Integral Equation Based Analysis of Electromagnetic Coupling to Antennas and Transmission Lines in Metallic Enclosures

Frank Gronwald, Jürgen Nitsch, and Sergey Tkachenko
Otto-von-Guericke-University Magdeburg, IGET, Universitätsplatz 2,
39106 Magdeburg, GERMANY, http://www.uni-magdeburg.de/iget/

Electromagnetic Compatibility Analysis includes interior electromagnetic coupling to antenna or transmission line structures (F.M. Tesche, M.V.Ianoz, and T. Karlsson: "EMC Analysis Methods and Computational Methods", John Wiley & Sons, New York 1997). While in free space antenna and transmission line theory is well-developed there is a number of nontrivial modifications that need to be done in order to apply these theories to interior problems. To exhibit these modifications it is required to start from electric field integral equations that incorporate the general solution of Maxwell's equation and the appropriate boundary conditions of cavities that resemble metallic enclosures. So far there is only a relatively small number results on this topic, see (F. Gronwald, IEEE Trans. on Electromagn. Compat. vol. 47, November 2005) or (S. Tkachenko, F. Gronwald, J. Nitsch, and T. Steinmetz, V$^{\text{th}}$ Int. Symp. on EMC, St. Petersburg, 2003, 68–74), for example.

In this presentation we focus on transmission lines that are viewed as two single, coupled antennas and are enclosed by a rectangular cavity. We are interested to calculate for a given excitation the current on the transmission line and compare the results to the analogous situation in free space. Our solution procedure includes the following points:

- Simplification of the relevant electric field integral equation by a thin-wire approximation.
- Application of the method of analytical regularization to separate the Coulomb singularity from the cavity resonances.
- Computation of the cavities' Green's function by means of computationally efficient hybrid representations that are supplemented by a Spline-interpolation scheme.
- Subsequent application of the method of moments in the general case or calculation of approximate, analytical solutions in limiting cases.

Our results show that the coupling between a transmission line and a cavity depends on how well the assumptions of conventional transmission line are met by the specific line. If the geometry and the excitation are such that the transmission line can be modelled by conventional transmission line it will not strongly couple to the cavity modes, and vice versa. It follows that in the modelling of transmission lines the excitation of resonances inside a cavity is an effect which is analogous to the generation of radiation in free space.