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EMI Analysis and Design of a Complex Assembly of RF/Digital Electronic Modules

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The integration of multiple electronic modules inside a single assembly has become a very common practice in the design of complex systems. The designer has to face at least two issues from the electromagnetic compatibility (EMC) point of view: the intra- and infra-module coupling. The former is due to the unwanted radiation from parts or components of a module that is generally represented by one or more printed circuit boards generating electromagnetic interferences (EMI) on the same boards. This unwanted electromagnetic noise propagates outside the module through apertures and slots and can couple to other modules giving rise to the infra-module coupling. This work proposes an efficient approach for the identification of these problems and their solution aimed at improving the EMC performances of the modules and the overall assembly. A complex mixed signal board is considered embedded into a metallic enclosure. Multiple metallic enclosures are set aside into a larger assembly.

The board is represented by a 3D model used for a full-wave simulation to evaluate the S-parameters among equivalent ports representing the ends and terminations of critical lines. The coupling among these ports is due to the noise radiated by each interconnect, hosting the most relevant and critical RF and digital signals. Such unwanted coupling and the main physical mechanisms generating it are highlighted and quantified by the spatial distribution of the electric field across the module. A typical design solution involves the use of electromagnetic absorber materials [3] to decrease the magnitude of the field. However, it presents some critical disadvantages such as weight, thermal dissipation, long term reliability. The analysis carried out identified specific resonant frequencies excited within the module that leads to strong coupling among critical lines/ports. The proposed solution involves the use of ground (GND) posts between the PCB ground planes and the metallic enclosure at specific locations in order "to break" the resonant patterns. As shown in Figure 1 the unwanted radiation is strongly decreased by the proper placement of the ground posts, that has been optimized taking into account geometrical and functional constraints, and the specific distribution of the field at different frequencies.

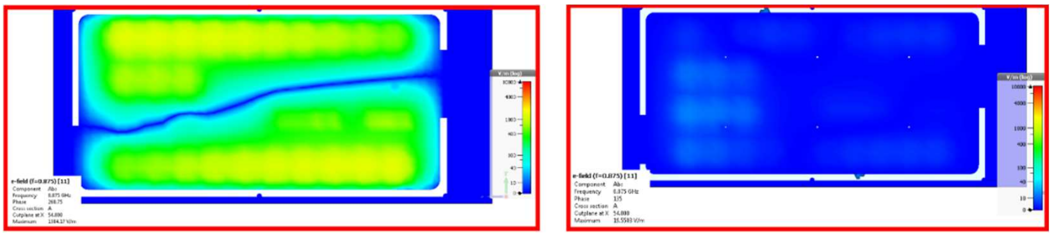

Figure 1. Spatial distribution of the electric field inside a module: without (left) and with (right) ground posts

Each module is part of a mechanical assembly that contains 8 of them. The unwanted electromagnetic radiation inside each module leaks through the module apertures and slots and propagates inside the assembly coupling into the other modules. Due to the high complexity of the system, the numerical analysis for the evaluation of the electric field intensity within the assembly is impractical, thus this work implements the Huygen's surfaces (HS) to evaluate the effectiveness of the GND posts inside each module. The use of the GND posts is demonstrated to be effective to reduce unintentional coupling within each single module, and toward adjacent modules and within the main enclosure do to noise leakage through the module apertures. This is achieved since the resonant frequencies are moved at frequencies higher than the main operating band of the module, thus keeping the original PCB layout. The proposed solution is cost-effective since it involves only a slight change in the mechanical design.