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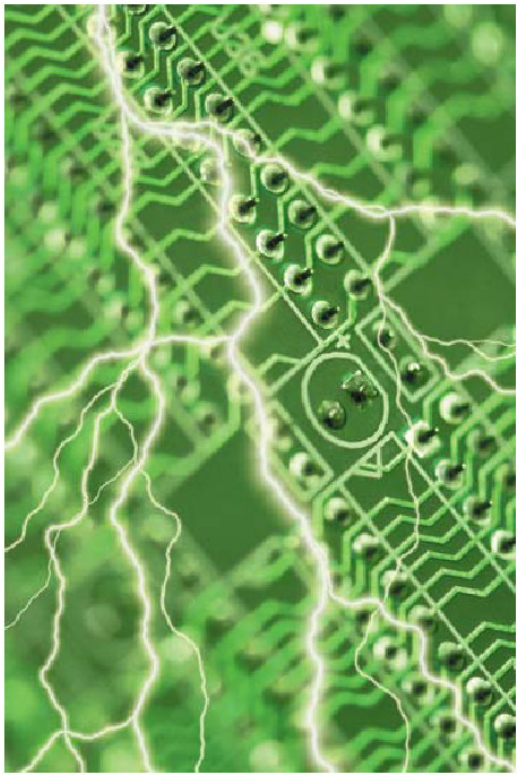
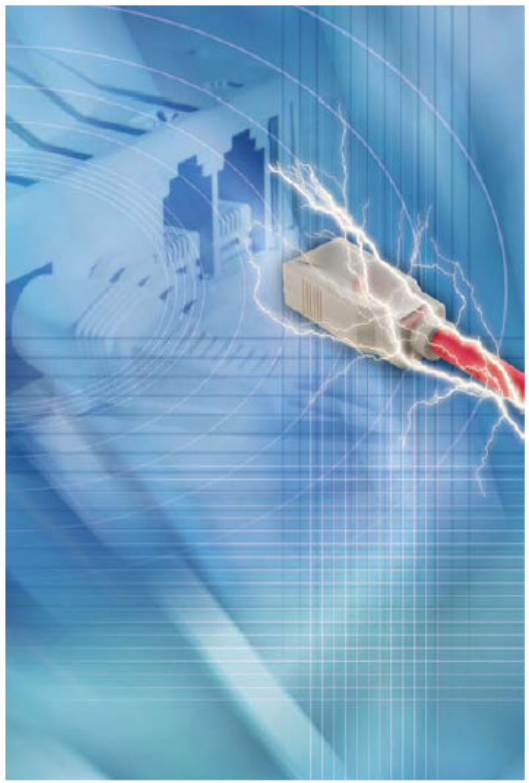
ESD Protection Diode

ESD Introduction

ESD is the discharge of static electricity. Static electricity is an excess or deficiency of electrons on one surface with respect to another surface or to ground. A surface exhibiting an excess of electrons is negatively charged, and an electron deficient surface is positively charged. Static electricity is measured in terms of voltage (volts) and charge (coulombs).

Electrostatic Discharge (ESD) frequently occurs in nature, as well in Manufacturing environments and in-use finished electronic equipments.

The Discharge occurs at our fingertips when our body is electrically charged and is in close proximity of contact points attached to electronics devices.

The latest IC technology is becoming more sensitive to these events due to the extreme complexity of circuits, and the size of the semiconductor structures used so, circuit designers must provide an effective ESD Protection.

Implications of ESD on IC industry

Major reliability threat in IC industry :
-Cause of approximately 1/3 of IC failures
-ESD protection is very challenging against rapidly changing technologies

Standard model is used to characterize ESD :
- Human Body Model (HBM)
- Machine Model (MM)
- Charged Device Model (CDM)

ESD control is indispensable throughout devices' life :
- Eliminating static charges from the workplaces
- Proper handling from manufacturing, shipping and field handling
- On-chip protection (clamp input voltage and bypass ESD current)

ESD Requirements (U.S.A.)

Human Body Model
+/- 2 kV Required by most customers Waivers given at 1 KV in some cases
+/- 4 kV Delco (Auto Manufacturer)
+/- 8 kV On Special Automotive Pins (Power Outputs)

Machine Model
No Standard for reliable testing Waivers given to 100 V in some cases

Protection Schemes

The solutions for avoiding or reducing ESD failures

1) identifying and rectifying possible ESD sources
2) identifying and undertaking adequate prevention measures while handling the ESD sensitive devices
3) incorporating built-in ESD protection networks in devices
4) providing awareness and training to users at all levels.

Two ways to reduce IC failures under ESD conditions :

The first approach focuses on reducing the amount of ESD induced charges and redistributing them through proper handling of devices and controlling the handling environments.

The second approach is to implement on-chip protection circuits in order to improve the circuit robustness against ESD events by improving ESD performance of the individual circuit components.

Typical Generated ESD Voltages

Examples of Static Generation Typical Voltage Levels		
Means of Generation	10-25% RH	65-90% RH
Walking across carpet	35,000V	1,500V
Walking across vinyl tile	12,000V	250V
Worker at bench	6,000V	100V
Poly bag picked up from bench	20,000V	1,200V
Chair with urethane foam	18,000V	1,500V

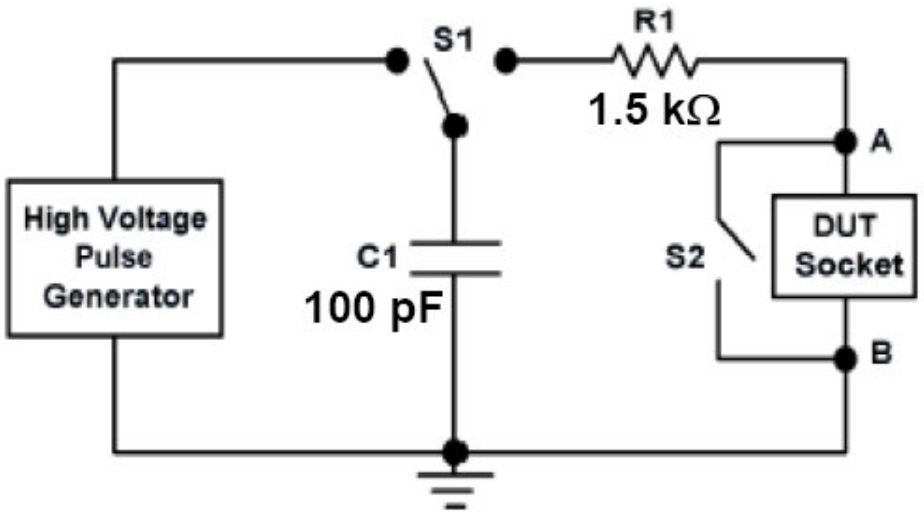
International ESD Models

The ESD events are modeled under several industry standards, where the Most representatives and accepted are:

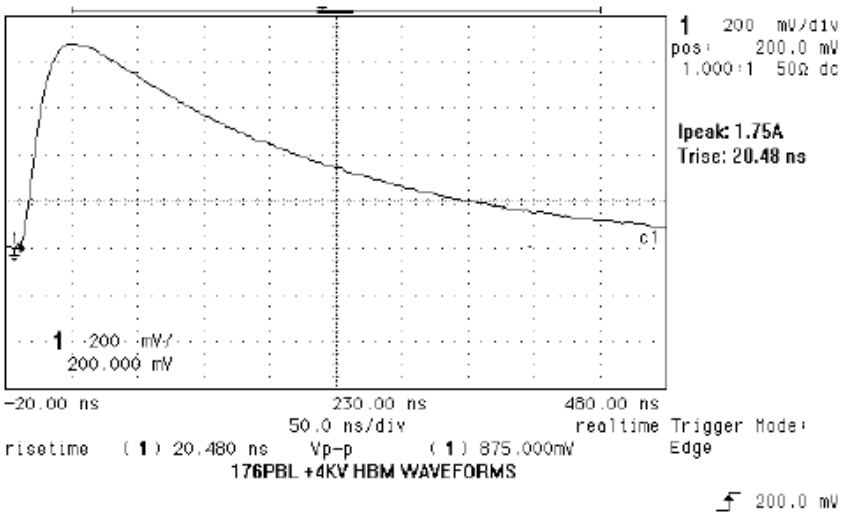
- **IEC 61000-4-2 (Recognized internationally)**
- **MIL STD 883**
- **JEDEC A114 and A115**

Standard	Model	C, pF	R, Ohms
IEC61000-4-2	HBM	150	330
MIL STD 883	HBM	100	1500
JEDEC A115	MM	200	0

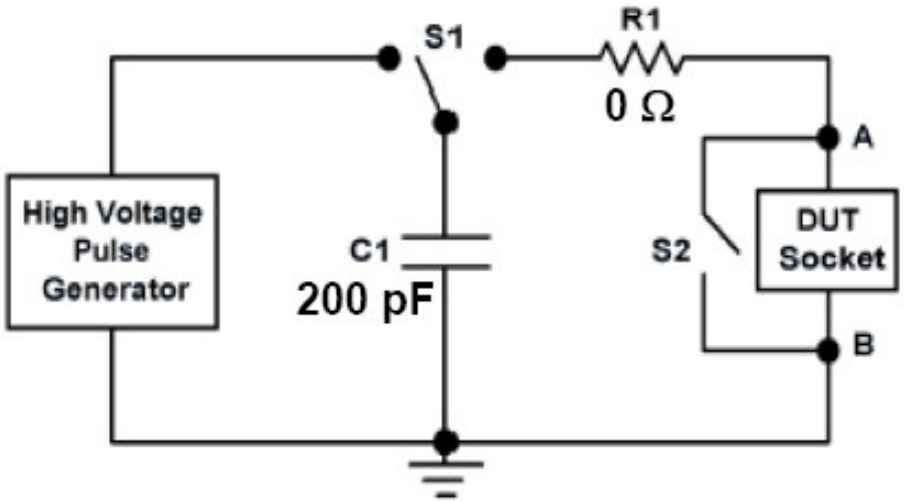
Human Body Model (HBM)



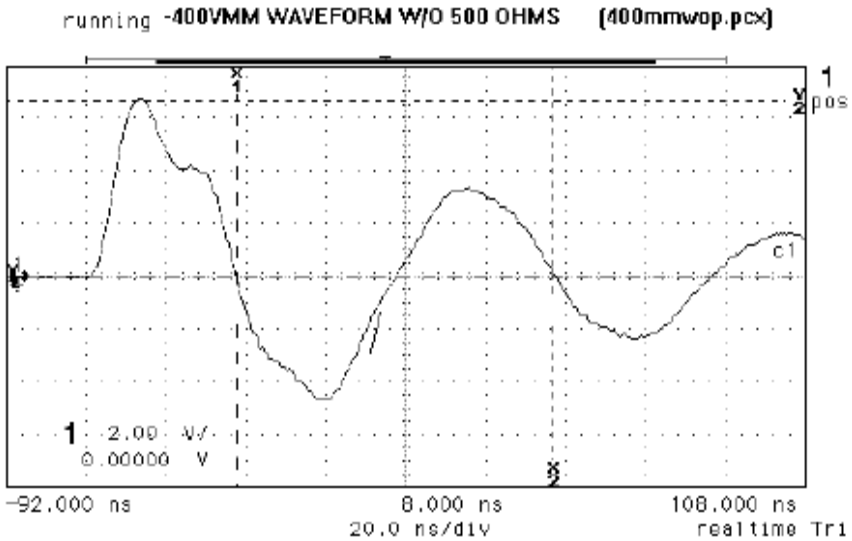
Typical HBM Current Waveform



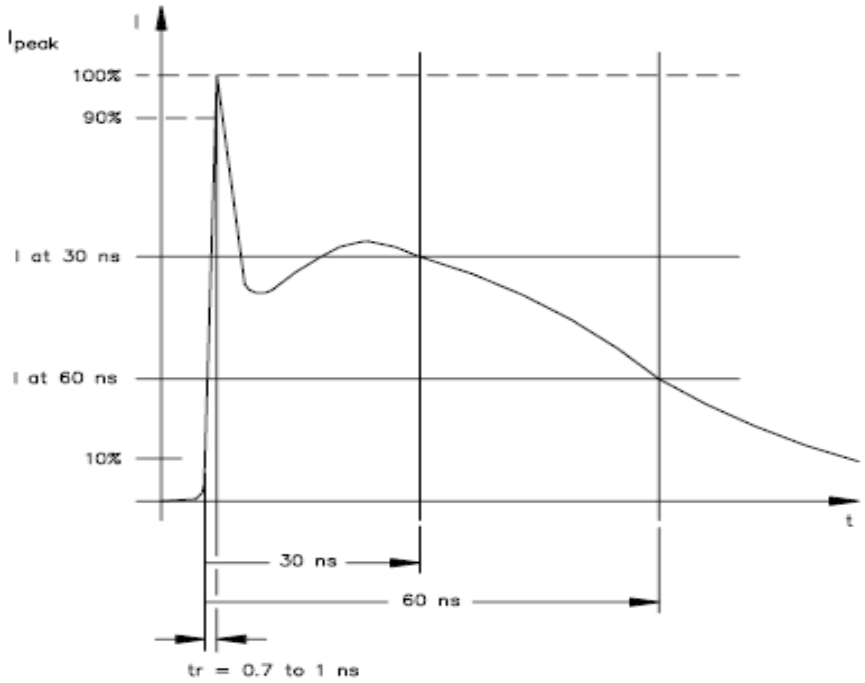
Machine Model (MM)



Typical MM Current Waveform

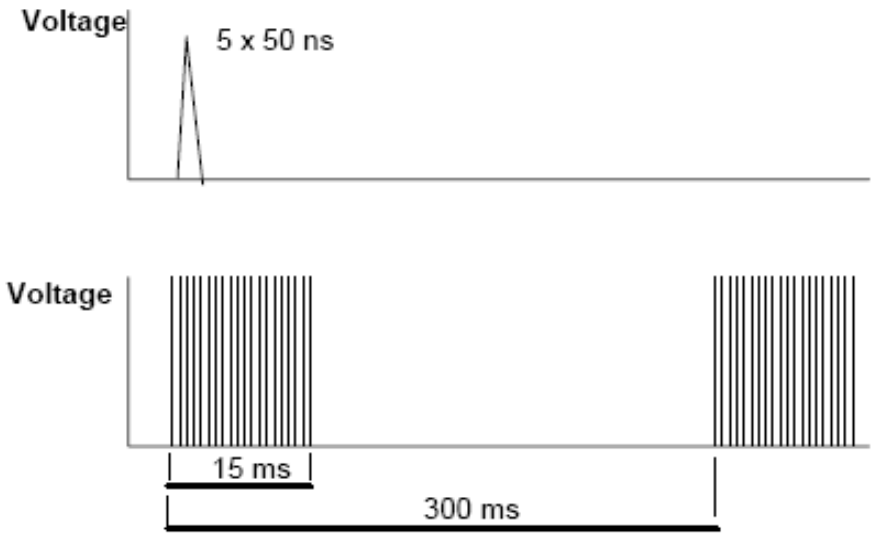


Electrostatic Discharge (ESD)
IEC 61000-4-2



LEVEL	Test Voltage Air Discharge (kV)	Test Voltage Contact Discharge (kV)	First Peak Current (A)	Peak Current at 30ns (A)	Peak Current at 60ns (A)
1	2	2	7.5	4	2
2	4	4	15	8	4
3	8	6	22.5	12	6
4	15	8	30	16	8

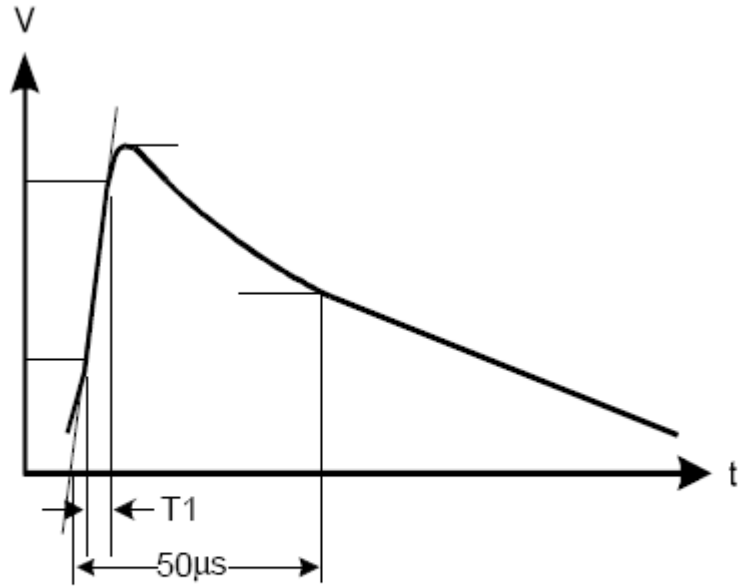
Electrical Fast Transient (EFT)
IEC 61000-4-4



EFT Burst

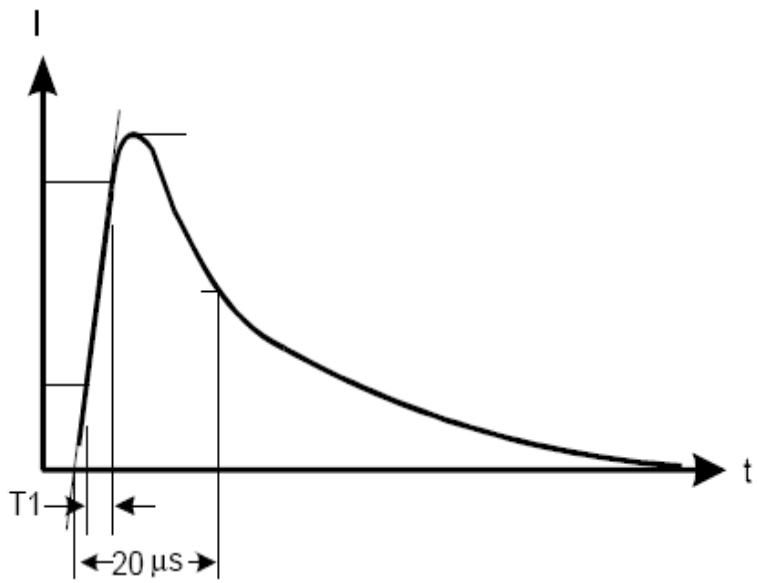
	Peak Amplitude			
	Power Supply Port		I/O, Signal, Data & Control Lines	
Level	V_{OC} (kV)	I_{SC} (A)	V_{OC} (kV)	I_{SC} (A)
1	0.5	10	0.25	5
2	1	20	0.5	10
3	2	40	1	20
4	4	80	2	40

Surge immunity (Lighting)
IEC 61000-4-5



T1 x 1.67 = 1.2µ s

Voltage Impulse

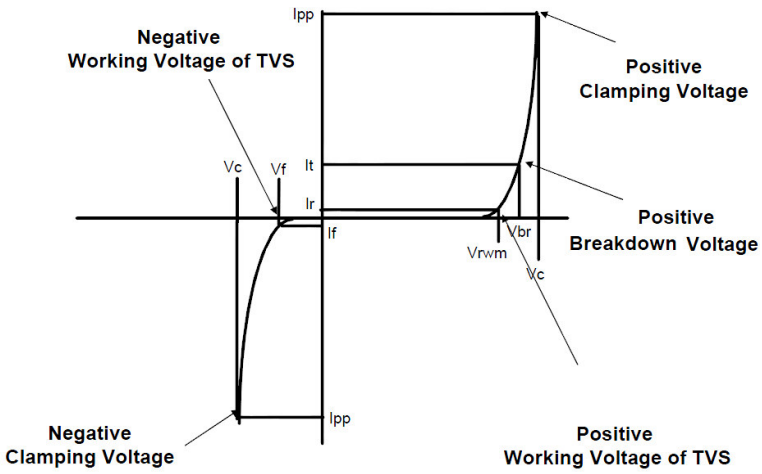


T1 x 1.25 = 8.0µ s

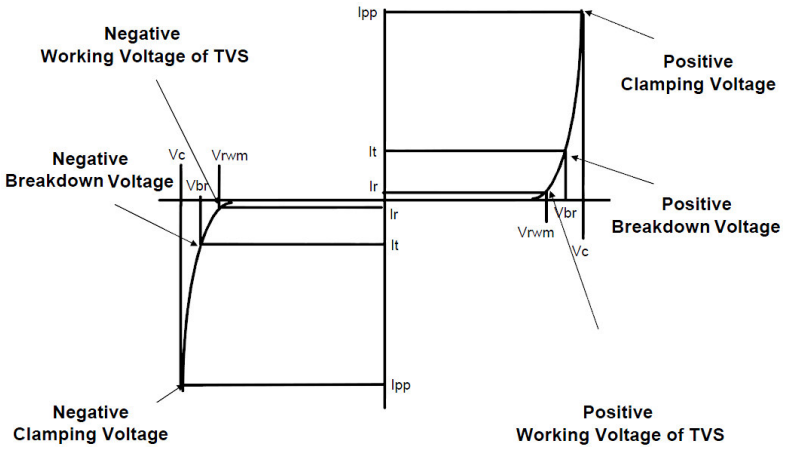
Current Impulse

Transient Suppression

- Constant advances in semiconductor process technologies make the design of protection very challenging.
- Protection circuit must ***divert transient current and clamp transient voltage*** below the failure threshold of the protected



Uni-directional TVS



Bi-directional TVS

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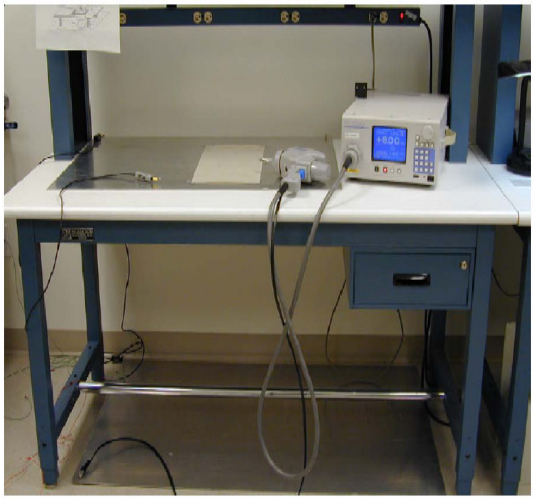
ESD Testing Setup



Contact Discharge Tip

Air Discharge Tip

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ESD Protection Diode Application Field

Digital Photography	Gadgets	Game Controllers	Graphics & Sound	Input Devices
•Digital Photo Frames •Digital Cameras •Portable Web cams •Web cams	•PDA •GPS •NES	•Gaming Pads •Joysticks •Steering Wheels •PS2 / PSP / XBOX	•Audio headsets •Microphones •Speakers •TV Tuners •Video Capture	•Mice •Wireless Keyboard •Remote Control •Digitizing Tablets •Trackballs
Modems & Telephony	**Networking**	**Portable Audio Video**	**Storage**	**Printers & Scanners**
•56K USB Modems •Cable Modems •Internet Telephony •ISDN Modems •XDSL Modems	•Bluetooth Adapters •Direct Connect •USB Ethernet •USB Phone Line Network •USB Wireless Network	•I-Pods •MD Players •MP3 Players	•CD RW / CD ROM / HD •DVD Drivers •Ext Floppy Dr •Flash Readers •Removable Disks Dr •Solid State Drivers	•Inkjet •LaserJet •Photo Printers •Card Scanners •USB Film Scanners •Flatbed scanners

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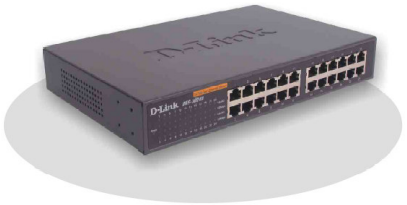
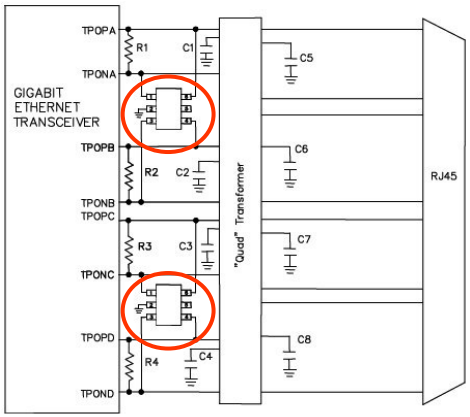


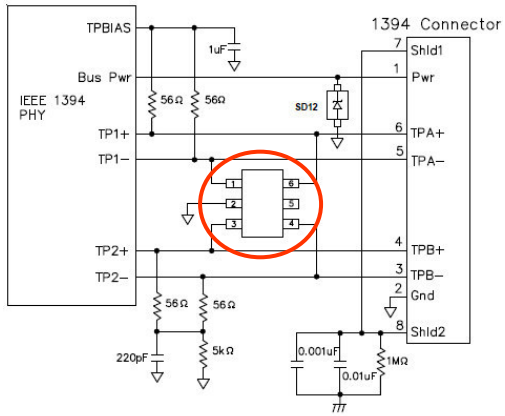
ESD Protection Diode for Ethernet

AFE0504
SOT-363

AFE0514
SOT-563



Gigabit Ethernet Protection



IEEE 1394 Firewire Protection

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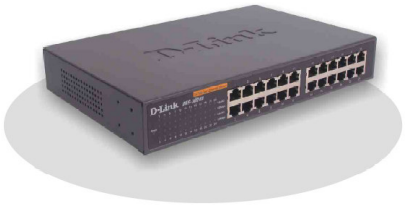
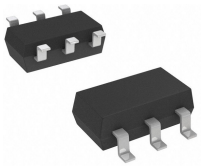
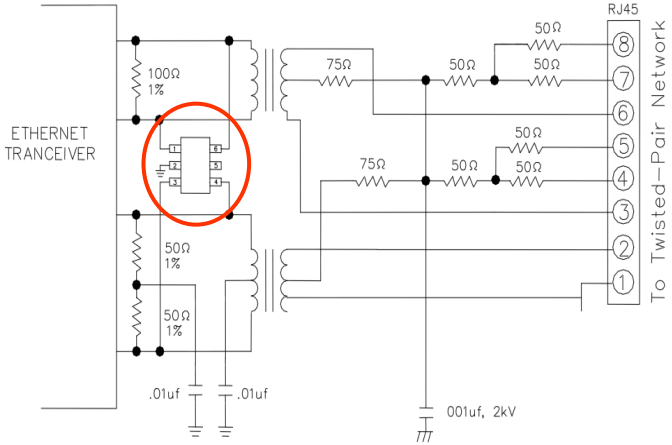


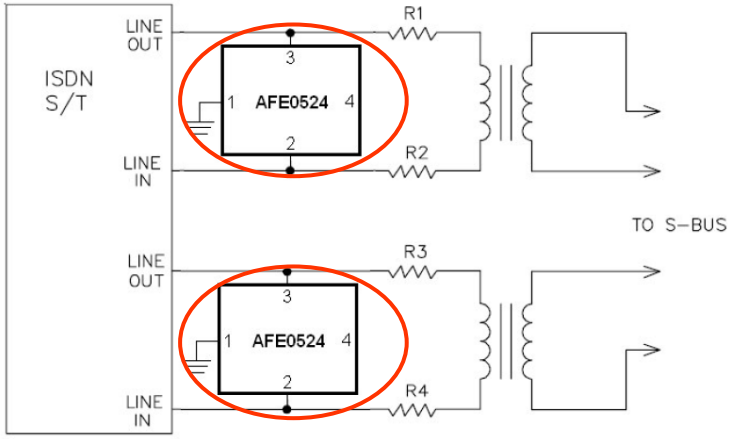
ESD Protection Diode for Ethernet



AFE0505
SOT-23-6L

AFE0524
SOT-143





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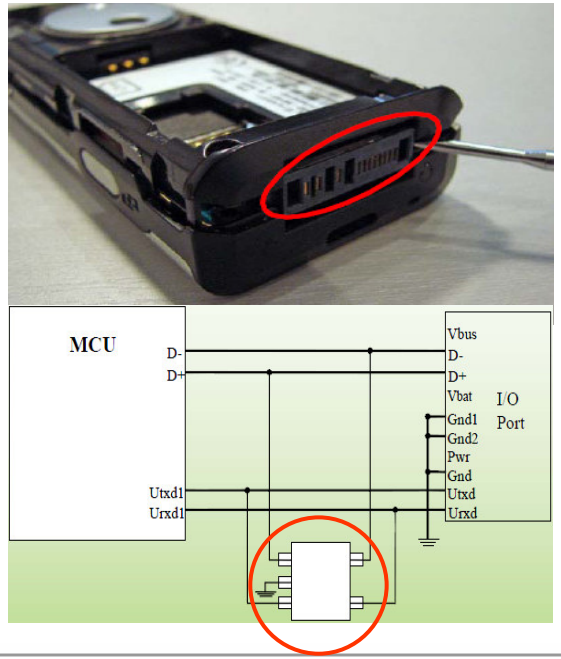
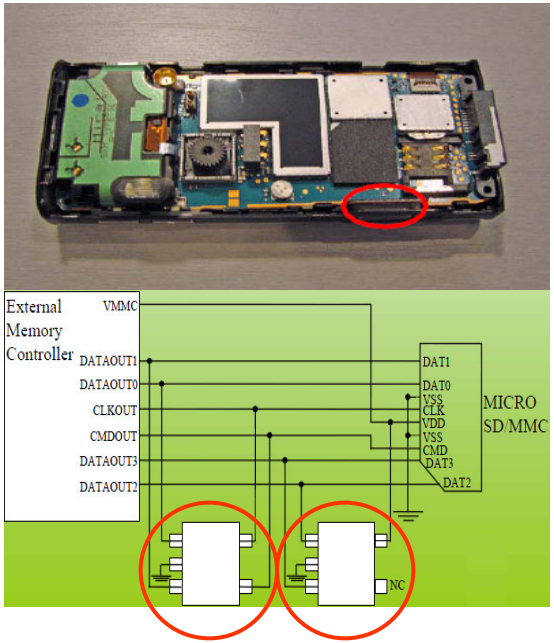
ESD Protection for Cell Phone / Smart Phone

AFE0514
SOT-563





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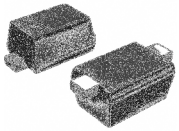
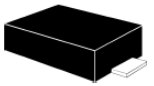
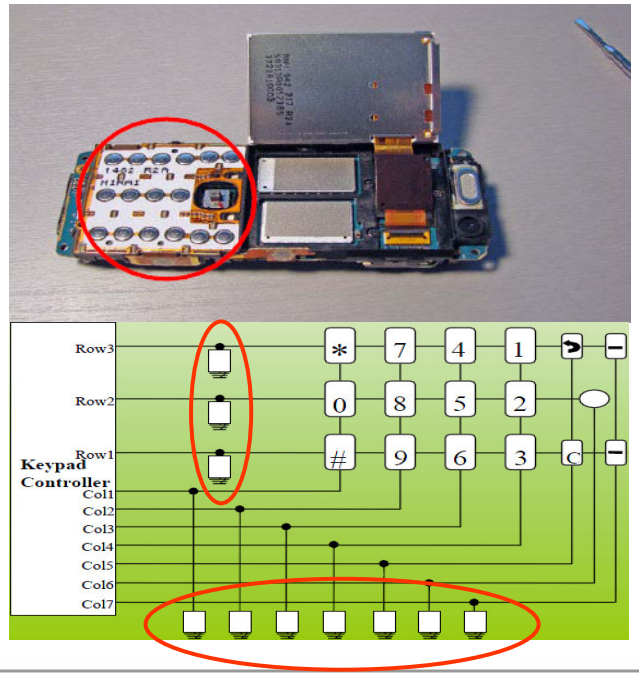
ESD Protection Diode for Cell Phone / Smart Phone

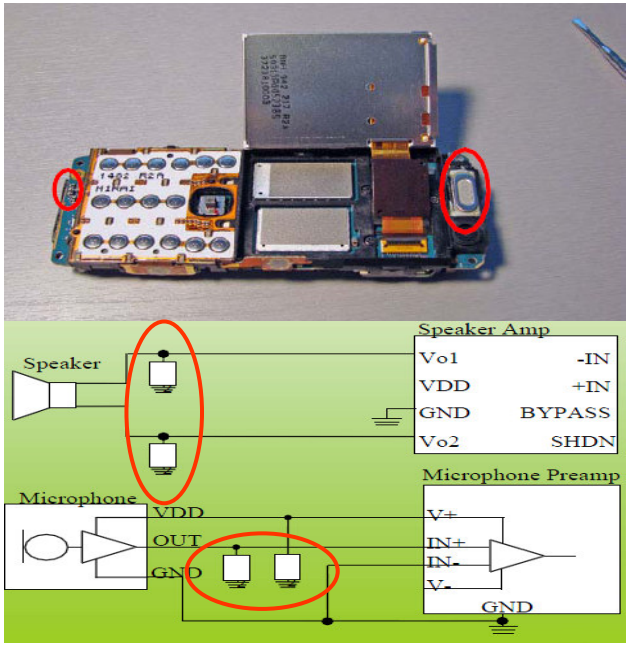


AFE0521
SOD-523



AFE0572
SOD-723





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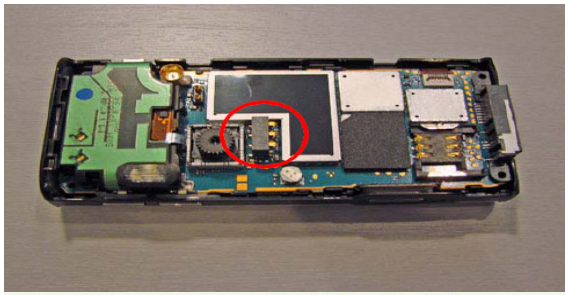
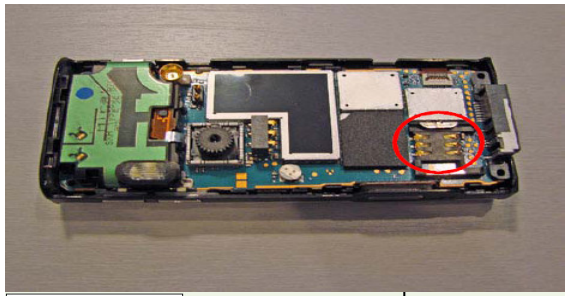
ESD Protection Diode for Cell Phone / Smart Phone

AFE0562
SOD-323

AFE6V8UW
SOT-363





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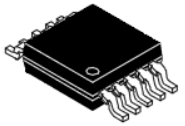
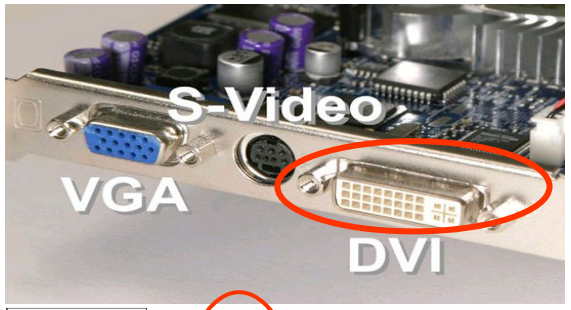
ESD Protection Diode for LCD TV/DVD/Set-Top Box

AFE6V8UD
DFN-10



AFE6V8UH
MSOP-10L



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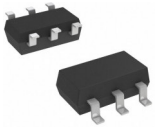
ESD Protection Diode for Notebook / iPad

AFE6V8UD
DFN-10
(HDMI)

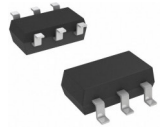
AFE0504
SOT-363
(USB 2.0)



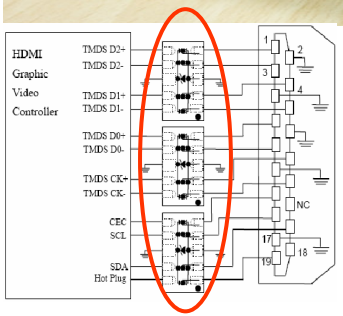
AFE6V8UF
SOT-23-6L
(USB 3.0)

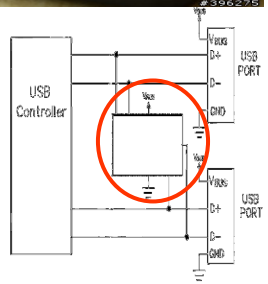
AFE6V8UW
SOT-363
(USB 3.0)

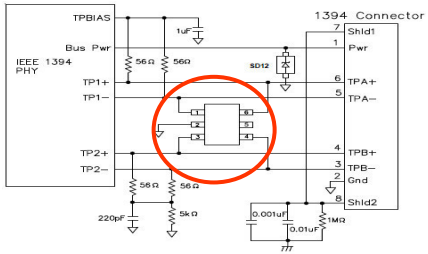
AFE0514
SOT-563
(IEEE1394)



AFE0505
SOT-23-6L
(IEEE1284)







IEEE 1394 Firewire Protection