

SAR – Human Head Exposed to Mobile Phone

In modern times, due to the increased integration of electronic devices into everyday life, it has become imperative to calculate the impact of electronic devices to human body. In this application note we simulate the effects of a mobile phone to a human head at 1.8 GHz.

WIPL-D Software suite offers a great set of tools for general **3D electromagnetic (EM)** simulation of real-life geometries. WIPL-D Pro CAD enables import of extremely complex and versatile geometries from all popular CAD files. This product also includes an in-house developed mesher which performs subdivision of complex geometries into generalized quadrilaterals which serve as input for numerical kernel. The meshing is automated and extremely efficient to allow **precise modeling of details, curvatures and small features** while the requirements for EM simulation are kept as minimal as possible.

After a proper quad mesh is created, WIPL-D Pro allows EM simulation in most efficient manner available among commercial tools. WIPL-D kernel allows mesh elements (quads) of size up to 2 wavelengths by 2 wavelengths due to its **higher order basis functions** (current expansion on mesh elements is a polynomial of 8th degree for 2 wavelengths edge). The number of unknown coefficients to be stored in the **Method of Moments (MoM)** matrix is minimal and it can be estimated as 30 unknown coefficients per lambda square for metallic surfaces, and 60 for dielectric surfaces.

PIFA

Simulation capabilities of WIPL-D software suite will be demonstrated by simulating SAR in the human head, due to the influence of a mobile phone. The realistic model of human head with a mobile phone is imported in **WIPL-D Pro CAD** through one of many supported formats. Additionally, the tool offers full modeling capabilities and a built-in quadrilateral mesher. The first building block in the model is the radiating part of the telephone, the PIFA antenna. Meshed model is shown in Fig. 1, together with the internal structure of this simple antenna.

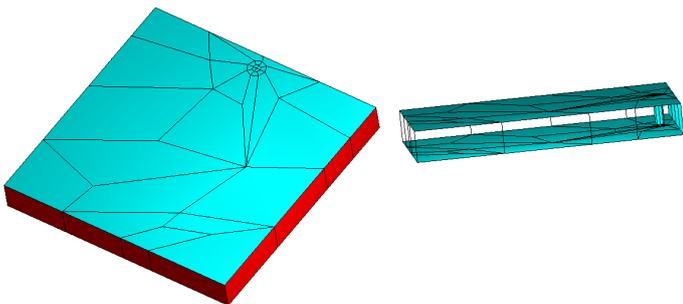


Figure 1. Meshed PIFA antenna model

Simulation is performed on a regular desktop PC (quad core i7 CPU 7700). It requires **1,116 unknown coefficients** in the MoM system matrix with **simulation time under 1 s**.

Fig. 2 shows the calculated radiation pattern of the antenna.

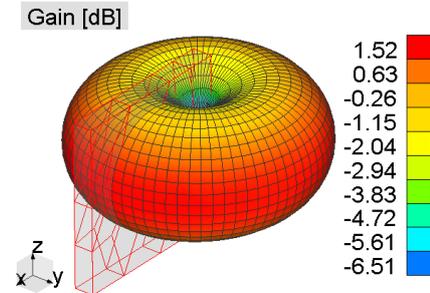


Figure 2. PIFA antenna standalone radiation pattern

Mobile Phone

The second building block in the model is the full CAD phone model, as shown in Fig. 3 (left). Meshed model is shown to the right, along with parts of the internal structure. The PIFA antenna is located inside the red ellipse.

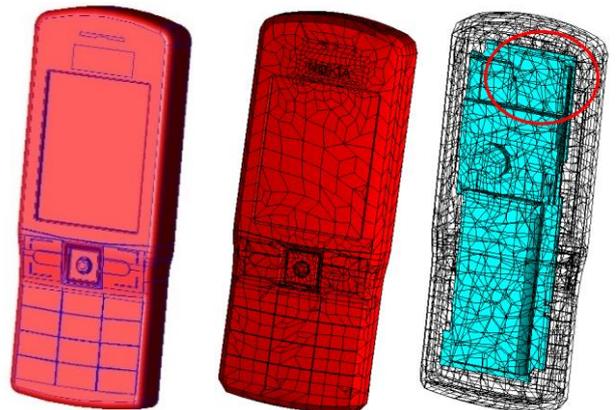


Figure 3. WIPL-D Pro CAD mobile phone model, also meshed with marked metallic parts and PIFA

Simulation is performed on the same hardware configuration as for the PIFA, but the PC was empowered with Nvidia GeForce GTX 1080 GPU card and 64 GB of RAM. It requires **21,832 unknown coefficients**, yielding simulation time of **87 seconds**. The radiation pattern of the mobile phone is shown in Fig. 4.

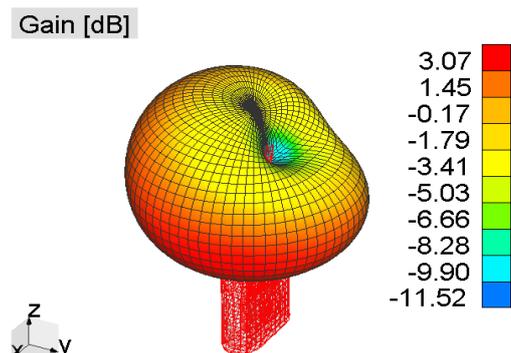


Figure 4. Mobile phone radiation pattern

Human Head Model

Meshed model is shown in Fig. 5. In the same model we have **both very large and very small mesh elements**, which yields **minimum EM requirements for WIPL-D simulation** and results in ultimate performances.



Figure 5. Meshed human head model with mobile phone

On the same hardware configuration, the simulation requires **40,327 unknown coefficients**. The **simulation time is 240 s**. The full model radiation pattern is shown in Fig. 6.

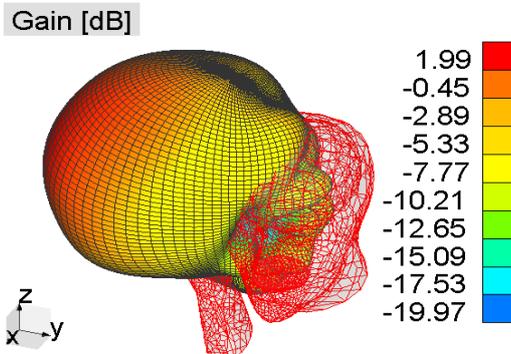


Figure 6. Human head with mobile phone radiation pattern

The near field is shown in Fig. 7. The SAR distribution results are shown in Fig. 8, for the average power of 0.125 W for the mobile device at 1.8 GHz.

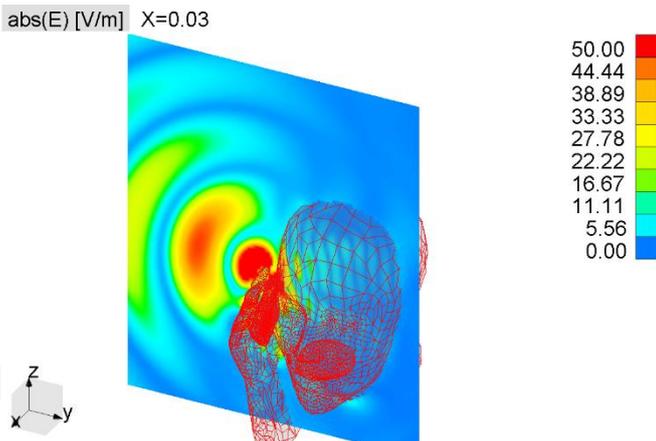


Figure 7. Human head with mobile phone - near field

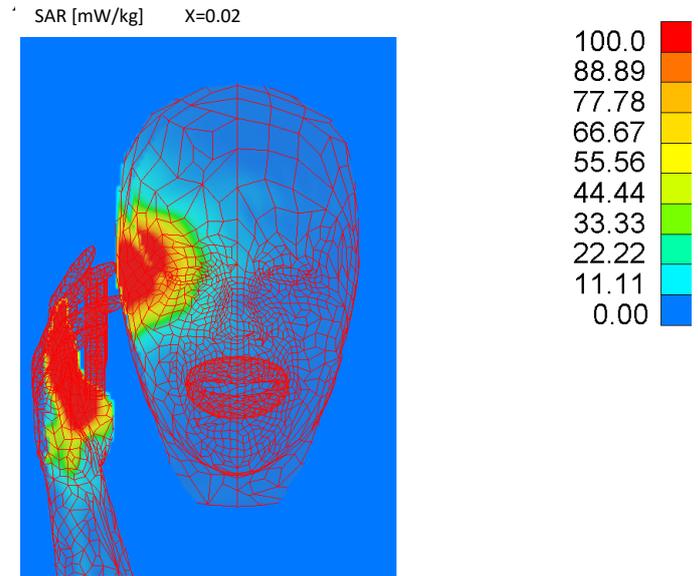


Figure 8. Human head with mobile phone - SAR

Conclusion

With common use of modern communication devices, it has become an imperative to **calculate the impact of EM fields to human body**. This application note focuses to the effects of a mobile phone to human head at 1.8 GHz.

By using the **WIPL-D MoM efficiency**, it is possible to simulate **realistic model** of the cell phone and the human head. The geometries were provided as CAD files, imported, repaired and meshed in WIPL-D Pro CAD with all the details originating in the mechanical CAD model.

The mobile radiates via PIFA and exposes the human phantom to EM radiation, which is demonstrated via both near field and SAR. Results also include radiation pattern for 3 scenarios (PIFA in free space, mounted to cell and in vicinity of head).

All simulations are carried out at **regular desktop quad core PC**. However, for electrically more complicated models, the simulation time has been decreased by using **WIPL-D GPU solver** and widely available inexpensive Nvidia GPU cards. The GTX series offers large computing power for rather small investment. The end result is that simulation time are measured in seconds or minutes at most, as summarized in Table 1.

Table 1. Simulation requirements for the 3 scenarios

Scenario	Number of unknowns	Simulation time [sec]
PIFA in free space	1,116	1
PIFA mounted to cell	21,832	87*
Cell with PIFA near human head	40,327	240*

*Matrix inversion by using single inexpensive GPU card.