EClamp5xxxZA

EMIClamp®
Integrated ESD Protection and RF Decoupling Capacitor

PROTECTION PRODUCTS

Description

EMIClamp® TVS diodes are designed to protect sensitive electronics from damage or latch-up due to ESD. These state-of-the-art devices utilize solid-state silicon-avalanche technology for superior clamping performance and DC electrical characteristics. They have been optimized for ESD and EMI protection of digital lines in cellular phones and other portable electronics.

EClamp®5xxxZA replaces two discrete components in a small 0201 footprint. Each consists of a TVS diode and a parallel RF decoupling capacitor. The capacitors are manufactured using Semtech's TrenchCap™ technology. TrenchCap technology allows integration of capacitors and TVS diodes in a small area. The capacitors have the advantage of not being inherently voltage dependent like the TVS diode, thus making them more suitable for decoupling applications. Three capacitor options are available: 33pF, 68pF, 100pF. The TVS diode provides effective suppression of ESD voltages in excess of ±18kV (contact discharge) and ±20kV (air discharge) per IEC 61000-4-2. Each device will protect one data line operating at 5 Volts.

EClamp5xxxZA is in a 2-pin, SLP0603P2X3F package measuring 0.6 x 0.3 mm with a nominal height of only 0.25mm. Leads are finished with lead-free NiAu.

Features

- High ESD withstand Voltage: +/-18kV (Contact) and +/- 20kV (Air) per IEC 61000-4-2
- Bidirectional TVS Diode with Integrated RF Decoupling Capacitor
- Ultra-small package
- Protects one data line
- Low ESD clamping voltage
- Working voltage: 5V
- Low leakage current
- Capacitor Options: 33pF, 68pF, 100pF
- Extremely low dynamic resistance: 0.37 Ohms (Typ)
- Solid-state silicon-avalanche technology

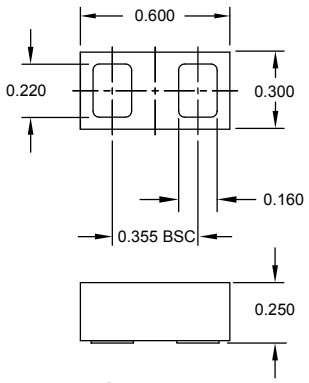
Mechanical Characteristics

- SLP0603P2X3F package
- Pb-Free, Halogen Free, RoHS/WEEE Compliant
- Nominal Dimensions: 0.6 x 0.3 x 0.25 mm
- Lead Finish: NiAu
- Marking: Marking code
- Packaging: Tape and Reel

Applications

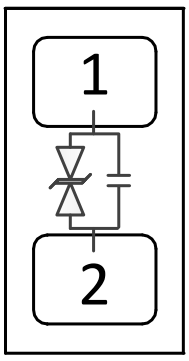
- Cellular Handsets & Accessories
- Portable Instrumentation
- Audio Ports
- MIPI SoundWire
- Keypads and Side Keys
- Tablet PC

Package Dimension



Nominal Dimensions in mm

Schematic & Pin Configuration



SLP0603P2X3F (Bottom View)

Absolute Maximum Rating

Rating	Symbol	Value	Units
Peak Pulse Power (t_p = 8/20µs)	P_{PK}	25	W
Peak Pulse Current (t_p = 8/20µs)	I_{PP}	2	A
ESD per IEC 61000-4-2 (Air)(1) ESD per IEC 61000-4-2 (Contact)(1)	V_{ESD}	±20 ±18	kV
Operating Temperature	T_J	-40 to +125	°C
Storage Temperature	T_{STG}	-55 to +150	°C

Electrical Characteristics (T=25°C unless otherwise specified)

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Units
Reverse Stand-Off Voltage	V_{RWM}	T=-40 to +125°C			5	V
Reverse Breakdown Voltage	V_{BR}	I_{BR} = 1mA T=-40 to +125°C	6.5	8.5	10.5	V
Reverse Leakage Current	I_R	V_{RWM} = 5V		<5	50	nA
Clamping Voltage	V_C	I_{PP} = 2A, t_p = 8/20µs			12.5	V
ESD Clamping Voltage(2)	V_C	I_{PP} = 4A, t_p = 0.2/100ns		9.5		V
		I_{PP} = 16A, t_p = 0.2/100ns		14		V
Dynamic Resistance(2), (3)	R_{DYN}	t_p = 0.2/100ns		0.37		Ω
Capacitance (EClamp5033ZA)	C_{TOTAL}	V_R = 0V to 5V, f = 1MHz T=-40 to +125°C	28	33	38	pF
Capacitance (EClamp5068ZA)	C_{TOTAL}	V_R = 0V to 5V, f = 1MHz T=-40 to +125°C	58	68	78	pF
Capacitance (EClamp5100ZA)	C_{TOTAL}	V_R = 0V to 5V, f = 1MHz T=-40 to +125°C	85	100	115	pF

Notes

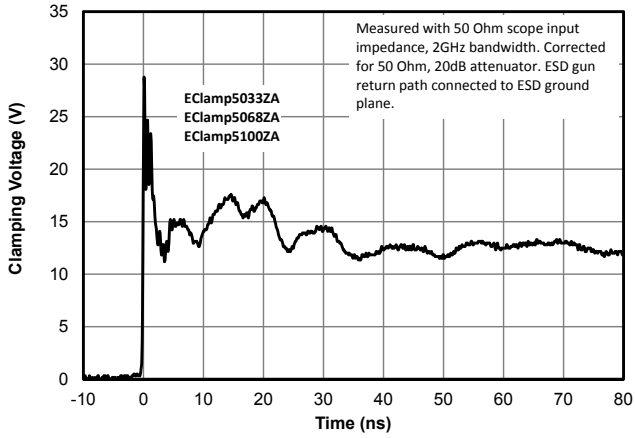
1) ESD gun return path connected to ESD ground plane. Measured with 50 Ohm scope input impedance, 2GHz bandwidth.

2) Transmission Line Pulse Test (TLP) Settings: tp = 100ns, tr = 0.2ns, I_{TLP} and V_{TLP} averaging window: t1 = 70ns to t2 = 90ns.

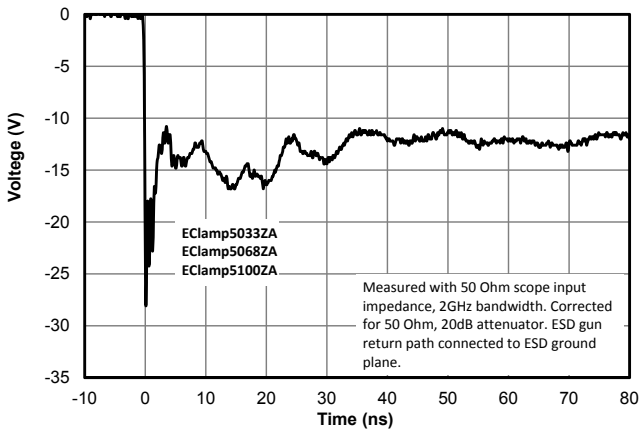
3) Dynamic resistance calculated from I_{TLP} = 4A to I_{TLP} = 16A

Typical Characteristics

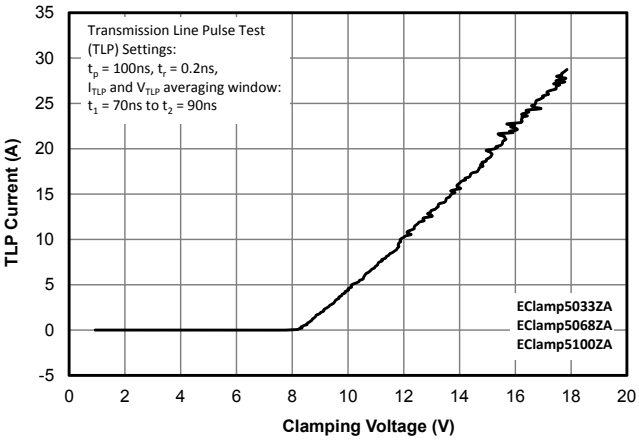
ESD Clamping (8kV Contact per IEC 61000-4-2)



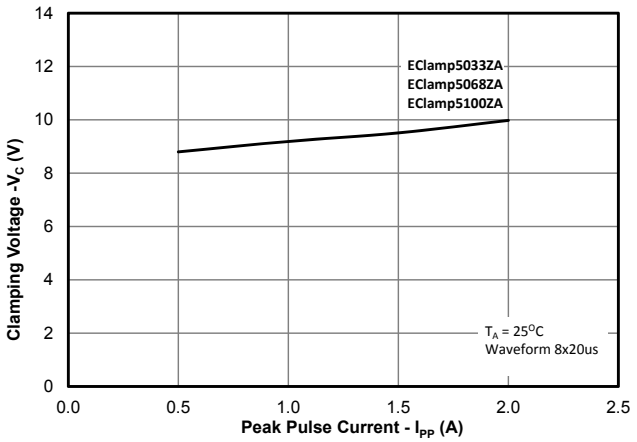
ESD Clamping (-8kV Contact per IEC 61000-4-2)



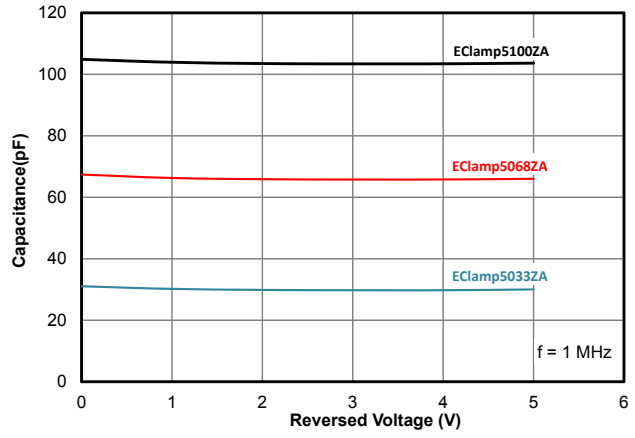
TLP Characteristic



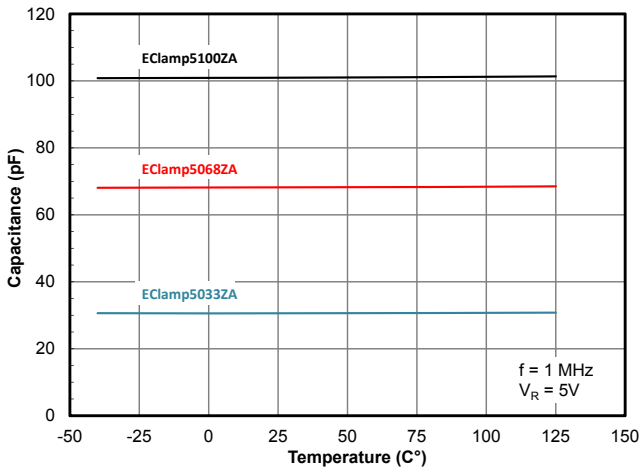
Clamping Voltage vs. Peak Pulse Current (t_p=8/20µs)



Capacitance vs. Reverse Voltage

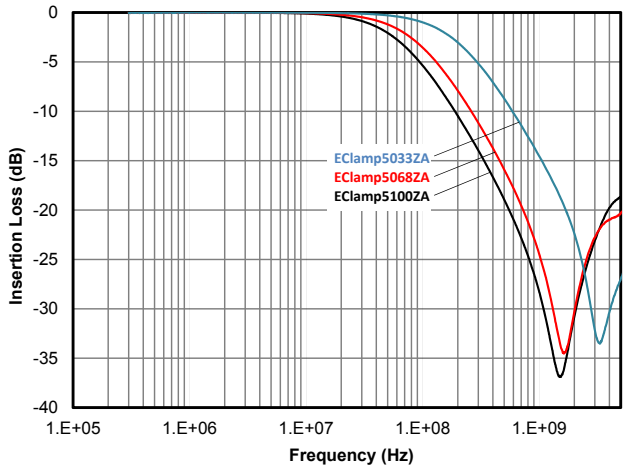


Capacitance vs. Temperature

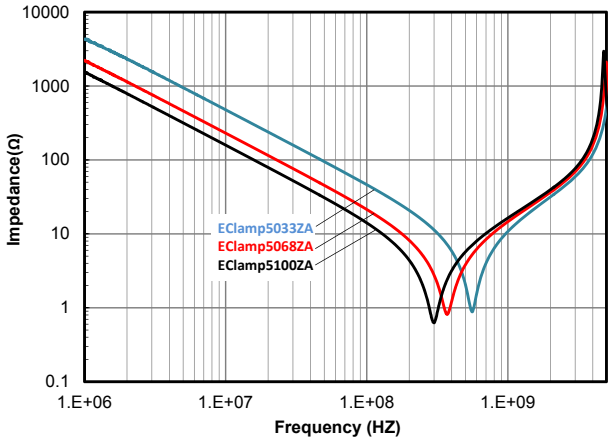


Typical Characteristics

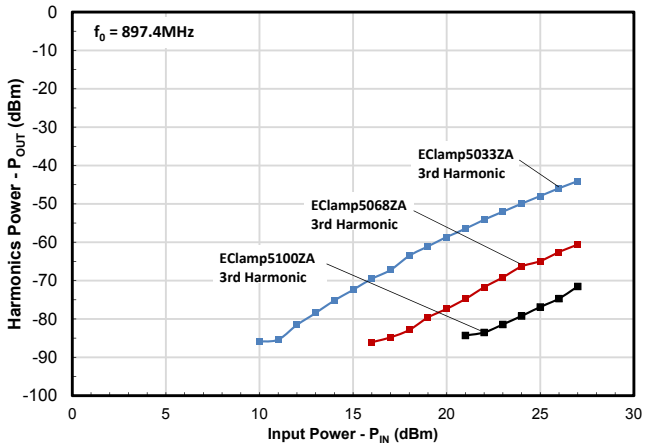
Insertion Loss-S21(dB)



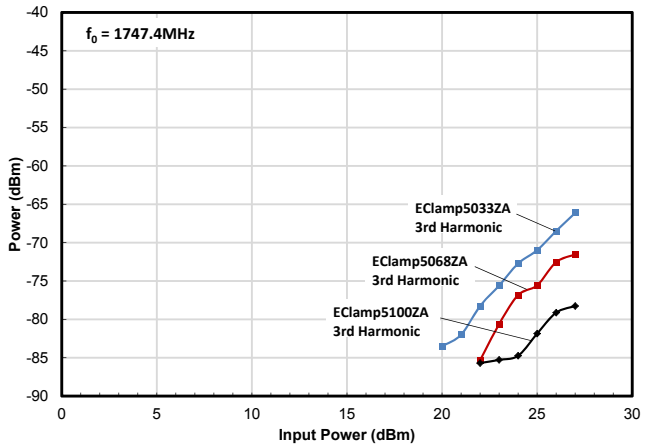
Impedance vs. Frequency - Z11 (Ohms)



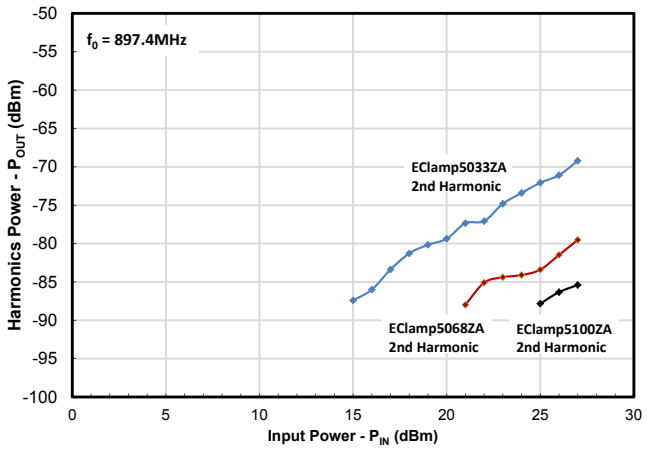
3rd Harmonic Generation - GSM Low Band



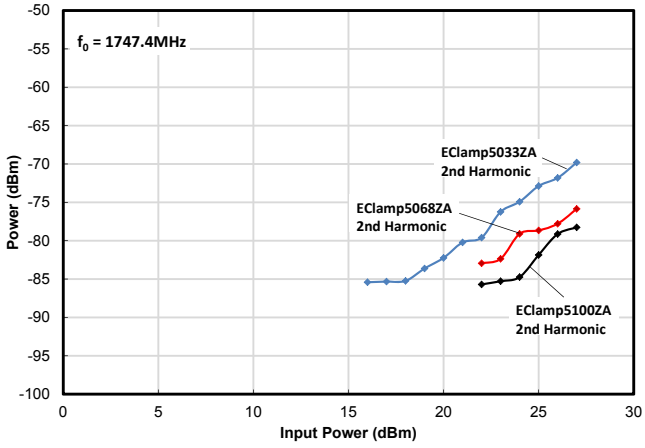
3rd Harmonic Generation - GSM High Band



2nd Harmonic Generation - GSM Low Band



2nd Harmonic Generation - GSM High Band

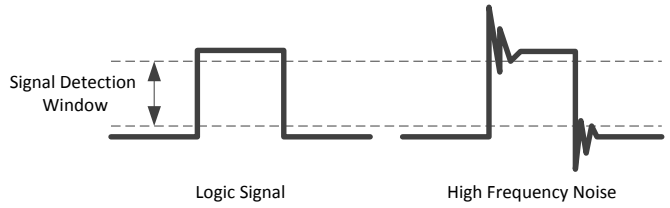


Application Information

Decoupling Capacitors

Decoupling capacitors are widely used in portable electronics to reduce switching noise generated by the RF circuitry. High frequency noise on logic signals can cause system errors or generate unwanted radiated emissions. For example, logic signals have a window of detection to determine the state (on/off, high/low, etc). Noise on the signal near the minimum detection levels can cause the system to make a random determination of the logic state, causing an error (Figure 1). Decoupling capacitors are used to reduce ripple noise and increase signal integrity in the system.

Figure 1 - Logic Error Conditions



Decoupling Capacitors and TVS Diodes

Most RF applications use decoupling capacitors with values ranging from 33pF to 100pF. They are implemented as shunt elements and serve to carry RF energy from a specific point in the circuit to ground. A properly selected bypass capacitor will exhibit very low impedance to ground over the desired operating frequency. The capacitance of a typical ceramic decoupling capacitor is also stable over temperature and voltage. Decoupling capacitors are normally chosen with a self resonating frequency close to the value of the frequency to be decoupled.

TVS diodes are used to shunt ESD energy to ground, protecting downstream circuits from damage. Depending on the application, TVS diodes can be obtained with high capacitance values similar to decoupling capacitors. TVS diodes however, have an inherent, non-linear capacitance vs. voltage characteristic and therefore are not a good substitute for decoupling capacitors.

Integrated TrenchCap™ Technology

EClamp5xxxZA utilizes Semtech's TrenchCap technology to integrate RF decoupling capacitors with TVS diodes. The TrenchCap process builds a dielectric capacitor using the vertical area of the silicon to form oxide filled trenches. The resultant trenches form a large capacitor in a small space. Capacitance values in the EClamp5xxx-ZA devices range from 33pF to 100pF which includes approximately 7pF of junction capacitance contribution from the TVS diode. Compared to the capacitance of a pn junction, the oxide TrenchCap has a much more stable temperature and voltage coefficients. As shown in Figure 2, the typical capacitance of a 5V TVS diode decreases almost 40% between 0V and 5V whereas EClamp5100ZA decreases less than 0.5% over the same range. EClamp-5100ZA also exhibits more stable capacitance characteristics over temperature as shown in Figure 3.

Figure 2 - Capacitance vs. Reverse Voltage Comparison

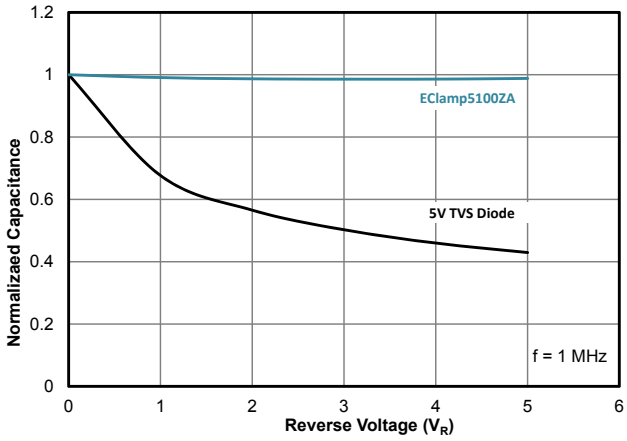
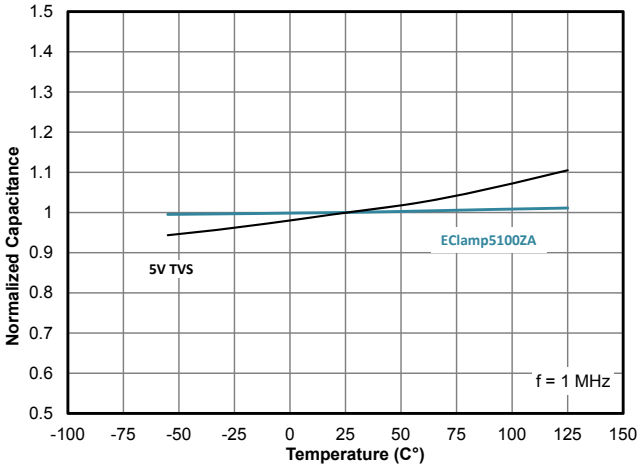


Figure 3 - Capacitance vs. Temperature Comparison

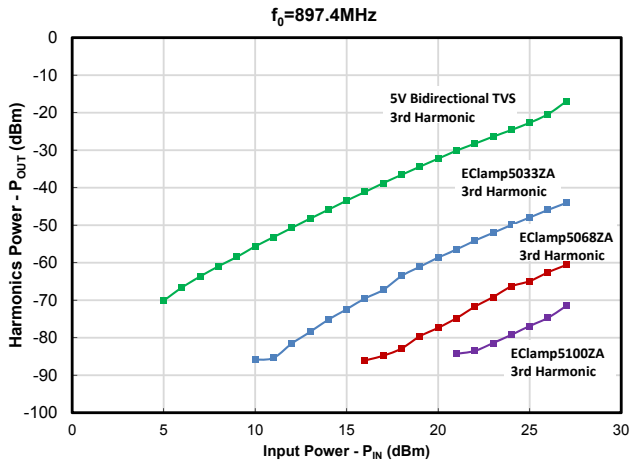


Application Information

Improving Harmonic Distortion

Due to their non-linear nature, TVS diodes located near RF lines can generate unwanted harmonics. This is of particular concern in large signal RF applications. The linear capacitance characteristics of EClamp5xxxZA mean it can be used in ESD protection applications without the unwanted side effect of harmonic generation. Figure 4 shows harmonics generated by a typical 5V ESD protection device as compared to EClamp5xxxZA. Maximum harmonic generation is specified in various EMC standards, but as a general rule, harmonic power must not exceed -30dBm at cellular frequencies.

Figure 4 - Harmonics at GSM Low Band Frequency

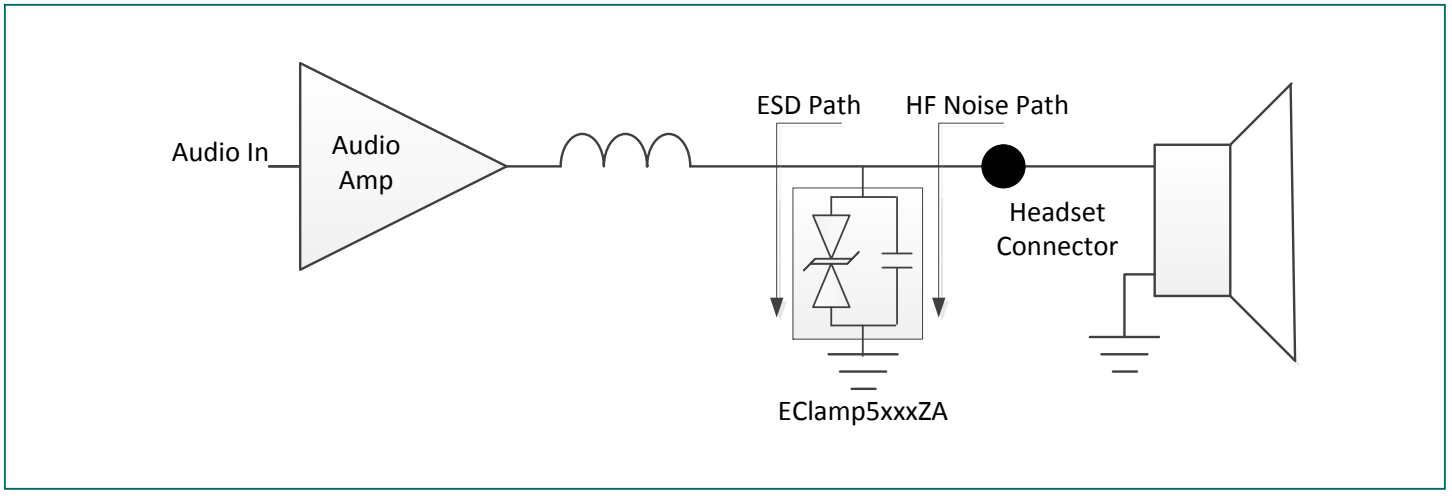


Protecting Audio Ports

Audio interfaces in mobile phones are highly susceptible to ESD damage during normal use. Additionally, RF amplifiers in close proximity to audio lines are a source of RF radiation. TVS diodes are needed to suppress ESD events, but RF energy conducted by the device can generate unwanted harmonics leading to EMC issues and/or audio port "buzzing". EClamp5xxxZA can be utilized on the port in lieu of discrete TVS diodes as shown in Figure 5. Audio amplifiers are typically very sensitive to damage from ESD. They have limited on-chip protection that is not designed to withstand system level ESD voltage and current levels. The integrated TVS diodes in the EClamp5xxxZA feature low ESD peak clamping voltage and extremely low dynamic resistance for protecting the audio power amplifier from ESD strikes. High frequency signals will be shunted through the integrated bypass capacitor instead of the TVS diode, thus avoiding harmonic generation in the TVS diode.

Audio port protection is just one example application. EClamp5xxxZA can be used to replace single line TVS diodes on any low speed lines that are susceptible to RF energy.

Figure 5 - Audio Port Protection Example



Application Information

Assembly Guidelines

The small size of this device means that some care must be taken during the mounting process to insure reliable-solder joints. The figure at the right details Semtech's recommended mounting pattern. Recommended assembly guidelines are shown in Table 1. Note that these are only recommendations and should serve only as a starting point for design since there are many factors that affect the assembly process. Exact manufacturing-parameters will require some experimentation to get the desired solder application. Semtech's recommend-ed mounting pattern is based on the following design guidelines:

Land Pattern

The recommended land pattern follows IPC standards and is designed for maximum solder coverage. Detailed dimensions are shown elsewhere in this document.

Solder Stencil

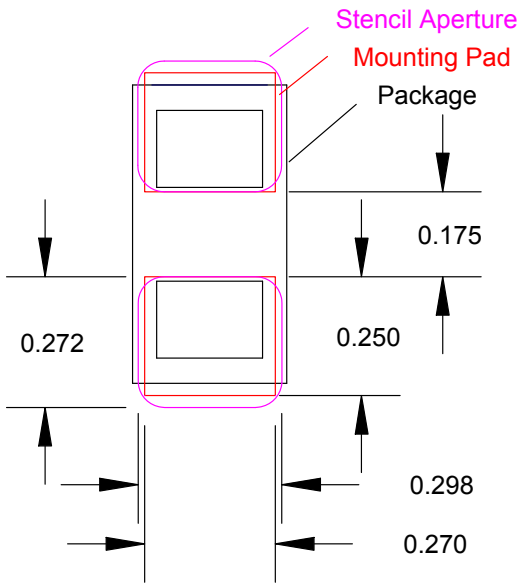
Stencil design is one of the key factors which will deter-mine the volume of solder paste which is deposited onto the land pad. The area ratio of the stencil aperture will determine how well the stencil will print. The area ratio takes into account the aperture shape, aperture size, and stencil thickness. An area
ratio of 0.70 – 0.75 is preferred for the subject package. The area ratio of a rectangular aperture is given as:

Area Ratio = (L * W)/ (2 * (L + W) * T)

Where:
L = Aperture Length
W = Aperture Width
T = Stencil Thickness

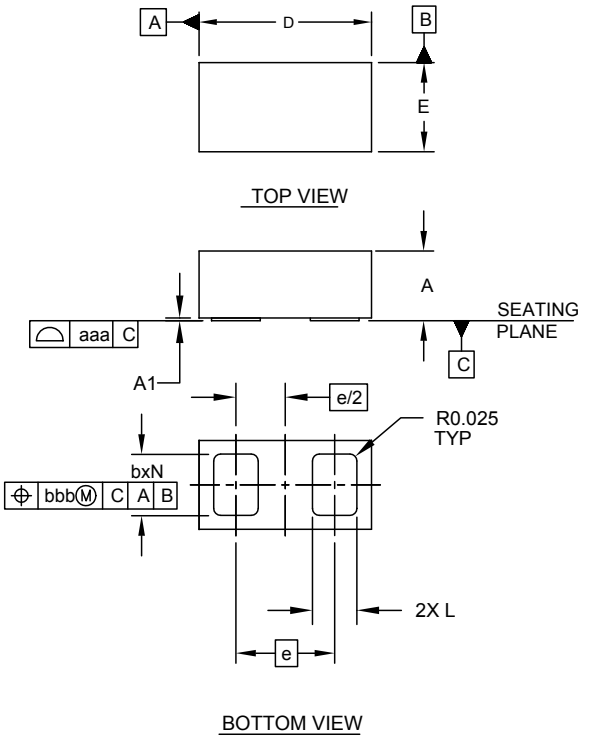
Semtech recommends a stencil thickness of 0.100mm for this device. The stencil should be laser cut with electrop-olished finish. The stencil should have a positive taper of approximately 5 degrees. Electro polishing and tapering the walls results in reduced surface friction and better paste release. For small pitch components, Semtech recommends a square aperture with rounded corners for consistent solder release. Due to the small aperture size, a solder paste with Type 4 or smaller particles is recom-mended.

Recommended Mounting Pattern



Assembly Parameter	Recommendation
Solder Stencil Design	Laser cut, Electro-polished
Aperture shape	Rectangular with rounded corners
Solder Stencil Thickness	0.100 mm (0.004")
Solder Paste Type	Type 4 size sphere or smaller
Solder Reflow Profile	Per JEDEC J-STD-020
PCB Solder Pad Design	Non-Solder mask defined
PCB Pad Finish	OSP OR NiAu

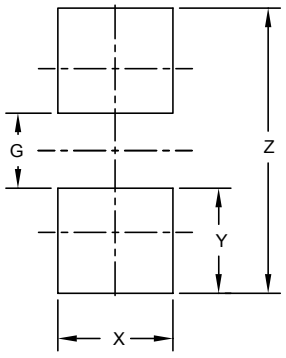
Outline Drawing - SLP0603P2X3F



DIMENSIONS			
DIM	MILLIMETERS		
	MIN	NOM	MAX
A	0.235	0.250	0.265
A1	0.000	0.010	0.050
b	0.200	0.220	0.240
D	0.580	0.600	0.620
E	0.280	0.300	0.320
e	0.355 BSC		
L	0.140	0.160	0.180
N	2		
aaa	0.08		
bbb	0.10		

NOTES:
1. CONTROLLING DIMENSIONS ARE IN MILLIMETERS (ANGLES IN DEGREES).

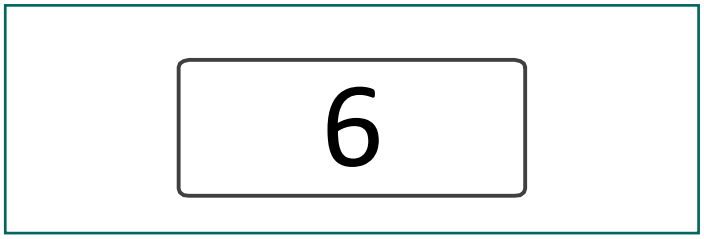
Land Pattern - SLP0603P2X3F



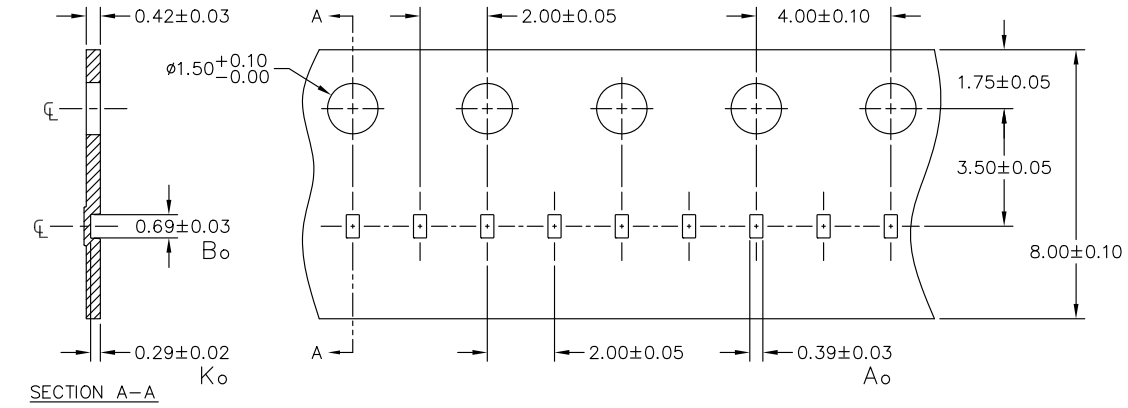
DIMENSIONS	
DIM	MILLIMETERS
G	0.177
X	0.272
Y	0.247
Z	0.671

NOTES:
CONTROLLING DIMENSIONS ARE IN MILLIMETERS (ANGLES IN DEGREES).
THIS LAND PATTERN IS FOR REFERENCE PURPOSES ONLY.
CONSULT YOUR MANUFACTURING GROUP TO ENSURE YOUR
COMPANY'S MANUFACTURING GUIDELINES ARE MET.

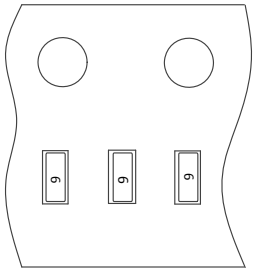
Marking Example



Tape and Reel Specification



NOTES: ALL DIMENSIONS IN MILLIMETERS UNLESS OTHERWISE SPECIFIED.



Ordering Information

Part Number	Capacitance Value	Marking Code	Qty per Reel	Reel Size
EClamp5033ZATFT	33pF	3	15,000	7″
EClamp5068ZATFT	68pF	6	15,000	7″
EClamp5100ZATFT	100pF	0	15,000	7″
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Contact Information

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