Tilted Verticals

Effect of Tilting on Directional Patterns

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The recent use of "tilted verticals" by G3BDQ,[1] W4LKB, K4LYW, and others raises the question of what changes occur in the far-field radiation when a ¼ wave or ½ wave antenna slopes away from the normal direction. The following note specifically considers the angular variation of the *E* field in two planes — the vertical plane defined by the tilted antenna and its image, and the horizontal plane parallel to ground.

The patterns were derived by using an analogous V-antenna approach. Fig. 1 illustrates the geometry of the antenna system. The antenna *AO* is tilted at an angle θ with respect to a perfectly conducting ground. The net radiation was approximated by summing the fields from *AO* and its image antenna *OB* inclined at the same angle θ and driven by a current of opposite phase to that in *AO*. No change in current distribution was assumed in going from a base-fed to a center-fed antenna. Therefore using sinusoidal driving currents, *E*-field expressions were evaluated as a function of the angle of elevation Δ. For the present case an additional term associated with the antenna phase center enters the expressions when the antenna is not truly vertical. Thus the resulting radiation patterns plot the absolute magnitude of the relative radiation field vs Δ.

Graphical results of the vertical field computations are given in Fig. 2. In these patterns the dotted line is the angular multiplying factor of the field of a ¼-wavelength antenna while the solid line corresponds to a ½-wavelength antenna. Four angles of θ were considered; namely, 90, 75, 60, and 45 degrees. Note that only half of the pattern is shown since the field is symmetric about the normal in the vertical plane.

Radiation in the horizontal plane was found to be essentially omnidirectional regardless of the tilt. There was a slight increase in radiation along the *GOF* direction. The table below gives the maximum per cent departure of the radiation from a circular pattern drawn through the average of the extremum values.

	Per cent Deviation			
Tilt Angle →	90	75	60	45
AO = ¼ wave	0	0.1	0.9	1.8
AO = ½ wave	0	0.8	2.6	5.9

The vertical radiation patterns clearly indicate that there is an increase of high-angle radiation as the antenna shifts away from the normal. The ¼-wave antenna in this respect is less susceptible to tilting than the ½-wave. Calculations for longer antennas reveal even more drastic increases in high-angle radiation, although the ⅝-wave antenna maintains a large percentage of radiation below 30 degrees until θ decreases below 60 degrees. For low-frequency use, tilting a vertical could permit utilization of some of the net gain of the ½-wave vertical over the ¼-wave while still achieving good local coverage and a considerable reduction in tower-support height. At the higher frequencies θ less than 70

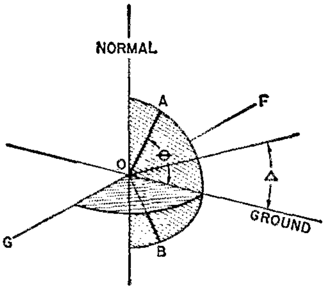

Fig. 1 — Antenna coordinate system.

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[1] Heys, "A Grounded Semi-Vertical Aerial for the L. F. Bands," *RSGB Bulletin*, Feb. 1964.

Antenna analysis in the literature is confined almost entirely to certain standard configurations — in the case of the dipole, to vertical and horizontal conductors. Here are some theoretical patterns for antennas tilted off vertical, a type of installation that is not uncommon in practice. They are based on the usual assumption of a perfectly-conducting ground.

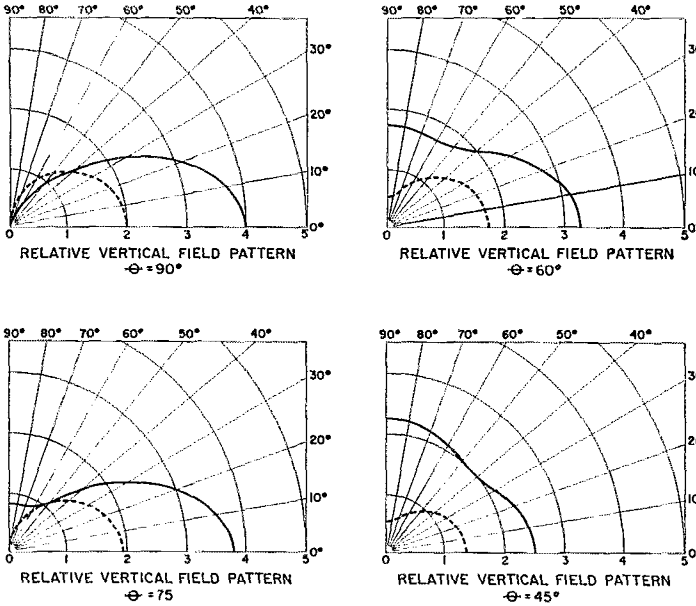
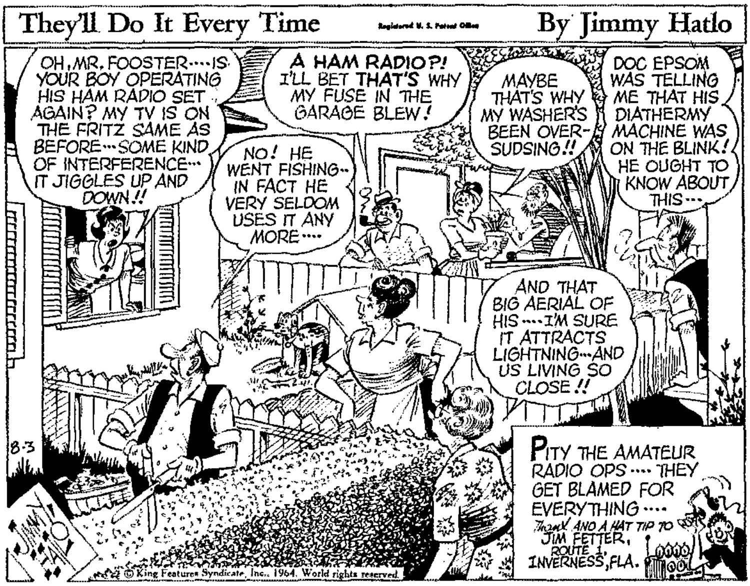


Fig. 2—Vertical field patterns for antennas having no tilt (90 degrees) and tilts of 75, 60, and 45 degrees from the horizontal. Dashed pattern, ¼-wavelength antenna; solid pattern, ½-wavelength antenna.

degrees or so would affect DX capabilities. For example, at an angle of 10 degrees the field of a ½-wave vertical is 3.7 db. greater than the field of a ½ wave at 45 degrees fed by the same drive current.

Comparisons between the fields of the various antenna configurations for a constant input power must of course involve the inverse square root of the sum of the radiation resistance and any loss resistance. The radiation resistance calculation is rather sticky, involving the antenna length, θ, and a number of mathematical approximations of questionable accuracy. In general however, the expected decrease of radiation resistance as θ decreases would tend to cancel the corresponding reduction of the angular multiplying factor. Thus for the same *power* input, the net change in field strength would be somewhat more gradual than the patterns indicate. QST



A tip of the ARRL hat to famed cartoonist, Jimmy Hatlo for so effectively illustrating wild neighborhood rumors which often plague amateurs. (© King Features Syndicate, Inc.)