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Service Note

03-022B
2 May, 2007

ESD Prevention

I. PURPOSE:
This service note provides background and instruction to help prevent ESD damage on API manufactured equipment.

II. TOOLS:
ESD wrist strap

III. PARTS:
None

IV. PROCEDURE:

A Primer on Electro-Static Discharge

Teledyne Instruments considers the prevention of damage caused by the discharge of static electricity to be extremely important part of making sure that your analyzer continues to provide reliable service for a long time. This section describes how static electricity occurs, why it is so dangerous to electronic components and assemblies as well as how to prevent that damage from occurring.

How Static Charges are Created

Modern electronic devices such as the types used in the various electronic assemblies of your analyzer, are very small, require very little power and operate very quickly. Unfortunately the same characteristics that allow them to do these things also makes them very susceptible to damage from the discharge of static electricity. Controlling electrostatic discharge begins with understanding how electro-static charges occur in the first place.

Static electricity is the result of something called triboelectric charging which happens whenever the atoms of the surface layers of two materials rub against each other. As the atoms of the two surfaces move together and separate, some electrons from one surface are retained by the other.

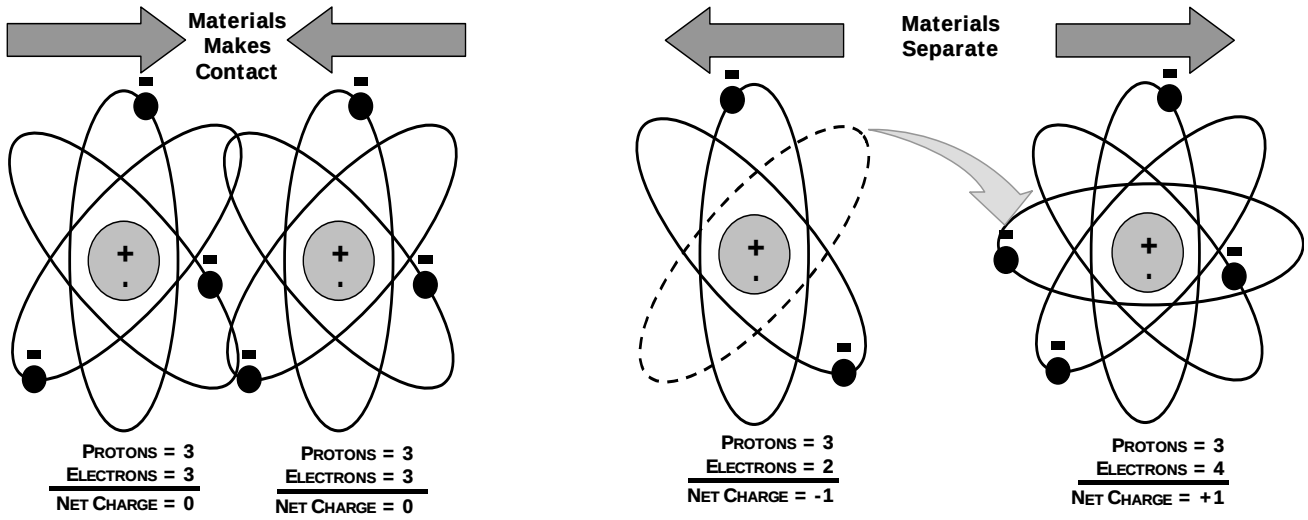

Figure 1: Triboelectric Charging

If one of the surfaces is a poor conductor or even a good conductor that is not grounded, the resulting positive or negative charge can not bleed off and becomes trapped in place, or static. The most common example of triboelectric charging happens when someone wearing leather or rubber soled shoes walks across a nylon carpet or linoleum tiled floor. With each step electrons change places and the resulting electro-static charge builds up, quickly reaching significant levels. Pushing an epoxy printed circuit board across a workbench, using a plastic handled screwdriver or even the constant jostling of Styrofoam pellets during shipment can also build hefty static charges

Table 1: Static Generation Voltages for Typical Activities

MEANS OF GENERATION	65-90% RH	10-25% RH
Walking across nylon carpet	1,500V	35,000V
Walking across vinyl tile	250V	12,000V
Worker at bench	100V	6,000V
Poly bag picked up from bench	1,200V	20,000V
Moving around in a chair padded with urethane foam	1,500V	18,000V

How Electro-Static Charges Cause Damage

Damage to components occurs when these static charges come in contact with an electronic device. Current flows as the charge moves along the conductive circuitry of the device and the typically very high voltage levels of the charge overheat the delicate

traces of the integrated circuits, melting them or even vaporizing parts of them. When examined by microscope the damage caused by electro-static discharge looks a lot like tiny bomb craters littered across the landscape of the component's circuitry.
A quick comparison of the values in Table 1 with the those shown in the Table 2, listing device susceptibility levels, shows why *Semiconductor Reliability News* estimates that approximately 60% of device failures are the result of damage due to electro-static discharge.

Table 2: Sensitivity of Electronic Devices to Damage by ESD

DEVICE	DAMAGE SUSCEPTIBILITY VOLTAGE RANGE	
	DAMAGE BEGINS OCCURRING AT	CATASTROPHIC DAMAGE AT
MOSFET	10	100
VMOS	30	1800
NMOS	60	100
GaAsFET	60	2000
EPROM	100	100
JFET	140	7000
SAW	150	500
Op-AMP	190	2500
CMOS	200	3000
Schottky Diodes	300	2500
Film Resistors	300	3000
Thin Film Resistors	300	7000
ECL	500	500
SCR	500	1000
Schottky TTL	500	2500

Potentially damaging electro-static discharges can occur:

- Any time a charged surface (including the human body) discharges to a device. Even simple contact of a finger to the leads of an sensitive device or assembly can allow enough discharge to cause damage. A similar discharge can occur from a charged conductive object, such as a metallic tool or fixture.

- When static charges accumulated on a sensitive device discharges from the device to another surface such as packaging materials, work surfaces, machine surfaces or other device. In some cases, charged device discharges can be the most destructive.

  A typical example of this is the simple act of installing an electronic assembly into the connector or wiring harness of the equipment in which it is to function. If the assembly is carrying a static charge, as it is connected to ground a discharge will occur.

- Whenever a sensitive device is moved into the field of an existing electro-static field, a charge may be induced on the device in effect discharging the field onto the device. If the device is then momentarily grounded while within the electrostatic field or removed from the region of the electrostatic field and grounded somewhere else, a second discharge will occur as the charge is transferred from the device to ground.

Common Myths About ESD Damage

- **I didn't feel a shock so there was no electro-static discharge**: The human nervous system isn't able to feel a static discharge of less than 3500 volts. Most devices are damaged by discharge levels much lower than that.
- **I didn't touch it so there was no electro-static discharge**: Electro Static charges are fields whose lines of force can extend several inches or sometimes even feet away from the surface bearing the charge.
- **It still works so there was no damage**: Sometimes the damaged caused by electro-static discharge can completely sever a circuit trace causing the device to fail immediately. More likely, the trace will be only partially occluded by the damage causing degraded performance of the device or worse, weakening the trace. This weakened circuit may seem to function fine for a short time, but even the very low voltage and current levels of the device's normal operating levels will eat away at the defect over time causing the device to fail well before its designed lifetime is reached.
  These latent failures are often the most costly since the failure of the equipment in which the damaged device is installed causes down time, lost data, lost productivity, as well as possible failure and damage to other pieces of equipment or property.
- **Static Charges can't build up on a conductive surface**: There are two errors in this statement.

Conductive devices can build static charges if they are not grounded. The charge will be equalized across the entire device, but without access to earth ground, they are still trapped and can still build to high enough levels to cause damage when they are discharged.
A charge can be induced onto the conductive surface and/or discharge triggered in the presence of a charged field such as a large static charge clinging to the surface of a nylon jacket of someone walking up to a workbench.

- **As long as my analyzer is properly installed it is safe from damage caused by static discharges**: It is true that when properly installed the chassis ground of your analyzer is tied to earth ground and its electronic components are prevented from building static electric charges themselves. This does not, however, prevent discharges from static fields built up on other things, like you and your clothing, from discharging through the instrument and damaging it.

Basic Principles of Static Control

It is impossible to stop the creation of instantaneous static electric charges. It is not, however difficult to prevent those charges from building to dangerous levels or prevent damage due to electro-static discharge from occurring.

Basic anti-ESD Procedures for Analyzer Repair and Maintenance

Working at the Instrument Rack

When working on the analyzer while it is in the instrument rack and plugged into a properly grounded power supply

1. Attach your anti-ESD wrist strap to ground before doing anything else.
   - Use a wrist strap terminated with an alligator clip and attach it to a bare metal portion of the instrument chassis. This will safely connect you to the same ground level to which the instrument and all of its components are connected.
2. Pause for a second or two to allow any static charges to bleed away.
3. Open the casing of the analyzer and begin work. Up to this point the closed metal casing of your analyzer has isolated the components and assemblies inside from any conducted or induced static charges.
4. If you must remove a component from the instrument, do not lay it down on a non-ESD preventative surface where static charges may lie in wait.
5. Only disconnect your wrist strap after you have finished work and closed the case of the analyzer.

Working at an Anti-ESD Work Bench.

When working on an instrument of an electronic assembly while it is resting on an anti-ESD work bench

6. Plug you anti-ESD wrist strap into the grounded receptacle of the work station before touching any items on the work station and while standing at least a foot or so away. This will allow any charges you are carrying to bleed away through the ground connection of the work station and prevent discharges due to field effects and induction from occurring.

7. Pause for a second or two to allow any static charges to bleed away.
8. Only open any anti-ESD storage bins or bags containing sensitive devices or assemblies after you have plugged your wrist strap into the workstation.

- Lay the bag or bin on the workbench surface.
- Before opening the container, wait several seconds for any static charges on the outside surface of the container to be bled away by the workstation's grounded protective mat.

9. Do not pick up tools that may be carrying static charges while also touching or holding an ESD Sensitive Device.
    - Only lay tools or ESD-sensitive devices and assemblies on the conductive surface of your workstation. Never lay them down on any non-ESD preventative surfaces.
10. Place any static sensitive devices or assemblies in anti-static storage bags or bins and close the bag or bin before unplugging your wrist strap.
11. Disconnecting your wrist strap is always the last action taken before leaving the work bench.

Transferring Components from Rack To Bench and Back

When transferring a sensitive device from an installed Teledyne Instruments analyzer to an anti-ESD workbench or back:

12. Follow the instructions listed above for working at the instrument rack and workstation.
13. Never carry the component or assembly without placing it in an anti-ESD bag or bin.
14. Before using the bag or container allow any surface charges on it to dissipate:
    - If you are at the instrument rack hold the bag in one hand while your wrist strap is connected to a ground point.
    - If you are at an anti-ESD workbench, lay the container down on the conductive work surface.
    - In either case wait several seconds.
15. Place the item in the container.
16. Seal the container. If using a bag, fold the end over and fastening it with anti-ESD tape. Never use standard plastic adhesive tape as a sealer.
    - Folding the open end over isolates the component(s) inside from the effects of static fields.
    - Leaving the bag open or simply stapling it shut without folding it closed prevents the bag from forming a complete protective envelope around the device.
17. Once you have arrived at your destination, allow any surface charges that may have built up on the bag or bin during travel to dissipate:
    - Connect your wrist strap to ground.
    - If you are at the instrument rack hold the bag in one hand while your wrist strap is connected to a ground point.
    - If you are at an anti-ESD work bench, lay the container down on the conductive work surface
    - In either case wait several seconds
18. Open the container.

Opening Shipments from and Packing Components for Return to Teledyne Instruments Customer Service.

Packing materials such as bubble pack and Styrofoam pellets are extremely efficient generators of static electric charges. To prevent damage from ESD, Teledyne

Instruments ships all electronic components and assemblies in properly sealed ant-ESD containers.

Static charges will build up on the outer surface of the anti-ESD container during shipping as the packing materials vibrate and rub against each other. To prevent these static charges from damaging the components or assemblies being shipped make sure that you:

- Always unpack shipments from Teledyne Instruments Customer Service by:
  - Opening the outer shipping box away from the anti-ESD work area
  - Carry the still sealed anti-ESD bag, tube or bin to the anti-ESD work area
  - Follow steps 6 and 7 above when opening the anti-ESD container at the work station
  - Reserve the anti-ESD container or bag to use when packing electronic components or assemblies to be returned to Teledyne Instruments
- Always pack electronic components and assemblies to be sent to Teledyne Instruments Customer Service in anti-ESD bins, tubes or bags.
  - Do not use pink-poly bags.
  - If you do not already have an adequate supply of anti-ESD bags or containers available, Teledyne Instruments' Customer Service department will supply them.
  - Always follow steps 1 through 5 above.