



## Industry First Low Capacitance ESD Protection Arrays w/Backdrive Protection

### Features

- 2, 4, and 8 channels of ESD protection with integrated backdrive protection on all lines
- Provides ESD protection to IEC61000-4-2 Level 4
  - 8kV contact discharge
  - 15kV air discharge
- Low channel input capacitance of 1.0pF typical
- Minimal capacitance change with temperature and voltage
- Channel I/O to Gnd capacitance difference of 0.02pF typical is ideal for differential signals
- Mutual capacitance between signal pin and adjacent signal pin - 0.11pF typical
- Zener diode protects supply rail and eliminates the need for external by-pass capacitors
- Pin compatible with CM1213-02, -04, and -08
- Each I/O pin can withstand over 1000 ESD strikes
- Available in SOT, and MSOP packages
- Lead-free version available

### Applications

- USB2.0 ports at 480Mbps in desktop PCs, notebooks and peripherals
- IEEE1394 Firewire® ports at 400Mbps / 800Mbps
- DVI ports, HDMI ports in notebooks, set top boxes, digital TVs, LCD displays
- UDI and Displayport
- Serial ATA ports in desktop PCs and hard disk drives
- PCI Express ports
- General purpose high-speed data line ESD protection

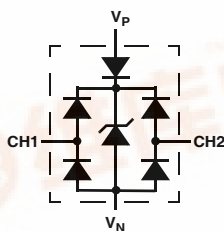
### Product Description

The CM1223 family of diode arrays has been designed to provide ESD protection for electronic components or sub-systems requiring minimal capacitive loading. These devices are ideal for protecting systems with high data and clock rates or for circuits requiring low capacitive loading. Each ESD channel consists of a pair of diodes in series which steer the positive or negative ESD current pulse to either the positive ( $V_P$ ) or negative ( $V_N$ ) supply rail. A Zener diode is embedded between  $V_P$  and  $V_N$ , absorbing positive ESD strikes and also providing ESD protection for the  $V_P$  rail. An additional diode is added in this device to serve as backdrive current protection. The CM1223 will protect against ESD pulses up to  $\pm 8kV$  per the IEC 61000-4-2 standard and using the MIL-STD-883D (Method 3015) specification for Human Body Model (HBM) ESD, all pins are protected from contact discharges of greater than  $\pm 15kV$ .

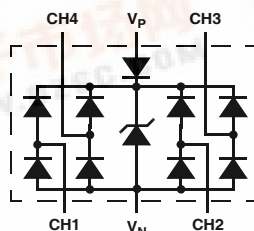
These devices are particularly well-suited for protecting systems using high-speed ports such as USB2.0, IEEE1394 (Firewire®, iLink™), Serial ATA, DVI, HDMI and corresponding ports in removable storage, digital camcorders, DVD-RW drives and other applications where extremely low loading capacitance with ESD protection are required in a small package footprint.

The CM1223 family of devices is available with optional lead-free finishing.

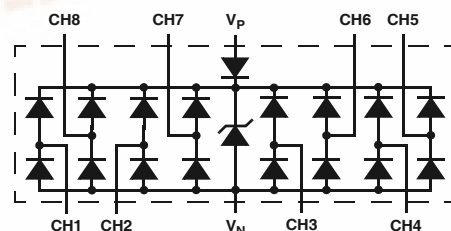
### Electrical Schematics



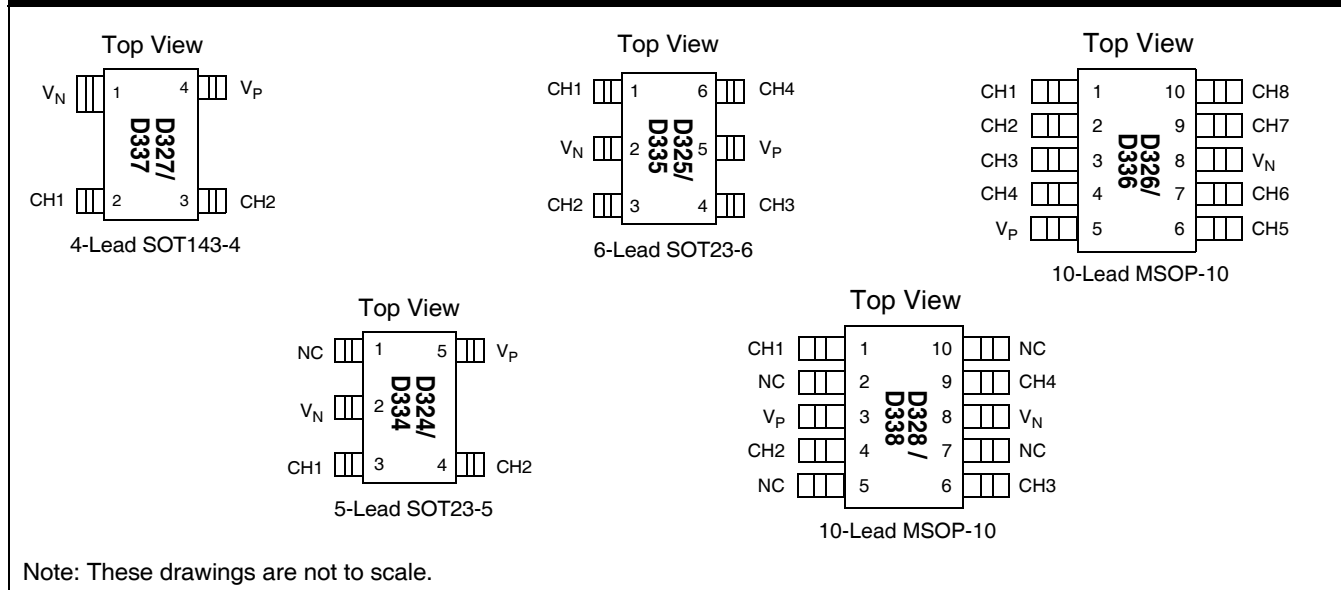
CM1223-02ST/SO  
CM1223-02SS/SR



CM1223-04ST/SO  
CM1223-04MS/MR



CM1223-08MS/MR

**PACKAGE / PINOUT DIAGRAMS**

**Pin Descriptions**

2-CHANNEL, 4-LEAD SOT143-4 PACKAGE			
PIN	NAME	TYPE	PIN
1	V <sub>N</sub>	GND	Negative voltage supply rail
2	CH1	I/O	ESD Channel
3	CH2	I/O	ESD Channel
4	V <sub>P</sub>	PWR	Positive voltage supply rail

2-CHANNEL, 5-LEAD SOT23-5 PACKAGE			
PIN	NAME	TYPE	DESCRIPTION
1	NC		No connect
2	V <sub>N</sub>	GND	Negative voltage supply rail
3	CH1	I/O	ESD Channel
4	CH2	I/O	ESD Channel
5	V <sub>P</sub>	PWR	Positive voltage supply rail

4-CHANNEL, 6-LEAD SOT23-6 PACKAGE			
PIN	NAME	TYPE	DESCRIPTION
1	CH1	I/O	ESD Channel
2	V <sub>N</sub>	GND	Negative voltage supply rail
3	CH2	I/O	ESD Channel
4	CH3	I/O	ESD Channel
5	V <sub>P</sub>	PWR	Positive voltage supply rail
6	CH4	I/O	ESD Channel

4-CHANNEL, 10-LEAD MSOP-10 PACKAGE			
PIN	NAME	TYPE	DESCRIPTION
1	CH1	I/O	ESD Channel
2	NC		No connect
3	V <sub>P</sub>	PWR	Positive voltage supply rail
4	CH2	I/O	ESD Channel
5	NC		No connect
6	CH3	I/O	ESD Channel
7	NC		No connect
8	V <sub>N</sub>	GND	Negative voltage supply rail
9	CH4	I/O	ESD Channel
10	NC		No connect

8-CHANNEL, 10-LEAD MSOP-10 PACKAGE			
PIN	NAME	TYPE	DESCRIPTION
1	CH1	I/O	ESD Channel
2	CH2	I/O	ESD Channel
3	CH3	I/O	ESD Channel
4	CH4	I/O	ESD Channel
5	V <sub>P</sub>	PWR	Positive voltage supply rail
6	CH5	I/O	ESD Channel
7	CH6	I/O	ESD Channel
8	V <sub>N</sub>	GND	Negative voltage supply rail
9	CH7	I/O	ESD Channel
10	CH8	I/O	ESD Channel

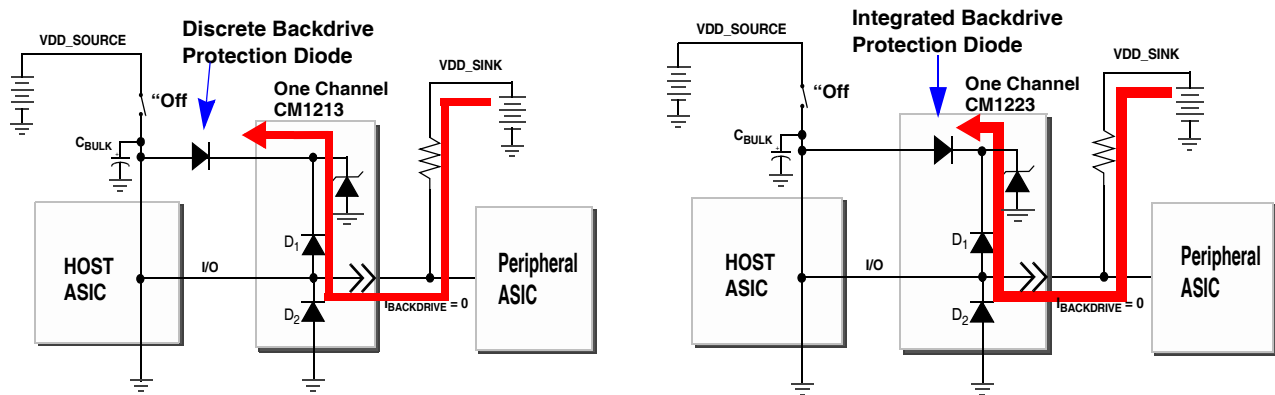
## Backdrive protection

Backdrive protection is needed to block against backdrive current flowing from a high potential voltage node toward a lower potential voltage node through the interface cable.

For example, consider a DVD player connected to a TV via an HDMI interface. If the DVD player is switched off and the TV is left on, there is a possibility of reverse current flow back into the main power supply rail of the DVD player. Typically, the DVD's power supply has some form of bulk supply capacitance associated with it. Because all CMOS logic exhibits a very high impedance on the power rail node when "off", if there is very little parasitic shunt resistance and as little as a few

milliamps of "backdrive" current flowing back into the power rail, it is possible over time to charge that bulk supply capacitance to some intermediate level. If this level rises above the power-on-reset (POR) voltage level of some of the integrated circuits, the DVD player may not reset properly when the DVD player is turned back on.

To avoid this situation, the CM1223 with integrated backdrive protection diode was designed to block backdrive current, guaranteeing no more than 5µA on any I/O pin when the I/O pin voltage is greater than the CM1223 supply voltage.



**Figure 1. Backdrive Protection Diagram.**

## Ordering Information

PART NUMBERING INFORMATION						
# of Channels	Leads	Package	Standard Finish		Lead-free Finish	
			Ordering Part Number <sup>1</sup>	Part Marking	Ordering Part Number <sup>1</sup>	Part Marking
2	5	SOT23-5	CM1223-02ST	D324	CM1223-02SO	D334
2	4	SOT143-4	CM1223-02SS	D327	CM1223-02SR	D337
4	6	SOT23-6	CM1223-04ST	D325	CM1223-04SO	D335
4	10	MSOP-10	CM1223-04MS	D328	CM1223-04MR	D338
8	10	MSOP-10	CM1223-08MS	D326	CM1223-08MR	D336

Note 1: Parts are shipped in Tape & Reel form unless otherwise specified.

## Specifications

ABSOLUTE MAXIMUM RATINGS		
PARAMETER	RATING	UNITS
Operating Supply Voltage ( $V_P - V_N$ )	6.0	V
Operating Temperature Range	-40 to +85	°C
Storage Temperature Range	-65 to +150	°C
DC Voltage at any channel input	( $V_N - 0.5$ ) to ( $V_P + 0.5$ )	V

STANDARD OPERATING CONDITIONS		
PARAMETER	RATING	UNITS
Operating Temperature Range	-40 to +85	°C
Package Power Rating		
SOT143-4 Package (CM1223-02SS/SR)	225	mW
SOT23-5 Package (CM1223-02ST/SO)	225	mW
SOT23-6 Package (CM1223-04ST/SO)	225	mW
MSOP-10 Package (CM1223-04MS/MR)	400	mW
MSOP-10 Package (CM1223-08MS/MR)	400	mW

**ELECTRICAL OPERATING CHARACTERISTICS (SEE NOTE 1)**

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
$V_P$	Operating Supply Voltage ( $V_P-V_N$ )			3.3	5.5	V
$I_P$	Operating Supply Current	$(V_P-V_N)=3.3V$			8.0	$\mu A$
$V_{SCL}$	Signal Clamp Voltage Positive Transients Negative Transients	$I_F = 8mA; T_A=25^\circ C$	6.7 0.60	8.2 0.80		V V
$I_{LEAK}$	Channel Leakage Current	$T_A=25^\circ C; V_P=5V, V_N=0V$		$\pm 0.1$	$\pm 1.0$	$\mu A$
$C_{IN}$	Channel Input Capacitance	At 1 MHz, $V_P=3.3V, V_N=0V, V_{IN}=1.65V$ ; Note 2 applies		1.0	1.5	pF
$\Delta C_{IN}$	Channel Input Capacitance Matching	At 1 MHz, $V_P=3.3V, V_N=0V, V_{IN}=1.65V$ ; Note 2 applies		0.02		pF
$C_{MUTUAL}$	Mutual Capacitance between signal pin and adjacent signal pin	At 1 MHz, $V_P=3.3V, V_N=0V, V_{IN}=1.65V$ ; Note 2 applies		0.11		pF
$V_{ESD}$	ESD Protection Peak Discharge Voltage at any channel input, in system a) Contact discharge per IEC 61000-4-2 standard b) Human Body Model, MIL-STD-883, Method 3015	Notes 2, 4 & 5; $T_A=25^\circ C$  Notes 2, 3 & 5; $T_A=25^\circ C$	$\pm 8$  $\pm 15$			kV  kV
$V_{CL}$	Channel Clamp Voltage Positive Transients Negative Transients	$T_A=25^\circ C, I_{PP} = 1A, t_P = 8/20\mu S$ ; Notes 2 & 5		+8.8 -1.4		V V
$R_{DYN}$	Dynamic Resistance Positive Transients Negative Transients	$T_A=25^\circ C, I_{PP} = 1A, t_P = 8/20\mu S$ Any I/O pin to Ground; Notes 2 & 5		0.7 0.4		$\Omega$ $\Omega$

Note 1: All parameters specified at  $T_A = -40^\circ C$  to  $+85^\circ C$  unless otherwise noted.

Note 2: These parameters guaranteed by design and characterization.

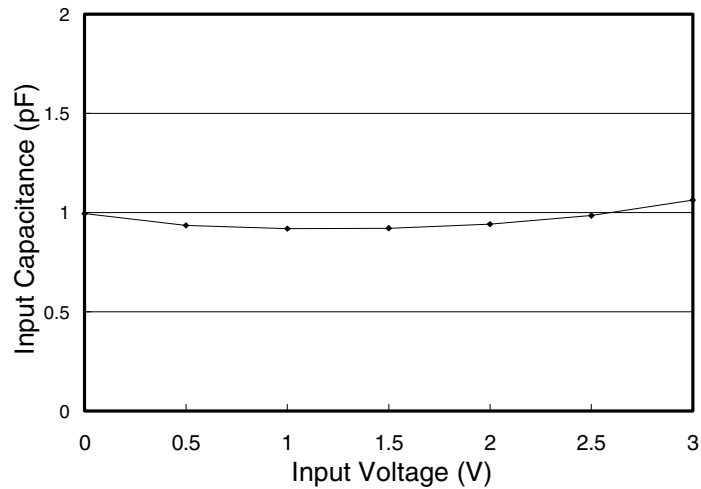
Note 3: Human Body Model per MIL-STD-883, Method 3015,  $C_{Discharge} = 100pF$ ,  $R_{Discharge} = 1.5K\Omega$ ,  $V_P = 3.3V$ ,  $V_N$  grounded.

Note 4: Standard IEC 61000-4-2 with  $C_{Discharge} = 150pF$ ,  $R_{Discharge} = 330\Omega$ ,  $V_P = 3.3V$ ,  $V_N$  grounded.

Note 5: These measurements performed with no external capacitor on  $V_P$  ( $V_P$  floating).

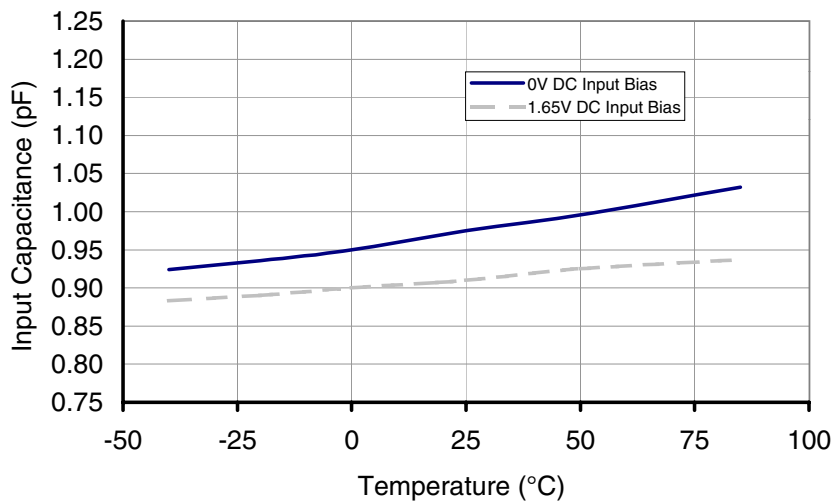
**Performance Information**

**Input Channel Capacitance Performance Curves**



**Typical Variation of  $C_{IN}$  vs.  $V_{IN}$**

( $f=1\text{MHz}$ ,  $V_P = 3.3\text{V}$ ,  $V_N = 0\text{V}$ ,  $0.1 \mu\text{F}$  chip capacitor between  $V_P$  and  $V_N$ ,  $25^\circ\text{C}$ )

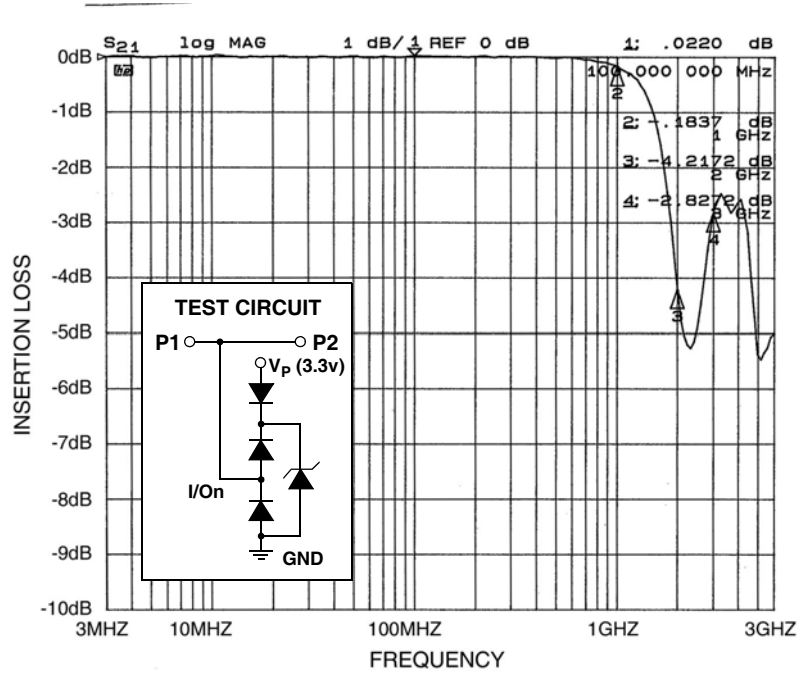


**Typical Variation of  $C_{IN}$  vs. Temp**

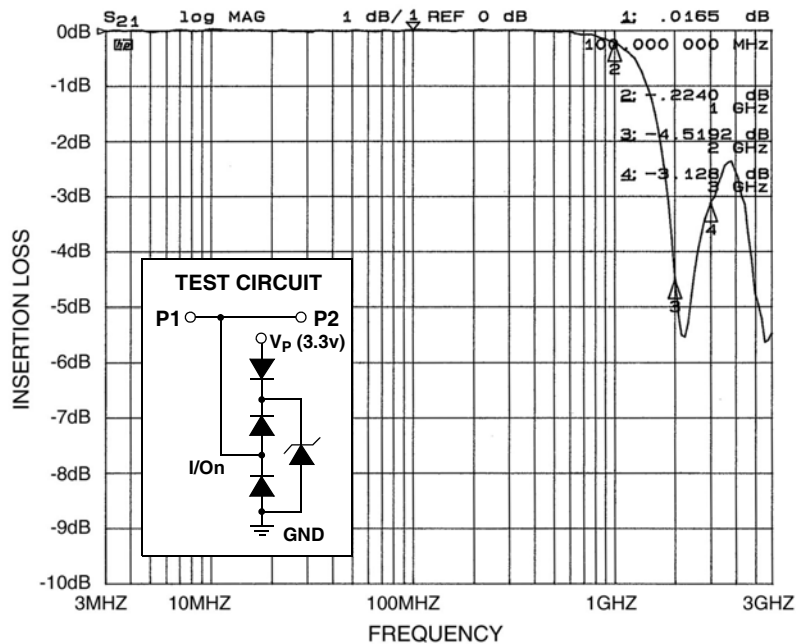
( $f=1\text{MHz}$ ,  $V_{IN}=30\text{mV}$ ,  $V_P = 3.3\text{V}$ ,  $V_N = 0\text{V}$ ,  $0.1 \mu\text{F}$  chip capacitor between  $V_P$  and  $V_N$ )

**Performance Information (Cont'd)**

Typical Filter Performance (nominal conditions unless specified otherwise, 50 Ohm Environment)



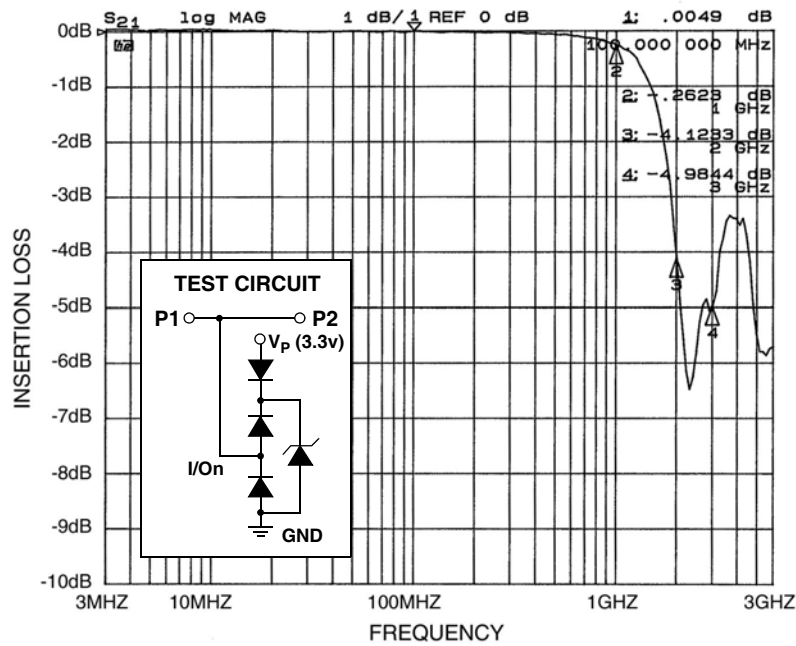
**Figure 2. Insertion Loss (S21) VS. Frequency (0V DC Bias,  $V_p=3.3V$ , MSOP-8 Package)**



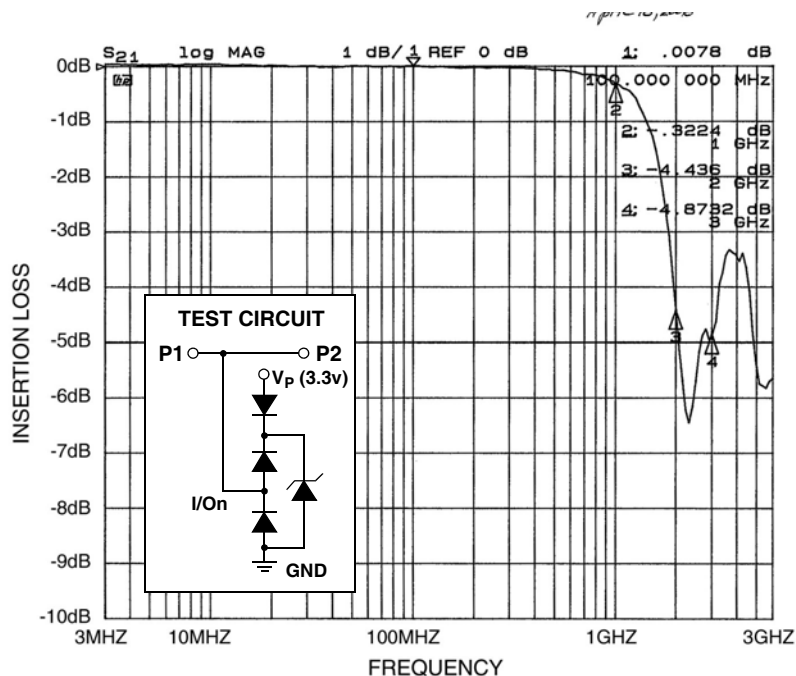
**Figure 3. Insertion Loss (S21) VS. Frequency (2.5V DC Bias,  $V_p=3.3V$ , MSOP-8 Package)**

**Performance Information (Cont'd)**

Typical Filter Performance (nominal conditions unless specified otherwise, 50 Ohm Environment)



**Figure 4. Insertion Loss (S21) VS. Frequency (0V DC Bias,  $V_p=3.3V$ , MSOP-10 Package)**



**Figure 5. Insertion Loss (S21) VS. Frequency (2.5V DC Bias,  $V_p=3.3V$ )**



## Application Information

### Design Considerations

In order to realize the maximum protection against ESD pulses, care must be taken in the PCB layout to minimize parasitic series inductances on the Supply/Ground rails as well as the signal trace segment between the signal input (typically a connector) and the ESD protection device. Refer to [Figure 6](#), which illustrates an example of a positive 8kV ESD pulse striking an input channel. The 8kV ESD current pulse will divert along the path as indicated in Figure 4, through the D1 diode and the Zener diode back to the ground rail.

An ESD current pulse can rise from zero to its peak value in a very short time. As an example, a level 4 contact discharge per the IEC61000-4-2 standard results in a current pulse that rises from zero to 30 Amps in 1ns. The CM1223 has a fast response time of less than 1ns and low clamp voltage to handle this pulse.

Similarly for negative ESD pulses, parasitic series inductance from the  $V_N$  pin to the ground rail will lead to drastically increased negative voltage on the line being protected.

The CM1223 has an integrated backdrive diode between  $V_P$  and  $V_N$  to prevent backdrive current flow from the powered sources.

As a general rule, the ESD Protection Array should be located as close as possible to the point of entry of expected electrostatic discharges.

### Additional Information

See also California Micro Devices Application Note AP209, "Design Considerations for ESD Protection", in the Applications section at [www.cmd.com](http://www.cmd.com).

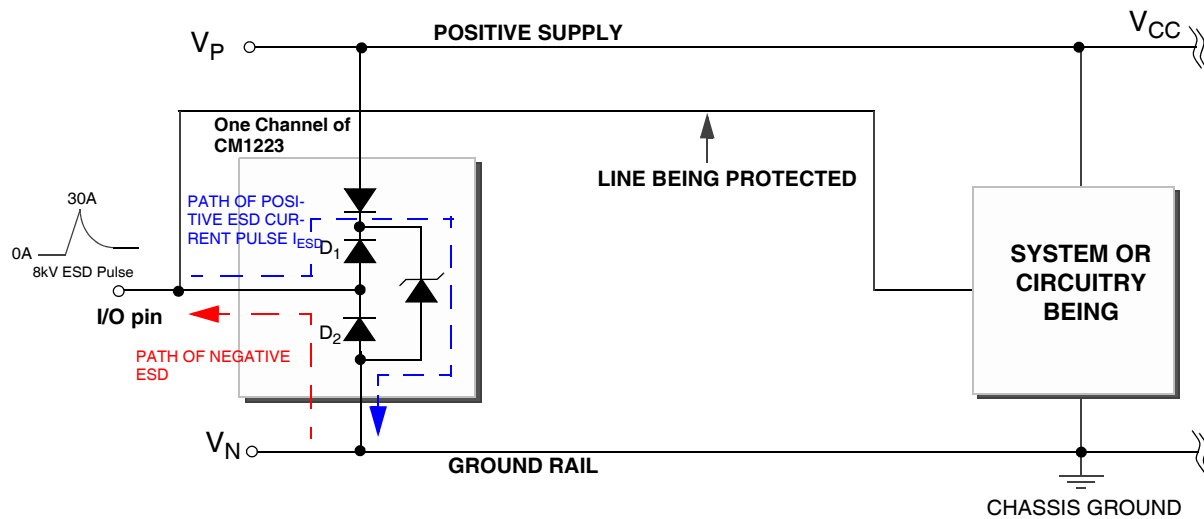


Figure 6. Application of Positive ESD Pulse between Input Channel and Ground

## Mechanical Details

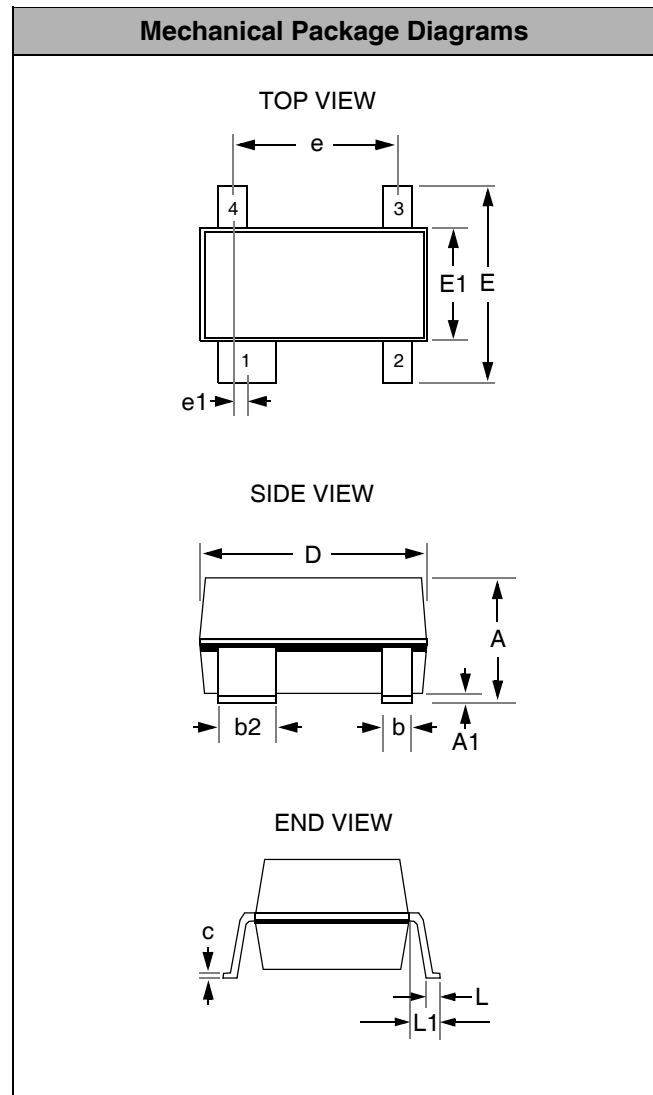
The CM1223 is available in SOT143-4, SOT23-5, SOT23-6, and MSOP-10 packages with a lead-free finishing option. The various package drawings are presented below.

### SOT143 Mechanical Specifications

Dimensions for CM1223-02SS/SR devices supplied in 4-pin SOT143 packages are presented below.

For complete information on the SOT143, see the California Micro Devices SOT143 Package Information document.

PACKAGE DIMENSIONS				
Package	SOT143			
Pins	4			
Dimensions	Millimeters		Inches	
	Min	Max	Min	Max
A	0.80	1.22	0.031	0.048
A1	0.05	0.15	0.002	0.006
b	0.30	0.50	0.012	0.019
b2	0.76	0.89	0.030	0.035
c	0.08	0.20	0.003	0.008
D	2.80	3.04	0.110	0.119
E	2.10	2.64	0.082	0.103
E1	1.20	1.40	0.047	0.055
e	1.92 BSC		0.075 BSC	
e1	0.20 BSC		0.008 BSC	
L	0.4	0.6	0.016	0.024
L1	0.54 REF		0.021 REF	
# per tape and reel	3000 pieces			
Controlling dimension: millimeters				



**Package Dimensions for SOT143.**

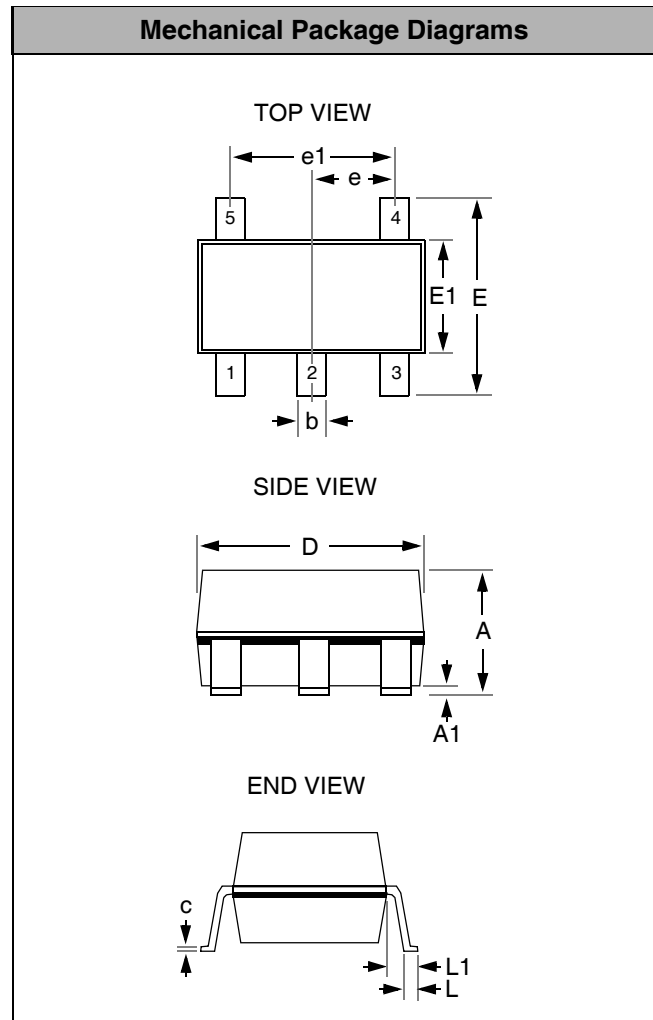
## Mechanical Details (cont'd)

### SOT23-5 Mechanical Specifications

Dimensions for CM1223-02ST/SO devices packaged in 5-pin SOT23 packages are presented below.

For complete information on the SOT23-5 package, see the California Micro Devices SOT23 Package Information document.

PACKAGE DIMENSIONS				
Package	SOT23-5 (JEDEC name is MO-178)			
Pins	5			
Dimensions	Millimeters		Inches	
	Min	Max	Min	Max
A	--	1.45	--	0.0571
A1	0.00	0.15	0.0000	0.0059
b	0.30	0.50	0.0118	0.0197
c	0.08	0.22	0.0031	0.0087
D	2.75	3.05	0.1083	0.1201
E	2.60	3.00	0.1024	0.1181
E1	1.45	1.75	0.0571	0.0689
e	0.95 BSC		0.0374 BSC	
e1	1.90 BSC		0.0748 BSC	
L	0.30	0.60	0.0118	0.0236
L1	0.60 REF		0.0236 REF	
# per tape and reel	3000 pieces			
Controlling dimension: millimeters				



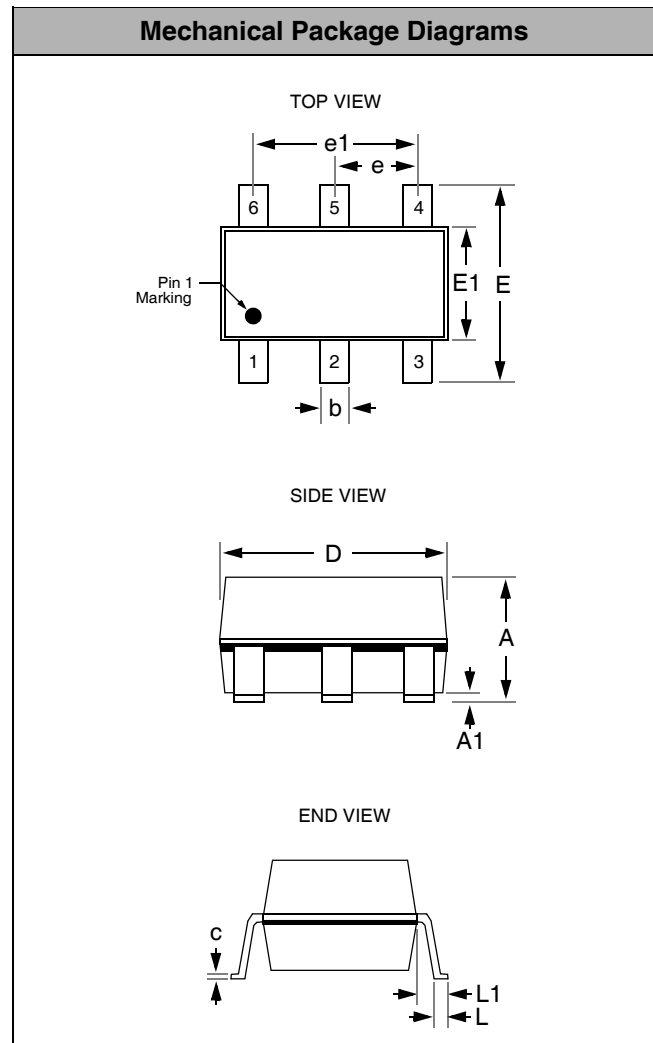
## Mechanical Details (cont'd)

### SOT23-6 Mechanical Specifications

CM1223-04ST/SO devices are packaged in 6-pin SOT23 packages. Dimensions are presented below.

For complete information on the SOT23-6 package, see the California Micro Devices SOT23 Package Information document.

PACKAGE DIMENSIONS				
Package	SOT23-6 (JEDEC name is MO-178)			
Pins	6			
Dimensions	Millimeters		Inches	
	Min	Max	Min	Max
A	--	1.45	--	0.0571
A1	0.00	0.15	0.0000	0.0059
b	0.30	0.50	0.0118	0.0197
c	0.08	0.22	0.0031	0.0087
D	2.75	3.05	0.1083	0.1201
E	2.60	3.00	0.1024	0.1181
E1	1.45	1.75	0.0571	0.0689
e	0.95 BSC		0.0374 BSC	
e1	1.90 BSC		0.0748 BSC	
L	0.30	0.60	0.0118	0.0236
L1	0.60 REF		0.0236 REF	
# per tape and reel	3000 pieces			
Controlling dimension: millimeters				



Package Dimensions for SOT23-6.

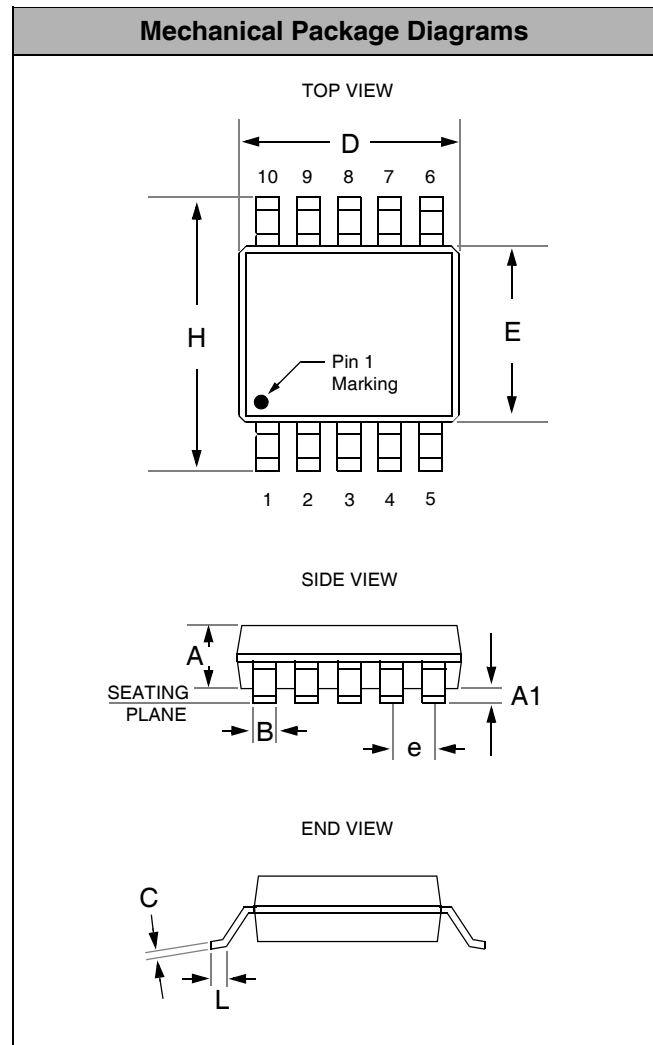
## Mechanical Details (cont'd)

### MSOP-10 Mechanical Specifications

CM1223-04MS/MR and CM1223-08MS/MR devices are packaged in 10-pin MSOP packages. Dimensions are presented below.

For complete information on the MSOP-10 package, see the California Micro Devices MSOP Package Information document.

PACKAGE DIMENSIONS				
Package	MSOP			
Pins	10			
Dimensions	Millimeters		Inches	
	Min	Max	Min	Max
<b>A</b>	0.75	0.95	0.028	0.038
<b>A1</b>	0.05	0.15	0.002	0.006
<b>B</b>	0.17	0.27	0.007	0.011
<b>C</b>	0.18		0.007	
<b>D</b>	2.90	3.10	0.114	0.122
<b>E</b>	2.90	3.10	0.114	0.122
<b>e</b>	0.50 BSC		0.0196 BSC	
<b>H</b>	4.80	5.00	0.187	0.197
<b>L</b>	0.40	0.70	0.0137	0.029
<b># per tape and reel</b>	4000			
Controlling dimension: millimeters				



**Package Dimensions for MSOP-10**