Applicability of Local-MoM and Frequency Dependence of Computational Cost in Scattering Analysis of a Rectangular Plate from a Dipole

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The method of moments (MoM) is the electromagnetic computation method where an integral equation is constructed for unknown currents assumed over the whole surface of scatterer and is solved by matrix inversion. The number of unknown currents N therefore becomes longer in proportion to the electrical size of scatterer. When the direct method is adopted as matrix inversion, computational times for matrix filling and matrix inversion are proportional to N^2 and N^3, respectively. A required capacity of computer memory is proportional to N^2 as well. Since the electrical size of scatterer is proportional to square of frequency f when the physical size of scatter is unchanged, frequency dependencies of computational times and a memory capacity amount to $O(f^4)$, $O(f^6)$ and $O(f^4)$ respectively. Various techniques to suppress these dependencies have been proposed. The authors have also proposed a different type of the MoM computation with the smaller matrix size named "Local-MoM" (K. Ito, et al., IEICE Trans. Electron., vol.E94-C, no.1, pp72-79, Jan. 2011) as one of these techniques.

The Local-MoM is a technique based upon the locality of high frequency scattering phenomena which dominant components of the field come to an observer only from the local area near the scattering centers such as reflection and diffraction points (analogous to the method of stationary phase). Reflecting this locality, in the Local-MoM computation, unknown currents are placed only on truncated local areas and a matrix is constructed only for these local currents. "Fresnel zone number" is adopted as the criterion to determine the size and shape of local areas and as an argument of raised-cosine-shaped weighting function to suppress the errors due to the truncation. Since the number of unknown currents in the Local-MoM ($=n$) is smaller than N, computational time in one-time matrix operation can be suppressed. In addition, the frequency dependence of n is suppressed to $O(f)$ so the required capacity of memory can be surely saved by the Local-MoM technique, In higher frequency, the localization is more effective and the difference of frequency dependence between n and N provides the saving of computational costs. On the other hand, in Local-MoM, the integral equation must be solved repeatedly for the number of observation angle unlike the normal MoM, so the computation time becomes longer than that for the normal MoM for some situations, especially lower frequency cases.

In this paper, we examined the applicability of the Local-MoM to a rectangular plate with a small dipole as an example of 3-dimensional problem. The Local-MoM calculates the scattered field with a reasonable accuracy. Since the special procedures in the Local-MoM computation are only the truncation of analysis model and the calculation of the windowing function based on Fresnel zone criterion, they could be easily implemented in existing commercial simulator. Here Local-MoM is implemented in a commercial electromagnetic simulator WIPL-D.

We also discussed the frequency dependence of computational time and capacity of computer memory required for MoM computation. If scatterer's dimension a and distance d from the plate to dipole increase as $a=8d$ in proportion to the frequency, the Local-MoM is available up to $a=d=160\lambda$ by a computer with 32GB memory while the normal MoM is limited below about 40λ. The detailed discussion on computation accuracy and frequency dependence of computational cost will be done with the numerical results in the symposium.