New Features in Feko and WinProp 2019

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***Abstract*—This paper describes some of the latest features in the commercial electromagnetic software Feko (including WinProp). These include the modeling of non-ideal cable shield connections, the parallel direct adaptive cross approximation (ACA) solver, edge and wedge diffraction for the ray launching geometrical optics (RL-GO) solver, and several new features related to automotive radar.**

Keywords*—*adaptive cross approximation, automotive radar, cable shield connections, diffraction, Feko, RL-GO, WinProp.

I. INTRODUCTION

Altair Feko [1] is a popular computational electromagnetics code widely used for academic research and commercial applications. Due to continuous improvements and extensions, it remains an industry leader in this field. This paper highlights some of the recent extensions made in the 2019 release.

II. MODELING OF NON-IDEAL CABLE SHIELD CONNECTIONS

Earlier, the Feko team developed the combined MoM/MTL method [2] as a solution approach to modeling shielded cable harnesses that do not run near a conducting installation surface. By using the method of moments (MoM) to model the outside of the harness within its environment, the frequency or so-called height limitation of the multiconductor transmission line (MTL) formulation can be relaxed.

The combined MoM/MTL method relies on the assumption that the exterior (structure and shield) and interior (cable bundle) problems only couple weakly through the shield transfer impedance, thereby limiting terminating connectors to be included as ideal in the model. In practice, however, not all connectors are manufactured with such high quality and coupling of currents and voltages through imperfect connectors should be considered.

Two new circuit components (a transformer and a voltage-controlled voltage source) were introduced to include connector leakage as a one- or bi-directional coupling effect in the model. In Fig. 1 an RG217 coaxial cable with double shield was modeled to illustrate the change in shielding effectiveness due to the inclusion of coupling effects (ideal versus non-ideal connection) at the harness terminations.

The harness was also modeled with an additional 50 mm pigtail at each connector to illustrate how the combined MoM/MTL method (different to the MTL) would take the additional line length (resulting in a downward resonant frequency shift) of the pigtail connections at the terminations into account.

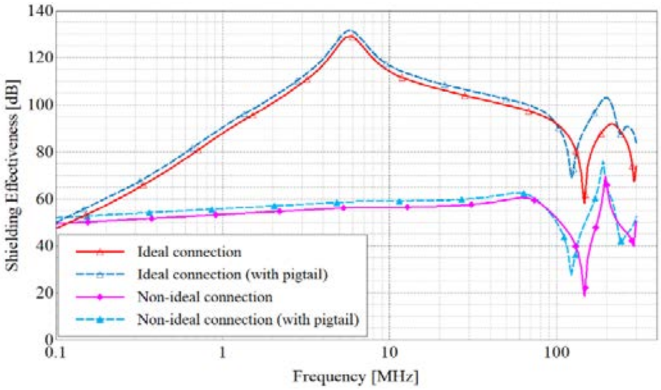

Fig. 1. Shielding effectiveness of an RG217 coaxial cable illustrating the effect of different terminal connections.

III. PARALLEL DIRECT ACA SOLVER

The adaptive cross approximation (ACA) available in Feko is a well-known technique for approximating a large dense matrix, like the MoM matrix, as the product of two much smaller matrices, saving memory and computational time. In a previous paper we have discussed the direct ACA solver [3]. This solver, however, is highly recursive due to the tree-like structure of the ACA matrix representation and is therefore not straightforward to parallelize.

We have extended the direct ACA solver to run in parallel in shared memory environments. This was accomplished by traversing the sequence of operations in the direct ACA solver and, rather than executing the operations, recording the basic operations on the leaves of the ACA tree one by one in a list of tasks to be executed later. These tasks can then be sent to multiple threads for execution.

Some tasks depend on the results of other tasks and cannot

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be executed until the tasks on which they depend are executed. As the number of threads increases the efficiency of the parallel calculation may suffer due to this dependency tree.

Fig. 2 shows some initial efficiency results for a sample Feko ACA calculation with 27464 unknowns. Using 8 threads the efficiency is still high at 89%.

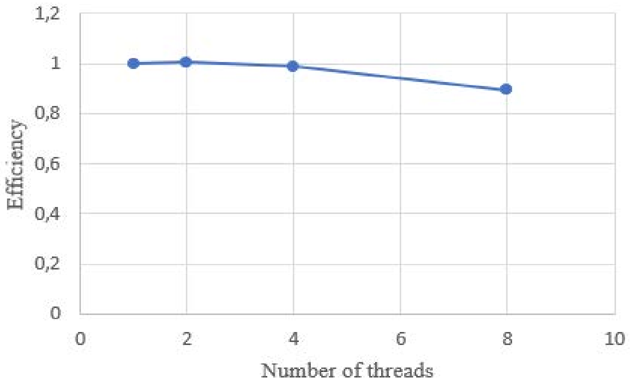

Fig. 2. ACA parallel efficiency versus the number of threads.

IV. RL-GO EDGE AND WEDGE DIFFRACTION

The RL-GO solver in Feko calculates high frequency specular reflection effects using a shooting-and-bouncing ray (SBR) type algorithm. Edge and wedge diffraction are often dominant in objects such as fins on aircraft. The calculation of these edge and wedge effects following [4] has recently been added to our existing RL-GO high frequency approximation.

Fig. 3 demonstrates the importance of edge diffraction for a simple canonical plate. High frequency results agree much better with the full wave multilevel-fast-multipole-method (MLFMM) results, especially when the plate is illuminated from an edge on direction. Improvements to results for general structures with dominant edge and wedge reflections are evident.

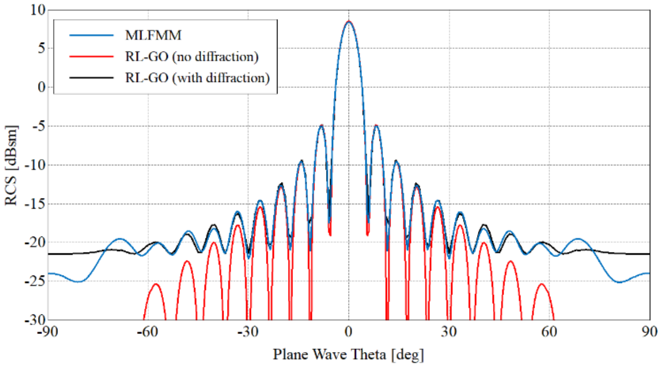

Fig. 3. Full wave MLFMM versus RL-GO results comparing the monostatic RCS (HH Polarization) of a 15cm x 15cm square plate at 10 GHz.

V. AUTOMOTIVE RADAR

WinProp is the simulation tool bundled with Feko for electromagnetic propagation and wireless network planning, including 5G. Its computational methods range from empirical via proprietary semi-empirical to rigorous uniform theory of diffraction (UTD). One recent new WinProp application is automotive radar. For this, several new features have been added such as the ability to have both the transmitting and the receiving antenna moving with a car in a time-variant simulation, as well as the output of Doppler shift.

The analysis of the traffic scenario in Fig. 4 with UTD brings a challenge: the trade-off of accuracy and simulation time. The (simplified) car models consist of flat panels. An analysis with UTD includes specular reflections, diffuse scattering around the reflections, and edge diffractions. The simulation frequency is typically 77 GHz. At this high frequency, specular reflections rarely hit the receiver, while edge diffractions, which have a 1/sqrt(f) dependence, will under-estimate the received signal. The remaining contribution, diffuse scattering, depends on an un-scientific parameter set by the user.

The solution is to enhance the car models in WinProp by monostatic radar cross section (RCS) information determined with one of the full wave or asymptotic solvers in Feko. Feko can easily determine the RCS of a much more detailed car model and export it to WinProp. WinProp will then know, for every ray that hits the (possibly even more-simplified) car model, what the contribution will be to the signal received by the radar. The monostatic RCS is, for every snapshot in time, corrected for the finite distance. With this new approach, the simulation of automotive radar in WinProp gains both accuracy and speed.

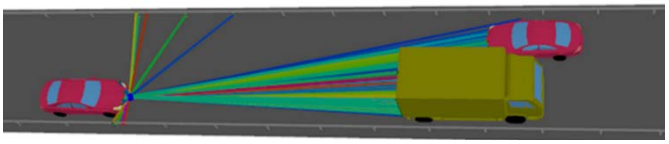

Fig. 4. Automotive radar simulation with traffic.

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