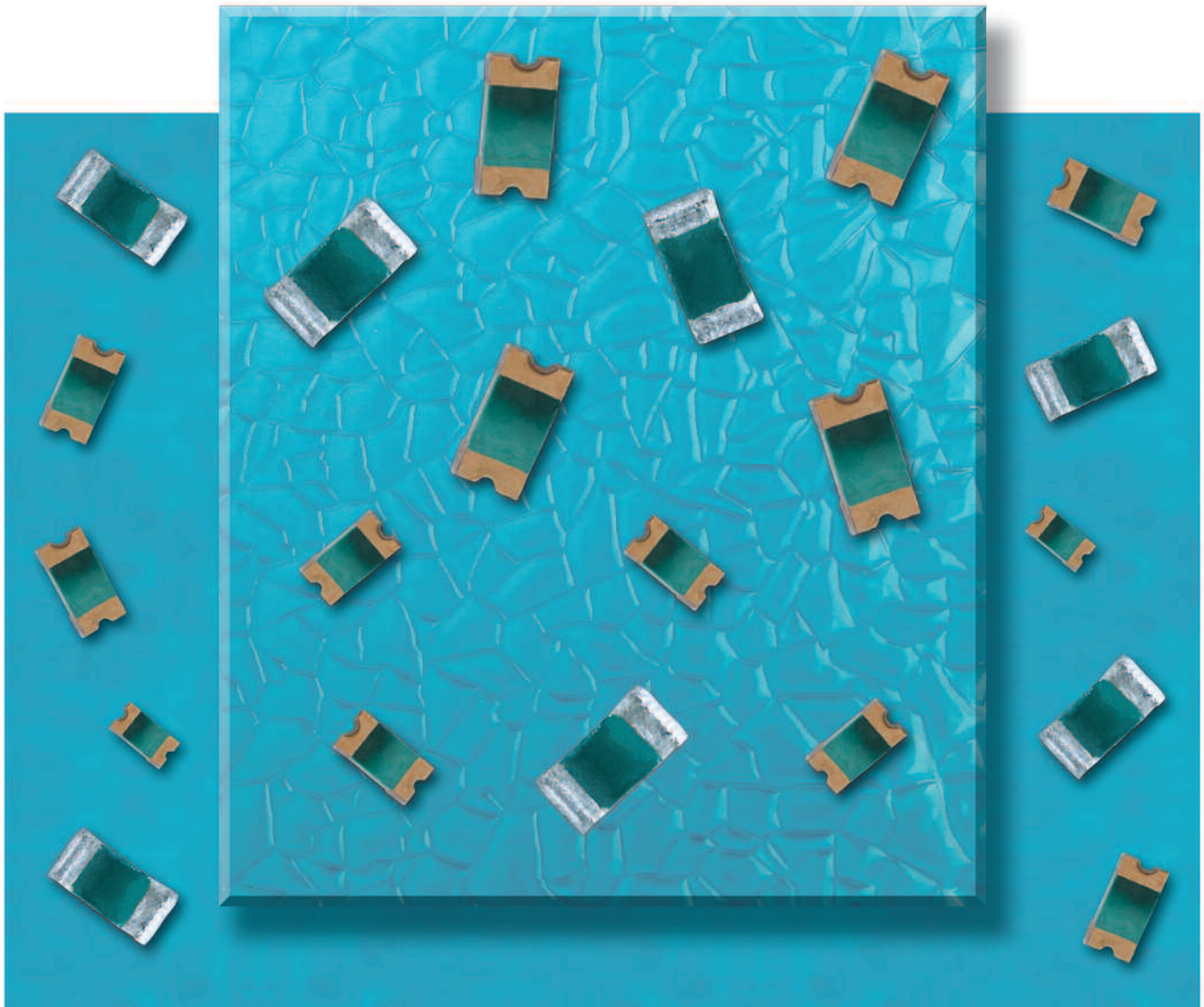


OVERVOLTAGE PROTECTION



COOPER Bussmann

Ihr Vertriebspartner:
HY-LINE®
POWER COMPONENTS

Inselkammerstraße 10	Gründenstrasse 10
D-82008 Unterhaching	CH-8247 Flurlingen
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Fax: +49 (0)89 614503 20	Fax: +41 (0)52 647 42 01
E-Mail: power@hy-line.de	E-Mail: power@hy-line.ch
URL: www.hy-line.de	URL: www.hy-line.ch

INTRODUCTION

From overcurrent and overvoltage protection to supercapacitors and magnetics, Cooper Bussmann provides integrated solutions that meet the evolving needs of technology-driven markets. Cooper Bussmann is a leader and an innovator in providing cost-effective, comprehensive solutions that utilize the high quality brand names that customers know and trust.

Overcurrent

The Bussmann® Electronic Fuse family offers fail-safe circuit protection devices in SMD, Thru-Hole, and traditional Ferrule Fuse packages.

Magnetics

The Coiltronics® family of transformers and inductors offers a broad range of solutions to meet precise specifications in a variety of applications.

Overvoltage

The PolySURG™ family offers protection for sensitive electronic circuits from the damaging effects of electrostatic discharge (ESD).

Supercapacitors

The PowerStor® family of aerogel capacitors offers ultra-low resistance supercapacitors, unique high-energy storage devices.

Cooper Bussmann continues its 90-year history of blazing new trails of innovative technologies. Cooper Bussmann manufactures the industry's first truly global product line. Each item is backed by an efficient worldwide network of distribution, customer service and technical support. Bussmann products include the most extensive circuit protection solutions approved for use in compliance with a variety of major standards: UL, CSA, IEC within wide range of applications: industrial motor protection, power conversion, medium voltage, power distribution, telecommunications network equipment, electronics, and automotive. Manufacturing operations in North America, Europe, and Asia have earned ISO 9000 certification. Bussmann customers are assured of only the utmost quality across every product line. Our team is knowledgeable, responsive and customer focused. Bussmann continues to set the standard for circuit protection solutions around the world.

To receive further information on Cooper Bussmann products, visit www.cooperbussmann.com or contact customer service at 888-414-2645.

Overvoltage Protection Group

PolySURG™



PolySURG™ ESDA Family of ESD Suppression Devices



PolySURG™ ESDA devices are a family of bi-directional ESD overvoltage protection devices that respond in less than 1ns and can protect against a threat voltage up to 15kV per IEC standard 61000-4-2. With leakage current of less than 1nA and an ultra low capacitance less than 0.15pF, these devices are an especially viable solution for high data rate applications. With an insertion loss of less than -0.2dB at frequencies up to 6 GHz, the ESDA devices are invisible to the protected circuit, introducing no additional loading or signal distortion.

ESD Protection for High Frequency, Low Voltage Designs

PolySURG™ surface mount devices are ideally suited for ESD protection of data

I/O ports, computers and peripherals, media interfaces (DVI and HDMI), mobile communication products, hand-held test equipment and other similar uses.

PolySURG™ Overcomes the Performance Deficiencies of Competing Technologies

Other solutions such as zener diodes, multi-layer varistors (MLV's) and TVS all exhibit capacitance levels, as well as leakage current levels, that are too large for them to be practical solutions in high speed digital video (DVI and HDMI) applications. Use of traditional, low capacitance, steering diodes in high-speed circuits may result in latch up of the protection circuit. Typically, steering diodes are not rated for the high transient currents associated with ESD. Exposure to such transients results in short cycle life and eventual diode failure, commonly in short circuit mode, yielding a product that no longer functions even though the ESD event has passed. PolySURG™ ESDA devices are designed so that, in the rare instance of device failure, the typical failure mode is open circuit.

MLP Series Now Available

The MLP Series, comprised of the 0402ESDA-MLP and 0603ESDA-MLP ESD suppression devices, is now available as discrete devices in an 0402 and 0603 footprint, respectively. This series utilizes Cooper Bussmann's patented PolyFAMILY design to deliver enhanced ESD protection using state of the art process and material technologies.

All PolySURG™ Devices are in Full Compliance with RoHS Requirements¹

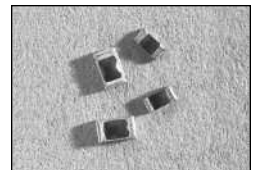
Notes: 1. Produced on or after March 2004 (January 2004 for 0603ESDA-TR1).

TABLE OF CONTENTS

The PolySURG™ ESDA product family is specifically designed to protect sensitive electronic circuits from the threat of electrostatic discharge (ESD). These products react instantly to the high voltage transient and effectively clamp it typically to 35V for less energy absorption during the voltage stress period and greater IC protection. The design of these devices inherently produces an ultra low capacitance part. In the off-state, the device is virtually invisible to the circuit. Installed from signal line to ground, the device exhibits a high impedance and low capacitance that makes it transparent to high speed data circuits. Signals are not distorted or disrupted due to very low off-state current leakage. With ESDA devices, waveform definition stays true and high-speed signals do not degrade. ESDA products utilize a unique polymer-based voltage variable material. The nature of the material creates a bi-directional part, which means that only one device is required to provide complete ESD protection regardless of the surge polarity. The combination of this material with proven substrate technology produces a reliable, surface mount product that will help protect mobile communications, computers, data processing, test equipment, and many other electronic applications from ESD.

ESD Suppression Selection Guide

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0402ESDA-MLP, MLP Series ESD Suppressor

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0603ESDA-MLP, MLP Series ESD Suppressor

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0603ESDA-TR, TR Series ESD Suppressor

Page OV-12



Application Notes, ESD Suppression

ESD Protection of Set Top Appliances with PolySURG™ ESDA Devices

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ESD Protection of High-Speed Data Lines

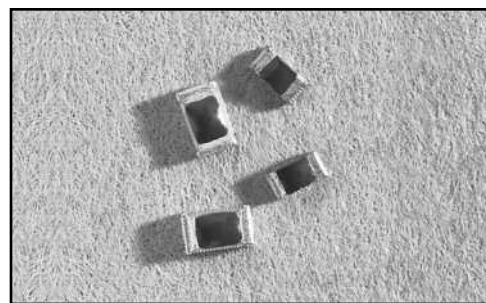
Page OV-17

ESD Protection for High Speed Digital Video Solutions (DVI & HDMI)

Page OV-19

Features:

- Outstanding ESD protection for high frequency, low voltage applications.
- Exceeds testing requirements outlined in IEC 61000-4-2
- Extremely low capacitance
- Very low leakage current
- Fast response time
- Bi-directional
- Surface mount
- Solder Termination



What is it:

Our Voltage Variable Material (VVM) has unique properties that are highly preferred in ESD suppression applications. The polymer matrix responds to an over-voltage condition by rapidly changing from an over-voltage condition by rapidly changing from a high impedance state to a low impedance state.

Cooper Bussmann utilizes this polymeric matrix in the ESDA device family for fast response, ultra low capacitance, and very low current leakage. The device is activated by over-voltage threat and clamps to a low value to protect sensitive circuit components.

How it Works:

The ESDA-TR and MLP Series are board level circuit protection devices designed exclusively for the fast, transient over-voltages associated with ESD. When a sufficient over-voltage occurs it exhibits a dramatic increase in the ability to conduct electrons. The nature of the material creates a bi-directional part, which means that only one device is required to provide complete ESD protection regardless of the surge polarity. In a typical application, the device is placed across a signal line leading to an integrated circuit and ground. The device exhibits minimal capacitance

and is “invisible” to the circuit during the normal operation. Under normal operating voltages (typically 3 to 15V) the high impedance of the device insulates each signal line from ground. When an ESD event occurs, the voltage variable material switches to a conductive state within nanoseconds. The voltage across signal line collapses to the clamping level, and current is shunted through the device to the ground. When the overvoltage event ends, the circuit returns to its normal operating state as the device switches back to its $>10^{12}\Omega$ high resistance state and “invisibility.”

ESDA Series Selection Guide:

Part Number	Package Size	Lines	Operating Voltage (VDC)	Capacitance (pF @ 1KHz ~ 1.8GHz)	Current Leakage (nA @ 12VDC)	Clamp Voltage V	Specification
0402ESDA-MLP7	0402	1	0 ~ 30	< 0.15	< 0.1	35	IEC61000-4-2, Level 4
0603ESDA-MLP7	0603	1	0 ~ 30	< 0.15	< 0.1	35	IEC61000-4-2, Level 4
0603ESDA-TR1	0603	1	0 ~ 24	< 0.15	< 0.1	35	IEC61000-4-2, Level 4

Ihr Vertriebspartner:

 POWER COMPONENTS

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 Fax: +41 (0)52 647 42 01
 E-Mail: power@hy-line.ch
 URL: www.hy-line.ch

Device Marking

PolySURG™ ESDA devices are marked on the tape and reel packages, not individually. Since the product is bi-directional and symmetrical, no orientation marking is required.

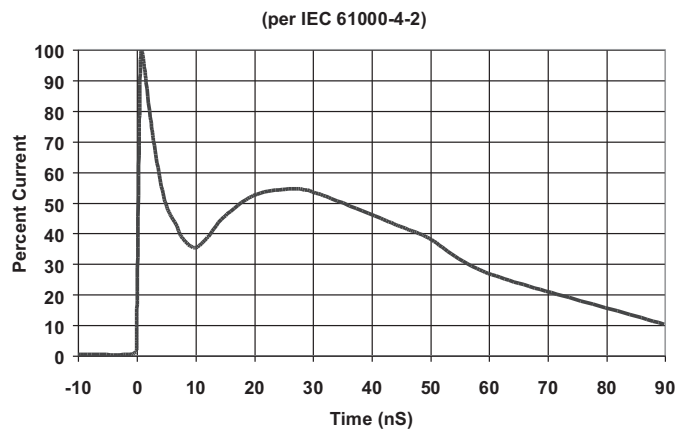
Test Methodology

Full product characterization requires use of multiple test methods. Each test method reveals unique information about the device response. The results of all of the tests must be analyzed to fully understand the PolySURG™ ESDA device response to an over-voltage event.

Electrostatic Discharge (ESD) Pulse

The ESD pulse is the defining test for an ESD protective device. The ESD pulse is an extremely fast rising transient event. The pulse, as characterized in IEC 61000-4-2, has a rise time of less than 1ns, peak currents up to 45A, and voltage levels to 15 kV. Characteristics determined by this test are those such as voltage overshoot, peak voltage, clamping voltage, peak current, and device resistance.

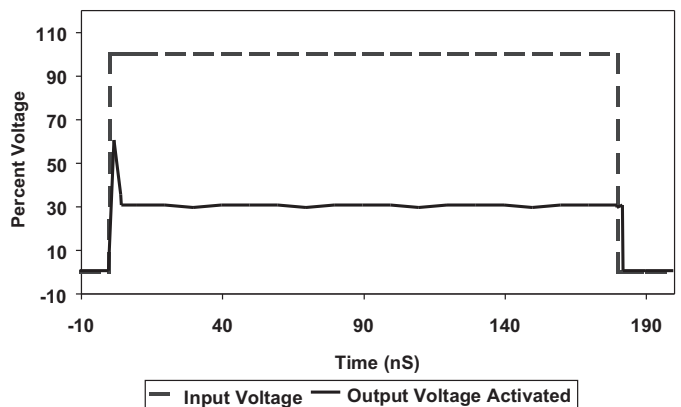
Due to the extremely fast rate of rise of the ESD pulse, the test setup can have a definite impact on the above factors. Variables such as wiring inductance and probe capacitance can produce inaccurate readings on an otherwise capable oscilloscope.



Transmission Line Pulse (TLP)

The Transmission Line Pulse tester implements a controlled impedance cable to deliver a square wave current pulse. The advantage of this technique is that the constant current of the square wave allows the behavior of the protection structure to be more accurately studied.

The actual implementation of this technique produces a waveform that has a slightly slower rise time than the ESD pulse but can be correlated to the deliver approximately the same surge current and energy. This controlled impedance pulse provides a more accurate depiction of the trigger voltage of the device because of the reduced voltage overshoot caused by a fast rising transient and the reactive components of the test fixture.



Definition of Terms

Clamp Voltage – The voltage at which the PolySURG™ device stabilizes during the transition from high to low impedance. This is the voltage experienced by the circuit, after stabilizing, for the duration of the ESD transient.

Trigger Voltage – The voltage at which the PolySURG™ device begins to function. When the ESD threat voltage reaches this level, the PolySURG™ device begins the transition from high impedance to low impedance, shunting the ESD energy to ground.

Threat Voltage – The voltage that the test equipment is set to operate (i.e. the voltage across the discharge capacitor).

Peak Current – The maximum instantaneous current level that a device will receive. IEC-61000-4-2 states that the peak current should be 30A at 8kV ESD and 45A at 15kV ESD.

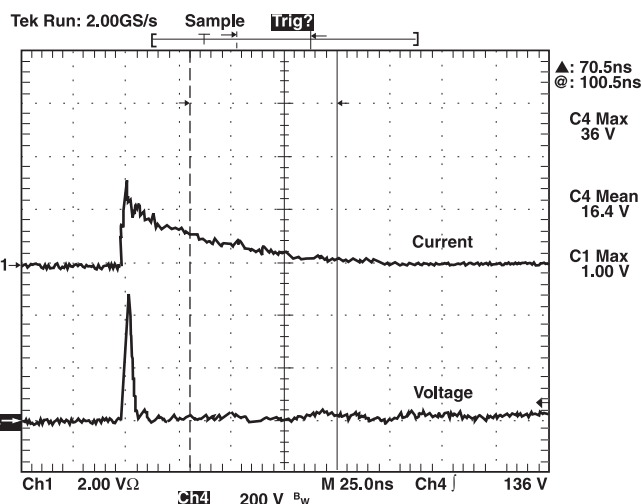
Selected Characterization Data

ESD Transient Pulse Energy Controlled by PolySURG™

Figure 1 shows typical PolySURG™ ESDA device response to an 8 kV contact ESD pulse. Triggered polymer in the ESDA device conducts excess energy to ground and prevents system damage by ESD transient threat. As the polymer resistance drops current flows to ground.

The top scope trace indicates current, and the bottom scope trace indicates voltage.

Figure 1. Typical Device Response to 8kV ESD



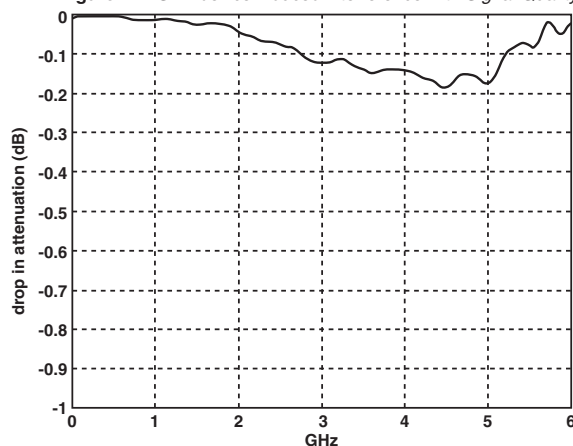
PolySURG™ Protects against ESD Voltage Transient without Affecting Signal Quality

The PolySURG™ ESDA devices have an ultra low capacitance of <math><0.15\text{pF}</math> and when typically installed from the signal line to ground PolySURG™ has a negligible effect on the signal.

As Figure 2 shows, the test conducted with a precision network analyzer on a 50 Ω circuit at up to 6GHz. Only a 0.2dB deviation from the original signal was recorded.

The setup was similar to the addition of the PolySURG™ ESDA device to a circuit with very fast digital signal or a cellular phone antenna.

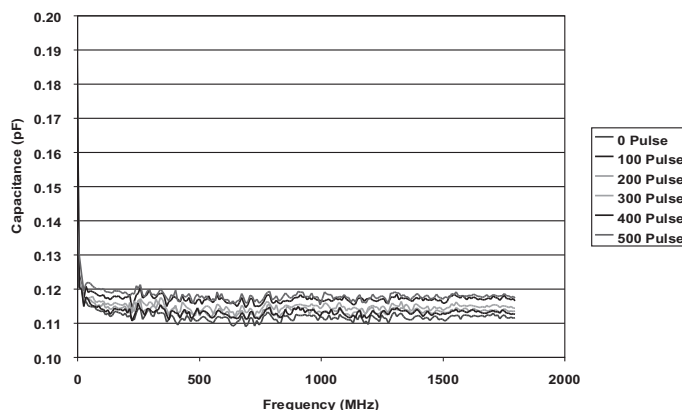
Figure 2. ESDA device induced interference with Signal Quality



Signal Frequency does not affect the Capacitance of the Device

The device capacitance is very low and constant over wide frequency range. The typical capacitance is less than 0.15pF over the tested range of 0.1MHz to 1.8GHz. In addition, as shown in Figure 3, the capacitance will remain same over the life cycle of the device (i.e. the number of the ESD pulse does not change the device capacitance.)

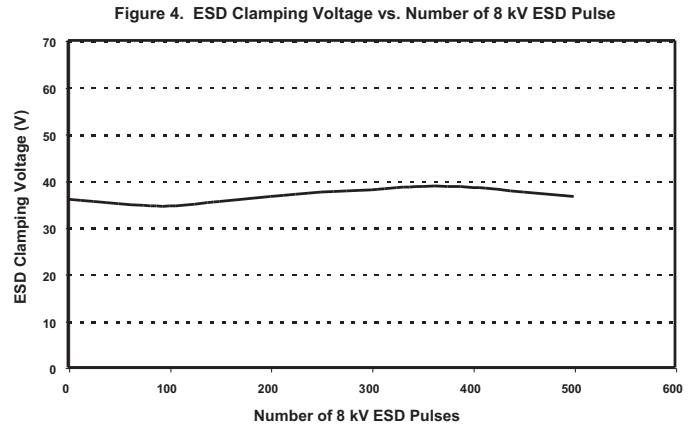
Figure 3. Capacitance vs. Frequency



Clamp Voltage Remains Consistent Despite Repeated ESD Pulses

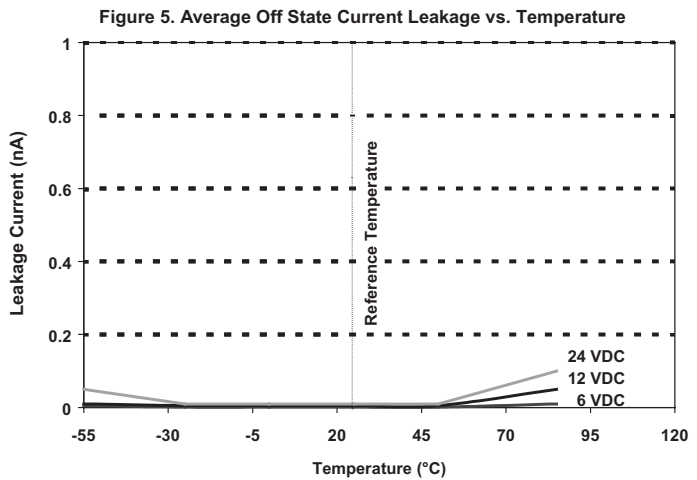
As Figure 4 shows, the PolySURG™ ESDA device is highly reliable and stable over hundreds of pulses.

The PolySURG™ ESDA device has been tested with fast rate ESD pulses at 8kV contact discharge. Clamping voltage measured at every pulse shows minimal changes throughout the test.



Typical non-triggered (Off State) Current Leakage of PolySURG™ is Very Low at Normal Operating Voltages and Temperatures

As shown by Figure 5 the current leakage of the PolySURG™ ESDA device is typically very low, well under 1nA, even over 12VDC operating voltage. Some increase in the current leakage may be expected at much higher operating voltage and elevated temperature.



Features & Benefits

- Ultra-low capacitance (0.05pF typ.) ideal for high speed data applications
- Provides ESD protection with fast response time (<1ns) allowing equipment to pass IEC 61000-4-2 level 4 test
- Single-line, bi-directional device for placement flexibility
- Low profile 0402/1005 design for board space savings
- Low leakage current (<0.1nA typ.) reduces power consumption



Applications

- | | | |
|---|---|--|
| <ul style="list-style-type: none"> • Computers & Peripherals • HDTV Equipment • DVD Players • A/V Equipment • Satellite Radio • Cell Phones | <ul style="list-style-type: none"> • PDA's • Digital Still Cameras • Digital Camcorders • MP3 / Multimedia Players • Set Top Boxes • External Storage • DSL Modems | <ul style="list-style-type: none"> • High Speed Data Ports <ul style="list-style-type: none"> • USB 2.0 • IEEE 1394 • HDMI • DVI • High Speed Ethernet • Infiniband® |
|---|---|--|

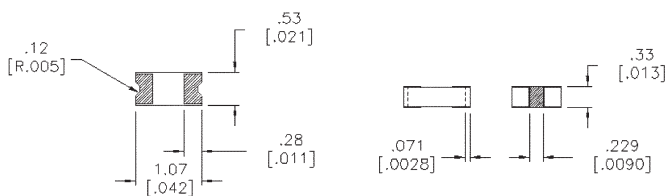
Description

The PolySURG™ 0402ESDA-MLP ESD Suppressors protect valuable high-speed data circuits from ESD damage without distorting data signals as a result of its ultra-low (0.05pF typical) capacitance.

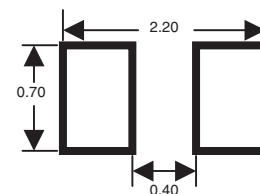
Ordering Information

Catalog Number	Packaging
0402ESDA-MLP7	10,000 pieces in paper tape on 7" (178mm) reel
0402ESDA-MLP8	2,500 pieces in paper tape on 7" (178mm) reel

Product Dimensions: mm [inches]



Solder Pad Recommendation: mm [inches]



Design Considerations

The location in the circuit for the MLP series has to be carefully determined. For better performance, the device should be placed as close to the signal input as possible and ahead of any other component. Due to the high current associated with an ESD event, it is recommended to use a "0-stub" pad design (pad directly on the signal/data line and second pad directly on common ground).

Electrical Characteristics

Characteristic	Value
Rated Voltage	30VDC maximum
Clamping Voltage ¹	35V typical
Trigger Voltage ²	300V typical
Capacitance (@ 1MHz)	0.05pF typ., 0.15pF max.
Attenuation Change (0-6GHz)	-0.2dB typical
Leakage Current (@ 12VDC)	<0.1nA typical
ESD Capability	
IEC61000-4-2 Direct Discharge	8kV typical
IEC61000-4-2 Air Discharge	15kV typical
ESD Pulse Withstand ¹	>1000 typical

Notes:

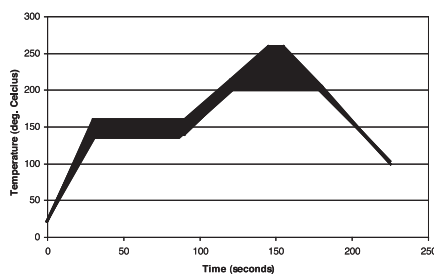
1. Per IEC61000-4-2, Level 4 waveform (8kV direct, 30A) measured 30ns after initiation of pulse.
2. Trigger measurement made using Transmission Line Pulse (TLP) method.
3. Minor shifting in characteristics may be observed over multiple ESD pulses at very rapid rate.

Environmental Specifications:

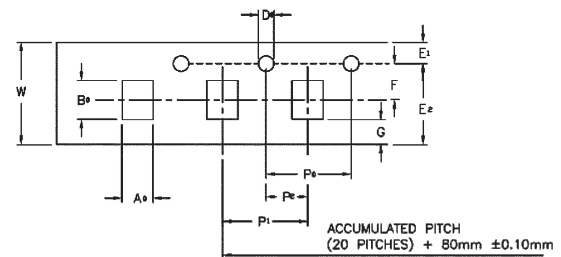
- Load Humidity: 12VDC per EIA/IS-772 Para. 4.4.2, +85°C, 85% RH for 1000 hours
- Thermal Shock: EIA/IS-722 Para 4.6, Air to Air -55°C to +125°C, 5 cycles
- Moisture Resistance Test: MIL-STD-202G Method 106G, 10 cycles
- Mechanical Shock: EIA/IS-722 Para. 4.9
- Vibration: EIA/IS-722 Para. 4.10
- Resistance to Solvent: EIA/IS-722 Para. 4.11
- Operating & Storage Temperature Range: -55°C to +125°C

Soldering Recommendations

- Compatible with lead and lead-free solder reflow processes
- Peak reflow temperatures and durations:
 - IR Reflow = 260°C max for 10 sec. max.
 - Wave Solder = 260°C max. for 10 sec. max.
- Recommended IR Reflow Profile:



Tape & Reel Specifications



CARRIER DIMENSIONS (mm)											
A ^a	B ^a	D ^a	E ¹	E ²	F	G	P ²	P ¹	P ²	T	W
0.65	1.15	1.50	1.75	6.25	3.50	2.75	4.00	2.00	2.00	0.43	8.00
±0.05	±0.05	±0.05	±0.10	±0.10	±0.05	±0.10	±0.10	±0.05	±0.05	±0.05	±0.20

- 10,000 pieces in paper tape on 7 inch (178mm) plastic reel per EIA Standard 481-1

Features & Benefits

- Ultra-low capacitance (0.05pF typ.) ideal for high speed data applications
- Provides ESD protection with fast response time (<1ns) allowing equipment to pass IEC 61000-4-2 level 4 test
- Single-line, bi-directional device for placement flexibility
- Low profile 0603/1608 design for board space savings
- Low leakage current (<0.1nA typ.) reduces power consumption



Applications

- Computers & Peripherals
- HDTV Equipment
- DVD Players
- A/V Equipment
- Satellite Radio
- Cell Phones
- PDA's
- Digital Still Cameras
- Digital Camcorders
- MP3 / Multimedia Players
- Set Top Boxes
- External Storage
- DSL Modems
- High Speed Data Ports
 - USB 2.0
 - IEEE 1394
 - HDMI
 - DVI
 - High Speed Ethernet
 - Infiniband®

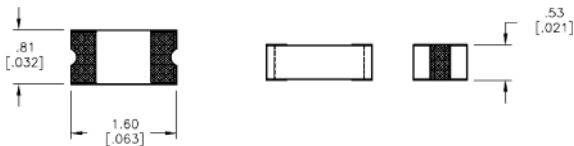
Description

The PolySURG™ 0603ESDA-MLP ESD Suppressors protect valuable high-speed data circuits from ESD damage without distorting data signals as a result of its ultra-low (0.05pF typical) capacitance.

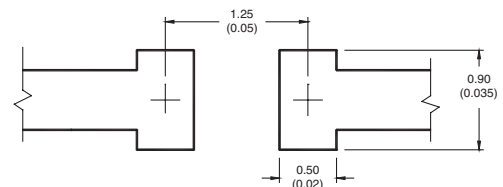
Ordering Information

Catalog Number	Packaging
0603ESDA-MLP7	5,000 pieces in paper tape on 7" (178mm) reel

Product Dimensions: mm [inches]



Solder Pad Recommendation: mm [inches]



Design Considerations

The location in the circuit for the MLP series has to be carefully determined. For better performance, the device should be placed as close to the signal input as possible and ahead of any other component. Due to the high current associated with an ESD event, it is recommended to use a "0-stub" pad design (pad directly on the signal/data line and second pad directly on common ground).

0603ESDA-MLP, MLP Series Suppressor

Ihr Vertriebspartner:
HY-LINE®
 POWER COMPONENTS

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 E-Mail: power@hy-line.de
 URL: www.hy-line.de

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 CH-8247 Flurlingen
 Tel.: +41 (0)52 647 42 00
 Fax: +41 (0)52 647 42 01
 E-Mail: power@hy-line.ch
 URL: www.hy-line.ch

Electrical Characteristics

Characteristic	Value
Rated Voltage	30VDC maximum
Clamping Voltage ¹	35V typical
Trigger Voltage ²	300V typical
Capacitance (@1MHz)	0.05pF typ., 0.15pF max.
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Leakage Current (@ 12VDC)	<0.1nA typical
ESD Capability	
IEC61000-4-2 Direct Discharge	8kV typical
IEC61000-4-2 Air Discharge	15kV typical
ESD Pulse Withstand ¹	>1000 typical

Notes:

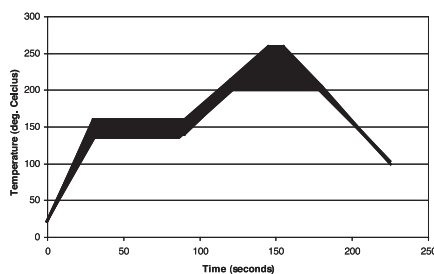
1. Per IEC61000-4-2, Level 4 waveform (8kV direct, 30A) measured 30ns after initiation of pulse.
2. Trigger measurement made using Transmission Line Pulse (TLP) method.
3. Minor shifting in characteristics may be observed over multiple ESD pulses at very rapid rate.

Environmental Specifications:

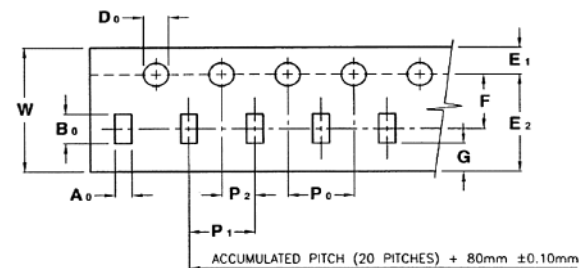
- Load Humidity: 12VDC per EIA/IS-772 Para. 4.4.2, +85°C, 85% RH for 1000 hours
- Thermal Shock: EIA/IS-722 Para 4.6, Air to Air -55°C to +125°C, 5 cycles
- Moisture Resistance Test: MIL-STD-202G Method 106G, 10 cycles
- Mechanical Shock: EIA/IS-722 Para. 4.9
- Vibration: EIA/IS-722 Para. 4.10
- Resistance to Solvent: EIA/IS-722 Para. 4.11
- Operating & Storage Temperature Range: -55°C to +125°C

Soldering Recommendations

- Compatible with lead and lead-free solder reflow processes
- Peak reflow temperatures and durations:
 - IR Reflow = 260°C max for 10 sec. max.
 - Wave Solder = 260°C max. for 10 sec. max.
- Recommended IR Reflow Profile:



Tape & Reel Specifications



A ₀	1.02mm	G	0.75 mm
B ₀	1.85 mm	P ₀	4.00 mm
D ₀	1.50 mm	P ₁	4.00 mm
E ₁	1.75 mm	P ₂	2.00 mm
E ₂	6.25 mm	W	8.00 mm
F	3.50 mm	Thickness	0.75 mm

- 5,000 pieces in paper tape on 7 inch (178mm) plastic reel per EIA Standard 481-1



Features:

- 0603/1608 foot print
- Ideal ESD protection for high frequency, low voltage applications.
- Exceeds testing requirements outlined in IEC 61000-4-2
- Ultra low capacitance (0.15pF maximum)
- Very low leakage current
- Fast response time
- Bi-directional
- Surface mount

Applications

- Computers & Peripherals
- HDTV Equipment
- DVD Players
- A/V Equipment
- Satellite Radio
- Cell Phones
- PDA's
- Digital Still Cameras
- Digital Camcorders
- MP3 / Multimedia Players
- Set Top Boxes
- External Storage
- DSL Modems
- High Speed Data Ports
 - USB 2.0
 - IEEE 1394
 - HDMI
 - DVI
 - High Speed Ethernet
 - Infiniband®

Description

The PolySURG™ 0603ESDA-TR ESD Suppressors protect valuable high-speed data circuits from ESD damage without distorting data signals as a result of its ultra-low (0.15pF maximum) capacitance.

Ordering Information

Catalog Number	Packaging
0603ESDA-TR1	5,000 pieces in paper tape on 7" (178mm) reel

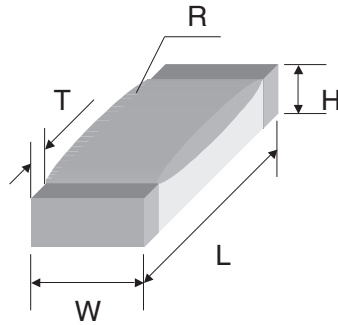
Part Ratings and Characteristics:

Performance Characteristics	Units	Min	Typ	Max
Continuous operating voltage	VDC	-	-	24
Clamping voltage ²	V	-	35	60
Trigger voltage ³	V	-	125	-
ESD Threat voltage capability ⁴	kV	-	8	15
Capacitance (@ 1 KHz ~ 1.8GHz)	pF	-	-	0.15
Leakage current (@ 12 VDC)	nA	0.01	<0.1	-
Peak current ²	A	-	30	45
Operating temperature	°C	-56	+25	+105
ESD pulse withstand ²	# pulses	20	>500 ¹	-

Notes:

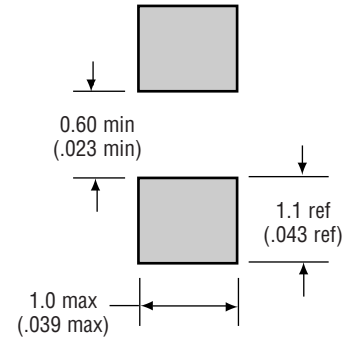
1. Some shifting in characteristics may occur when tested over several hundred ESD pulses at very rapid rate of 1 pulse per second or faster.
2. Per IEC 61000-4-2, 30A @ 8kV, level 4, clamp measurement made 30ns after initiation of pulse, all tests in contact discharge mode.
3. Trigger measurement made using Transmission Line Pulse (TLP) method
4. PolySURG™ devices are capable of withstanding up to a 15 kV, 45A ESD pulse. Device ratings are given at 8kV per Note 1, unless otherwise specified.

Product Dimension

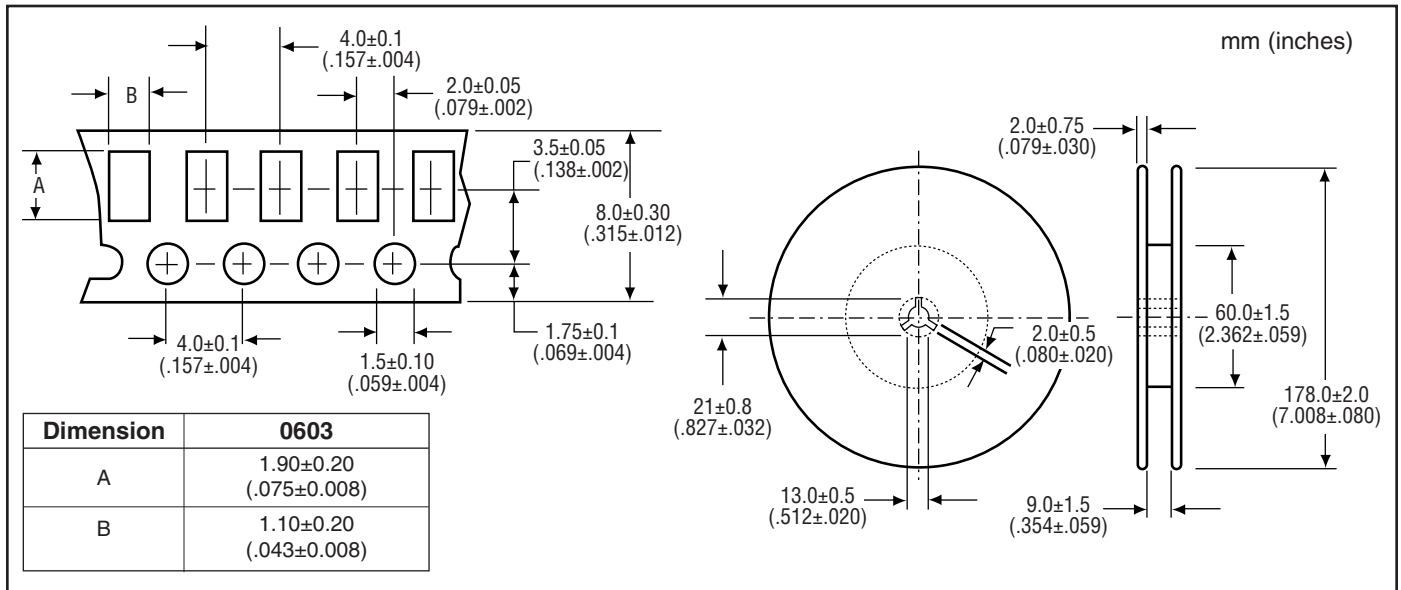


EIA Size mm (in)	L	W	H	T	R
0603ESDA	1.60 ± 0.10 (.063 ± .004)	0.80 ± 0.10 (.031 ± .004)	0.50 ± 0.10 (.020 ± .004)	0.30 ± 0.20 (.012 ± .008)	0.70 ± 0.10 (.028 ± .004)

Recommended Solder Pad Outline
(per IPC-SM-782)



Tape-and-Reel Specification



Environmental Specifications:

- Moisture Resistance per EIA/IS-722 Paragraph 4.4.2. This standard is based upon MIL-STD-202G Method 103B but with temperature and relative humidity at +85°C and 85% RH respectively. Test condition 'A' (240Hr) per MIL-STD-202G
- Thermal shock: MIL-STD-202, Method 107G, -55°C to 125°C, 30 min. cycle, 10 cycles
- Vibration: MIL-STD-202F, Method 201A, (10 to 55 to 10 Hz, 1 min. cycle, 2 hrs each in X-Y-Z)
- Chemical resistance: ASTM D-543, 4 hrs @ 40°C, 3 solutions (H₂O, detergent solution, defluxer)
- Operating temperature characteristics, measurement at +25°C, +105°C and -56°C
- Full load voltage: 14.4VDC, 18VDC & 24VDC for 1000 hrs, 25°C
- Solder leach resistance and terminal adhesion: Per EIA-576
- Solderability: MIL-STD-202, Method 208 (95% coverage)

Device Marking

ESDA devices are marked on the tape and reel packages, not individually. Since the product is bi-directional and symmetrical, no orientation marking is required.

Design Consideration

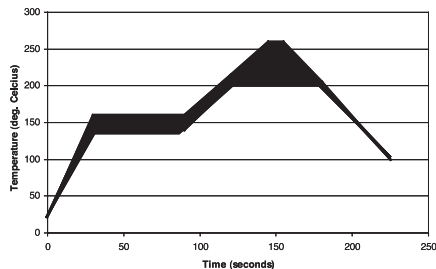
The location in the circuit for the TR series has to be carefully determined. For better performance, the device should be placed as close to the signal input as possible and ahead of any other component. Due to the high current associated with an ESD event, it is recommended to use a "0-stub" pad design (pad directly on the signal/data line and second pad directly on common ground).

Processing Recommendations

The TR series currently has a convex profile on the top surface of the part. This profile is a result of the construction of the device. They can be processed using standard pick-and-place equipment. The placement and processing techniques for these devices are similar to those used for chip resistors and chip capacitors.

Soldering Recommendations

- Compatible with lead and lead-free solder reflow processes
- Peak reflow temperatures and durations:
 - IR Reflow = 260°C max for 10 sec. max.
 - Wave Solder = 260°C max. for 10 sec. max.
- Recommended IR Reflow Profile:



ESD Protection of Set Top Appliances with PolySURG™ ESDA Devices



What Are Set Top Boxes?

The continuing trend is to link broadband signal delivery to the home entertainment display, and other devices via set top boxes. Set top boxes used to be just an analog cable tuner/decoder but now it includes the likes of digital cable, satellite controller, internet service controllers, digital video recording systems and home networking.

These devices allow the various cable and satellite signal operators to deliver a wide variety of services from television to internet and the hardware manufacturers can provide many features and benefits including home networking capabilities. There is digital video recording onto hard disk drives, replacing the cassette format, allowing pause and replay of and live television, or interactive TV. There are new standards being created to facilitate the design of the boxes such as a recent reference blueprint development by communications chipmaker Broadcom using the Microsoft interactive TV software system. The set top box is going to be a high volume commodity with many forms and functions.

Why are Set Top boxes vulnerable to ESD

The more sophisticated boxes include a variety of I/O jacks such as front panel USB, Audio/Video, S-Video, rear panel Satellite, cable, TV antenna, Wireless transmitter connection, home networking HPNA option, Toslink digital input, connections for CD, DVD, VCR, Outputs for Video, Audio, and more. Most of these jacks are susceptible to ESD threat.

The PolySURG™ solution to the ESD protection problem

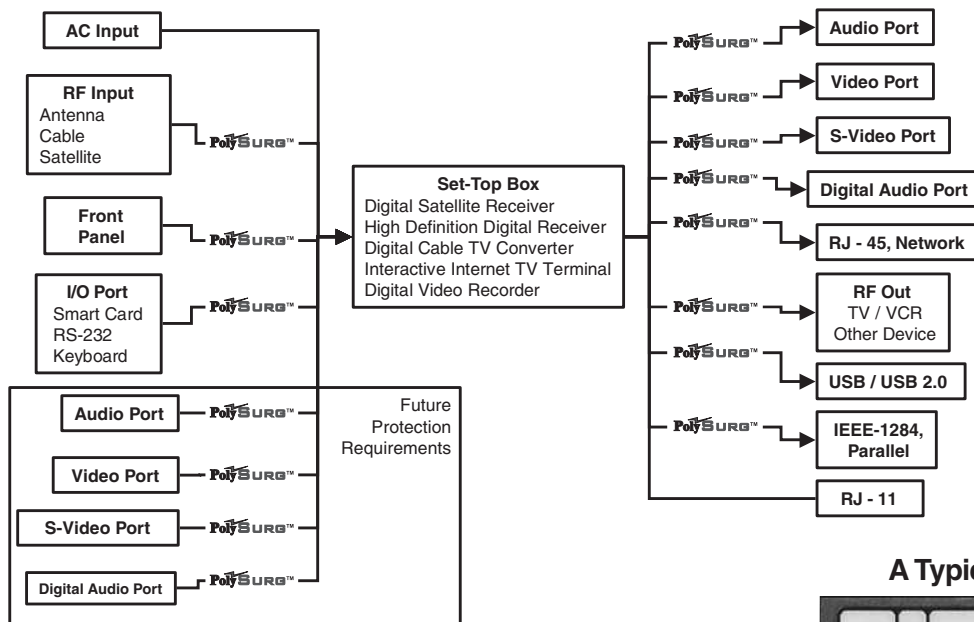
Utilize the 0402ESDA-MLP, 0603ESDA-MLP, or 0603ESDA-TR1 PolySURG™ devices to protect the set top box electronics from catastrophic ESD damage at each potential outside metal contact or connector on each line. Audio, Video, RF, USB and RS-232 lines may be protected from ESD TVS occurrences on set top systems.

Design Wins with Set Top boxes

Cooper Electronic Technologies has recorded some notable design wins already with it's PolySURG™ ESD Suppression devices in applications involving the protection of set top systems.



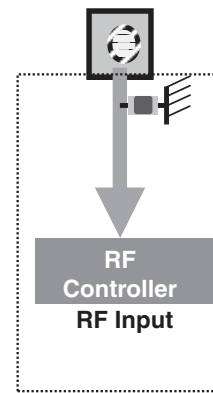
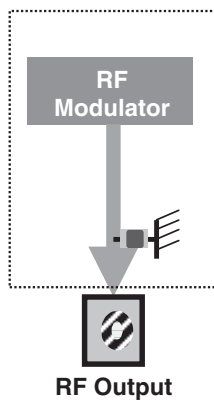
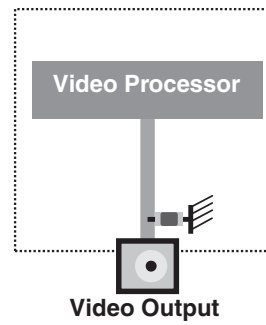
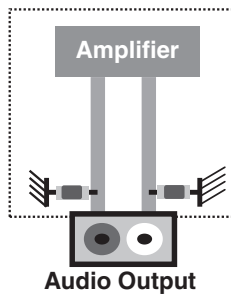
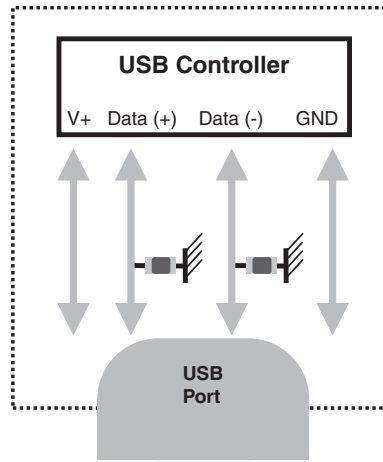
Protection Against ESD Threat for Set Top System Input/Output Ports with PolySURG™



A Typical Set Top Box Rear View



**Typical ESD Protection Applications with
 PolySURG™ 0402ESDA-MLP, 0603ESDA-MLP, or 0603ESDA-TR**



ESD Protection of High-Speed Data Lines

DVI/HDMI High Speed Data Rates

Communication data lines continue to be increasingly vulnerable to ESD transients. The ever-increasing bandwidth of the faster data lines such as the 10/100 or Gigabit Ethernet, USB 2.0, IEEE-1394b, make the traditional ESD protection schemes such as silicon based devices, or multi layer varistors less desirable, due to signal distortion from the relatively high capacitance of these components.

PolySURG™ ESDA Product Family

The typical capacitance of the ESDA device (0402ESDA-MLP, 0603ESDA-MLP, or 0603ESDA-TR) is measured to be below 0.15pF, in a range of 0.1 kHz to nearly 2 GHz. The low capacitance throughout this wide frequency range makes these devices suitable for ESD protection of low analog signals to fast digital data lines.

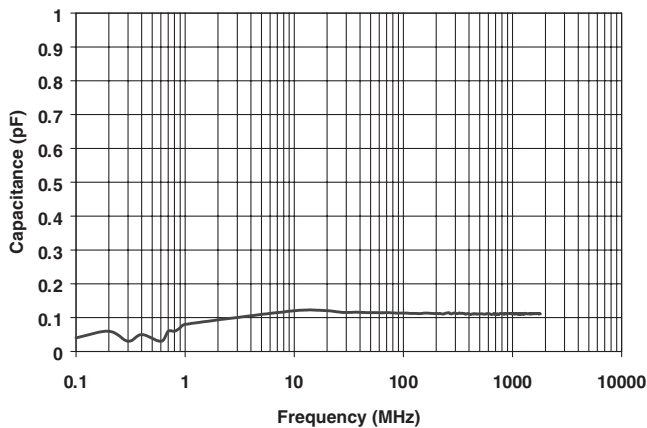


Chart 1. The Capacitance of 0603ESDA from 0.1MHz to 1.8GHz

ESDA Family Devices

Another special characteristic of the ESDA family device is that it is virtually invisible to the circuit at normal operation. The off-state resistance of the device is over 10^{13} Ohms, and the typical current leakage of the device is a negligible, 0.01nA at 12VDC. As Chart 2 shows, the additional attenuation in a 50ohm circuit measured at frequencies up to 6GHz is less than -0.2dbB.

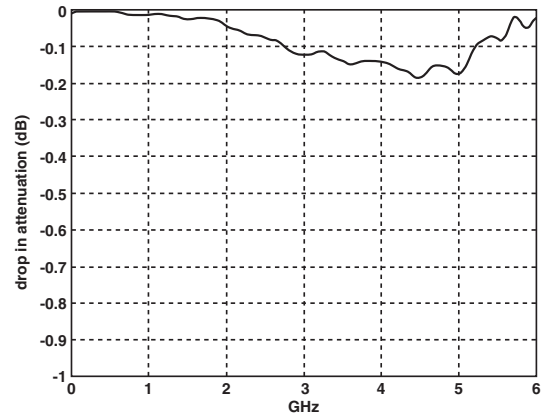


Chart 2. Additional Attenuation in a 50ohm System due to 0603ESDA

Example of devices that ESDA family devices can protect from ESD:

- Network interface cards for desktops
- PC cards for laptops
- DSL / Cable modems.
- Routers and switches /hubs

Selected Protection Applications

Ethernet ports: The RJ-45 is the most common Ethernet connection. The typical 10Base-T/100Base-TX uses 4 out of 8 lines. Each line in use can be protected with one ESDA family device installed between the data line and the ground. For the best performance, place the devices at the closest location to the RJ-45 port (See Figure 1)

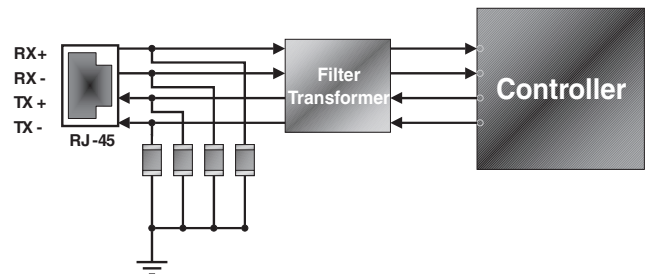


Figure 1. The ESD Protection of 10 / 100 Ethernet (RJ-45) device with an ESDA family device

Firewire: The IEEE-1394 (Firewire) series are the newest serial ports for computer and other instruments with data transfer rates up to 1,600Mbps (1394a is 400Mbps, and 1394b will be 800~1,600Mbps.) This higher transfer speed data is more easily subject to distortion (Chart 3). The 0603ESDA can protect data lines from ESD without distorting the high speed signal possible from IEEE-1394 connection. All data lines should be protected individually. (See Figure 2)

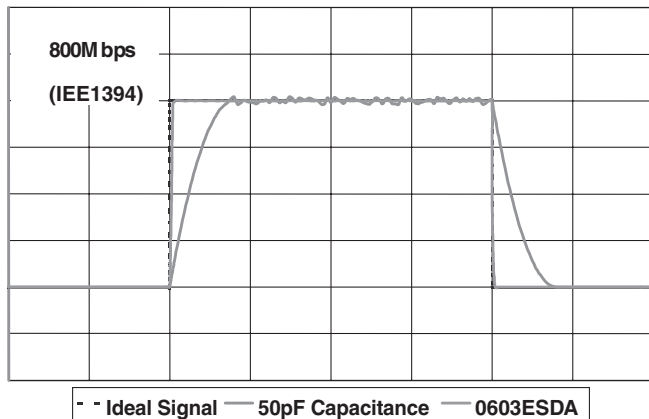


Chart 3. Signal distortion comparisons at 800Mbps

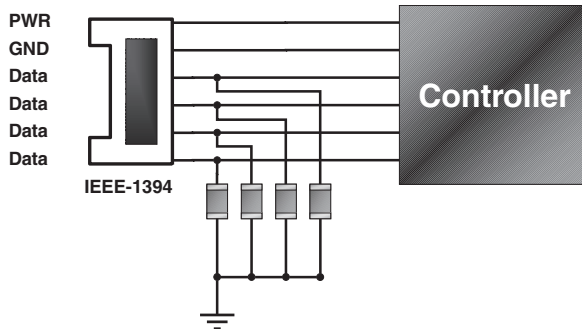


Figure 2. The ESD Protection of Typical IEEE-1394a device with an ESDA family device

Example of devices that ESDA family devices can protect from ESD:

- Firewire interface cards
- Digital camcorders
- Printers / scanners
- Other peripherals with Firewire capability

USB 2.0: The USB 2.0 has a fast data transfer rate of 400Mbps. A device equipped with USB 2.0 will give the best performance when protected with the ultra low capacitance ESDA family device. This will result in much less data distortion than if zener diodes or multi layer varistors are used for ESD protection (See Figure 3)

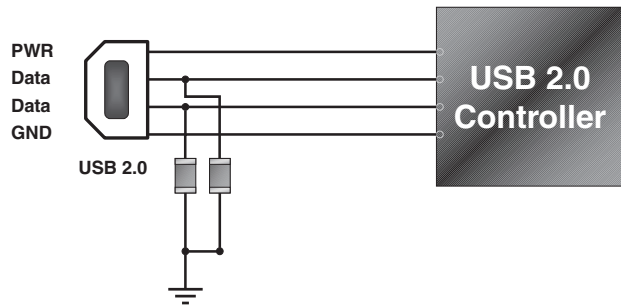


Figure 3. ESD protection of USB 2.0 devices with an ESDA family device

Special Applications

When the unused data port is connected to a higher operating voltage such as 24V or higher for special applications, the ESDA family device can be installed in series for ESD protection on the higher voltage line. The operating voltage capability will be increased without changing total capacitance or the current leakage of the devices.

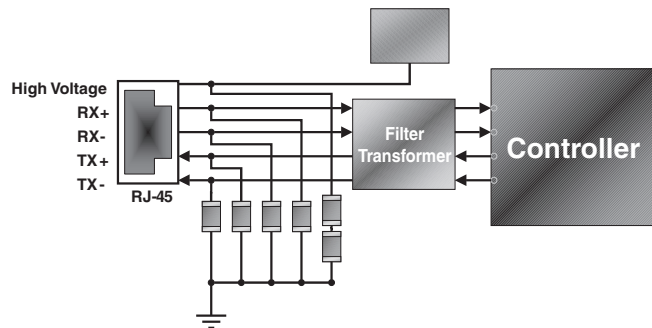


Figure 4. The Parallel connection for high voltage line protection using an ESDA family device on RJ-45

ESD Protection for High Speed Digital Video Solutions (DVI & HDMI)

High speed, uncompressed, digital video solutions such as Digital Visual Interface (DVI) and High Definition Multimedia Interface (HDMI) utilize small geometry CMOS processes in order to provide maximum performance in a small package. However these geometries are more susceptible to electrostatic discharge (ESD) and the high-speed digital signals present a real challenge when selecting an appropriate protection device.

DVI/HDMI High Speed Data Rates

DVI equipment can, currently, transmit at up to 1.6 Gbps for a 1600 x 1200 resolution signal. The receiver end can support up to 1.08 Gbps for 1280 x 1024 resolution but will soon increase to 1.65 Gbps. HDMI is an advancement of DVI that handles both audio and video signals with enough bandwidth for data rates of up to 5 Gbps. These high-speed data rates require any ESD protection device to have low capacitance in order to minimize signal distortion. At high frequency any capacitance will be seen as a low impedance path to ground, thus loading the data signal. Figure 1 shows the minimal effect of a PolySURG™ ESDA family device on an 800 Mbps data signal compared to a 50pF capacitor.

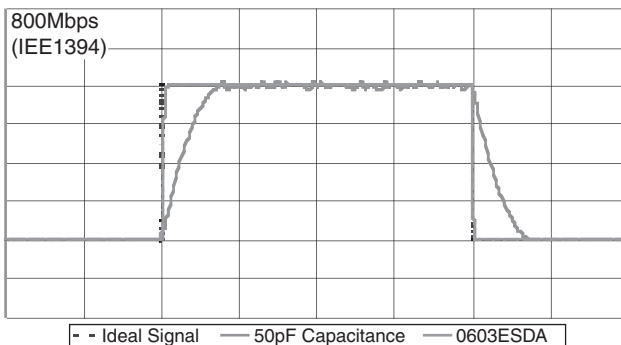


Figure 1 – IEE1394 Signal Distortion due to 50pF and 0603ESDA PolySURG™

Traditional low capacitance steering diode solutions have a number of problems when used in high-speed data applications such as HDMI & DVI. Diodes are typically connected rail to rail as shown in Figure 2. During a negative voltage transient the bottom diode conducts clamping the voltage to a diode drop below ground. During a positive voltage transient the top diode will conduct the surge current (I_1) into the power rail. Dumping the surge current into an unprotected supply rail can cause latch up of the protection circuit, so an additional transient voltage suppression (TVS) device between the supply rail and ground is required.

Typically discrete steering diodes are not rated for the high transient currents associated with ESD. This misuse results in a short cycle life and eventual diode failure, which is commonly in short circuit mode. This short circuit failure mode usually results in the equipment no longer functioning, even though the ESD event has passed. The preferred failure mode is open, since the equipment will certainly not operate with a shorted device, but has a potential to operate longer if the device were to fail open.

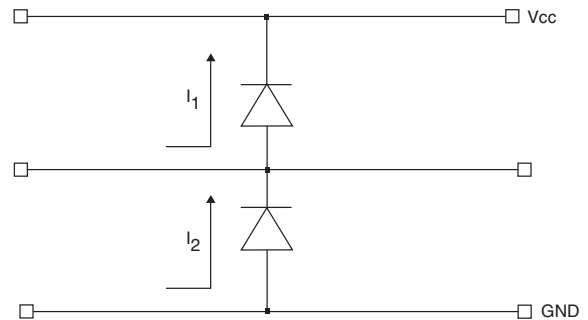


Figure 2 – Rail to Rail Diode Connection

In order to make a low capacitance diode a small junction area is used which presents a high resistance during ESD transients. Also, diode response time is slow compared to the ESD voltage rise time and the complete solution has significant parasitic inductance associated with the device leads and tracking. All this results in a large amount of voltage overshoot and a much higher clamping voltage. With the HDMI/DVI chip still exposed to several hundred or even one thousand volts following an ESD event, using this protection technique, there is potentially enough stress to damage the device.

Other solutions such as zener diodes, multi-layer varistors (MLV's) and TVS all exhibit levels of capacitance that are too large for them to be practical solutions in DVI and HDMI applications. With capacitance values from 25pF to 500pF coupled with leakage currents of 0.5-50µA the level of loading on the signal lines becomes unacceptable.

PolySURG™ ESDA Product Family

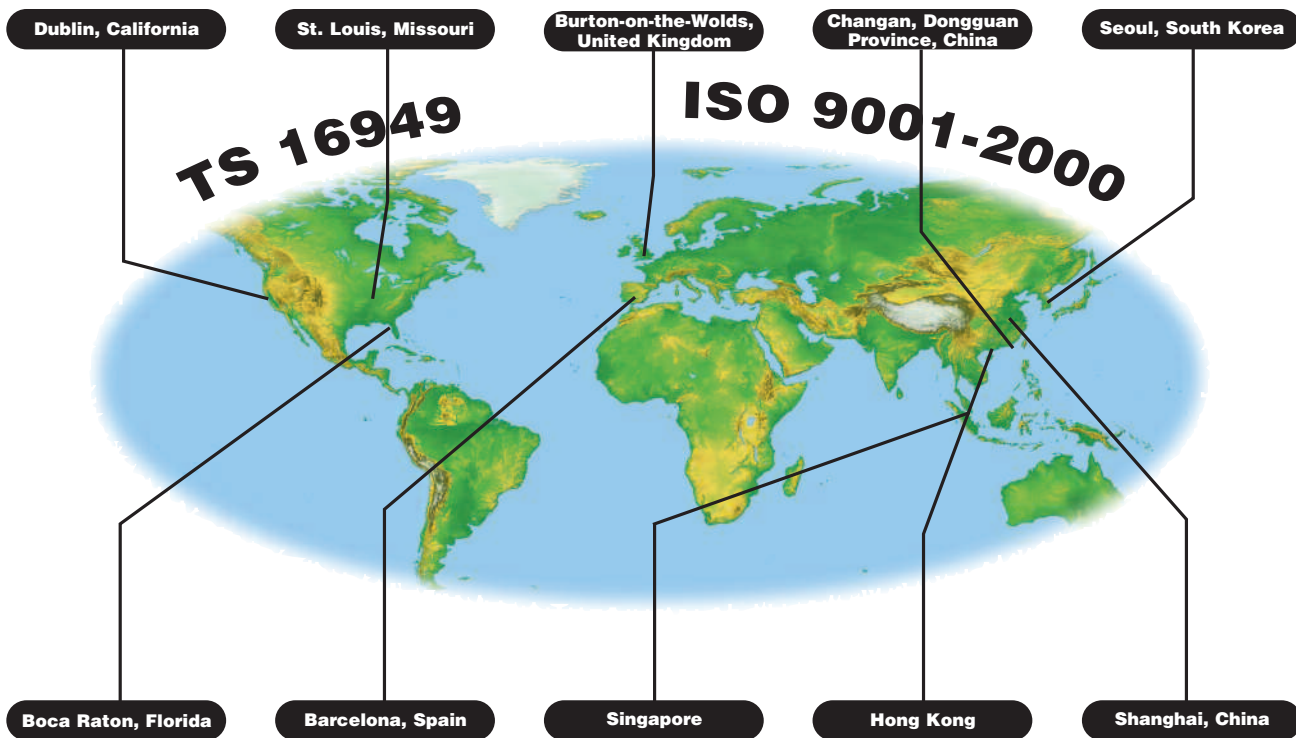
The PolySURG™ ESDA device from Cooper Bussmann provides the solution to the problem of providing ESD protection for these new high-speed circuits. This product is a bi-directional device that has leakage current of less than 1nA and capacitance less than 0.15pF. This ultra-low capacitance makes the PolySURG™ ESDA device a viable solution for high data rate protocols like HDMI and DVI. With an insertion loss of less than -0.2dB at frequencies up to 6GHz the PolySURG™ ESDA device is invisible to the circuit, introducing no additional loading or signal distortion.

The PolySURG™ ESDA product family is comprised of the 0402ESDA-MLP, 0603ESDA-MLP, and 0603ESDA-TR series ESD suppression devices. All are discrete devices exhibiting ultra-low capacitance to maintain signal integrity while protecting all but the most sensitive IC's from the harmful effects of ESD strikes up to 15kV (air discharge).

Summary

Commercial products require ESD surge protection of all the interface hardware schemes. New higher end consumer electronics are increasingly using high data rate protocols such as DVI and HDMI. The traditional protection devices have all been used with varying success, however the increase in data rates now indicates a need for ultra low capacitance devices, such as the PolySURG™ ESDA product family ESD suppression devices.

NOTES



This bulletin is intended to present product design solutions and technical information that will help the end user with design applications. Cooper Bussmann reserves the right, without notice, to change design or construction of any products and to discontinue or limit distribution of any products. Cooper Bussmann also reserves the right to change or update, without notice, any technical information contained in this bulletin. Once a product has been selected, it should be tested by the user in all possible applications.

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