Reliability of Grid-Connected Power Electronics: A Case Study (GR-14-03)

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Project Objectives

- To perform a case study on a commercial product to evaluate power electronics reliability.
- To identify the areas of reliability concern in the specific product and provide recommendations for improvement.
- To generalize the results and develop general guidelines and methodologies to study reliability of grid-connected power electronics systems.

Understanding Converter Topology

Computer Simulation

Experimental Reliability Study

Identifying Reliability Concerns in the Electrolyzer Product by Proton On-Site

- Component Concerns
  - Resistive current sensing in PFC stage is vulnerable to noise.
  - Power switching devices such as MOSFETs are the most vulnerable components.
  - Electrolytic DC capacitor reliability

- Control Concerns
  - Current Sharing between two paralleled ZVS converter stages is not guaranteed.
  - Average current mode programming in the PFC stage does not provide cycle-by-cycle peak switch current limit.

- Thermal Concerns
  - During a Temperature cycle there is strain at all material interfaces. Over repetitive temperature cycles this strain can cause fatigue, cracks, joint degradation and eventual failure.
  - Power cycling failures on the MOSFET discretes. The stress is caused by differences in the linear expansion characteristics of the different materials.

Experimental Reliability Study

- Measurements of internal quantities
  - Static and dynamic current sharing within the two paralleled DC-DC stages inside a power supply
  - Heatsink temperature
  - AC-DC stage MOSFET switching voltage waveform
  - DC-DC stage MOSFET switching voltage waveform
  - Boost power factor correction inductor current measurement
  - Output rectifier current measurement

- Measurements of external quantities
  - Dynamic output current response
  - Dynamic three-phase input current response
  - Steady-state and dynamic output current sharing among paralleled power supplies

Summary

- Insight into Converter Different Power Stages & Components
- Computer Simulation
- Analysis of failure statistical data provided by Proton On-Site
- Performed experimental study and measurements to evaluate single power supply performance
  - Unequal internal output current sharing is a reliability concern.
- Procedure for System-Level Reliability of Power Supply Systems
  - Understand system level requirements and operation
  - Study operation and control of individual working blocks
  - Examine system level operation and overall control
  - Study reliability data if available
  - Examine transient operation
  - System level EMI