Combined Electromagnetic and Mechanical Vibration Environments

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It is well established that the shielding characteristics of an enclosed electrical system can be highly sensitive to the integrity of the mechanical joint features. The sensitivity of the coupling of electromagnetic (EM) fields into the system cavity increases with frequency, where the fine details of the joint begin performing as receiving antennas (guiding energy into the interior of the cavity). Thus, field enhancements associated with mechanical changes of an enclosed system are of concern when assessing electromagnetic susceptibility. More specifically, a key question becomes "how do the mechanical characteristics of the enclosure influence electrical performance?" Hence, there is clearly a need to understand electromagnetic-coupling performance for scenarios that include combined electromagnetic, shock, and vibrational environments.

Mechanical changes of an enclosure affect electromagnetic boundary conditions (e.g. physical deformation of cavity walls) and thereby change the interior electromagnetic characteristics (i.e. EM resonant frequency, Q, …). However, mechanical changes associated with thermal changes or quasi-static mechanical loading typically occur over a very long times (corresponding to fractions of a Hertz) relative to both the period of the high frequency electromagnetic waves and the time constants associated with the cavity and electrical circuits. Thus, from the electromagnetic point of view, these mechanical changes are essentially static. On the other hand, since mechanical changes associated with shock and vibration can occur at rates of 100‘s to 1000‘s of Hertz and it is well known that high-frequency fields modulated in this same range of frequency can induced undesired effects in electrical systems, amplitude modulation of the field induced by mechanical changes at these rates could analagously impact electrical circuit performance.

The purpose of this presentation is to describe efforts at Sandia National Laboratories to investigate environments where mechanical shock and vibration produce rapid changes in the electromagnetic fields. These efforts focus primarily on the electromagnetic coupling through mechanical joints into a shielding enclosure that experiences rapid mechanical changes due to shock and vibration. Results will be presented including analysis, electromagnetic and mechanical simulations, and experiment that demonstrate the effects of combined electromagnetic and mechanical vibration environments.

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