

App Note

Why Power Supplies and Semiconductors Fail

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Causes and results of power disturbances

A power disturbance can be defined as unwanted excess energy that is presented to the load.

Comments regarding power disturbances

- Power quality varies significantly from one area to another. Some countries have very stable power grids while others are extremely short on capacity.
- Power disturbances are caused by the generation, distribution and use of power; and lightning.
- A power disturbance can be defined as unwanted excess energy that is presented to the load.

Causes of power disturbances

- Power disturbance originate both outside and inside customer facilities.
- Load switching causes surges because of collapsing fields ($-e = l * di/dt$).
- Over loaded power distribution systems can cause significant voltage variations between peak and off-peak hours.
- Significant momentary load changes, such as heavy inrush currents can cause severe voltage variations.
- Black-outs can cause severe voltage surges both on loss and return of power.
- Circuit-breaker tripping and fuse blowing can cause severe surge voltages.
- Large ups and variable-speed drives can cause various surge voltages inside buildings.

Results of power disturbances

- Sags and under voltages can cause component overheating or destruction.
- Surges and over voltages can cause component overheating, destruction or can trigger other electronic components such as SCR's.
- Component overheating reduces the life and deteriorates the real reliability as opposed to the estimated reliability based on steady-state conditions of the product.
- False triggering of other components can create nuisance alarm tripping or, worse, can cause overheating or destruction of other electronic components.



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Why semiconductors fail

- Most semiconductor devices are intolerant to surge voltages in excess of their voltage ratings.
- Even a fast surge of a few microseconds can cause the semiconductor to fail catastrophically or may degrade it so as to shorten its useful life.
- Damage occurs when a high reverse voltage is applied to a non-conducting pn junction.
- The junction may avalanche at a small point due to the non-uniformity of the electric field. In this case, thermal runaway can occur because of localized heat build up and cause a melt-through which destroys the junction.

Problems with current solutions

- Common-mode voltage disturbances can be amplified in non-tn-s ac distribution systems.
- Typical emi filters are not well damped. This has a dramatic effect on any voltage disturbances, resulting in oscillations inside the emi filter under any transitional conditions. Severe voltage surges may result from fly-back from saturated inductors looking for a path to release energy.
- Boost converters can be destroyed by surges causing increased energy storage in input filter, the output capacitor (c) is charged to an unsafe level depending on capacitance value and load levels for the dc/dc converter connected to the output of the boost.

Limitations of commercial UPS equipment

- The industry is driven by lowest cost.
- Users normally don't care about power quality.
- Users really care about saving data which means that they are satisfied with orderly shut down to protect data files.
- Most UPS do not have quality battery chargers and chargers are nor designed for long-term back-up.
- Most UPS equipment does not provide real power conditioning (there are exceptions).
- Some UPS equipment is poorly protected against surge voltages.
- Extended back-up requires the addition of expensive rectifier/chargers and battery packs.



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About the author

Mr. Peter Nystrom has been active in the power protection industry since 1979 and is the founder of two companies. He has also been active as a consultant to major telecommunication equipment manufacturers for several years. Since 1998, he has been the CEO of TSi Power Corporation (located in Wisconsin, USA), a manufacturer of UPS, line conditioner, automatic voltage regulator, and dc to ac inverter systems designed to meet the challenging international power conditions.