

Laptop with Inverted F Antenna

Laptop Simulation in WIPL-D

Electromagnetic (EM) simulations of laptop and mobile devices have gained popularity in the recent years due to rapidly growing market, increasing number of manufacturers, high demand for miniaturization and performance improvement, but mostly because of expanding abilities of modern simulation software and hardware.

Laptops or mobile devices are usually developed through a relatively complex process with an antenna coming into play in the final design phases. In such a scenario, an antenna design must accurately take into account all of the details of the particular device environment. For an example, the modeling of a laptop antenna typically starts with an import of the laptop geometry created in third-party software into EM model editor with an intention to subsequently add the antenna model. However, from the perspective of EM analysis, the imported models have several deficiencies. Typically, an imported model has huge number of details irrelevant for EM simulation, and may in addition contain a number of geometry irregularities.

In that sense, the first step in the preparation of an imported model for EM simulation is the healing of the model irregularities. Generally, the irregularities can be classified in two groups: the entities with faults and the entities with adjacent faces not having a common edge. Both types of irregularities are automatically recognized and marked in WIPL-D Pro CAD. The advanced tools for healing, simplifying and sewing enable easy repairing of the irregularities.

The next step in preparation of the model for EM simulation is removal of the details irrelevant for EM simulation. Rich set of repair and rebuild tools available in WIPL-D Pro CAD make this process relatively simple. The tools available for this purpose are: fill hole, remove hole, remove feature, remove blend, delete open loop, and many others. The final step of elimination the small features is performed in meshing procedure, where the details with a size below user-defined defeature tolerance are automatically eliminated.

WIPL-D Pro CAD includes native, in-house developed quadrilateral mesher optimized for WIPL-D Higher Order Basis Functions (HOBFs). It creates large mesh elements for flat or mainly smooth model surfaces, and small mesh elements for model parts where small details and features are present. It also creates elongated mesh elements over the model parts which are flat or smooth along one axis and curved along another. That way, the mesher yields models with both large and small mesh elements. Such models are optimal for WIPL-D EM simulation core. The mesh elements can be up to two wavelengths by two wavelengths in size with the order of approximation adaptively determined between 1 and 8 on each element.

After the meshing, EM simulation can run quickly even on an inexpensive desktop PC. Furthermore, WIPL-D GPU solver uses inexpensive GPUs to speed up CPU simulation by the order of magnitude.

The example presented in this application note elaborates how WIPL-D Pro CAD is used for EM simulation of antenna placement of inverted F antenna mounted on a laptop.

Laptop Model

The model of a laptop with PIFA antenna, which is prepared for EM simulation is shown in Figure 1.



Figure 1: Laptop model

Figure 2 shows the metallic parts inside the laptop in the left top corner, then the thin film over the laptop screen ($\epsilon_r=5$) in the right top corner, keyboard buttons ($\epsilon_r=2.75$) and plastic cover ($\epsilon_r=2.5$) in the left bottom corner.



Figure 2: Laptop parts

Inverted F Antenna

A relatively simple inverted F antenna is installed in the laptop, as shown in Figure 3 and Figure 4. The operating band is around 2.4 GHz.

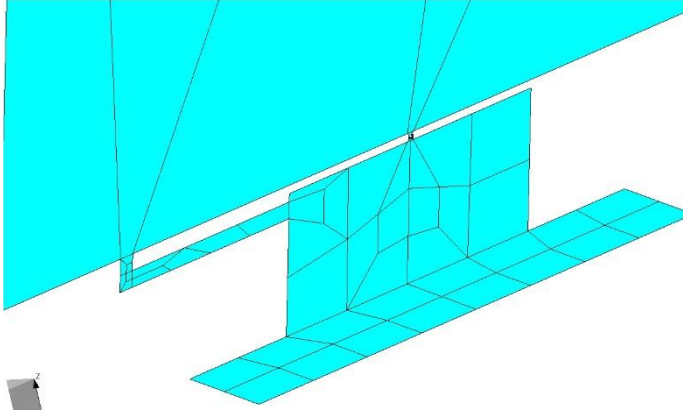


Figure 3: Inverted F antenna, meshed detail

Antenna is connected to the screen metallic holder, which serves as the ground conductor and provides mechanical support, as shown in Figure 4.

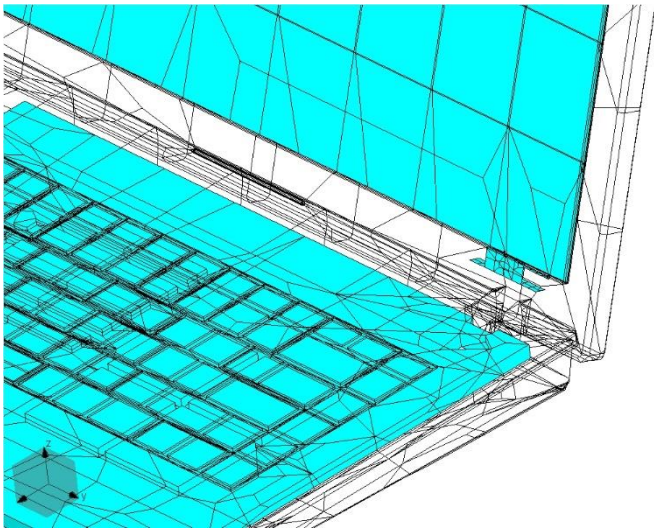


Figure 4: Inverted F antenna, position within laptop

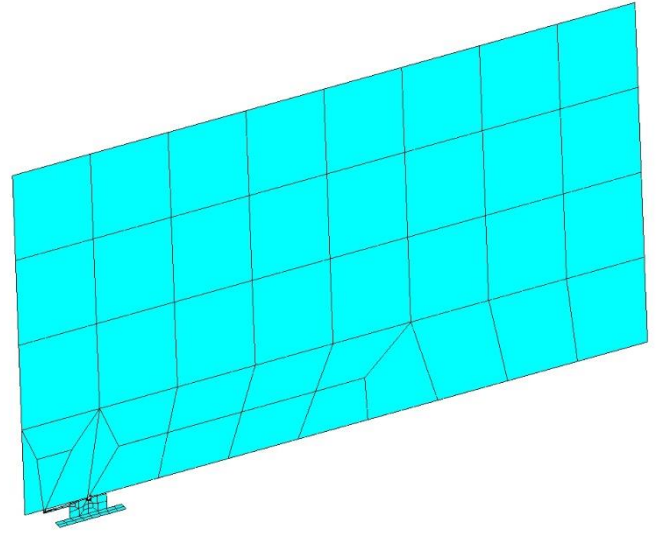


Figure 5: Inverted F antenna mounted to metallic wall of the thin screen, emulating IFA in free space

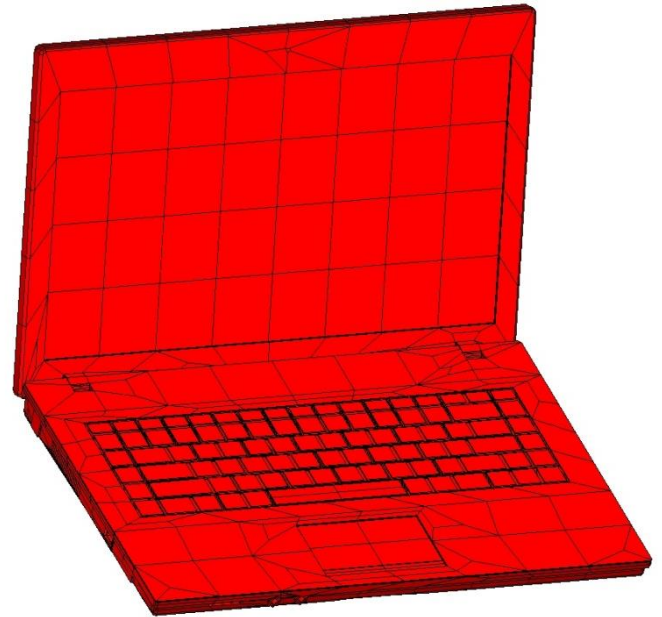


Figure 6: Laptop model, meshed

Simulations and Results

The antenna is placed at the righthand side, at the hinge joining the screen and the keyboard, as shown in Figure 4. Simulation of antenna in the free space requires only 378 unknowns. Simulation time for this EM model is less than 1 second on any modern laptop or desktop PC.

However, simulation of entire laptop is far more challenging. The meshed laptop model is shown in Figure 6. It consists of approximately 3,500 mesh elements (quadrilateral plates). EM simulation is performed on a regular desktop PC powered by inexpensive Nvidia GeForce GTX GPU: Intel i7 7700 CPU (3.6 GHz), 24 GB RAM, Nvidia GeForce GTX 1080 GPU. All simulation times are listed in Table 1.

Table 1 Summarized simulation details.

Model	Number of unknowns	CPU time [sec]	GPU time [sec]
Free space	378	1	-
Mounted on laptop	30,712	369	166

Return losses of the antenna in free space and the antenna mounted in the laptop housing are shown in Figure 7. As expected, performance of the antenna changes when mounted in the laptop environment.

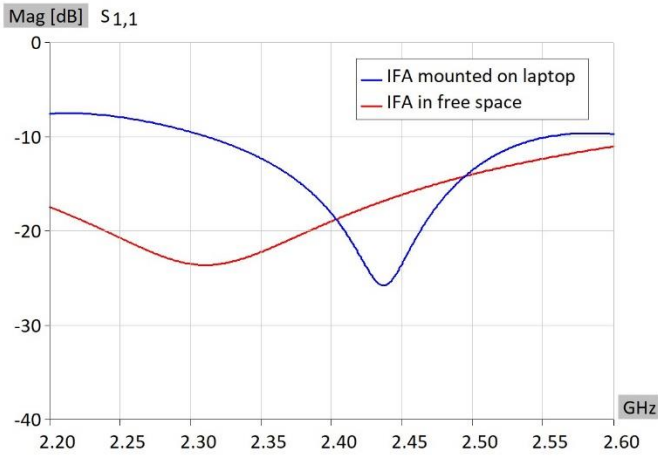


Figure 7: Return loss of the antenna

Radiation pattern of the antenna radiating into free space and the radiation pattern of the antenna mounted in the laptop housing are presented in Figure 8 to Figure 10. In both cases, the structures are placed over infinite, horizontal PEC plane.

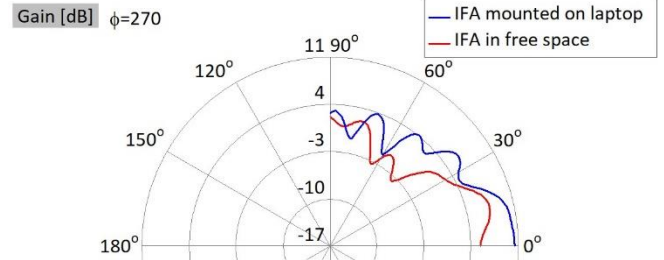


Figure 10: Radiation pattern compared

Finally, the near field plots in the vicinity of the antenna in two principle planes are presented in Figure 11 and Figure 12.

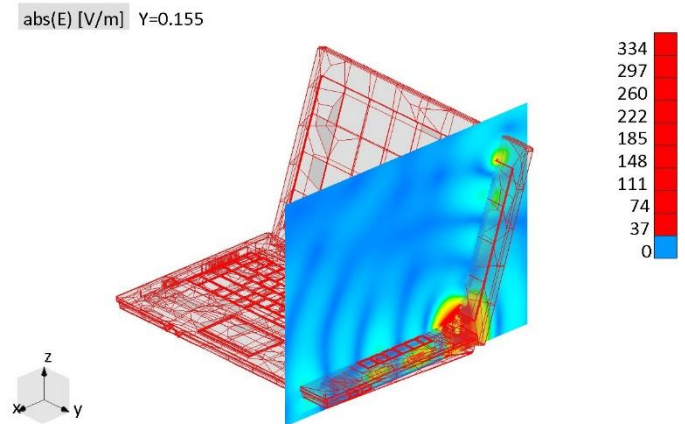


Figure 11: Near field perpendicular to the antenna

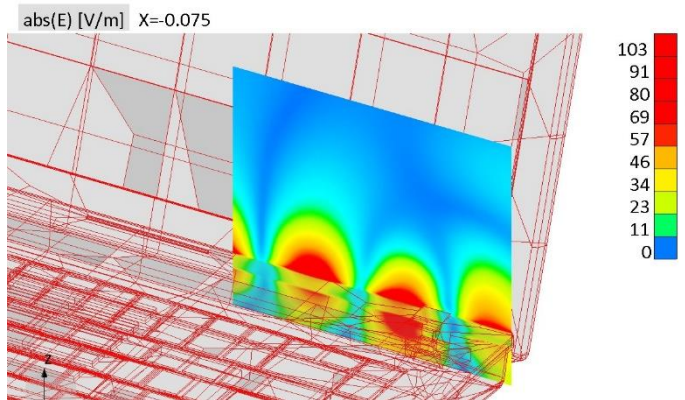


Figure 12: Near field along the antenna

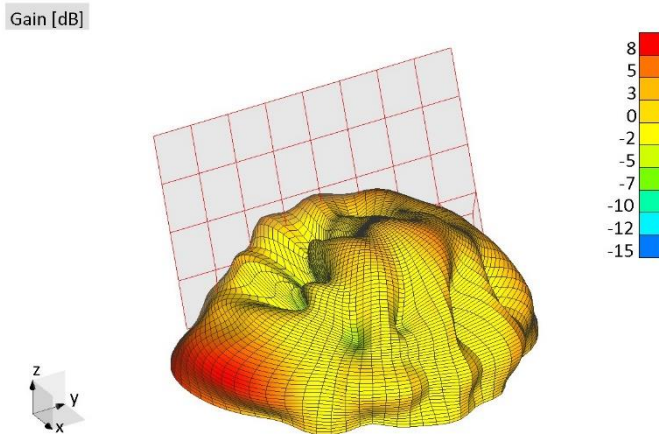


Figure 8: Free space radiation pattern at 2.4 GHz

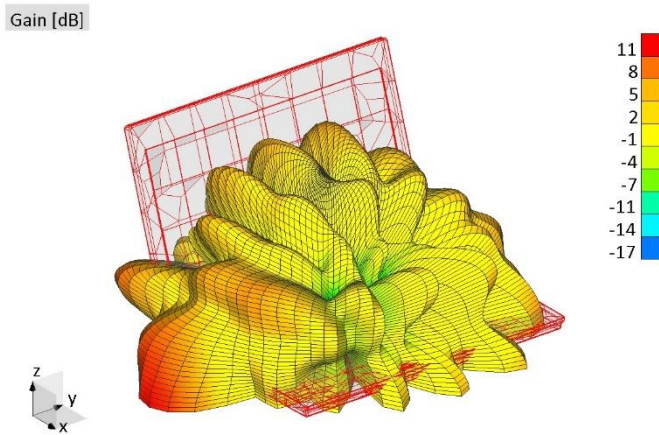


Figure 9: Mounted antenna radiation pattern at 2.4 GHz

Conclusion

EM simulations and modeling options presented demonstrate high efficiency of WIPL-D software suite for modeling and EM simulation of complex geometries at RF frequencies, in particular the antenna placement analysis. Although laptop model comprises many details and fine features, simulation model has only 3,500 mesh elements as WIPL-D quad meshing algorithm yields models optimal for EM simulation. Simulation time when using regular desktop PC enhanced with inexpensive GPU card is measured in minutes.