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Modal Analysis of Power Electronics Module of Spacecraft and its Health Monitoring - An Approach

Jiwan Kumar Pandit[a], D. Roy Mahapatra[b], R. Pandiyan[a]*

[a]*ISRO Satellite Centre, Bangalore, 560017, India*
[b]*Indian Institute of Science, Bangalore, 560012, India*

Abstract

The spacecraft launch environment is quite harsh which can damage the spacecraft electronics. The high intensity vibrations occurring during this phase are transmitted to the spacecraft structures and its electronic equipment. The high intensity vibrations can be sensed using flexible nano sensors and these inputs could be used by actuators to safeguard the spacecraft electronics.

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1. Introduction

The loads acting on a spacecraft, during its entire life-span, can be broadly categorised as Loads acting during Ground operations, Launch loads and On-orbit loads.

The Ground operation loads consist of:-

- Ground handling
- Transportation (horizontal or vertical by road, rail or air)

* Corresponding author. Tel.: +91 80-25082720; fax: +91 80-25082510.
E-mail address:jkpandit@isac.gov.in

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The Launch loads, though act for a lesser duration, but are quite critical for the electronics. These loads occur due to the following events:-

- Lift-off,
- Transonic Maximum Q,
- Engine Cut-off,
- Stage Separation,
- SRB End of flight,
- Spacecraft separation.

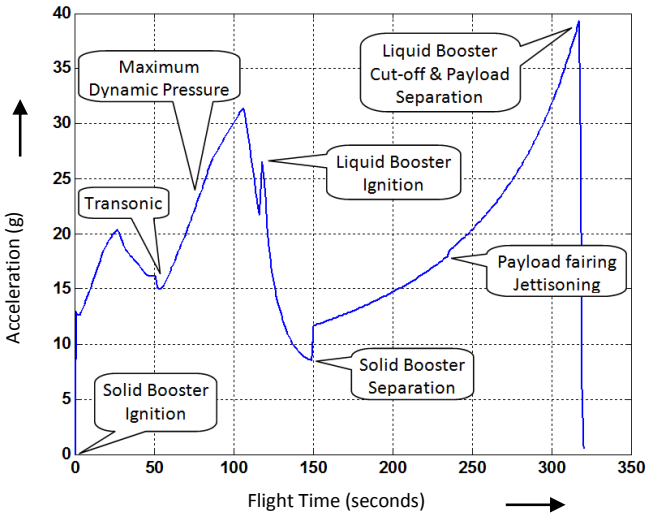

Fig. 1 – Steady state acceleration profile of a typical launch

The on-orbit loads can be caused due to different events as:-

- Pyro-shock for the deployment of appendages (like Solar Panel, or Hold Down and Release Mechanisms),
- Firing of Reaction Control elements (like Thruster, Liquid Apogee Motor etc.),
- Operation of Momentum/ Reaction Wheel
- Impact caused due to meteoroids,
- Thermal loads, etc.

The electronic packages on the spacecraft are adequately designed to withstand the launch loads and are screened out during the qualification level tests. In spite of the due care taken, majority of the failures have been observed during this phase, following a bath-tub curve pattern. This paper mainly focuses on the failure of the electronic packages during launch phase and techniques to mitigate the same with using health monitoring techniques.

2. Finite Element Analysis

The printed circuit board (PCB) of a typical power package having the size as 260X220X2.1 mm^3 has been considered in this study. The PCB material is FR4 and its mechanical properties have been experimentally derived. Eight number of spacers made up of AL6061 has been used as stand-offs so as to support the PCB in its enclosure.