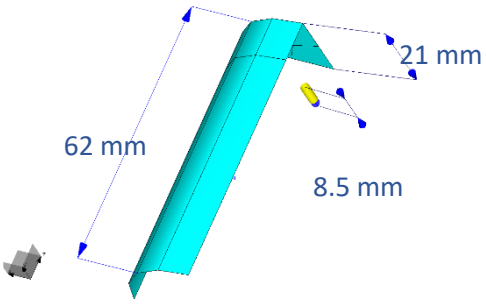
# Benchmarks Examples (1)

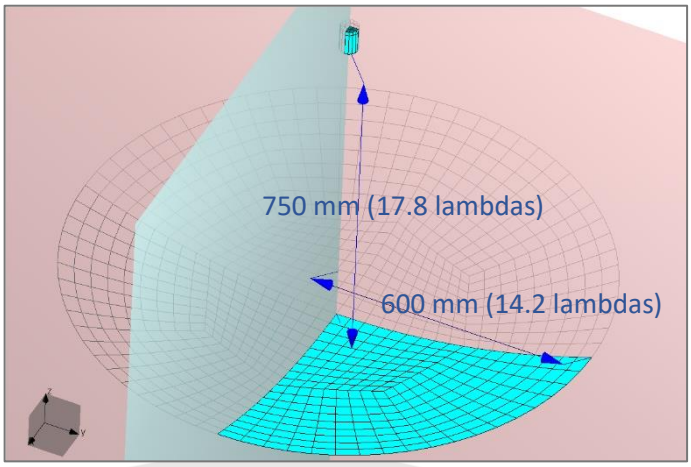
In this application note, several benchmark models are created and simulated in order to demonstrate WIPL-D Pro capabilities. WIPL-D Pro is full wave 3D EM solver, based on **Method-of-Moments** (MoM) and empowered with **quadrilateral mesh** and **higher-order basis functions** (**HOBFs**). All the models should be considered as demonstrational models. It is expected that the **output results** and **relatively short simulation times** will be in the focus of the reader of this document. Presented simulation times mainly consist of time necessary for matrix fill in, matrix inversion and time necessary for processing output results. Computer used for simulations is Intel® Core™ i7-7700 CPU@3.60 GHz.

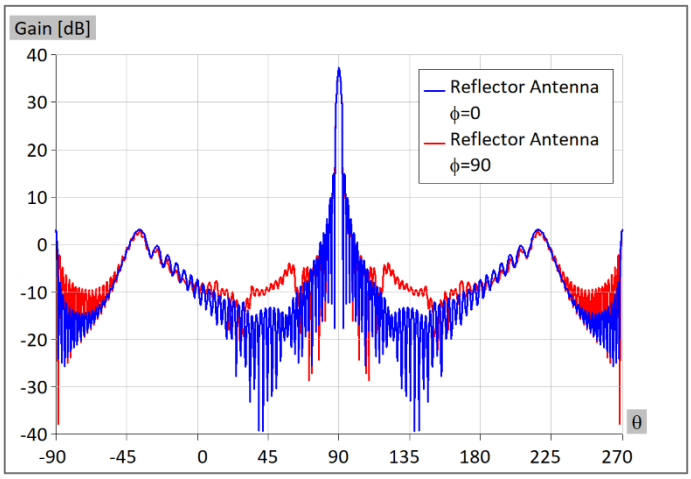
## Reflector Antenna

WIPL-D model of reflector antenna with parabolic dish was simulated. Using two symmetry planes enabled only quarter of the model to be simulated. The quarter of the feed with the dimensions of the feed are shown. Also, the model of the reflector with appropriate dimensions is shown. Radiation pattern in two principal planes is displayed. Simulation time encompasses time requested for calculating radiation pattern in 2*1801=3602 points.



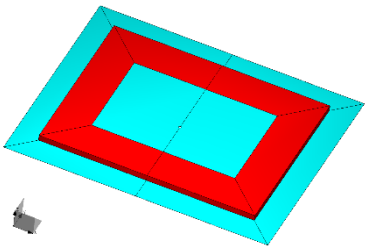

| Number of unknowns | Computer memory required [MB] | Total simulation time [sec] |
|---|---|---|
| 3,517 | 94.4 | 6 |



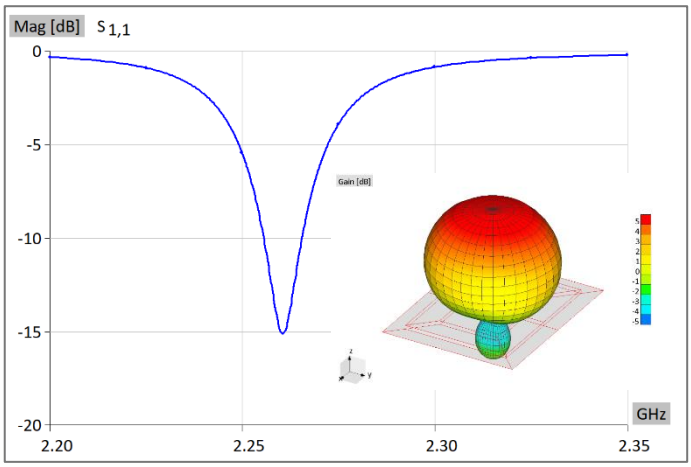




## Microstrip Patch Antenna

The model of the simply microstrip patch antenna is presented. Only full model, without applying any symmetry plane, was simulated. The antenna is modeled with the substrate with relative permittivity of 10.2. S-parameters and radiation pattern at 2.26 GHz are displayed.



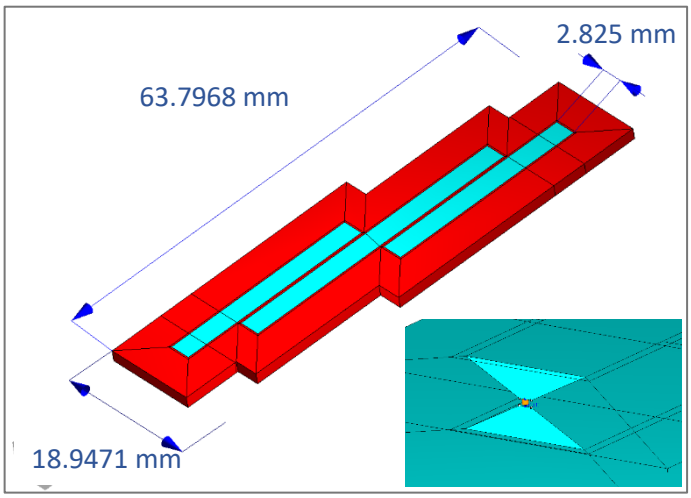
| Number of unknowns | Computer memory required [MB] | Simulation time per frequency [sec] |
|---|---|---|
| 1,499 | 17.2 | 1.9 |

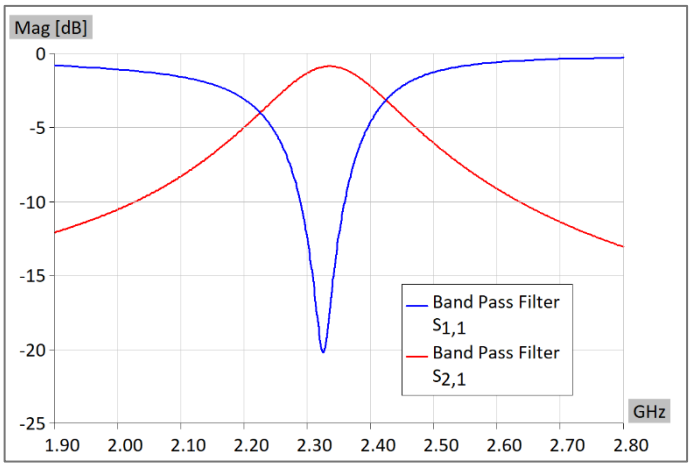


## Microstrip Band Pass Filter

The model of the band pass filter with appropriate dimensions is presented and simulated. In addition, a feeding zone is also presented. The band pass filter was printed on the substrate with thickness of 1.524 mm and relative dielectric permittivity of 3.38. The gap between the lines is 0.4427 mm. The project was simulated at 19 frequency points. Number of unknowns, computer memory required, simulation time per frequency and graphical representation of S-parameters are shown.

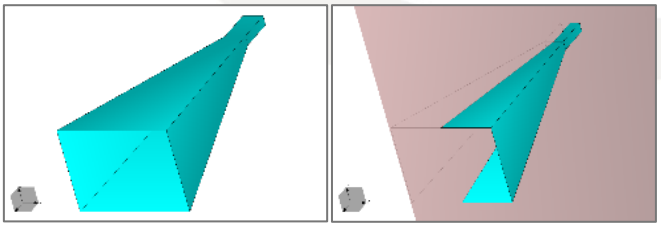
| Number of unknowns | Computer memory required [MB] | Simulation time per frequency [sec] |
|---|---|---|
| 1,126 | 9.7 | 1.5 |

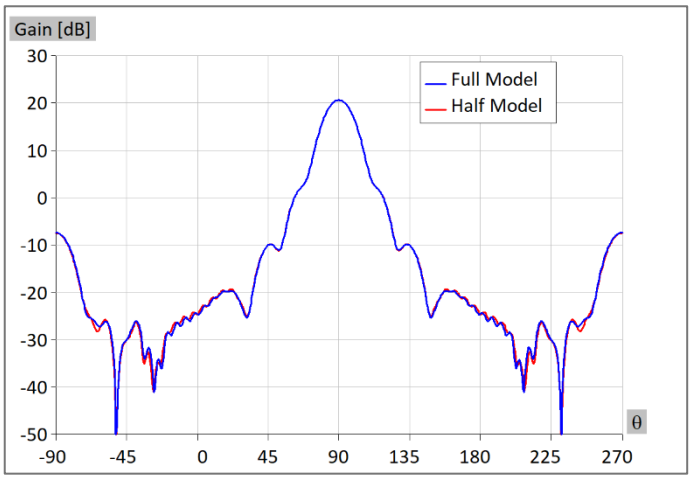


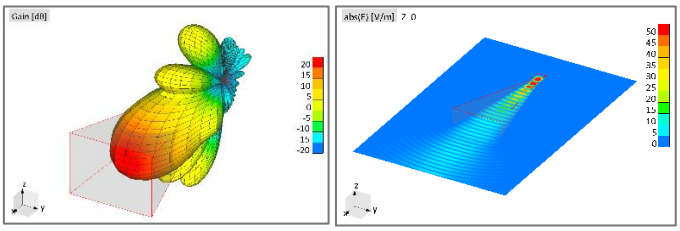




## Horn Antenna

Two models of horn antenna were simulated: *Full* model and *Half* model (one symmetry plane applied). The models are shown and 2D radiation patterns are compared. The results between two models are almost the same (due to the subdivision of the plates, the meshing of these model is not completely the same). In addition, the models are simulated in such manner that radiation pattern is calculated at 91x91=8,281 points, while near field distribution is calculated at 201x201x1=40,401 points.





Number of unknowns (with computer memory required) and total simulation time are presented in the table, below. Despite size of the problems are different (*Half* is about two times smaller than *Full*), total simulation times are quite similar. This happens since in these two scenarios, time required for calculating radiation pattern and near field is dominant. In the other words, in these, relatively small examples, calculating these output results occupies the greatest amount of simulation time.

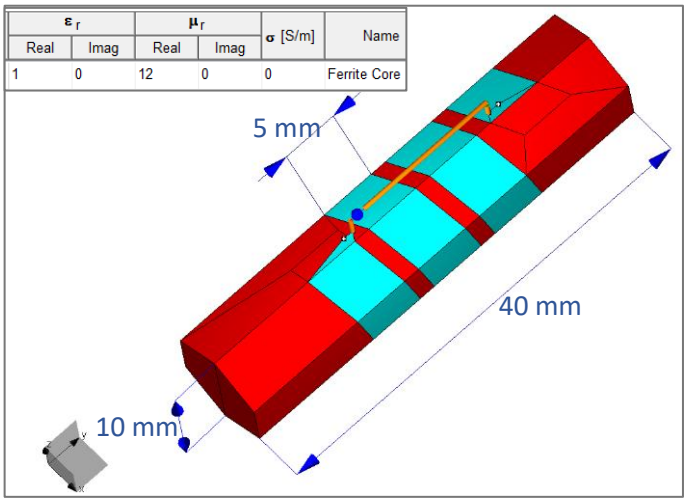
| Model | Number of unknowns | Computer memory required [MB] | Total simulation time[sec] |
|---|---|---|---|
| Full | 5,882 | 264 | 12.4 |
| Half | 3,133 | 75 | 9.5 |

## Coil with Ferrite Core

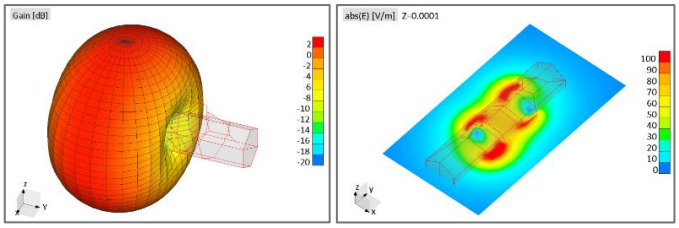
A coil with ferrite core is modeled and simulated using WIPL-D Pro. The model of the coil with appropriate dimensions and ferrite core parameters are shown in the following figure. In addition, number of unknowns (computer memory required) and total simulation times are given in the table. Beside matrix fill-in and time required for matrix inversion, total simulation time encompasses time required for calculating near field distribution at 51x51x1=2,601 points and radiation pattern at 1,369 points.

The model also contains a 0.126 nF capacitor which is modeled as a WIPL-D concentrated loading.

| Number of unknowns | Computer memory required [MB] | Total simulation time [sec] |
|---|---|---|
| 178 | 0.24 | 0.5 |

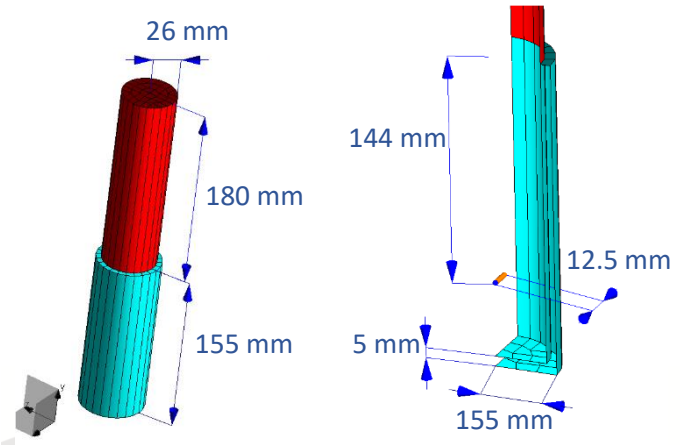



Radiation pattern and near field distribution are shown in the following figures.




## Dielectric Rod Antenna

Two models of dielectric rod antenna were simulated: *Full* model (no symmetry applied) and *Quarter* model (two symmetry planes applied). The models with appropriate dimensions are displayed.

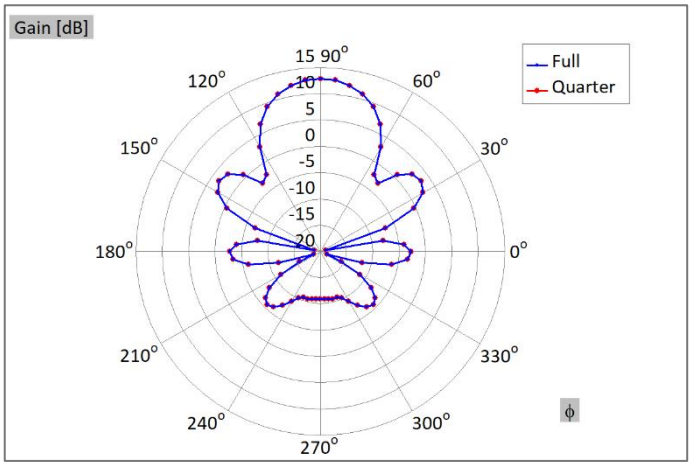


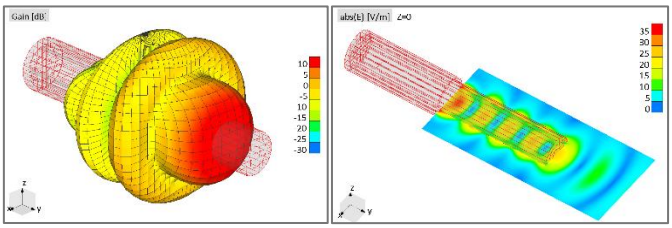

Used dielectric has relative dielectric permittivity of 2.5.

Calculated 2D radiation patterns (*Full* model and *Quarter* model) are compared. The compared results are the same. Radiation pattern calculated at 73x37=2,701 points and near field distribution calculated at 50x100x1=5,000 points are presented.

Simulation time does not contain time requested for output results processing.

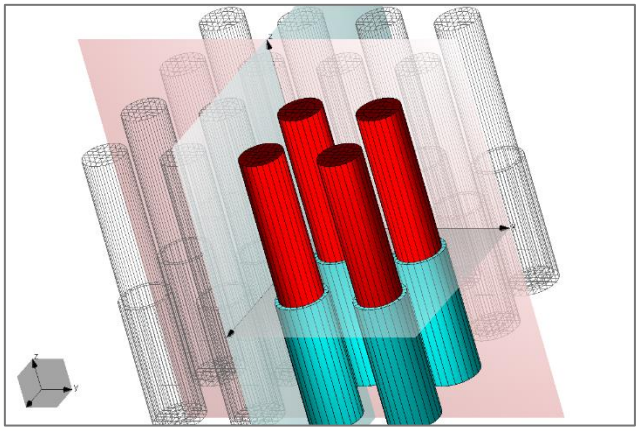
| Model | Number of unknowns | Computer memory required [MB] | Simulation time[sec] |
|---|---|---|---|
| Full | 1,899 | 27.5 | 1.6 |
| Quarter | 476 | 1.8 | 0.6 |




## Dielectric Rod Antenna Arrays

Two models of dielectric rod antenna arrays were simulated: *Full* model (no symmetry applied) and *Quarter* model (two symmetry planes applied). The distance between the elements is 100 mm.



Number of unknowns, computer memory required and simulation times for these two models are presented in the following table. Simulation times mainly consist of time requested for matrix fill-in, matrix inversion and time requested for calculating radiation pattern in 181x181=32,761 points.

| Model | Number of unknowns | Computer memory required | Total simulation time[sec] |
|---|---|---|---|
| Full | 30,384 | 7 GB | 322 |
| Quarter | 7,596 | 440 MB | 44 |

2D radiation patterns between the models (*Full* and *Quarter*) are compared. The compared results are the same.