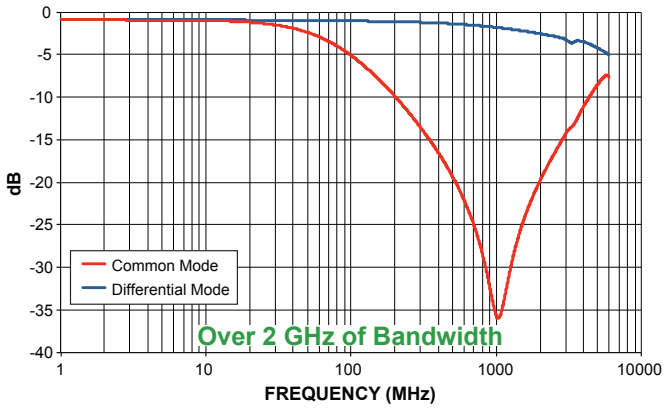
- 2, 3 and 4 pair configurations
- Integrated ESD protection
- –25 dB common mode rejection starting at 800 MHz
- 0.5 mm pin pitch
- 0.50 and 0.75 max package heights




Camera Mobile MIPI Application




| Device | Pairs | Capacitance @ 2.5 V (pF) | CM Attenuation @ 800 MHz (–dB) | DM Bandwidth F3dB (GHz) | Package | Size (mm) |
|---|---|---|---|---|---|---|
| EMI4182 | 2 | 0.8 | -25 | 2 | WQFN | 2.5 x 2.0 x 0.75 |
| EMI4183 | 3 | 0.8 | -25 | 2 | WQFN | 4.0 x 2.0 x 0.75 |
| EMI4182MU | 2 | 0.8 | -25 | 2 | UDFN | 2.5 x 2.0 x 0.5 |
| EMI4183MU | 3 | 0.8 | -25 | 2 | UDFN | 4.0 x 2.0 x 0.5 |
| EMI4184MU | 4 | 0.8 | -25 | 4 | UDFN | 5.0 x 2.0 x 0.5 |




Series Insertion Loss Curves

# Video Out for Portables

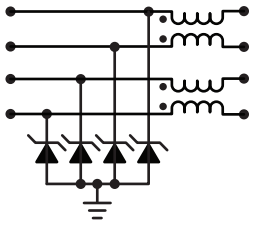
*Four High Speed Pairs, Up to Six Additional Interface Lines, Low Capacitance ESD + Common Mode Filters*

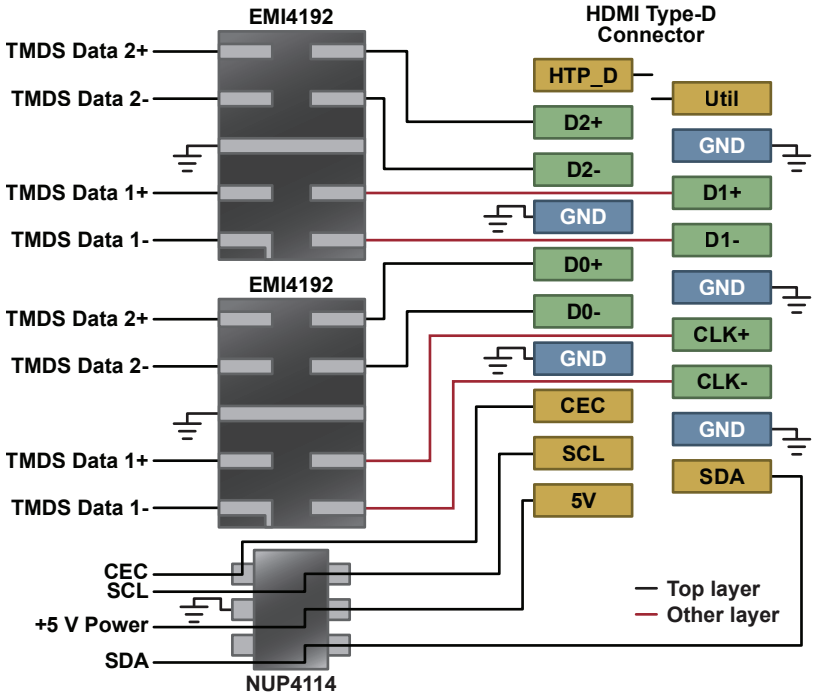
## Key Requirement

- Cap <1.5 pF
- Common Mode Filtering

## Features

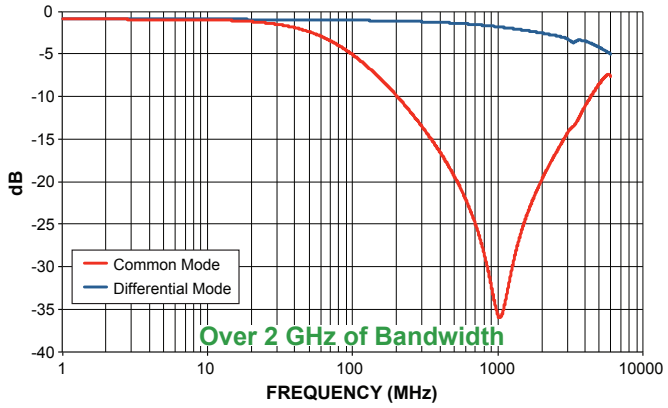
- 0.4 pF ESD protection
- CM Rejection – 15 dB at 500 MHz
- DM Insertion Loss – <1.0 dB at 500 MHz
- Flow through routing in high speed lines
- Industry leading low clamping voltage
- Supports MHL via EMI2180

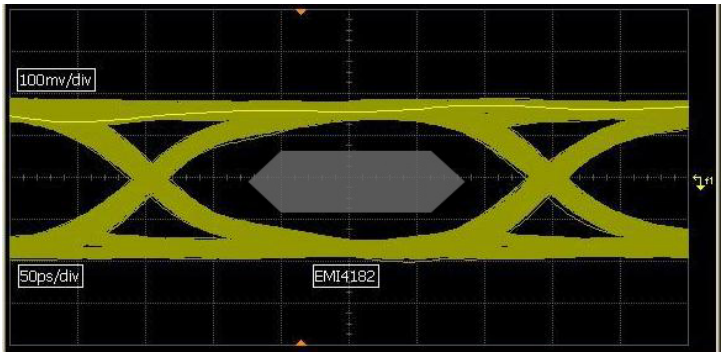





EMI4182

| Device | Pairs | Capacitance @ 2.5 V (pF) | CM Attenuation @ 800 MHz (-dB) | DM Bandwidth F3dB (GHz) | Package | Size (mm) |
|---|---|---|---|---|---|---|
| EMI4192 | 2 | 0.8 | -25 | 2 | WDFN | 2.5 x 2.0 x 0.75 |
| EMI2180 | 1 | 2.0 | -25 | 2.4 | WDFN | 1.6 x 2.0 x 0.75 |




HDMI 1.4 Requirement – 3.4 Gb/s

# HDMI, Display Port for Consumer

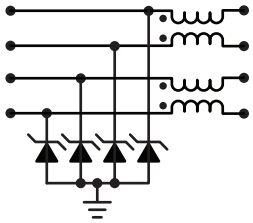
*Four High Speed Pairs, Up to Six Additional Lines, Low Capacitance ESD + Common Mode Filters*

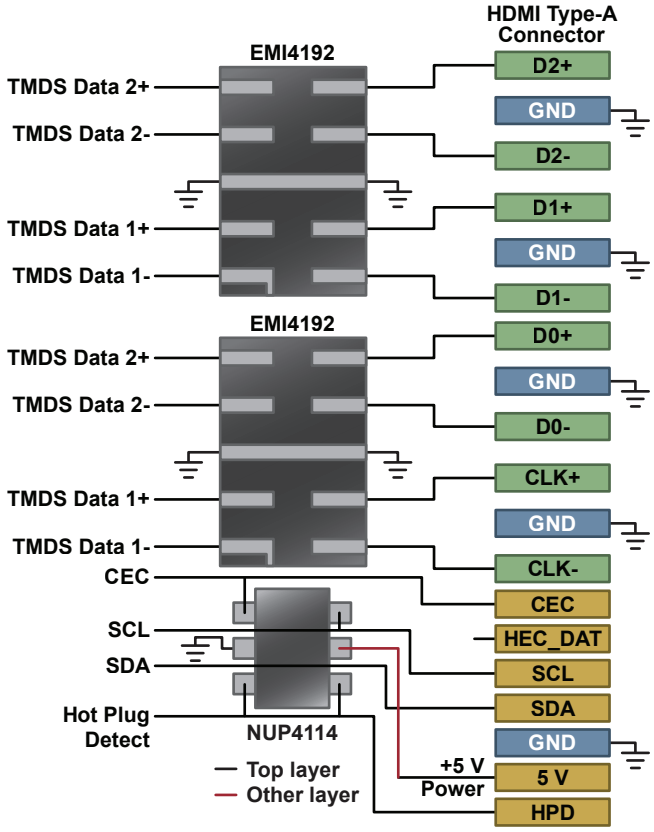
## Key Requirement

- Cap <1.5 pF
- Common Mode Filtering

## Features

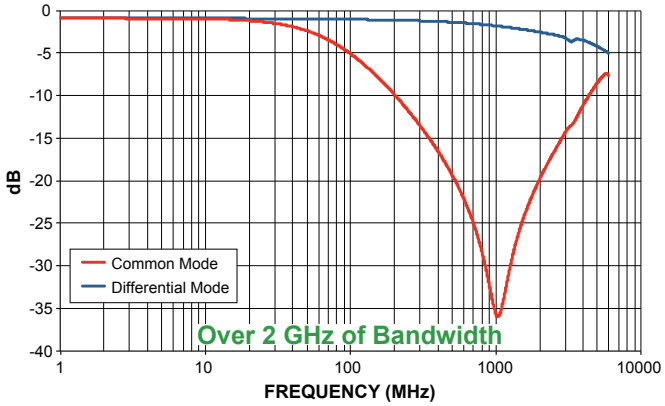
- 0.4 pF ESD protection
- CM Rejection – 15 dB at 500 MHz
- DM Insertion Loss – 1.0 dB at 500 MHz
- Flow through routing in high speed lines
- Industry leading low clamping voltage

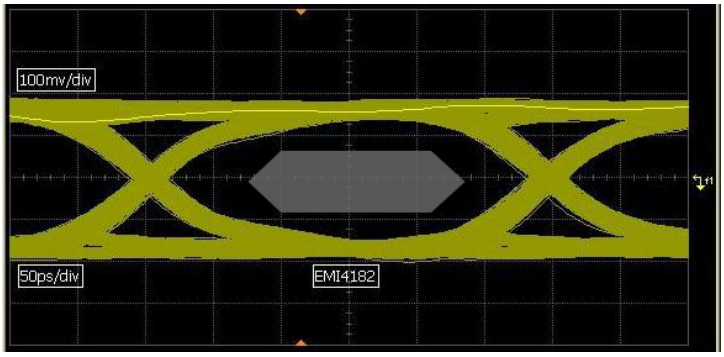





EMI4192

| Device | Pairs | Capacitance @ 2.5 V (pF) | CM Attenuation @ 800 MHz (-dB) | DM Bandwidth F3dB (GHz) | Package | Size (mm) |
|---|---|---|---|---|---|---|
| EMI4182 | 2 | 0.8 | -25 | 3 | WQFN | 2.5 x 2.0 x 0.75 |
| EMI4192 | 2 | 0.8 | -25 | 2 | WDFN | 2.5 x 2.0 x 0.75 |
| EMI4184 | 4 | 0.8 | -25 | 4 | UDFN | 5.0 x 2.0 x 0.50 |




HDMI 1.4 Requirement – 3.4 Gb/s

# HDMI, Display Port for Consumer

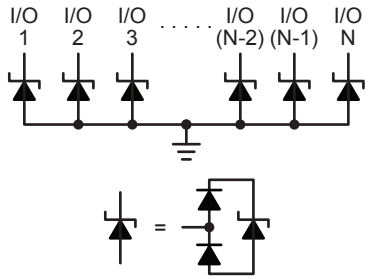
*Four High Speed Pairs, Up to Six Additional Interface Lines, Low Capacitance ESD*

## Key Requirement

- Cap < 0.5 pF

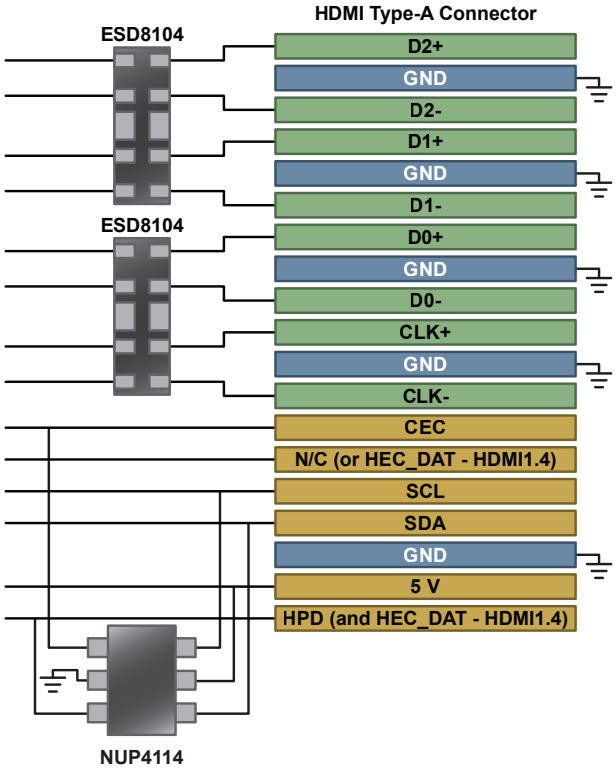
## Features

- 0.3 pF ESD protection
- Flow through routing in high speed lines
- Industry leading low clamping voltage

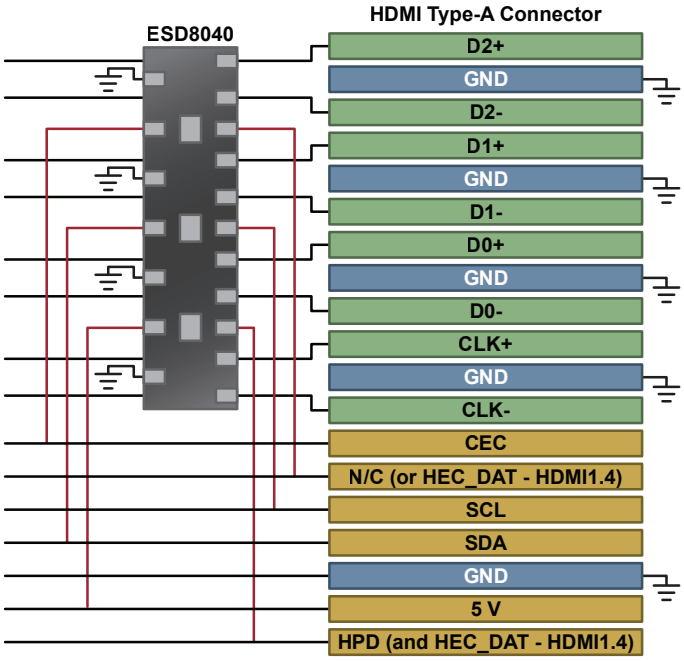



| Device | Lines | Capacitance (pF) | Package | Size (mm) |
|---|---|---|---|---|
| ESD8104* | 4 | 0.3 | UDFN-10 | 2.5 x 1.0 |
| ESD8040 | 14 | 0.3 | UDFN-18 | 5.5 x 1.5 |

* Pending 2H13.

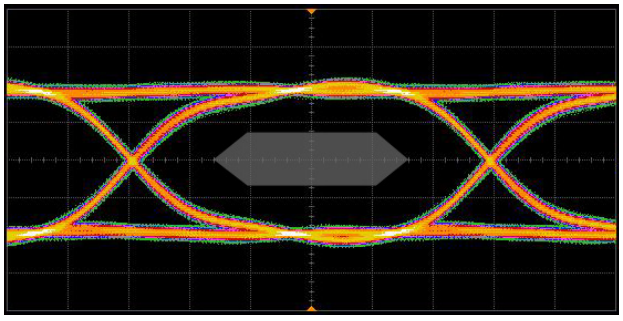



**ESD8104**

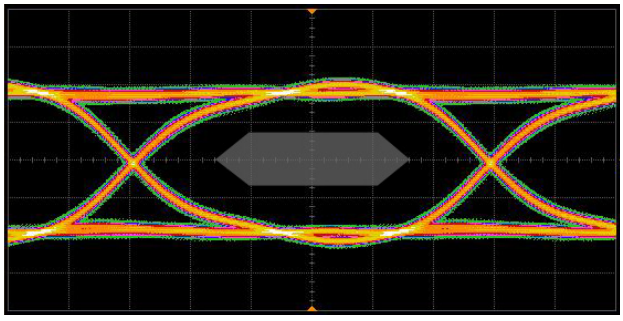



- MediaGuard fully integrated solution
- Includes ethernet protection (HDMI1.4)
- Backdrive current protection

**ESD8040**



**Without ESD**



**With ESD**

**HDMI 1.3 & 1.4 = 3.4 Gb/s**

# Audio

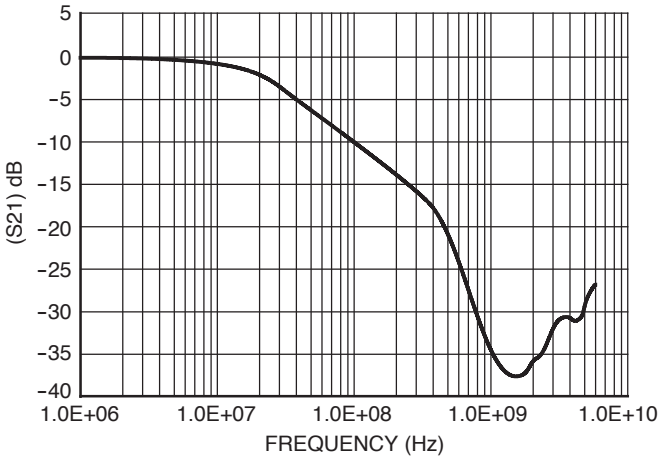
## *Speaker/Headset, EMI Filter + ESD Protection*

### Key Requirement

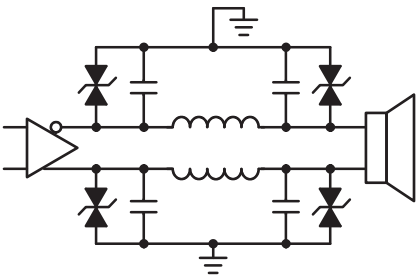
- F3dB < 3 MHz

### Features

- 2 channel EMI suppression
- Excellent low frequency filtering
- Integrated ESD protection
- 0.7 mm max package height




**Typical Insertion Loss Curve**



**NUF2441FC**

| Device | Line Capacitance @ 2.5 V (pF) | Series Inductance (nH) | Series Resistance (Ω) | Package | Size (mm) |
|---|---|---|---|---|---|
| NUF2441FC* | 250 | 2.9 | 0.28 | CSP | 1.7 x 1.2 x 0.7 |
| NUF2450MU | 240 | 2.3 | 1.3 | UDFN | 1.8 x 1.2 x 0.5 |

* Bidirectional

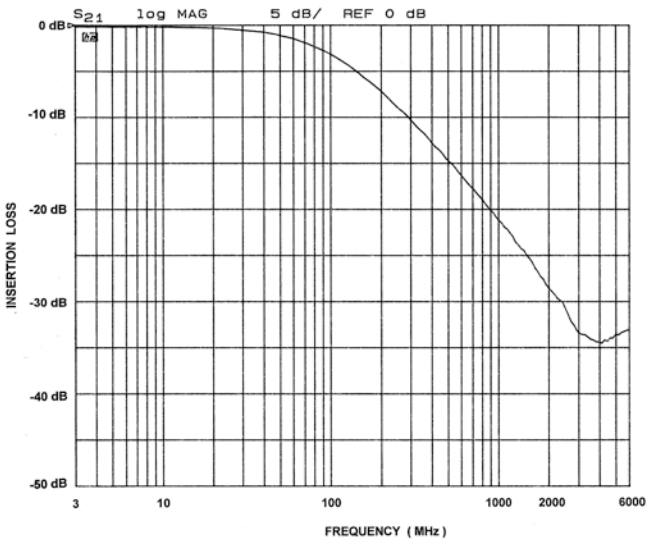
## *Audio and I/O Interface Protection with EMI Suppression*

### Key Requirement

- High level of ESD protection with excellent EMI suppression when device is in shunt mode

### Features

- Due to high capacitance, offers attenuation curve protecting wireless frequencies
- Bidirectional protection for analog signals
- $F_{CO} = ½ \pi RC$
- Space saving 0201 package




**Typical Insertion Loss Curve – CM1242-33**

| Device | Nominal Capacitance (pF) | Attenuation @ 1 GHz (-dBm) | Configuration | Package |
|---|---|---|---|---|
| CM1242-33 | 55 | >20 | Bidirectional | 0201 DSN |
| ESD5484 | 35 | >15 | Bidirectional | 0201 DSN |

| Application | Operating Frequencies | Benefit |
|---|---|---|
| Audio Line Protection | 200 to 30,000 Hz | Prevents audio and I/O harmonics from interfering with wireless |
| Analog I/O | <5 MHz | |

# μSD Interface Turnkey Solution

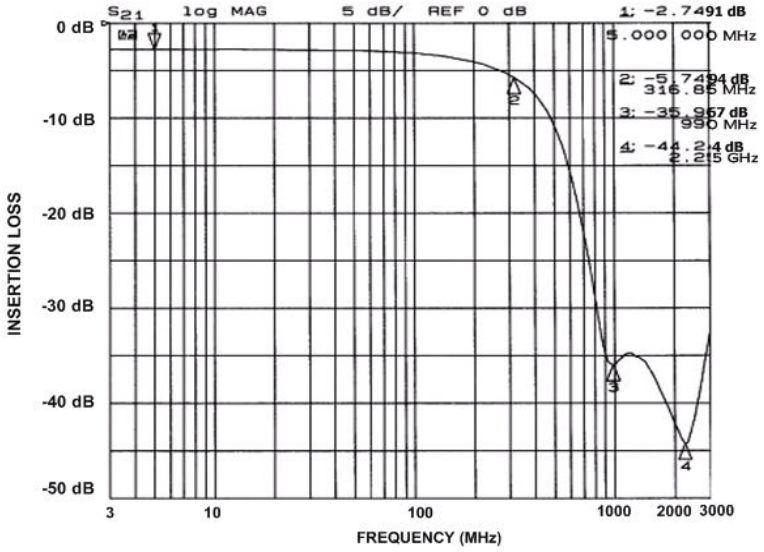
*Four Data Lines, One Clock, One Power, EMI Suppression with ESD Protection*

## Key Requirement

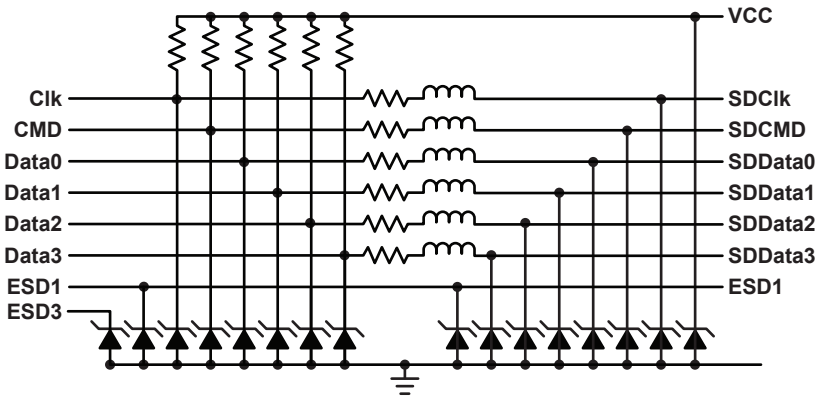
- F3dB > 300 MHz
- Clock frequencies up to 96 MHz
- Filters all data and clock lines

## Features

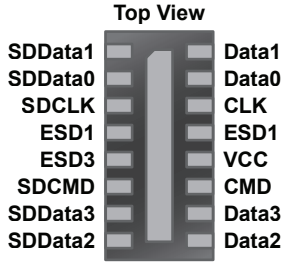
- Turnkey solution for standard μSD interface
- -25 dB stop band attenuation starting at 700 MHz
- Integrated pull-up resistors
- Integrated ESD protection
- 0.4 mm pin pitch
- 0.55 mm max package height




Typical Insertion Loss Curve




Device Circuit




| Device | Resistance (Ω) | Inductance (nH) | Capacitance @ 2.5 V (pF) | Attenuation @ Freq (-dB) | Bandwidth F3dB (MHz) | Package | Size (mm) |
|---|---|---|---|---|---|---|---|
| CM1624-08 | 40 | 20 | 12 | 35/700 | 300 | UDFN | 3.3 x 1.35 x 0.55 |
| EMI6316 | 40 | – | 11 | 10/1500 | 500 | WLCSP | 1.56 x 1.56 x 0.50 |

# SIM Card

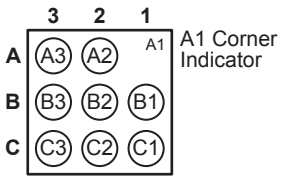
*Data, Clock, Reset Signals,*
*EMI Filter + ESD Protection*

## Key Requirement

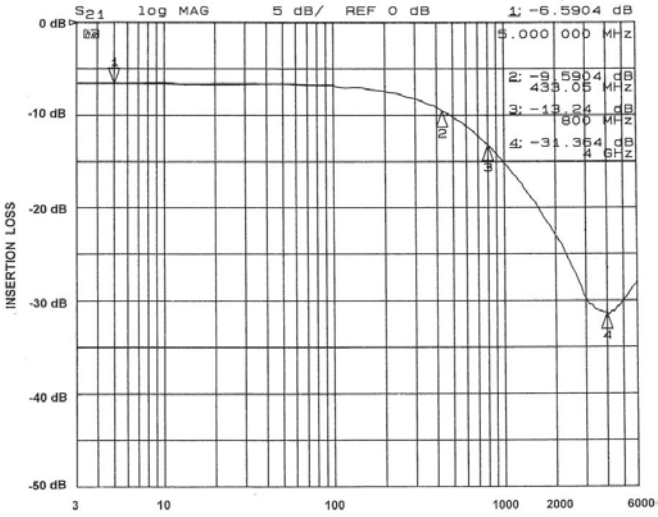
- Low line capacitance for low voltage operation

## Features

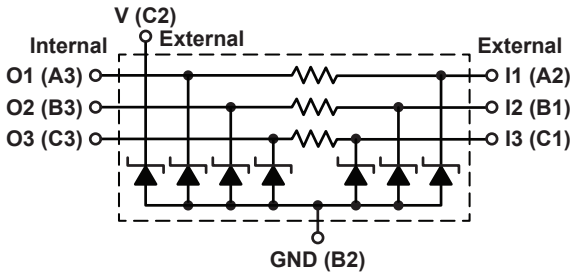
- SIM Interface filter
- Designed for <1.8 V operation
- Integrated ESD protection
- Space saving 0.4 mm pitch
- 0.6 mm max package height




**Package Pinout**




**Typical Insertion Loss Curve**




**CM6305**

| Device | Resistance (Ω) | Line Capacitance @ 0 V (pF) | Attenuation @/Freq (-dB) | Bandwidth F3dB (MHz) | Package | Size (mm) |
|---|---|---|---|---|---|---|
| CM6305 | 100 | 10 | 15/800 | 400 | CSP | 1.16 x 1.16 x 0.6 |

# Keypad EMI Suppression

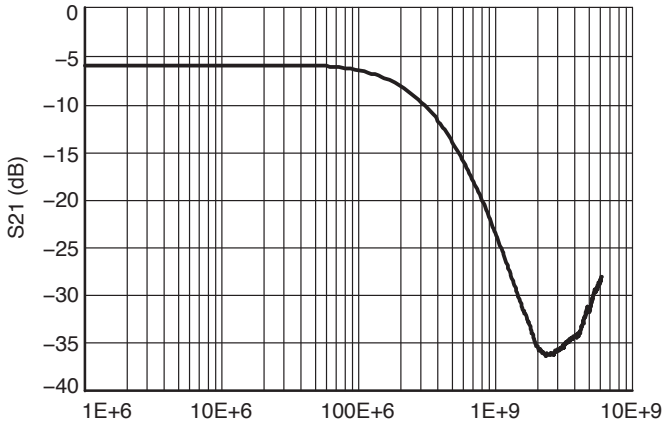
*Four to Sixteen Data Lines,*
*EMI Filters + ESD Protection*

## Key Requirement

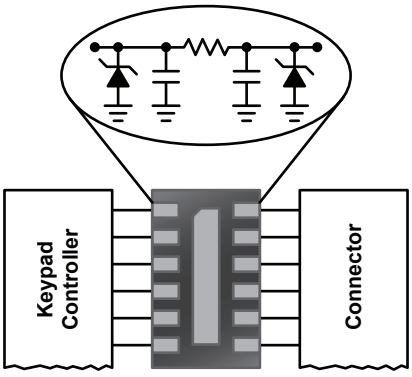
- ESD Protection
- EMI Suppression

## Features

- 4/6/8 Channel EMI+ESD
- 0.4 mm pin pitch
- 0.55 mm max package height




**Typical Insertion Loss Curve**




**Typical Keypad Circuit Use**

| Device | Ch's | Resistance (Ω) | Capacitance @ 2.5 V (nF) | Attenuation @ 800 MHz (-dB) | Bandwidth F3dB (MHz) | Pkg | Size (mm) |
|---|---|---|---|---|---|---|---|
| EMI5204 | 4 | 100 | TBD | 20 | 250 | UDFN | 1.7 x 1.35 x 0.55 |
| EMI5206 | 6 | 100 | TBD | 20 | 250 | UDFN | 2.5 x 1.35 x 0.55 |
| EMI5208 | 8 | 100 | TBD | 20 | 250 | UDFN | 3.3 x 1.35 x 0.55 |

# T1/E1, T3/E3, and xDSL Ports

*Surge protection for GR-1089, TIA-968-A, ITU-T and IEC 61000-4-5*

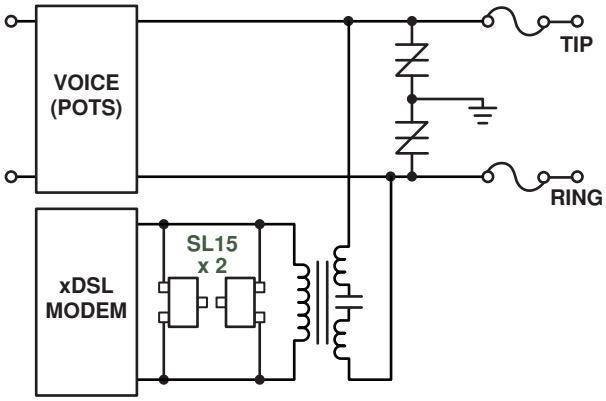
T1/E1 links (< 2 Mbps), T3/E3 links (< 43 Mbps) and xDSL lines (< 52 Mbps) are susceptible to ESD strikes, cable-discharge events and lightning-induced transients.

## TVS Features

- Capable of all T1/E1 and xDSL voltages with a variety of capacitance values, for driver-side protection

## Benefits

- Required data-rates are supported by TSPDs
- TVS devices provide high levels of tertiary protection without latching

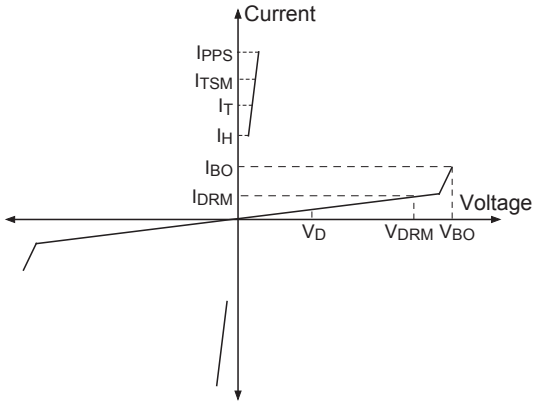



**SL15 x 2 (Bidirectional)**
**Typical xDSL + POTS Application**

### Thyristor Surge Protection Devices

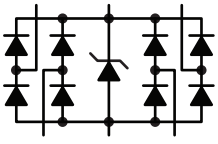
| Device | $V_{DRM}$ (V) | $V_{BO}$ (V) | $V_T$ (V) | $C_O$ (pF) | $I_H$ (mA) | Surge $I_{PP}$, 10/1000 µs (A) | Package |
|---|---|---|---|---|---|---|---|
| NP0080TA Series | 8-16 | 9.5-18 | – | 11-13 | 50 | 50 (8/20 µs) | TSOP-5 |

**TSPD**




### Transient Voltage Suppressors

| Device | $V_{DC}$ Max (V) | Surge $I_{PP}$, 8/20 µs (A) | Line-Line Capacitance (pF) | ESD Contact Rating (kV) | Package |
|---|---|---|---|---|---|
| SRDA3.3 | 3.3 | 25 | 4.0 | ±8 | SOIC-8 |
| SRDA05 | 5.0 | 23 | 5.0 | ±8 | SOIC-8 |
| LC03-6 | 6.7 | 100 | 8.0 | ±30 | SOIC-8 |
| SL05 to SL24 | 5 to 24 | 5 to 17 | 3.5 | ±8 | SOT-23 |



**TVS**

# Ethernet: 10/100BASE-T

*Two Pairs, Low Capacitance Surge and ESD Protection*

The 10/100BASE-T Ethernet interface is susceptible to ESD strikes, cable-discharge events and lightning-induced transients governed by IEC 61000-4-5, GR-1089-CORE and other standards.

## TSPD Features

- $C_{line}$ < 14 pF for 50 A surge under 8/20 μs (NP0080TA series)

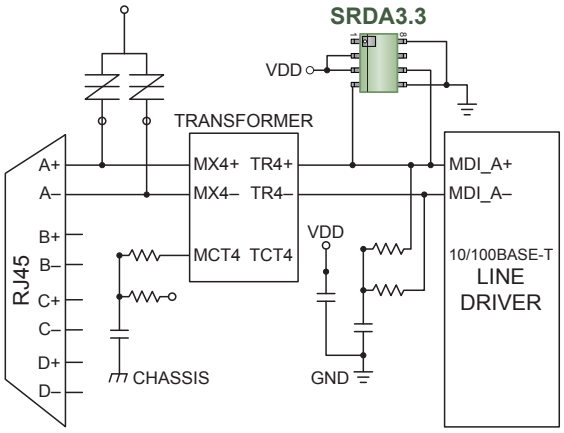
## TVS Features

- Wide range of voltages and capacitance values for tertiary protection

## Benefits

- The required data-rate is supported by NP0080TA, ensuring a high level of secondary surge protection
- TVS devices provide high levels of tertiary protection without latching

**Typical Application**

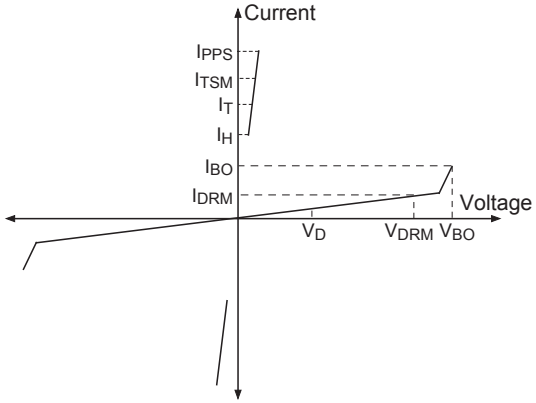



**Transformer Side – SRDA3.3**
**Line-to-Line protection against metallic strikes**

### Thyristor Surge Protection Devices

| Device | $V_{DRM}$ (V) | $V_{BO}$ (V) | $V_T$ (V) | $C_O$ (pF) | $I_H$ (mA) | Surge $I_{PP}$, 10/1000 μs (A) | Package |
|---|---|---|---|---|---|---|---|
| NP0080TA Series | 8-16 | 9.5-18 | – | 11-13 | 50 | 50 (8/20 μs) | TSOP-5 |

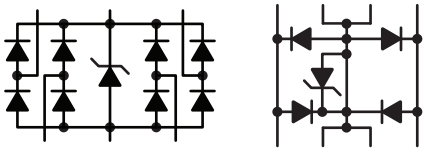
**TSPD**




### Transient Voltage Suppressors

| Device | $V_{DC}$ Max (V) | Line Transient Max (V) | Surge $I_{PP}$, 8/20 μs (A) | Typical Line-Line Capacitance (pF) | ESD Contact Rating (kV) | Package |
|---|---|---|---|---|---|---|
| NUP4114H | 5.0 | 5.0 | 12* | 0.4 | ±13 | TSOP-6 |
| SRDA3.3 | 3.3 | 5.0 | 25 | 4.0 | ±8 | SOIC-8 |
| SRDA05 | 5.0 | 7.0 | 23 | 5.0 | ±8 | SOIC-8 |
| ESD1014 | 3.3 | 5.0 | 25 | 1.5 | ±30 | UDFN-10 |
| LC03-6 | 6.7 | 7.0 | 100 | 8.0 | ±30 | SOIC-8 |

* On Pin 5



**TVS**

# Ethernet: 10/100BASE-T, 1000BASE-TX, and Gigabit

*Four Pairs, Low Capacitance Surge and ESD Protection*

The 1000BASE-T or Gigabit Ethernet interface operating at higher bitrates is susceptible to ESD strikes, cable-discharge events and lightning-induced transients. Our products help meet IEC 61000-4-5, GR-1089-CORE and other Standards.

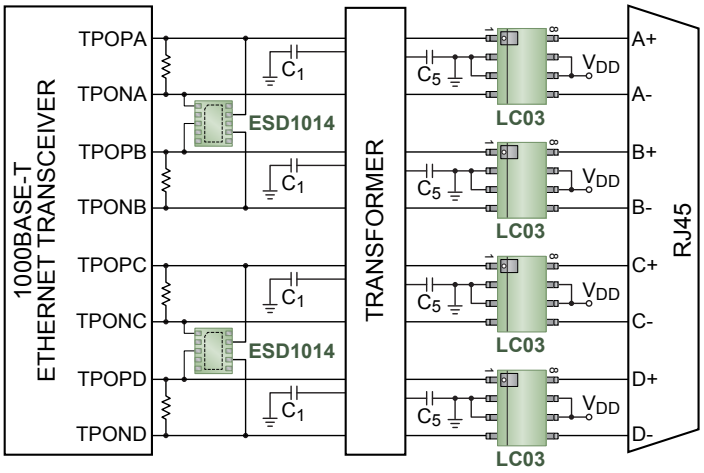
## Features

- Line-to-line capacitance < 3 pF
- $V_{clamp}$ (25 A surge) < 11 V
- IEC 61000-4-2 rating > 30 kV
- No latching danger
- Surge rating maintained to 125°C

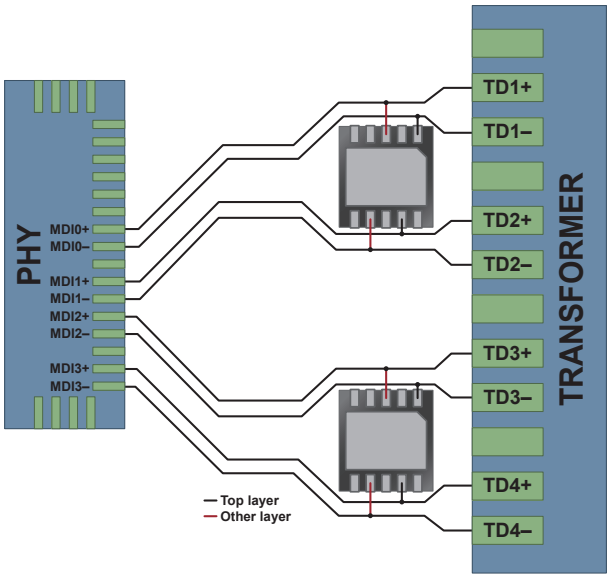
## Benefits

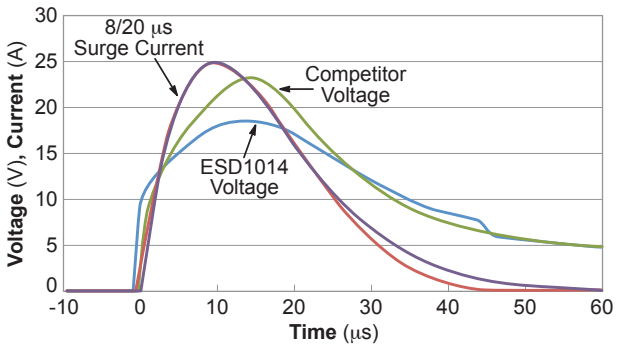
- Compatible with Gb Ethernet and beyond
- Enhanced protection for downstream electronics
- Accommodates operating transients above 3.3 V
- Small form-factor allows integration into connectors

**Typical Application**

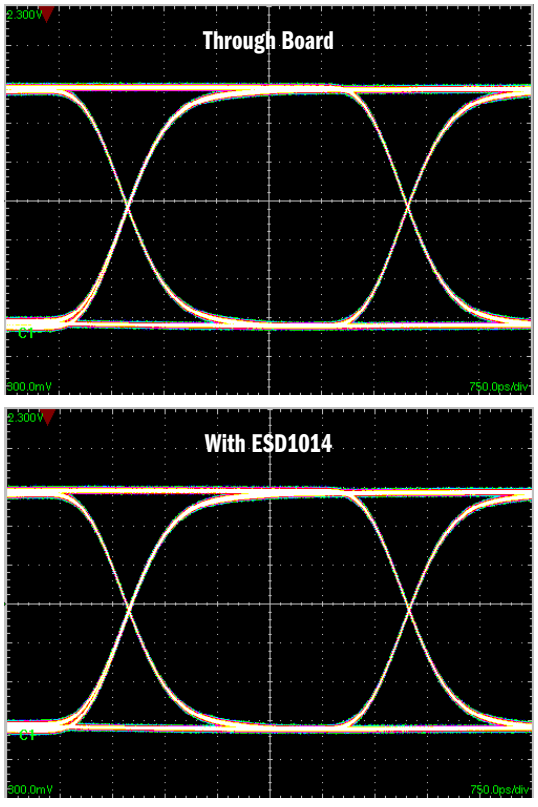



**Line Side : LC03-6 (optional)**
**Transformer Side: ESD1014**
**Protection against metallic (transverse) strikes**




**Line-to-Line Surge**




**Signal Integrity for Gigabit Ehternet**

# Protection for Automotive High Speed Signal Pairs

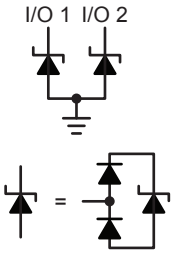
*Low Capacitance ESD Protection, Short to Battery Protection*

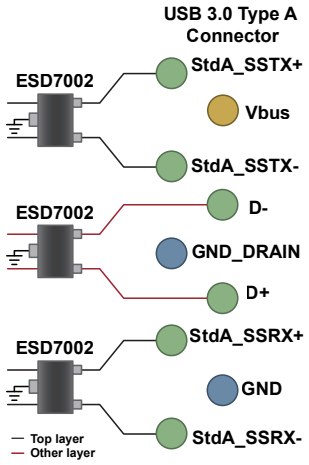
## Key Requirement

- Cap < 0.5 pF

## Features

- 0.4 pF
- Flow through routing
- Industry leading low clamping voltage
- $V_{BR}$ of 16 V to withstand short to battery

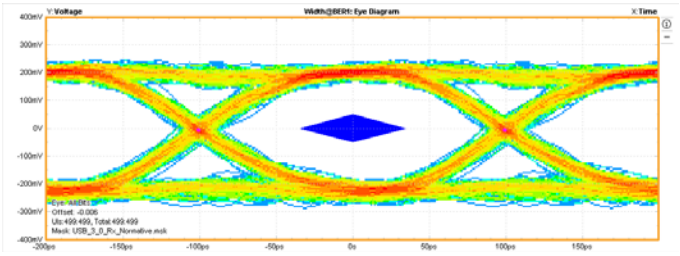


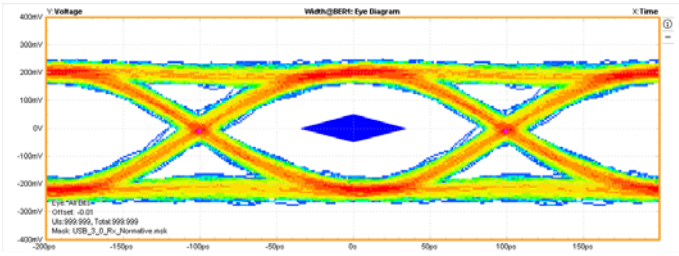

**ESD7002 – 0.4 pF, 2 Layer Routing of USB 3.0**

| Device | Lines | Capacitance (pF) | Package | Size (mm) |
|---|---|---|---|---|
| ESD7002* | 2 | 0.4 | SC-70 | 2.1 x 2.1 |

* Pending 2H13



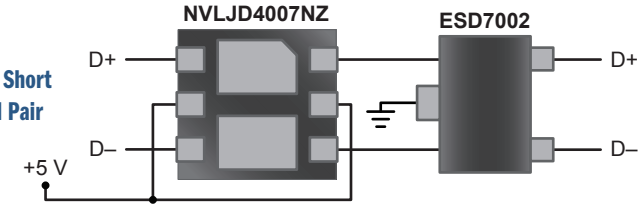
**Without ESD7002**



**With ESD7002**

**USB 3.0 @ 5 Gb/s**

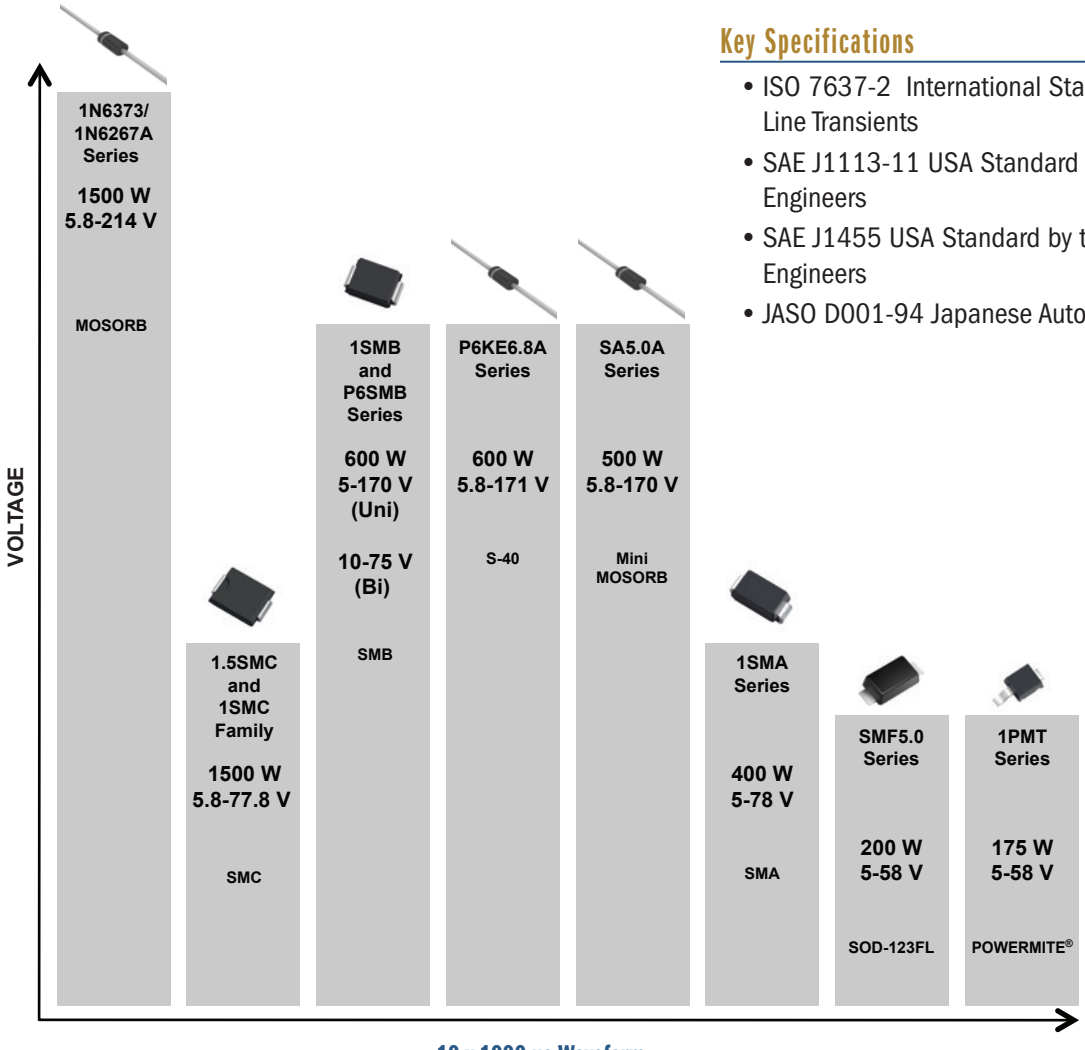
**ESD7002 with NVLJD4007* Dual MOSFET – Short to Battery Protection on High Speed Signal Pair**



# Protection for Automotive In-Vehicle Networking

| Application | Device | High Speed Pair(s) | Max Data Rate | Differential Impedance (Ω) | C Max (pF) | $V_{BR}$ Min (V) | $V_{RWM}$ Max (V) | $I_R$ Max (μA) | $I_{PP}$ Max (A) | $V_C$ Max (V) | No Ch | Topology | ESD IEC61000-4-2 (Contact/Air) | Package |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ethernet | NUP2114 | 1 | 100 Mb/s | 100-150 | 1 | 5.5 | 5 | 1 | 12 | 10 | 2 | Unidirectional | ± 8kV / ±15 kV | TSOP-6 |
| FlexRay | NUP2115 | 1 | 10 Mb/s | 90 | 10 | 26.2 | 24 | 0.1 | 3 | 39.7 | 2 | Bidirectional | ± 8kV / ±15 kV | SOT-23 |
| HS CAN | NUP2105 | 1 | 1 Mb/s @ 40 m | 120 | 30 | 26.2 | 24 | 0.1 | 8 | 44 | 2 | Bidirectional | ±30 kV / ±30 kV | SOT-23 |
| LIN & LS CAN | NUP1105 | Single Wire | 19.2 Kbaud @ 40 m | – | 30 | 25.7 | 24 | 0.1 | 8 | 44 | 2 | Bidirectional | ±30 kV / ±30 kV | SOT-23 |

# Automotive Transient Voltage Suppression




## Key Specifications

- ISO 7637-2 International Standard Organization for Supply Line Transients
- SAE J1113-11 USA Standard by the Society of Automotive Engineers
- SAE J1455 USA Standard by the Society of Automotive Engineers
- JASO D001-94 Japanese Automotive Standard

# Storage Power Buses: Electronic Fuses

*5 V and 12 V Power Bus Protection for HDDs, SSDs, and Other Applications*

## Key Requirement

- Low $R_{DS(ON)}$ high operating and trip currents ($I_{OP}$, $I_{TRIP}$) precision

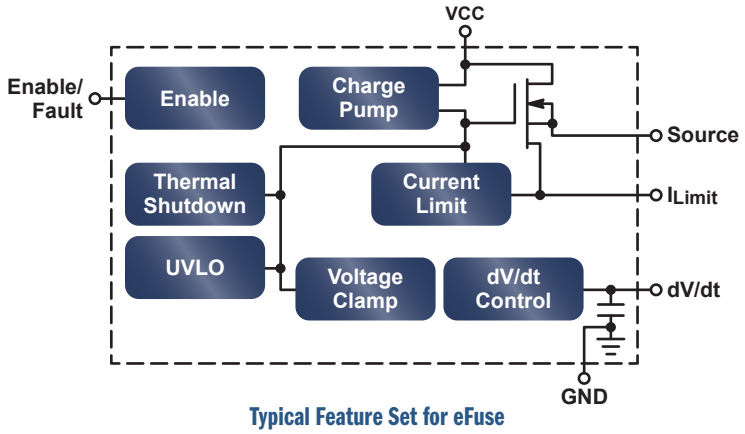
## Features

- Low $R_{DS(ON)}$, high operating and trip currents ($I_{OP}$, $I_{TRIP}$)
- Overvoltage protection
- Precise $I_{TRIP}$ control
- Thermal shut-down
- EN pin for synchronizing multiple eFuses
- Ability to combine eFuses in parallel
- Outperforms poly-fuses:
  - Tighter spec tolerances
  - Lower resistance
  - Lower trip-time
  - Superior repeatability

## Benefits

- High efficiency with high current capability
- eFuses combined in parallel achieve practically any desired level of $I_{OP}$ and $I_{TRIP}$

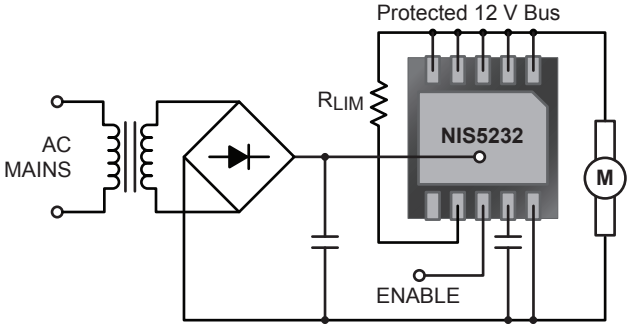
Electronic (resettable) fuses act as load-switches and protect against inrush currents resulting from load faults, especially in hot-pluggable applications.



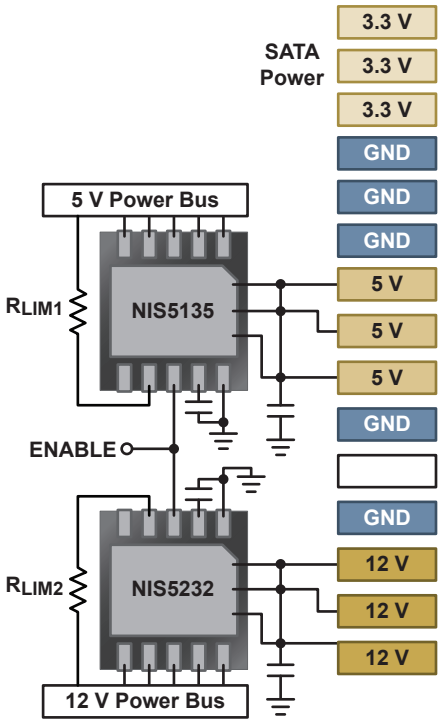

Typical Feature Set for eFuse

| Device | Input Voltage (V) | Output Clamping Voltage (V) | $I_{TRIP}$ Trip Current (A) | $R_{DS(ON)}$ (mΩ) | Auto Recovery Option | Latching Option | Package | Size (mm) |
|---|---|---|---|---|---|---|---|---|
| NIS5112 | -0.6 to 18 | 15 | 2.5 (Adjustable) | 28 | Yes | Yes | SOIC-8 | – |
| NIS5232 | -0.6 to 18 | 15 | 3.5 (Adjustable) | 44 | Yes | Yes | DFN-10 | 3.0 x 3.0 |
| NIS5135 | -0.6 to 18 | 6.65 | 3.5 (Adjustable) | 68 | Yes | Yes | DFN-10 | 3.0 x 3.0 |
| NIS2205* | -0.6 to 18 | 6.65 | 2.5 (Fixed) | 100 | Yes | No | DFN-10, TSOP-6 | – |

* Pending 2H13




Motor Bus Protection Application



# LED String Protection – NUD4700

The preferred method of driving LEDs is to have them in strings of LEDs in series, so that currents in the strings are matched for equal brightness. Although LEDs are very reliable, if any single LED were to fail OPEN, the entire string goes dark, because the LEDs within a string are connected in series. This is unacceptable for high-reliability applications such as street lighting. To solve this issue the NUD4700, from ON Semiconductor, is placed across each LED, and functions as a shunt bypass protector in the event of an LED failing as an OPEN circuit. This ensures that the remainder of the string stays lit.

### *Key Requirements*

- Low ON-state resistance, high OFF-state resistance and high reliability

### *Features*

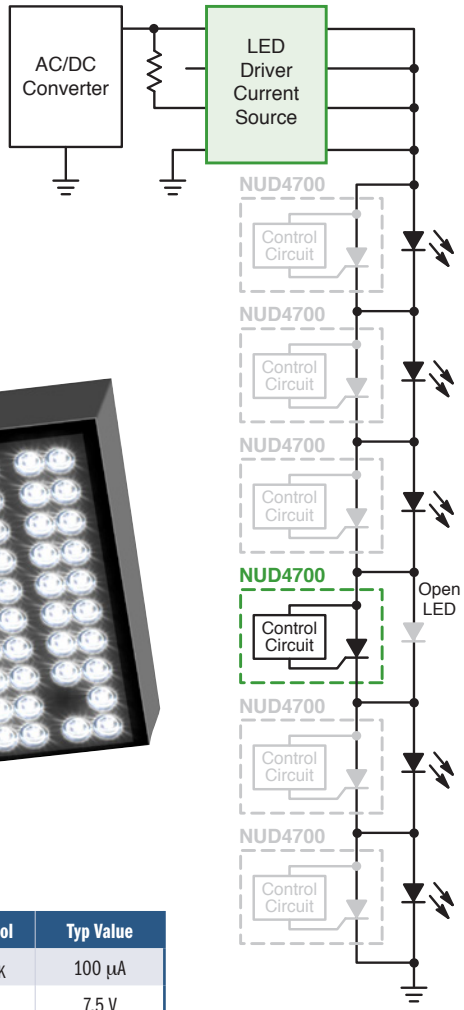
- High ON-state current capability
- Low off-state leakage
- Ability to auto-reset to off-state if LED heals
- low and repeatable response time

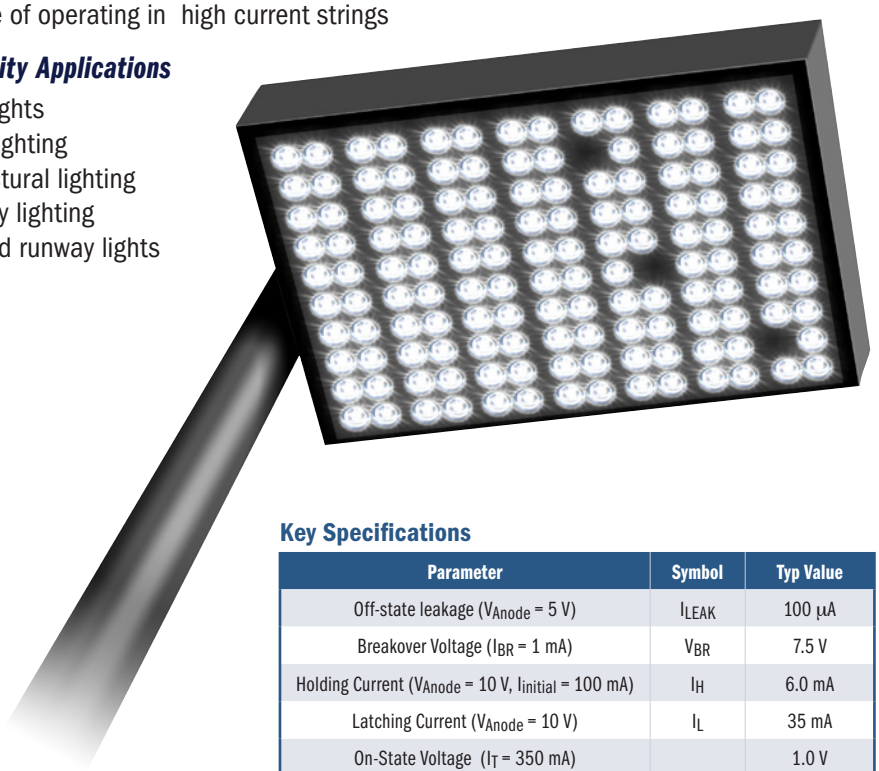
### *Benefits*

- High reliability, enables longevity of string and fixture
- Capable of operating in high current strings

### *High Reliability Applications*

- Street lights
- Tunnel lighting
- Architectural lighting
- High-bay lighting
- Train and runway lights



**Key Specifications**

| Parameter | Symbol | Typ Value |
|---|---|---|
| Off-state leakage ($V_{Anode}$ = 5 V) | $I_{LEAK}$ | 100 μA |
| Breakover Voltage ($I_{BR}$ = 1 mA) | $V_{BR}$ | 7.5 V |
| Holding Current ($V_{Anode}$ = 10 V, $I_{initial}$ = 100 mA) | $I_H$ | 6.0 mA |
| Latching Current ($V_{Anode}$ = 10 V) | $I_L$ | 35 mA |
| On-State Voltage ($I_T$ = 350 mA) | $V_T$ | 1.0 V |
| On-State Voltage ($I_T$ = 750 mA) | | 1.0 V |
| On-State Voltage ($I_T$ = 1000 mA) | | 1.0 V |

## Consumer Interface Solutions

| Interface Details | | | Protection Solution Details | | |
|---|---|---|---|---|---|
| **Interface** | **Data Pairs** | **Max Data Rate** | **Data Lines** | **ESD Only** | **ESD + Filter** |
| **USB3.0** | 2 (+1 USB2.0) | 5.0 Gb/s | 3 pair (Tx, Rx, D+, D-) | ESD8006* | |
| | | | 2 pair (Tx, Rx)** | ESD8004, ESD8104* | |
| | | | Single line 0201 | ESD8472 | |
| **USB2.0** | 1 | 480 Mb/s | 2 pair + Power | NUP4114 | EMI2121 |
| | | | 1 pail + ID + Power | NUP3115 | |
| | | | 1 pair** | ESD7L5.0 | |
| | | | Single line 0402 | ESD7001* | |
| | | | Single line 0201 | ESD7481, ESD8472 | |
| **Thunderbolt** | 4 | 10 Gb/s | 3 pair | ESD8006* | |
| | | | 2 pair** | ESD8004T* | |
| | | | Single line 0201 | ESD8472 | |
| **HDMI 1.2** | 4 | 1.65 Gb/s | 4 pair + CEC, SDL, SDA, 5V, HPD | MG2040 | |
| | | | 2 pair** | ESD7004 | EMI4192 |
| | | | Single line 0402 | ESD7001* | |
| | | | Single line 0201 | ESD7481, ESD8472 | |
| **HDMI 1.3/1.4** | 4 | 3.4 Gb/s | 4 pair + CEC, SDL, SDA, Power, HPD | ESD8040 | |
| | | | 2 pair** | ESD8104* | EMI4192 |
| | | | Single line 0402 | ESD7001* | |
| | | | Single line 0201 | ESD7481, ESD8472 | |
| **MIPI Camera and Display** | 4 | 4 Gb/s | 4 pair | | EMI4184 |
| | 3 | 4 Gb/s | 3 pair | | EMI4183 |
| | 2 | 4 Gb/s | 2 pair | | EMI4182 |
| **Display Port V1.1** | 2, 4 | 2.7 Gb/s | 4 pair + AUX, Power, HPD, Config | MG2040 | |
| | | | 2 pair** | ESD7004 | EMI4192 |
| | | | Single line 0402 | ESD7001* | |
| | | | Single line 0201 | ESD7481, ESD8472 | |
| **DisplayPort V1.2** | 2, 4 | 5.4 Gb/s | 4 pair + AUX, Power, HPD, Config | ESD8040 | |
| | | | 2 pair** | ESD8004 | EMI4192 |
| | | | Single line 0201 | ESD8472 | |
| **DVI** | up to 6 | 1.65 Gb/s | 2 pair | NUP4114 | |
| | | | 1 pair | ESD7L5.0 | |
| | | | Single line 0402 | ESD7001* | |
| | | | Single line 0201 | ESD7481 | |
| **Parallel Interfaces, Camera, Display, Touchscreen** | | 200 MHz | 8 line | | EMI9408*, EMI7208, CM1457-08 |
| | | | 6 line | | EMI9406*, EMI7206, CM1457-06 |
| | | | 4 line | | EMI9404, EMI7204, CM1457-04 |
| | | | Single line 0201 | ESD7381 | |
| **SIM CARD Interface** | | 15 MHz | 4 pair | | CM6305 |
| **Micro SD Card** | | 208 MHz 108 MHz | 5 pair + CLK, VCC | | EMI6316 |
| | | | 4 pair + CLK, CMD | | CM1624-08 |
| | | | 8 line | CM1230-08 | |
| | | | 4 line | CM1230-04 | |
| | | | 2 line | CM1230-02 | |
| | | | Single line 0201 | ESD5381 | |
| **eSATA 1.0** | 2 | 1.5 Gb/s | 2 pair | ESD7004 | |
| **eSATA 2.0** | 2 | 3.0 Gb/s | 2 pair | ESD8004 | |
| **eSATA 3.0** | 2 | 6.0 Gb/s | 2 pair | ESD8004 | |
| **10/100 Ethernet** | 2 | 50 Mb/s | 2 pair | ESD1014 | |
| **Gigabit Ethernet** | 4 | 250 Mb/s | 2 pair | ESD1014 | |
| **V-by-one** | 4 | 3.75 Gb/s | 4 pair | ESD8008* | |

* Pending 2H13. ** Additional part may be required to address lower speed lines in interface. See datasheet for recommendation.

## Automotive Infotainment Solutions

| Interface Details | | | Protection Solution Details | | |
|---|---|---|---|---|---|
| **Interface** | **Data Pairs** | **Max Data Rate** | **Data Pairs** | **ESD Only** | **ESD +Filter** |
| **USB 3.0** | 2 (+1 USB2.0) | 5.0 Gb/s | 3 pair (Tx, Rx, D+, D-) | ESD7016** | |
| | | | 2 pair (Tx, Rx)* | SZESD7004** | |
| | | | Short to Battery capable pairs | SESD7002** | |
| **USB 2.0** | 1 | 480 Mb/s | 2 pair + Power | SZNUP4114 | |
| | | | Short to Battery capable pairs | SESD7002** | |
| | | | 1 pair + Power | SESD7L5.0** + SZESD9X5.0 | SZEMI2121** |
| **HDMI 1.2** | 4 | 1.65 Gb/s | 4 pair + CEC, SDL, SDA, 5V, HPD | MG2040** | |
| | | | 2 pair | SZESD7004** + SZNUP4114 | EMI4192** |
| **SIM card** | | 15 MHz | 6 Lines | | SNUF6401 |
| **Various Low cap, 70 V Breakdown** | | | Single line | SZNUP1301 | |
| | | | 1 pair | SZNUP2301 | |
| | | | 2 pair | SZNUP3401**, SZNUP4304 | |
| **Antenna** | | GHz | Single Line | SESD9L5.0** | |
| **I2S** | 2 | 2.8 MHz | Bit Clk, WS(LRCLK), Data, MCLK | SZESD9X5.0 | |
| | | | 2 pair | | SNUF4211** |
| **SD card** | | 208 MHz | 4 data, Clk, CMD | | CM1624** |

* Additional part may be required to address lower speed lines in interface. See datasheet for recommendation. ** Auto qualification in progress.

## Automotive Transient Protection

| Topology | Device | $V_{BR}$ Min (V) | $V_{BR}$ Max (V) | $P_{pk}$ Max (W) | Package |
|---|---|---|---|---|---|
| **Unidirectional** | SZSMFxxA | 5 | 58 | 200 | SOD-123FL |
| | SZ1SMAxxA | 5 | 70 | 400 | SMA |
| | SZ1SMBxxA | 5 | 170 | 600 | SMB |
| | SZP6SMBxxA | 5.8 | 171 | 600 | SMB |
| | SZ1SMCxxA | 5 | 78 | 1500 | SMC |
| | SZ1.5SMCxxA | 5.8 | 77.8 | 1500 | |
| **Bidirectional** | SZ1SMAxxCA | 10 | 78 | 400 | SMA |
| | SZ1SMBxxCA | 10 | 75 | 600 | SMB |
| | SZP6SMBxxCA | 9.4 | 70.1 | 600 | |

## Clamping TVS Devices

| Interface | Data Pairs | Device | Channels | $V_{DC}$ Max (V) | $V_T$ Max (V) | $C_{(Line-Line)}$ Typ (pF) | $C_{(Line-Line)}$ Max (pF) | 8/20 µs Peak Surge Current (A) | ESD (IEC 61000-4-2) | Package |
|---|---|---|---|---|---|---|---|---|---|---|
| T1/E1, T3/E3 | TxT, TxR, RxT, RxR | SL05 to SL24 | 1 | 5.0 to 24.0 | 7.0 to 27.0 | 3.5 | 5.0 | 17 to 5 | ±8 kV | SOT-23 |
| | | SM05, SM12 | 1 | 5.0, 12.0 | 6.5, 13.5 | 112, 48 | N/A | 12 | ±8 kV | SOT-23 |
| | | SD12C | 1 | 12 | 13.5 | 64.0 | N/A | 15 | ±30 kV | SOD-323 |
| xDSL | T/R | SRDA3.3 | 4 | 3.3 | 5.0 | 4.0 | 7.0 | 25 | ±8 kV | SOIC-8 |
| | | SRDA05 | 4 | 5.0 | 7.0 | 5.0 | 8.0 | 23 | ±8 kV | SOIC-8 |
| 10/100BASE-T Ethernet | Tx+, Tx-, Rx+, Rx- | LC03 | 2 | 6.7 | 7.3 | 8.0 | 12.0 | 100 | ±30 kV | SOIC-8 |
| | | SRDA3.3 | 4 | 3.3 | 5.0 | 4.0 | 7.0 | 25 | ±8 kV | SOIC-8 |
| | | SRDA05 | 4 | 5.0 | 7.0 | 5.0 | 8.0 | 23 | ±8 kV | SOIC-8 |
| | | NUP4106 | 4 | 4.0 | 6.0 | 4.0 | 7.5 | 25 | ±8 kV | SOIC-8 |
| | | ESD1014 | 4 | 3.3 | 5.0 | 1.5 | 3.0 | 25 | ±30 kV | UDFN-10 |
| 1000BASE-T, Gigabit Ethernet | A+, A-, B+, B-, C+, C-, D+, D- | LC03 | 2 | 6.7 | 7.3 | 8.0 | 12.0 | 100 | ±30 kV | SOIC-8 |
| | | SRV05 | 4 | 5.0 | 7.0 | 1.5 | 3.0 | 12 | ±8 kV | TSOP-6 |
| | | ESD1014 | 4 | 3.3 | 5.0 | 1.5 | 3.0 | 25 | ±30 kV | UDFN-10 |
| | | NUP4114H | 4 | 5.0 | 6.0 | 0.4 | 0.6 | 12 | ±13 kV | SC-74 |
| | | LC03 | 2 | 6.7 | 7.3 | 8.0 | 12.0 | 100 | ±30 kV | SOIC-8 |

## Crowbar TVS Devices

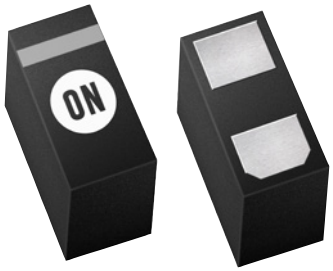
| Interface | Data Pairs | Device | $V_{DRM}$ (V) | $V_{BO}$ (V) | $C_O$ (pF) | $I_H$ (mA) | Surge IPP, 10/1000 µs (A) | Package |
|---|---|---|---|---|---|---|---|---|
| Various | Tip, Ring | NP0080TA | 8, 12 | 20, 30 | 13 | 50 | 50 (8/20 µs) | TSOP-5 |

## Small Outline Solutions

| Device | Performance | Application | $V_{RWM}$ Max (V) | Direction | Capacitance Max @ 0 V (pF) | ESD Protection (kV) |
|---|---|---|---|---|---|---|
| ESD11N5.0S | HSSI Line Protection | Antenna/USB | 5 | Bidirectional | 0.6 | 20 |
| ESD8472 | | USB 2.0/3.0/HDML | 5.3 | Bidirectional | 0.3 | 20 |
| ESD11B5.0S | Analog Line Protection | I/O | 5 | Bidirectional | 12 | 8 |
| ESD5481 | | I/O | 5 | Bidirectional | 15 | 20 |
| CM1242-07 | | I/O | 5 | Bidirectional | 5.8 | 17 |
| ESD5484 | Hi-CAP | Audio | 5 | Bidirectional | 45 | 30 |
| CM1242-33 | | Audio | 5 | Bidirectional | 55 | 30 |
| ESD5381 | Logic Line Protection | I/O | 3 | Unidirectional | 13 | 8 |
| ESD5382* | | I/O | 3 | Unidirectional | 6 | 20 |
| ESD7381 | | I/O | 3 | Unidirectional | 0.55 | 20 |
| ESD7481 | Low Power Antenna | I/O | 5 | Bidirectional | 0.4 | 20 |
| ESD5482 | Logic Line Protection | I/O | 3.3 | Bidirectional | 7 | 10 |

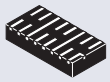
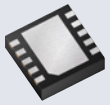
* Pending 2H13.


DSN Package




DFN Package

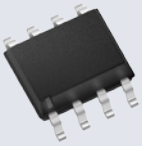
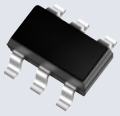
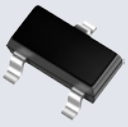
# Packaging Options for Protection Devices

| DFNs and WDFNs | | | |
|---|---|---|---|
| WDFN-16 | WDFN-10 | WDFN-8 | DFN-10 |
|  |  |  |  |
| 4.0 x 2.0 x 0.75 | 2.5 x 2.0 x 0.75 | 2.2 x 2.0 x 0.75 | 3.0 x 3.0 x 0.9 |
| EMI4183 | EMI4182 | EMI2121 | NIS5112, NIS5135 |

| UDFNs | | | | | |
|---|---|---|---|---|---|
| UDFN-18 | UDFN-10 | UDFN-16 | UDFN-8 | UDFN-10 | UDFN-8 |
|  |  |  |  |  |  |
| 5.5 x 1.5 x 0.5 | 2.6 x 2.6 x 0.5 | 3.3 x 1.35 x 0.5 | 1.7 x 1.35 x 0.5 | 2.5 x 1.0 x 0.5 | 3.3 x 1.0 x 0.5 |
| MG2040, ESD7008, ESD8040 | ESD1014 | CM1624, EMI9408 | EMI5204, EMI7204, EMI9404, CM16930 | ESD7004, ESD7104, ESD8004, ESD8104* | ESD7016, ESD8006* |

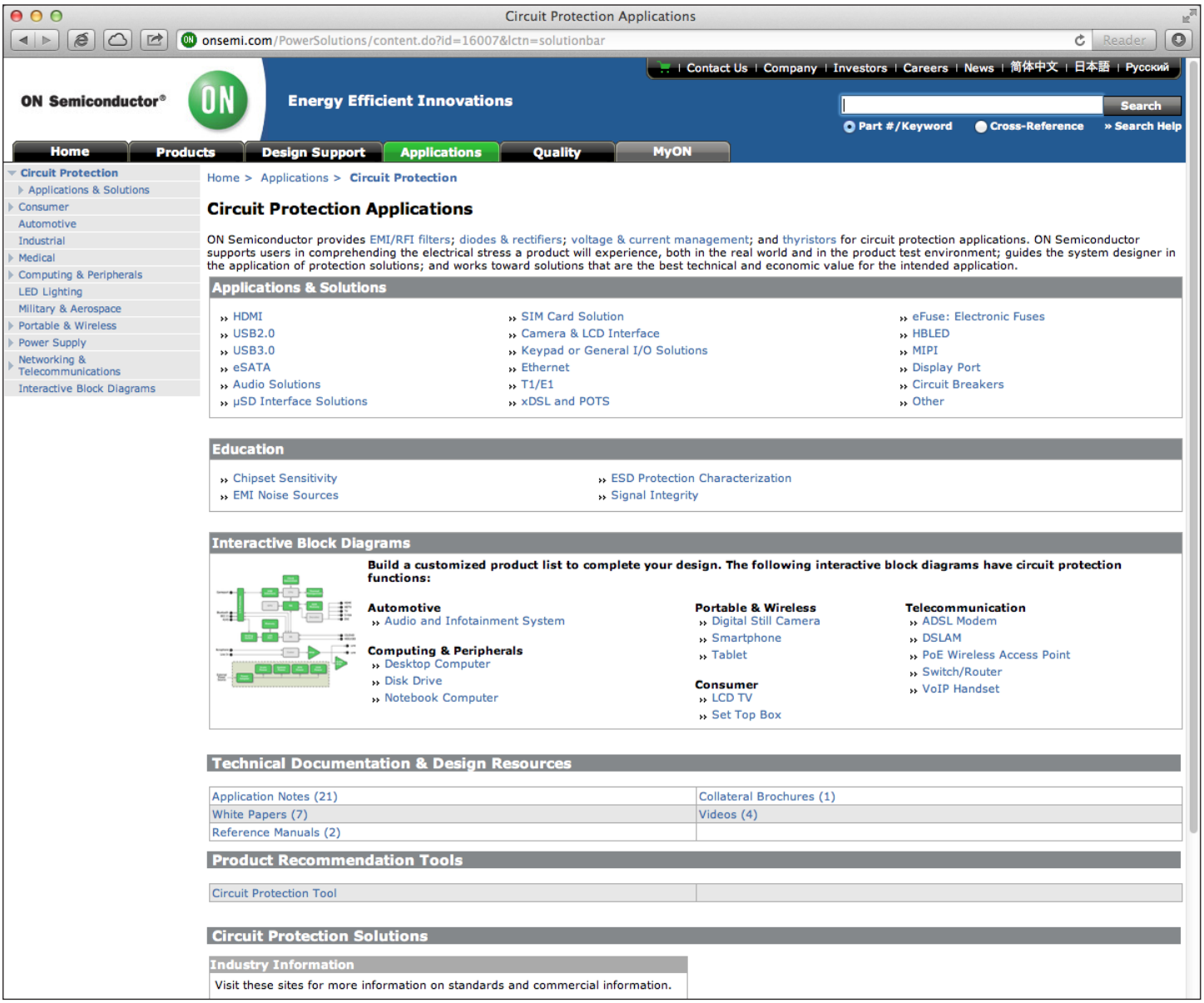
* Pending 2H13.

| Single Channel Packages | | | | | |
|---|---|---|---|---|---|
| SMB | SMA FL | SOD-323 | SOD-523 | SOD-923 | DSN-2 |
|  |  |  |  |  |  |
| NTVB Series, NPMC Series | NS6A Series, NSA5.0 | SD12, SD05 | ESD5Z | ESD9X, ESD9L | ESD11N, ESD11B, ESD5481 |

| Packages with Leads | | | |
|---|---|---|---|
| SOIC-8 | TSOP-6 | SC-88 | SOT-563 |
|  |  |  |  |
| NSI5112, NUP4201D | NUP4114H, NUP4201MR6 | NUP4114UC | NUP4114UPX |
| **SOT-23** | **SOT-723** | | **SOT-1123** |
|  |  | |  |
| SM12 | ESD7L | | ESD11L |

Package representations not to scale.

# For More Information, Visit the Circuit Protection Applications Page at www.onsemi.com



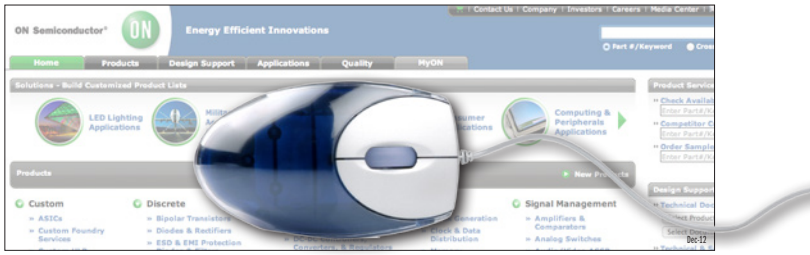
# Sales and Design Assistance from ON Semiconductor

| ON Semiconductor Distribution Partners | | |
|---|---|---|
| AMSC Co. | www.amsc.co.jp | (81) 422 54 6622 |
| Arrow Electronics | www.arrow.com | (800) 777-2776 |
| Avnet | www.em.avnet.com | (800) 332-8638 |
| Daiwa Distribution Ltd. | www.daiwahk.com | (852) 2341 3351 |
| Digi-Key | www.digikey.com | (800) 344-4539 |
| EBV Elektronik | www.ebv.com/en/locations.html | (49) 8121 774-0 |
| Fuji Electronics Co., Ltd. | www.fujiele.co.jp | (81) 3 3814 1411 |
| Future & FAI Electronics | www.futureelectronics.com/contact | 1-800-FUTURE1 (388-8731) |
| KH Electronics Inc. | www.khelec.com/kor | (82) 42 471 8521 |
| Marubun | www.marubun.co.jp | (81) 3 3639 5630 |
| Mitsui Electronics Inc. | www.btel.co.jp | (81) 3 6403 5900 |
| Mouser Electronics | www.mouser.com | (800) 346-6873 |
| Newark/Farnell | www.farnell.com/onsemi | (800) 4-NEWARK |
| Promate Electronic Co. | www.promate.com.tw | (886) 2 2659 0303 |
| Segyung Britestone Co. | www.britestone.com | (82) 2 3218 1511 |
| Serial Microelectronics, HK | www.serialsys.com.hk | (852) 2790 8220 |
| Taewon Inc. | www.taewon.net | (82) 2 6679 9000 |
| Tokyo Electron Device Co. | www.teldevice.co.jp | (81) 45 443 4000 |
| World Peace Industries Co. | www.wpi-group.com | (852) 2365 4860 |
| WT Microelectronics Co. | www.wtmec.com | (852) 2950 0820 |
| Yosun Electronics | www.yosun.com.tw | (886) 2 2659 8168 |

| INTERNATIONAL | | |
|---|---|---|
| **GREATER CHINA** | Beijing | 86-10-8577-8200 |
| | Hong Kong | 852-2689-0088 |
| | Shenzhen | 86-755-8209-1128 |
| | Shanghai | 86-21-5131-7168 |
| | Taipei, Taiwan | 886-2-2377-9911 |
| **FRANCE** | Paris | 33 (0)1 39-26-41-00 |
| **GERMANY** | Munich | 49 (0) 89-93-0808-0 |
| **INDIA** | Bangalore | 91-98-808-86706 |
| **ISRAEL** | Raanana | 972 (0) 9-9609-111 |
| **ITALY** | Milan | 39 02 9239311 |
| **JAPAN** | Tokyo | 81-3-5817-1050 |
| **KOREA** | Seoul | 82-2-2190-3500 |
| **MALAYSIA** | Penang | 60-4-6463877 |
| **SINGAPORE** | Singapore | 65-6442-1226 |
| **SLOVAKIA** | Piestany | 421 33 790 2450 |
| **UNITED KINGDOM** | Slough | 44 (0) 1753 70 1676 |

**For a comprehensive listing of ON Semiconductor Sales Offices, please visit:**
**www.onsemi.com/salessupport**

| AMERICAS REP FIRMS | | | |
|---|---|---|---|
| **Alabama** | Huntsville | e-Components | (256) 533-2444 |
| **Brazil** | Countrywide | Ammon & Rizos | (+55) 11-4688-1960 |
| **California** | Bay Area | L2 | (408) 453-5000 |
| | Southern California | Tech Coast Sales | (949) 305-6869 |
| **Canada** | Eastern Canada | Astec | (905) 607-1444 |
| | Western Canada | Sifore | (503) 977-6267 |
| **Connecticut** | Statewide | Paragon Electronic Systems | (603) 645-7630 |
| **Florida** | Statewide | e-Components | (888) 468-2444 |
| **Georgia** | Atlanta | e-Components | (888) 468-2444 |
| **Illinois** | Hoffman Estates | Stan Clothier Company | (847) 781-4010 |
| **Indiana** | Fishers | Bear VAI | (317) 570-0707 |
| **Iowa** | Cedar Rapids | Essig & Associates | (319) 363-8703 |
| **Kansas** | Overland Park | Stan Clothier Company | (913) 894-1675 |
| **Maine** | Statewide | Paragon Electronic Systems | (603) 645-7630 |
| **Maryland** | Columbia | Third Wave Solutions | (410) 290-5990 |
| **Massachusetts** | Statewide | Paragon Electronic Systems | (603) 645-7630 |
| **Mexico** | Countrywide | Ammon & Rizos | (+55) 11-4688-1960 |
| **Michigan** | St. Joseph | Bear VAI | (440) 526-1991 |
| **Minnesota** | Eden Prairie | Stan Clothier Company | (952) 944-3456 |
| **Missouri** | St. Charles | Stan Clothier Company | (636) 916-3777 |
| **New Hampshire** | Statewide | Paragon Electronic Systems | (603) 645-7630 |
| **New Jersey** | Statewide | S.J. Metro | (516) 942-3232 |
| **New York** | Binghamton | TriTech - Full Line Rep | (607) 722-3580 |
| | Jericho | S.J. Metro | (516) 942-3232 |
| | Rochester | TriTech - Full Line Rep | (585) 385-6500 |
| **North Carolina** | Raleigh | e-Components | (888) 468-2444 |
| **Ohio** | Brecksville | Bear VAI Technology | (440) 526-1991 |
| **Oregon** | Portland | SiFore Technical | (503) 977-6267 |
| **Puerto Rico** | Countrywide | e-Components | (888) 468-2444 |
| **Rhode Island** | Statewide | Paragon Electronic Systems | (603) 645-7630 |
| **Vermont** | Statewide | Paragon Electronic Systems | (603) 645-7630 |
| **Washington** | Bellevue | SiFore Technical | (425) 990-4701 |
| **Wisconsin** | Evansville | Stan Clothier Company | (608) 882-0686 |
| | Oconomowoc | Stan Clothier Company | (608) 882-0686 |






## PUBLICATION ORDERING INFORMATION

**LITERATURE FULFILLMENT:**
Literature Distribution Center for ON Semiconductor
P.O. Box 5163, Denver, Colorado 80217 USA
**Phone**: 303-675-2175 or 800-344-3860 Toll Free USA/Canada
Fax: 303-675-2176 or 800-344-3867 Toll Free USA/Canada
**Email**: orderlit@onsemi.com

**N. American Technical Support**: 800-282-9855 Toll Free USA/Canada.
**Europe, Middle East and Africa Technical Support**:
Phone: 421 33 790 2910
**Japan Customer Focus Center**
Phone: 81-3-5817-1050

**ON Semiconductor Website**: **www.onsemi.com**

**Order Literature**: http://www.onsemi.com/orderlit

For additional information, please contact your local Sales Representative