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ESD & EMI Protection Solutions

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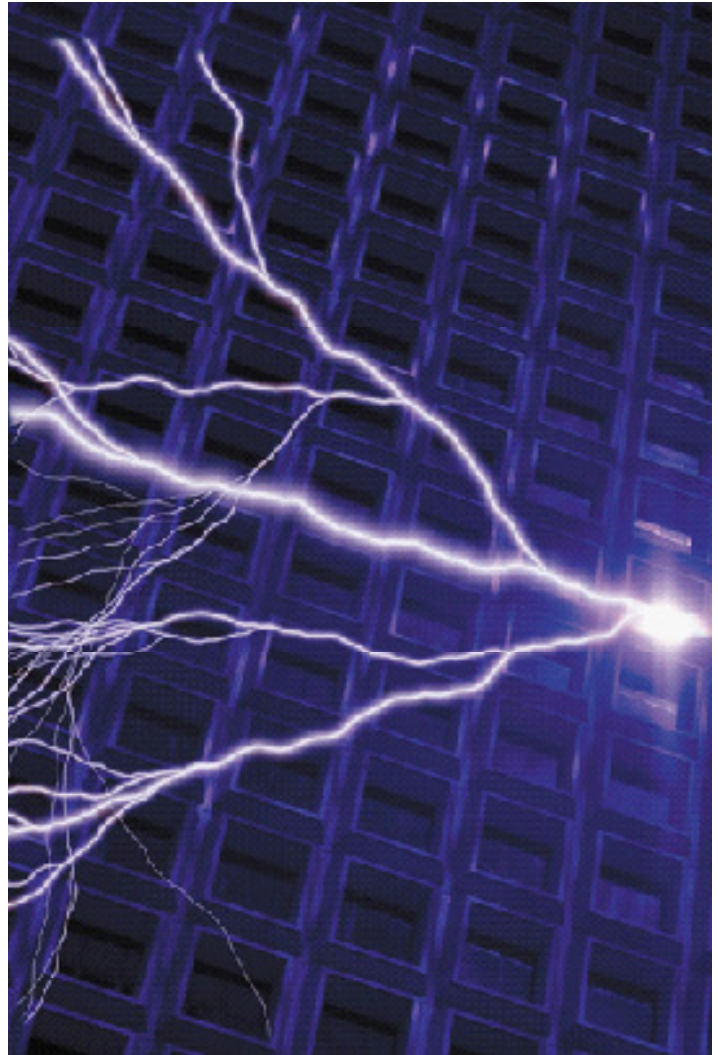


Introduction

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.





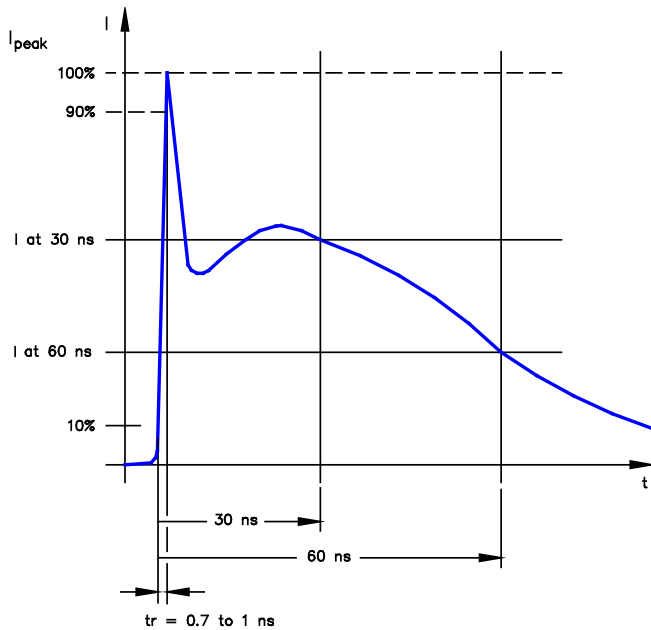
Introduction

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



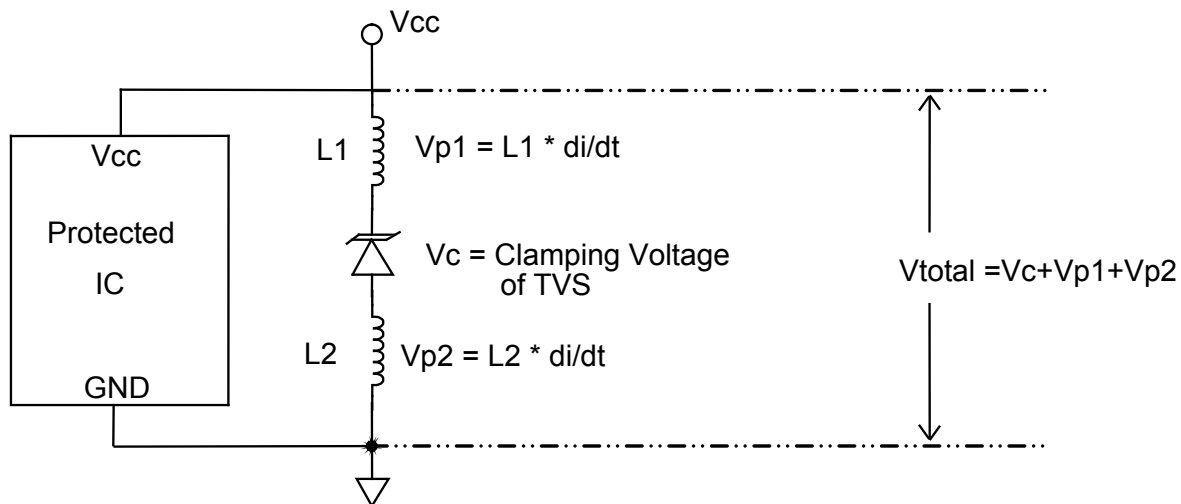
Introduction

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

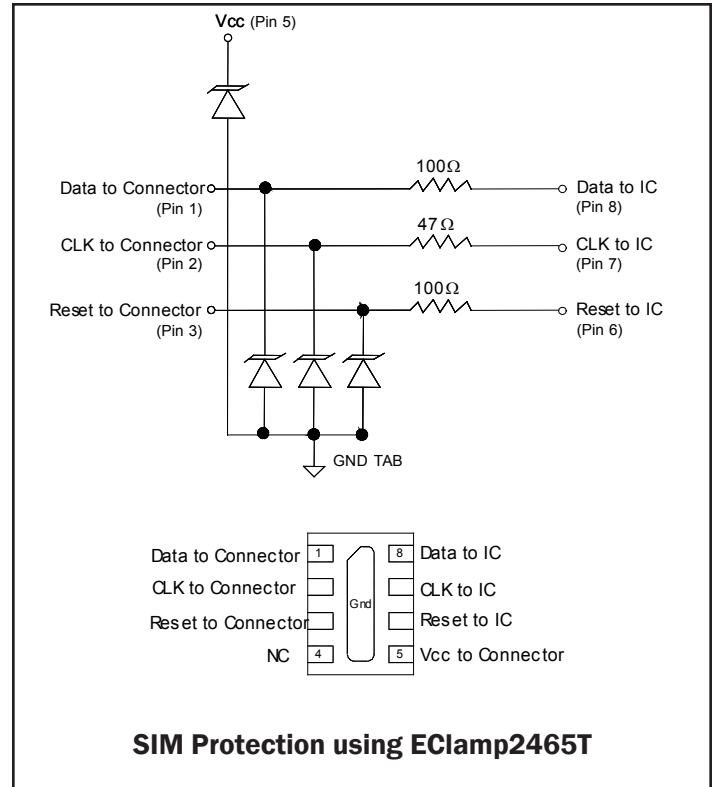


External Memory Interfaces

SIM Ports, microSD (SD or SPI Mode)

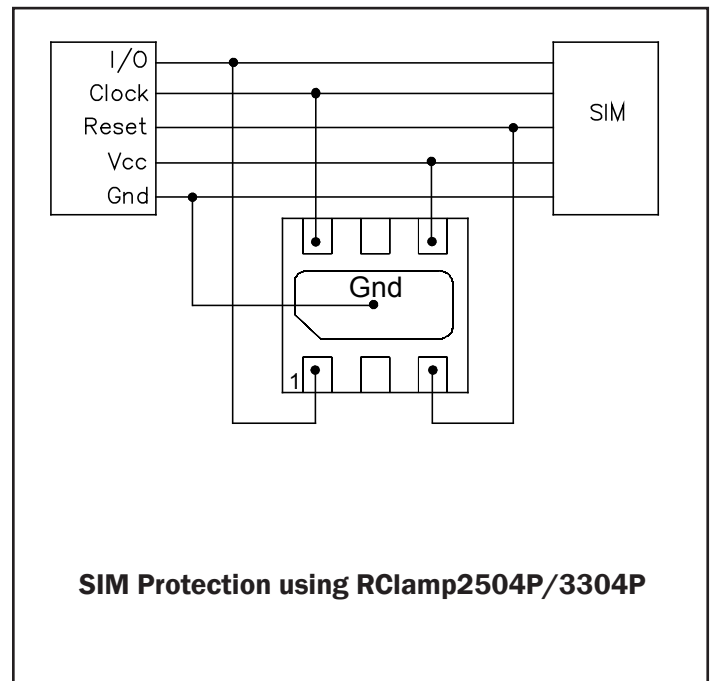
SIM Interface - EClamp® 2465T ESD Protection + Filtering

EClamp2465T 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 Reset 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. An additional TVS diode connection is included for protection of the voltage (Vcc) bus. The EClamp2465T is in a 8-pin, RoHS/WEEE compliant, SLP1713P8T package. It measures 1.7 x 1.3 mm with a nominal height of only 0.4mm. The leads are spaced at a pitch of 0.4mm and are finished with lead-free NiPdAu. The small package makes it ideal for use in portable electronics such as cell phones and digital still cameras. These packages are designed to replace flip chip solutions in the same application. The EClamp2455P/K are also available for SIM Interface Protection.



SIM Interface - Low Capacitance RClamp® 2504P & RClamp® 3304P

In applications where lower capacitance is needed, the RClamp series are ideal choices. A RailClamp protection device utilizes surge-rated steering diodes to compensate and lower the overall capacitance seen by the circuit. The RClamp2504P provides four lines of protection including the Vcc line with an operating voltages of 2.5V and the RClamp3304P is protecting lines with operating voltage of 3.3V. The RClamp2504P/3304P presents a maximum capacitance of 3pF 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 RClamp2504P/3304P are in a 1.6 x 1.6 x 0.6mm RoHS compliant leadless package (SLP1616P6). RClamp0504P is also available in the same footprint for 5V circuits.



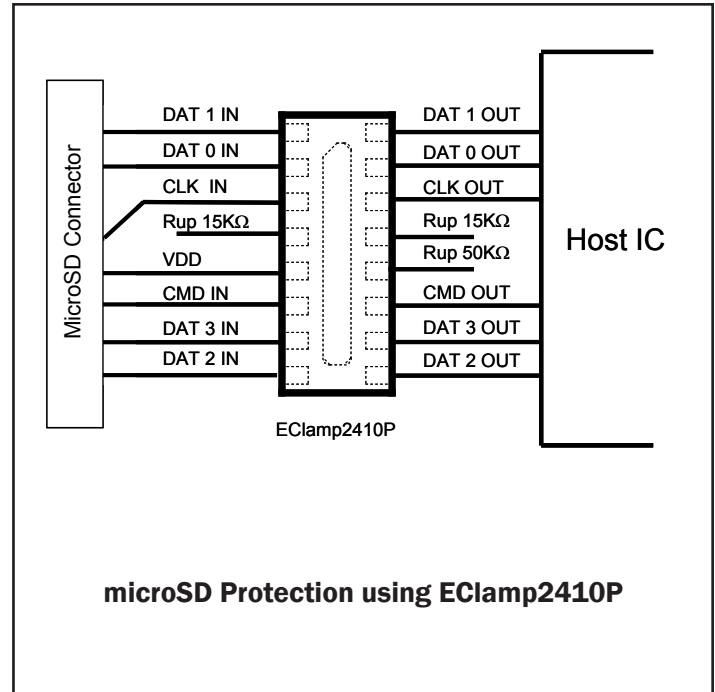


External Memory Interfaces

SIM Ports, microSD (SD or SPI Mode)

microSD Interface - EClamp[®] 2410P ESD Protection + Filtering

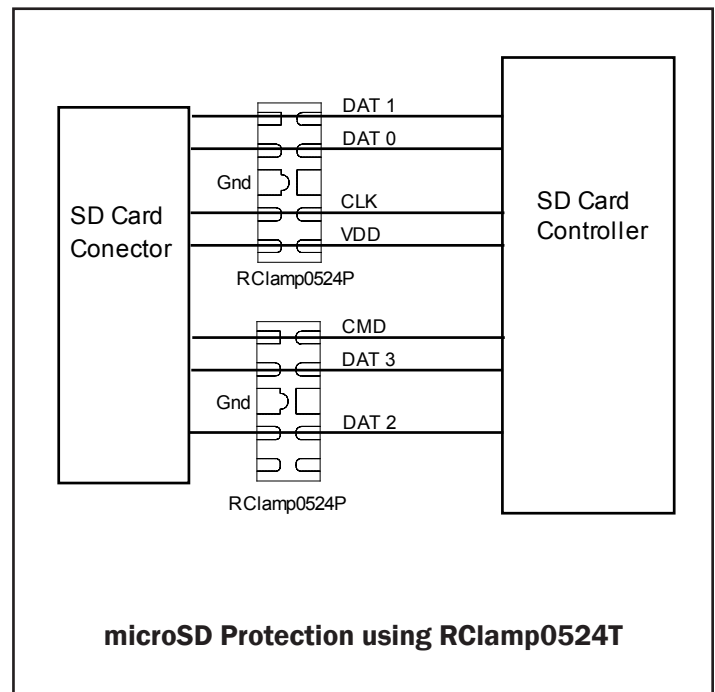
The EClamp2410P consists of six circuits that include series impedance matching resistors and pull up resistors as required by the SD specification. TVS diodes are included on each line for ESD protection. An additional TVS diode connection is included for protection of the voltage (Vdd) bus. Termination 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 Profile, Low Capacitance RClamp[®] 0524T

The RClamp0524T is an ultra-low capacitance ESD protection device that may be used on microSD interfaces that use external resistors. It has a typical capacitance of only 0.30pF between I/O pins and 0.80pF 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 RClamp0524T is in a 10-pin, RoHS/WEEE compliant, SLP2510P8T package. It measures 2.5 x 1.0 x 0.40mm. 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.

Also available for microSD protection is the RClamp0524P which is in a 10-pin, RoHS/WEEE compliant, SLP2510P8 package. It measures 2.5 x 1.0 x 0.58mm.





LCD Display - Serial & Parallel Interface

R-C Filters

Parallel Interface - EClamp® 237xK RC Filter + ESD Protection

The EClamp237xK 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 (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 EClamp2374K measures 1.7 x 1.3 x 0.5 mm.

The EClamp2376K measures 2.5 x 1.3 x 0.5 mm.

The EClamp2378K measures 3.3 x 1.3 x 0.5 mm.

Also, available is the EClamo237xP family in a slightly larger package size but offering similar performance characteristics of the EClamp237xK parts.

Parallel Interface - EClamp® 238xK RC Filter + ESD Protection

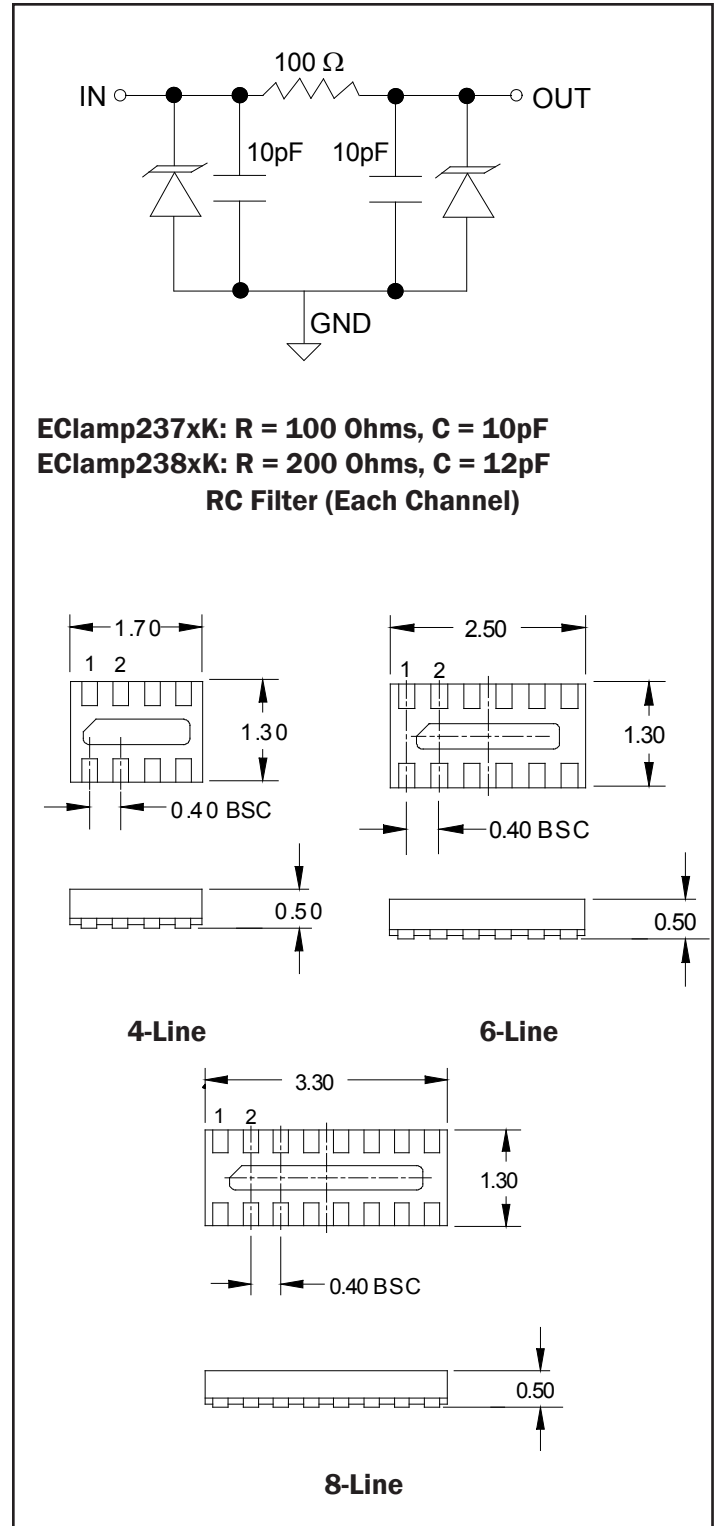
The EClamp238xK series is a RC filter consisting of TVS diodes for ESD protection, and a resistor - capacitor network for EMI/RFI filtering. A series resistor value of 200Ω and a capacitance value of 12pF are used to achieve 30dB minimum attenuation from 800MHz to 2.7GHz. The TVS diodes provide effective 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.

Also, available is the EClamo238xP family in a slightly larger package size but offering similar performance characteristics of the EClamp238xK parts.





LCD Display - Serial & Parallel Interface

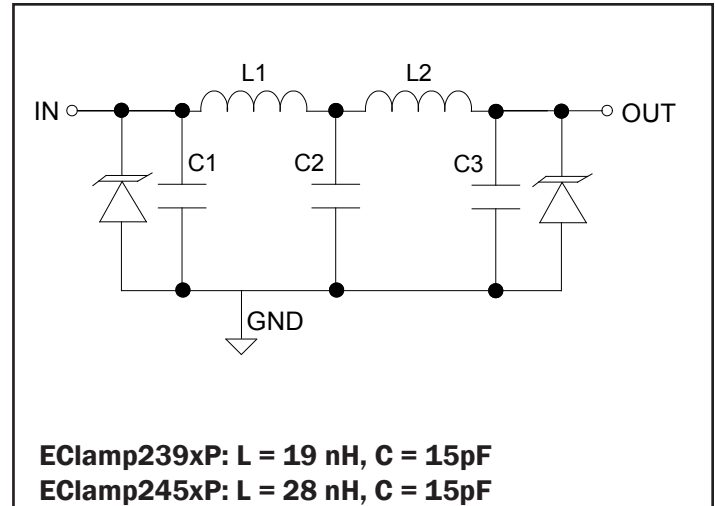
5-Pole L-C Filters

Parallel Interface - EClamp® 239xP LC Filter + ESD Protection

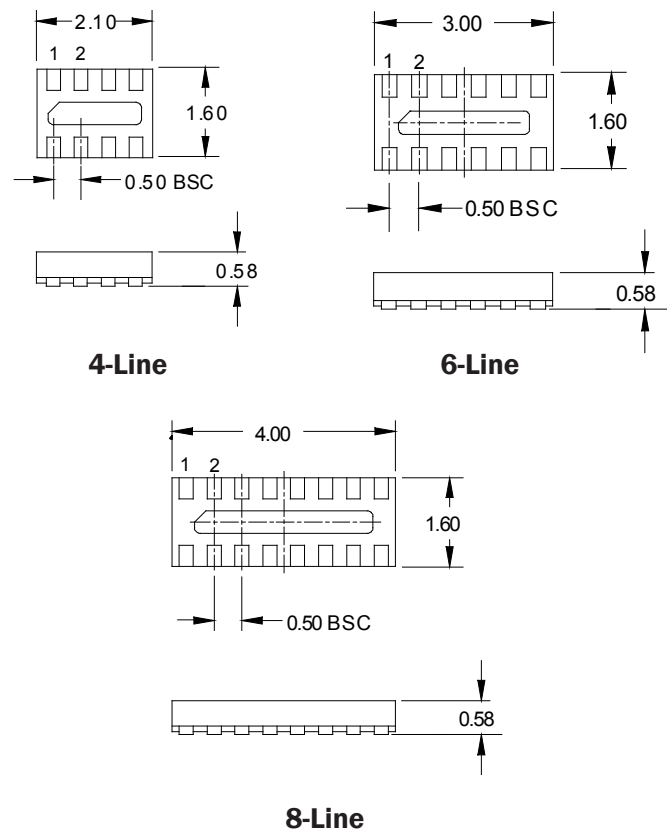
The EClamp239xP series is a LC filter consisting of TVS diodes for ESD protection, and a 5-pole inductor - capacitor network for EMI/RFI filtering. A typical inductor value of 19nH and a capacitor value of 15pF are used to achieve 30dB minimum attenuation from 800MHz to 2.7GHz. The TVS diodes provide effective suppression of ESD voltages in excess of ± 15 kV (air discharge) and ± 8 kV (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 - EClamp® 245xP LC 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 ± 15 kV (air discharge) and ± 8 kV (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.



5-Pole LC Filter (Each Channel)





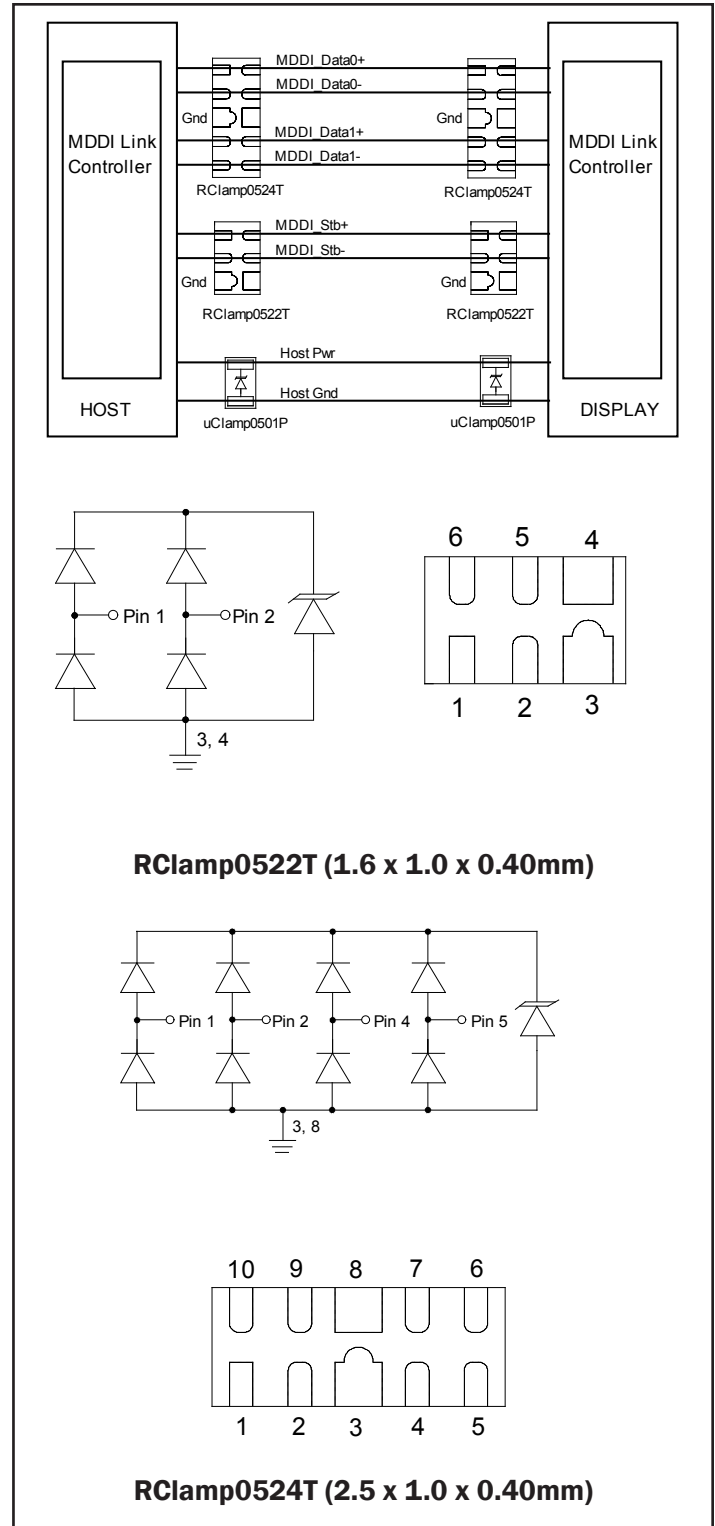
LCD Display - Serial & Parallel Interface

Low Capacitance MDDI/MIPI Port protection

MDDI Interface - Low Profile, Low Capacitance RClamp® 0522T and RClamp® 0524T

The RClamp0522T and RClamp0524T 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 0.30pF between I/O pins and 0.80pF 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 ($\pm 15\text{kV}$ air, $\pm 8\text{kV}$ contact discharge). The RClamp0522T is designed to protect two lines, while the RClamp0524T will protect four lines. The RClamp0522T is in a 6-pin, RoHS/WEEE compliant, SLP1610P4T package. It measures 1.6 x 1.0 x 0.40mm. The RClamp0524T is in a 10-pin, RoHS/WEEE compliant, SLP2510P8T package. It measures 2.5 x 1.0 x 0.40mm. 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.



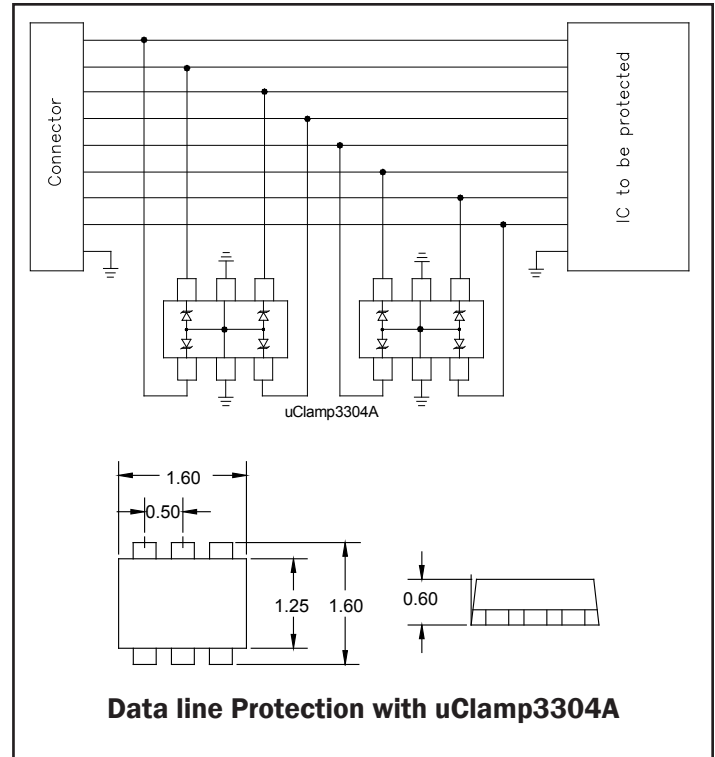


General Purpose ESD - 3.3V Multi-Line Arrays

Car Kit Connectors, Keypads, Data Ports

3.3V Leaded Package - uClamp® 3304A

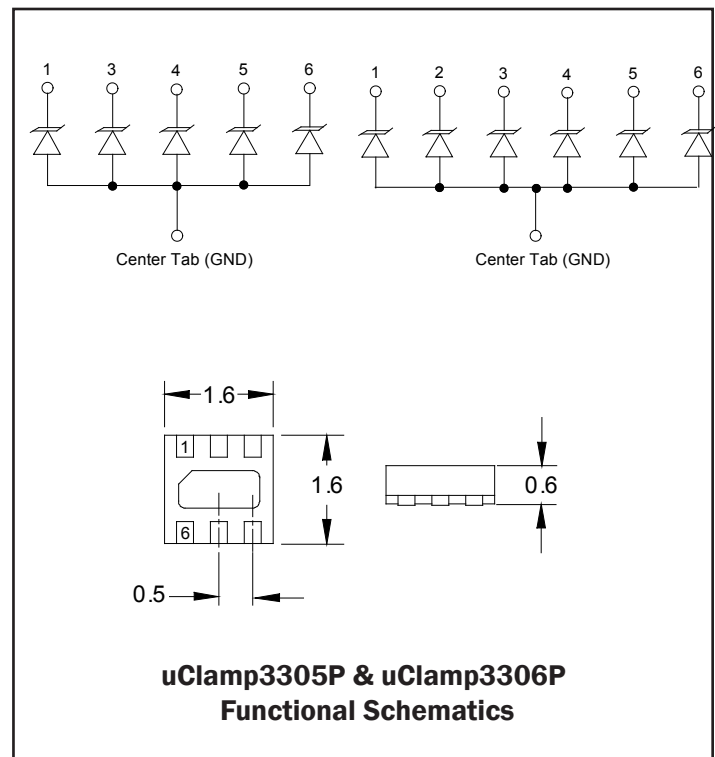
The uClamp3304A is a 4-line TVS array constructed using Semtech's proprietary EPD process technology. The EPD process provides low standoff voltages with significant reductions in leakage currents and capacitance over silicon-avalanche diode processes. They feature a true operating voltage of 3.3 volts 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 - uClamp® 3305P and uClamp® 3306P

The uClamp3305P and the uClamp3306P 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.



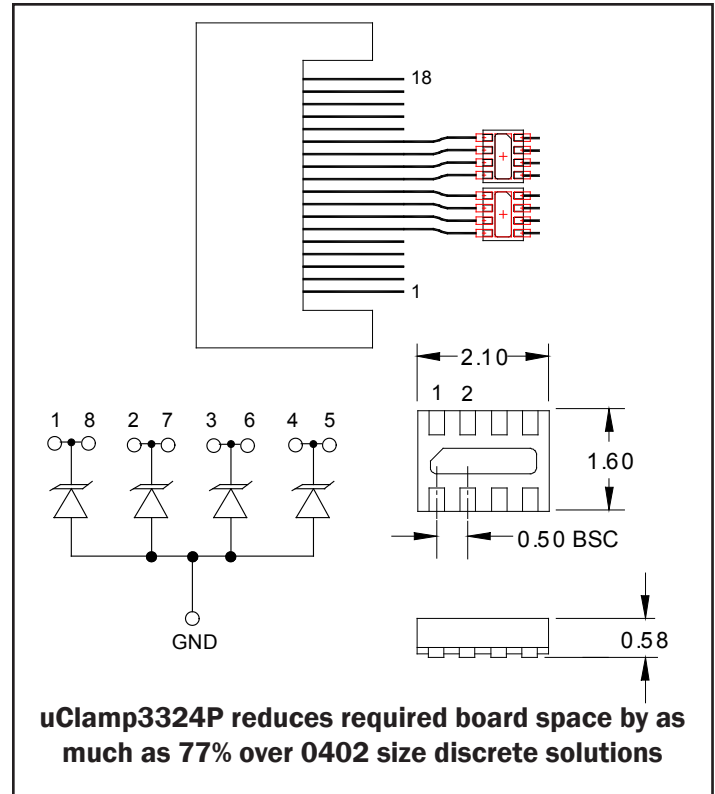


Flow Through ESD Protection Arrays

Car Kit Connectors, Keypads, Data Ports

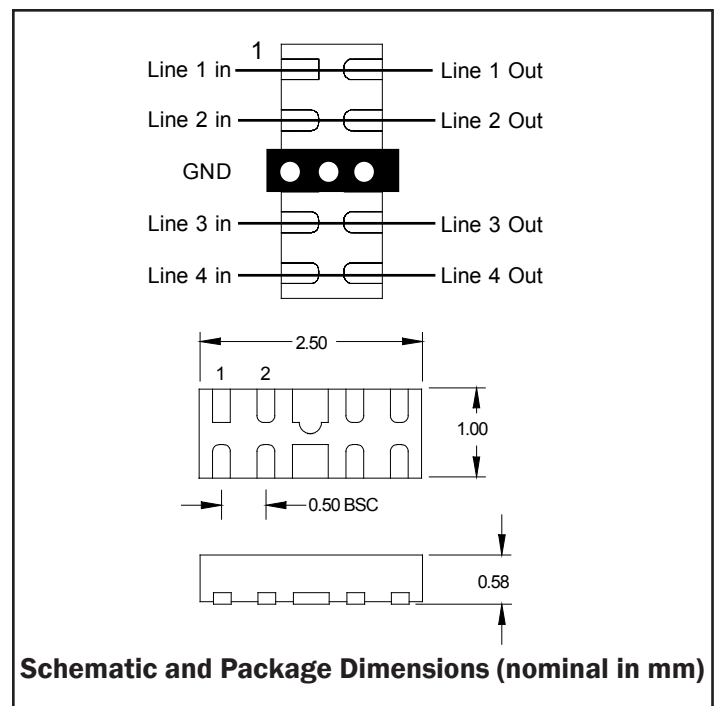
3.3V Flow-Thru Design - uClamp® 3324P

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 μ Clamp3324P may be used to meet the immunity requirements of IEC 61000-4-2, level 4 (± 15 kV air, ± 8 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 μ Clamp3324P 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.



5.0V Flow-Thru Design - uClamp® 0544P

The uClamp0544P is a 5.0 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 uClamp0544P may be used to meet the immunity requirements of IEC 61000-4-2, level 4 (± 15 kV air, ± 8 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 uClamp0544P is in an 10-pin, RoHs compliant, SLP2510P8 package measuring 2.1 x 1.0 x 0.58mm. The leads are spaced at a pitch of 0.5mm.



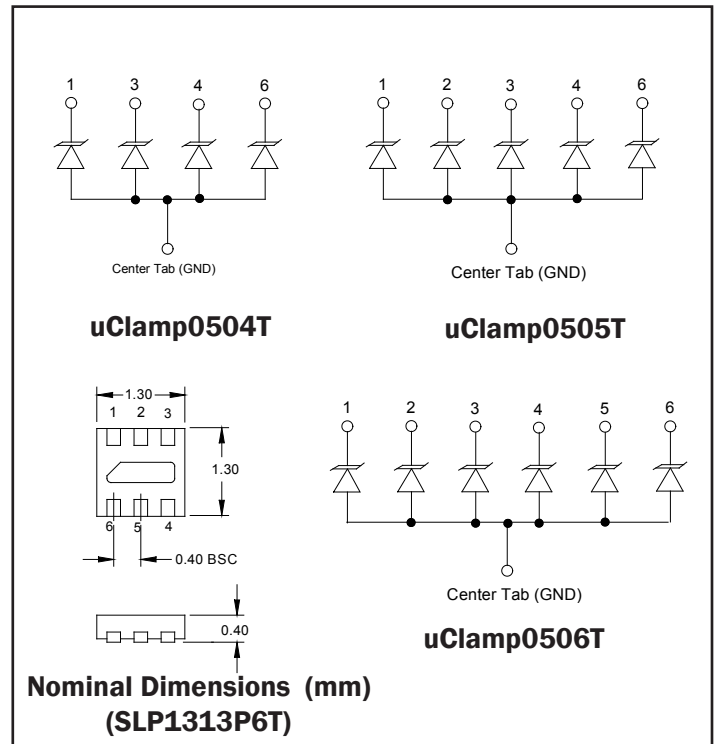


General Purpose ESD - 5V Multi-Line Arrays

Car Kit Connectors, Keypads, Data Ports

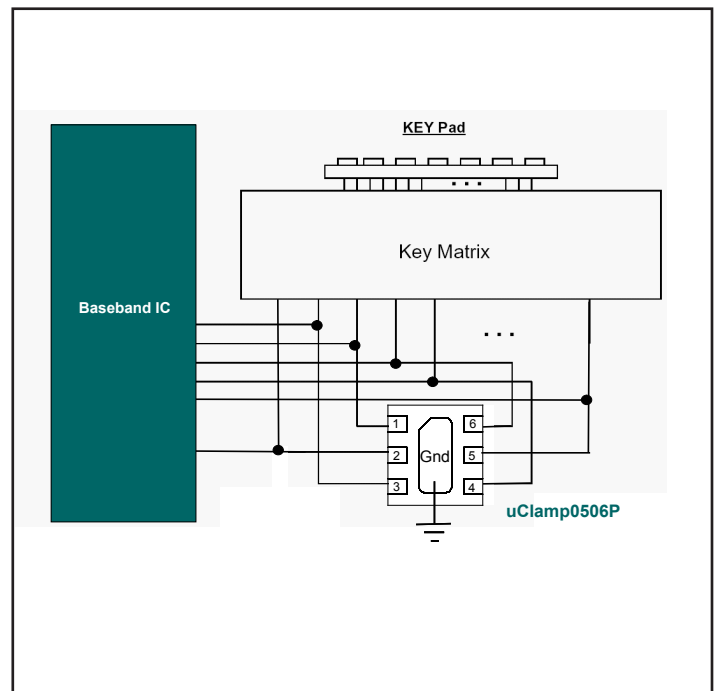
5V Protection - uClamp® 0504T, uClamp® 0505T, uClamp® 0506T - 10pF Capacitance

The uClamp0504T, uClamp0505T, and uClamp0506T are designed to protect sensitive electronics from damage or latch-up due to ESD. This multi-line protection family protects 4, 5, or 6 lines constructed using Semtech's proprietary process technology for maximum protection of today's digital circuits. These devices are in a 6-pin, RoHS/WEEE compliant, SLP1313P6T package. It measures 1.3 x 1.3 mm with a nominal height of only 0.4mm. The leads are spaced at a pitch of 0.4mm and are finished with lead-free NiPdAu. Applications include keypads, carkit connectors, audio ports, and side keys.



5V Leadless Packages - uClamp® 0506P

The uClamp0506P is designed to protect sensitive electronics from damage or latch-up due to ESD. 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. This device is in a SLP1616P6, RoHS compliant leadless package measuring 1.6 x 1.6 x 0.6mm. Applications include keypads, carkit connectors, and audio ports.



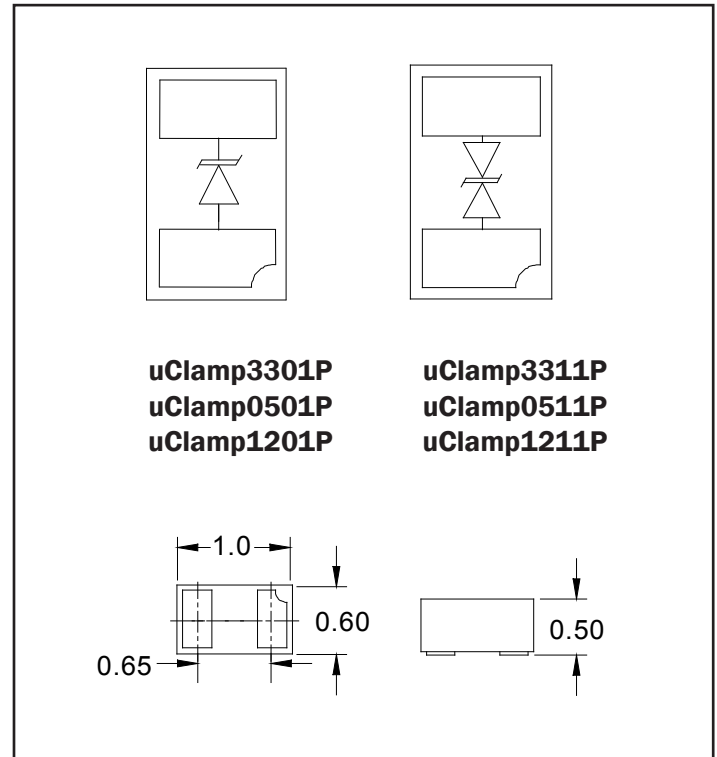


ESD Protection - Single and Dual Line

Side Keys, Bottom Connectors, Battery Lines

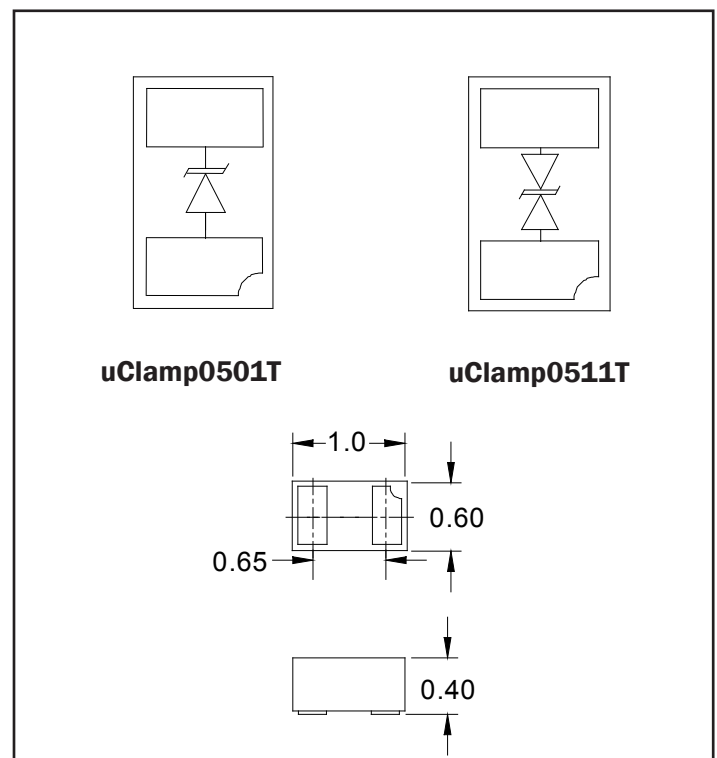
3.3V, 5V, 12V Single Line Devices - uClamp® 3301P, uClamp® 3311P, uClamp® 0501P, uClamp® 0511P, uClamp® 1201P, uClamp® 1211P

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.



5V Single Line Devices - uClamp® 0501T and uClamp® 0511T

The uClamp0501T and uClamp0511T are in a 2-pin, RoHS/WEEE compliant, SLP1006P2T package. It measures 1.0 x 0.6 mm with a nominal height of only 0.4mm. The leads are spaced at a pitch of 0.65mm and are finished with lead-free NiPdAu. Each device will protect one line operating at 5 volts with a maximum capacitance of 10pF. It gives the designer the flexibility to protect single lines in applications where arrays are not practical. They 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). The combination of small size and high ESD surge capability makes them ideal for use in portable applications such as cellular phones, digital cameras, and MP3 players.





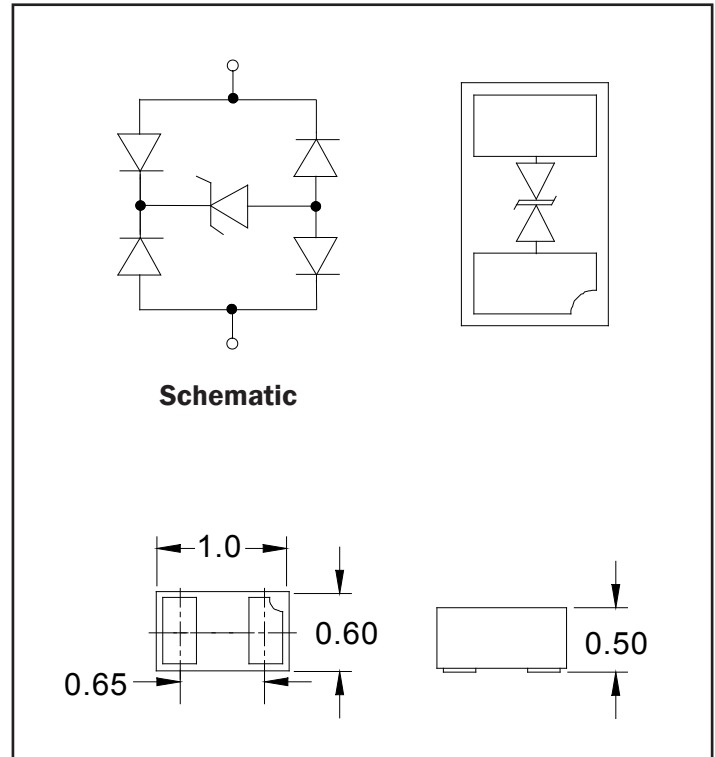
ESD Protection - Single and Dual Line

Side Keys, Bottom Connectors, Battery Lines

Low Capacitance Single Line Devices - RClamp® 0521P, RClamp® 0821P, RClamp® 1521P

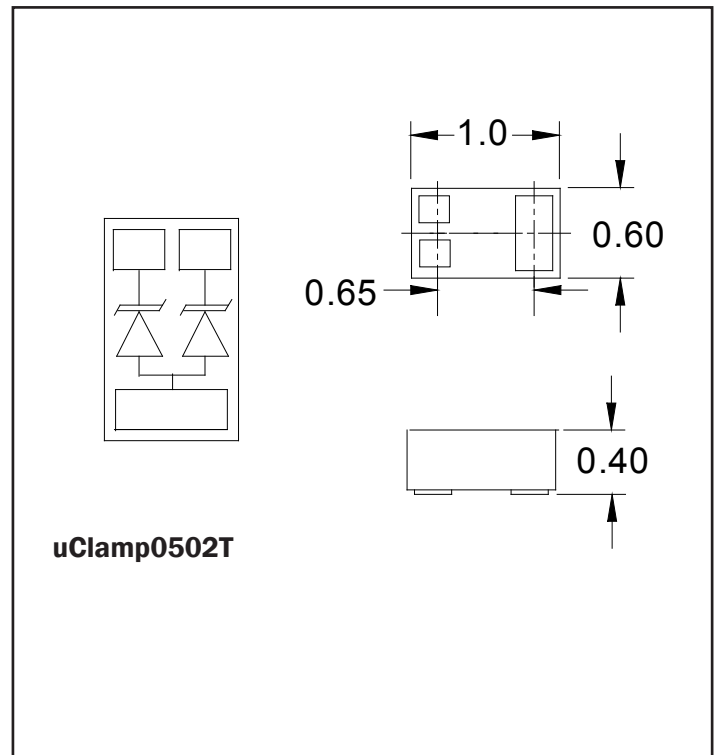
These devices are intended for use in applications where extremely low capacitance is critical. Each device features a maximum capacitance of 0.5pF meaning they may be used on lines operating to 3 GHz.

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 - uClamp® 0502T

The uClamp0502T is in a 3-pin, RoHS/WEEE compliant, SLP1006P3T package. It measures 1.0 x 0.6 mm with a nominal height of only 0.4mm. The leads are spaced at a pitch of 0.65mm and are finished with lead-free NiPdAu. Each device will protect two lines operating at 5 volts with a capacitance less than 10pF. It gives the designer the flexibility to protect single lines in applications where arrays are not practical. They 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). The combination of small size and high ESD surge capability makes them ideal for use in portable applications such as cellular phones, digital cameras, and MP3 players.





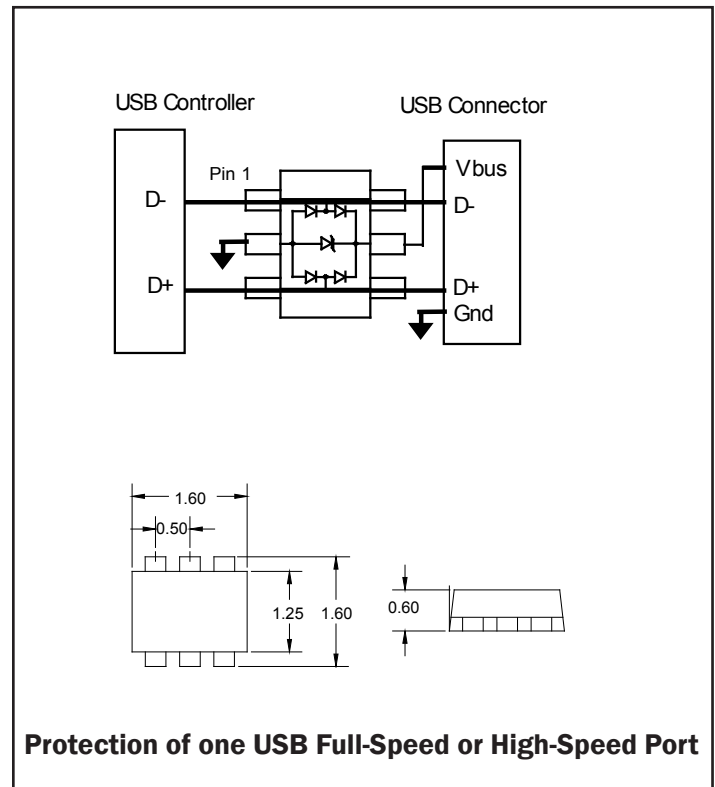
USB Interfaces

USB 1.1, USB 2.0, USB OTG

Single Port USB 2.0 - RClamp® 0502A

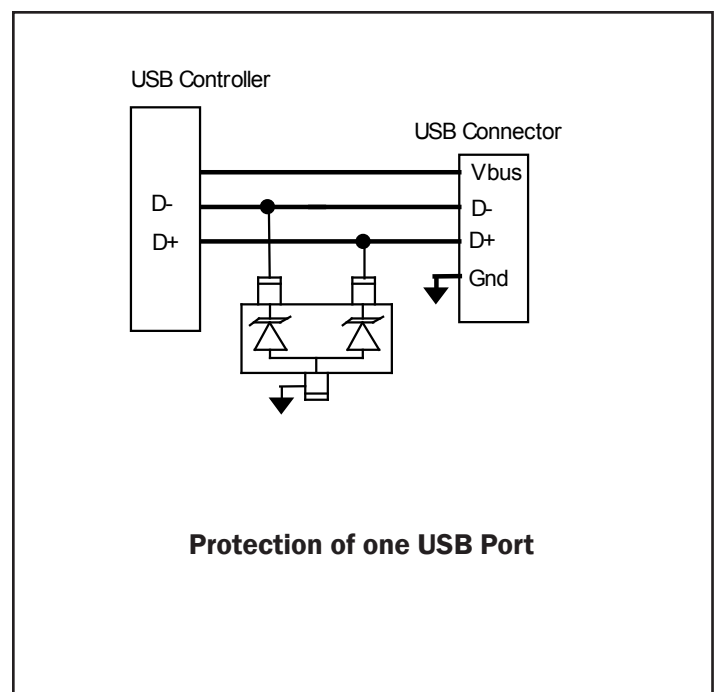
The RClamp0502A is designed to protect a single USB port. It features an ultra-low maximum capacitance of <math><1\text{pF}</math> meaning it can be used on ports operating at full-speed (12Mb/s) or high-speed (480Mb/s) without signal degradation. When the voltage on the data lines exceed the bus voltage, 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).



USB 2.0 Data Line Protection - RClamp® 0502B

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).





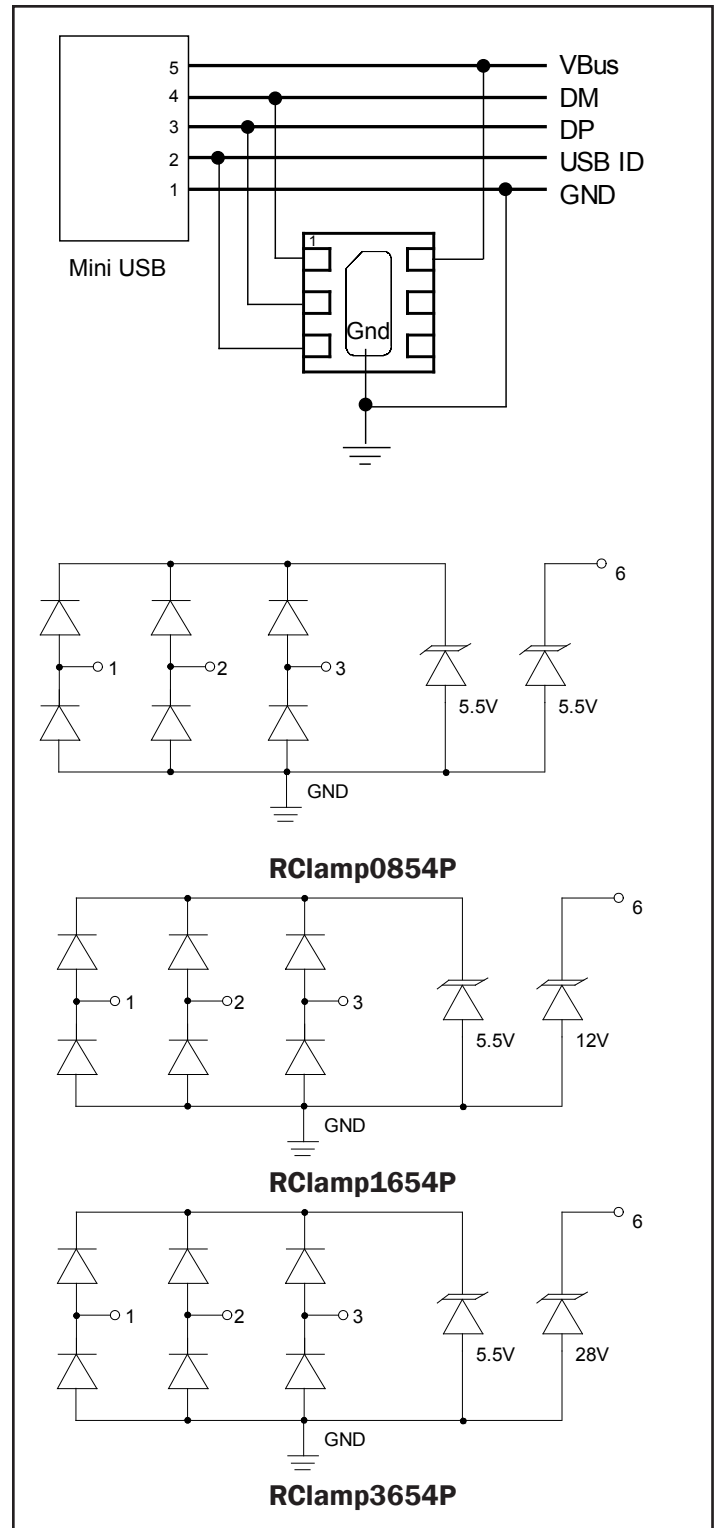
USB Interfaces

Interfaces that use USB 2.0 with Battery Charging

Single Port USB 2.0 - RClamp® XX54P Family

The RClampXX54P 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 <math><1\text{pF}</math> for maximum signal integrity. All three lines are referenced to an internal 5 volt TVS device. A separate TVS device is used for protection of the USB voltage bus. This allows battery charging without signal clipping. Depending on the Vbus voltage requirements Semtech offer three different devices. The RClamp0854P protects the Vbus to 5.5V, the RClamp1654P protects the Vbus to 12V, and the RClamp3654P protects the Vbus to 28V.

The RClampXX54P 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).





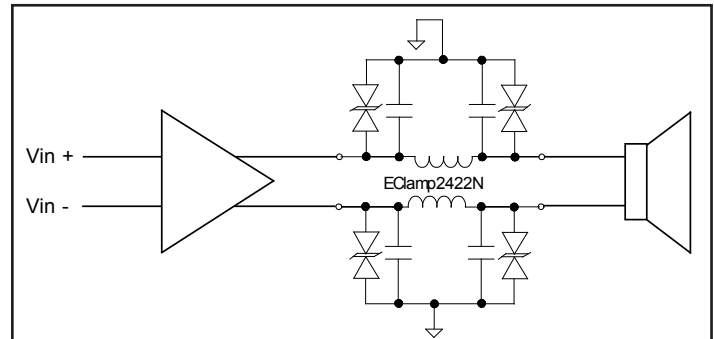
Audio Ports - RC & LC Filter Microphone, Speakers

Audio Port Protection - EClamp® 2422N

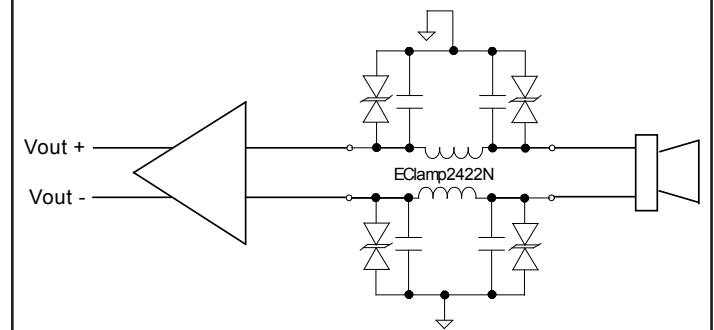
The EClamp2422N is a low pass filter array consisting of two identical circuits comprised of TVS diodes for ESD protection, and a C-L-C pi-filter for EMI/RFI filtering. A typical inductor value of 2nH and a capacitor value of 100pF are used to achieve 20dB minimum attenuation from 800MHz to 2.7GHz. It 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 $\pm 15\text{kV}$ (air discharge) and $\pm 8\text{kV}$ (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.

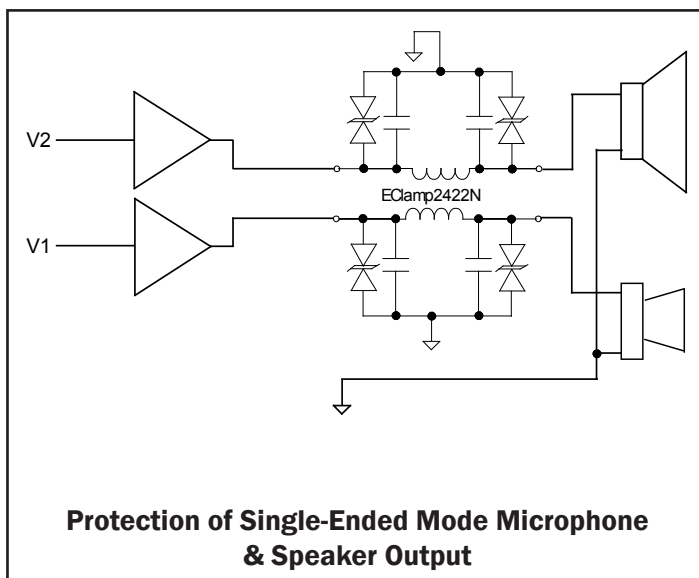
Semtech also offers the uClamp0511T for Audio Port Protection. See page 15 for additional details on this part.



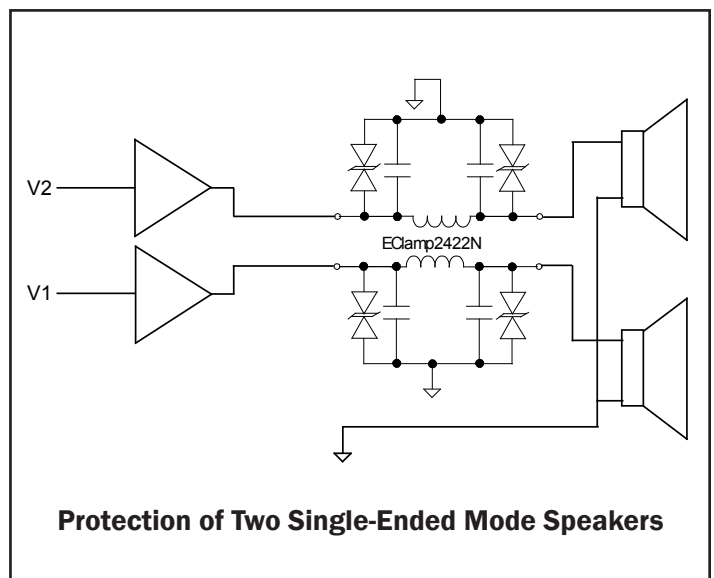
Differential Mode Protection with Speaker Output



Differential Mode Protection with Microphone Input



**Protection of Single-Ended Mode Microphone
& Speaker Output**



Protection of Two Single-Ended Mode Speakers

Part Selection Matrix

USB 1.1, 2.0, and OTG Protection

Semtech Part Number	VRWM (V)	# Lines	C (pF) max, L-G VR=0V	Pkg Size (mm)	Comment
RClamp0502B	5	2	1.2	1.6 x 1.6 x 0.6	No insertion loss to > 3GHz
RClamp0502N	5	3	0.5	1.2 x 1.0 x 0.6	Low Capacitance
RClamp0502A	5	3	0.9	1.6 x 1.6 x 0.6	Flow through package
RClamp0503N	5	4	0.5	1.45 x 1.0 x 0.6	Protects 3 I/O lines and 1 power line
RClamp0504F	5	5	3	2.0 x 2.1 x 0.9	Protects 4 I/O lines and 1 power line
RClamp0504N	5	4	3	2.0 x 2.0 x 0.6	Small package, 4 line protection
RClamp0504P	5	4	3	1.6 x 1.6 x 0.6	Low capacitance for high speed interfaces
RClamp0854P RClamp1654P RClamp3654P	5, 5 5, 12 5, 28	4	0.8	1.6 x 1.6 x 0.6	5Volt Vbus TVS protection 12Volt Vbus TVS protection 28Volt Vbus TVS protection

EMI Filter Devices for LCD and Camera Protection

Semtech Part Number	# Lines	Lead pitch (mm)	R (Ω) / L (nH)	C (pF)	Filter Performance	Pkg Size (mm)
EClamp2374P EClamp2376P EClamp2378P	4 6 8	0.5	100 Ohm	10	30dB from 1.8GHz to 2.5GHz	2.1 x 1.6 x 0.6 3.0 x 1.6 x 0.6 4.0 x 1.6 x 0.6
EClamp2394P EClamp2396P EClamp2398P	4 6 8	0.5	19 nH	15	30dB from 800MHz to 2.7GHz	2.1 x 1.6 x 0.6 3.0 x 1.6 x 0.6 4.0 x 1.6 x 0.6
EClamp2374K EClamp2376K EClamp2378K	4 6 8	0.4	100 Ohm	10	30dB from 1.8GHz to 2.5GHz	1.7 x 1.3 x 0.5 2.5 x 1.3 x 0.5 3.3 x 1.3 x 0.5
EClamp2384P EClamp2386P EClamp2388P	4 6 8	0.5	200 Ohm	12	30dB from 800MHz to 2.7GHz	2.1 x 1.6 x 0.6 3.0 x 1.6 x 0.6 4.0 x 1.6 x 0.6
EClamp2504K EClamp2506K EClamp2508K	4 6 8	0.4	17 nH	12	20dB from 800MHz to 2.7GHz	1.7 x 1.3 x 0.5 2.5 x 1.3 x 0.5 3.3 x 1.3 x 0.5
EClamp2384K EClamp2386K EClamp2388K	4 6 8	0.4	200 Ohm	12	30dB from 800MHz to 2.7GHz	1.7 x 1.3 x 0.5 2.5 x 1.3 x 0.5 3.3 x 1.3 x 0.5
EClamp2455P EClamp2456P EClamp2458P	4 6 8	0.5	28 nH	15	40dB from 800MHz to 2.7GHz	2.1 x 1.6 x 0.6 3.0 x 1.6 x 0.6 4.0 x 1.6 x 0.6

Audio Protection

Semtech Part Number	VRWM (V)	# Lines	C (pF), VR=0V	L (nH), typ	R (Ω), typ	Pkg Size (mm)
EClamp2422N	5	2	100	2	1.4	1.45 x 1.0 x 0.6
EClamp1002A	5	2	160	-	10	1.7 x 1.7 x 0.6

Keypad, Connectors, and Sidekey Protection

Semtech Part Number	VRWM (V)	# Lines	C (pF) max, VR = 0V	Pkg Size (mm)	Comment
uClamp0505A	5	5	75	1.7 x 1.7 x 0.6	5 Line ESD protection in SC-89 package
uClamp0511T	5	1	7	1.0 x 0.6 x 0.4	Bidirectional protection
uClamp0501T	5	1	10	1.0 x 0.6 x 0.4	Unidirectional protection
uClamp1201P uClamp1211P	12	1	60	1.0 x 0.6 x 0.5	Unidirectional protection
uClamp3311P uClamp3301P	3.3	1	15	1.0 x 0.6 x 0.5	Bidirectional protection Unidirectional protection
uClamp0502T	5	2	10	1.0 x 0.6 x 0.4	Unidirectional protection
uClamp0504T uClamp0505T uClamp0506T	5	4 5 6	10	1.3 x 1.3 x 0.4	Unidirectional protection
uClamp0508T	5	8	10	1.7 x 1.3 x 0.4	Unidirectional protection
uClamp0801T uClamp2401T	8 24	1	10 50	1.0 x 0.6 x 0.4	Unidirectional protection
uClamp3305P uClamp3306P	3.3	5 6	20	1.6 x 1.6 x 0.6	Low Voltage multi line protection
uClamp3304A	3.3	4	22	1.7 x 1.7 x 0.6	Low Voltage multi line protection
uClamp0506P	5	6	60	1.6 x 1.6 x 0.6	Multiline 5 V protection
uClamp0544P	5	4	10	2.5 x 1.0 x 0.6	Low Capacitance flow through package
uClamp3324P	3.3	4	25	2.1 x 1.6 x 0.6	Low Voltage flow through package
uClamp0501P uClamp0511P	5	1	160 75	1.0 x 0.6 x 0.5	Unidirectional protection Bidirectional protection

MMC, SIM, microSD, and LVDS

Semtech Part Number	VRWM (V)	# Lines	C (pF) max, L-G VR=0V	Pkg Size (mm)	Comment
RClamp0504P	5	4	3	1.6 x 1.6 x 0.6	MMC, SIM, MircoSD
RClamp0504F	5	5	3	2.0 x 2.1 x 0.9	SIM, HDMI, DVI
RClamp0522T	5	2	0.3	1.6 x 1.0 x 0.4	HDMI, LVDS
RClamp0524T	5	4	0.3	2.5 x 1.0 x 0.4	microSD, HDMI, LVDS
RClamp0522P	5	2	0.3	1.6 x 1.0 x 0.6	HDMI, LVDS
RClamp0524P	5	4	0.8	2.5 x 1.0 x 0.6	microSD, HDMI, LVDS
RClamp0521P RClamp0821P RClamp1521P	5 8 15	1	0.5	1.0 x 0.6 x 0.5	Ultra Low Capacitance
EClamp2455K	5	4	20	1.7 x 1.3 x 0.5	SIM
EClamp2455P	5	4	20	2.1 x 1.6 x 0.6	SIM
EClamp2465T	5	4	12	1.7 x 1.3 x 0.4	SIM
EClamp2410P	5	7	12	4.0 x 1.6 x 0.6	T-Flash, MicroSD

Watch Box - Please Contact Factory for Details.

- USB 3.0
- mini HDMI
- microUSB
- Fingerprint Sensors
- Touch Sensors
- FM/TV Antenna
- Near Field Communications

Contact Information

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