Lightning Pin Injection Testing on Power-MOSFETs

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IVHM Milestones: Diagnosis 2.1.2.2, Prognosis 2.1.3.1, Foundational 1.1.2.1

PURPOSE OF RESEARCH:

Modern aircraft power conditioning systems incorporate metal-oxide semiconductor field effect transistors (MOSFETs) to supply electrical power for vehicle controls, communications, navigation, and radar systems. Lightning strikes induce high-voltage transients on power cables, which can expose MOSFET components to off-nominal operating conditions resulting in damage or degradation. Research to characterize the electrical performance of MOSFET devices after exposure to lightning transients is allowing the development of prognostic methodologies and tools to predict remaining useful life of MOSFET components. Such work is of significant importance for ensuring safety as well as reducing cost of maintenance and operations.

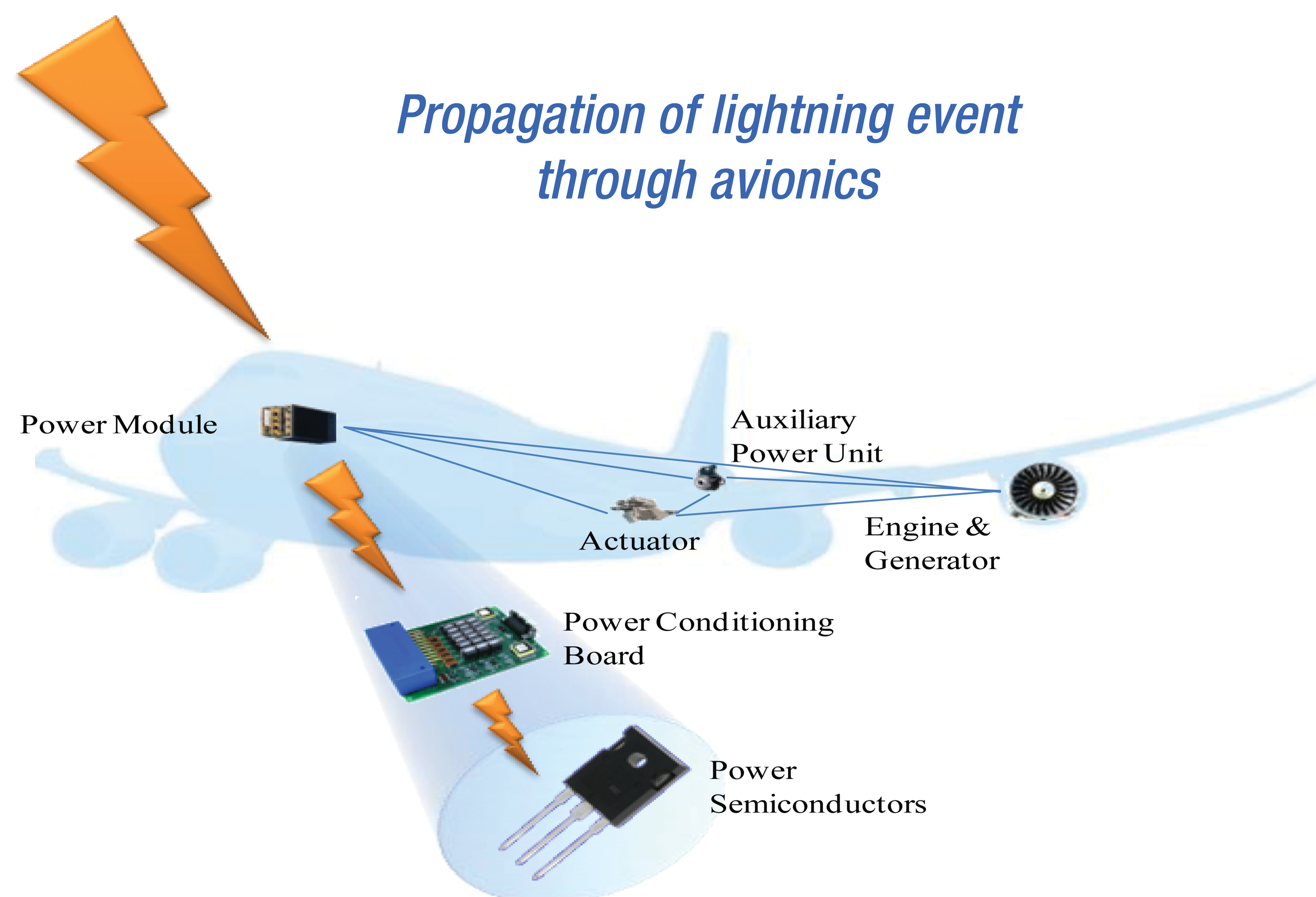
TEST PHASING

- 1) MOSFETS in "OFF" State
  - Test Dates: Jan 12-16, 2009
  - Challenges: Current & Voltage Measurement Methodology, MOSFET Failure Identification, Data Acquisition & Analysis, Evaluation of Lightning Test Waveforms 3, 4 and 5.
  - Publications:
    - "Lightning Pin Injection Testing on MOSFETS", NASA/TM-2009-215794 ", Sept. 2009
    - "Effects of Lightning Injection on Power-MOSFETs", PHM Society Conference, Oct. 2009.
- 2) MOSFETS in "ON" State
  - Test Dates: May 5-29, 2009
  - Challenges: Protecting the biasing circuitry & lightning generator from each other without corrupting the measurement. X-Ray failure analysis evaluation.
  - Publications: NASA TM In-Work
- 3) MOSFET-Powered System Test
  - Test Dates: TBD

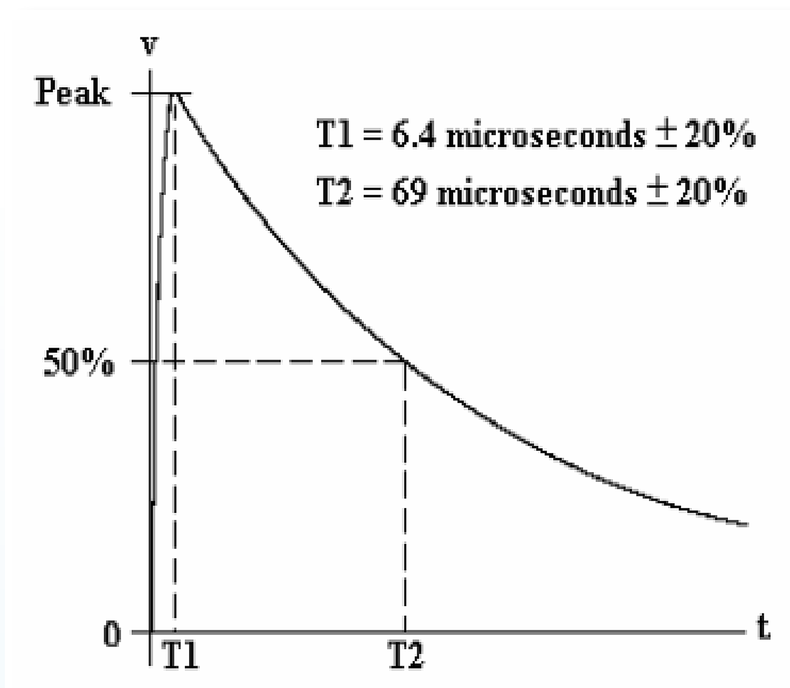
FINDINGS

- MOSFET Gate-Source connections may be susceptible to lightning-induced failure, even when installed in systems in well-shielded and partial-shielded aircraft locations (if not protected with transient-limiting circuitry). MOSFET Drain-Source connections were shown to be significantly less susceptible.
- Device impedance decreased (current increased) after every failure (MOSFET "OFF" State Testing. Such a failure mode may lead to cascading failures, as the damaged MOSFET may allow excessive current to flow through other circuitry.)
- Analysis of the characteristic curves of the devices showed that for certain injection modes the devices can accumulate noticeable damage, but still continue to function.
- Failure detection using X-Ray or optical techniques is not practical or not possible. Functional testing appears to be the most effective way to determine damage.

Propagation of lightning event through avionics

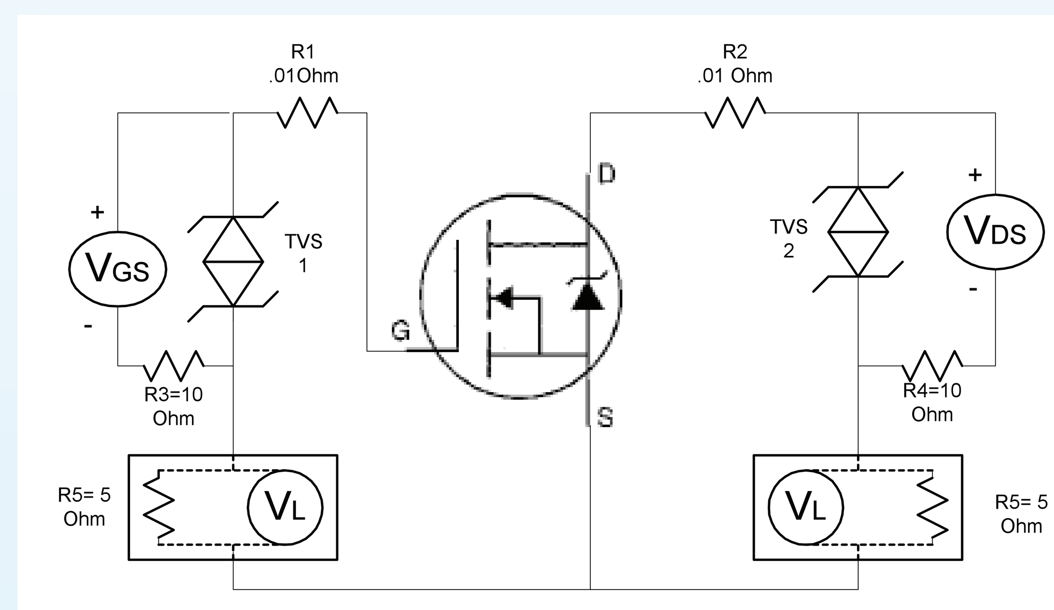


RTCA/DO-160E Section 22 Voltage Waveform 4

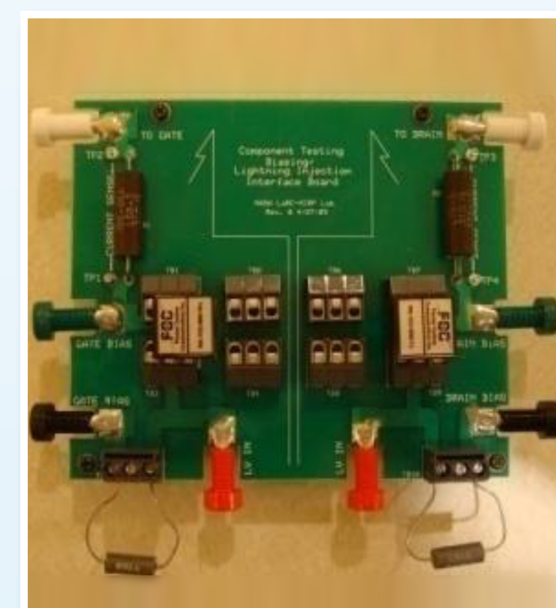


Lightning Pin-injection testing

Pin Injection Test Setup Schematic for MOSFET in "ON" State Testing



Component Testing Biasing/Lightning Injection Interface Board



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