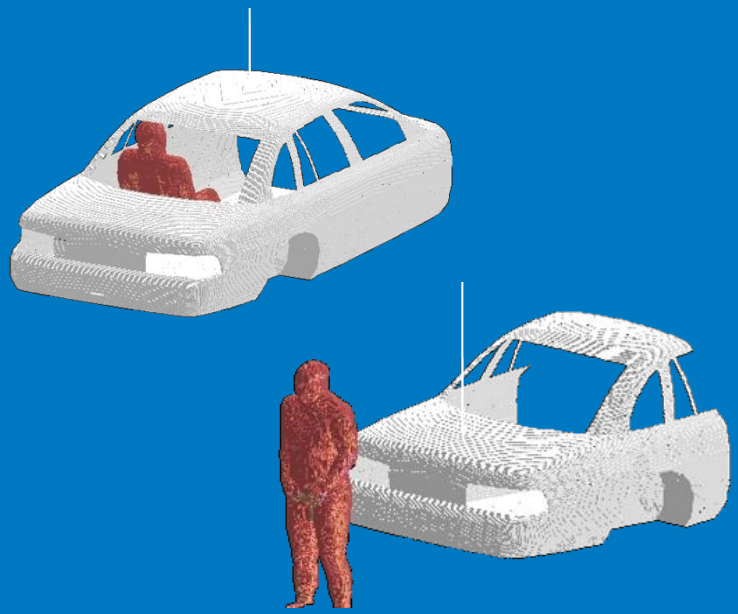
Validation of Mobile Antenna Modeling by Comparison with Near-field Measurements

Simulation & numerical assessment of RF exposure from vehicle-mount antennas

IEEE/ICES TC34 SC2 meeting:

Cancun, June 9, 2006



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IEEE/ICES/TC34/SC2 Meeting: Cancun. Mexico, 9-10 June 2006, Rev 1.0

THIS VERSION OF THE SLIDES WAS MODIFIED, ADDING SLIDE 13 IN DECEMBER 2016 AND SLIDE 16 IN OCTOBER 2018 TO PROVIDE SUPPORTING INFORMATION TO THE US FEDERAL COMMUNICATIONS COMMISSION

Objectives

Demonstrate validity of different vehicle mount antennas (monopoles) modeling using FDTD method for exposure assessment

- **Validity of simplified antenna models with helical loads represented by lumped inductor elements in limited resolution FDTD models**
- **Validity of ideal feed point impedance matching assumption in simulations without detailed consideration of the matching circuit located at the base of some real antennas**

Validation of XFDTD antenna models vs. near-field measurements

Antennas

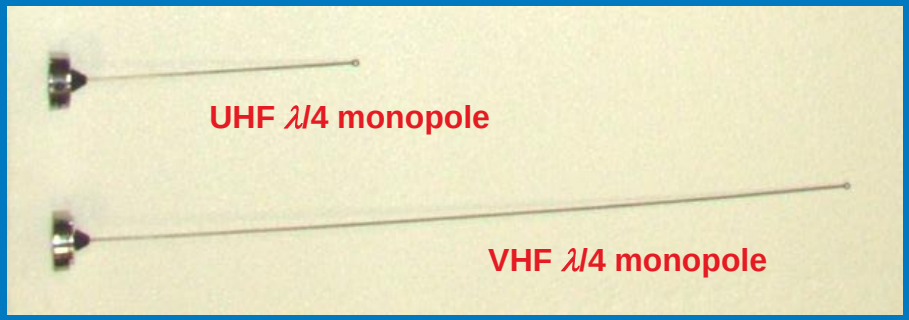
- **VHF** quarter-wave monopole
- **UHF** quarter-wave monopole
- HAE6010A (**UHF** gain antenna)
- HAE6011A (**UHF** gain antenna)
- HAE6013A (**UHF** gain antenna)

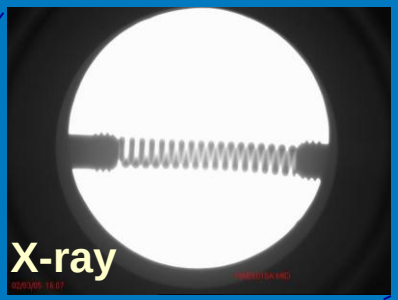
Mounted on the center of a circular (53 cm radius) ground plane

XFDTD™ modeling

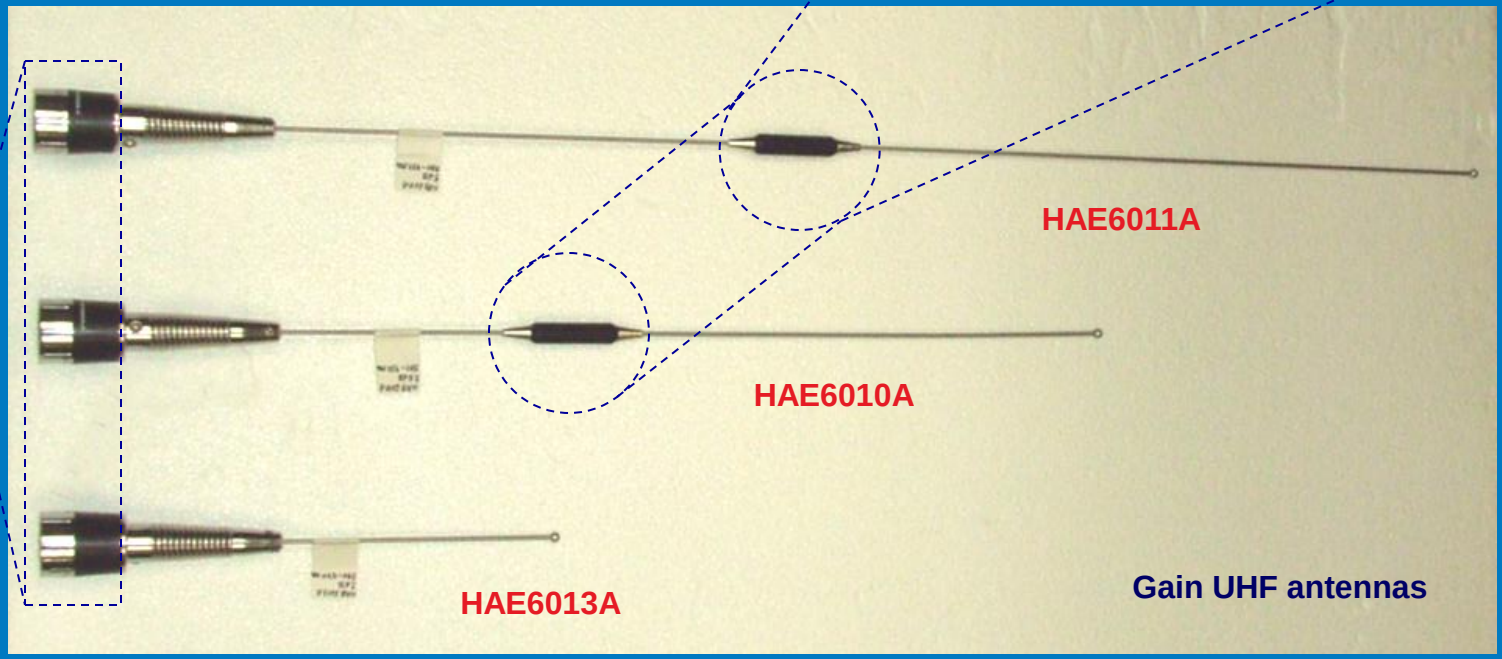
- 50 Ω resistive voltage source, no matching network
- PML BC at all domain bounds
- 5 mm discretization

Typical Vehicle Mount Antennas





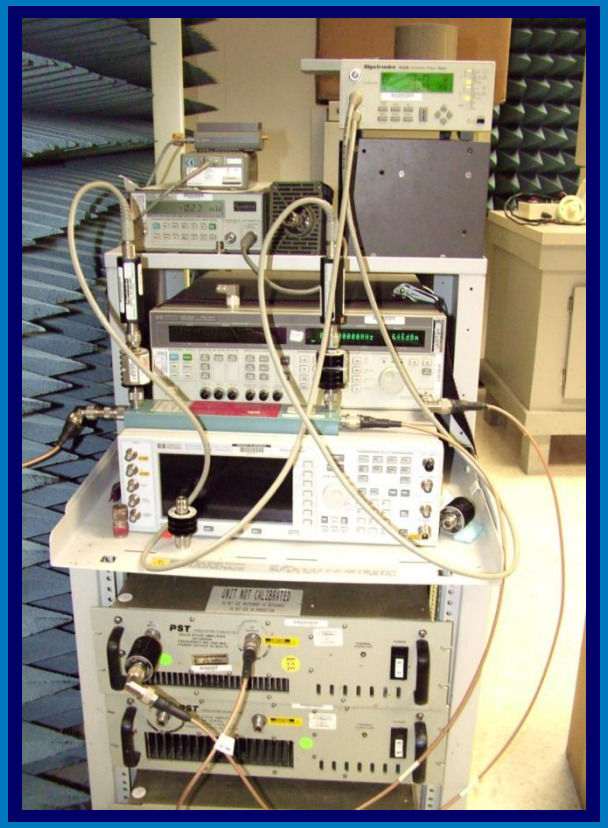
Embedded matching network



Description of measurements

Equipment Used:

DASY4
E and H field probes: *ER3DV5R & H3DV6*
Signal generator: *HP83732A*
Power amplifiers: *PST* 50 W, 1-500 MHz
Power meters: *HP437B & Giga-tronics 8542B*
Network Analyzer: *Wiltron 3721B*



Measurement Procedure:

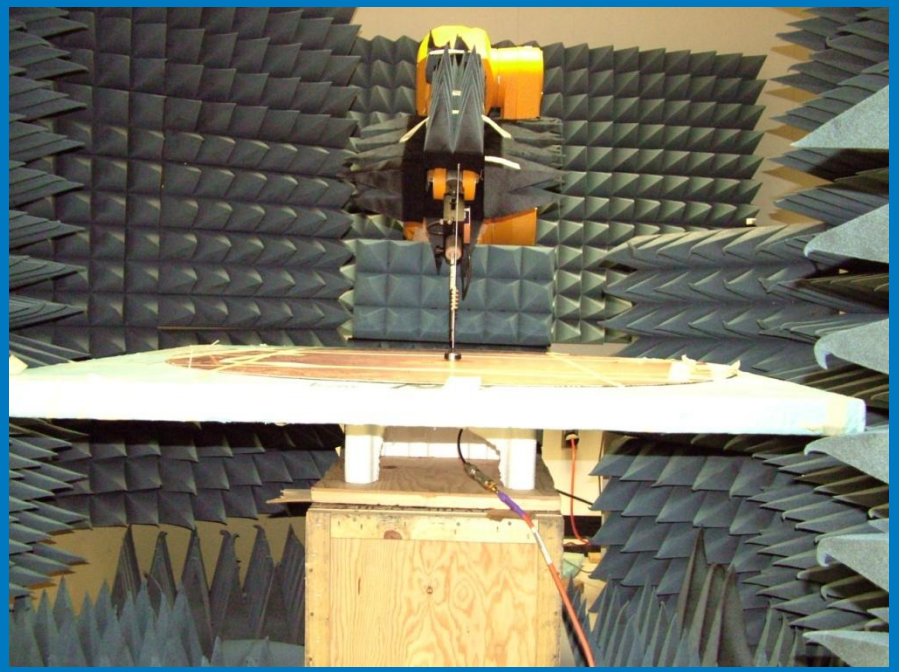
The near field of each antenna mounted on the center of circular ground plane was measured in the rectangular area covering the full height of the antenna and within the reach of the robot arm

Radius of the ground plane: 53 cm

Antenna return loss was measured and taken into account in normalization of the results to 1.0 W radiated power

Description of measurements

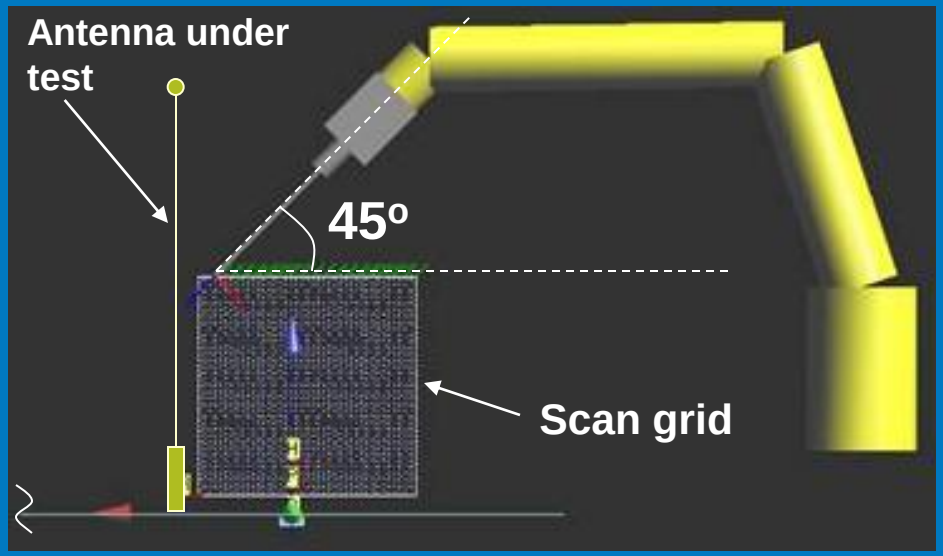
- Quasi-anechoic environment
- The DASY4 robot arm closest to the probe was covered with absorbing material
- Both E- and H- were measured within 43 cm distance from the antenna and with 1 cm grid step

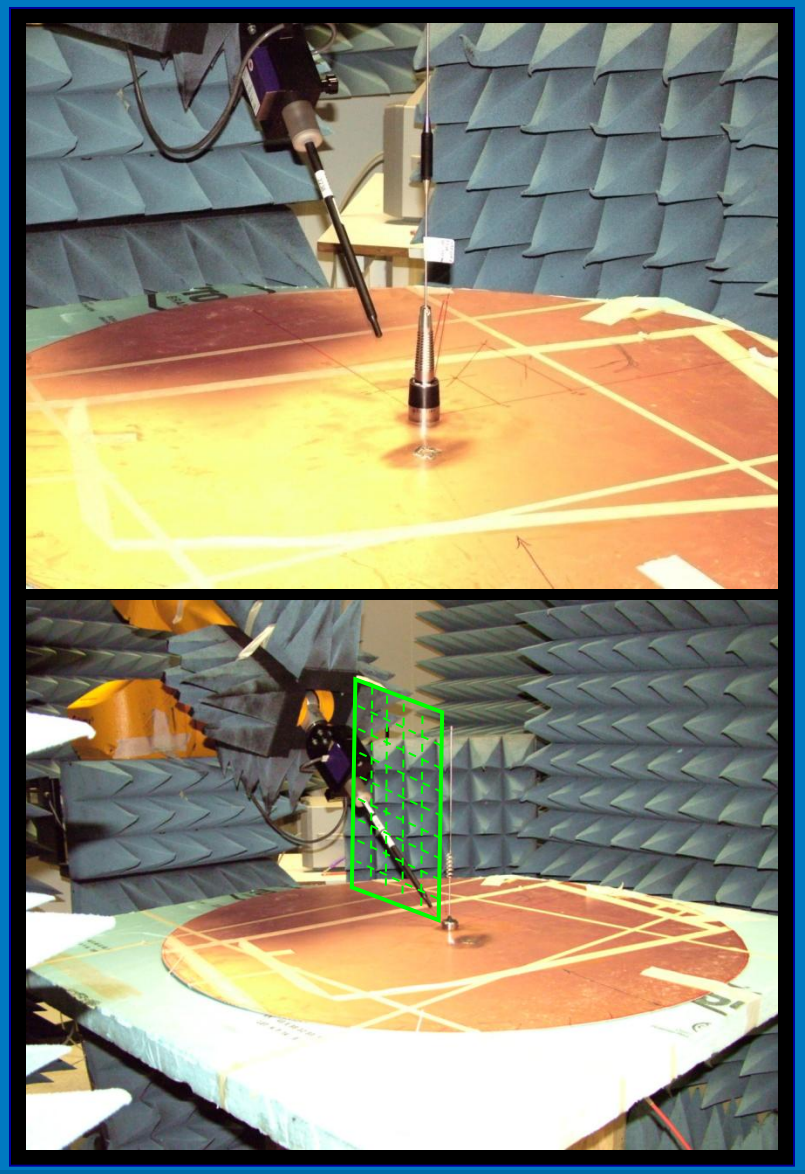


Description of measurements

DASY4 system

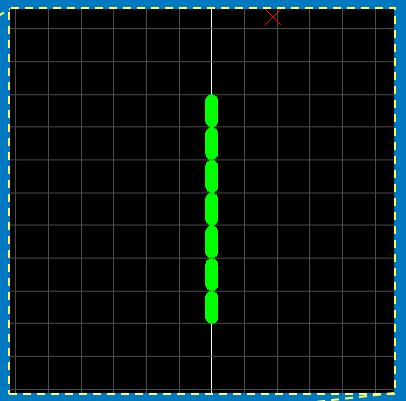
Probe at all time tilted at 45 degree from vertical position to minimize interaction with antenna and ground plane

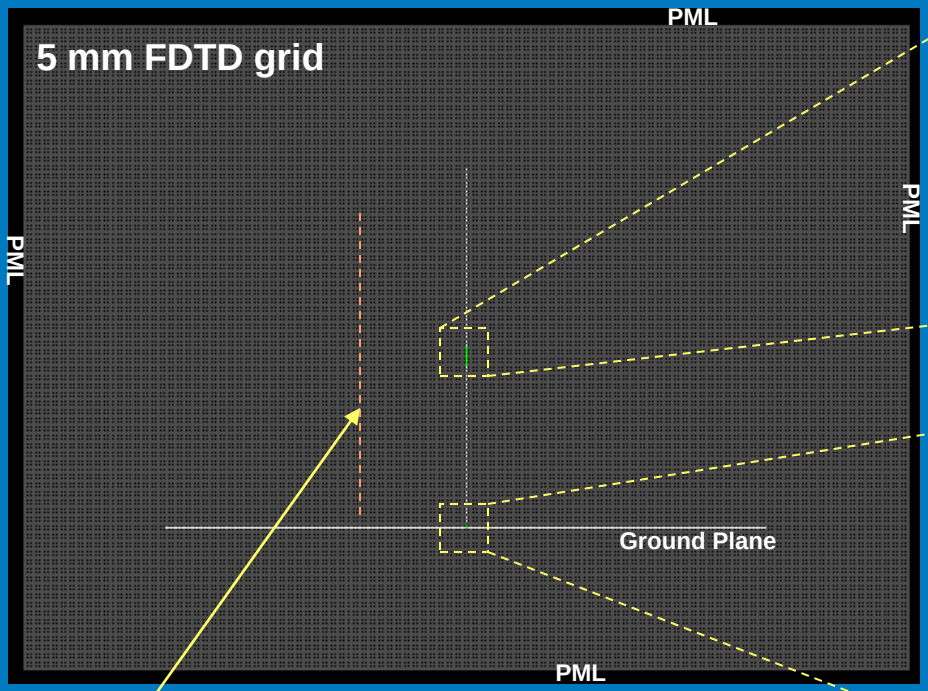


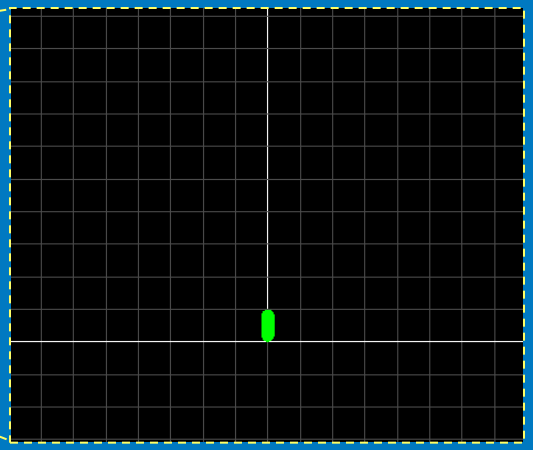


Details of the numerical model – FDTD

Coil along the antenna - Lumped inductors connected in series





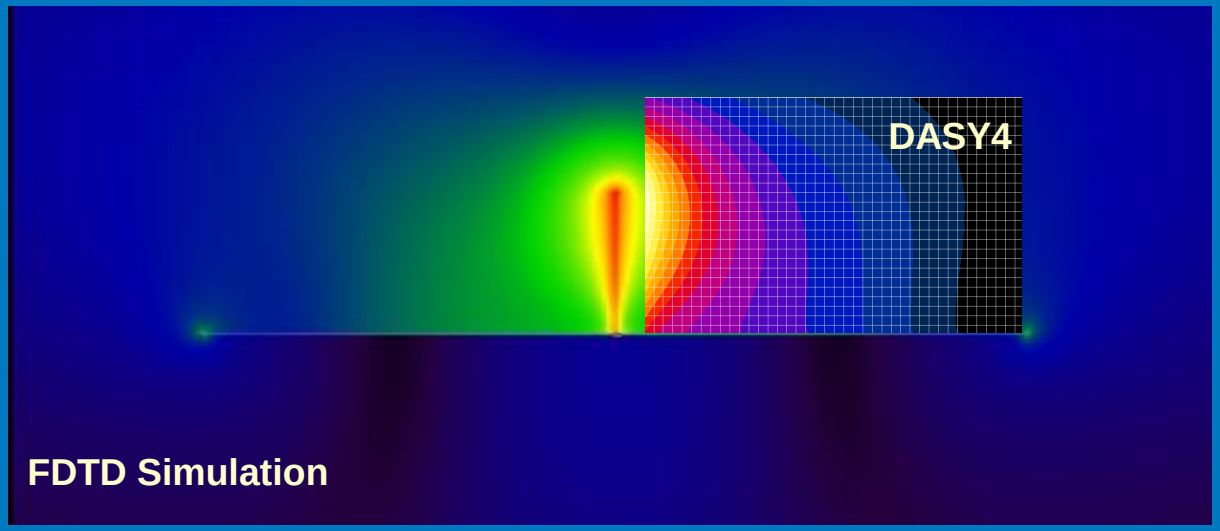


Lines at 20 cm from antenna along which the simulated and measured field values were compared

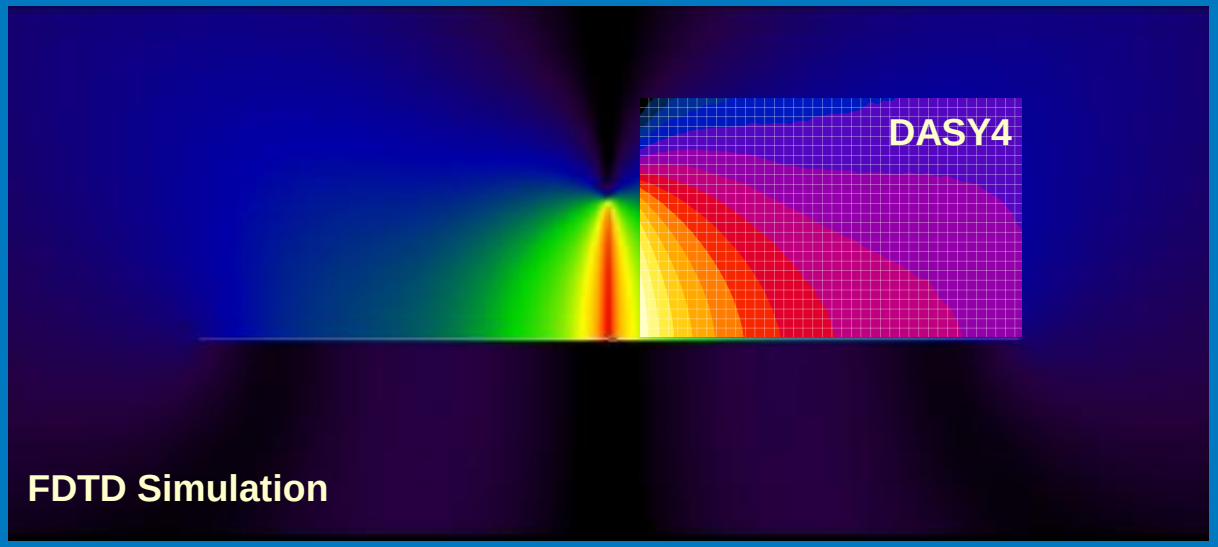
Feeding - Lumped Resistive Voltage Source

UHF $\lambda/4$ monopole – 400 MHz

E-field

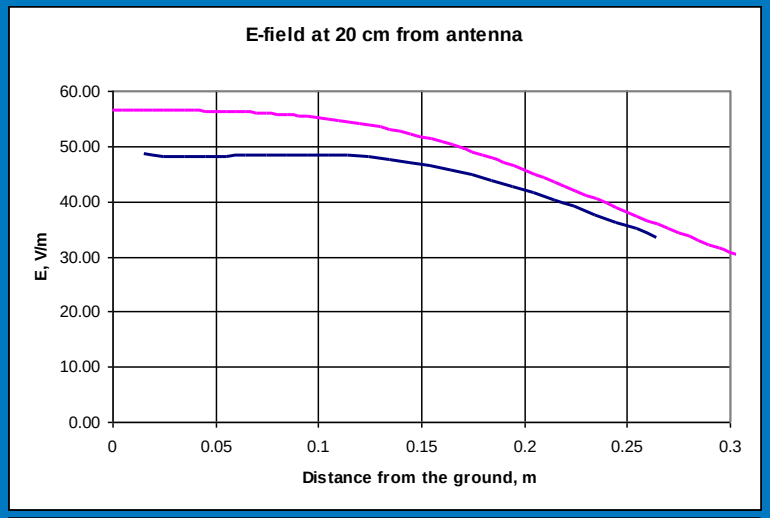


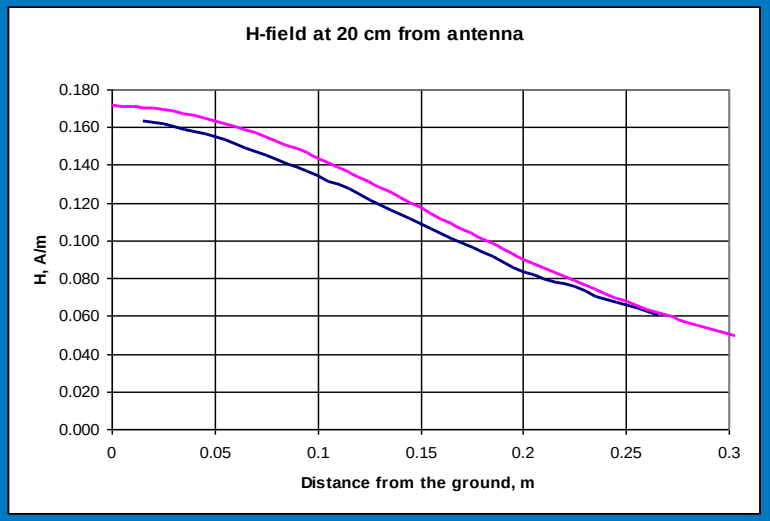
H-field



UHF $\lambda/4$ monopole – 400 MHz

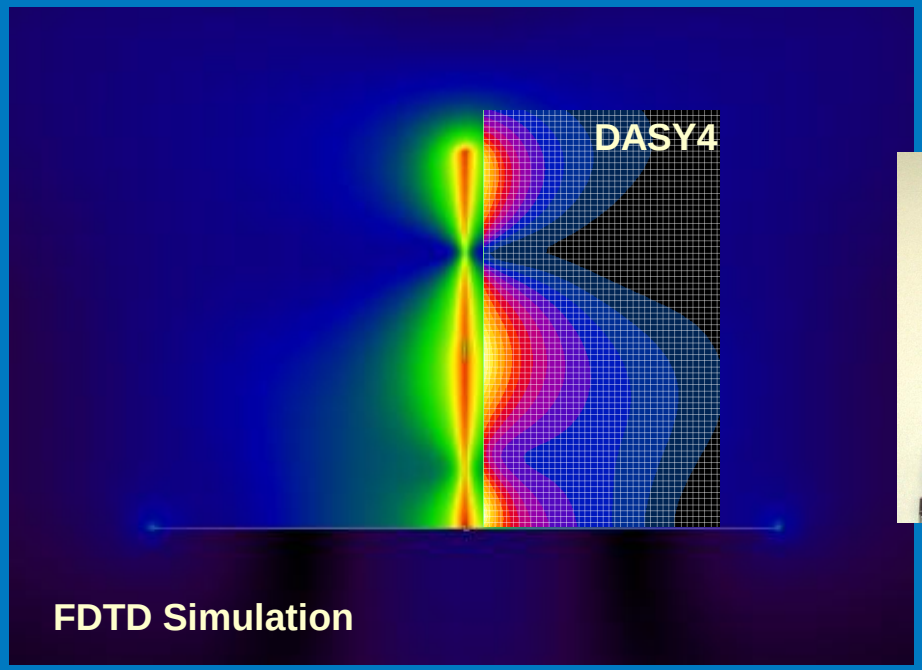
Simulated and measured E-field



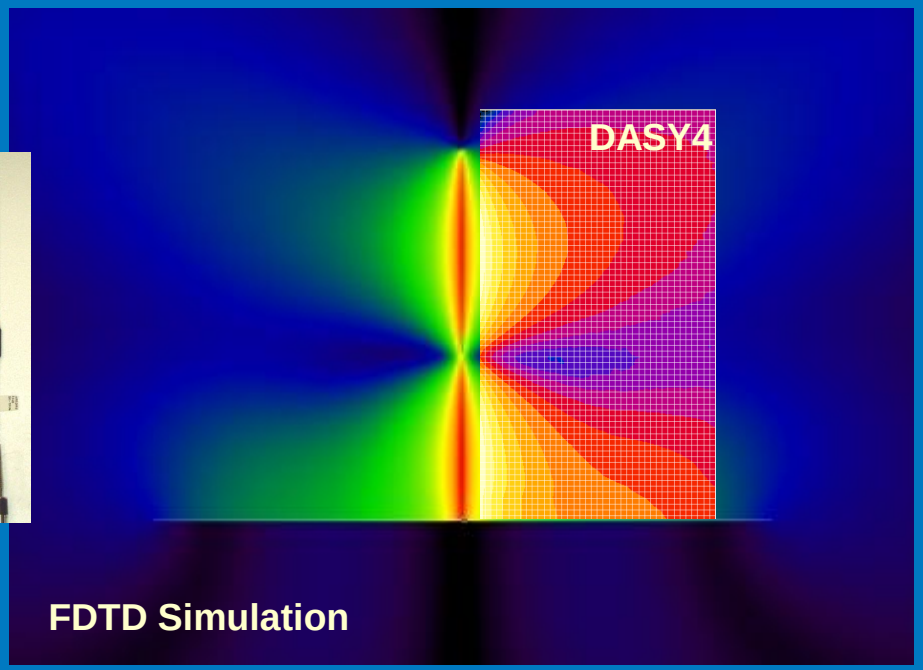


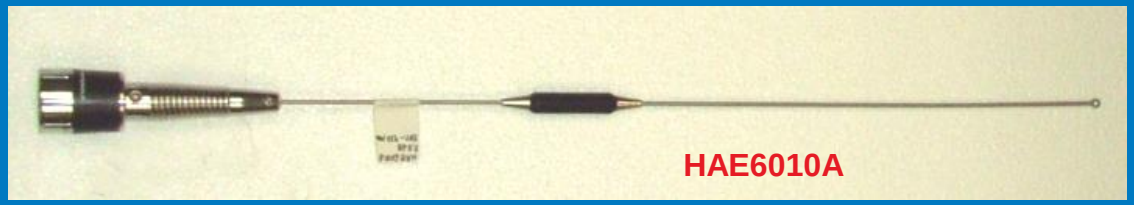
UHF Gain Antenna HAE6010A – 400 MHz

E-field



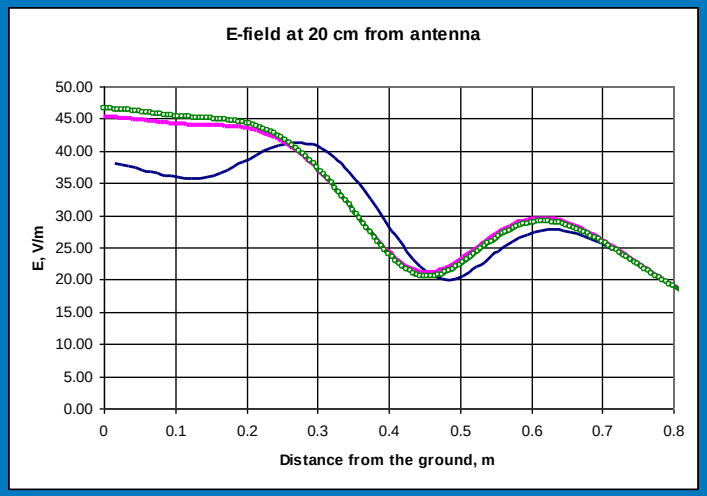
H-field

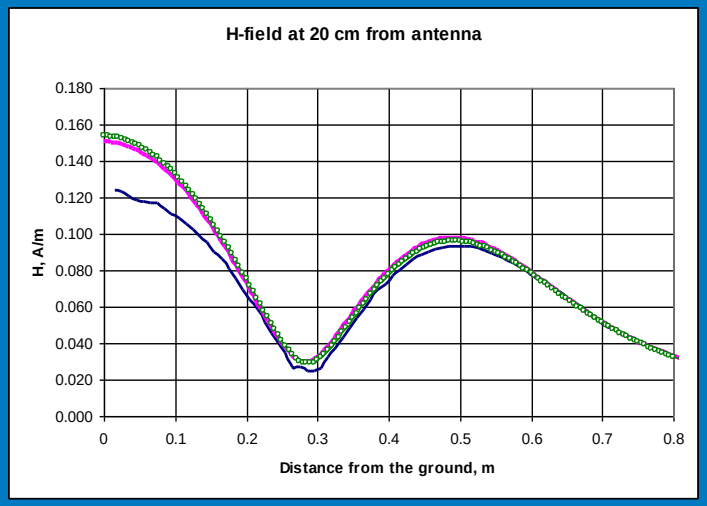


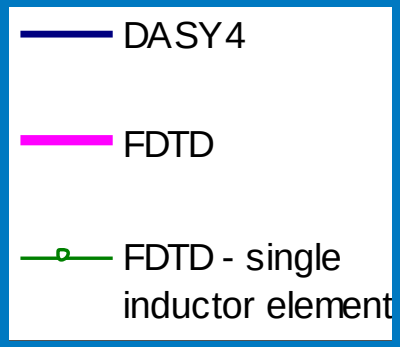


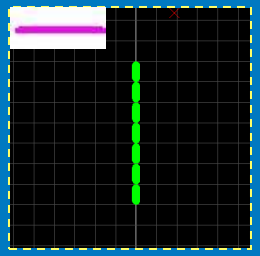
UHF Gain Antenna HAE6010A – 400 MHz

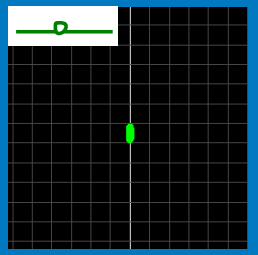
Simulated and measured E-field











UHF Gain Antenna HAE6010A – 400 MHz (IEC/IEEE 62704-2 numerical model uncertainty)

The uncertainty of the HAE6010A antenna model was evaluated based on experimental measurements, as permitted in the IEEE/IEC 62704-2 standard.

The electric and magnetic field values computed with XFDTD using 160 nH for the inductance value were compared to the reference values measured as described in this document and the deviation was evaluated according to equation (7) of the IEEE/IEC 62704-2 standard to quantify the uncertainty contribution of the numerical antenna model, resulting in **53.9% uncertainty**.

It should be noted that the simulated squared E fields were 15% larger on average than the measured ones, while the simulated squared H fields were 25% larger on average than the measured ones.

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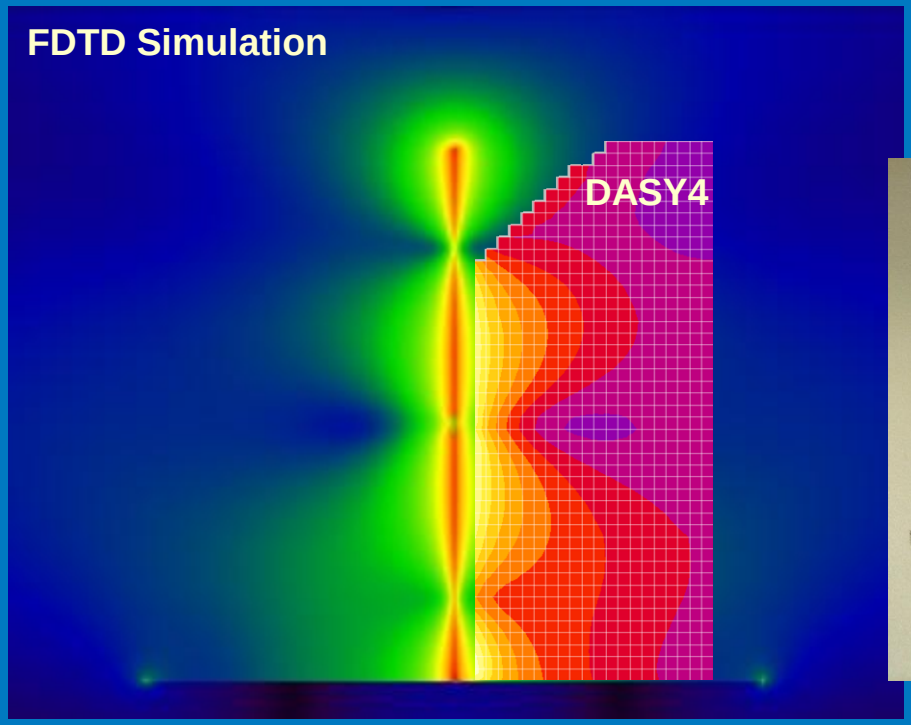
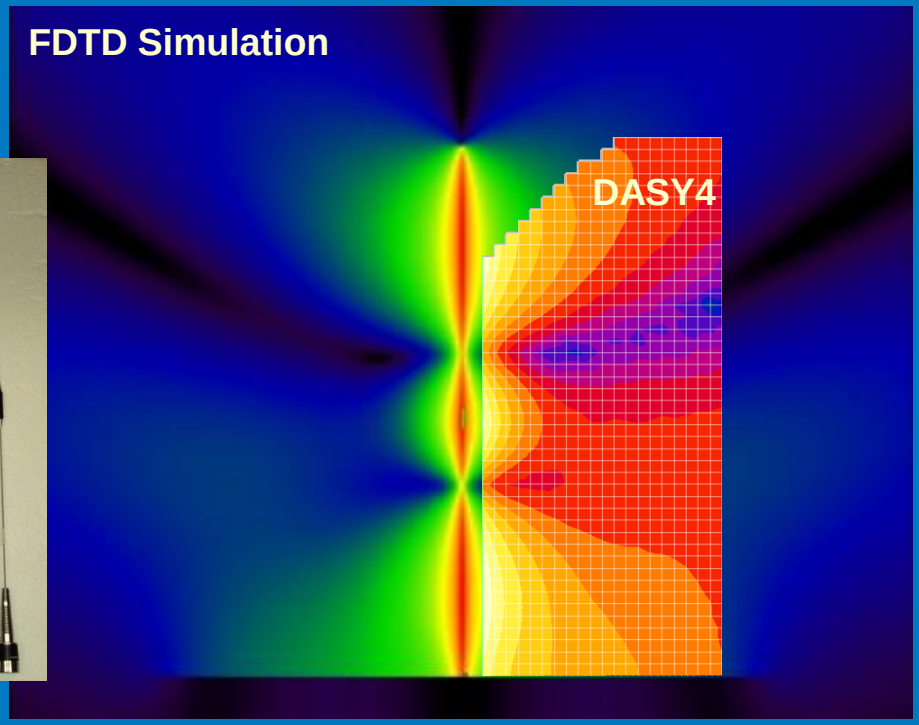
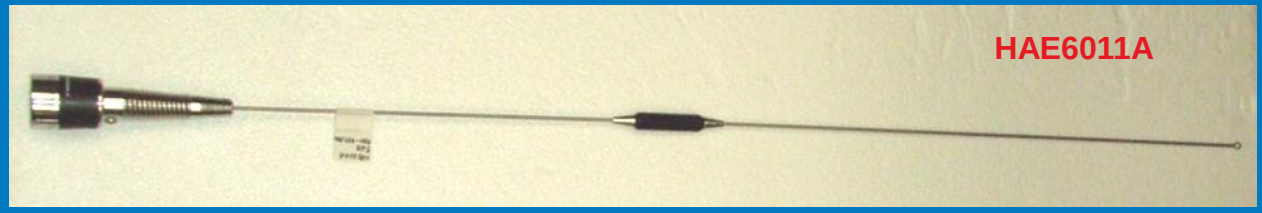
UHF Gain Antenna HAE6011A – 400 MHz

E-field



H-field





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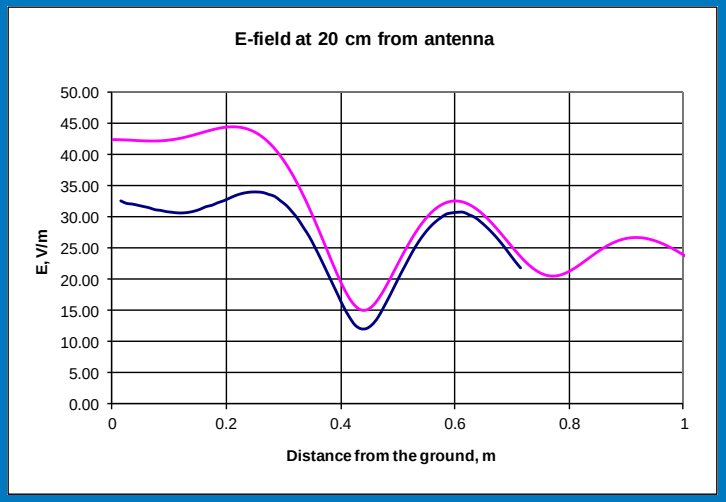
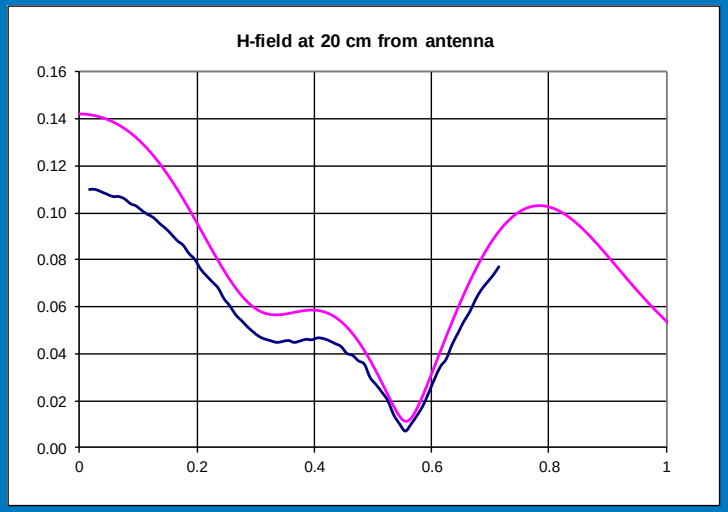
UHF Gain Antenna HAE6011A – 400 MHz

Simulated and measured E-field





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UHF Gain Antenna HAE6011A – 400 MHz (IEC/IEEE 62704-2 numerical model uncertainty)

The uncertainty of the HAE6011A antenna model was evaluated based on experimental measurements, as permitted in the IEEE/IEC 62704-2 standard.

The electric and magnetic field values computed with XFDTD using 160 nH for the inductance value were compared to the reference values measured as described in this document and the deviation was evaluated according to equation (7) of the IEEE/IEC 62704-2 standard. The maximum deviation of the simulated electric field squares was 81.9%. For the magnetic field squares it was 64.3%. Accordingly the larger value of **81.9%** was used as **uncertainty**.

It should be noted that the simulated squared E fields were 53% larger on average than the measured ones, while the simulated squared H fields were 56% larger on average than the measured ones.

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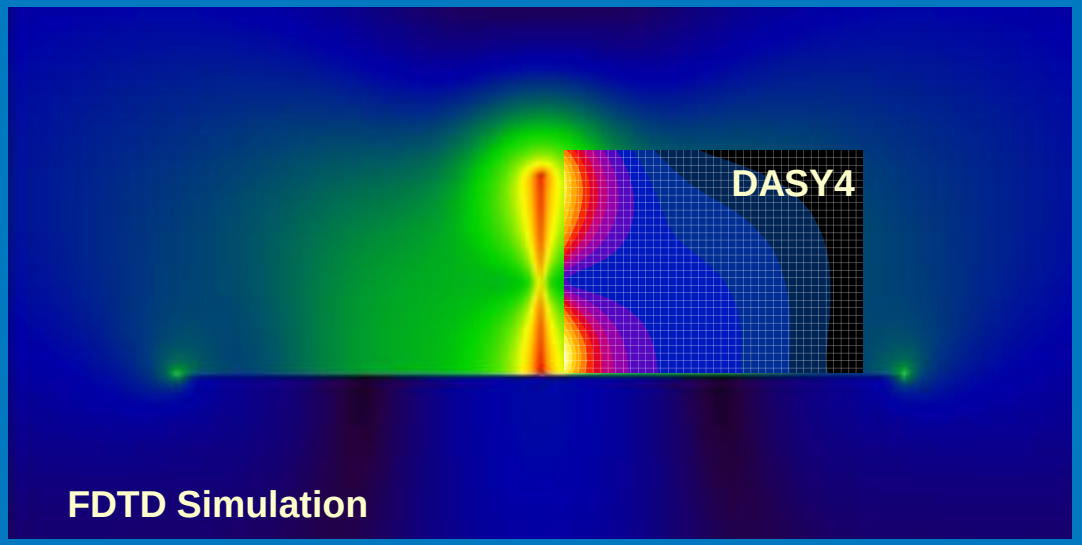
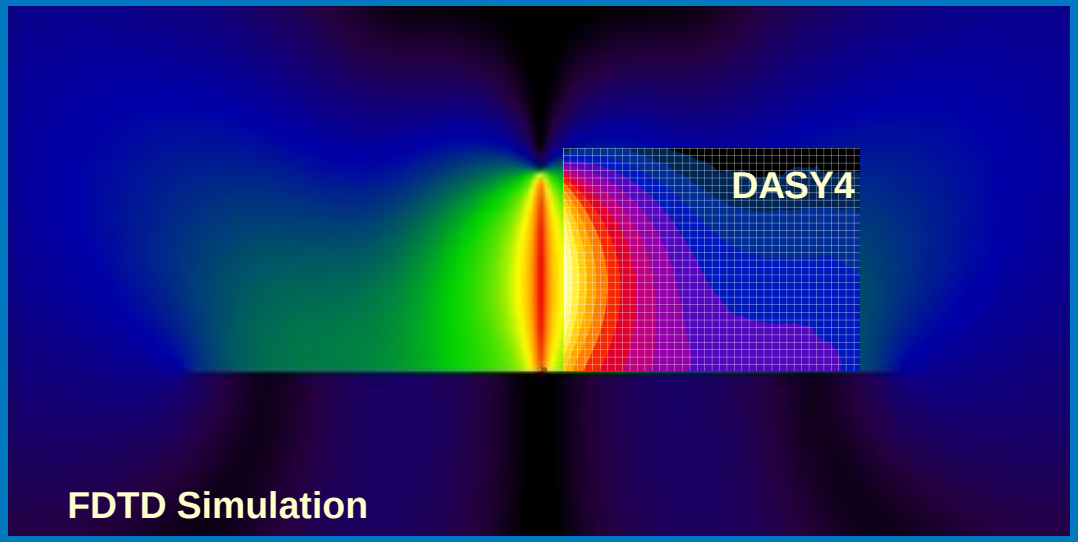
UHF Gain Antenna HAE6013A – 435 MHz

E-field

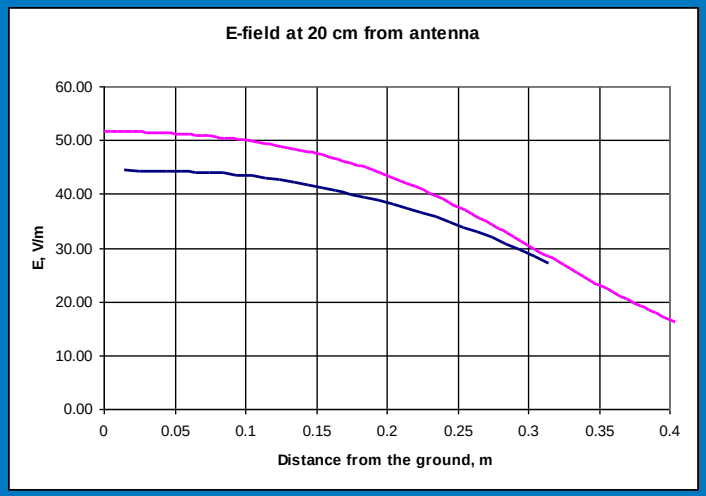


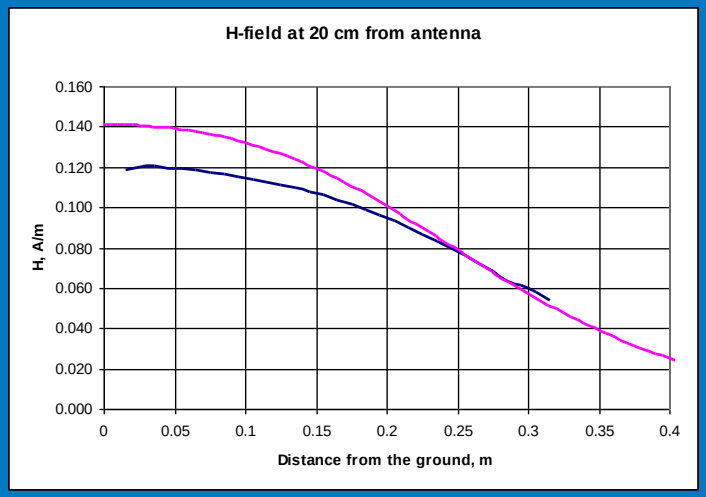
H-field



UHF Gain Antenna HAE6013A – 435 MHz

Simulated and measured E-field





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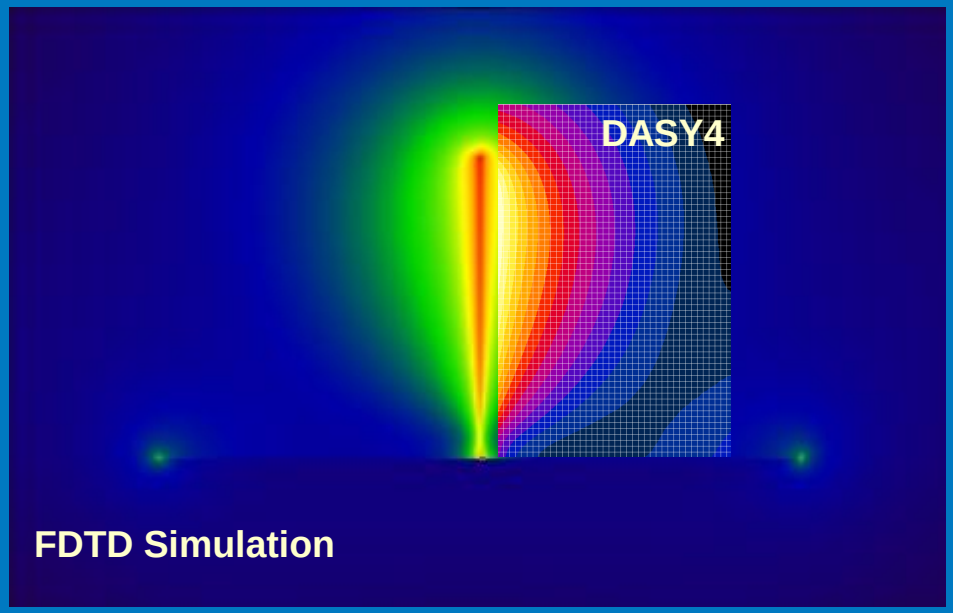
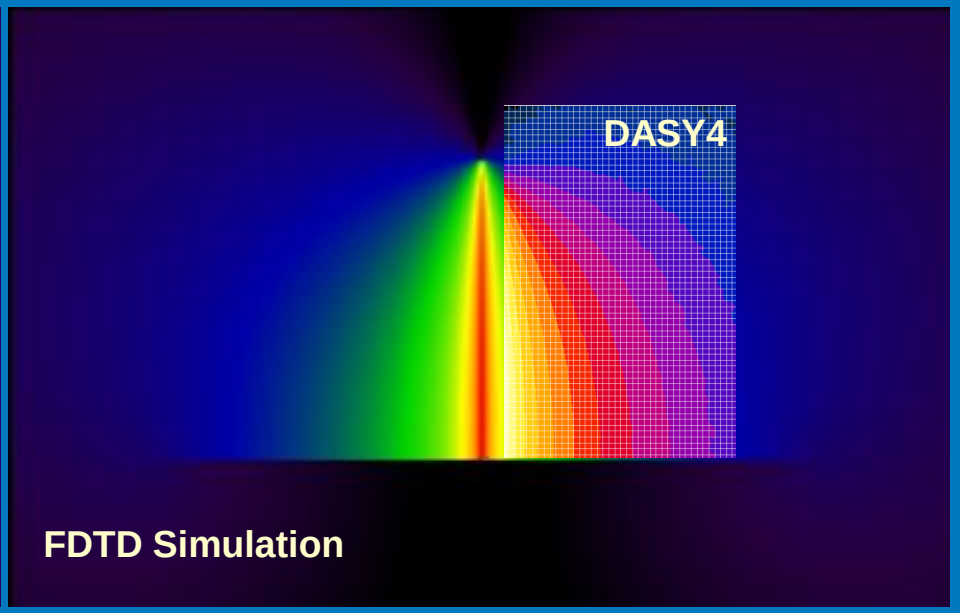
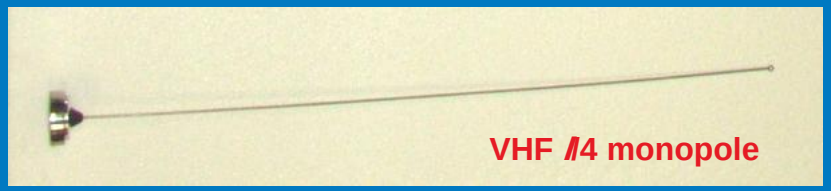
VHF λ/4 monopole – 150 MHz

E-field



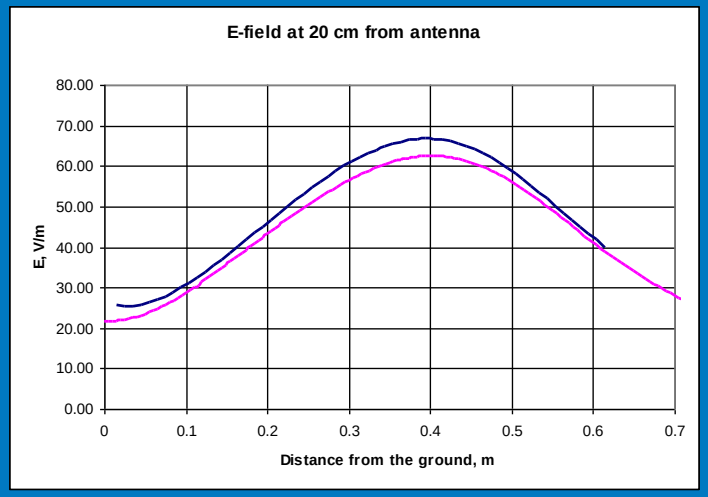
H-field

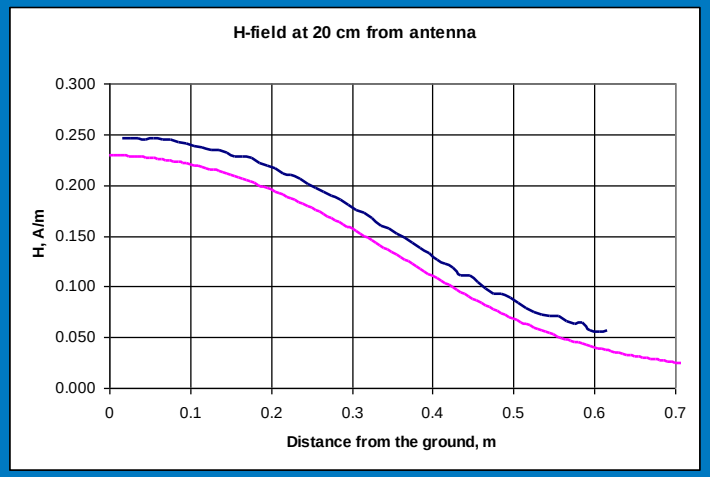




VHF $\lambda/4$ monopole – 150 MHz

Simulated and measured E-field





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FDTD

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Observations

The comparison of measured and simulated near-field for a number of mobile radio antennas appears to be satisfactory.

Spatial electric and magnetic field distributions in the vicinity of the antenna are well reproduced using FDTD models of the antennas mounted on a circular ground plane

The “traps” employed on gain antennas to re-phase currents on different antenna sections can be represented by means of individual or multiple lumped inductances in the FDTD model of the antenna.

The absolute values of the fields are well reproduced by assuming perfect match of antenna feed point impedance with the source that eliminates the need of modeling the matching circuit

Thank You

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