Reflector Impulse Antenna with Dual TEM Source

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Abstract

There are different demands on radiation efficiency and direction pattern according to various Ultra-Wideband (UWB) antennas and high power applications. To obtain more radiating gain on bore-sight of paraboloidal reflector and centralized radiating direction, a novel feeding structure called a dual TEM source has been designed and applied in half-paraboloidal reflector IRA applications. Simulation results proved that this proposed half-paraboloidal reflector IRA with dual TEM source provided greater radiation performance on bore-sight as a result of the synthesized power in the aperture space of paraboloid. Moreover, lots of simulation work and comparisons have been done in different feeding models to summarize a relative optimal feeding structure.

Key words

high-power, ultra-wideband (UWB), Impulse Radiating Antenna (IRA), finite-difference time-domain (FDTD), TEM-horn antenna, dual TEM source

I. Introduction

Of the various types of antennas for radiating and/or receiving transient pulses, TEM horn and paraboloidal Impulse Radiating Antenna (IRA) with single TEM source[1] are widely used in UWB and high power applications as two kinds of significant antenna forms. However, the radiation power of TEM horn antenna or IRAs with a single feeding source are limited and do not satisfy the demands of high power applications. Recently a novel approach being proposed is a transient array involving many sources feeding an aperture [2]. One of the arraying methods with several planar TEM horns described in [3] was to narrow the beam-width and improve the radiation energy. But numbers of TEM horn antenna are required to form this kind of geometrical array and inevitably much space has been occupied[4].Moreover, this kind of antenna array required synchronization of exciting pulses for multi-source without phase difference which is difficult for source manufacture. In this paper a novel half-paraboloidal reflector IRA with dual TEM source has been designed according to the latter idea. The dual source is designed to radiate at an angle θ inside the focus of paraboloid synchronously, thus to satisfy the request of radiation power in high power applications. The structure of antenna is shown in figure 1 and the improved radiation properties will be presented below.

II. Design of Paraboloidal IRA with Dual TEM Source

The typical IRA usually has one feed source located on the focal point of paraboloidal reflector. As to the array with dual source, offset-feeding should be applied to synthesize the radiating power.

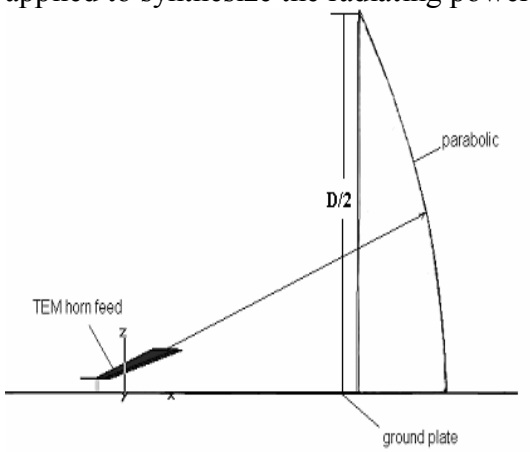


Fig.1. Structure of reflector IRA with dual source

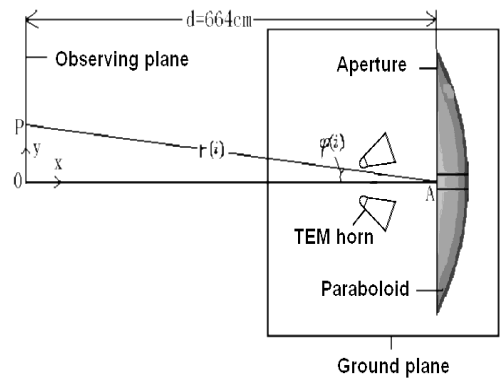
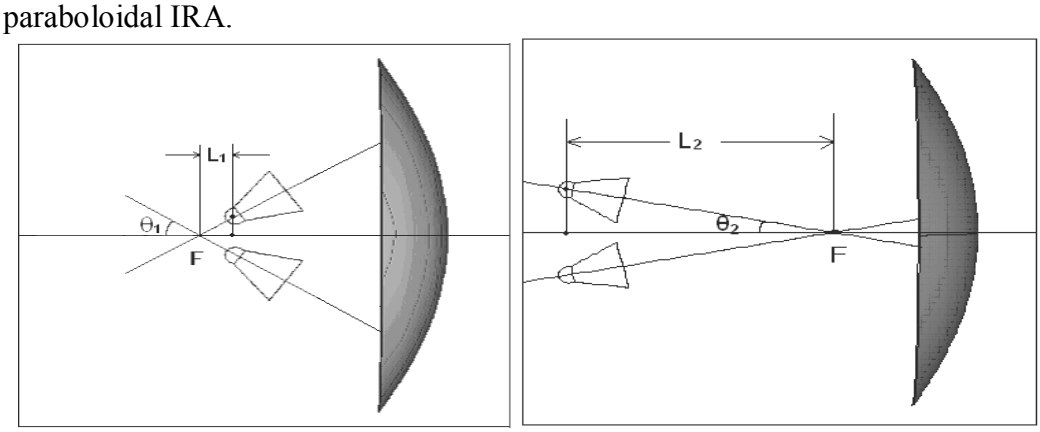


Fig.3. radiated far-field observation model

In this paper the offset-feeding structures showing in figure 2 are being applied. The dual source radiate by an angle with axis synchronously to synthesize the power in the aperture space of paraboloid. For better comparison of different feeding positions, we try to set the dual source inside and outside the focus with various angles along axis, as figure 2a and 2b show respectively. By adjusting the angle $\theta 1$ (or $\theta 2$) inside (or outside) the focus of paraboloid, the aperture-field and far-field of reflector IRA could be controlled and thus improved. The F/D of paraboloid reflector is 0.417, where focal length F=1.5m, radius R=1.8m. $\theta 1$(or $\theta 2$) indicates the angle between TEM horn and axis, while L1(or L2) indicates the distance between TEM horn and focus point. Considering the mutual coupling problem, maintain a fixed distance between two TEM horns and change $\theta 1$ (or $\theta 2$) and L1(or L2) to observe the far-field performance of the paraboloidal IRA.



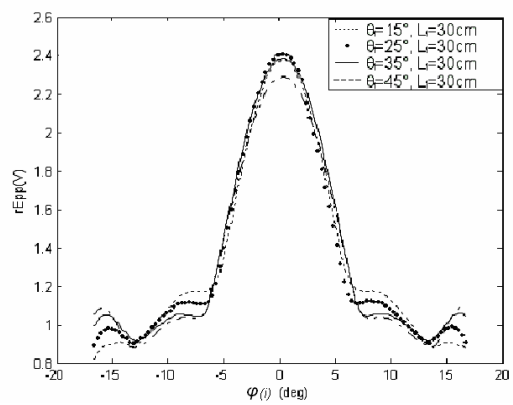
a. feeding structure inside the focus b. feeding structure outside the focus

Fig.2. feeding structures of half paraboloidal IRA with dual source

As to the outside-focus feeding structure, two TEM horns are set vis-a-vis with a close distance between; thereby the mutual coupling effects a lot in radiation. Moreover, the distance between TEM sources and the paraboloid is quite long, which will debase the feeding efficiency a great deal. Thus, in this paper, we won't take this outside-focus feeding structure into account.

III. Simulation and Analysis

Simulation work on the radiation properties of this proposed antenna with finite-difference time-domain (FDTD) numerical method will be presented below. Gaussian pulse is set as the excitation signal and is fed into the dual TEM horns simultaneously. Each signal has equal power and the -10dB pulse width is about 1ns while the working frequency is around 1GHz.



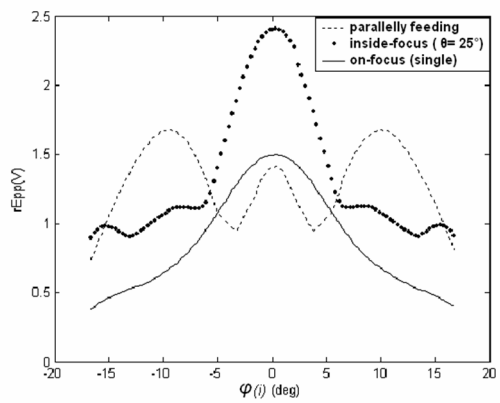


Fig.4. inside-focus, rE_{pp} along with θ_1 varying Fig.5.distribution of rE_{pp} in observation plane

For observing the radiated far-field Ez on bore-sight of the antenna in various angle θ, 100 equidistant(with space of 4cm) far-field observation points are horizontally set on the Y-Z plane which is 664cm away from the reflector aperture, as figure 3 shows. The electric-field peak power of far-field radiation can be observed by comparing the rE_{pp} value (where r is the distance between the observation point "P" and the center point "A" of the aperture, E_{pp} is the peak-to-peak value of the electric field, which is observed at the observation point "P"). Along with the variation of $\theta 1$ which is the angle between dual source and axis of paraboloid, a far-field rE_{pp} curve of inside-focus feeding structure which is shown in figure 2a could be obtained. The horizontal axis $\varphi(i)$, as shown in figure 3, represents the angle between the axis of the antenna OA and PA, where the point A is the origin of paraboloid, and P is the electric field observation point. The vertical axis represents the value of rE_{pp}.

Figure 4 represents several rE_{pp} curves along with variation of $\theta 1$, which is 15°, 25°, 35° and 45°, and L1 is fixed to be 30cm. The point line shows the optimal rE_{pp} curve according to $\theta 1$= 25°. It also can be concluded that neither the

direction pattern nor $\theta 1$ significantly affects rE_{pp} curves. The maximum rE_{pp} peak value on bore-sight emerges when $\theta 1 = 25°$, which is 2.4V.

Distribution curves of rE_{pp} value are shown in figure 5. The curves described by point line presents the dual source inside-focus feeding structure which is shown in figure 2a, and it is in the case of $\theta 1 = 25°$ which is optimal. The curves described by the solid line represent the single source on-focus feeding structure. The distribution curves of rE_{pp} value illuminate that when the dual source parallel feeding structure being adopted, two sporadic main-beams will be formed in far-field thus the field value is very low on bore-sight. The dual source inside-focus feeding structure has better front-radiating gain and directivity than the other feeding structures being mentioned here.

V. Conclusions

A half-paraboloidal reflector impulse radiating antenna(IRA) with dual TEM source driven by short pulse excitation signal has been designed. To obtain greater front-radiating power and better directivity, offset feeding by dual TEM source inside the focal length is applied to improve the performance of paraboloidal reflector IRA. Simulation results show that this proposed IRA with dual source inside the focal length remarkably increased the front-radiating field intensity more than 60% on bore-sight. Moreover, narrower beam-width and better front-radiating directivity were obtained.

References

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