Energy Patterns of the Prototype Impulse-Radiating Antenna

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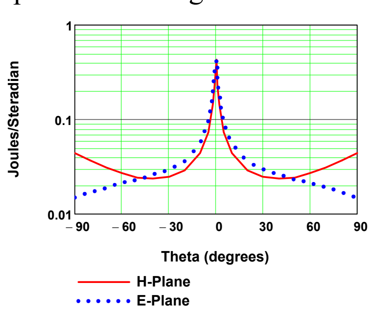
A question that often comes up in the context of an Impulse-Radiating Antenna (IRA) is "How is the transient energy from the pulser radiated in space"? Of course, the electromagnetic fields (both E and H), the power density and the energy density have their maximum on the boresight. The power pattern is a well-defined frequency domain concept, but it is a cumbersome descriptor for hyperband antennas like the IRA because of the multitude of frequencies involved. In this paper we explore the concept of an energy pattern, which is valid both in time and frequency domains. An energy pattern is useful in visualizing where the transient energy injected into the IRA is going. It is further noted that the energy and power patterns are identical for a CW antenna, but they can be vastly different for pulsed antennas.

In this paper we consider a reflector-type IRA as an example of a hyperband antenna. The radiation pattern of an IRA is a strong function of frequency. The lower frequencies of the input pulse have lower gain and large beam-widths, while the higher frequencies have a higher gain and smaller beam-widths. We describe an *energy pattern* of the IRA, as a simple and unique descriptor of the transient antenna. This pattern describes how the input energy is distributed in space. Let $\vec{E}_f(R,\theta,\phi,t)$ and $\tilde{\vec{E}}(R,\theta,\phi,\omega)$ denote the far electric field at an arbitrary location in time and frequency domains respectively. The energy pattern can be defined as

$$U(\theta,\phi) = \frac{1}{Z_0} \int \left| \vec{E}_f(r,\theta,\phi,t) \right|^2 r^2 \, dt = \frac{1}{2\pi Z_0} \int \left| \tilde{\vec{E}}(r,\theta,\phi) \right|^2 r^2 \, d\omega \quad (Joules/steradian) \quad (1)$$

We use an aperture integration method in the estimation of all components of the electric field in frequency domain and the total transient electric field is found by Fourier inversion. Equation (1) is then used to get the energy pattern.

The energy pattern has been calculated for the prototype IRA with a double exponential voltage excitation waveform and shown in Figure 1.



We have also computed the energy patterns for a damped sinusoidal voltage input centered at 1 GHz. The energy patterns of the same prototype IRA are considerably different for the two input voltages. In summary, the energy patterns are useful in visualizing where the transient energy provided to the IRA is being radiated in front of the antenna.

Figure 1. Plot of the radiated energy pattern in the horizontal (H) and vertical (E) planes for the prototype IRA

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