A key concept in the analysis of the response of a complex electrical system to an external electromagnetic (EM) field excitation is its representation in terms of a topological model. In this approach, the entire system is viewed as several concentric layers, or surfaces, through which energy must pass to penetrate into the system. Usually, such surfaces are highly conducting shields and they effectively isolate one volume of the system from another. However, in most real systems, there are imperfections in these shields and EM energy is able to enter the system, possibly causing upset or damage to electrical components. This view of shielding has been referred to as the "onion" concept (L. W. Ricketts, J. E. Bridges and J. Miletta, EMP Radiation and Protective Techniques, John Wiley and Sons, New York, 1976.). It was initially proposed by Baum (C. E. Baum, "Electromagnetic Topology for the Analysis and Design of Complex Electromagnetic Systems", Fast Electrical and Optical Measurements, Vol I, I.E. Thompson and L.H. Luessen, eds., Martinus Nijhoff, Dordrecht, 467-547, 1986.) and later formalized in the literature, (F. M. Tesche, IEEE Trans. AP, vol. 26, no. 1, 60-64, 1978.).

As a result of this topological view of a system, a transmission line network model has been developed for computing the EM-field induced responses within a complex system. This model uses the Baum-Liu-Tesche (BLT) equation [Baum 1986], which is a concise matrix representation of voltage and current responses on a distributed transmission line network. The formulation of the BLT equation involves the propagating voltage or current waves along conductors, together with a description of how these waves are reflected at the junction of the network.

It is apparent that similar propagation and scattering relationships exist for electromagnetic fields produced by localized sources, interacting with the system exterior, and penetrating into the interior. This suggests that it is possible to develop an extended BLT-type equation containing both traveling waves of EM fields and conductor voltage/current.

In this paper, the derivation of the conventional BLT equation for transmission line networks is reviewed, and then the extension of this analysis formalism to add EM field coupling paths is described. This approach uses additional system details for an internal interaction calculation, such as aperture penetration of the EM field and its effect on the response of a near-by transmission line. The hope is that, with this new approach, the effects of internal cavity resonances can also be incorporated into such system-level models of EM field interaction.