Characteristic mode analysis of open radiating structures based on Finite Element Method

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A characteristic mode eigenanalysis exploiting Finite Element Method (FEM) features is introduced. In the typical characteristic mode eigenanalysis the Method of Moment (MoM) is utilized (Harrington R. F., and Mautz J. R., IEEE Trans. on Ant. and Propagat., AP-19, 1971). Moreover, to solve composite structures including both metallic as well as material-dielectric loading, a modified surface integral equation of MoM is demanded (Shafai, IEEE Trans. on Ant. and Propagat., 34, 666-673, 1986). Equivalent electric and magnetic currents are defined in order to take into consideration the interaction between the different homogeneous parts. However, it is proved that the linear system that occurs, should be solved only in terms of the equivalent electric current that flows on the metallic parts, eliminating all the other currents from the final system (Maximidis R.T., Zekios C.L., Kaifas T.N., Vafiadis E.E. and Kyriacou, G.A., EuCAP 2014, 2822-2826, 2014).

The aforementioned idea can be developed in a more straightforward manner through the FEM analysis. Maximidis et al. (R. Maximidis, C.L. Zekios, P.C. Allilomes, A.V. Kudrin and G.A. Kyriacou, PIERS, 2012) have already developed a similar technique but with the aid of an analytical eigenfunction expansion for the description of the outer infinite domain, which was proved to be computation inefficient. In the current work this problem is overcame modeling the open radiating structure with the aid of the 1^{st} kind Absorbing Boundary Conditions (ABC). The initial FEM system which is of the form $A(k_0)[e] = 0$ is subdivided and re-written in terms of internal and external degrees of freedom. With the term "external" the degrees of freedom that give the equivalent radiating currents are assumed. The rest degrees of freedom are the "internal". The final system is solved only in terms of the external unknowns formulating the desired $[Z]$ matrix that appears in the classical MoM. Afterwards the same techniques used in characteristic modes are utilized.

With this technique the MoM necessity for the knowledge of arbitrary structures Green's functions is circumvented, while real structures of any material type can be solved. For this first step towards the establishment of this technique equivalent magnetic currents defined by tangential electric fields, will be retained as external degrees of freedom. These are defined over radiating apertures and the electric field vector wave equation will be solved for this purpose. Indicative examples of printed patch antennas will be demonstrated where the radiating apertures are formed between the patch edges and the metallic ground plane.