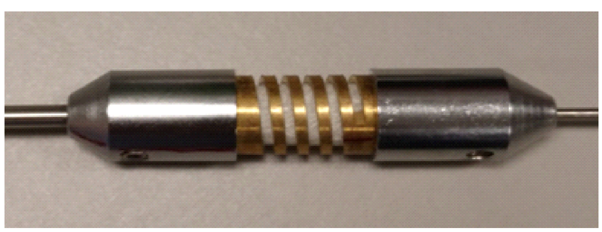
Validation of the numerical HAE4013A antenna model per IEC/IEEE 62704-2:2017 standard

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.

A high resolution FEM (Finite Element Method) 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 7 mm step up to a height of 800 mm above the ground plane, which is higher than the antenna tip (640 mm above the ground plane surface).

The physical antenna comprises a thicker base element, incorporating a spring-loaded RF-feed contact to the base connector on the ground plane, a first wire element starting from the base element and ending at an inductor trap, and a second wire element departing from the inductor trap.
The inductor trap comprises a top and bottom wire-mount end-caps made out of metal, and a brass coiled inductor element in between them, plus a low dielectric plastic tube inside the coil for mechanical support and a thin heat-shrink inductor cover for protection.

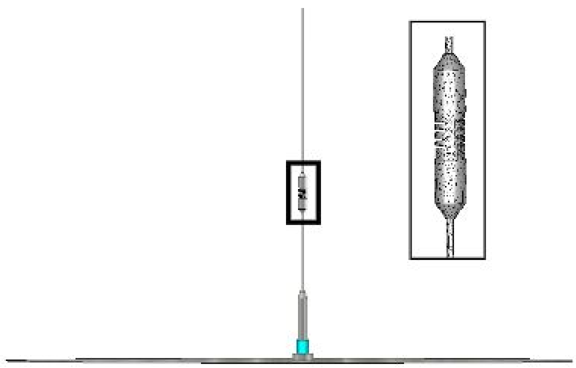
A picture of the antenna is in the MPE report, while a detailed picture of the coil is provided below, with the heat shrink cover removed to expose the coil.

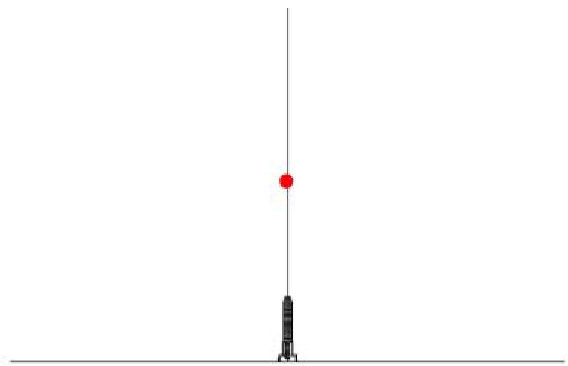


The reference antenna model was designed by taking accurate measurements of the antenna element physical dimensions and creating a model in CST MWS. The FEM simulations were performed with adaptive mesh refinement until the convergence of S-parameters at the antenna feeding port reached the preset level of 1e-4,[1] and near electric and magnetic field values along the vertical line were exported in text format. The same setup was simulated to compute the field values using XFDTD code with the same maximum resolution of the FDTD grid that was used in subsequent exposure compliance simulations as required by the IEEE/IEC 62704-2:2017 standard.

[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

The figures below illustrate the CST MWS (FEM) and XFDTD antenna models. The red dot in the latter represents the location of the lumped inductor.





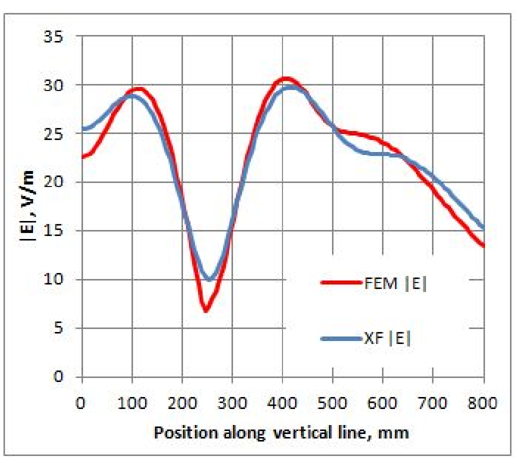
CST MWS (FEM) model of the HAE4013A antenna

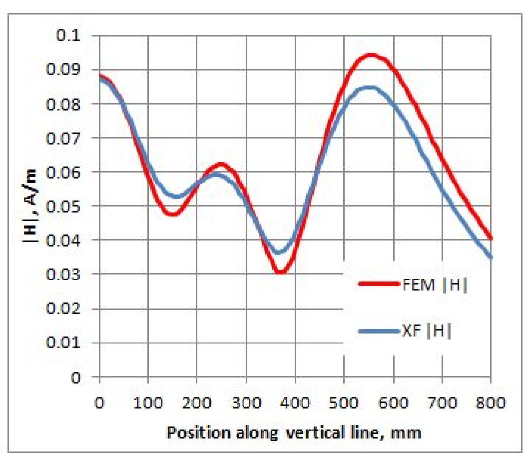
XFDTD model of the HAE4013A antenna

The XFDTD antenna model was realized similarly; however a single, lumped inductor element was inserted along the wire extending from the antenna base element. The inductance associated to this lumped element was determined by successive approximations in order to fit as well as possible the FEM near fields along the vertical line at 503 MHz, yielding a value of 90 nH.

Finally, the electric and magnetic field values computed at 503 MHz with XFDTD using that inductance value were compared to the reference values computed using high resolution FEM model and the deviation was evaluated according to equation (7) of the IEEE/IEC 62704-2:2017 standard to quantify the uncertainty contribution of the numerical antenna model, resulting in **20.2% uncertainty**.

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 (FEM) and XFDTD codes, and normalized to 0.5W net input power at 503 MHz.





Electric field magnitude

Magnetic field magnitude