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Technical Note - TN10

Impulse Radiating Antennas Formulary

This document gives the basic calculation formulas concerning the impulse radiating antenna (half-IRA).

1) Estimation of the theoretical far field limit

The distance d_{far} where the far field conditions begin is:

$$d_{far} = \frac{D^2}{2\,c\,t_r} \qquad (1)$$

with d_{far} = distance where the far field conditions begin [m]

D = diameter of the parabolic reflector [m]

c = speed of light [m/s]

t_r = rise time of the pulse [s]

Remark: The measurements have shown that the far field condition is also achieved for shorter distances. For this model and a rise-time of 130 ps, the far field conditions are already fulfilled at a distance of less than 13 m from the antenna feeding point. The reason of the difference between the calculated and measured values is not known for the moment.

2) Calculation of the on-axis radiated electric field

The peak value of the electric field, for a half-IRA, in the far field region is approximately:

$$E_{peak} \cong \frac{D}{4\sqrt{2}}\,\frac{1}{2\pi c\, f_g}\,\frac{1}{r}\,\frac{V_{peak}}{t_r} \qquad (2)$$

With the geometrical impedance factor:

$$f_g = \frac{Z_L}{Z_0} \qquad (3)$$

and D = diameter of the paraboloïdal reflector [m]

c = speed of light [m/s]

V_{peak} = peak voltage of the generator connected to the antenna [V]

t_r = rise time of the pulse [s]

Z_L = TEM characteristic impedance of the feed line [Ω]

Z_0 = characteristic impedance of free space [Ω]

r = distance IRA feed point - point of observation [m]

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2) Calculation of the rE factor

The gain and radiation aperture are often used for directive CW antennas, for instance parabolic reflectors. These specifications are not sufficient for impulse devices because of the very broadband behaviour. In that case the gain is not constant in the frequency range corresponding to the impulse and this is the reason why another definition must be used: the "rE" factor. This is the product of "r" the distance to the point of observation by "E" the peak field at this place. This factor depends on the risetime of the impulse and of the peak voltage on the generator connected to the antenna. This allows the theoretical estimation of the peak field at a certain distance of the antenna.

From (2) and (3), the far field rE product for a half-IRA is:

$$rE \cong \frac{D}{4\sqrt{2}} \frac{1}{2\pi c\, f_g} \frac{V_{peak}}{t_r} \tag{4}$$

3) Calculation of the electric field at a certain distance

Finally, the electric field can be easily calculated at any distance in the far field conditions by the following equation:

$$E_{peak} = \frac{rE}{r} \tag{5}$$

4) Example of results

With:

$D = 1.8$ m

$V_{peak} = 20$ kV

$t_r = 130$ ps

$Z_L = 100\ \Omega$

$r = 16$ m

Results:

→ $D_{peak} = 41.5$ m

→ $rE = 98$ kV

→ $E_{peak} = 6.1$ kV/m

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