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Fast Time Domain Physical Optics for the Analysis of Non Linear Phenomena in Large Reflector Antennas

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Very large reflector antennas are generally constructed of a large number of metallic tiles that are joined with rivets or other fasteners. The imperfect metal-metal contacts give raise to non linear electromagnetic effects such as passive intermodulation (PIM) that become significant under high power excitation conditions. These phenomena are best analyzed by time domain (TD) methods. For electrically large problems involving smooth geometries, efficient calculation of the radiation patterns or scattering cross sections is often performed via high frequency methods such as the physical optics (PO). In this context, the time domain physical optics (TD PO) appears as the natural tool for the computation of the radiated fields after they have undergone non linear transformations.

The proposed fast TD PO is based on a hierarchical decomposition of the reflector surface into smaller surfaces (patches). The decomposition process continues until obtaining at the last level patches that are roughly square wavelength in size at the highest frequency significantly excited by the non-linear phenomenon. For these patches, angular-temporal far-field patterns over a sparse angular grid of directions and a short temporal duration are calculated explicitly from the bandpass filtered known electric and magnetic equivalent currents. Subsequent steps of the algorithm involve repeated transitions between the successive decomposition levels until obtaining the transient far-field response of the whole antenna. Each transition comprises angular and temporal interpolations followed by an aggregation of sets of delayed patches' contributions. Angular resolution and temporal duration at different levels are determined by the corresponding size of the surfaces at each level and the signal's characteristics. Due to the multilevel hierarchy of the calculations, the proposed algorithm attains a computational complexity substantially lower than that of the direct evaluation

of the far field response over the fine grid of directions and extended temporal duration.

This fast TD PO algorithm will be illustrated by its application to the calculation of the radiated field of a parabolic reflector that is made of metallic tiles. The non linear PO scattering at the tiles' contacts will be modeled as in (S. Selleri et al. IEEE Trans. Electromagn. Compat., 2001). The accuracy of the fast algorithm will be assessed through comparison with a regular TD PO algorithm. Computation time variation with the size of the problem will be investigated.