

Protection Design Guide for Portable Electronics

ESD and EMI Protection Solutions

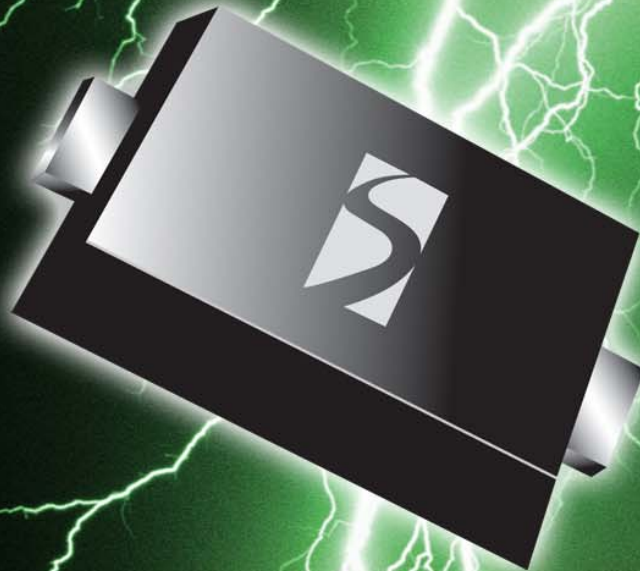
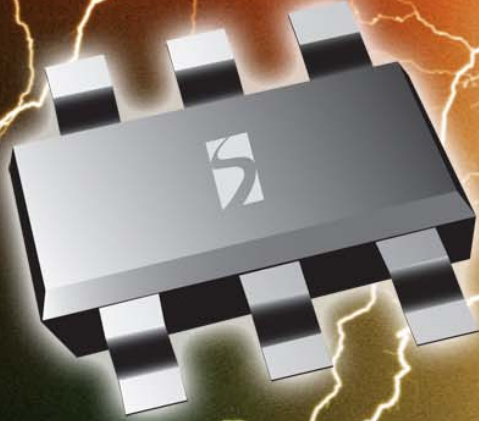




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PROTECTION PRODUCTS

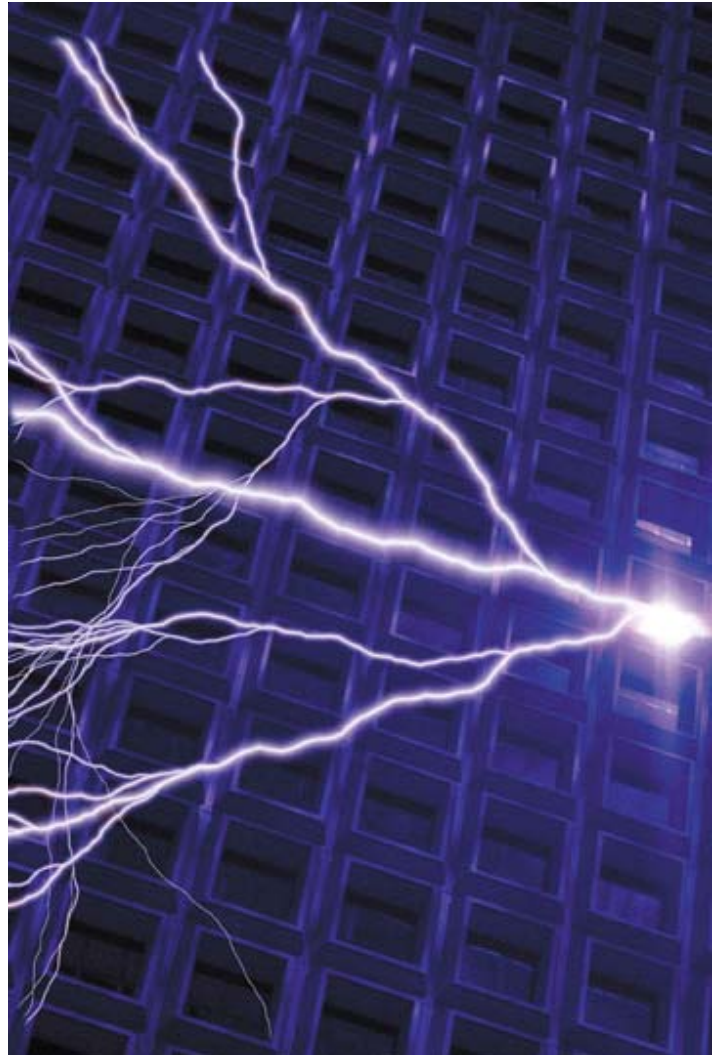
Introduction

ESD Testing - IEC 61000-4-2

The Need for Robust ESD Protection

Designers of portable systems are constantly challenged to make smaller devices with increased functionality. To do so, semiconductors have to become more complex, requiring sub-micron processes and very fine line widths. In turn, they become increasingly more sensitive to the effects of electrostatic discharge (ESD). Making matters worse, in the race to provide more and faster functionality, on-chip ESD protection is by necessity being sacrificed in favor of chip performance. It is expected that the integrated circuits of tomorrow will not sustain the current levels of on-chip ESD protection. As on-chip protection is reduced, ICs will become even more sensitive to the effects of electrostatic discharge (ESD).

With increased ESD sensitivity of digital ICs, the need to protect systems with more robust off-chip transient voltage suppression will be greater than ever. Portable systems are constantly exposed to the damaging effects of electrostatic discharge (ESD). An unsuspecting user can inject a hazardous charge during normal device operation. The consumer usually perceives system failures as poor quality by the consumer. Increased device sensitivity coupled with increasingly miniaturized form factors have increased the challenge of designing adequate ESD protection. It requires a combination of good board layout and state-of-the-art protection components to properly complete the task.



PROTECTION PRODUCTS



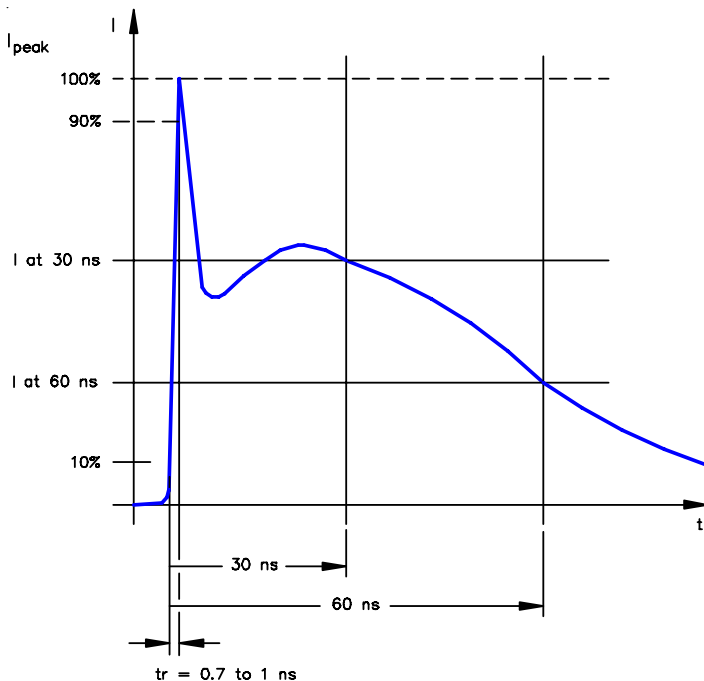
Introduction

ESD Testing - IEC 61000-4-2

ESD Compliance Standard - IEC 61000-4-2

Several models exist to simulate the ESD event. Each is designed to describe the threat in a real world environment. The discharge model is typically a voltage source feeding a resistor/capacitor network. Resistor and capacitor values vary depending upon the standard. Today the most internationally recognized ESD standard is IEC 61000-4-2. IEC 61000-4-2 is a system level standard used by manufacturers to model ESD events from human contact. The test is performed by discharging a 150pF capacitor through a 330 ohm resistor. The peak current achieved is approximately 5 times greater than that of component level ESD tests such as JEDEC STD 883, Method 3015. This is one reason why devices may fail at the system level even though they pass the component level test. Discharge into the equipment may be through direct contact (contact discharge) or just prior

to contact (air discharge). IEC 61000-4-2 divides the ESD into four threat levels. Test voltages at the threat levels range from 2kV to 15kV with peak discharge currents as high as 30A. Most manufacturers adhere to the most stringent level, level 4, which defines a +/- 15kV air discharge test and a +/- 8kV contact discharge test. However, many manufacturers test their equipment beyond these levels. The ESD waveform as defined by IEC 61000-4-2 reaches peak magnitude in 700ps to 1ns and has a total duration of only 60ns. While the ESD pulse contains little energy, the resulting effect can be devastating to sensitive semiconductor devices. Sensitive points of the equipment are to be tested with a combination of positive and negative discharges. Sensitive areas of a cell phone for example would include I/O ports, audio ports, battery contacts, LED displays, antenna, external memory ports, and the keypad.



LEVEL	Test Voltage Air Discharge (kV)	Test Voltage Contact Discharge (kV)	First Peak Current (A)	Peak Current at 30ns (A)	Peak Current at 60ns (A)
1	2	2	7.5	4	2
2	4	4	15	8	4
3	8	6	22.5	12	6
4	15	8	30	16	8

ESD Waveform and Discharge Levels per IEC 61000-4-2

PROTECTION PRODUCTS



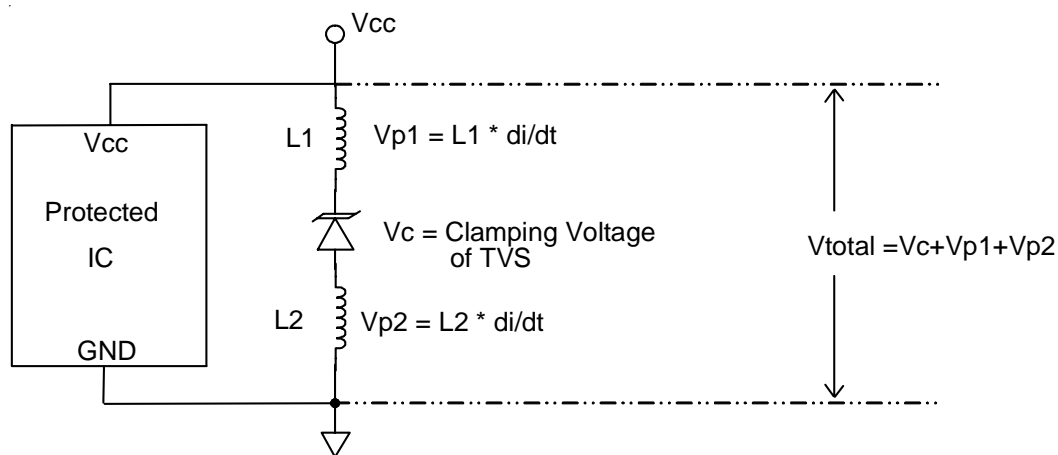
Introduction

ESD Protection - Board Layout

ESD Protection Strategies - Board Layout

PC board layout is an important part of transient immunity design. This is especially critical in portable systems where the threat of ESD exists. Parasitic inductance in the protection path can result in significant voltage overshoot and may exceed the damage threshold of the protected IC. This is especially critical in the case of fast rise-time transients such as ESD or EFT. Recall that the voltage developed across an inductive load is proportional to the time rate of change in current ($V = L di/dt$). An ESD induced transient reaches a peak in less than 1ns (per IEC 1000-4-2). Assuming a trace inductance of 20nH per inch and a quarter inch trace, the voltage overshoot will be 50 volts for a 10A pulse. The primary rule of thumb is to minimize the effects of parasitic inductance by making the shunt paths as short as possible. All inductive paths must be considered

including the ground return path, the path between the TVS and the protected line, and the path from the connector to the TVS device. Additionally, The TVS device should be placed as close to the connector as possible to reduce transient coupling into nearby traces. The secondary effects of radiated emissions can cause upset to other areas of the board even if there is no direct path to the connector. Long signal traces will act as antennas to receive energy from fields that are produced by the ESD pulse. By keeping line lengths as short as possible, the efficiency of the line to act as an antenna for ESD related fields is reduced. Minimize interconnecting line lengths by placing devices with the most interconnects as close together as possible. Finally, avoid running critical signal lines near board edges or next to protected lines.



- * L1 represents the parasitic inductance of the trace between TVS and Vcc
- * L2 represents the parasitic inductance of the trace between TVS and GND
- * Vtotal represents the voltage that will be see between Vcc and GND of the IC during a transient.

Effects of Parasitic Inductance

PROTECTION PRODUCTS

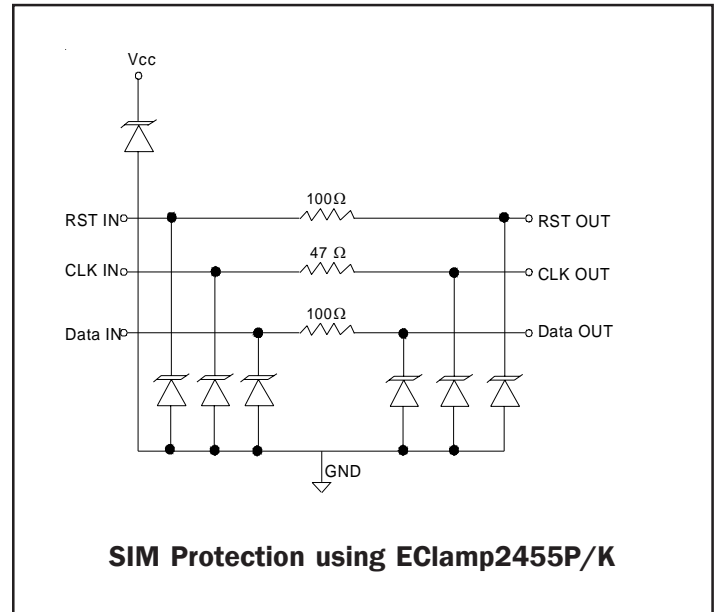


External Memory Interfaces

SIM Ports, Micro SD (SD or SPI Mode)

SIM Interface - EClamp2455P & EClamp2455K ESD Protection + Filtering

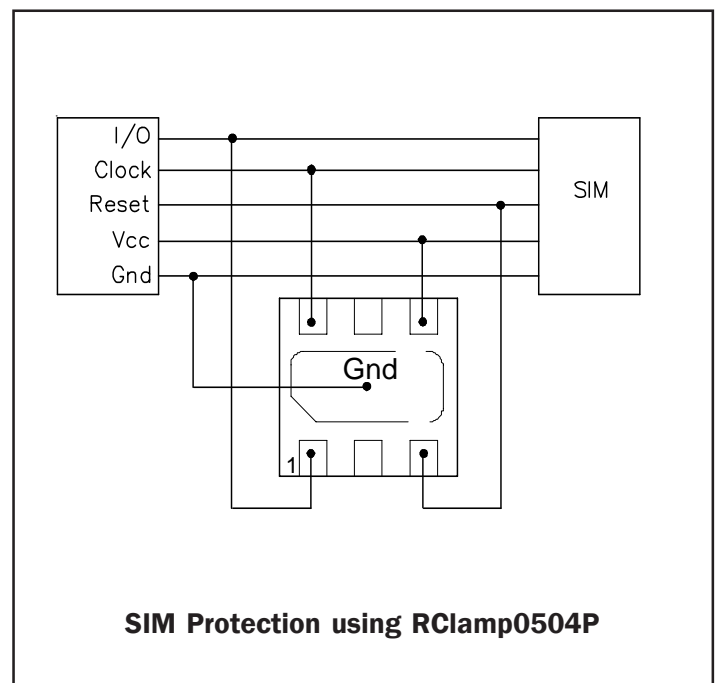
EClamp2455P/K consists of three circuits that include series impedance matching resistors for proper termination of the SIM card interface. Termination resistor value of 100 Ohms is included on the RST and Data lines and 47 Ohms on the CLK line. TVS diodes are also included on each line for ESD protection in excess of $\pm 15\text{kV}$ (air discharge) and $\pm 8\text{kV}$ (contact discharge) per IEC 61000-4-2, level 4. The total capacitance of each line is 24pF maximum. The low capacitance along with the series resistors help maintain signal rise times to within specified parameters. An additional TVS diode connection is included for protection of the voltage (Vcc) bus. The EClamp2455P is in a 2.1 x 1.6 x 0.6mm RoHS compliant leadless package. The leads are spaced at a pitch of 0.5mm. The EClamp2455K is in a 8-pin, RoHS/WEEE compliant, SLP1713P8 package. It measures 1.7 x 1.3 x 0.50mm. The leads are spaced at a pitch of 0.4mm. These packages are designed to replace flip chip solutions in the same application.



0.400mm Pitch (EClamp2455K)

SIM Interface - Low Capacitance RailClamp0504P

In applications where lower capacitance is needed, the RClamp series are ideal choices. A RailClamp protection device utilizes surge-rated steering diodes to compensate & lower the overall capacitance seen by the circuit. The RClamp0504P provides four lines of protection including the Vcc line. The RClamp0504P presents a maximum capacitance of <math><3\text{pF}</math> per line. Note that one of the I/O pins are used to protect the Vcc pin. This is done to provide complete isolation for the SIM Vcc during ESD events on the I/O, clock, or reset lines. The RClamp0504P is in a 1.6 x 1.6 x 0.6mm RoHS compliant leadless package (SLP1616P6). RClamp3304P is also available in the same footprint for sub 5V circuits.



PROTECTION PRODUCTS

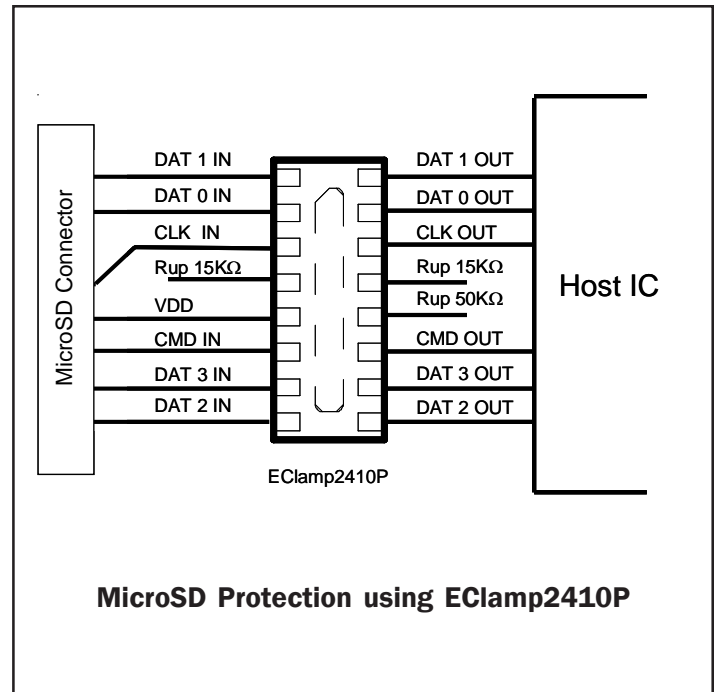


External Memory Interfaces

SIM Ports, Micro SD (SD or SPI Mode)

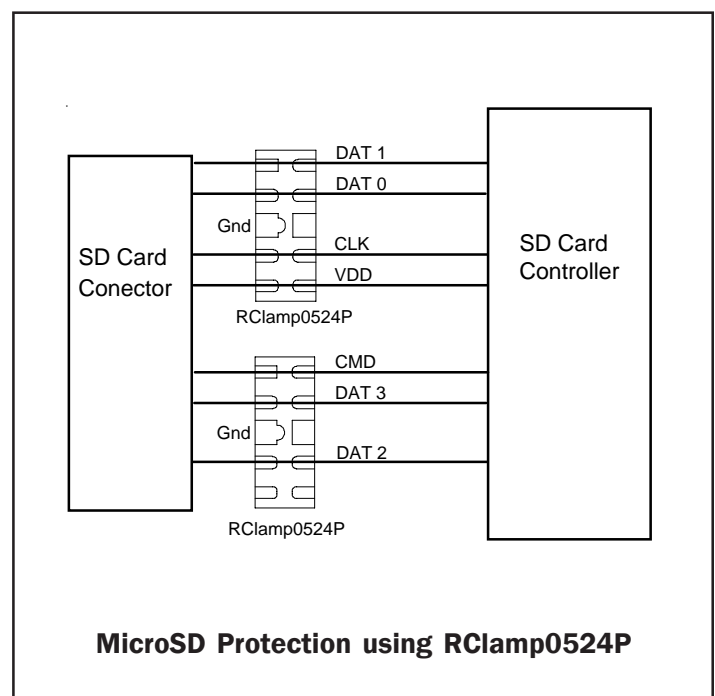
MicroSD Interface - EClamp2410P ESD Protection + Filtering

The EClamp2410P consists of six circuits that include series impedance matching resistors and pull up resistors as required by the SD specification. TVS diodes are included on each line for ESD protection. An additional TVS diode connection is included for protection of the voltage (Vdd) bus. Termination resistor value of 45 Ohms is included on the DAT0, DAT1, DAT2, DAT3, CMD, and CLK lines. Pull up resistors of 15k Ohms are included on DAT0, DAT1, DAT2, and CMD lines while a 50k Ohm pull up is included on the DAT3 line. These may be configured for devices operating in SD or SPI mode. The TVS diodes provide effective suppression of ESD voltages in excess of ±15kV (air discharge) and ±8kV (contact discharge) per IEC 61000-4-2, level 4. The EClamp2410P is in a 16-pin, RoHS/WEEE compliant, SLP4016P16 package. It measures 4.0 x 1.6 x 0.58mm. The leads are spaced at a pitch of 0.5mm and are finished with lead-free NiPdAu.



MicroSD Interface - Low Capacitance RClamp0524P

The RClamp™0524P is an ultra-low capacitance ESD protection device that may be used on micro SD interfaces that use external resistors. It has a typical capacitance of only 0.20pF between I/O pins and 0.30pF between any I/O pin and ground. Each device will protect up to four lines and may be used to meet the ESD immunity requirements of IEC 61000-4-2, Level 4 (±15kV air, ±8kV contact discharge). The RClamp0524P is in a 10-pin, RoHS/WEEE compliant, SLP2510P8 package. It measures 2.5 x 1.0 x 0.58mm. The leads are spaced at a pitch of 0.5mm. They are designed for easy PCB layout by allowing the traces to run straight through the device. The leadless design and flow through layout minimizes impedance stubs for maximum signal integrity.



PROTECTION PRODUCTS



LCD Display - Serial & Parallel Interface

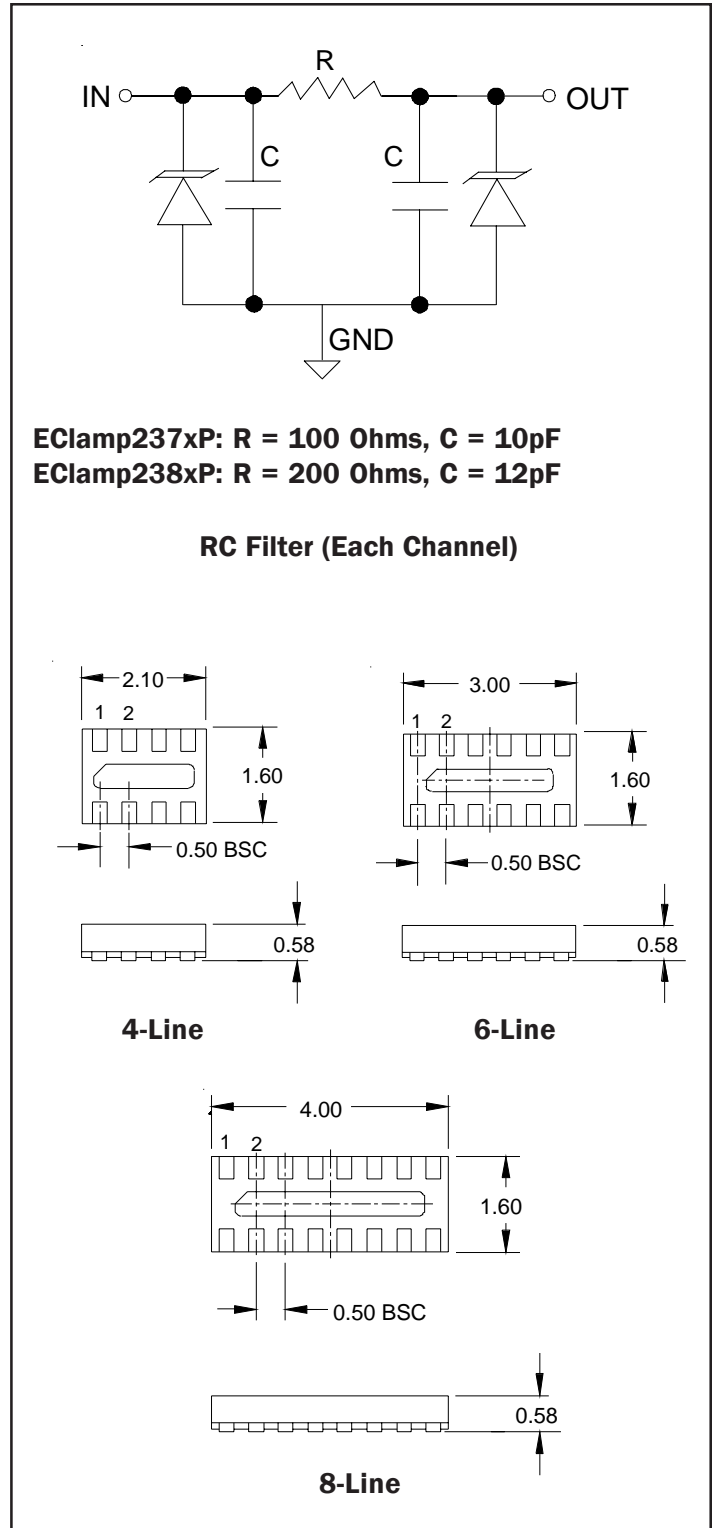
R-C Filters

Parallel Interface - EClamp237xP RC Filter + ESD Protection

The EClamp237xP series is a RC filter consisting of TVS diodes for ESD protection, and a resistor - capacitor network for EMI/RFI filtering. A series resistor value of 100Ω and a capacitance value of 10pF are used to achieve 30dB minimum attenuation from 1.8GHz to 2.5GHz. The TVS diodes provide effective suppression of ESD voltages in excess of ±15kV (air discharge) and ±8kV (contact discharge) per IEC 61000-4-2, level 4. These devices are available in 4-line (EClamp2374P), 6-line (EClamp2376P), and 8-line (EClamp2378P) versions for maximum design flexibility. Each is in a RoHS/WEEE compliant SLP package, designed to replace comparable flip chip devices. The EClamp2374P measures 2.1 x 1.6 x 0.58 mm. The EClamp2376P measures 3.0 x 1.6 x 0.58 mm. The EClamp2378P measures 4.0 x 1.6 x 0.58 mm. The leads are spaced at a pitch of 0.5mm.

Parallel Interface - EClamp238xP RC Filter + ESD Protection

The EClamp238xP series is a RC filter consisting of TVS diodes for ESD protection, and a resistor - capacitor network for EMI/RFI filtering. A series resistor value of 200Ω and a capacitance value of 12pF are used to achieve 30dB minimum attenuation from 800MHz to 2.7GHz. The TVS diodes provide effective suppression of ESD voltages in excess of ±15kV (air discharge) and ±8kV (contact discharge) per IEC 61000-4-2, level 4. These devices are available in 4-line (EClamp2384P), 6-line (EClamp2386P), and 8-line (EClamp2388P) versions for maximum design flexibility. Each is in a RoHS/WEEE compliant SLP package, designed to replace comparable flip chip devices. The EClamp2384P measures 2.1 x 1.6 x 0.58 mm. The EClamp2386P measures 3.0 x 1.6 x 0.58 mm. The EClamp2388P measures 4.0 x 1.6 x 0.58 mm. The leads are spaced at a pitch of 0.5mm.



PROTECTION PRODUCTS



LCD Display - Serial & Parallel Interface

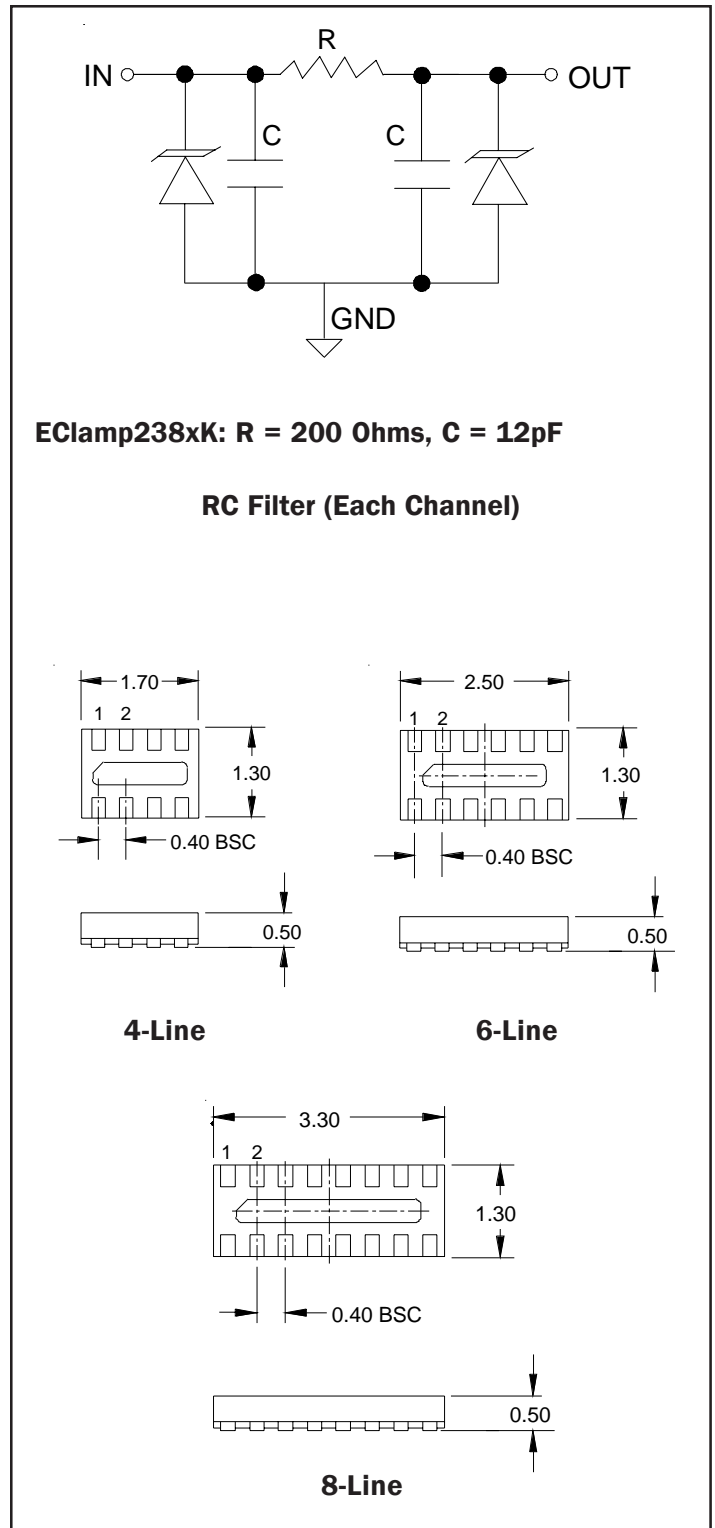
R-C Filters

Parallel Interface - EClamp238xK RC Filter + ESD Protection

The EClamp238xK series is a RC filter consisting of TVS diodes for ESD protection, and a resistor - capacitor network for EMI/RFI filtering. A series resistor value of 200Ω and a capacitance value of 12pF are used to achieve 30dB minimum attenuation from 800MHz to 2.7GHz. The TVS diodes provide effective suppression of ESD voltages in excess of ±15kV (air discharge) and ±8kV (contact discharge) per IEC 61000-4-2, level 4.

These devices are available in 4-line (EClamp2384K), 6-line (EClamp2386K), and 8-line (EClamp2388K) versions for maximum design flexibility. Each is in a RoHS/WEEE compliant SLP package with a lead pitch of 0.400mm. The EClamp2384K measures 1.7 x 1.3 x 0.5 mm. The EClamp2386K measures 2.5 x 1.3 x 0.5 mm. The EClamp2388K measures 3.3 x 1.3 x 0.5 mm.

0.400mm Pitch SLP Package



PROTECTION PRODUCTS



LCD Display - Serial & Parallel Interface

5-Pole L-C Filters

Parallel Interface - EClamp239xP RC Filter + ESD Protection

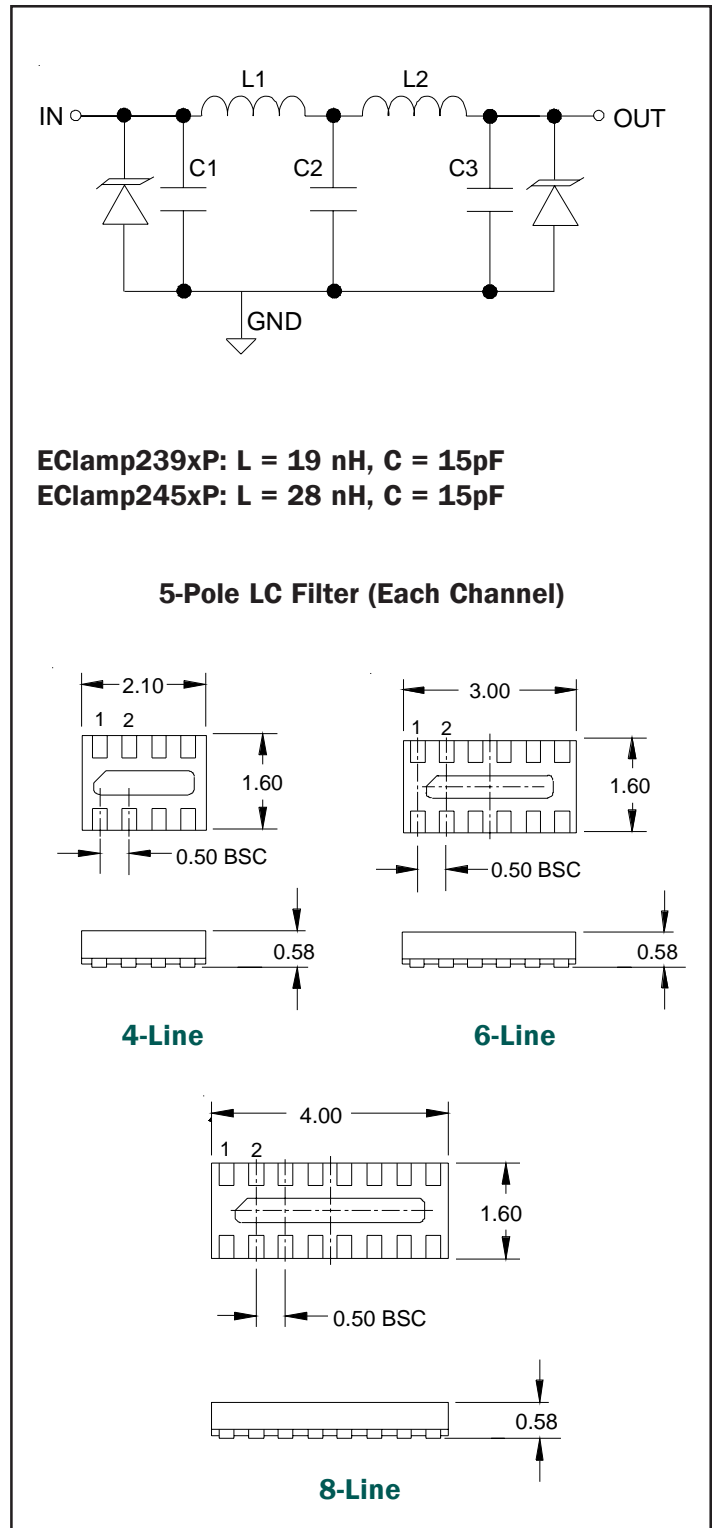
The EClamp239xP series is a LC filter consisting of TVS diodes for ESD protection, and a 5-pole inductor - capacitor network for EMI/RFI filtering. A typical inductor value of 19nH and a capacitor value of 15pF are used to achieve 30dB minimum attenuation from 800MHz to 2.7GHz. The TVS diodes provide effective suppression of ESD voltages in excess of ±15kV (air discharge) and ±8kV (contact discharge) per IEC 61000-4-2, level 4.

These devices are available in 4-line (EClamp2394P), 6-line (EClamp2396P), and 8-line (EClamp2398P) versions for maximum design flexibility. Each is in a RoHS/WEEE compliant SLP package, designed to replace comparable flip chip devices. The EClamp2394P measures 2.1 x 1.6 x 0.58 mm. The EClamp2396P measures 3.0 x 1.6 x 0.58 mm. The EClamp2398P measures 4.0 x 1.6 x 0.58 mm. The leads are spaced at a pitch of 0.5mm.

Parallel Interface - EClamp245xP RC Filter + ESD Protection

The EClamp245xP series is a LC filter consisting of TVS diodes for ESD protection, and a 5-pole inductor - capacitor network for EMI/RFI filtering. A typical inductor value of 28nH and a capacitor value of 15pF are used to achieve 40dB minimum attenuation from 800MHz to 2.7GHz. The TVS diodes provide effective suppression of ESD voltages in excess of ±15kV (air discharge) and ±8kV (contact discharge) per IEC 61000-4-2, level 4.

These devices are available in 4-line (EClamp2454P), 6-line (EClamp2456P), and 8-line (EClamp2458P) versions for maximum design flexibility. Each is in a RoHS/WEEE compliant SLP package, designed to replace comparable flip chip devices. The EClamp2454P measures 2.1 x 1.6 x 0.58 mm. The EClamp2456P measures 3.0 x 1.6 x 0.58 mm. The EClamp2458P measures 4.0 x 1.6 x 0.58 mm. The leads are spaced at a pitch of 0.5mm.



PROTECTION PRODUCTS



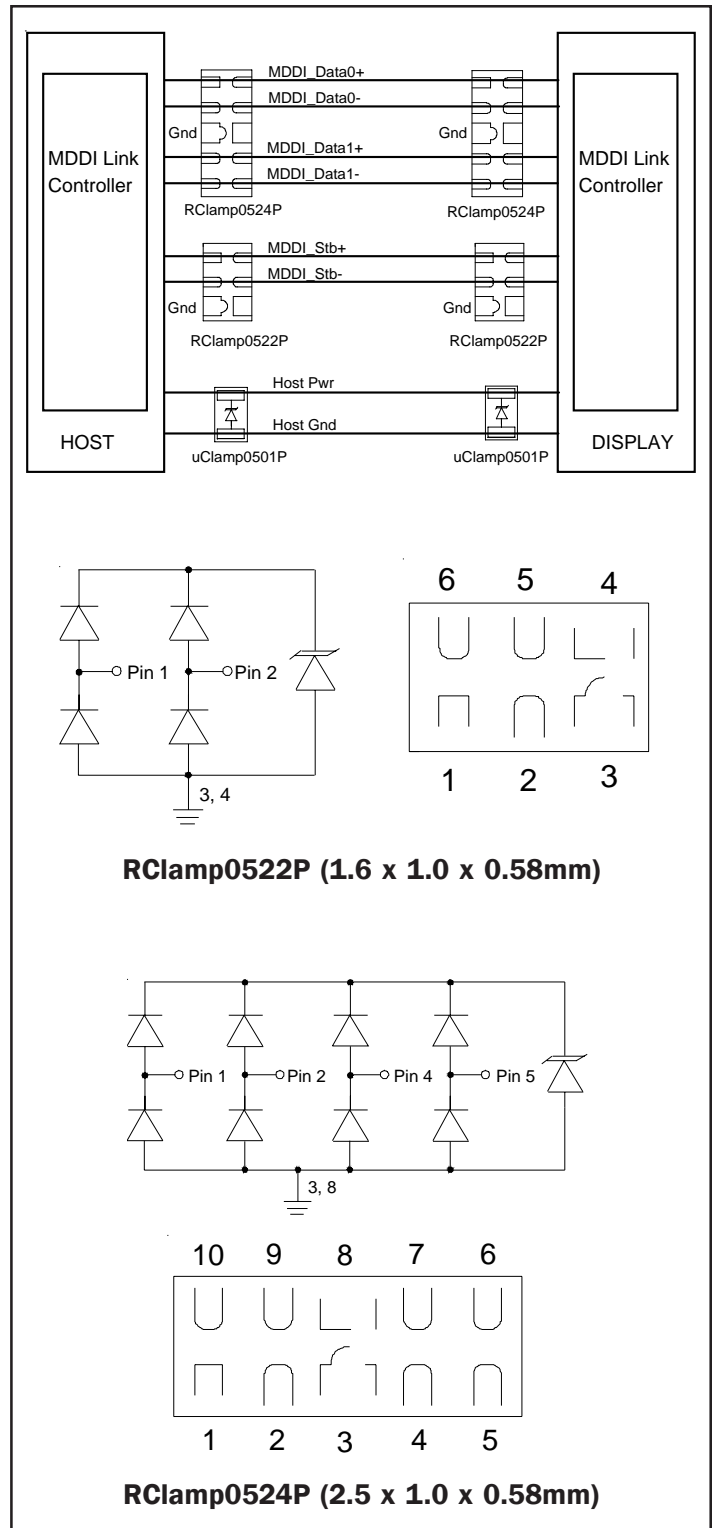
LCD Display - Serial & Parallel Interface

Low Capacitance MDDI/MIPI Port protection

MDDI Interface - Low Capacitance RailClamp0522P and RClamp0524P

The RClamp™0522P and RClamp™0524P are ultra-low capacitance ESD protection devices that have been optimized for use on next generation serial display interfaces. Each have a typical capacitance of only 0.20pF between I/O pins and 0.30pF between any I/O pin and ground. This allows it to be used on circuits operating in excess of 3GHz without signal attenuation. They may be used to meet the ESD immunity requirements of IEC 61000-4-2, Level 4 (±15kV air, ±8kV contact discharge). The RClamp0522P is designed to protect two lines, while the RClamp0524P will protect four lines. The RClamp0522P is in a 6-pin, RoHS/WEEE compliant, SLP1610P4 package. It measures 1.6 x 1.0 x 0.58mm. The RClamp0524P is in a 10-pin, RoHS/WEEE compliant, SLP2510P8 package. It measures 2.5 x 1.0 x 0.58mm. The leads are spaced at a pitch of 0.5mm. They are designed for easy PCB layout by allowing the traces to run straight through the device. The leadless design and flow through layout minimizes impedance stubs for maximum signal integrity.

For a complete solution, the power lines should also be protected. Here a “general purpose” single line device such as uClamp0501P will suffice.



PROTECTION PRODUCTS

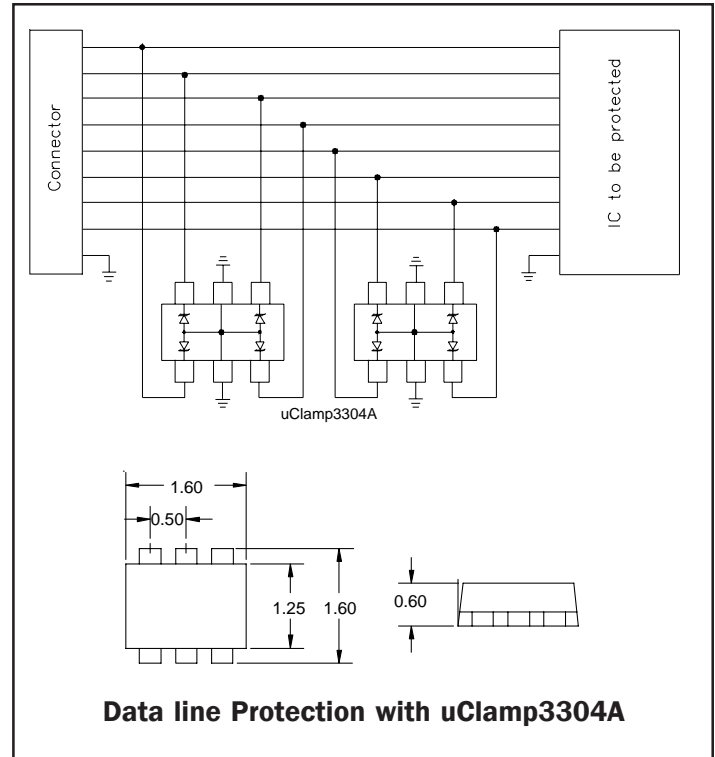


General Purpose ESD - 3.3V Multi-Line Arrays

Car Kit Connectors, Keypads, Data Ports

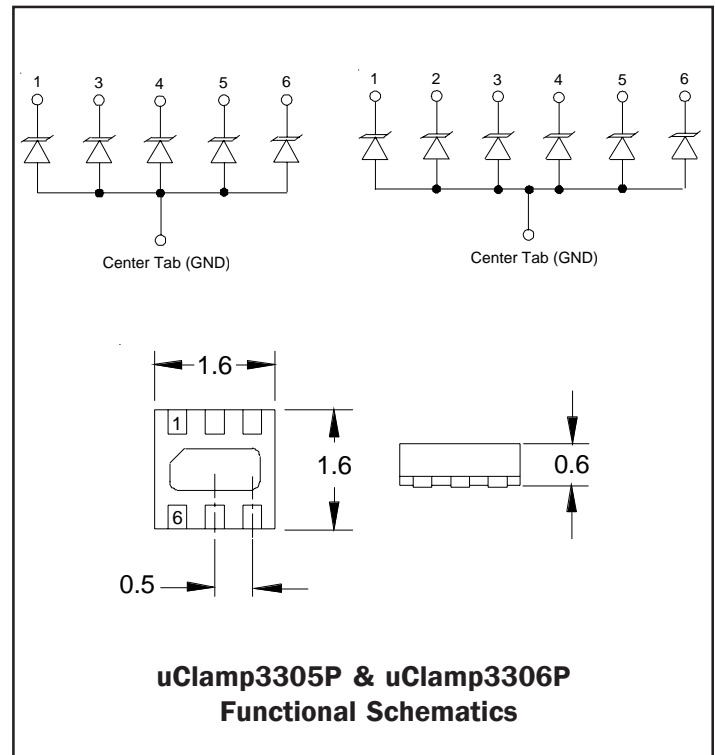
3.3V Leaded Package - uClamp3304A

The uclamp™3304A is a 4-line TVS array constructed using Semtech's proprietary EPD process technology. The EPD process provides low standoff voltages with significant reductions in leakage currents and capacitance over silicon-avalanche diode processes. They feature a true operating voltage of 3.3 volts for superior protection when compared to traditional pn junction devices. This device is in an industry standard SC-89 (SOT-666) package that requires less than 2.9mm² of PCB area. They are unidirectional devices and may be used on lines with positive signal polarities.



3.3V Leadless Packages - uClamp3305P, uClamp3306P

The uclamp™3305P and the uclamp™3306P are designed to protect sensitive electronics from damage or latch-up due to ESD. The uClamp3305P will protect up to 5 lines and the uClamp3306P will protect up to 6 data lines operating at 3.3 volts. Each is constructed using Semtech's proprietary EPD process technology. The EPD process provides low standoff voltages with significant reductions in leakage currents and capacitance over silicon-avalanche diode processes. These devices are in a SLP1616P6, RoHS compliant leadless package measuring 1.6 x 1.6 x 0.6mm.



PROTECTION PRODUCTS

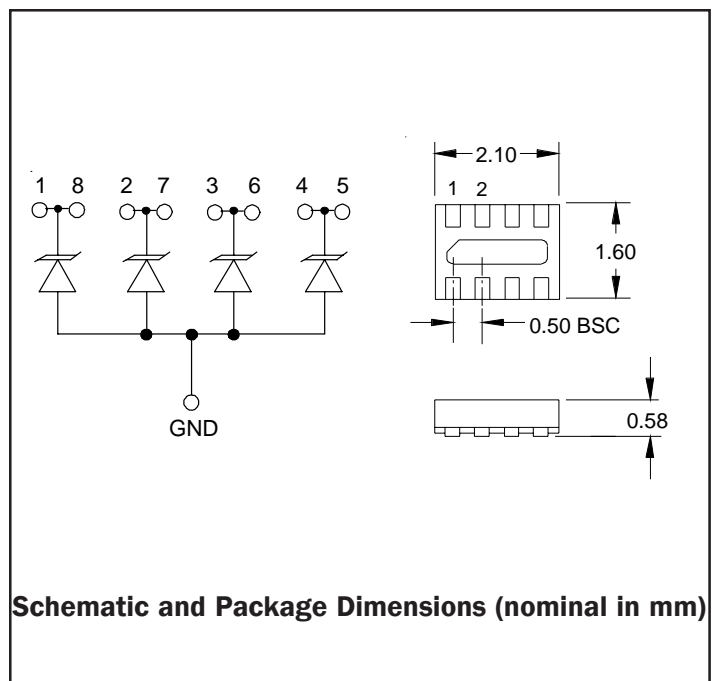
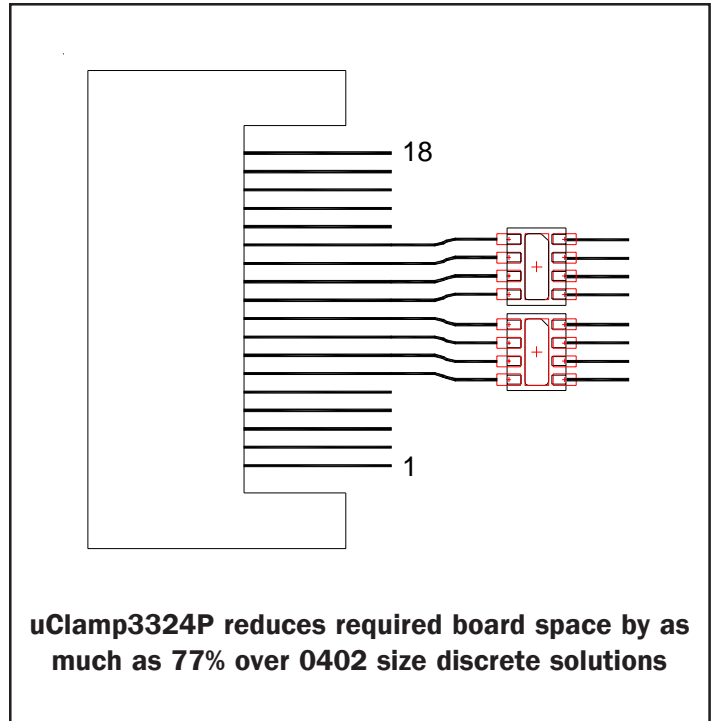


General Purpose ESD - 3.3V Multi-Line Arrays

Car Kit Connectors, Keypads, Data Ports

3.3V Flow-Thru Design - uClamp3324P

The uClamp3324P is a 3.3 volt, 4-Line ESD protection array designed to replace multiple single line discrete devices. It features a flow thru design that simplifies layout and reduces board space requirements when compared to discrete devices. The uClamp3324P may be used to meet the immunity requirements of IEC 61000-4-2, level 4 ($\pm 15\text{kV}$ air, $\pm 8\text{kV}$ contact discharge). The flow-thru design further enhances ESD performance due to reduced board trace inductance. The result is lower clamping voltage and a higher level of protection when compared to conventional TVS devices. The uClamp3324P is in an 8-pin, RoHs compliant, SLP2116P8 package measuring 2.1 x 1.6 x 0.58mm. The leads are spaced at a pitch of 0.5mm.



PROTECTION PRODUCTS

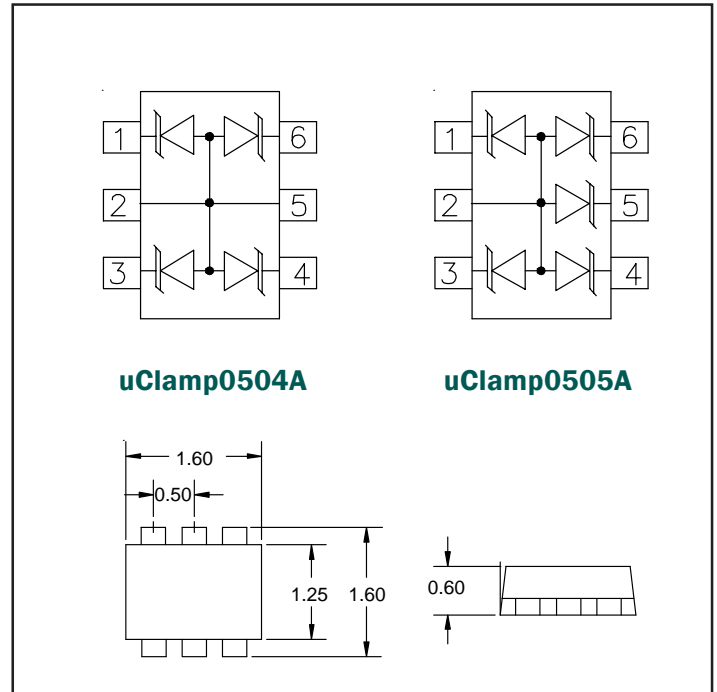


General Purpose ESD - 5V Multi-Line Arrays

Car Kit Connectors, Keypads, Data Ports

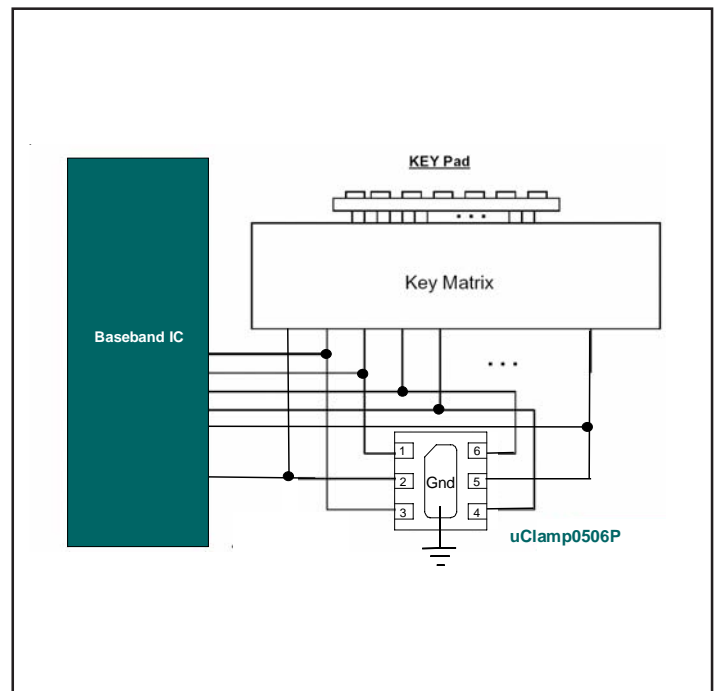
5V Protection - uClamp0504A, uClamp0505A

The uclamp™0504A and the uclamp™0505A are designed to protect sensitive electronics from damage or latch-up due to ESD. The uClamp0504A will protect up to 4 lines and the uClamp0505A will protect up to 5 lines operating at 5 volts. Each is constructed using Semtech's proprietary process technology for maximum protection of today's digital circuits. These devices are in an industry standard RoHS/WEEE compliant, SC-89 (SOT-666) package that requires less than 2.9mm² of PCB area. Applications include keypads, carkit connectors, audio ports, and side keys.



5V Leadless Packages - uClamp0505P, uClamp0506P

The uclamp™0505P and the uclamp™0506P are designed to protect sensitive electronics from damage or latch-up due to ESD. The uClamp0505P will protect up to 5 lines and the uClamp0506P will protect up to 6 lines operating at 5 volts. Each is constructed using Semtech's proprietary process technology for maximum protection of today's digital circuits. These devices are in a SLP1616P6, RoHS compliant leadless package measuring 1.6 x 1.6 x 0.6mm. Applications include keypads, carkit connectors, and audio ports.



PROTECTION PRODUCTS

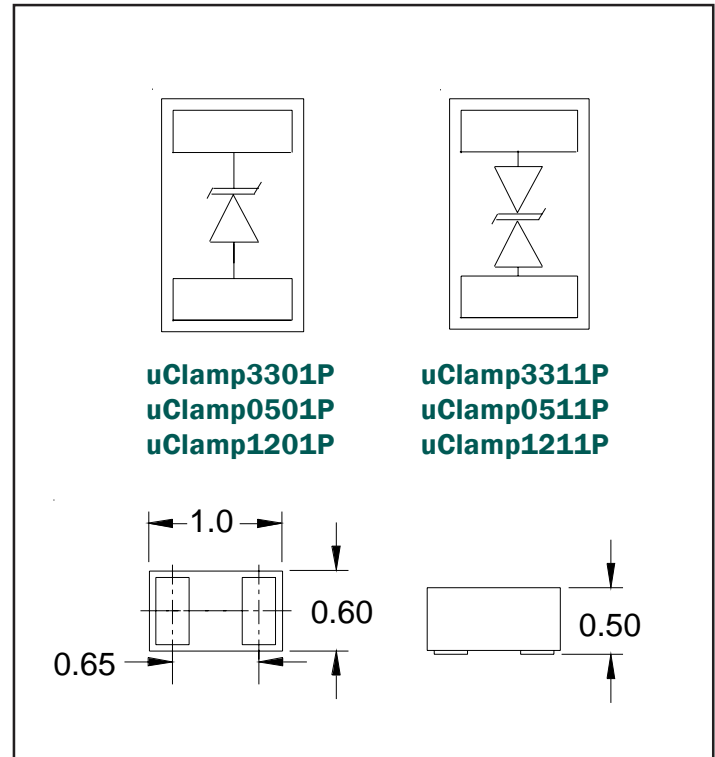


ESD Protection - Single and Dual Line

Side Keys, Bottom Connectors, Battery Lines

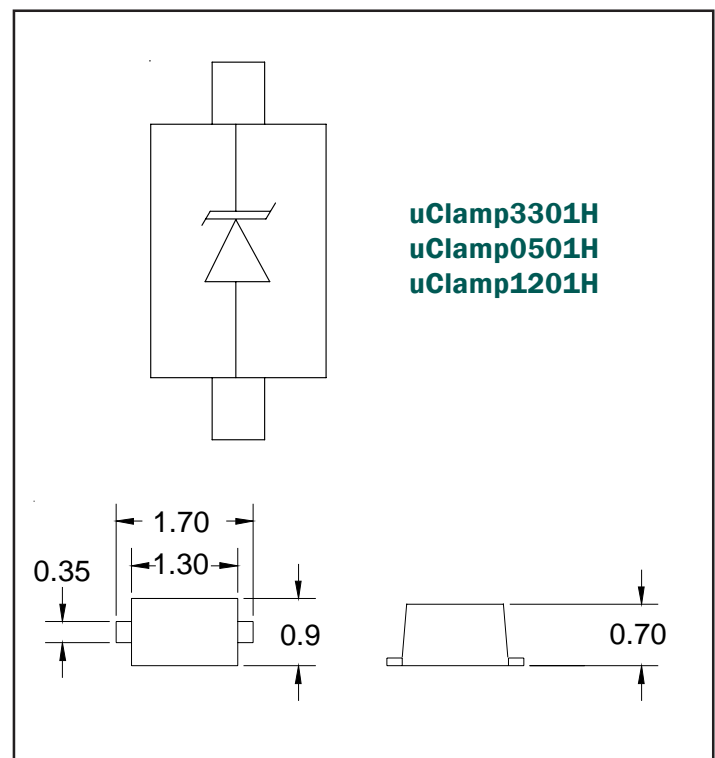
3.3V, 5V, 12V Single Line Devices - uClamp3301P, uClamp3311P, uClamp0501P, uClamp0511P, uClamp1201P, uClamp1211P

The uClamp™ series of protection devices are designed to protect sensitive electronics from damage or latch-up due to ESD. These single line devices give the designer the flexibility to protect single lines in applications where arrays are not practical. Each is in a small 2-pin, RoHS/WEEE compliant, SLP1006P2 package measuring 1.0 x 0.6 x 0.5mm. The leads are spaced at a pitch of 0.65mm and are finished with lead-free NiPdAu. The uClamp3301P and uClamp3311P may be used on data lines operating at 3.3 volts, the uClamp0501P and uClamp0511P are for use on 5 volt data and power lines, and the uClamp1201P and uClamp1211P may be used on 12 volt data and power lines. Applications include keypads, carkit connectors, audio ports, power rails, and side keys.



3.3V, 5V, 12V Single Line Devices - uClamp3301H, uClamp0501H, uClamp1201H

The uClamp™ series of protection devices are designed to protect sensitive electronics from damage or latch-up due to ESD. These single line devices give the designer the flexibility to protect single lines in applications where arrays are not practical. Each is in a small 2-pin, RoHS/WEEE compliant, SOD-523 package measuring 1.7 x 1.7 x 0.7mm. The leads are finished with lead-free matte tin. The uClamp3301H may be used on data lines operating at 3.3 volts, the uClamp0501H is for use on 5 volt data and power lines, and the uClamp1201H may be used on 12 volt data and power lines. Applications include keypads, carkit connectors, audio ports, power rails, and side keys.



Note: 3.3V devices are not intended for use on DC supply rails.

PROTECTION PRODUCTS

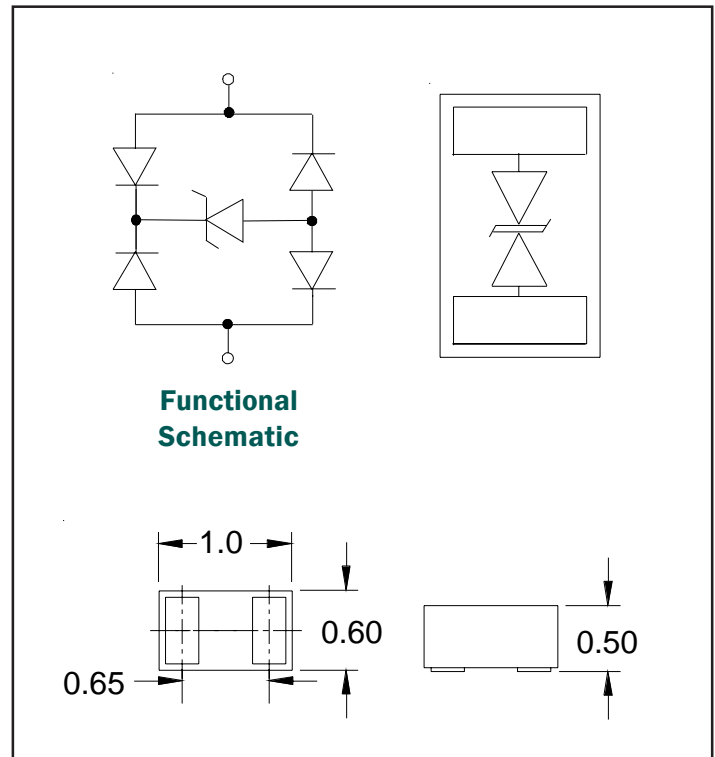


ESD Protection - Single and Dual Line

Side Keys, Bottom Connectors, Battery Lines

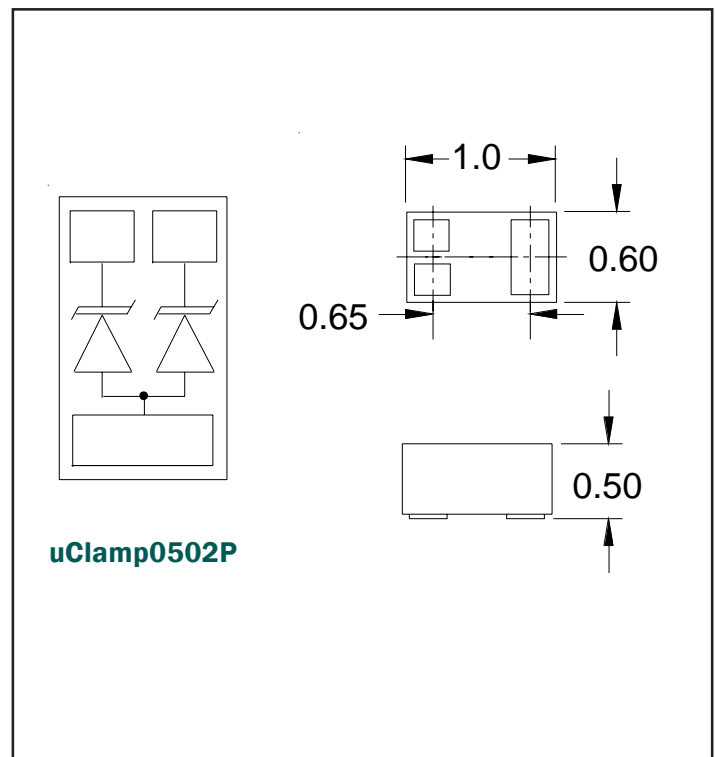
Low Capacitance Single Line Devices - RClamp0521P, RClamp0821P, RClamp1521P

These devices are intended for use in applications where extremely low capacitance is critical. Each device features a maximum capacitance of 0.5pF meaning they may be used on lines operating to 3 GHz. Each is in a small 2-pin, RoHS/WEEE compliant, SLP1006P2 package measuring 1.0 x 0.6 x 0.5mm. The leads are spaced at a pitch of 0.65mm and are finished with lead-free NiPdAu. The RClamp0521P may be used on circuits operating at 5 volts, the RClamp0821P is for use on 8 volt circuits, and the RClamp1521P may be used on 15 volt circuits.



5V Two - Line Device - uClamp0502P

The uClamp™ series of protection devices are designed to protect sensitive electronics from damage or latch-up due to ESD. This dual line device gives the designer the flexibility to protect two lines in a device the same size as a small single line device. It has a low operating voltage of 5 volts and a capacitance of less than 10pF making them suitable for digital interfaces where low loading capacitance is crucial. They are in a 3-pin, RoHS/WEEE compliant, SLP1006P3 package measuring 1.0 x 0.6 x 0.5mm. The leads are spaced at a pitch of 0.65mm and are finished with lead-free NiPdAu.



PROTECTION PRODUCTS



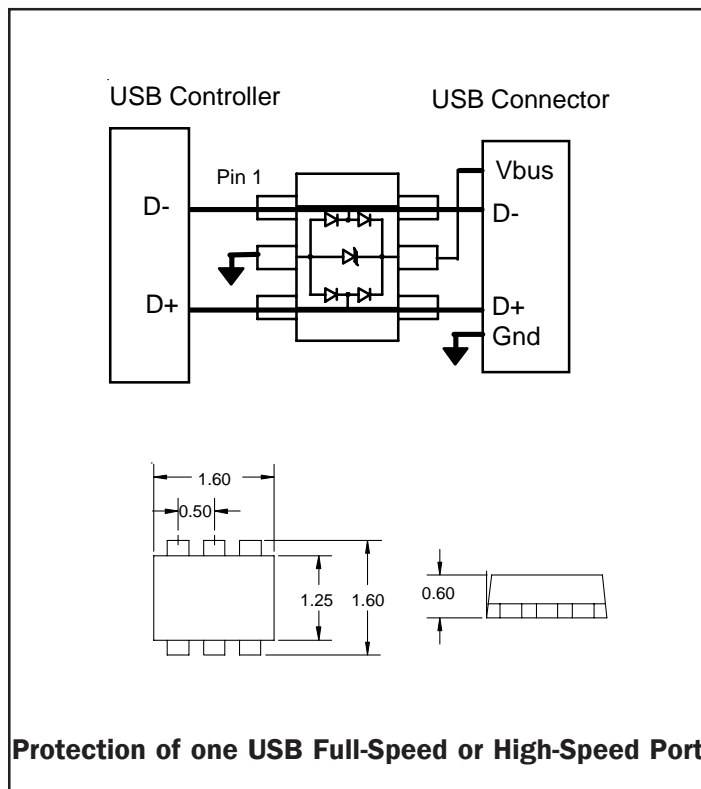
USB Interfaces

USB 1.1, USB 2.0, USB OTG

Single Port USB 2.0 - RClamp0502A

The RClamp0502A is designed to protect a single USB port. It features an ultra-low maximum capacitance of <math><1\text{pF}</math> meaning it can be used on ports operating at full-speed (12Mb/s) or high-speed (480Mb/s) without signal degradation. When the voltage on the data lines exceed the bus voltage, the internal rectifiers are forward biased conducting the transient current away from the protected controller chip. The TVS diode directs the surge to ground. The TVS diode also acts to suppress ESD strikes directly on the voltage bus. Thus, both power and data pins are protected with a single device.

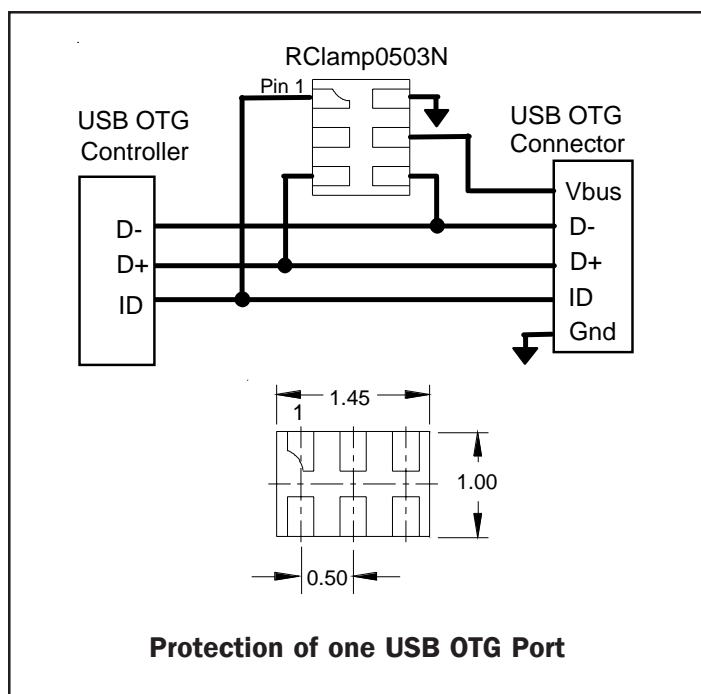
The RClamp0502A is in a 6-pin, RoHS/WEEE compliant, SC-89 (SOT-666) package. It measures 1.6 x 1.6 x 0.6mm. The leads are finished with lead-free matte tin. The flow through design simplifies PCB layout and improves ESD protection. This device may be used to meet the ESD immunity requirements of IEC 61000-4-2, Level 4 ($\pm 15\text{kV}$ air, $\pm 8\text{kV}$ contact discharge).



Single Port USB OTG - RClamp0503N

The RClamp0503N is designed to protect a single USB OTG port. It is designed to protect both data lines, the ID pin, and the external USB Vbus. It features an ultra-low maximum capacitance of 1pF meaning it can be used on ports operating at full-speed (12Mb/s) or high-speed (480mb/s) without signal degradation. The internal TVS of the RClamp0503N is designed with a stand-off voltage of 5.25V to allow for protection of the external Vbus connection.

The RClamp0503N is in a 6-pin, RoHS/WEEE compliant, SLP1510N6 package. It measures 1.45 x 1.0 x 0.58mm. These devices may be used to meet the ESD immunity requirements of IEC 61000-4-2, Level 4 ($\pm 15\text{kV}$ air, $\pm 8\text{kV}$ contact discharge).



PROTECTION PRODUCTS



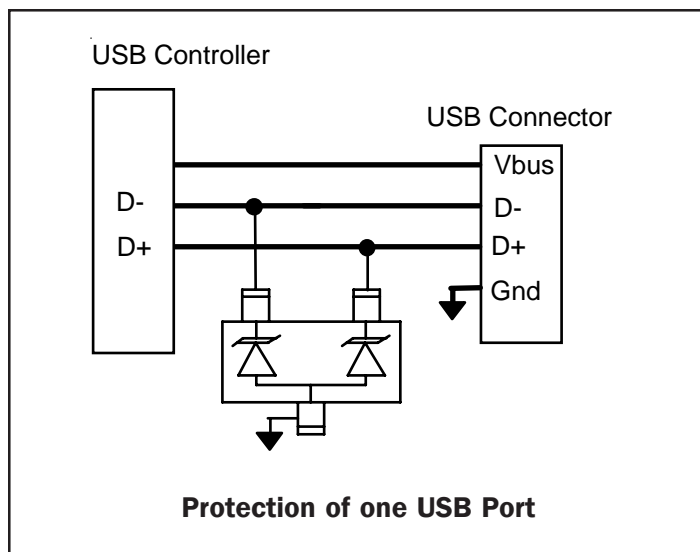
USB Interfaces

Interfaces that use USB 2.0 with Battery Charging

USB 2.0 Data Line Protection - RClamp0502B

The RClamp0502B is designed to protect a two USB data lines where VBus protection is not needed. It features an low maximum capacitance of 1.2pF meaning it can be used on ports operating at full-speed (12Mb/s) or high-speed (480Mb/s) without signal degradation.

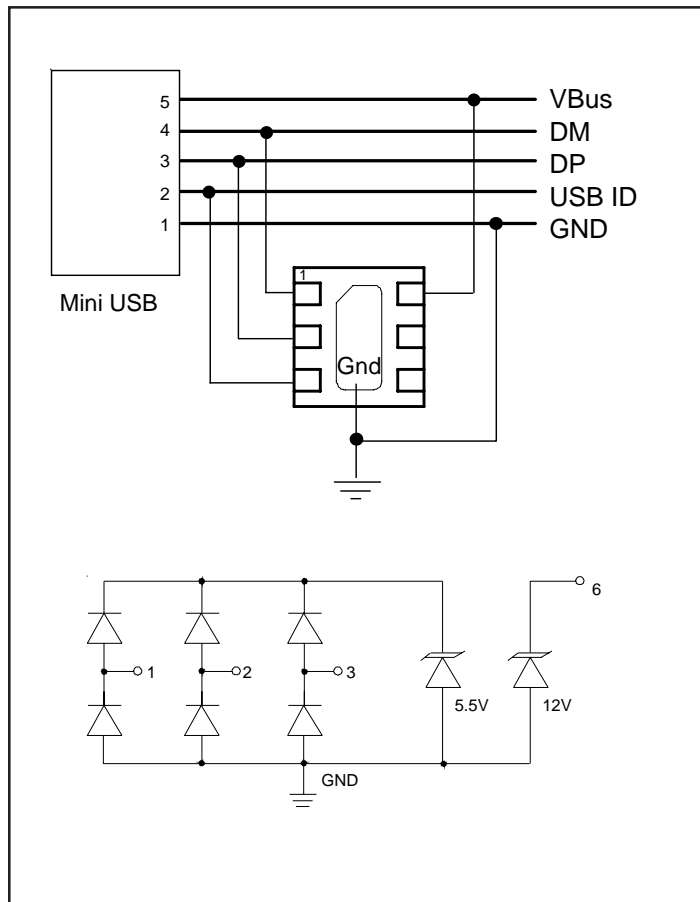
The RClamp0502B is in a 3-pin, RoHS/WEEE compliant, SC-75 package. It measures 1.6 x 1.6 x 0.75mm. These devices may be used to meet the ESD immunity requirements of IEC 61000-4-2, Level 4 ($\pm 15\text{kV}$ air, $\pm 8\text{kV}$ contact discharge).



Single Port USB 2.0 - RClamp1654P

The RClamp1654P is optimized for use on systems that utilize the USB interface for battery charging. Low capacitance protection is provided for the USB data (DM, DP) and USB ID pins. The maximum capacitance on these lines is $<1\text{pF}$ for maximum signal integrity. All three lines are referenced to an internal 5 volt TVS device. A separate 12 volt TVS device is used for protection of the VBus voltage bus. This allows battery charging without signal clipping. Leakage current of the VBus protection is $<50\text{nA}$ when operating at 12 volts.

The RClamp1654P is in a 6-pin, RoHS compliant, SLP1616P6 package. It measures 1.6 x 1.6 x 0.58mm. The leads are spaced at a pitch of 0.5mm and are finished with lead-free NiPdAu. They may be used to meet the ESD immunity requirements of IEC 61000-4-2, Level 4 (15kV air, 8kV contact discharge).



Available Q2, CY07

PROTECTION PRODUCTS



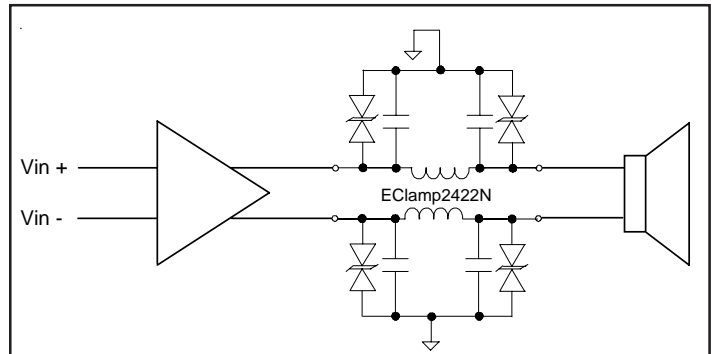
Audio Ports - RC & LC Filter

Microphone, Speakers

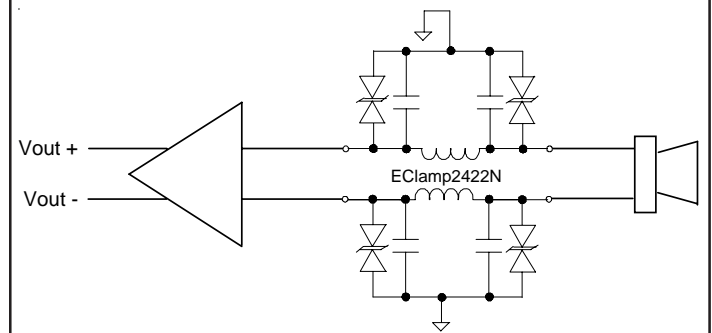
Audio Port Protection - EClamp2422N

The EClamp™2422N is a low pass filter array consisting of two identical circuits comprised of TVS diodes for ESD protection, and a C-L-C pi-filter for EMI/RFI filtering. A typical inductor value of 2nH and a capacitor value of 100pF are used to achieve 20dB minimum attenuation from 800MHz to 2.7GHz. It has a very low series resistance of 2 Ohms, making it ideal for use on headset audio interfaces. The TVS diodes provide effective suppression of ESD voltages in excess of ±15kV (air discharge) and ±8kV (contact discharge) per IEC 61000-4-2, level 4.

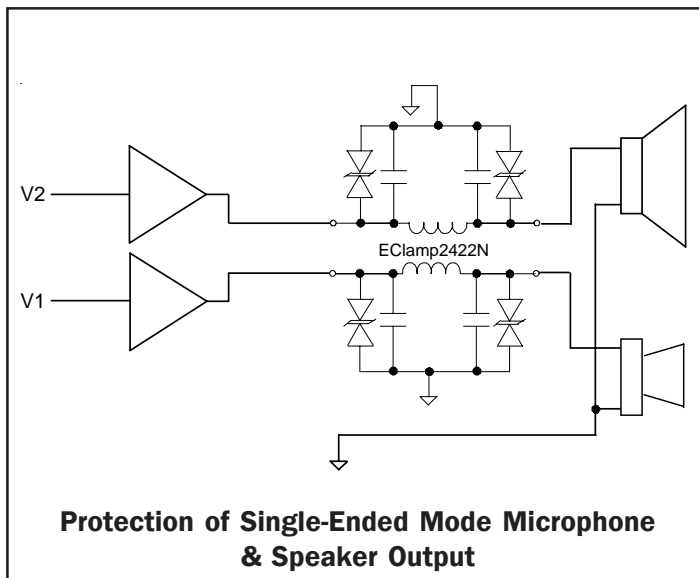
The EClamp2422N is in a 6-pin, RoHS/WEEE compliant, SLP1510N6 package. It measures 1.45 x 1.0 x 0.58mm. The leads are spaced at a pitch of 0.5mm and are finished with lead-free NiPdAu.



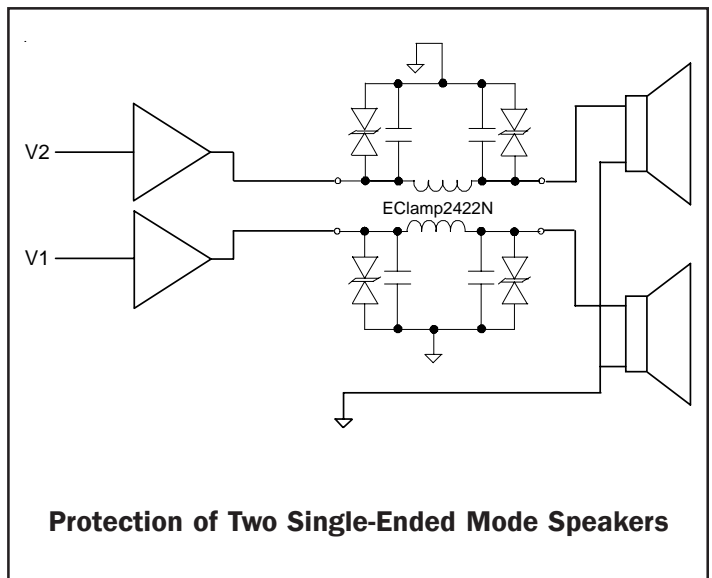
Differential Mode Protection with Speaker Output



Differential Mode Protection with Microphone Input



Protection of Single-Ended Mode Microphone & Speaker Output



Protection of Two Single-Ended Mode Speakers

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