TECH BRIEF

The ESD Problem

What is ESD?

Electrostatic Discharge(ESD) is the transfer of electrical charge between any two objects. A common example of this is the static shock that a person experiences after walking across a carpet and then touching a metallic object such as a door knob or file cabinet. The "shock" is felt at the point of contact and is typically accompanied by a small spark and a slight snapping sound.

The process of creating an ESD event begins with the generation of *static electricity.* As one material (in this case the soles of a person's shoes) comes into contact with another material (carpeted floor) which are then separated, an imbalance of electrical charge is created (*figure 1*.). The interaction of the soles of the shoes

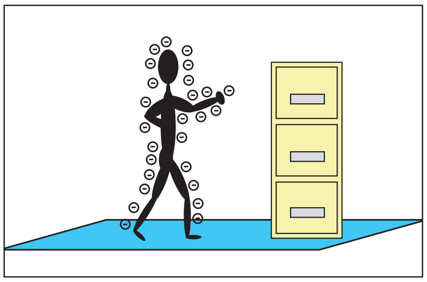

Figure 1. Generation of static electricity on the Human Body.

and the carpeted floor causes a build-up of electrons on the surface of the person, while the flooring becomes more positively charged as it gives up electrons. The static electricity continues to increase until a maximum level is reached or the person contacts another surface (in this case, a metal file cabinet) that is at a different electrical potential. The static electricity is then

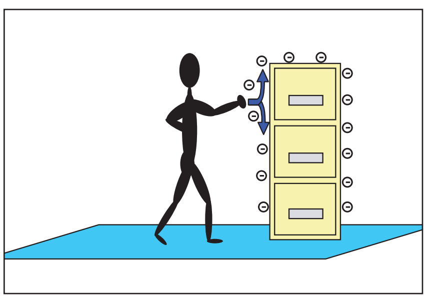

Figure 2. Discharge of static electricity.

transferred from the person in an *electrostatic discharge event (figure 2).*

ESD is different from other, common overvoltage events (switching and surge transients) in that the time it takes ESD to transition from zero to maximum current and voltage is very short. The rise time of an ESD event is less than 1 nanosecond, while the other transients take longer than 1 microsecond to reach their peaks.

The International Electrotechnical Commission (IEC) has developed a model of the human-generated ESD event (figure 3.). This model is used in the IEC's test specification for determining if systems (computers, networks, cell phones, set top boxes, etc.) are susceptible to ESD events. The test specification quantifies the methodology for introducing ESD into the system as well as the various voltage and current levels that define the ESD event. Note again how fast the rise time is for the ESD event.

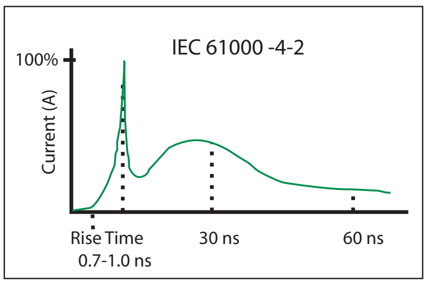

Figure 3. ESD waveform

What is the problem?

As previously mentioned, people experience an ESD event as a momentary nuisance. The shock is felt, but no physical harm is done to the person. However, during everyday activities, it is possible that ESD can be discharged into a piece of electronic equipment (instead of a file cabinet or a door). Again, the person is not in any danger, but the current and voltage that result from the ESD event can cause electronic upset or permanent damage to the equipment.

As an example, here is a path that an ESD transient can use to get from the I/O interface to the sensitive circuitry (IC) inside the electronic equipment:
As an example, suppose a technician is assembling a computer network. He will be working with electronic equipment and

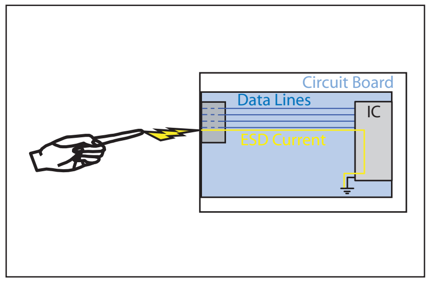

Figure 4. Path of an ESD transient in an electronic device.

various cabling and connector components. In the process of moving and interconnecting the individual parts, he can inadvertently create an ESD event that is discharged into the equipment or cables.

In general, this situation is not a problem if the discharge is to the metallic shell (cabinet) of the equipment. When this happens, the ESD current is channeled from the chassis of the equipment into the system ground to which it is normally attached.

However, it is also possible that the ESD current can be coupled directly into the communication (data, signal, and control lines) bus of the equipment. In this event, the integrated circuits (IC's) and application specific integrated circuits (ASIC's) are subjected to the current and voltage of the ESD event and can be damaged.

What is the problem, continued...

While these circuits have typical maximum ESD protection levels of 2,000 V, humans can generate ESD voltages in excess of 15,000 V. This level of ESD is in excess of the on-chip protection circuits and can damage them.

While the above example involved a technician assembling a computer network, other examples include everyday users of cell phones, computers, personal digital assistants (PDA's), set top boxes, and any other electronic device.

Once an ESD transient is discharged into an electronic system, there are three general types of adverse effects that the ESD can generate in the electronic system:

Soft Failures
Data corruption can occur to a part of the data stream, or the system may latch up. This is a temporary problem and is solved by data correction (for data corruption) or by re-booting the system (for latch up).

Latent Defects
A component within the system may by partially degraded, but is able to function properly. A typical result of a latent defect is that the system may experience premature failure due to the defective component.

Catastrophic Failures
A component within the system is rendered inoperable, and cannot function properly. This is a permanent condition and will not correct itself. This problem can manifest itself as junction breakdowns, oxide failures and the melting of interconnects. This is the type of damage that is being protected against by the use of ESD circuit protection components.

Examples of catastrophic failures include:

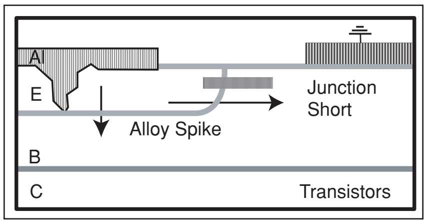

Figure 5. Junction Burnout

In the case of Junction Burnout, a short circuit condition is created in a transistor of the circuit. The metallic interconnect (trace line) is "pulled through" one of the semiconductor layers (Alloy Spike) or one of the semiconducting junctions is directly short circuited (Junction Short).

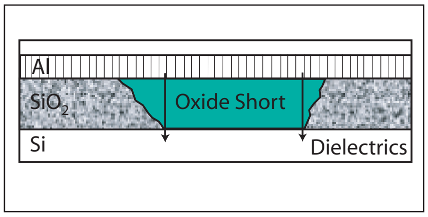

Figure 6. Oxide Punch-Through

In Oxide Punch-through, the metallic interconnect is "pulled through" the oxide layer to provide a short circuit on the signal line.

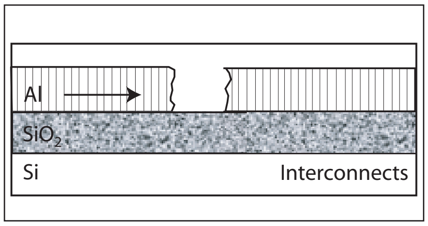

Figure 7. Metallization Burnout

In Metallization Burnout, the metallic interconnect is melted, much like a fuse. It creates an open circuit condition on the signal line.

What is the solution?

It should be reiterated that today's IC's and ASIC's include some level of on-chip protection so that they can survive ESD events that occur during chip and board manufacturing processes. These are typified in standards such as CDM (Charged Device Model), MM (Machine Model), and HBM (Human Body Model).

However, ESD transients seen by the end product will be much more severe and require off-chip, board-level ESD protection. In future Technical Briefs, we'll introduce the solutions that are available to reduce catastrophic failures in electronic equipment and allow the equipment to reliably withstand user-generated ESD events, as typified in the IEC test specification 61000-4-2.

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