ALLEN-BRADLEY

Guarding Against Electrostatic Damage

Testing and Maintenance

Introduction

Electrostatic damage (ESD) is a major cause of failures and malfunctions in today's sophisticated electrical components and systems.

Some manufacturers of electronic systems may tell you that ESD is not a problem with their products. This is misleading. All conscientious manufacturers take anti-static precautions when they design their products. However, even the best anti-static designs cannot keep ESD from affecting sophisticated electronic systems, particularly when they are disassembled.

Proper education combined with simple work-related procedures and precautions can guard against many of the effects of ESD. This data sheet explains the causes of ESD, and how you can guard against its effects.

Data Sheet Contents

This data sheet provides the following information:

Table 1.A
Data Sheet Organization

Practices that Guard against ESD

There are three things you can do to guard against electrostatic damage:

- create a static-safe work area
- handle sensitive components correctly
- wear a wrist strap that grounds you during work.

WARNING: To avoid shock or personal injury from accidental contact with line voltage, the ground lead of the wrist strap must provide a high resistance, a minimum 1 Mohm, path to ground.

Creating a Static-safe Work Area

An important aspect of guarding against ESD is creating a static-safe work area. This includes:

- covering a work bench with a conductive surface that is grounded
- covering the floor of the work area with a conductive material that is grounded
- removing nonconductive materials from the work area such as:
  - plastics
  - nylon
  - styrofoam
  - cellophane
- grounding yourself by touching a conductive surface before handling static-sensitive components
- being careful with loose parts of clothing such as sleeves, ties, and scarfs, which can easily carry a charge
- being careful not to touch the backplane connector or connector pins of the system
- being careful not to touch other circuit components in a module when you configure or replace internal components in a module

Wearing a Wrist Strap

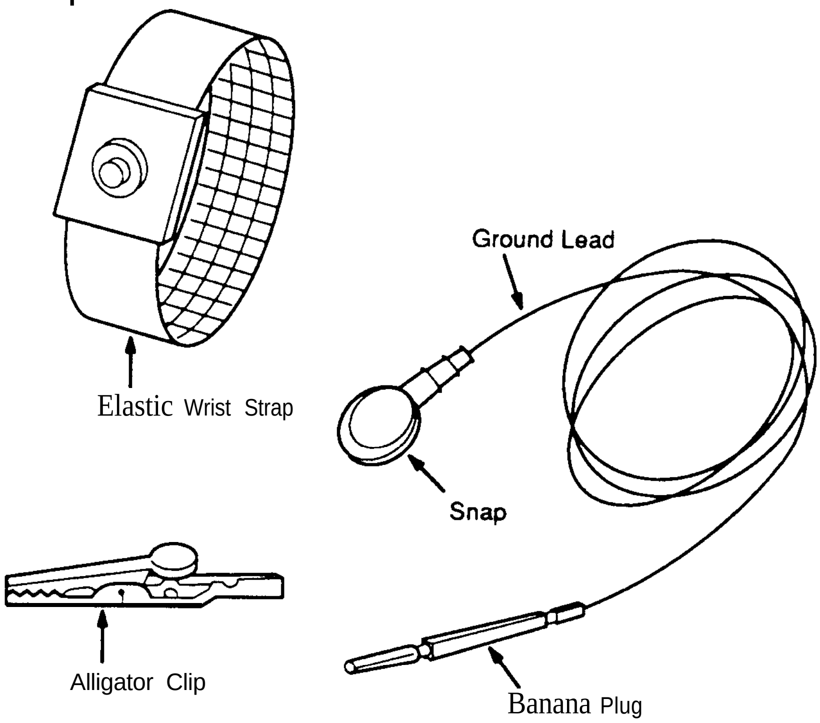
The most important aspect of guarding against ESD is wearing a wrist strap that connects you to ground in a static safe work area. A wrist strap usually consists of:

- elastic wrist strap with snap fastener
- molded ground lead with snap and banana plug – has a built-in 1 Mohm resistor in series to guard against hazardous electrical shock caused by accidental contact with line voltage
- alligator clip – for connection with the ground lead and with ground

You should always wear and use a wrist strap in normal work activities around sensitive components:

- Put the wrist strap on before beginning work.
- Make sure the wrist strap fits snugly.
- Make sure the ground lead of the wrist strap is assembled properly and connected securely to ground each time you use it.
- Take off the wrist strap as the last thing you do before leaving the work area.

Figure 1
Wrist Strap



Handling Sensitive Components Correctly

The last important aspect of guarding against ESD is to always store and carry components and modules in static-shielding containers that guard against the effect of electric fields.

Remove components and modules from static shielding packages only at a static-safe work area. Modules are only protected when they are completely in a static-shielding bag. Using the bag to hold the module does not protect the module.

You should use correct handling procedures even with modules that are being returned for repair. This protects the good components for rework.

Common Electrostatic Voltages at Work

You need to build up only 3,500 volts to feel the effects of ESD. only 4.500 volts to hear them, and only 5,000 volts to see a spark. The normal movements of someone around a work bench can generate up to 6,000 volts. The charge that builds up on someone who walks across a nylon carpet in dry air can reach 35,000 volts. Potentials as high as 56,000 volts can be measured when a roll of plain polythylene is unwound. Potentials of more common work situations range up to 18,000 volts.

Table 1 .B
Common Electrostatic Voltages

Situation	Voltage
Person walking on carpet	
-humid day	2,000
-dry day	35,000
Person walking on vinyl floor	
-humid day	400
-dry day	12,000
Person in padded chair	up to 18,000
Styrofoam coffee cup	up to 5,000
Plastic solder sipper	up to 8,000 at tip
Plastic or scotch tape	up to 5,000
Vinyl covered notebook	up to 8.000

Sensitivity of Components of ESD

Many of today's electronic components are sensitive to electrostatic voltage as low as 30 volts and current as low as 0.001 amps, far less than you can feel, hear, or see.

Table 1.C
Component Sensitivity to ESD

Device Type	Electrostatic Voltage	
	To Degrade	To Destroy
VMOS	30	1,800
MOSFET	100	200
GaAsFET	100	300
EPROM	100	–
JFET	140	7,000
OP AMP	190	2,500
CMOS	250	3,000
Schottky Diodes	300	2,500
Film Resistors (thick, thin)	300	2,500
Bipolar Transistors	380	7,000
ECL (board level)	500	1,500
SCR	680	1,000
Schottky TTL	1,000	2,500

Hidden Effect of Electrostatic Damage

ESD immediately destroys sensitive devices in only 10% of most ESD incidents. It degrades performance in the remaining 90%. Only a quarter of the voltage required to destroy the component is needed to degrade its performance

A device that is merely degraded in performance may pass all normal diagnostic tests. However, it may fail intermittently as temperature, vibration, and load on the device vary. Ultimately, the device may fail prematurely: days, weeks, or even months after the ESD incident that degraded it.

If you have some minimal static control procedures, you may only experience a device failure rate of 0.5%. But, if there are:

- 10 devices per board = 5% defective boards
- 10 boards per system = 40% defective systems

This points out the need to follow rigorous static control procedures at all times when handling and working with static-sensitive devices and modules.

What Causes Electrostatic Damage?

Electrostatic damage is caused by the effects of an electric field that surrounds all charged objects. The electric field can damage sensitive components by:

- discharge – the charge associated with the field is suddenly grounded and the movement of the charge creates currents in the device.
- induction – the electric field moves in relation to the device and generates a current in the device.
- polarization – the electric field remains stationary and polarizes the device. Subsequent handling and grounding first charges then discharges the device.

Electric fields are invisible, and exist around all charged materials. They can generate currents in conductors simply by moving near them. The size of the current depends on the strength of the field and the speed of movement. Electric fields can polarize sensitive devices. Subsequent handling can cause charging and discharging of the device.

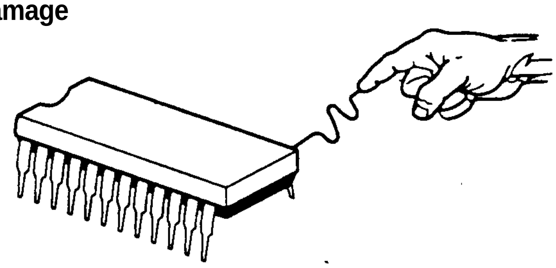
Damage Due to Discharge

The surfaces of nonconductive materials develop equal and opposite charges when they come in contact, move against each other, then separate quickly. An electric field surrounds a nonconductive material once it is charged.

We normally develop charge on our bodies and clothing as we move. When we walk on carpet, our feet rub on then separate from the carpet, which can give us a charge very quickly.

When we approach a conductor, like a door knob or one of today's sensitive electronic devices, the air between our body and the conductor initially acts as an insulator. At some point, the amount of charge we have built up exceeds the insulating ability of the air, and a spark jumps to the conductor.

Figure 2
Discharge Damage



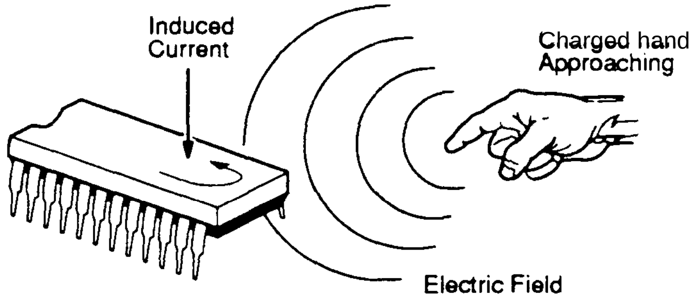
The spark introduces currents in the conductor. These currents could destroy a sensitive device or degrade performance.

Damage Due to Induction

A conductor that moves in a magnetic field generates an electric current. This is the basic principle of a generator: induction. The principle is the same if the magnetic field moves and the conductor is at rest. The electric field is similar to the magnetic field in its ability to generate a current.

Walking across a carpet, building up charge, and approaching a sensitive device causes your electric field to move across the conductors of the device. The stronger your electric field, and faster your approach, the more likely you are to induce damaging currents.

Figure 3
Induction Damage

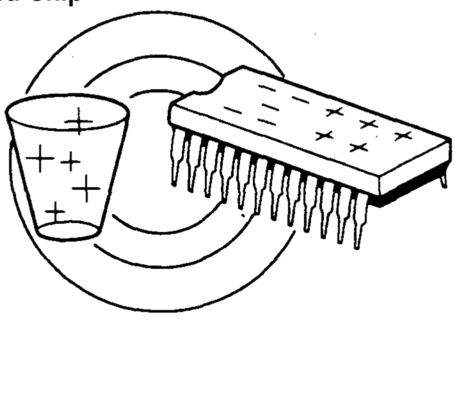


Damage Due to Polarization

If the electric field and a sensitive device remain stationary, but close to each other, a polarization effect may occur.

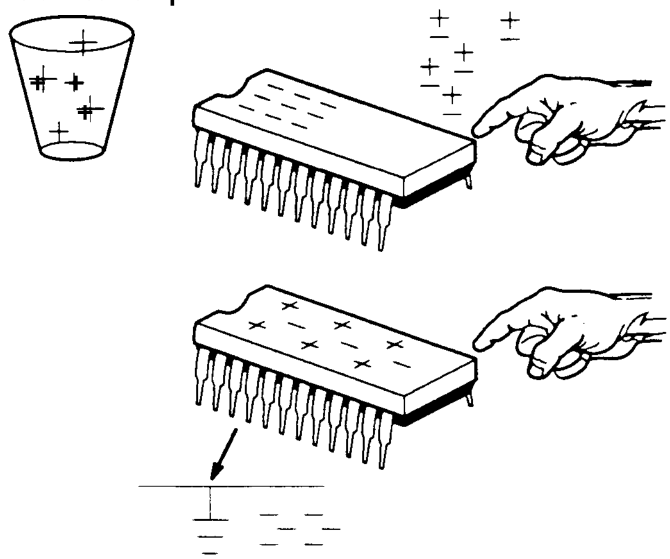
A good example of polarization is a styrofoam coffee cup placed next to a chip. The cup is a nonconductor that is easily charged by handling, or even by simple movement in the air. Polarization causes the electrons on the chip, which are negative, to be attracted to the cup, which is positively charged. At this point the chip is not charged. It is polarized.

Figure 4
Uncharged Polarized Chip



If we pick up the chip, it becomes negatively charged as free electrons flow from our hand to the chip. If we then place the chip on a grounded surface, it discharges. The discharge currents can degrade or destroy the chip.

Figure 1.1
Charged Polarized Chip



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