Revisiting the Modeling of a Two Step Integral Equation Calculation with Primary/Secondary Problems

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Many electromagnetic problems are based on the hypothesis of a known "incident" field leading to induced currents on an object, the addition of the "scattered" field gives the "total" field. In all the Integral Equation formalisms, the unknown currents are solution of a linear system where the right hand side vector (RHS) is obtained by a scalar product of the incident field with the current basis functions chosen for expansion. In most of the cases, the RHS represents the "source" of the electromagnetic field which is either a plan wave - or any analytical available expression of the incident field – or a lumped source, such as a voltage generator.

In this paper, we revisit several modelling configurations based on more complex situations. We define a primary problem (PP), which represents a known initial situation, the secondary problem (SP) being obtained by modifying the primary geometry. Many examples are given:

- The PP can be obtained as the solution of a first numerical computation of a complex object; for the SP, major changes may be done such as addition of wires on the surface of the structure, or such as addition of new parts of arbitrary size.
- The PP can simply be locally known currents localized on a wire and appearing as a generator; the classical "voltage" and "current" sources are revisited as examples of the general methodology of this paper. One more complex variant is presented: the modelling of an channel of lighting currents leading to a current distribution on an aircraft or on a building over the soil. In that case, a specific problem is due to the delicate truncation of the channel and a solution is given.

All these cases of computation are unified in a single general formalism starting from the SP, which appears as the total problem of interest. The relevant geometry is then split in two parts by removing a part of arbitrary size, the remaining geometry being the PP. The total currents are expended on a set of basic functions (BFs) that compose 2 groups: group P (for "primary") are the BFs which support is present in the PP; group S (for 'secondary") is the complementary set of BFs needed for the SP. In step 1, we obtain a vector of current magnitudes IP1 of the PP. In step 2, we obtained the modified current magnitudes IP2 of the primary geometry, and IS2, those of the complement. The general methodology introduces a RHS for the SP obtained as the radiation of the IP1 currents on the SP geometry complement. Starting from a bloc domain decomposition of the linear system for the SP, one can demonstrate that the addition of the currents for the 2 steps gives the total current.

Many examples computed with Integral Equations solvers are presented. Some are very classical generator sources which are simply revisited. More complex situations, such as those described previously prove the potential of the general method. The "approximation free" nature of the 2 steps methodology is also emphasized.