Coupling Among Multi-Conductor Transmission Lines and Complex Structures

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This work focuses on generalizations and improvements of methods used to analyze field-excited (external radar excitation) multi-conductor transmission lines surrounded by arbitrary complex structures. The typical challenge with such analyses deals with the large size of the surrounding structure in presence of cable bundles that require extreme geometrical details for their modeling and characterization. Consequently, it is instructive to consider modeling of the cable bundle separately from the large nearby structure (aircraft or automobile) and to subsequently interact the two structures via field bouncing.

Methods for field-excited multi-conductor transmission lines in the presence of structure have been proposed by Taylor (C.D.Taylor et al., IEEE Trans. Antennas Propag., November 1987), Aggrawal (A.K.Agrawal et al., IEEE Trans. Electromagnet. Compat., May 1980) and Rachidi (Rachidi, IEEE Trans. Electromagnet. Compat., August 1993) . However, these approaches are only valid for those cases where the transmission line is close to conducting surfaces -- in other words, where quasi-TEM conditions are valid. Nevertheless, such methods have been widely used for characterizing the coupling between transmission lines and nearby structures even though they provide poor accuracy when the quasi-TEM condition is violated.

To carry out trustworthy field analysis of the coupling between multi-conductor transmission lines, in this paper we propose the integration of rigorous computational techniques for the analysis of surrounding structures in conjunction with multi-conductor cables. In our analysis, transmission lines are segmented into small sections and scattering information from each of them is used to develop inductance and capacitance parameters. The incident field along these lines is included by introducing distributed voltage sources using Aggrawal's approach. To take into account the scattering effects from other segments throughout the transmission lines, a field bouncing technique is carried out. In other words, the field radiated by the transmission lines is subsequently used to excite the nearby structures analyzed using rigorous computational methods such as the Moment Method. In this manner, interactions between the cables and the structure can be iterated until a desired accuracy is attained. A similar study was done by Tkatchenko et.al. (IEEE Trans. Electromagnet. Compat., November 1995) for a single open ended wire above an infinite ground plane and analytical expression were obtained for this case. In this work, we develop a completely general approach for the field coupling among multi-conductor cables in the presence of complex structures.