A Scattering Matrix Approach for Transmission Lines Passing Through Cavities Coupled to Exterior Fields

F. Capolino[1,2], D. R. Jackson[1], and D. R. Wilton [1]

[1] Dept. of ECE, University of Houston, Houston, TX, USA
[2] Dept. of Information Engineering, University of Siena, Siena, Italy

In various electronic systems signals are transmitted via transmission lines (TLs) that connect the various system components. In some situations, TLs may pass through metallic enclosures that act as resonant cavities, which, depending on the geometry, may significantly affect the signal reflection and transmission in certain frequency bands. Furthermore, additional electromagnetic interference (EMI) signals may couple to the cavity and thus be transmitted to the TL of interest.

We analyze here a scenario consisting of a TL passing through a cavity that is also coupled to an external field via an additional aperture on the cavity wall. We focus on the effects of the cavity on transmission of the signal through the cavity, and to the signal picked up by the TL by coupling to an incident wave impinging on the cavity from the exterior. The wire penetrating the cavity is represented in terms of a scattering matrix obtained by a domain decomposition approach that separates the interior and exterior problem analyses. The scattering-matrix description of the cavity allows for its convenient inclusion into a more complicated system via the BLT equations, in which the behavior of the total system is obtained from the scattering matrices of the components that comprise the complete system. The coupling to the TL wire by the external field impinging on the cavity is represented by adding a port in the scattering-matrix formulation while maintaining a consistent definition of the relevant scattering parameters.

As an application it will be shown how the cavity affects the input impedance of a TL that passes through a cavity and the voltage signal that is transmitted through the cavity. Results are compared with full wave simulations where the entire circuit is modeled with the method of moments. Also investigated is how cavity resonances and the geometry of the TL wire inside the cavity affects signal transmission through the cavity. Another area of investigation is the mitigation of cavity-resonance affects by the introduction of intentional loss inside the cavity.