RClamp0554S
RailClamp®
Low Capacitance TVS Diode Array

PROTECTION PRODUCTS - RailClamp®

Description

A RailClamp® is a low capacitance TVS array designed to protect high speed data interfaces. This series has been specifically designed to protect sensitive components which are connected to data and transmission lines from overvoltage caused by electrostatic discharge **(ESD)**, electrical fast transients **(EFT)**, and **lightning.**

The unique design incorporates eight surge rated, low capacitance steering diodes and a TVS diode in a single package. During transient conditions, the steering diodes direct the transient to either the positive side of the power supply line or to ground. The internal TVS diode prevents over-voltage on the power line, protecting any downstream components.

The RClamp®0554S is in a 6-lead SOT-23 package. The leads are finished with lead-free matte tin. Each device will protect up to four high-speed lines. They may be used to meet the ESD immunity requirements of IEC 61000-4-2, Level 4 (15kV air, 8kV contact discharge). The combination of small size, low capacitance, and high surge capability makes them ideal for use in applications such as Ethernet, USB 2.0, and video interfaces.

Features

- ESD protection for high-speed data lines to
  IEC 61000-4-2 (ESD) ±15kV (air), ±8kV (contact)
  IEC 61000-4-4 (EFT) 40A (5/50ns)
  IEC 61000-4-5 (Lightning) 25A (8/20µs)
- Array of surge rated diodes with internal TVS Diode
- Small package saves board space
- Protects four I/O lines and Voltage Bus
- Low capacitance: 5pF (VR=0V)
- Low clamping voltage
- Low operating voltage: 5.0V
- Solid-state silicon-avalanche technology

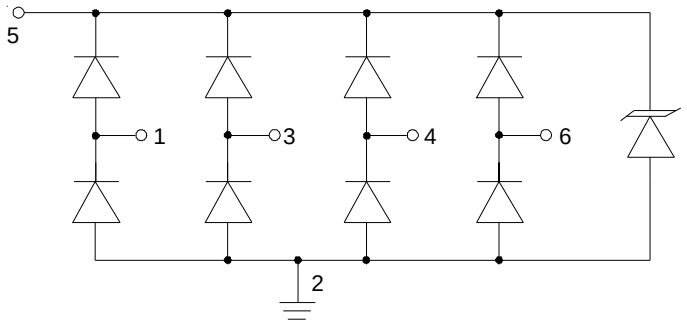
Mechanical Characteristics

- JEDEC SOT-23 6L package
- Pb-Free, Halogen Free, RoHS/WEEE Compliant
- Molding compound flammability rating: UL 94V-0
- Marking : Marking code + date code
- Packaging : Tape and Reel

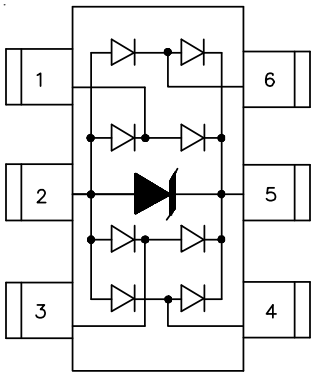
Applications

- USB 2.0 Power and Data Line Protection
- 10/100/1000 Ethernet
- Video Graphics Cards
- Monitors and Flat Panel Displays
- Digital Video Interface (DVI)
- Notebook Computers
- IEEE 1394 Firewire Ports

Circuit Diagram



Schematic and PIN Configuration



SOT-23 6L (Top View)

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Absolute Maximum Rating

Rating	Symbol	Value	Units
Peak Pulse Power (tp = 8/20μs)	P_{pk}	375	Watts
Peak Pulse Current (tp = 8/20μs)	I_{PP}	25	A
ESD per IEC 61000-4-2 (Air) ESD per IEC 61000-4-2 (Contact)	VESD	+/- 30 +/- 25	kV
Operating Temperature	T_J	-55 to +125	°C
Storage Temperature	T_{STG}	-55 to +150	°C

Electrical Characteristics (T=25°C)

Parameter	Symbol	Conditions	Minimum	Typical	Maximum	Units
Reverse Stand-Off Voltage	V_{RWM}				5	V
Reverse Breakdown Voltage	V_{BR}	I_t = 1mA	6			V
Reverse Leakage Current	I_R	V_{RWM} = 5V, T=25°C			0.5	μA
Clamping Voltage	V_C	I_{PP} = 1A, tp = 8/20μs Any I/O to GND			9.8	V
Clamping Voltage	V_C	I_{PP} = 10A, tp = 8/20μs Any I/O to GND			12	V
Clamping Voltage	V_C	I_{PP} = 25A, tp = 8/20μs Any I/O to GND			15	V
Junction Capacitance	C_j	Any I/O to GND V_R = 0V, f = 1MHz			5	pF
		I/O to I/O V_R = 0V, f = 1MHz		3		pF

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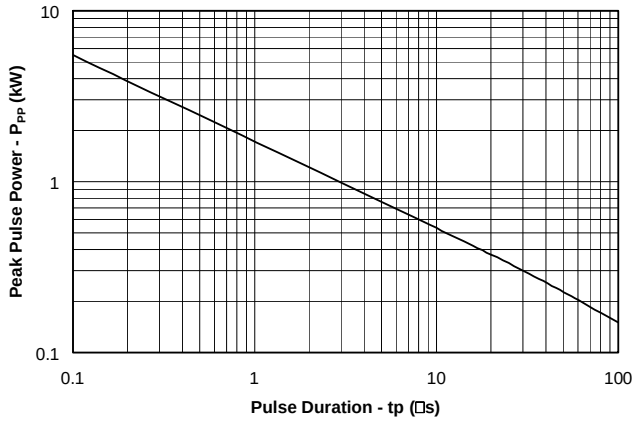
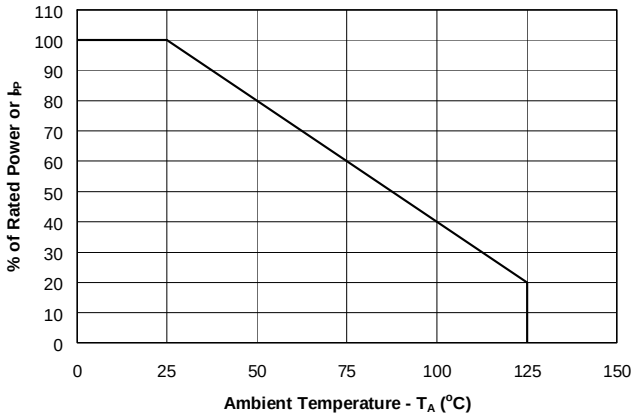
Typical Characteristics

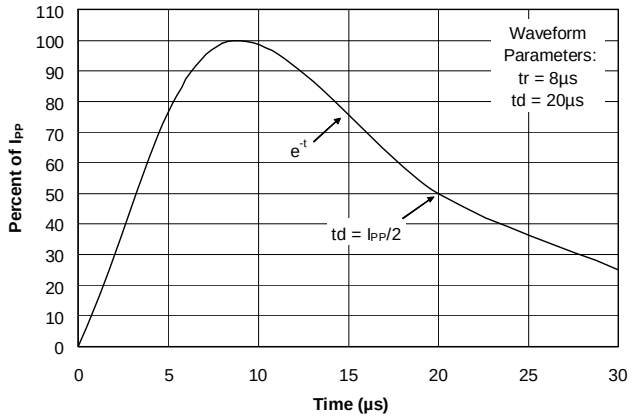
Non-Repetitive Peak Pulse Power vs. Pulse Time



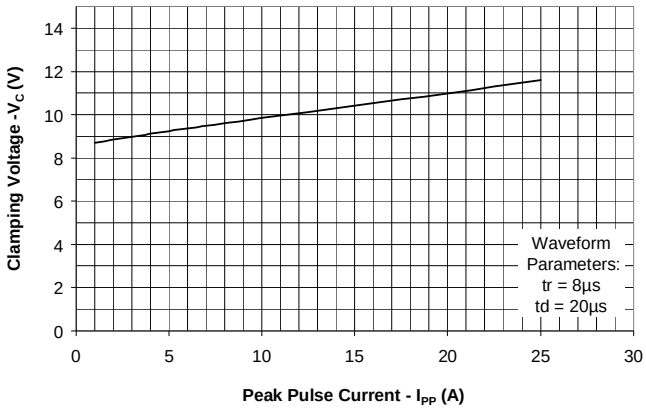
Power Derating Curve



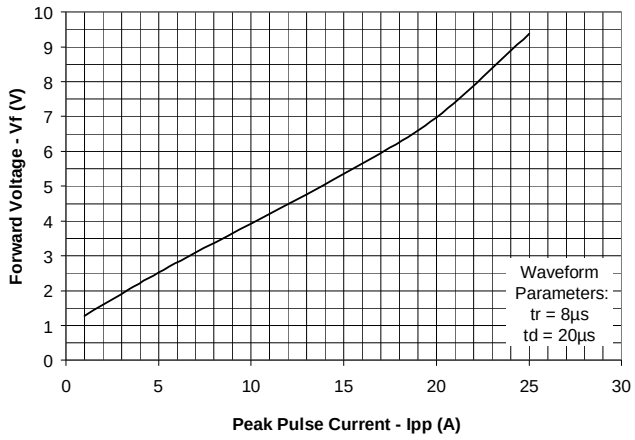
Pulse Waveform



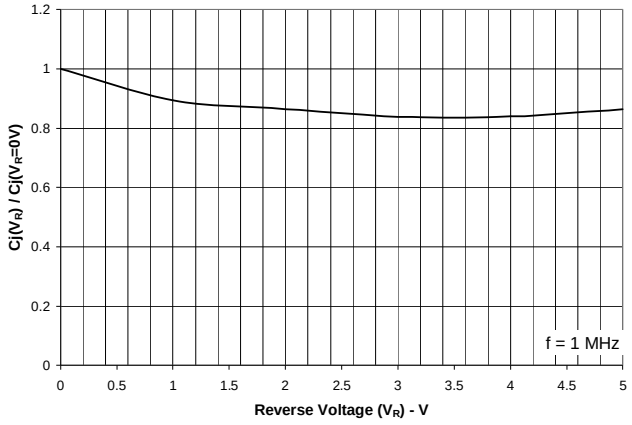
Clamping Voltage vs. Peak Pulse Current



Forward Voltage vs. Forward Current



Normalized Capacitance vs. Reverse Voltage



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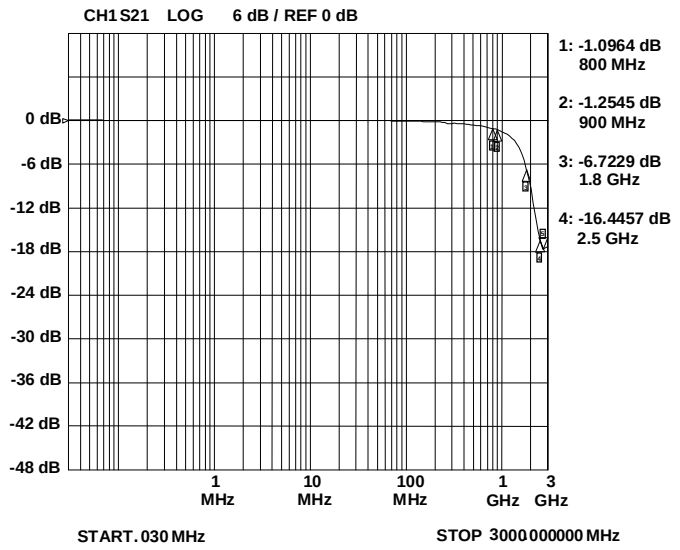
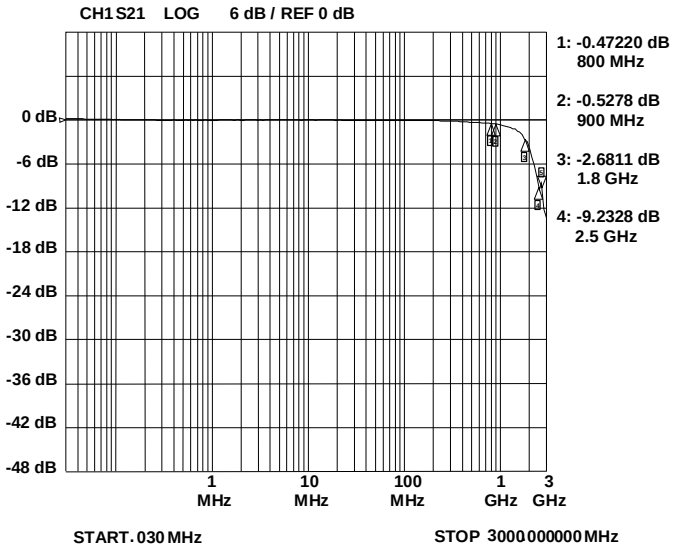
Applications Information

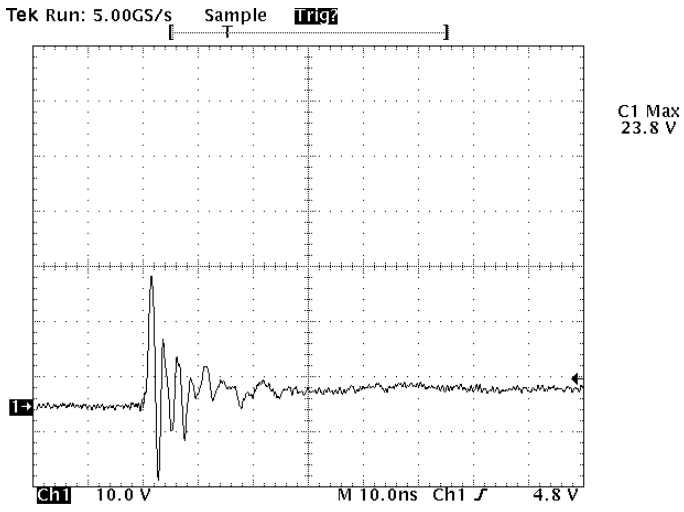
Insertion Loss S21 - Any I/O to GND



Insertion Loss S21 - I/O to I/O

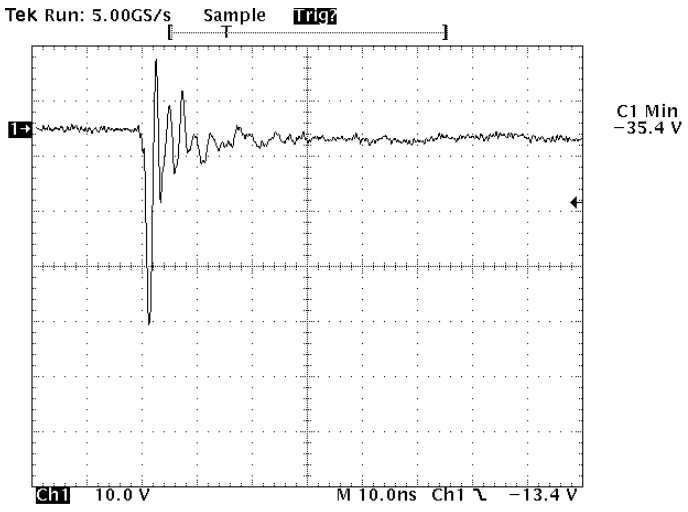


ESD Clamping - Between any I/O and GND (+8kV Contact per IEC 61000-4-2)



Note: Data is taken with a 10x attenuator

ESD Clamping - Between any I/O and GND (-8kV Contact per IEC 61000-4-2)



Note: Data is taken with a 10x attenuator

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Applications Information

Device Connection Options for Protection of Four High-Speed Data Lines

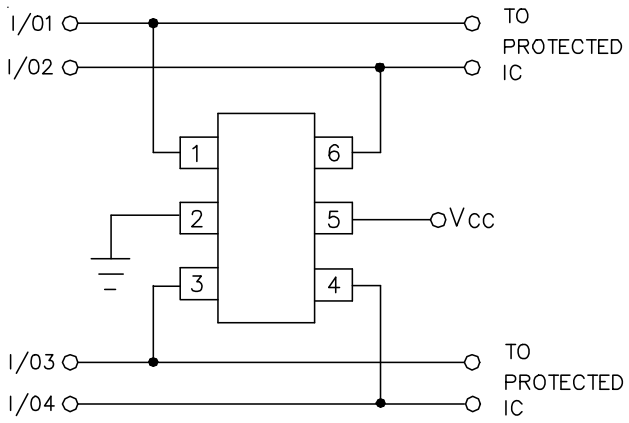
The RClamp0554S is designed to protect four data lines from transient over-voltages by clamping them to a fixed reference. When the voltage on the protected line exceeds the reference voltage (plus diode V_F) the steering diodes are forward biased, conducting the transient current away from the sensitive circuitry. Data lines are connected at pins 1, 3, 4 and 6. The negative reference (REF1) is connected at pin 2. This pin should be connected directly to a ground plane on the board for best results. The path length is kept as short as possible to minimize parasitic inductance. The positive reference (REF2) is connected at pin 5. The options for connecting the positive reference are as follows:

1. To protect data lines and the power line, connect pin 5 directly to the positive supply rail (V_{CC}). In this configuration the data lines are referenced to the supply voltage. The internal TVS diode prevents over-voltage on the supply rail.
2. The RClamp0554S can be isolated from the power supply by adding a series resistor between pin 5 and V_{CC}. A value of 100kΩ is recommended. The internal TVS and steering diodes remain biased, providing the advantage of lower capacitance.
3. In applications where no positive supply reference is available, or complete supply isolation is desired, the internal TVS may be used as the reference. In this case, pin 5 is not connected. The steering diodes will begin to conduct when the voltage on the protected line exceeds the working voltage of the TVS (plus one diode drop).

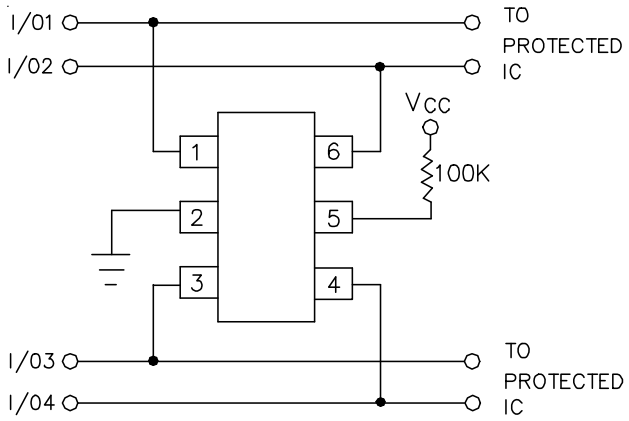
ESD Protection With RailClamps®

RailClamps are optimized for ESD protection using the rail-to-rail topology. Along with good board layout, these devices virtually eliminate the disadvantages of using discrete components to implement this topology. Consider the situation shown in Figure 1 where discrete diodes or diode arrays are configured for rail-to-rail protection on a high speed line. During positive duration ESD events, the top diode will be forward biased when the voltage on the protected line exceeds

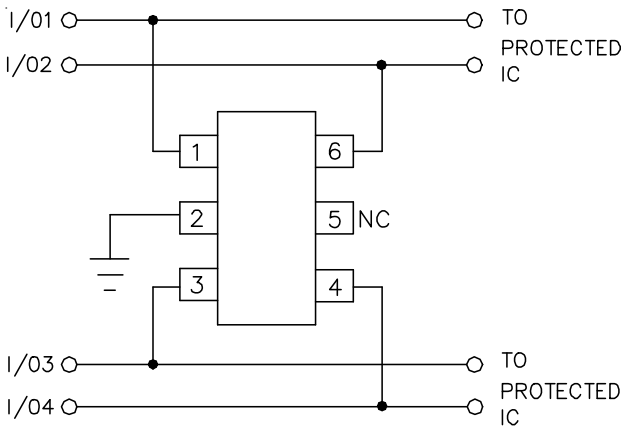
Data Line and Power Supply Protection Using Vcc as reference



Data Line Protection with Bias and Power Supply Isolation Resistor



Data Line Protection Using Internal TVS Diode as Reference



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Applications Information *(continued)*

the reference voltage plus the V_F drop of the diode. For negative events, the bottom diode will be biased when the voltage exceeds the V_F of the diode. At first approximation, the clamping voltage due to the characteristics of the protection diodes is given by:

$V_C = V_{CC} + V_F$ (for positive duration pulses)
$V_C = -V_F$ (for negative duration pulses)

However, for fast rise time transient events, the effects of parasitic inductance must also be considered as shown in Figure 2. Therefore, the actual clamping voltage seen by the protected circuit will be:

$V_C = V_{CC} + V_F + L_P\, di_{ESD}/dt$ (for positive duration pulses)
$V_C = -V_F - L_G\, di_{ESD}/dt$ (for negative duration pulses)

ESD current reaches a peak amplitude of 30A in 1ns for a level 4 ESD contact discharge per IEC 61000-4-2. Therefore, the voltage overshoot due to 1nH of series inductance is:

$V = L_P\, di_{ESD}/dt = 1X10^{-9}\ (30 / 1X10^{-9}) = 30V$

Example:
Consider a V_{CC} = 5V, a typical V_F of 30V (at 30A) for the steering diode and a series trace inductance of 10nH. The clamping voltage seen by the protected IC for a positive 8kV (30A) ESD pulse will be:

$V_C = 5V + 30V + (10nH \times 30V/nH) = 335V$

This does not take into account that the ESD current is directed into the supply rail, potentially damaging any components that are attached to that rail. Also note that it is not uncommon for the V_F of discrete diodes to exceed the damage threshold of the protected IC. This is due to the relatively small junction area of typical discrete components. It is also possible that the power dissipation capability of the discrete diode will be exceeded, thus destroying the device.

The RailClamp is designed to overcome the inherent disadvantages of using discrete signal diodes for ESD suppression. The RailClamp's integrated TVS diode

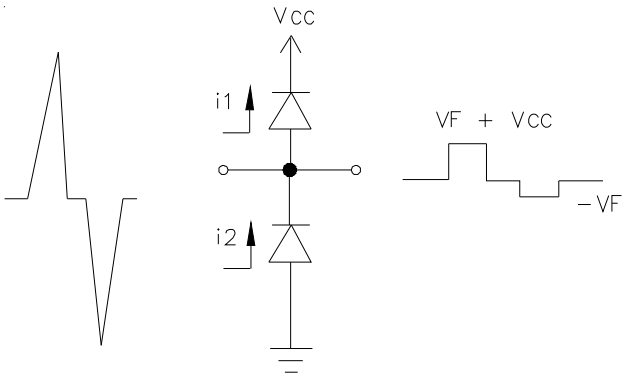

Figure 1 - "Rail-To-Rail" Protection Topology (First Approximation)

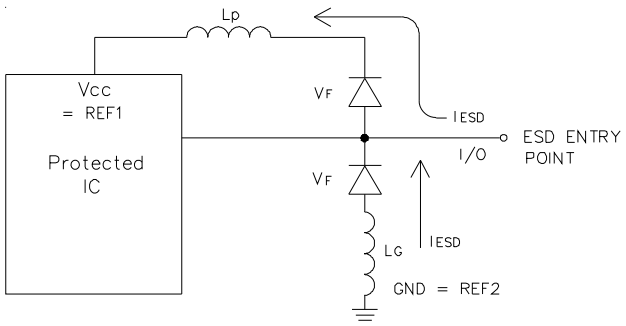

Figure 2 - The Effects of Parasitic Inductance When Using Discrete Components to Implement Rail-To-Rail Protection

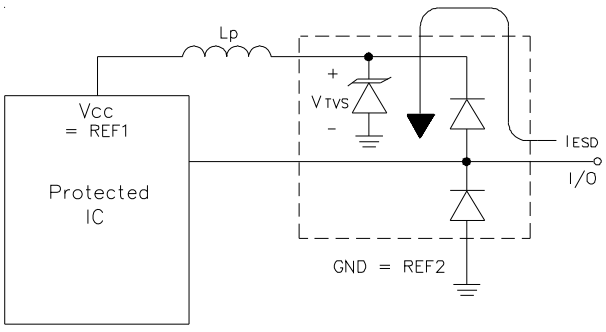

Figure 3 - Rail-To-Rail Protection Using RailClamp TVS Arrays

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Applications Information *(continued)*

helps to mitigate the effects of parasitic inductance in the power supply connection. During an ESD event, the current will be directed through the integrated TVS diode to ground. The maximum voltage seen by the protected IC due to this path will be the clamping voltage of the device.

Universal Serial Bus ESD Protection

The RClamp0554S may also be used to protect the USB ports on monitors, computers, peripherals or portable systems. Each device will protect up to two USB ports (Figure 4). When the voltage on the data lines exceed the bus voltage (plus one diode drop), 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.

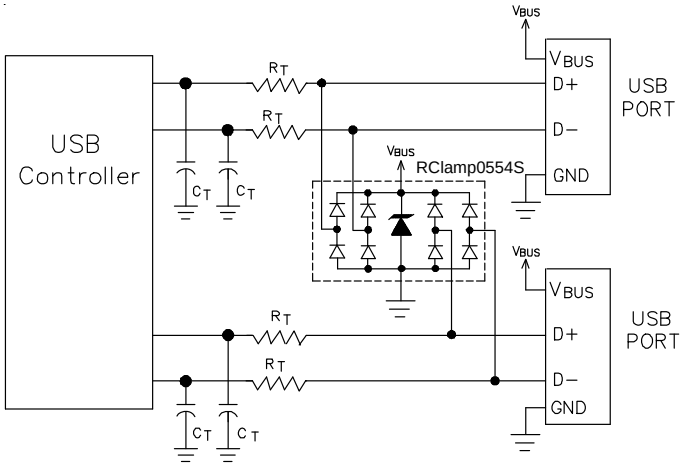

Figure 4 - Dual USB Port Protection

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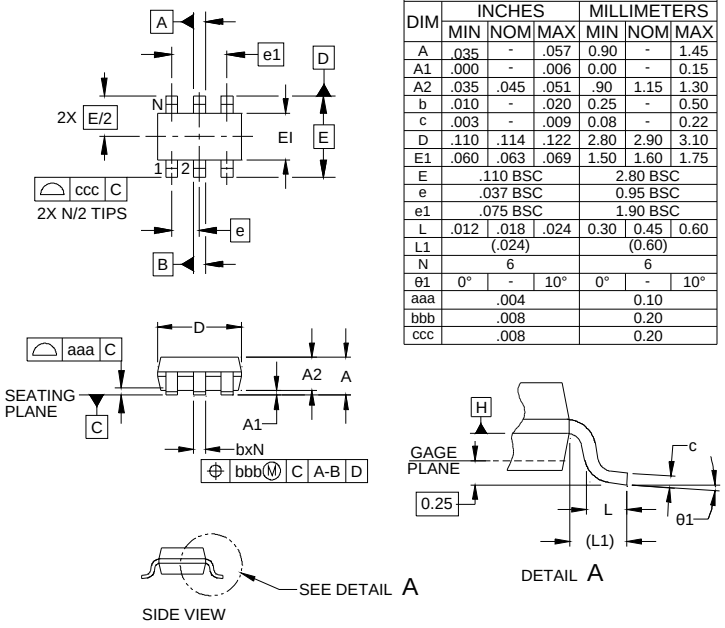
Outline Drawing -SOT23 6L

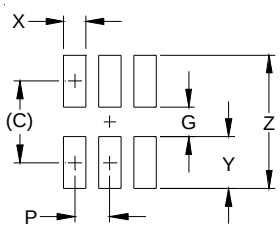


DIM	INCHES			MILLIMETERS		
	MIN	NOM	MAX	MIN	NOM	MAX
A	.035	-	.057	0.90	-	1.45
A1	.000	-	.006	0.00	-	0.15
A2	.035	.045	.051	.90	1.15	1.30
b	.010	-	.020	0.25	-	0.50
c	.003	-	.009	0.08	-	0.22
D	.110	.114	.122	2.80	2.90	3.10
E1	.060	.063	.069	1.50	1.60	1.75
E	.110 BSC			2.80 BSC		
e	.037 BSC			0.95 BSC		
e1	.075 BSC			1.90 BSC		
L	.012	.018	.024	0.30	0.45	0.60
L1	(.024)			(0.60)		
N	6			6		
θ1	0°	-	10°	0°	-	10°
aaa	.004			0.10		
bbb	.008			0.20		
ccc	.008			0.20		

NOTES:

1. CONTROLLING DIMENSIONS ARE IN MILLIMETERS (ANGLES IN DEGREES).
2. DATUMS -A- AND -B- TO BE DETERMINED AT DATUM PLANE -H-
3. DIMENSIONS "E1" AND "D" DO NOT INCLUDE MOLD FLASH, PROTRUSIONS OR GATE BURRS.

Land Pattern -SOT23 6L



DIM	INCHES	MILLIMETERS
C	(.098)	(2.50)
G	.055	1.40
P	.037	0.95
X	.024	0.60
Y	.043	1.10
Z	.141	3.60

NOTES:

1. THIS LAND PATTERN IS FOR REFERENCE PURPOSES ONLY. CONSULT YOUR MANUFACTURING GROUP TO ENSURE YOUR COMPANY'S MANUFACTURING GUIDELINES ARE MET.

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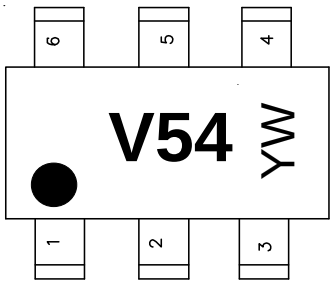
Marking Codes

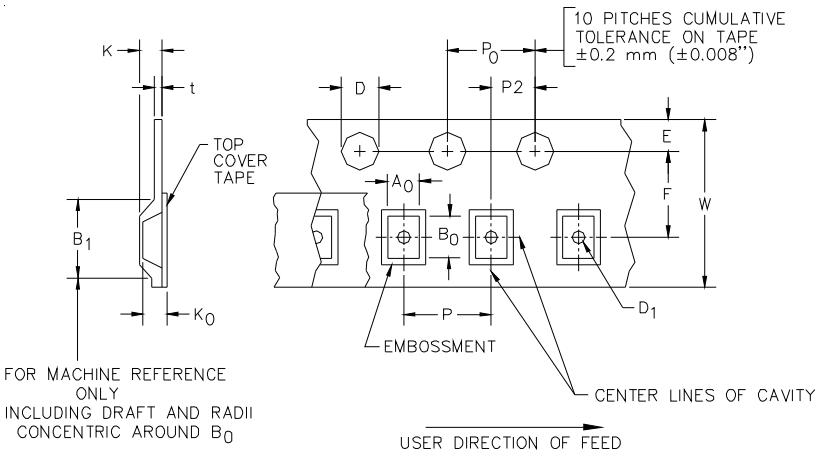


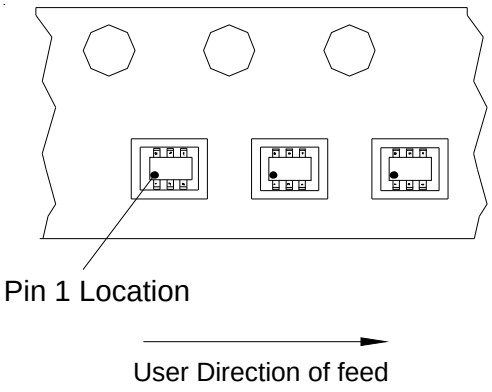
YW = 2 - Alphanumeric characters for Date Code

Ordering Information

Part Number	Lead Finish	Qty per Reel	Reel Size
RClamp0554S.TCT	Matte Tin	3,000	7 Inch

Tape and Reel Specification





A0	B0	K0
3.23 +/-0.05 mm	3.17 +/-0.05 mm	1.37 +/-0.05 mm

Tape Width	B, (Max)	D	D1	E	F	K (MAX)	P	P0	P2	T(MAX)	W
8 mm	4.2 mm (.165)	1.5 + 0.1 mm - 0.0 mm	1.0 mm ±0.05	1.750±.10 mm	3.5±0.05 mm	2.4 mm	4.0±0.1 mm	4.0±0.1 mm	2.0±0.05 mm	0.4 mm	8.0 mm + 0.3 mm - 0.1 mm

Contact Information

Semtech Corporation
Protection Products Division
200 Flynn Road, Camarillo, CA 93012
Phone: (805)498-2111 FAX (805)498-3804

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