





Static electricity can mean

SHOCKING

DAMAGE

by Ron J. Zzulka

It's a fact!

Static electricity is not only a lethal ignition hazard in flammable atmospheres, it can destroy our electronics equipment. Static electricity, or, more accurately, electrostatic discharge (ESD), is responsible for more damage to electronics than all other failure mechanisms combined. The loss of product and related productivity results in the avoidable loss of millions of dollars.

Numerous studies have indicated that ESD is responsible for 50 to 80 per cent of all failed electronic circuits. We can damage the devices every time we handle them without understanding the nature of ESD and when we fail to use the correct control tools and processes. Bare devices, printed circuit boards and unprotected assemblies are especially at risk when handled without ESD controls.

The problem has been around since the first microelectronic devices were produced in the 1960s and is getting worse every day. In the race to make the devices smaller, faster and more power efficient, we are making the devices more susceptible to the devastating effects of miniature lightning bolts.

What has not changed much since the 1960s is our level of awareness and understanding of the problem. The level of ESD that can damage most of today's commonly used devices is far below the level of human perception. Although a person cannot feel a static discharge much below 3.0 kV, the devices can be degraded or destroyed by voltages as low as 25 volts.

Degradation vs. destruction

The most common type of ESD damage is degradation or weakening of the device. The damaged device may pass quality inspections and tests, but fail prematurely in service, or worse, operate erratically or intermittently. 'No fault found', 'Clear on arrival' and 'Came clear while testing' reports are all indicators of ESD degradation.

The Canadian electronics industry has spent millions of dollars on tools and materials to combat the static problem, often in vain. Why? ESD failure mechanisms are as complex and varied as the sources of static itself. Without thoroughly understanding the nature of ESD, control tools and materials are often not effectively used.

Static electricity is simply that: static; not moving; essentially an excess or deficiency of electrons at rest. ESD (Electrostatic Discharge) occurs when that charge is allowed to move rapidly through a conductor in the form of a mini lightning bolt.

In a device, static electricity may cause a difference in electrical potential between two metal oxide layers causing an arc through the dielectric. Contamination from the metal oxide creates a short circuit between the metal oxide layers creating the failure. In other cases, the spike of current from the ESD event actually vaporizes the conductive trace in the component.

In both cases, static electricity was allowed to form and then discharge rapidly through the conductive paths of an integrated circuit.



Static charge may be created by ion beam charging, dissimilar metal contact, thermionic emission, photoelectric emission and piezoelectric charging. However, in industry, the most common sources of ESD damage are from triboelectric generation and inductive charging.

Tribogeneration or frictional charging

Tribogeneration is the generation of static electricity through friction. It happens whenever two dissimilar materials are brought into intimate contact. When the materials are separated, a transfer of electrons takes place leaving one material with a positive charge, the other with a negative.

Some common examples of tribogeneration of charge include shoe soles separating from a carpet, packing tape pulled from the roll and integrated circuits sliding out of a DIP tube.

The precise quantity of charge is a function of the intimacy of contact, speed of separation, conductivity of the materials, and the triboelectric series position of the materials. (A triboelectric series is an approximate list of materials arranged in order of polarity and magnitude of charge in relation to other materials on the list.)

Static electricity and humidity

Relative humidity is a measure of the actual amount of water vapor in the air compared to how much it could hold relative to temperature. For example, air at 30° C can hold 30 grains of water. Air at 20° holds 17 grains and air at 10° can hold nine grains. At each temperature, the relative humidity was 100%. If we took air at 10° C and nine grains of water (RH = 100%) and heated the air to 30° C without adding water, the relative humidity would drop to 30%.

The ability of two materials to develop and retain an electrostatic charge through friction is inversely proportional to the ambient level of relative humidity. In other words, the higher the relative humidity, the harder it is to generate static and the shorter it lasts.

Moist or humid air will leave a microscopic moisture layer on surfaces. The moisture layer is somewhat conductive and will resist tribocharging against another material. In addition, humid air has a higher concentration of free-floating positive and negative ions.

Charged surfaces attract the free-floating ions, speeding the charge decay process. This is why we notice more static electricity in the cold dry winter months than we do in the moist summer months. (Note: During hot summer days air conditioning units dehydrate outside air by cooling it far below desired temperature and then allowing it to reheat to the desired setting.)

In Western Canada (excluding coastal regions), even our 'enclosed and packaged end user systems' are at risk. High electric fields from clothing and direct discharges to keyboards and controls can disrupt even the most robust of electronic systems. The electronics industry in North America recommends a minimum humidity level of 30% in any environment where electronic devices are handled.

Polarization and inductive charge

Inductive charging takes place when a neutral conductor is placed in an electric field. The presence of the electric field causes the surface of the material to polarize. The polarization produces uniform charge separation resulting in an electrostatic field.

Polarization of a device is not likely to result in physical damage directly. (It may if the field is of sufficient magnitude and the field is introduced rapidly.) However, polarization may cause the device to operate erratically or intermittently. These failures are defined as 'soft' failures and are usually self-recoverable. The system returns to normal when the field is removed or the power is recycled. Commonly known as latch-ups, this failure mechanism leaves the circuit out of service until it is reset.

Inductive charging takes place if the device or circuit is handled or grounded in the presence of an electric field (from a statically charged object). A potentially damaging rapid pulse of current will equalize the device to the electromotive force being applied by the field. The device is now at zero potential to the field but has considerable charge with respect to ground. If the electric field is now removed, the device will remain charged with respect to ground. If the device is handled or grounded at this point, a second violent discharge will take place.

A properly grounded technician handling devices or assemblies close to non-antistatic packing materials may cause several ESD events to take place through the inductive charging mechanism.

Analysis by model

In an effort to characterize the ESD event, a variety of waveforms must be examined. Historically, only the charge transfer from human to device (HBM, Human Body Model) was studied. Today, intense research into Charged Device Model (CDM), Field Induced Model (FIM) and Machine Model (MM) has shown us a multitude of waveforms and failure mechanisms.

ESD damage is not a simple problem. Nor are the solutions simple. Any effective ESD awareness and control program must start with a thorough understanding of the nature of ESD and how it will affect your equipment. Only then will ESD control tools and materials become completely effective. #

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