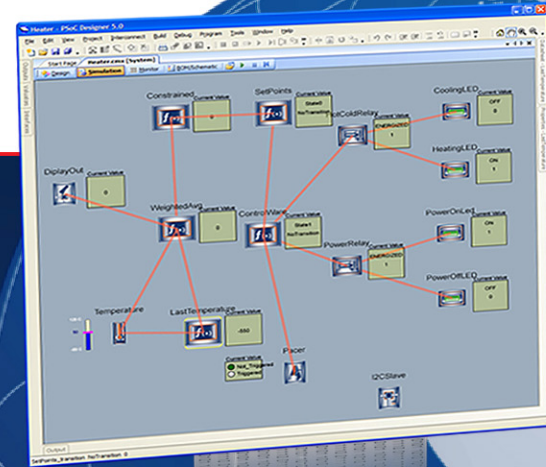


Electrical Overstress EOS



Electrical Over-Stress



Electrical Over-Stress (EOS)

Electrical Over-Stress (EOS) is a term/acronym used to describe the thermal damage that may occur when an electronic device is subjected to a current or voltage that is beyond the specification limits of the device.

EOS Damage

The thermal damage is the result of the excessive heat generated during the EOS event.

The heat is a result of resistive heating in the connections within the device. The high currents experienced during the EOS event can generate very localized high temperatures even in the normally low resistance paths. The high temperature causes destructive damage to the materials used in the device's construction.

Electrical Over-Stress



An EOS event can be a momentary event lasting only milliseconds or can last as long as the conditions persist.

EOS can be the result of a single non-recurring event or the result of ongoing periodic or non-periodic events.

ESD and EOS are related types of over stress events but at opposite ends of a continuum of current/voltage/time stress conditions.

ESD is a very high voltage (generally $>500\text{V}$) and moderate peak current ($\sim 1\text{A}$ to 10A) event that occurs in a short time frame (generally $<1\mu\text{s}$).

EOS is a lower voltage ($<100\text{V}$) and large peak current ($>10\text{A}$) event that occurs over longer time frame (generally $>1\text{ms}$).

Latch-up occurs when the device reaches a threshold (current and voltage) that causes a parasitic SCR structure to turn on. Once turned on the latch-up condition will persist until the supply voltage is removed. Latch-up can create EOS damage if the current is large and/or if it persists over a long time period.

Electrical Over-Stress



The electrical failure in the customer's application may show one or more of the following symptoms:

- Excess supply current
- Low resistance between the supply voltage and ground
- Shorted input or output pins to either the supply voltage or ground
- Open connections to one or multiple pins – IO, supply voltage, or ground
- Functional failure due to internal damage to the device

Electrical Over-Stress



Visual Damage

EOS damage can at times be seen as visual damage to the device. This damage is the result of the high temperatures experienced during the EOS event.

External (visible to the naked eye or with low power microscope)

- Visible bulge in mold compound
- Physical hole in mold compound
- Burnt/discolored mold compound
- Cracked package

Internal (visible after decapsulation with high power microscope)

- Melted or burnt metal
- Carbonized mold compound
- Signs of heat damage to metal lines
- Melted or vaporized bond wires

Electrical Over-Stress

EOS External Damage



Package Bulge



Package Hole

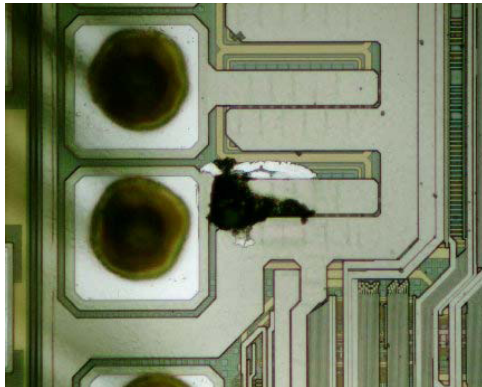


Package Burnt/Cracked

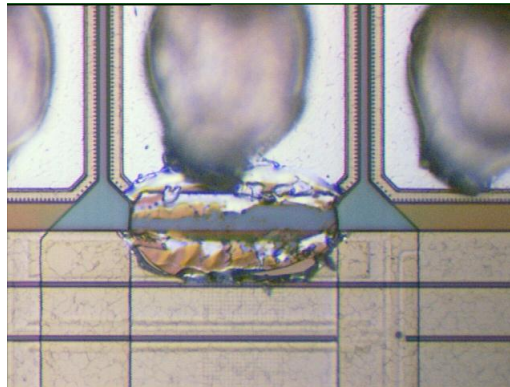
Electrical Over-Stress



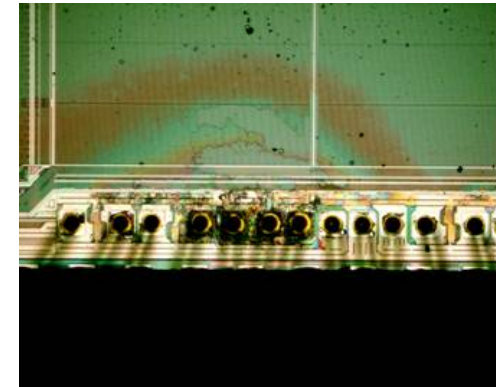
EOS Internal Damage



Burnt Metal



Open Connection



Heat Stress



Melted Bond Wire

Electrical Over-Stress



Possible causes of EOS

- Uncontrolled voltage surge on the power supply.
- Voltage spikes due to internal PCB switching.
- Voltage spikes due to an external connection – capacitive charge on an external cable, antenna pick-up of external switching noise, inductive loads.
- Poor grounding resulting in excessive noise on the ground plane.
- Overshoot or undershoot during IO switching.
- EMI (electromagnetic interference) due to poor shielding in an electrically noisy environment.
- ESD events that trigger a larger EOS event or cause damage that weaken the device making it more susceptible to future EOS events.
- Latch-up events may result in EOS damage if the current is high or if it persists for an extended time period.

EOS Prevention



Manufacturing Area ESD Control

- Proper use of conductive flooring and work spaces.
- Proper use of personnel grounding straps.
- Proper cart and shelving grounding.
- Proper checking of solder rework equipment for EM leakage.
- Proper control of humidity levels in work areas.

EOS Prevention



Manufacturing Area Operations

- Poor test equipment grounding
- Multiple ground connections
- Ground loop currents
- Mix-ups between Chassis ground and electrical safety ground
- AC power line surges (large switching currents)
- Inductive/Capacitive loads
- Connecting long cables to active circuits
- Damaged or poorly maintained sockets on programmers
- Incorrect insertion into programmer sockets
- Component board mounted in wrong orientation

EOS Prevention



Product/Application Level

- Clean Vcc and Vss supplies
- Controlled Vcc ramp at power up and power down
- Proper power/ground de-coupling capacitors
- Data buss contentions
- PCB low resistance conduction paths for power and ground
- Connecting external cable to an unprotected IO port

Electrical Over-Stress FAQ



What is EOS?

EOS is thermally induced damage to a component induced by an overvoltage condition.

How is EOS different from ESD?

EOS and ESD are related voltage overstress conditions but they differ in the total energy and time span of the event. EOS has higher energy and a longer time span.

How do I prevent EOS?

A careful review of the power supply variations and input signals to look for possible conditions that exceed the product specifications.

Does Cypress test for EOS?

No. There are currently no industry standards that allow for testing for EOS type conditions.

Is EOS and Latch-up the same?

No. Latch-up is a specific event that occurs when the parasitic SCR device is triggered, while EOS is a general description of any electrical overstress. EOS may not be caused by Latch-up and Latch-up can occur without causing permanent EOS damage to the component.

Electrical Over-Stress FAQ



Does Cypress have a specification for EOS tolerance?

No. Cypress tests for ESD and Latch-up per JEDEC standards. See the Cypress web site for more information on the product qualification requirements.

Does Cypress have specific PCB layout rules to prevent EOS?

No. EOS is an event that can occur on any PCB layout.

What process parameter will cause EOS tolerance to degrade or improve?

Cypress tests all products to function properly under the specification limits. An EOS event is an event that occurs outside the specification limits.

How do I detect an EOS problem in the field?

(See list of electrical signatures in this presentation)

Why is the Cypress component the only part failing on my board?

Normally, in an EOS event more than one component will experience the voltage surge. However, based on placement and electrical connections on the PCB and sensitivity of the components, one component will fail first and the current will be shunted to that component, resulting in more damage that component.

Electrical Over-Stress FAQ



My power supply is clean. How can you tell me the Vcc damage is a customer problem?

Variations in the Vcc supply or ground can be non-periodic and be influenced by external conditions. A limited time review of the voltage supply may not reveal the problem. Monitoring the supply voltage over a longer time and with properly set trigger levels may reveal the problem if the issue is periodic in nature. If, however, the EOS was triggered by non-recurring event then monitoring the supply voltage may never reveal the problem.

My IO signals have small/no over/under shoot. How can I still have EOS damage?

Variations in the IO signal can be non-periodic and be dependent on external and internal switching. It is possible for large spike on the IO pin to cause a latch-up event. This event if not terminated may cause thermal damage to the component. Monitoring the IO voltages over an extended time with properly set trigger levels may reveal voltage spikes that can cause a component to fail.

Electrical Over-Stress FAQ



Why can you not tell me exactly what happened?

The damage caused by EOS is typically so extensive that the origin of the problem can not be determined. An initial small voltage perturbation can cascade into a large event and cause damage that overwhelms the original damage site. The analysis report will identify which package pins are damaged and with this information you should be able to identify potential areas for further investigation such as power supplies or IO signals.

Why is this not a Cypress design/process/manufacturing problem?

Cypress designs and tests its parts to function within the specified operating parameters. We also qualify our parts using industry standard test methods including ESD and Latch-up. Qualification data is available on the Cypress web site, <http://www.cypress.com/?id=1090&source=header>.

However, all semiconductor components will eventually fail if exposed to conditions beyond the datasheet specifications. EOS damage can not be generated by the internal conditions of the component when operating within the datasheet specifications. The EOS damage can only occur when abnormal conditions are present.

Cypress Information



Additional Information is available at the Cypress web site

General product information and datasheets are available at:

Cypress Corporate Web site –

<http://www.cypress.com/>

Additional reliability and qualification data is available at:

Cypress Corporate Quality web site –

<http://www.cypress.com/?id=1090&source=header>

EOS Reference Material



The following is a list of other resources located on various web sites.

The ESD Association is a very good resource for learning or training on ESD and EOS. The association has an annual symposium dedicated to ESD and EOS.

ESD Association – www.esda.org

Annual EOS/ESD Symposium

Classes/Books on ESD and EOS

Below are listed a few web sites that discuss EOS. A general search of the web will find many more references.

www.bestesd.com/library/Origins-of-EOS.pdf

www.ce-mag.com/archive/02/Spring/dangelmayer.html