MOTOROLA SOLUTIONS

Validation of the numerical HAF4014A antenna model per IEC/IEEE 62704-2-2017 standard

The numerical antenna model validation was performed according to Clause 6.1 of the IEEE/IEC 62704-2:2017 standard. Accordingly, a 1070 mm diameter ground plane model was used with the antenna mounted in the center to calculate the electric and magnetic field values along a vertical line parallel to the antenna axis, at 20 cm separation distance from it.

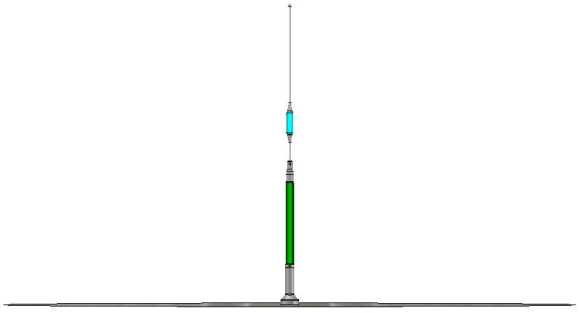
The physical antenna comprises a thicker base element, incorporating a spring-loaded RF-feed contact to the base connector on the ground plane, the spring feed has a inner coaxial feed attach to quarter wave choke that feeds helical coil base with a first wire element and ends with a second wire element. The antenna operating frequency range is 764-870 MHz. Three frequencies were evaluated corresponding to 764 MHz, 817 MHz, and 870 MHz.

A high resolution FIT ((Finite Integration Technique) based simulation was conducted using CST Microwave Studio® (CST MWS) software to generate the reference field values at test points equally spaced along the vertical line, with 10 mm step up to a height of 600 mm above the ground plane, which is higher than the antenna tip 576 mm length. The reference antenna model was designed by taking

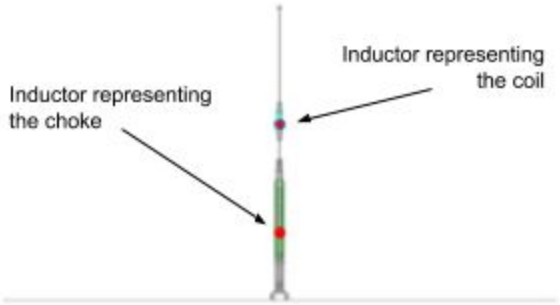
accurate measurements of the antenna element physical dimensions as well as using the detailed CAD model and creating a model in CST MWS. The accuracy of the high resolution reference model was verified by comparing the simulated return loss and the far field pattern with measured results.

The FIT simulations were performed and the electric and magnetic near field values along the vertical line were computed. The convergence level for mesh refinement was set to 1e-2[1] for S-parameters at the antenna feeding port. The same setup was simulated to compute the E and H field values using XFDTD model. The XFDTD model was simulated with the same maximum resolution of the FDTD grid as would be used in subsequent exposure compliance simulations as required by the IEEE/IEC 62704-2:2017 standard. To properly model within the limited resolutions the important functional elements of the antenna, namely the loading coil and the choke the two lumped inductor elements were used to represent those elements in XFDTD. One lumped inductor was representing the loading coil and the other one the inductive impedance of the quarter wave choke at the lower section of the a antenna. The values of the inductances were tuned in XFDTD in order for the model to match the radiation pattern and impedance response of the reference model. The coil inductor was optimized to fixed value of 80 nH and the choke inductor to 57 nH at 764 MHz, 68 nH at 817 MHz, and 70 nH at 870 MHz. The frequency dependency of the latter inductance was implemented using the second order fit based on these three values.

The figures below illustrate the CST MWS (FIT) and XFDTD antenna models.



CST MWS model

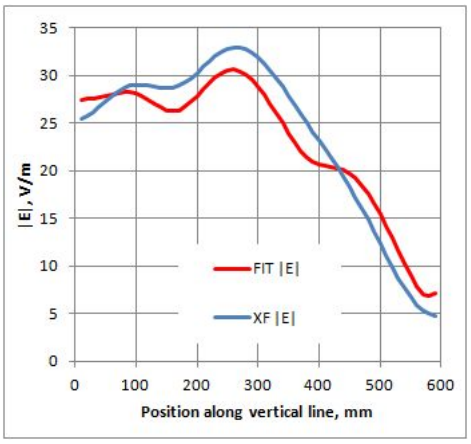


XFDTD model

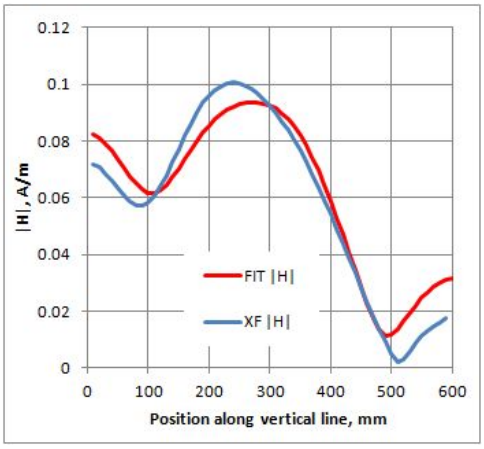
Finally, the amplitudes of the electric and magnetic field values computed at 764/817/870 MHz in XFDTD were compared to the corresponding reference values from high resolution CST FIT model and the deviation was evaluated according to equation (7) of the IEEE/IEC 62704-2:2017 standard resulting in 22.2% at 764 MHz, 21.3% at 817 MHz, and 24.5% at 870 MHz uncertainty. The worst case of **24.5%** was used as the uncertainty of this numerical antenna model within all applicable frequency range of this antenna.

The plots below illustrate the magnitudes of electric and magnetic fields along the vertical line, at 20 cm from the antenna axis, computed using CST MWS (FIT) and XFDTD codes and normalized to 0.5W net average input power at 764/817/870 MHz.

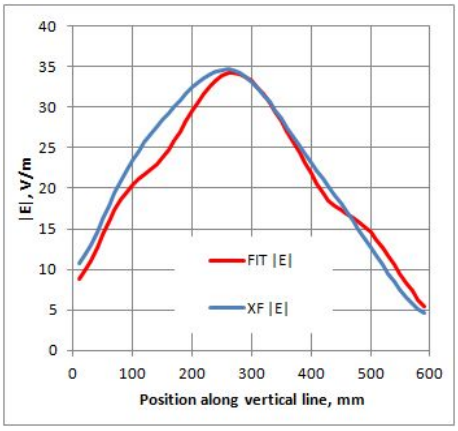
[1] The convergence criterion for S-parameters was defined as the maximum deviation of the absolute value of the complex difference of the S-parameters between two subsequent passes.



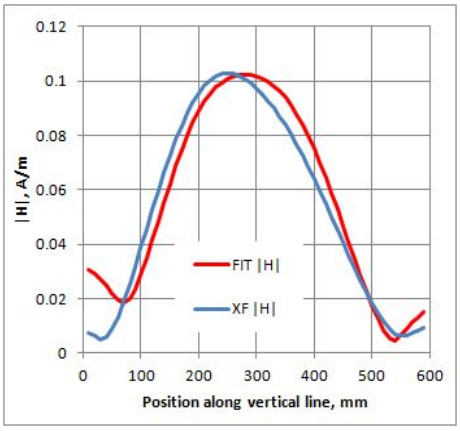
Electric field magnitude (764 MHz)



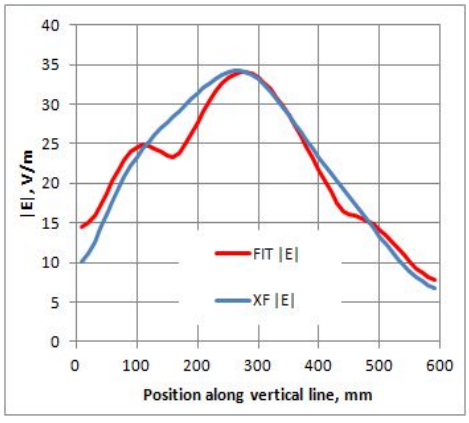
Magnetic field magnitude (764 MHz)



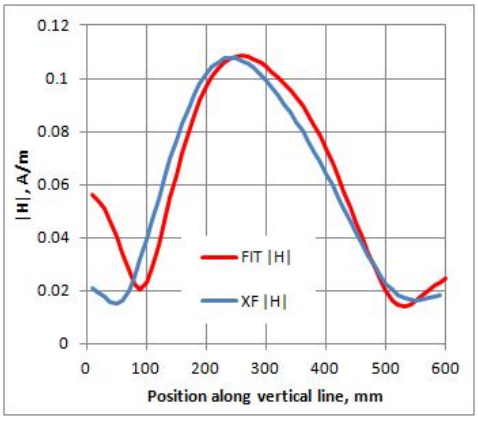
Electric field magnitude (817 MHz)



Magnetic field magnitude (817 MHz)



Electric field magnitude (870MHz)



Magnetic field magnitude (870MHz)