Electromagnetic Dampeners to Improve Cavity Shielding Effectiveness

Salvatore Campione, Isak C. Reines*, Larry K. Warne, Jeffery T. Williams, Roy K. Gutierrez, Rebecca S. Coats, and Lorena I. Basilio
Sandia National Laboratories (SNL), Albuquerque, NM USA 87185

Many of today's electrical circuits and systems are protected against harsh external electromagnetic (EM) environments that can adversely affect their electrical performance and reliability. Often, circuits critical to system operation are encapsulated by a metallic cavity (which may become resonant at certain frequencies depending on materials, size, etc.) whose purpose is to shield the circuit against unwanted interactions with external EM fields. The cavity may contain pathways, such as holes associated with mechanical joints, seams, and rivets, which can allow the external field to couple into the cavity. For high-Q resonant cavities, internal field levels can be much higher than the incoming field.

Radio-frequency circuits can have an unwanted impedance change due to the high field levels within the cavity; similarly, some low-frequency circuits can be negatively impacted if the field levels within the cavity are modulated in the low kHz range. However, reducing the internal cavity field levels by eliminating the EM entry paths can be very challenging due to often opposing mechanical and electrical system requirements. Another approach is to introduce EM absorbing (lossy) materials within the cavity to dampen the cavity quality factor. Although the concept of introducing absorbing materials within a cavity to drive the interior field levels down is well known, designing the cavity loading to realize prescribed specifications (placement, frequency performance, etc.) as opposed to the more qualitative approach of essentially randomly adding lossy materials to decrease Q has not yet been considered. In general, one needs to factor in requirements other than just EM including mechanical, thermal, material aging, etc. This paper examines the EM performance, where the challenge is to realize lower quality factors over a broad spectrum of frequency dictated by stringent system requirements, while not negatively impacting the other environments.

The purpose of this paper is to describe efforts at SNL to investigate EM absorbing materials and placement within a slotted cylindrical cavity to dampen the internal fields, thus improving system shielding. While a simple canonical structure (cylinder with a single slot) is used for demonstration purposes, the conclusions presented here can be leveraged for use with more complex cavity structures. Simulations and experiments of empty cavities demonstrating internal high field levels will be shown, as well as simulations showing significant improvements in shielding effectiveness with very minimal amounts of absorbing material placed in appropriate locations. This approach maximizes the interior cavity real-estate and may be critical for practical implementation.

Supported by the Laboratory Directed Research and Development program at Sandia National Laboratories, a multimission laboratory managed and operated by National Technology and Engineering Solutions of Sandia, LLC, a wholly owned subsidiary of Honeywell International, Inc., for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-NA-0003525.