montena

Technical Note - TN16

Half Impulse Radiating Antenna Type HIRA140 Measurements and simulations

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1. Introduction

The Half Impulse Radiating Antenna (HIRA) is a special type of antenna designed to radiate ultra wideband (UWB) electromagnetic field signals. It is specialized for pulsed applications, but can also be used for CW signals.

This technical note describes the main parameters and particularities of the montena emc HIRA140 based on both measurements and simulations.

2. Antenna principles

The antenna is composed of a metallic half-parabol connected to a ground plane. The electromagnetic energy fed by two metallic arms is reflected by the parabol to form a narrow radiation beam in the antenna boresight direction. The coaxial input of the antenna is connected to the metallic arms through an impedance adaptor. A picture of the HIRA140 is shown in Figure 1.

Figure 1 : Prototype of the montena emc HIRA140.

The main characteristic of the antenna is its ability to radiate electromagnetic energy over a large bandwidth, preserving the signal phase coherence. The radiated pulse is a time-derivative of the voltage pulse fed at the input.

The electromagnetic pulse produced by the antenna can be separated into the following subcomponents:

- the prepulse (caused by the direct radiation of the feedpoint).
- the time-derivated impulse (electromagnetic field reflected by the reflector).
- the ground reflexion (depending on the nature of the soil, a ground reflexion may reach the target after some delay).

A typical pulsed electric field waveform in boresight direction is shown in Figure 2.

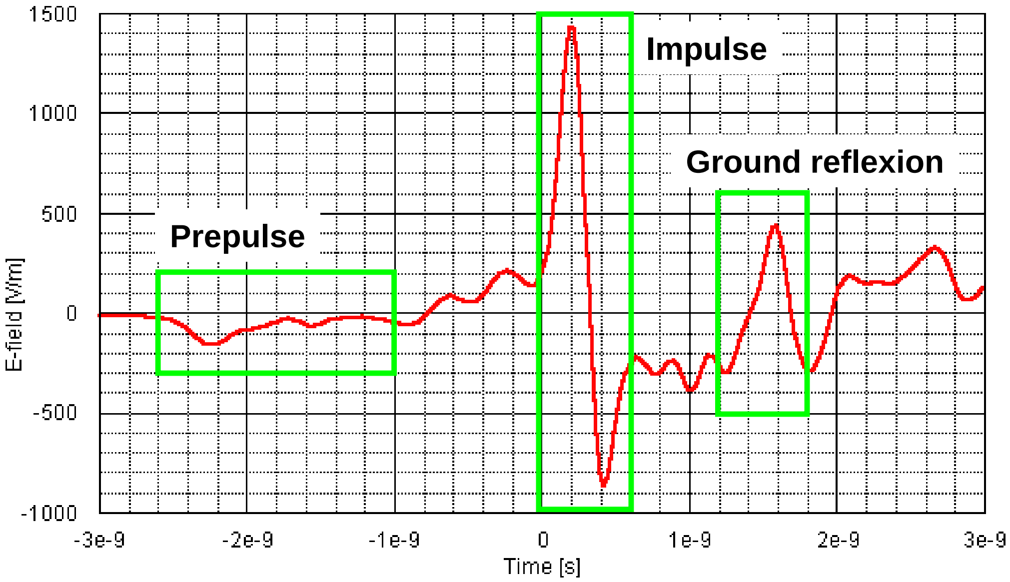


Figure 2 : Typical pulse and subcomponents.

3. Impedance structure inside the antenna

The input of the antenna is 50 Ω. A tapered transmission line transforms the impedance to 100 Ω at the feedpoint. From there, two 200 Ω transmission lines and 200 Ω resistive loads are connected in parallel.

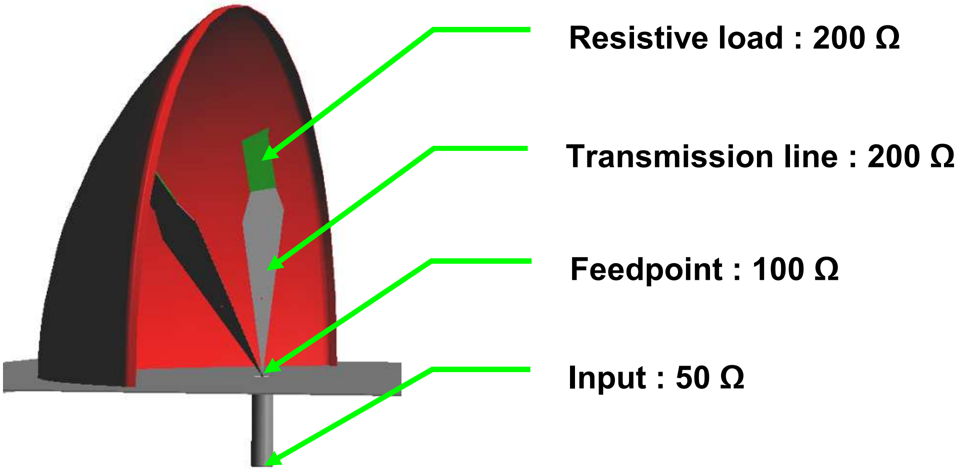


Figure 3 : Impedances inside the antenna.

4. Time Domain Reflectometry

A time-domain reflectometry at the input of the HIRA140 confirms the impedances explained above: for early times, a smooth adaptation from 50 to 100 Ω, and then a value oscillating around 100 Ω, because of the slight imperfections at the different interfaces.

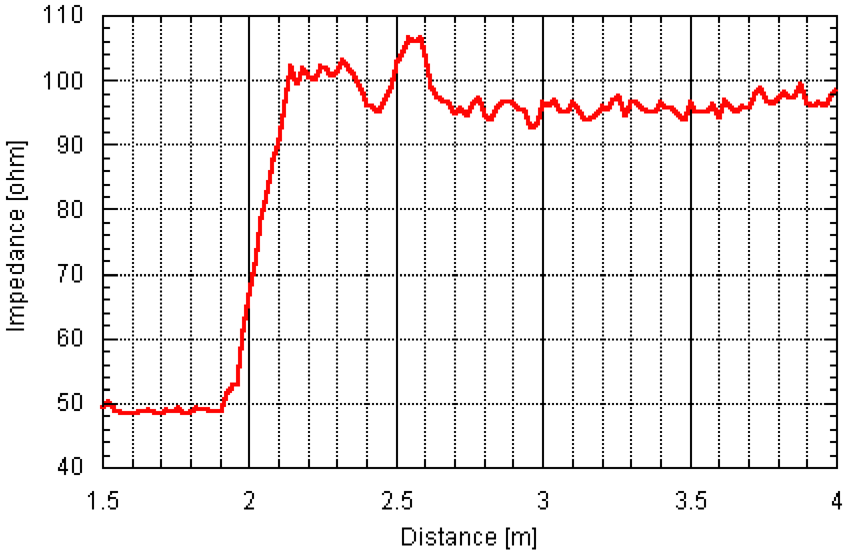


Figure 4 : Time-domain reflectometry of the HIRA140.

5. Measurement of the input voltage

All the measurements are performed with a pulse generator FPG 10-50MK. It has a specified peak output voltage on 50 Ω of 10 kV, a rise-time 10-90% of 140 ps and a duration of 550 ps. The measurement of the input voltage is performed with a PICOTEM cell with the generator loaded by the HIRA140.

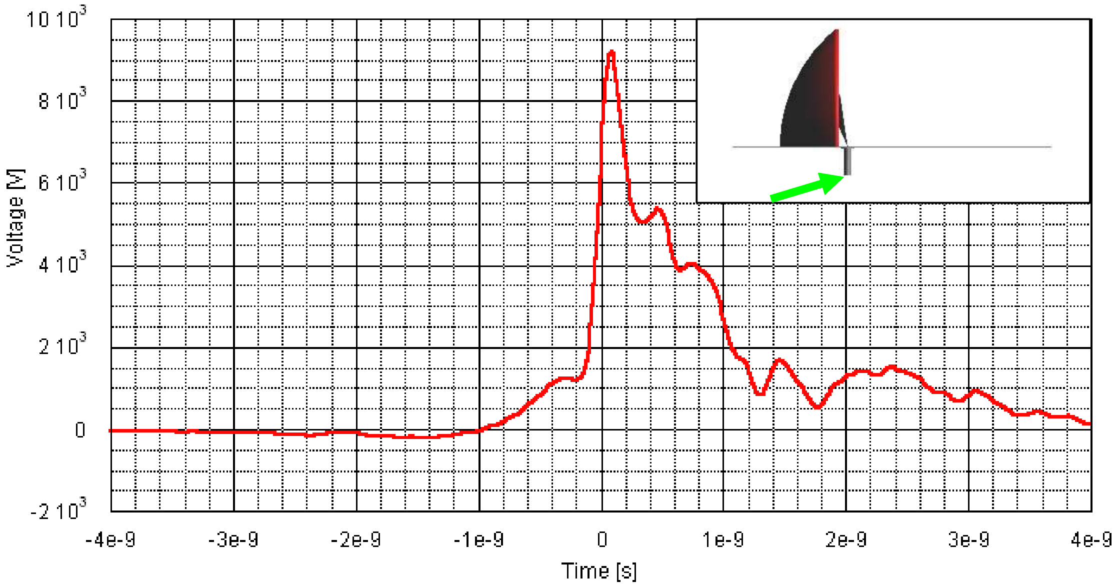


Figure 5 : Input voltage of the HIRA140 with the generator used for the field measurements. The peak voltage is 9.2 kV.

6. Measurement of the field on the antenna reflector

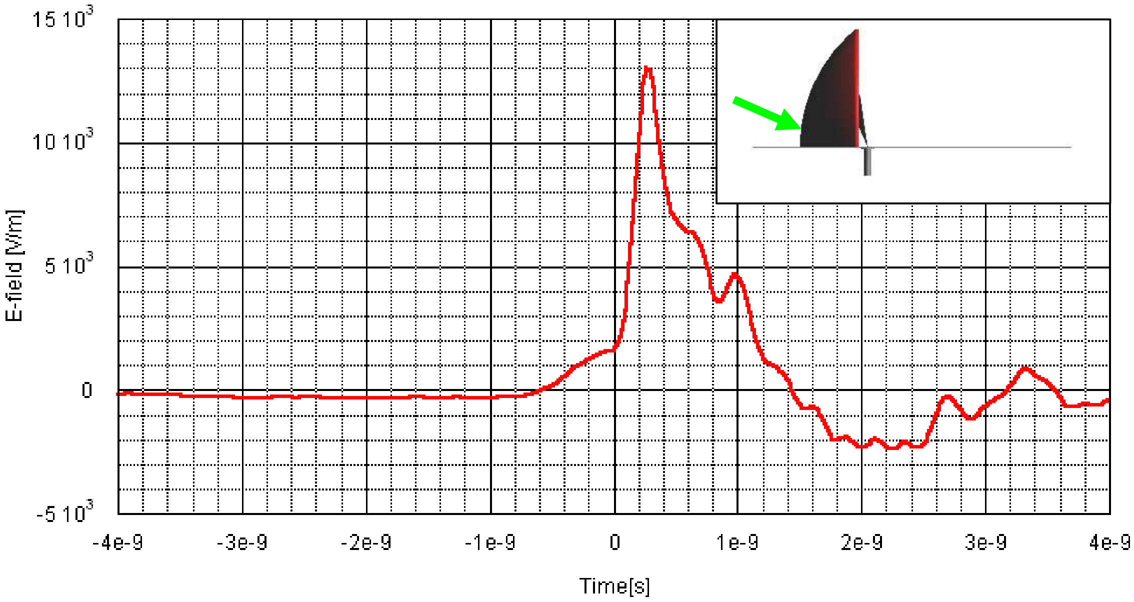


Figure 6 : Electric field on the antenna reflector. The peak electric field is 13 kV/m.

7. Measurement of the field on the antenna ground plane

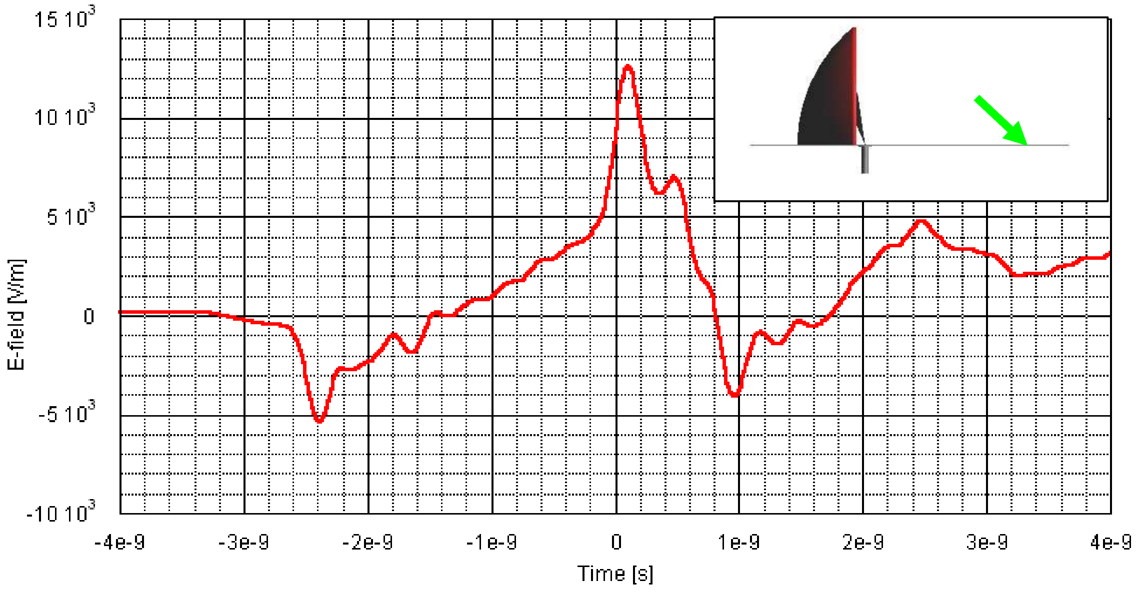


Figure 7 : Electric field on the antenna ground plane. The peak electric field is 12.8 kV/m.

8. Measurement of the peak E-field in the boresight direction

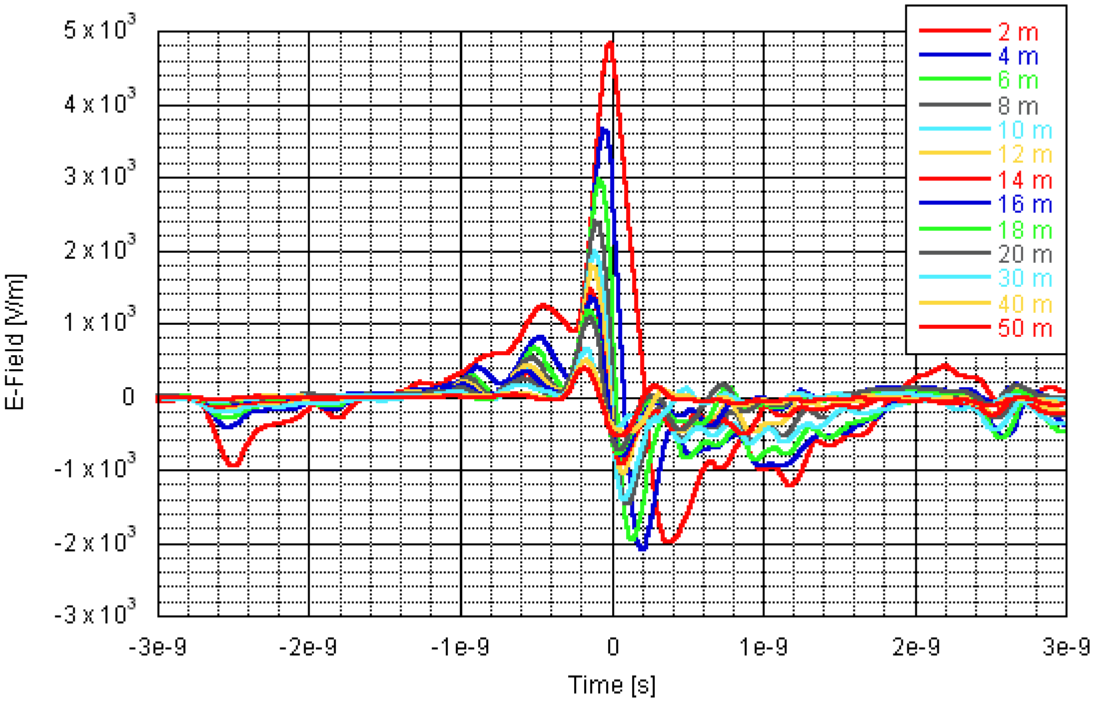


Figure 8 : E-field waveforms at different distances from the feedpoint.

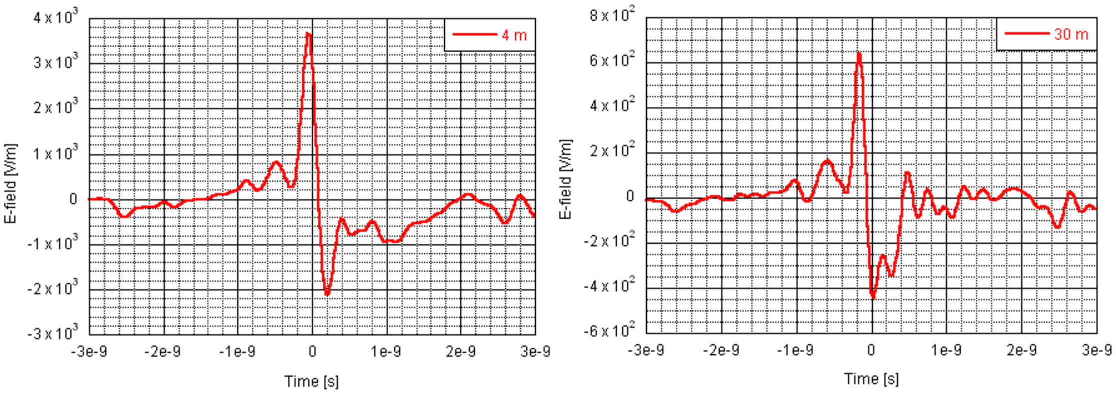


Figure 9 : Comparison of the E-field waveform at 4 m and 30 m.

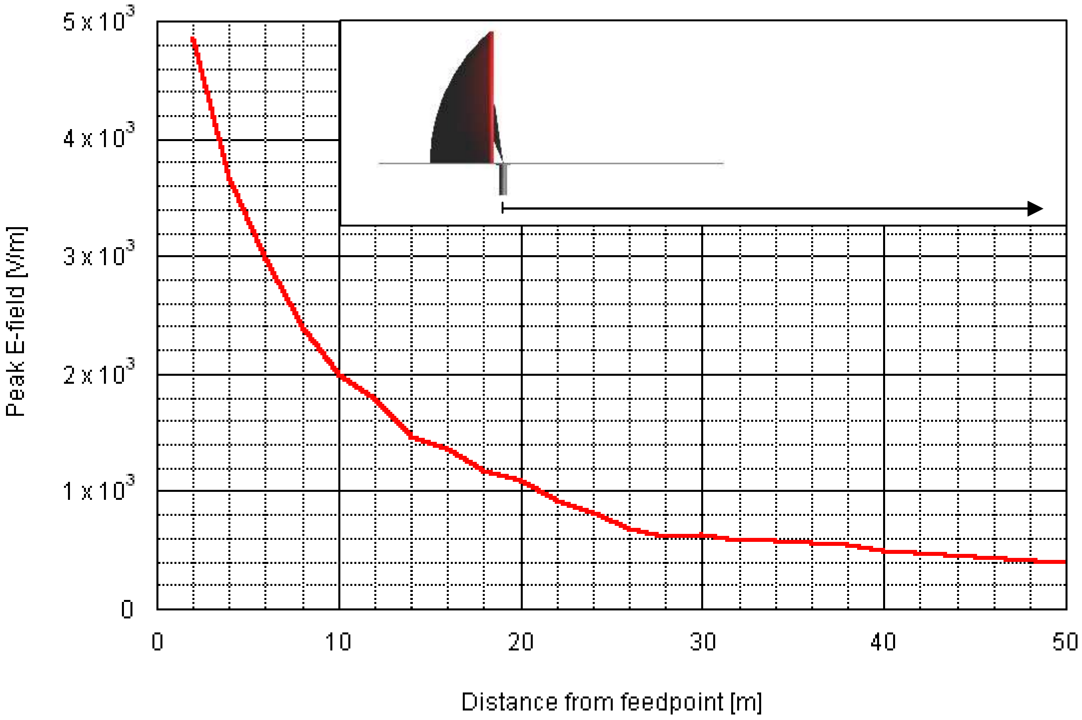


Figure 10 : Peak E-field decay in the boresight direction.

9. Measurement of the peak H-field in the boresight direction

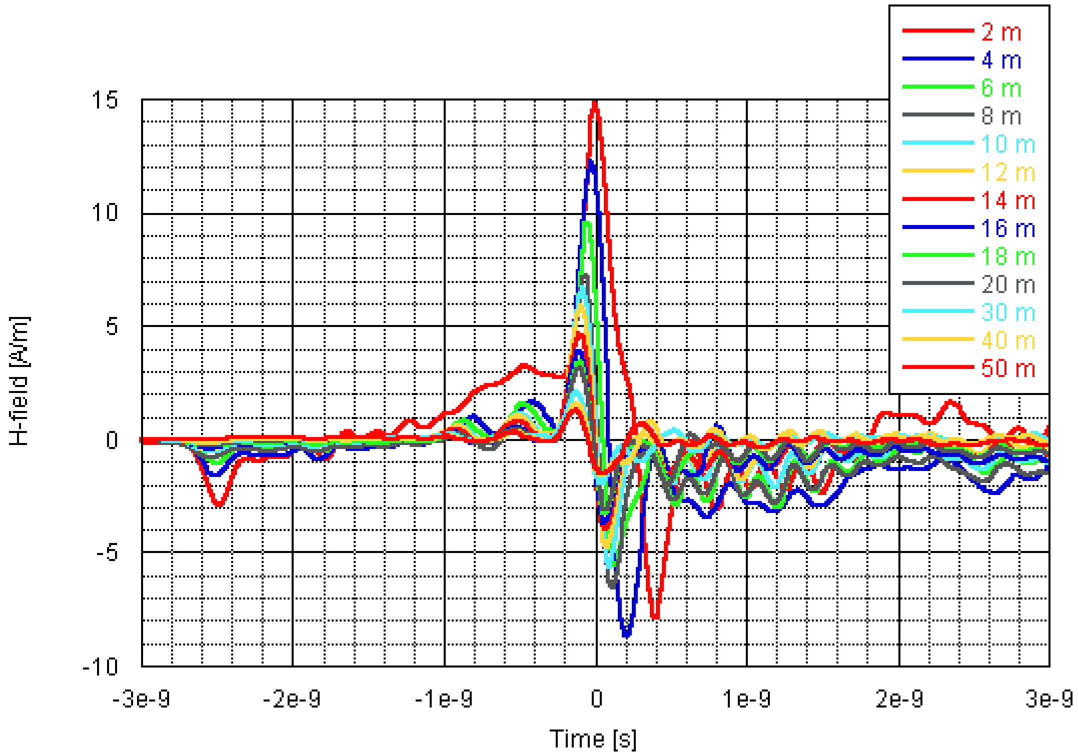


Figure 11 : H-field waveforms at different distances from the feedpoint.

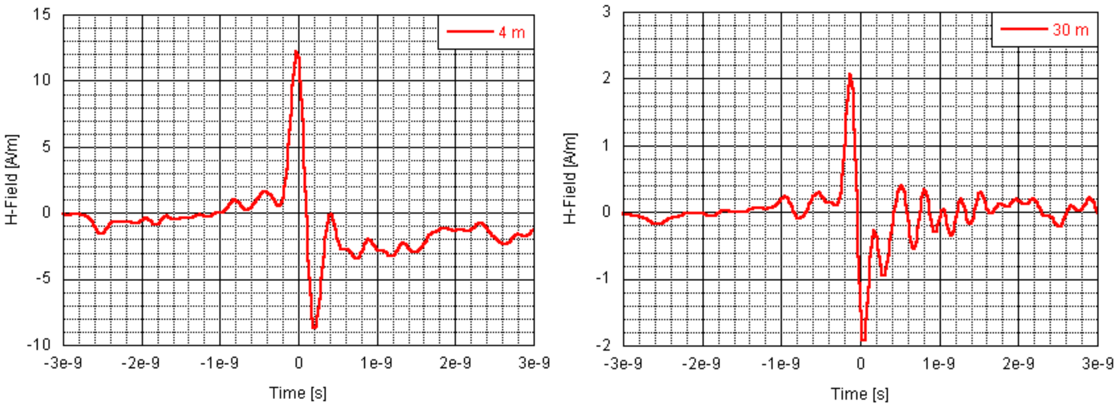


Figure 12 : Comparison of the H-field waveform at 4 m and 30 m.

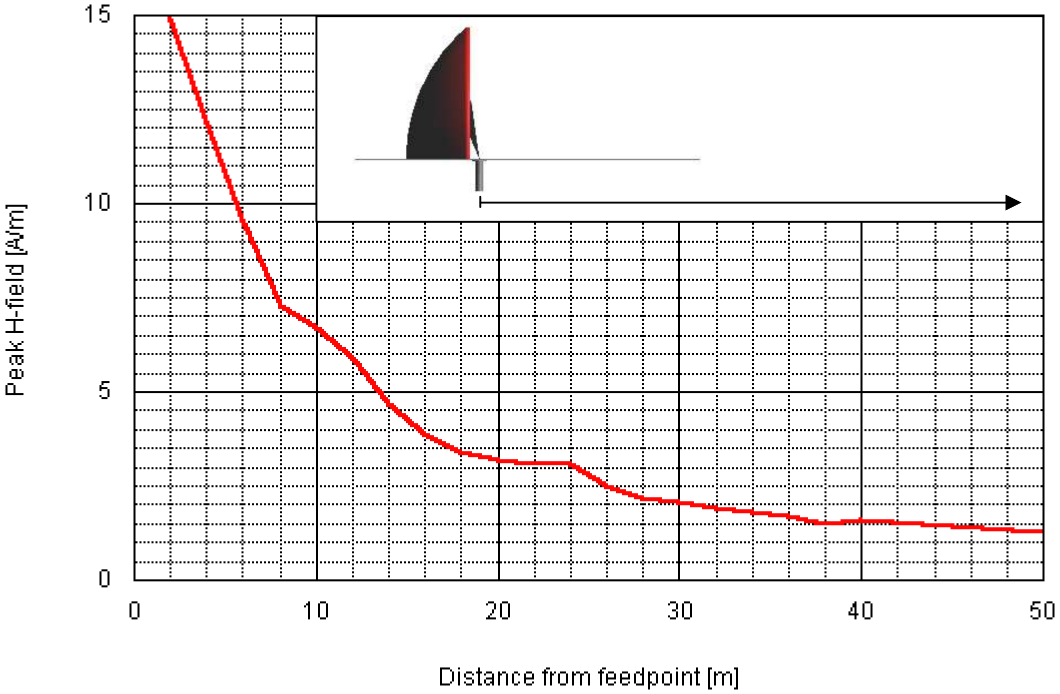


Figure 13 : Peak H-field decay in boresight direction.

10. Wave impedance in the boresight direction

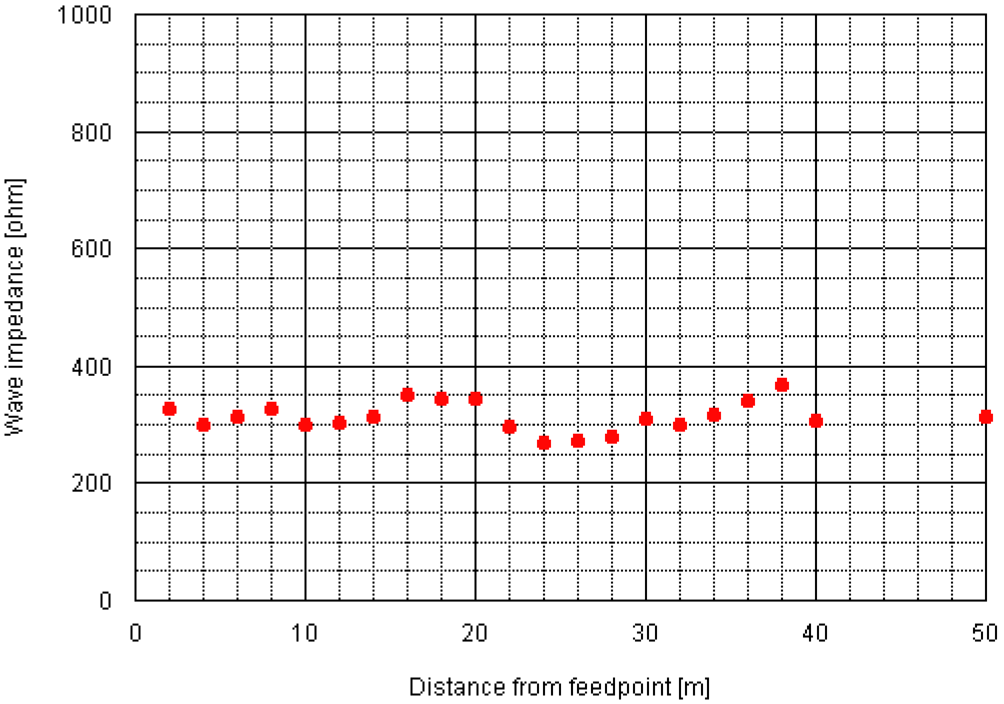


Figure 14 : Wave impedance for different distances.

11. Measurement of the peak E-field homogeneity

The peak E-field is measured at different distances from the feedpoint, in both the vertical and the horizontal direction. The definition of the measurement points are shown in Figure 15

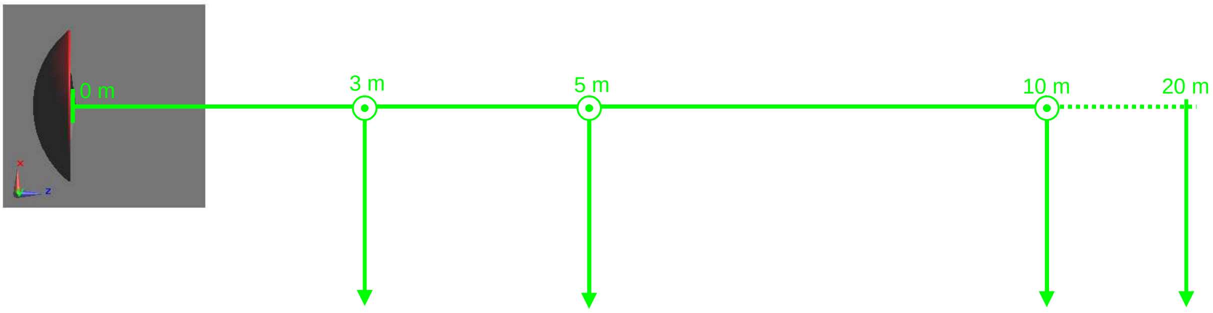


Figure 15 : Definition of the measurements axis for the peak E-field homogeneity

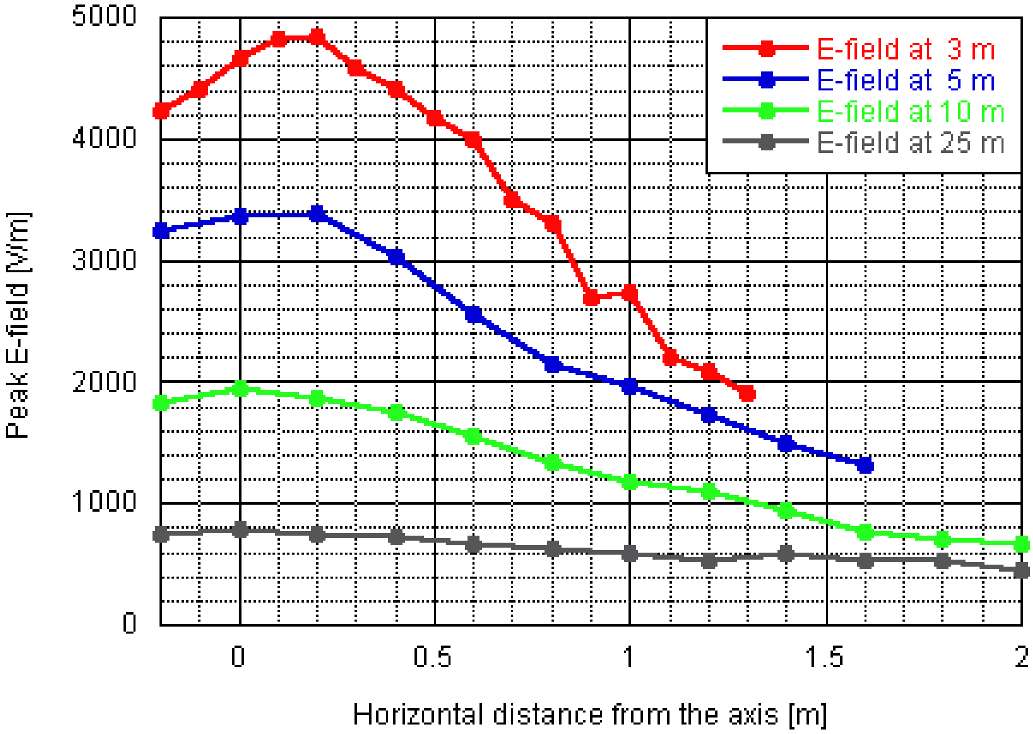


Figure 16: Measurement of the peak E-field for different distances from the feedpoint in horizontal direction.

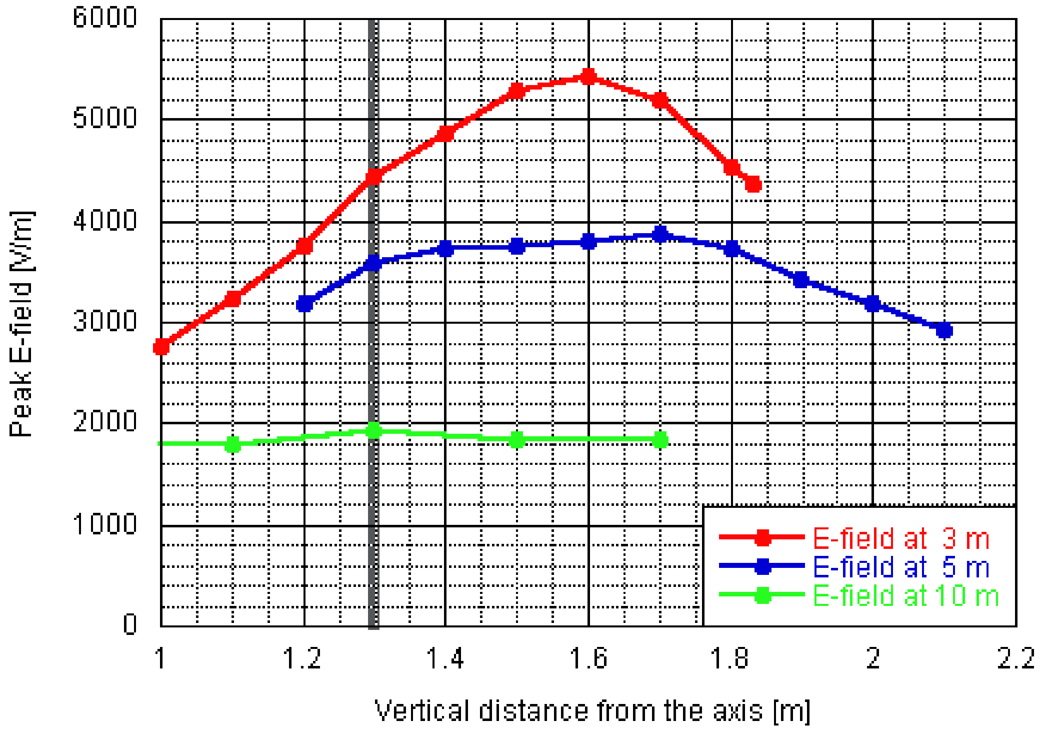


Figure 17: Measurement of the peak E-field for different distances from the feedpoint in vertical direction. The gray vertical line represents the height of the table on which the HIRA140 is placed.

There is a slight positive antenna tilt visible in the "3 m" and "5 m" curves of Figure 17. The maximum field is not reached at the height of 1.3 m.

12. Effect of the ground reflexion

The pulse injected in a HIRA is radiated in boresight direction. A multipath propagation cannot be avoided if objects are placed in the neighbourhood. This is the case for instance if the antenna is located over a metallic ground as represented in Figure 18 above. The sketch represents the different propagation path for measurement points located respectively at 10 m (red arrows) and 12m (blue arrows) from the feedpoint.

The electromagnetic pulse can either propagate directly by following the dashed lines or by following the plain lines. The delay between the impulse and the ground reflexion corresponds to the distance difference between the plain and the dashed lines.

Using the light speed in free space, the time delays can be computed very easily. They match the measurements shown in Figure 18.

The ground reflexion is well separated from the impulse and its amplitude is much lower. The worst-case amplitude occurs when the ground is metallic. This is the case represented in Figure 18.

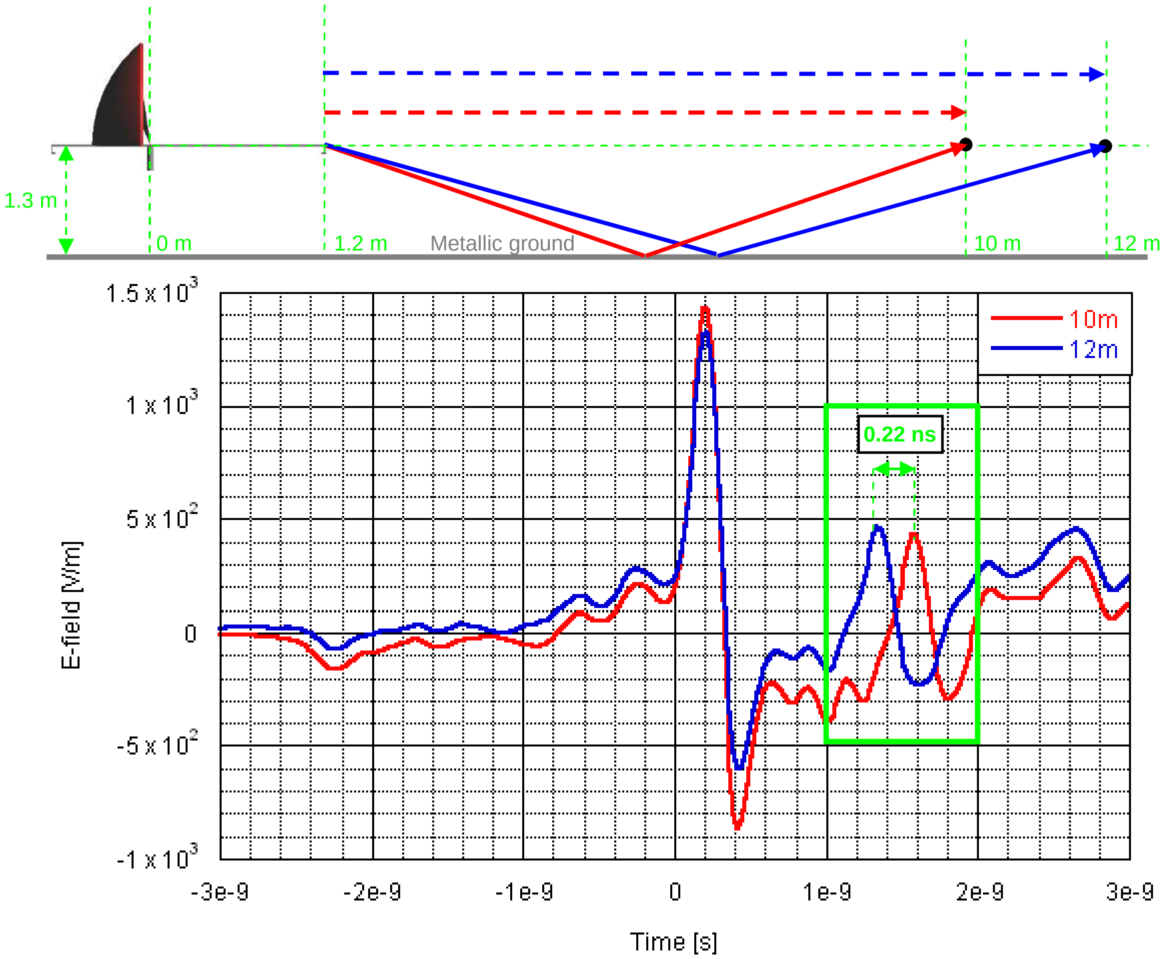


Figure 18 : Example of the delay of a metallic ground reflexion compared to the impulse for E-field measurements at 10 and 12 m.

13. FDTD simulation

Electromagnetic simulations are an excellent tool to assess specific antenna parameters. In order to check the suitability of the method, the measurement and simulation results for the electric field on the antenna ground plane are compared.

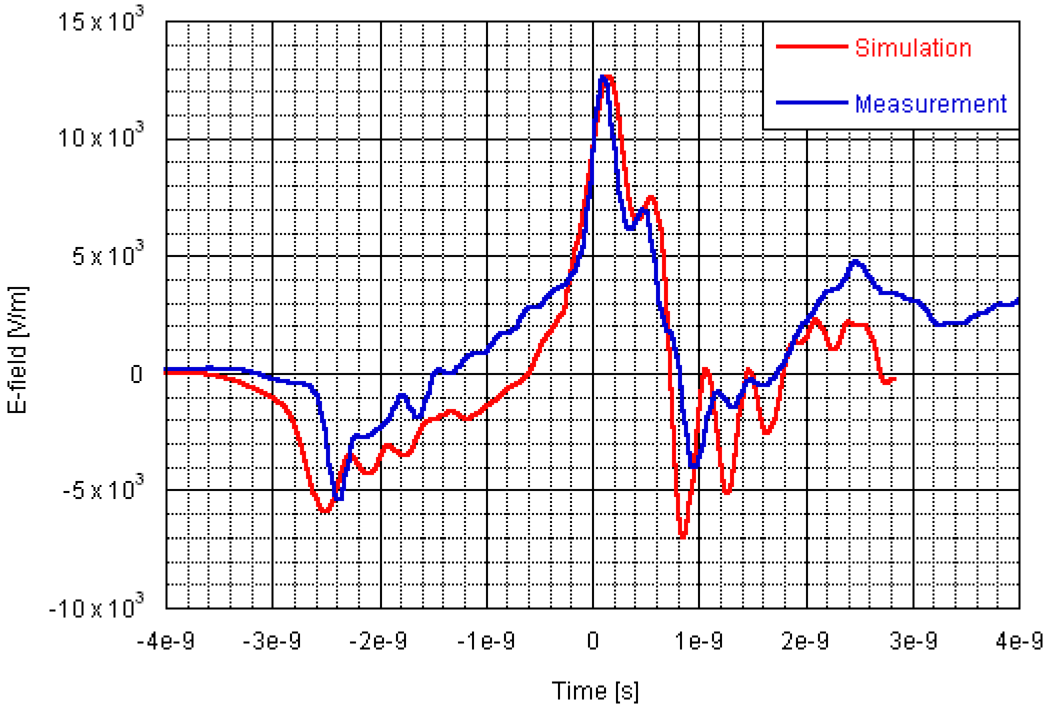


Figure 19 : Comparaison between the measurement and the simulation of the E-field on the HIRA140 ground plane.

Conclusion: the simulation and the measurement are in very good agreement.

14. Simulation of the gain for different frequencies

The gain of the HIRA140 is simulated at different frequencies.

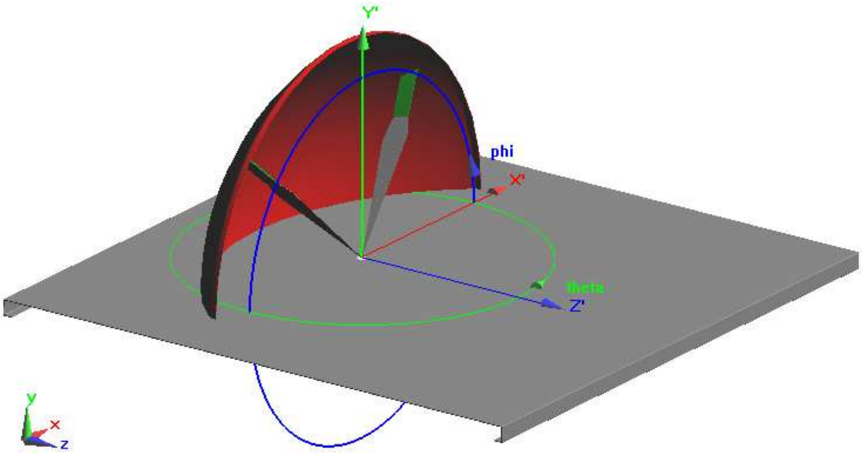


Figure 20 : Planes definition for the far-field simulations.

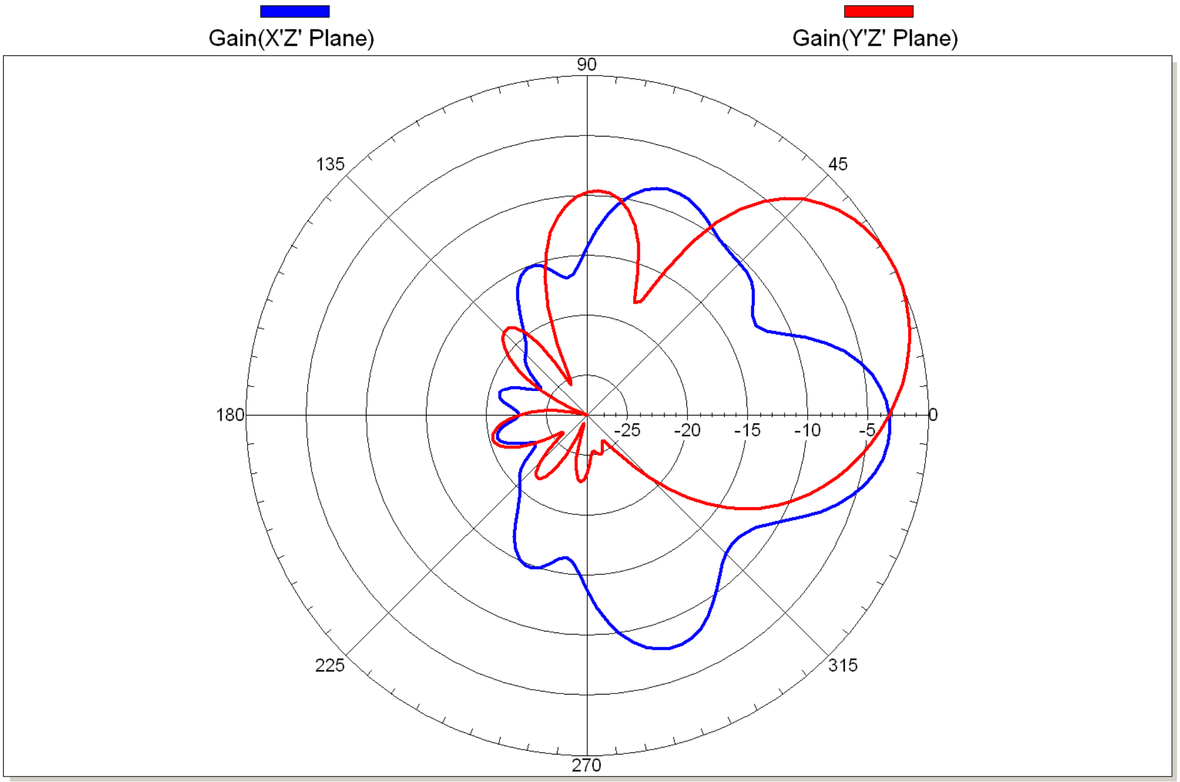


Figure 21 : Far-field gain pattern at 300 MHz. 0dB corresponds to a gain of 7.9 dBi.

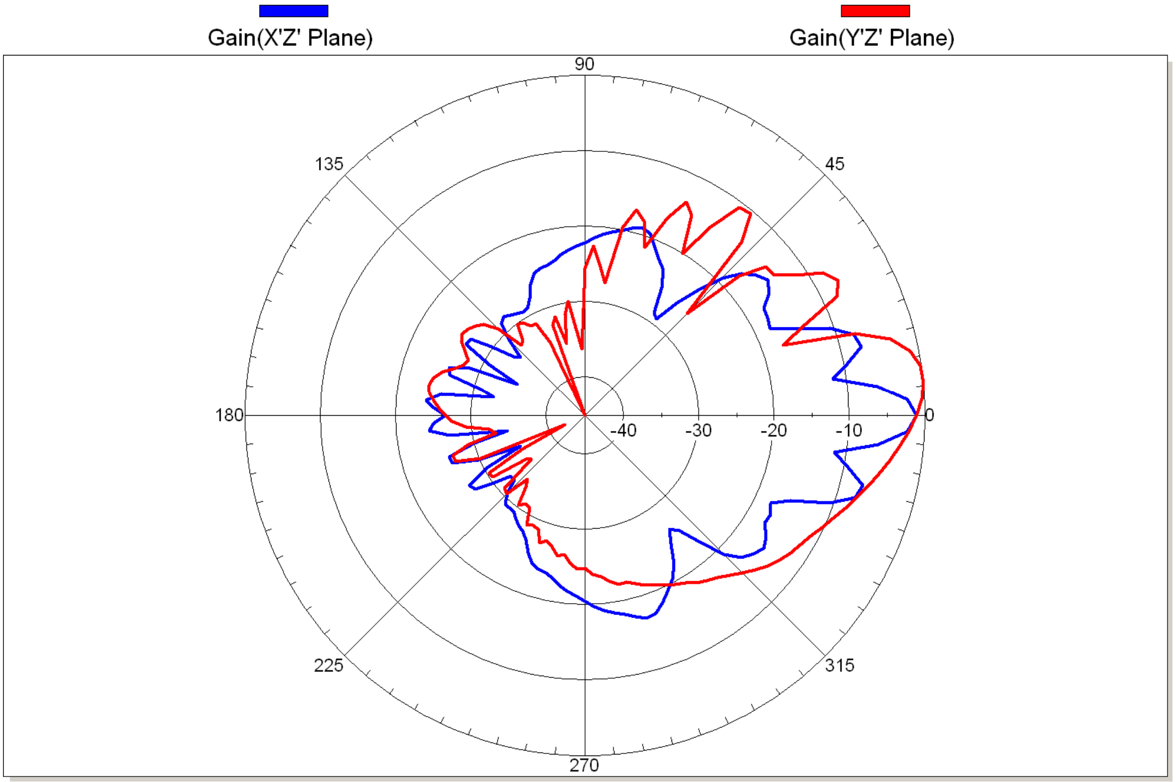


Figure 22: Far-field gain pattern at 1200 MHz. 0dB corresponds to a gain of 17.6 dBi.

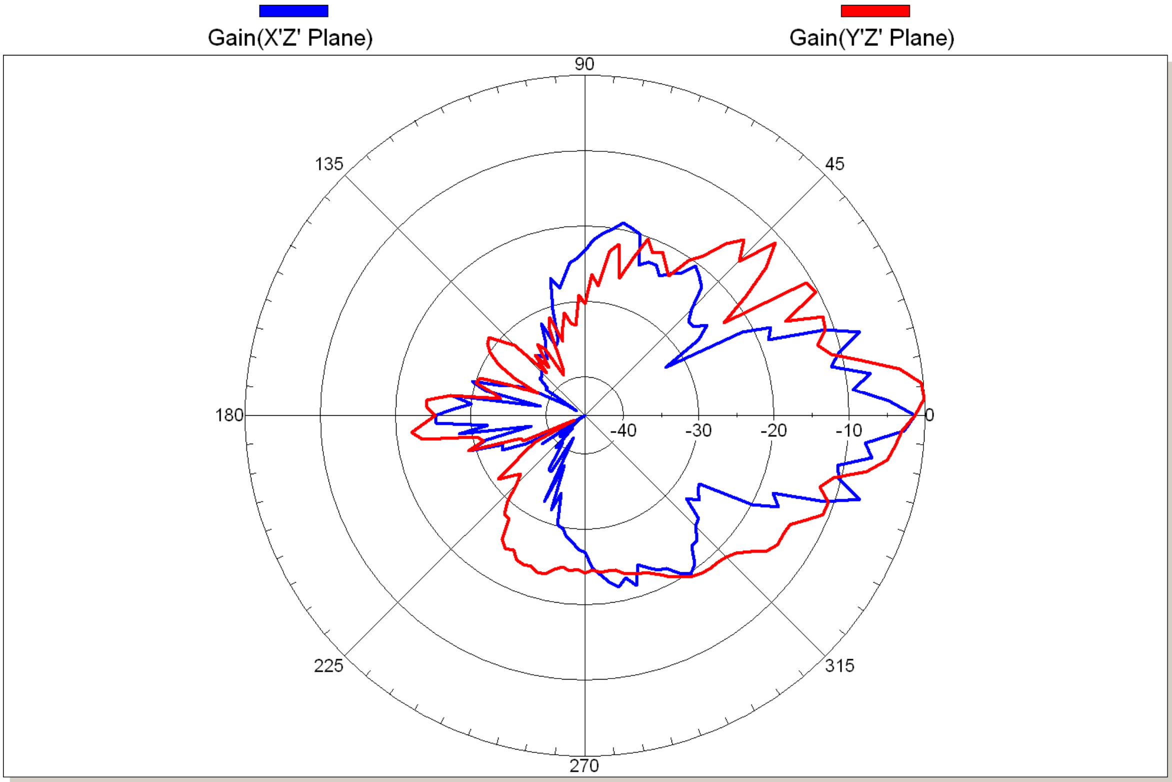


Figure 23: Far-field gain pattern at 2400 MHz. 0dB corresponds to a gain of 21.3 dBi.

Conclusion: the antenna gain is symmetrical in the XZ plane. In the YZ plane, the main beam is tilted, due to the diffraction at the end of the ground plane. The tilt decreases as the frequency increases.

The gain over the frequency from 100 MHz to 3 GHz is shown in Figure 24.

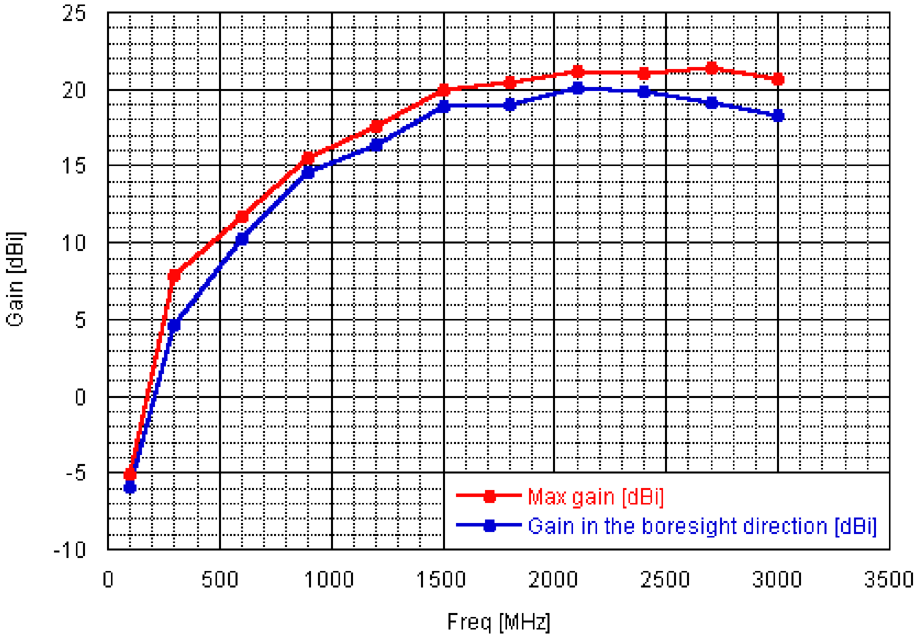
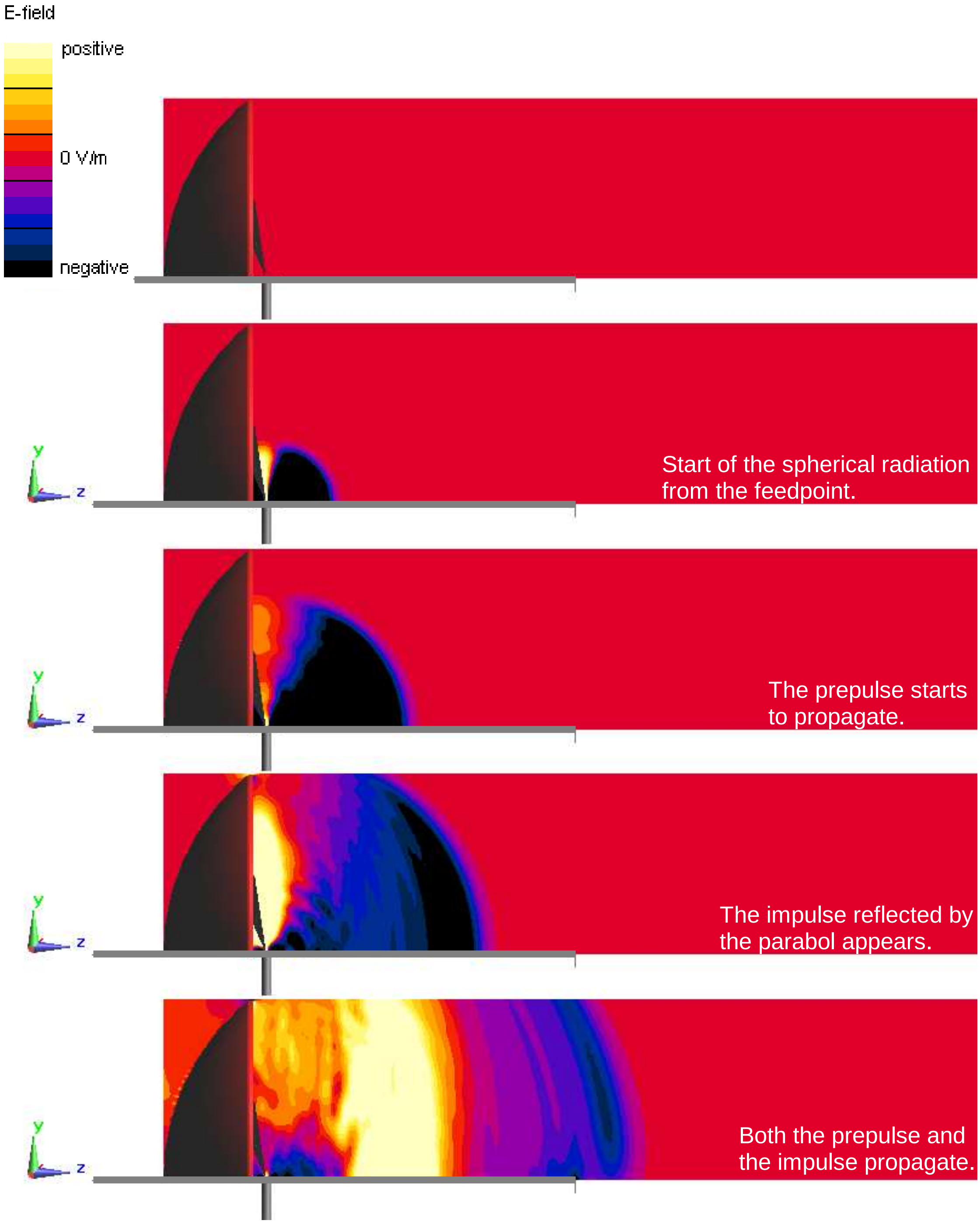


Figure 24 : Simulated gain of the HIRA140 from 100 MHz to 3 GHz.

15. Simulation of the pulse propagation

The following pictures show the propagation of the electric field pulse in the near field of the antenna. The pre-pulse and the reflected impulse are clearly visible. Only the electric field in the Y axis is represented.

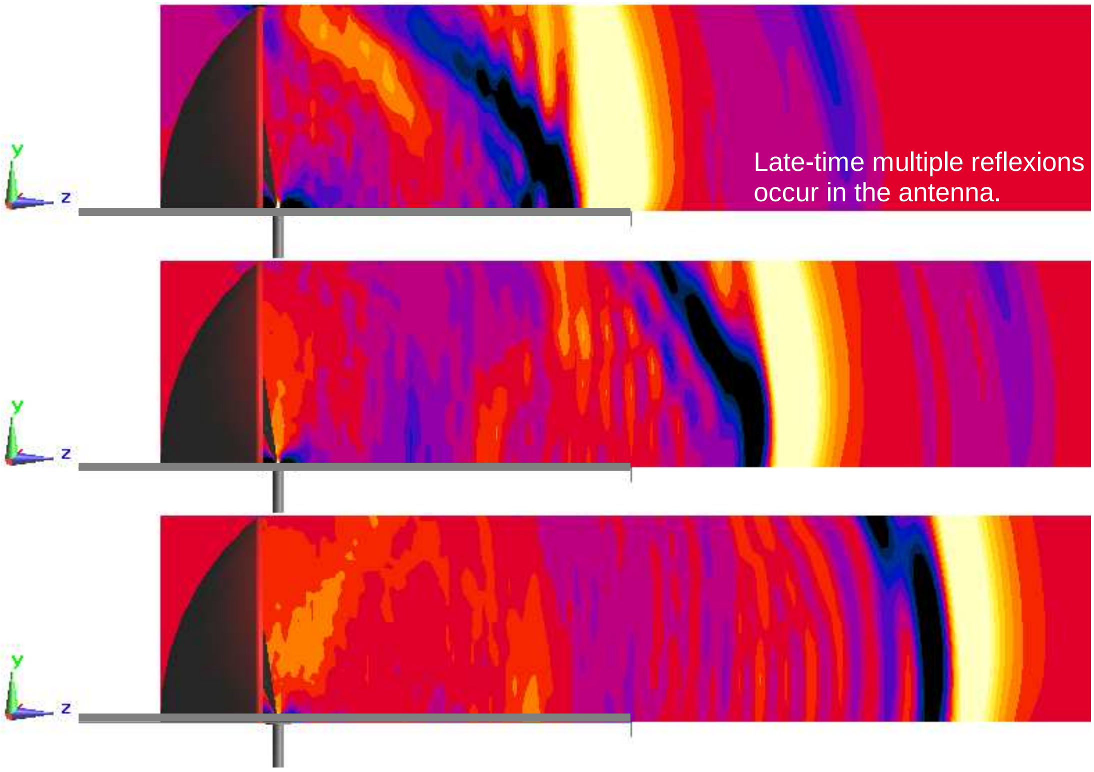


Start of the spherical radiation from the feedpoint.

The prepulse starts to propagate.

The impulse reflected by the parabol appears.

Both the prepulse and the impulse propagate.



Late-time multiple reflexions occur in the antenna.