Technical Note - TN28

Comparison between IRA and horn antennas

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1. Introduction

Several antennas have been considered for UWB applications. Only some antennas can properly radiate pulses. TEM horns and IRA or HIRA can be used for this application. The purpose of this short paper is to compare the radiation performances of the IRA and horn antennas. This comparison is based on different discussion with Dave Giri and on papers written by Baum and Farr.

2. Calculation

The radiated far field step responses on boresight of both antennas are calculated.

Horn equation:

$$E(r,t) = -\frac{V_o}{r}\frac{h}{4\pi c f_g}\left[\delta_a(t) + \frac{c}{2}\left[-u(t) + u(t-2\ \ /c)\right]\right]$$

IRA equation:

$$\vec{E}(r,t) = \frac{D}{4\pi c f_g}\frac{1}{r}\left\{\frac{\partial V}{\partial t}(t-T) - \frac{1}{T}[V(t) - V(t-T)]\right\}$$

3. Comparison

These two equations are plotted for the 3 different antennas shown in the figure 1. The driving pulse has a rise-time of 200 ps and a duration of about 25 ns. The same peak power is applied to the three antennas.

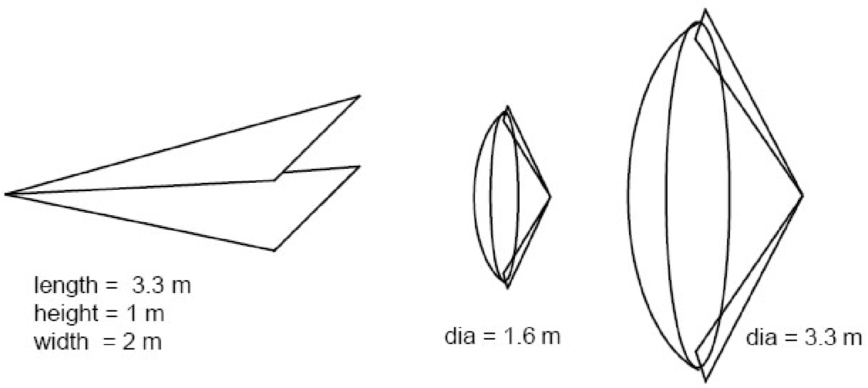

Figure 1: antennas used for the comparison

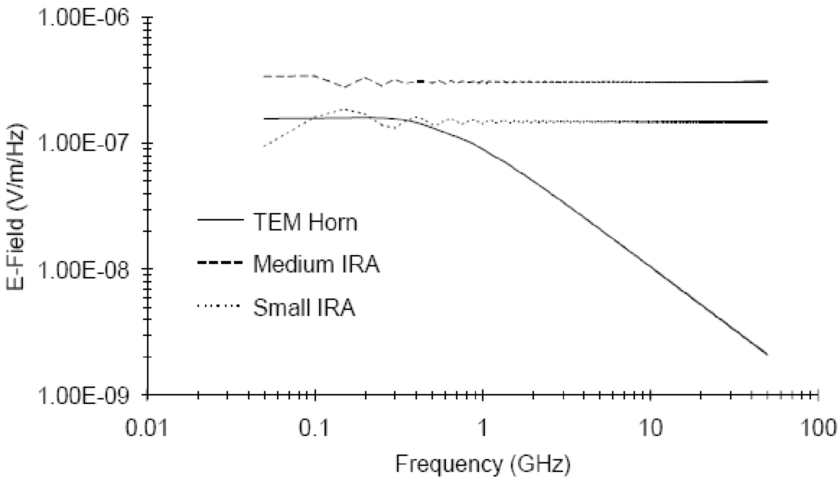

Figure 2: step response of the TEM horn and of the two IRAs at 1 km

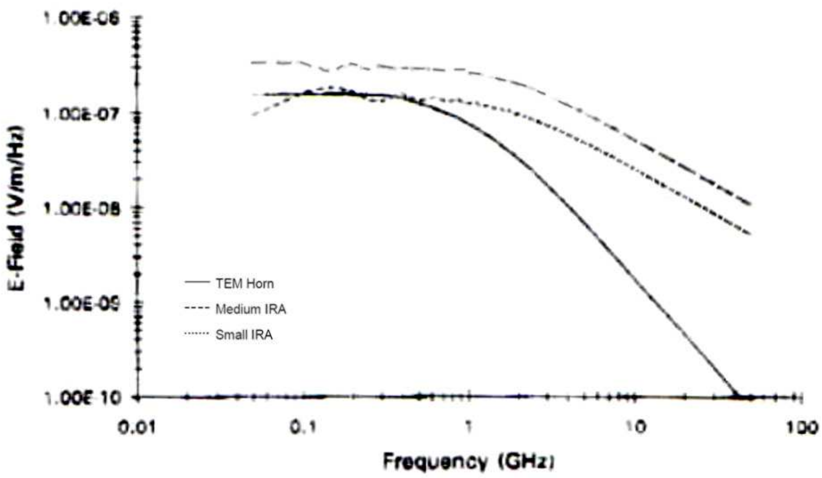

Figure 3: frequency response of the three antennas at 1 km

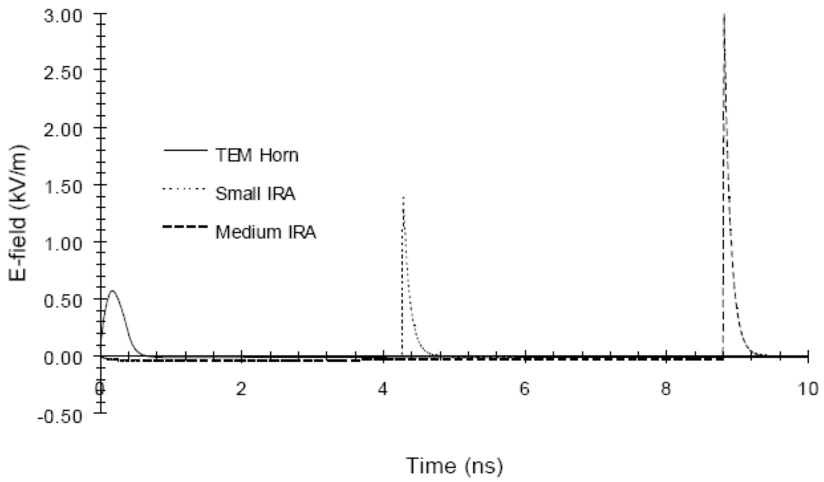

Figure 4: time domain responses of the three antennas at 1 km

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4. Conclusions

The biggest advantage of an IRA is the bandwidth. It has no upper frequency limit. It can be made to work up to 15-20 GHz, by a careful design of the feed point.

The TEM Horn has an upper cut off frequency approximately given by:

$$F_c = \frac{2L\,Co}{H^2} * \frac{Zo}{Z_{horn}}$$

F_c = cut off frequency
L = length of the horn antenna
C_0 = speed of light
H= height of the horn
Z_{horn} = horn impedance
Z_0 = 377 Ω

As an example: with L = 3.3 m, h = 1 m, width w = 2 m, Z_{horn} = 116 Ω, the upper cut off is 610 MHz.

In other words, TEM horn works like a low-pass filter with the frequency determined by the antenna size and impedance.

The IRA has very superior high-frequency performance.

There are 2 ways to compare the TEM Horn antenna to an IRA.

1) put same power into both antennas; length of horn = diameter of IRA

2) put same power into both antennas, make the aperture the same.

Both comparisons lead to a superior performance by the IRA in terms of peak field and also of larger bandwidth. So the bandwidth of an IRA is a winner. But of course the final choice of the antenna really depends on the application of the enduser.

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