Generalized FE-BI for solving mixed surface and volume geometries

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Recent developments in fast computational electromagnetic simulation tools such as the multilevel fast multipole moment method (MLFMM) have enabled analysis of complex real-life problems in shorter solution times using less computer memory. Most realistic problem geometries require the treatment of both volumetric and surface regions concurrently. In this paper, we present a hybrid approach combining the finite element-boundary integral (FE-BI) method with exterior surface modeling through boundary integral coupling between the volume boundary and the surface geometry. Such formulation is intended to couple FE-BI, BI and surface integral methods into a single system. This allows two or more geometries to be modeled in the most efficient manner. For our specific application (Fig. 1), the microstrip circuit board with dielectrics is modeled with FE-BI whereas surface integral with curvilinear basis functions is used to model the PEC surfaces of the cavity and the automobile chassis.

The traditional approach for the FE-BI method involves solving the internal electric fields within the volume of the geometry and the surface electric and magnetic fields on the closed boundary. On the other hand, the solution of PEC structures with the traditional Method of Moments (MoM) using EFIE yields the currents flowing along open PEC surfaces. These two systems can be linked by coupling the surface fields along the volume boundary to currents on the PEC surface. A typical matrix system is given below where I^n refers to the current coefficients along the PEC surfaces, b^n and b^e are the external incident fields on the exterior PEC surface and volume boundary respectively.

$$\begin{bmatrix} A^{VI} & A^{VS} & 0 & 0 \\ A^{SV} & A^{SS} & B & 0 \\ 0 & P & Q & L' \\ 0 & P' & Q' & L \end{bmatrix} \begin{Bmatrix} E^v \\ E^s \\ H^s \\ I^n \end{Bmatrix} = \begin{Bmatrix} b^i \\ b^s \\ b^e \\ b^n \end{Bmatrix} \qquad (1)$$

The sub-matrix L' indicates the forward coupling of the surface PEC currents onto the surface fields along the volume boundary whereas sub-matrices P' and Q' denotes the reverse coupling. This generalized approach is applied to two problem geometries shown in figure 1. The EM induced effects at the output ports of the printed circuit in the presence of these surface enclosures, under external illumination, will be presented.

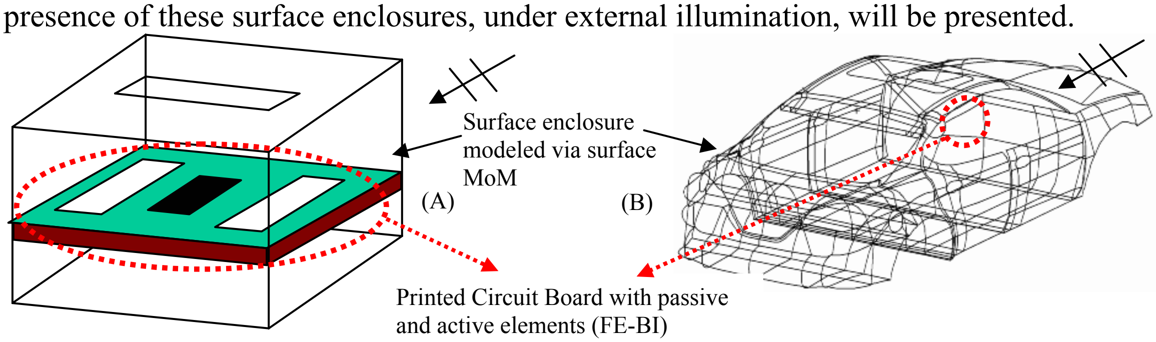

Fig 1: Geometry of PCB (A) within a cavity and (B) within an automobile chassis.