5/8 WAVELENGTH VERTICALS

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Many articles, manuals and even full-length books are devoted to antennas in general and as specifically applicable to the amateur radio service. Unfortunately, one of the most effective simple antennas for both local ground-wave and long-haul DX communications on the higher frequency bands is almost invariably conspicious by its absence. Consequently, few amateurs are familiar with the characteristics, design, or construction of the 5/8-wavelength vertical antenna.

It will be immediately apparent to most amateurs that the 5/8-wavelength vertical antenna will provide an omnidirectional radiation pattern and a vertically polarized signal. And the antenna itself will be 2½ times as tall as the more familiar ¼-wavelength vertical or groundplane. What will not be so obvious, to the uninitiated, is the even lower angle of vertical radiation, the gain obtainable and an additional improvement in reception due to increased capture area over the conventional ¼-wavelength antenna.

These characteristics have made the 5/8-wavelength antenna very popular in the land mobile services and in amateur 2 meter FM operations where omnidirectional vertically polarized ground-wave communications with low-power mobile stations are desired on a full-time basis.

Vertical antennas, almost invariably of the ¼-wavelength variety, have been widely employed in the amateur radio service for DX communications where their low angle of radiation (assuming an adequate ground system) has proved very effective. Since the polarization of radio signals is generally rotated significantly in the process of reflection, cross-polarization losses are seldom a consideration in sky-wave communications.

Unfortunately, the additional advantages of the 5/8-wavelength antenna have seldom been employed for normal amateur communications. True, a 150 ft vertical for 75 meters or 80 ft for 40 meters is beyond the facilities of most amateurs. However, a 30 ft antenna for 15 meters is well within amateur capability, and 50 ft (20 meters) is within the realm of reason.

Theory of Operation

As a short grounded vertical antenna is increased in length, the radiation lobe narrows, increases in intensity, and the angle of maximum radiation lowers toward the horizon. As the length exceeds ½ wavelength, a secondary lobe of radiation at high vertical angles develops; but the low-angle radiation continues to increase until a height of 5/8 wavelength is reached (Fig. 1). With no equalizing factor, as the length is increased beyond 5/8 wavelength, the high-angle radiation increases and the low-angle radiation decreases.

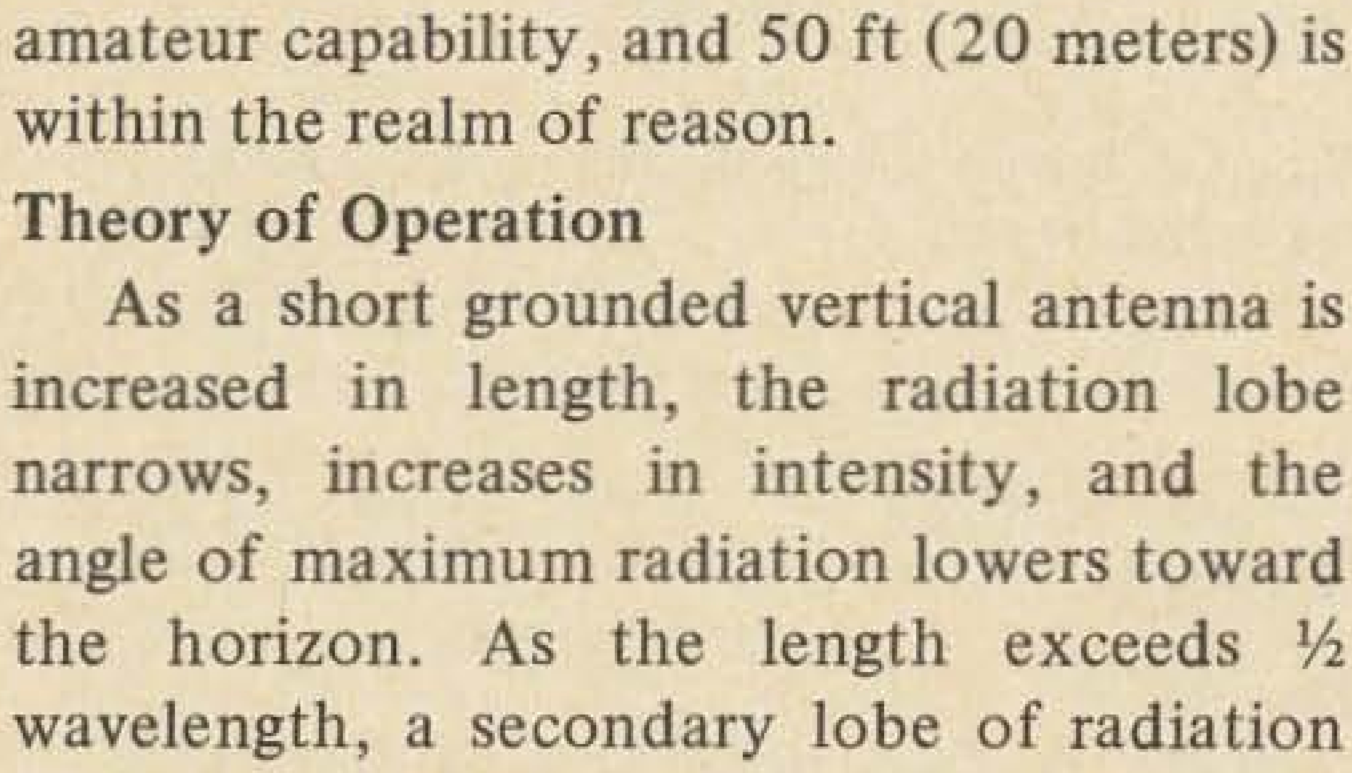

Fig. 1. Low-angle radiation increases as antenna length increases up to 5/8 wavelength.

Since the 5/8-wavelength antenna is nonresonant, it presents a highly reactive load impedance unsuitable for direct feeding. At least three basic methods are available to transform this impedance to a 50Ω nonreactive feedpoint.

Probably the simplest method is use of a small series inductance as shown schematically in Fig. 2. The inductance can be considered as base loading the antenna to 3/4 wavelength (with no change in the radiation pattern). This is a resonant length which will present a feedpoint resistance of approximately 50Ω, a very close match to RG-8/U or RG-58/U coaxial cable. Adjustments to the loading coil should provide an swr of less than 1.2:1. In the groundplane configuration, some additional improvement in swr can be obtained by dropping the radials. Approximately 30° below the horizontal will be about optimum with a resulting swr of less than 1.1:1. This configuration has the advantage in simplicity and ease of construction and tuning. It will also be relatively broadbanded when fabricated of materials of adequate strength.

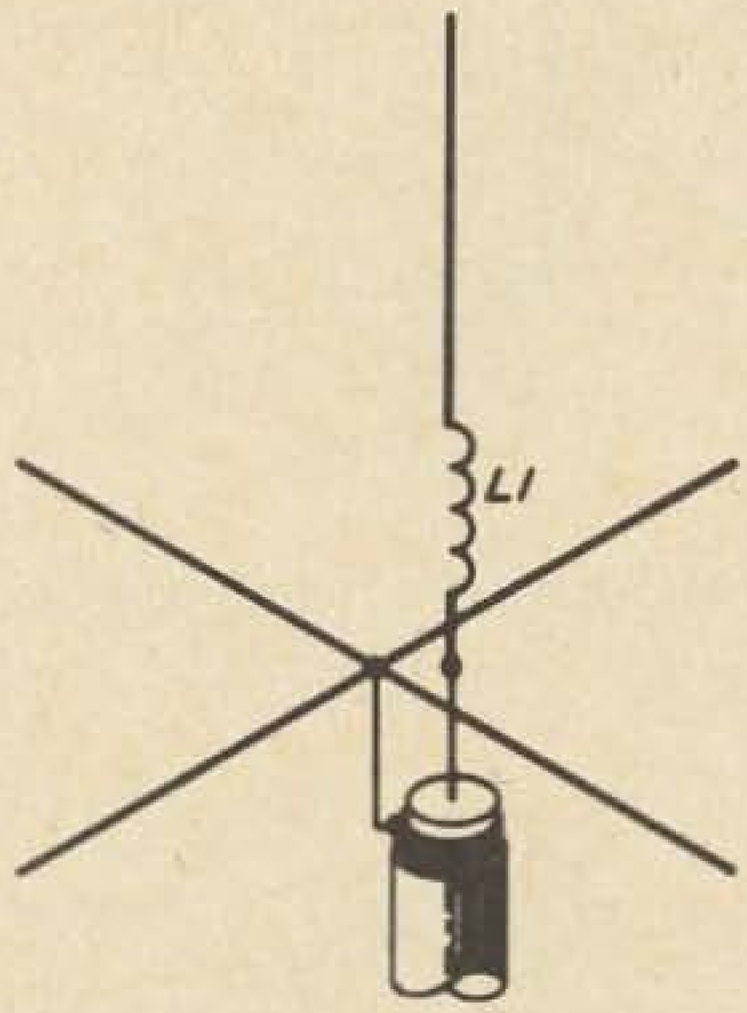

Fig. 2. 5/8-wavelength vertical base-loaded to 3/4 wavelength with series inductance.

The second feed method utilizes a parallel-resonant circuit tuned to the operational frequency with the feedpoint tapped at a low impedance point on the coil, as shown in Fig.3. This arrangement may be considered as providing high-impedance feed to the base of the radiating element and a direct ground connection to minimize ignition noise and provide a

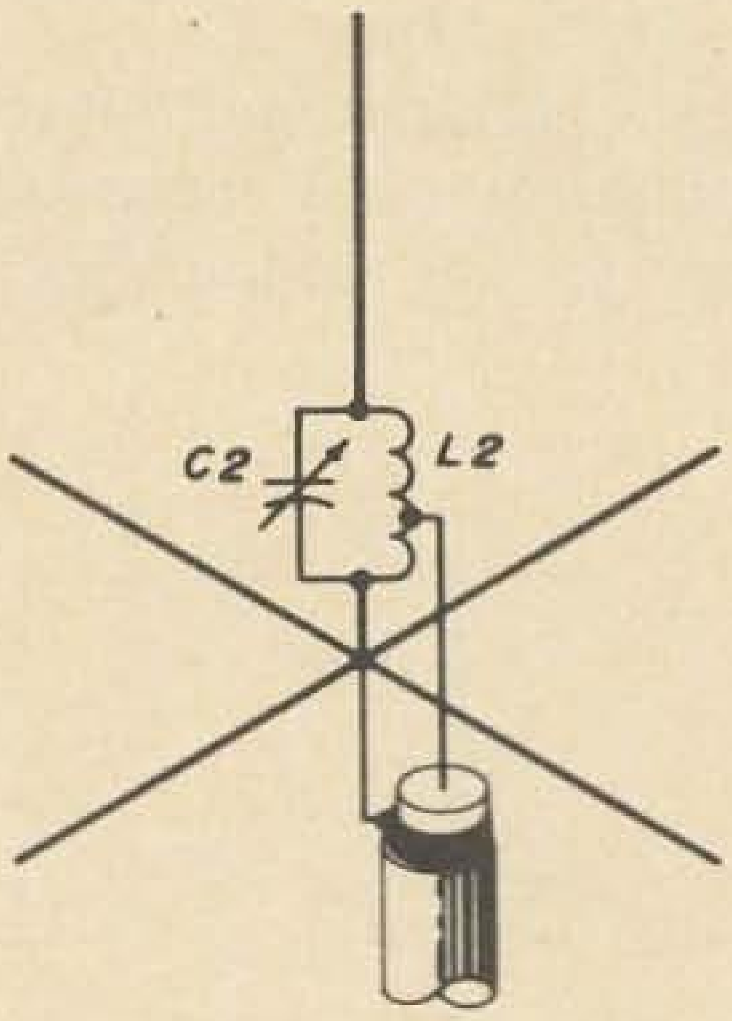

Fig. 3. 5/8-wavelength vertical using parallel-tuned -circuit feed.

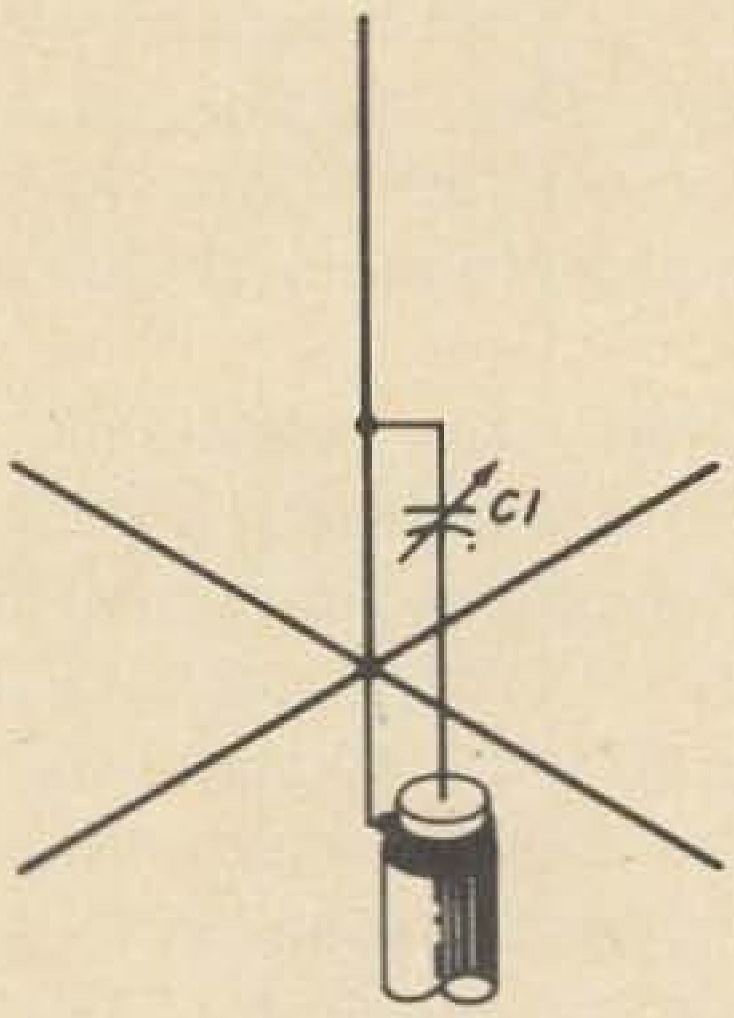

Fig. 4. 5/8-wavelength grounded vertical with gamma match feed.

degree of lightning protection. Coaxial feedpoint tap adjustments in conjunction with minor tuning changes can provide nearly a 1:1 swr at the operating frequency.

The tap point and tuning adjustment interact slightly and initial adjustments are slightly more time-consuming. However, the coil–capacitor combination can be grid-dipped to the approximate frequency on the bench so that only minor touch-up is required.

This configuration has the additional advantages of providing a very low swr without decoupling-radial droop or when mounted on a mobile installation. It will not normally be quite as broadbanded as the first.

A third method of feeding is through the familiar gamma match, as shown in Fig. 4. Here the radiator itself is grounded and the feedline is tapped onto the radiator through a series capacitance. This arrangement also provides a direct ground connection for minimization of ignition noise and a reasonable degree of lightning protection. Feedpoint tap variations combined with series capacitor adjustments can provide nearly a 1.0:1 swr at the operating frequency.

This configuration is particularly adaptable to feeding existing grounded towers as ground system of heavy radials will be required.

Design

The 5/8-wavelength vertical radiator should be reasonably close to a full 5/8 wavelength at the desired frequency but should preferably be no longer. Consequently, the decoupling radials should be a 5/8 wavelength at the high end of the band of operation. Conversely, the decoupling radials should be a minimum of ¼ wavelength at the low end of the operating band. The following formulas are based on reasonable velocity factors for materials probably available in amateur construction and should prove adequate for preliminary design purposes.

$$\text{Radiator length, in.} = \frac{7020}{\text{f in MHz}} \quad \text{or}$$

$$\text{Radiator length, ft} = \frac{585}{\text{f in MHz}}$$

$$\text{Decoupling radial length, in.} = \frac{2880}{\text{f in MHz}} \quad \text{or}$$

$$\text{Decoupling radial length, ft} = \frac{240}{\text{f in MHz}}$$

Using these dimensions, the coupling circuit can then be selected to resonate or provide minimum swr at the desired operating frequency. Though theoretically any coil or coil–capacitor combination which can be resonated at the desired frequency would work, it is important that good tank-circuit design principles and full weather protection be considered to minimize circuit losses and provide for maximum energy transfer. In general, this implies that all coils be space-wound with large wire or tubing and that length-to-diameter ratios be less than 4:1 (and preferably 2:1). Capacitors should be high quality, ceramic insulated or wide air-spaced variables for ease of circuit adjustment and reasonable power handling capability.

The coaxial feed tap point will vary with different constructional methods and materials and the optimum point must be determined experimentally for each installation. It will invariably be quite close to the ground end of the coil, varying from approximately 1 turn on 2 meters to possibly 3 or 4 turns on 20 meters.

Construction

While this is not intended as a "hardware" style construction article, a few approaches possibly worthy of further consideration have been accumulated.

Conventional TV masting or aluminum tubing is readily available, rugged and inexpensive, although insulation and installation are more difficult than with some other materials.

Of course, the surplus whip antenna segments and their matching insulators are relatively inexpensive, free standing to heights approaching 20 feet; they are relatively light in weight and are available from numerous sources.

Insulated (or even grounded) antenna towers should make effective radiators for the lower frequency bands, providing an adequate ground radial system is incorporated.

On 2 meters or even 6, a fiber-glass fishing pole covered with shield braid from RG-8/U and RG-58/U makes an ideal radiator. Of course, 1/8 in. welding rod works adequately on 2 meters or higher bands also.

Although this antenna will probably not compete with a good beam or quad at optimum elevations above ground, it is a very effective antenna, readily and economically fabricated with minimum facilities.

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