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TRANSIENT RADIATION FIELD OF A PULSE-EXCITED LOOP ANTENNA PARALLEL TO A CONDUCTING PLANE

by

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For remote points in various directions from the geometric center of an antenna and its image in a parallel perfectly conducting plane (Fig.1), the electromagnetic field produced by pulse excitation of the antenna is computed and waveforms representing the time variation of the field at representative points are plotted.

For the results given in this paper it was assumed that the loop had a radius b and was placed above a conducting plane at a height equal to the radius of the loop. The ratio of the loop radius to wire radius was assumed to be equal to 288.

The loop is assumed to be driven by a generator whose internal impedance is 550 ohms (the absorption impedance of the loop) and which produces a periodic waveform whose period is such that the transient field produced by one pulse has died out before the next pulse occurs. For the waveform used in the computation in this paper(Fig.2) the pulse parameters are expressed in terms of the loop half-length propagation time $\pi b/c$. The waveform used is that produced by a terminated Fourier series representation of a rectangular pulse of width $0.4(\pi b/c)$, and whose repetition time is $32(\pi b/c)$. The number of terms used in the terminated Fourier series representation of the pulse was 128.

The moment method as outlined by Harrington[1] and used by the authors in previous papers[2,3] was used to find the antenna current distribution for each frequency component. In this method the antenna and its image are divided into equal length short segments. The current is assumed to be uniform in each segment and the array of the segments is treated mathematically as a multi-mesh circuit problem in which self- and mutual impedances are known and only two meshes are driven. The resulting set of linear equations is solved for the current in each segment. When the currents are known, the electric and magnetic field intensities for each segment for each frequency component are obtained using the short dipole formulas. The contributions of the various segments to each field intensity component are combined to obtain a resultant single-frequency field intensity component. The superposition of the contributions to a single field intensity component from each frequency component in the periodic pulse yields the resultant time variation of the field intensity component.

Fig. 3 represents the electric fields for three remote points in the xz plane. The electric fields for the points in this plane are in the y direction. Fig. 4 represents the electric fields for two remote points in the $\phi = 90^\circ$ plane. The first point is in the direction $\theta = 60^\circ$ and the second point in the direction $\theta = 30^\circ$. The electric fields for these two points are represented by their two components E_θ and E_ϕ.

The values plotted in Figs. 3 & 4 are normalized to unit distance by multiplying each field intensity by the distance R from the measuring point to the center of the co-ordinates system, therefore the ordinates of the electric field plots are in volts.

The radiation fields seen in Figs. 3 & 4 are the superposition of two parts - one due to the antenna itself and the other due to its image. They are different in sign and the first leads the second by a time interval equal to (2b/c) cos θ.

The results show how the time variations differ for different points in space, depending upon the direction to that point from the midpoint of the antenna-antenna image system. They also show the delay in the contribution from the ground plane of image.

References

1. R.F. Harrington, "Matrix Methods for Field Problems, "Proc. IEEE, vol. 55, pp. 136-149, February, 1967.
2. A.M. Abo-Zena and R.E. Beam, "Electromagnetic Fields at Points near a Pulse-Excited Linear Antenna," IEEE Trans. Antennas Propagat., vol. AP-19, pp. 129-131, January, 1971.
3. A.M. Abo-Zena and R.E. Beam,"Transient radiation Field of a Pulse-excited Linear Antenna Parallel to a conducting Plane," IEEE 1970 G-AP International Symposium Digest, pp. 310-317, September 1970.

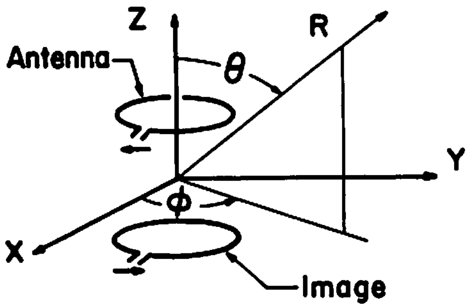

Fig. 1. The antenna and its image. The xy plane is conducting, the excitation at φ = 0°.

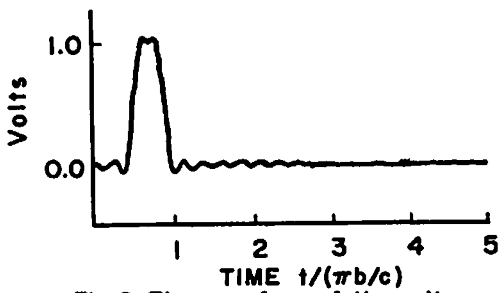

Fig. 2. The waveform of the voltage pulse used to excite the antenna.

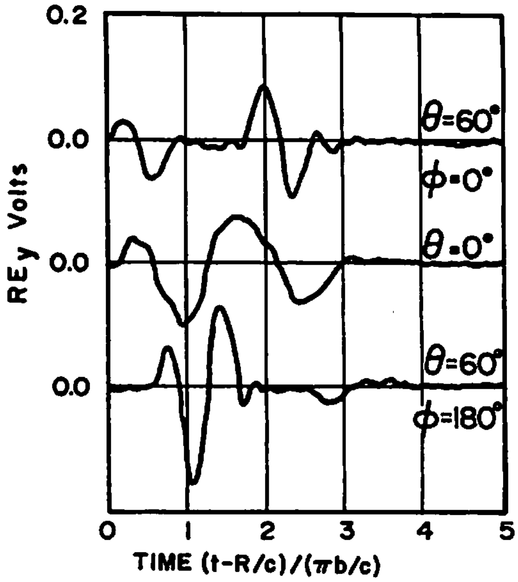

Fig. 3. Computed time history of the radiation field at remote points in the xz plane.

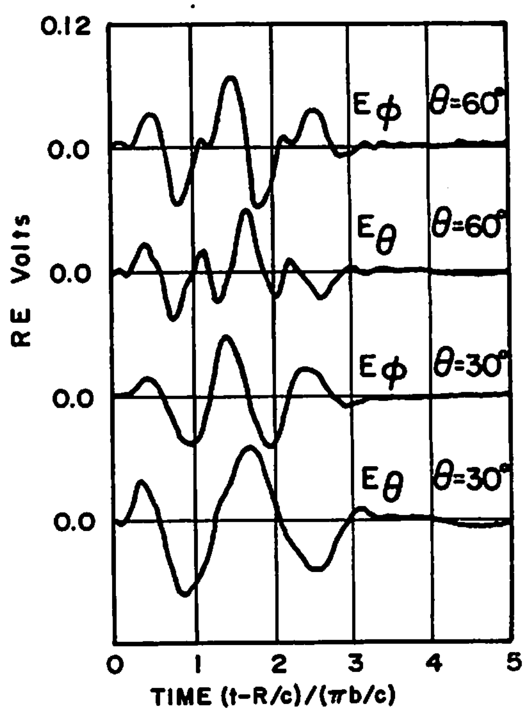

Fig. 4. Computed time history of the radiation field at two remote points in the plane φ = 90°.