Why do Power Supplies Fail, and What can be done about it?

Randy Malik, Rick Fishbune, Tim Daun-Lindberg, Pat Frank, Eric Swenson, Dale Wilhite, Charles Dishman, Brian Steenburgh
Major Causes of Failure

“When power supplies fail, it isn’t because designers choose components they know will fail; they often have insufficient information about the problems that result from their choices.”

1. **Components**
   - Semiconductor Devices
   - Capacitors - Electrolytic, Ceramic, Poly Film
   - Magnetic Components

2. **Power Supply Construction**
   - Spacing on Board
   - Device Mounting on Heat Sinks
   - Placement of Components

3. **Environment**
   - High Humidity – chemicals
   - Conductive Metal Parts
   - Bugs

4. **Qualification & Testing**
   - HALT Tests
   - Control and Run Charts

5. **Failure Analysis**
   - Root Cause Determination
   - Field failure data
MOSFET Construction Analysis

Electrical Components from two suppliers A and B are different. See Construction details.

Figure 1 Supplier A: Delaminating between epoxy and lead frame shown by red color. C-SEM front side.

Figure 2 Supplier B: No Delaminating.

Figure 3 Supplier A: Voids between the die and lead frame (die attach) are found as represented by the white dots.

Figure 4 Wire bond Comparison Supplier A and Supplier B.
MOSFET Failure = f (time)

MOSFET with the Soft Knee, Can't run with the soft knee for long

Figure 1: Craters on the EPI layer
MOSFETs from Supplier A and B

If you don’t know whether a component used in a product is robust or not, how would you expect the product not to fail in the field?

Figure 1 Voltage Breakdown (BVdss) Distribution

Figure 2 Leakage Current (Idss)
Electrolytic Capacitors

If you believe in plug and play, then learn to pray. Always Use Brand name quality Caps

Good capacitor brands

- Rubycon
- Nichicon
- Panasonic
- Sanyo
- Nippon
- United Chemi

Electrolyte formulation unstable, - hydrogen buildup inside the metal Can and failure in the field
Multilayer Ceramic Capacitors

Cut corners in cost, and then place them near corners, the result is obvious.

Figure 1. The corner of an MLCC, in cross-section. The red arrows show the cracked line.

Figure 2. Close up of area denoted by the red box in figure 1. The crack bridges between the conductors.
Poly-Propylene Capacitors

1. Flattened capacitors rely on heat and temperature to create a consolidated winding. This creates stresses, particularly at the centre of the winding where the film is forced to fold through 180°.

2. It is difficult to create consistent conditions for flattening, excessive pressure on some winding and insufficient pressure on others due to film thickness variations.

Who says POLYP Capacitors don’t burn. When they do, they burn spectacularly
Magnetic Components

Another Inductor Burnt, WOW! Did we learn anything here?

PFC Choke Burnt …. Two Powder Iron Chokes used in series
Zinc Whiskers and MOSFET Failures

**WOW! Zinc Whiskers again! Remember the lessons learned.**

![Image of Zinc Whisker](image)
Roaches Infestation - Power Supply Failure

One thing is sure, nothing is Bug Proof
Best Practices - Power Supply Construction

Good design can help to prevent manufacturing defects and service errors and to reduce the need for non-value-adding inspection practices.

Figure 1  Power Supply Component Placement and PC windows

Figure 2  Heat Sink Assembly to mount semiconductor devices with no screws and no clips
PARETO Diagrams

Treating the symptoms is a short term relief, find the root cause and have a long term relief

Figure 1: Failed Components in the field

Figure 2: Causes of MOSFET Failure
Relative Cost to fix a Problem

The costs of preventing problems at the design stage are much lower than costs of correcting problems that occur “downstream.”
Reliability and Learning Curve

Through a process of learning, knowledge is developed.
PPM Defects for a Server Power Supply – Today and in Future

Cost being ($0.08/Watt), Quality will have a definite competitive advantage.

- PPM - today
- PPM - Future

Competitive Advantage

Time - months

PPM
“Kaizen” – Journey of Continuous Improvement

Sustaining total quality requires viewing quality efforts as a journey, not an end.

The purpose of the design review is to stimulate discussion, raise questions, and generate new ideas and solutions to help designers anticipate problems before they occur.

If you can’t find the root cause of failure, you can not prevent it.

Eliminating symptoms of problems usually provides only temporary relief; eliminating root cause provides long-term relief.

How the data is collected, analyzed, and to whom it is presented, and if this does not go to the right people … What a waste of resources?