Domain Decomposition Solver in Simulation of the Electrically Very Large Reflector Antenna

This application note expands the work described in previously published application note *Domain Decomposition Solver in Simulation of The Electrically Large Reflector Antenna*. It is recommended that the reader familiarize himself with the content of the mentioned application note. However, for the reason of clarity and completeness, some previously published details are repeated here.

One of WIPL-D Company flagship products is **WIPL-D Pro, a full wave 3D electromagnetic Method-of-Moments (MoM) software.** Although WIPL-D Pro is a state-of-the-art electromagnetic solver, it has certain limitations. Accordingly, another product of WIPL-D Company, the **Domain Decomposition Solver (DDS)** has been developed for solving **electrically very large problems**, those beyond the reach of the direct MoM Solver. **The basic idea behind DDS is to divide the original problem into a number of groups**. A group is composed of a number of neighboring plates and wires. Basis functions, which correspond to plates and wires from the same group, are grouped into a macro-basis function (MBFs). All MBFs are multiplied by corresponding weighting coefficients, then replaced into full MoM matrix and residua of all equations are calculated. Weights of MBFs are determined by minimizing residuum of full MoM matrix. The residuum of the final solution in each iteration is used as the excitation in the next iteration. MBFs excited by low values of residua can be eliminated in iterative procedure. **The entire iterative procedure finishes when the total residuum becomes smaller than the predefined threshold.** Generally, DDS converges rapidly and the solution with acceptable accuracy is typically found after 1 to 3 iterations.

This application note **shows the radiation patterns of an electrically very large Cassegrain reflector antenna calculated using DDS**.

WIPL-D and DDS Models of Reflector Antenna with 750 Wavelengths Diameter

WIPL-D Pro has a unique library of **built-in objects**. Built-in objects allow for fast and easy creation of various model elements and include predefined optimal meshing parameters providing **highly efficient simulations**. In this particular case, the most important built-in objects are reflectors

The WIPL-D Pro preview of simulated reflector antenna is shown in Figure 1. The feeding zone is also shown as inset in the same figure. Number of patches (bilinear surfaces) per quarter of reflector circumference originally set for simulations of the reflector have been reduced from 376 to 40 to increase the clarity of the picture. The model has two symmetry planes which are used to decrease the size of the simulated model geometry and reduce the simulation time.

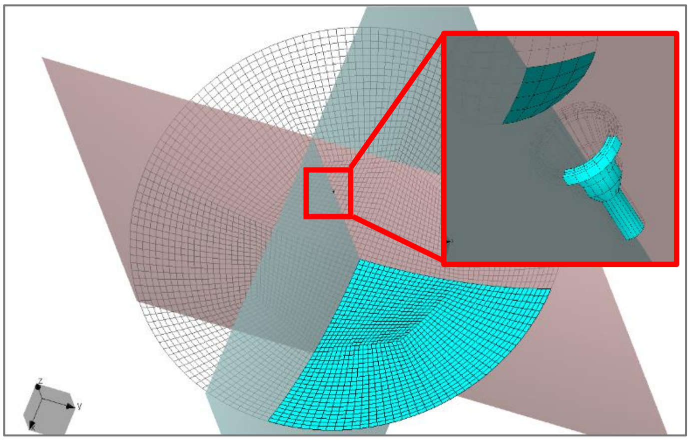

Figure 1. Cassegrain reflector antenna in WIPL-D Pro with magnified feeding horn antenna and secondary reflector

The WIPL-D Pro model shown in Figure 1 can be easily converted to Domain Decomposition Solver (DDS). The feeding zone parameters within DDS are set the first. The initial shape and the location of feeding zone is **automatically determined within DDS.** In this case, the DDS feeding zone should be extended by increasing size of the feeding zone ellipsoid so that the horn antenna with secondary reflector become encompassed with feeding zone area. The ellipsoid is defined with parameters a=0.2 m, b=0.2 m, c=0.2 m, and Z0=3.21953 m. The other feeding zone parameters are default.

The next is to define DDS groups. In this case, parameter *Group size* which is used in the simulations is set to default value of 3,000. The groups over a part of the reflector surface are shown in the preview in Figure 2.

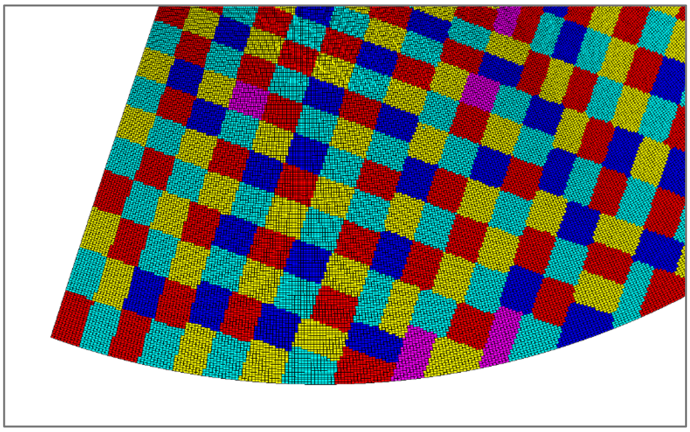

Figure 2. DDS groups over a part of the reflector surface

The final step assumes invoking DDS run. The run is invoked after performing settings within *DDS* tab. The workstation used for simulations contains GPU cards. The GPU cards will be used for matrix inversion as indicated by checking the *Use GPU for partial projects* field. The recommended value for defining a number of unknowns above which GPU inversion is activated is set to 5,000. The default value for *Error*, which is used as a threshold for accepting the solution as accurate, has been left unchanged. The total of 3 iterations will be performed. **The field *Residual* has been changed from default 60% to 100% and this value is applied to all iterations. This is required for reflector antenna simulations.** After applying all required settings, the DDS run is invoked.

DDS Simulations and Results for Reflector Antenna with 750 Wavelengths Diameter

The antenna was simulated at 25.5 GHz calculating the radiation pattern in phi=90 degrees plane at 3601 equidistant directions along theta angle. The antenna simulations were performed using a workstation with the hardware specification as presented in Table 1. The number of elements and number of unknowns required for WIPL-D Pro simulation are given in Table 2 (these numbers are for illustration only; the actual simulation has not been performed). Simulation times when using DDS iterations are presented in Table 3. Compared radiation pattern results obtained after DDS iterations are shown in Figure 3.

Table 1. Workstation used for the simulations

Hardware	Description
Processor	Intel® Xeon® Gold 6248R CPU @ 3.00GHz 3.00 GHz (2 processors)
RAM	768 GB
GPU	2 cards: NVIDIA GeForce RTX 3080

Conclusion

An electrically very large reflector antenna was modeled using WIPL-D Pro and simulated using Domain Decomposition Solver (DDS).

Having in mind an electrical size of the structure, one can conclude that all the results were calculated in relatively short amount of time. In addition, the workstation on which the calculations were performed is a highly sophisticated but an affordable desktop PC empowered with GPU cards.

Convergence of the results is very good. The accuracy improves after the 2nd iteration and becomes even better after the 3rd iteration. Considering that all iterations are completed in less than 15 hours, a conclusion can be drawn that with WIPL-D Domain Decomposition Solver, **very high numerical efficiency can be achieved** even for electrically very large and demanding structure such as reflector antenna with 750 wavelengths diameter.

Table 2. Number of elements and number of unknowns required for WIPL-D Pro simulation

Model	Number of elements	Number of unknowns
750 wavelengths diameter reflector antenna	424,674	1,485,040

Table 3. DDS iterations and simulation times

Iterations	Simulation time [minutes]
0th+1st	336
0th+1st+2nd	572
0th+1st+2nd+3rd	808

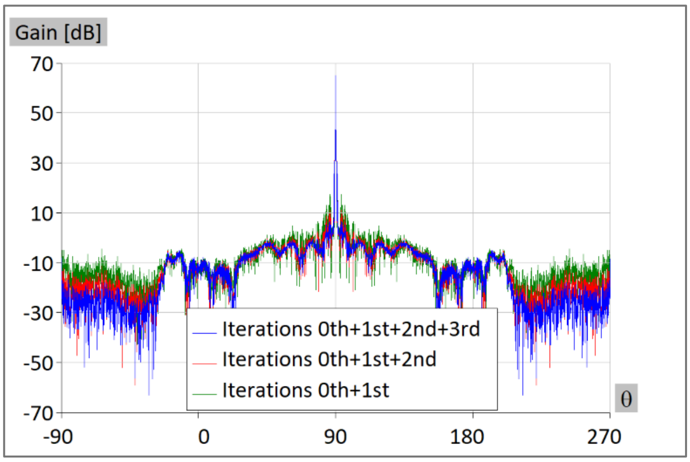

Figure 3. Radiation pattern results after DDS iterations