White Paper

Preventing Electrostatic Discharge (ESD)

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What Is Electrostatic Discharge and How Does It Occur?

Many electronic components are sensitive to electrostatic discharge (ESD). A static charge is an unbalanced electrical charge at rest. An electrostatic discharge is created when insulator surfaces rub together or pull apart. One surface gains electrons while the other surface loses electrons. These actions result in an unbalanced electrical condition recognized as static charge. Networks built into many integrated circuits provide some protection, but in many cases the discharge contains enough power to alter device parameters or melt silicon junctions.

When contact and separation occurs between two materials, a transfer of electrons from the atoms on the surface takes place. ESD is a miniature bolt of static charge that moves between two surfaces that have different potentials. ESD only occurs when the voltage differential between the two surfaces is sufficiently high to break down the dielectric strength of the medium separating two surfaces. When a static charge moves, it becomes a current that damages or destroys oxides, metallizations, and junctions. ESD can occur in one of four ways:

- A charged body touches an IC
- A charged IC touches a grounded surface
- A charged machine touches an IC
- An electrostatic field induces a voltage across a dielectric that is sufficient to break it down

Static Electricity and Product Quality

In the processing of film materials or plastics, static electricity can cause materials to cling to each other causing product quality problems or production slowdown. In clean rooms, charged materials can hold static-laden dust, preventing these dust particles from being circulated and picked up by the filtration system.

Static electricity causes a different problem with microelectronics. Electronic components are composed of micro-miniature traces and structures of alternating layers that may be insulative, conductive or semi-conductive. Rapid electrostatic discharge can cause damage to these underlying structures.

Latent Defects

Devices with latent ESD defects are devices that have been degraded by ESD but not destroyed. This condition occurs when an ESD pulse is not strong enough to destroy a device but causes damage. Often, the device suffers junction degradation through increased leakage or a decreased reversed breakdown, but the

device still functions and is still within specification limits. A device can be subjected to numerous weak ESD pulses, with each one further degrading a device before it finally becomes a catastrophic failure. There is no known practical screen for devices with latent ESD defects. To avoid this type of damage, devices must be continually provided with ESD protection, as outlined in the section See “Preventing ESD in ICs” on page 4.

What Voltage Levels of ESD are Possible?

Human beings can be charged up to 38,000 volts just by walking across a carpet on a low-humidity day. For an ESD pulse to be seen, felt, or heard, it must be in the range of 3000–4000 volts. Many devices can be damaged well below this threshold.

Preventing ESD in ICs

The best way to avoid ESD damage is to keep ICs at the same potential as their surroundings. The logical reference potential is ESD ground. The first and most important rule in avoiding ESD damage is to keep ICs and everything that come in close proximity to them at ESD ground potential. There are four supplementary rules that support this first rule:

Grounding

Any person handling the ICs should be grounded with either a wrist strap or ESD-protective footwear used in conjunction with a conductive or static-dissipative floor or floor mat. Figure 1 illustrates one version of a wrist strap and footgrounders.

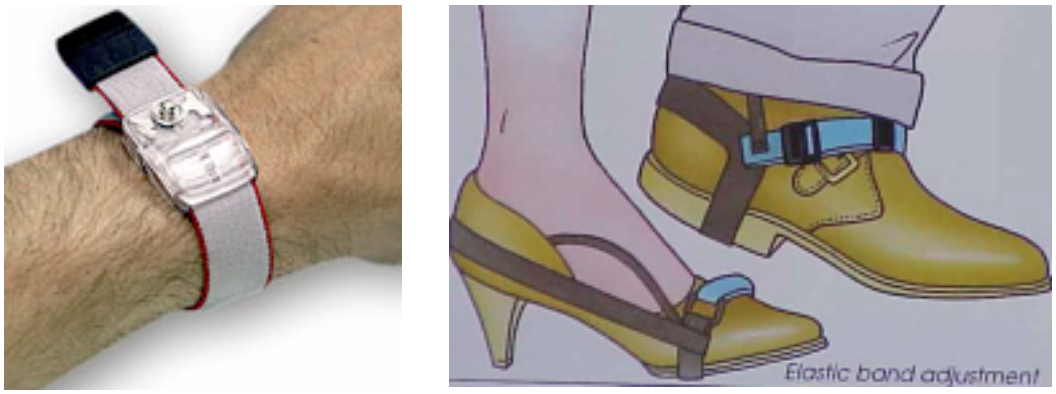


Figure 1. Wrist Strap and Foot Grounders

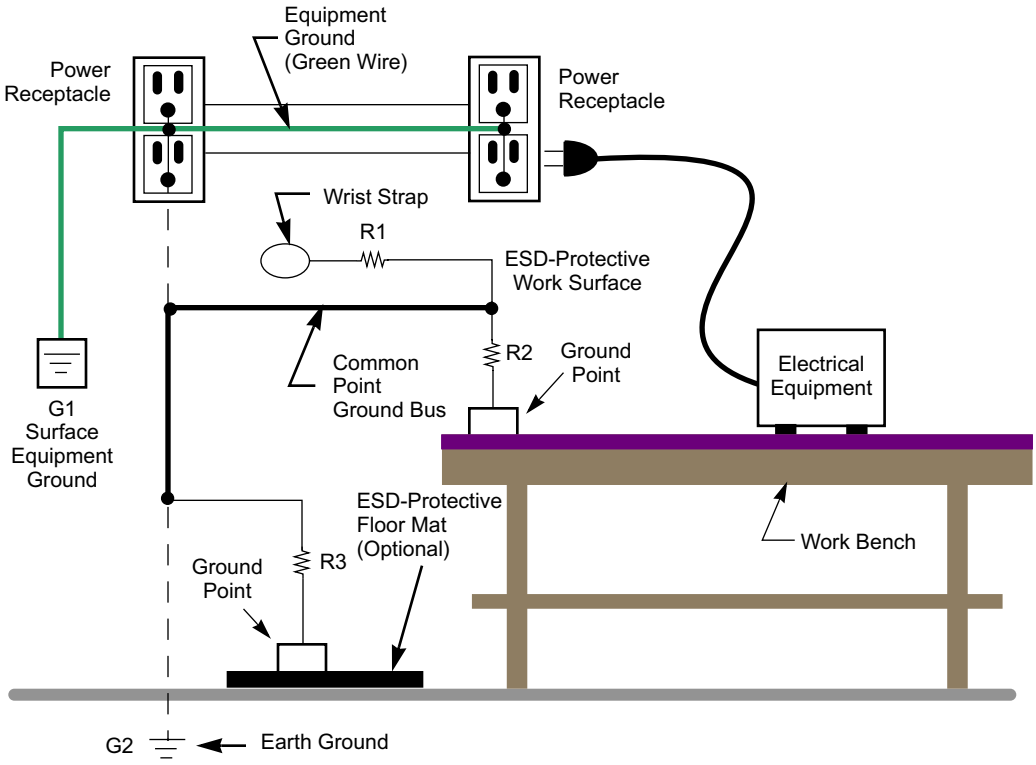
The work surface for device handling, processing, testing, and so on, should be made of static-dissipative material and connected to ESD ground.

Shielding

All insulator materials must either be removed from the work area or must be neutralized with an ionizer. Static-generating clothing must be covered with an ESC-protective smock.

When storing ICs, transferring them between operators or workstations or shipping them, they must be kept in a Faraday Cage with inside surfaces (surfaces touching the ICs) that are static-dissipative.

Figure 2 illustrates a typical ESD-protected workstation.



1. G1 (surface equipment ground) or G2 (earth ground) is acceptable for ESC ground. Where both grounds are used, they are connected (bonded) together.
2. R1 is mandatory for all wrist straps.
3. R2 (for static-dissipative work surface) and R3 (for ESD-protective floor mats) are optional.
4. This ESD-protected workstation complies with JEDEC Standard No. 42.

Figure 2. ESD-Protected Workstation (Side View)

Preventing ESD in Non-Conductors

Neutralization

Nonconductors must be neutralized in some other manner. As they do not conduct electricity, grounding does not work. The most common method of neutralizing insulators is through ionization, flooding an area with alternating positive and negative charged particles (ions). A charged material attracts ions of the opposite polarity and becomes neutral.

Humidity

Humidity is a very important factor in the generation of static electricity. This factor is especially true when insulators are present. Humidity affects the surface resistivity of insulator materials. As humidity increases, the surface resistively decreases. This condition means that insulator materials rubbed together or pulled apart in a humid environment generate lower static charges than the same materials rubbed together or pulled apart in a dry environment. It is recommended that relative humidity be maintained between 40% and 60%. Humidity above 60% is uncomfortable for humans. Humidity below 40% increases the risks of static generation from insulators. Humidity is a supplementary control and is not sufficient by itself to reduce static voltages to safe levels.

Packaging and Transporting Precautions

Use the following grounding precautions when packaging and transporting equipment.

- Transport products in static-safe containers such as tubes, bags, or boxes
- Protect all electrostatic-sensitive parts and assemblies with conductive or approved containers or packaging
- Keep all electrostatic-sensitive part in their containers until they arrive at a static-free location
- Place items on a grounded surface before removing them from their container