Radiated Power Patterns for Multiband Dipoles

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If one is given both the azimuthal compass direction from the installed antenna and the vertical angle of elevation aboveground which are optimum for transmitting via the ionosphere to any desired station in the world, the question naturally arises, "How well does the antenna radiate power in the direction defined by these two angular components?"[1] The answer to this question is of particular interest in a stationary, multiband wire antenna such as the popular W3DZZ.[2,3]

This article investigates the theoretical power-density pattern of a W3DZZ antenna installed at a feed height above ground of approximately ten meters, a height often encountered in practice. The same center height was used for a horizontal and an inverted-V form of the antenna in order that the effect of bending the legs could be directly compared.

Mathematical Approach

The actual W3DZZ antenna was represented mathematically by a collection of current elements located over a perfectly conducting ground plane. Current magnitudes for the elements were assigned for a simple sinusoidal current distribution which neglected the perturbing influences of the traps, the finite antenna diameter, and the feedline. The advantage of using incremental current elements was that the far-field patterns could be calculated by a computer for a rather general form of antenna with nonsymmetrical bends in the radiating elements. Table 1 summarizes the electrical details of the model while Fig. 1 gives the geometric details.

The computation proceeded as follows. First, the E and H fields radiated by each current element were found for every two-degree increment of azimuth and elevation in the first quadrant of the far-field hemisphere above the antenna. This yielded a matrix of the radiated power. Next the power matrix was searched for the maximum value of radiated power and all the remaining coordinates were referenced to it. The values in dB down from the maximum were printed out by the computer for each matrix coordinate. Contour lines for 3, 6, 9, 12, etc. dB down were then drawn from these data. With the symmetrical antennas being treated here, it was only necessary to find the power-density matrix for one quadrant of the hemisphere. Other quadrants are obtained by relabeling the azimuth axis as shown in Fig. 2A.

Computed Results

Unfortunately, lack of available computer time made it impossible to use enough increments to get

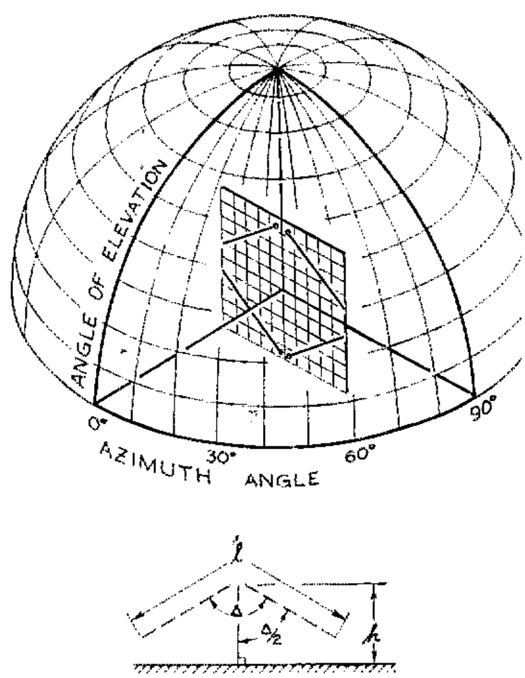

Fig. 1 — Isometric view of the multiband dipole and its image located at the center of the hemisphere which defines the angles of elevation and azimuth for the antenna. Patterns were computed for the outlined quadrant.

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[1] It is relatively easy to obtain an estimate of these two angles. For any given circuit, the azimuth angle is found from the appropriate azimuthal world map or by mathematical calculations. Useful information and graphs relating ray paths and ionospheric layers to the angle of elevation are given in:
Chapter 12, "Propagation," *Radio Communication Handbook*, 4th Ed., Radio Society of Great Britain, 1968.
Davies, *Ionospheric Radio Propagation*, National Bureau of Standards Monograph 80, 1965.
Ionospheric Predictions, edited by M. Leftin, Institute for Telecommunication Sciences, Boulder, Colo., 1971.

[2] Buchanan, "The Multimatch Antenna System," *QST*, March, 1955.

[3] McCoy, "A Coax-Fed Trap-Dipole for 80 Through 10-Meters," *QST*, November, 1969.

TABLE 1

Electrical Model of W3DZZ Antenna Located
10.7 Meters above Perfect Ground

Freq. (MHz)	*h (height in λ)*	*l (length in λ)*	*No. Elements per length l*	*∠(angle°)*	*Pattern*
3.5	λ/8	≈λ/2	18	180°	Fig. 2A
			18	120°	Fig. 2E
7.0	λ/4	λ/2	18	180°	Fig. 2B
			18	120°	Fig. 2F
14.0	λ/2	3λ/2	30	180°	Fig. 2C
			36	120°	Fig. 2G
21.0	3λ/4	5λ/2	30	180°	Fig. 2D
			—	120°	—

accurate results on the highest bands. The bands for which patterns were found are listed in Table 1. The patterns are plotted in Fig. 2. An angular-coordinate accuracy of two degrees appears to be consistent with the previously stated approximations regarding the quantized antenna and the hemisphere above it.

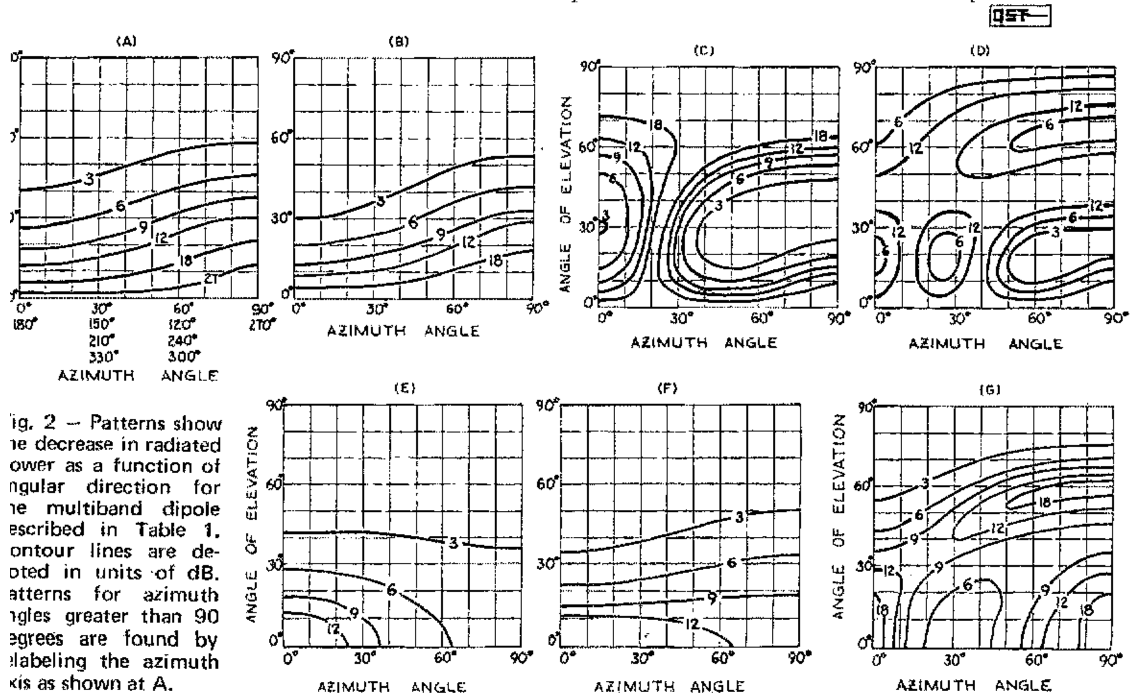
One should note that the horizontal antenna patterns could be computed manually by multiplying the free space pattern of the long wire, center fed antenna by the pattern for two isotropic point sources driven 180 degrees out of phase and separated by a distance of 2H. This procedure would not be valid, however, for the inverted V.

In the case of the horizontal antenna, Figs. 2A through 2D dramatically show the shift in the direction of maximum radiated power from the overhead direction at 3.5 and 7.0 MHz to end-fire, low-elevation-angle lobes at 14.0 and 21.0 MHz. The inverted-V form of multiband antenna (120 degrees), as the patterns of Figs. 2E through 2G indicate, is a more omnidirectional antenna. Performance off the ends at the lower frequencies should be better for the V than for the horizontal antenna. However, the horizontal form makes the better 14.0-MHz antenna except along an azimuth of about 20 degrees.

Conclusions

Patterns have been displayed of the variation of radiated power from a multiband antenna over perfect ground as a function of azimuth angle and angle of elevation. In practice, real ground will cause more decrease in the radiated power at the lowest angles of elevation than indicated by the patterns. Furthermore, polarization effects for both real ground and the ionosphere introduce additional complicating factors not treated here. Nevertheless the theoretical patterns do locate the directions in space through which most of the radiated power flows. Relative signal strengths in other directions can be determined from the charts. This information can be used either to position the antenna in such a way as to achieve the best results or to gauge the effectiveness of the present antenna on the various bands of operation.

QST



ig. 2 — Patterns show ne decrease in radiated ower as a function of ngular direction for ne multiband dipole escribed in Table 1. ontour lines are deoted in units of dB. atterns for azimuth ngles greater than 90 egrees are found by elabeling the azimuth xis as shown at A.