seven-tenths-wavelength ground plane for two meters

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The subject of gain antennas will often produce a varied response when taken under discussion by amateurs. This is especially true in vhf mobile applications where the system uses a grounded vertical as the radiating element.

The purpose of this article is to point out some of the basic characteristics of the ground plane, and to show how these properties were used to adapt an existing antenna to 147 MHz.

characteristics

Commercial mobile antennas designed for the frequency spectrum of 140-170 MHz have certain structural characteristics that distinguish them from their lower-band counterparts. At these higher frequencies, the heavy-duty spring mount base is not practical. Gain antennas within this range are generally limited to half-wave or five-eighths-wave radiating elements that are base loaded to extend the electrical length to three-quarter wavelength. The matching network is sealed within a thin cylinder that forms the mounting base for the entire antenna.

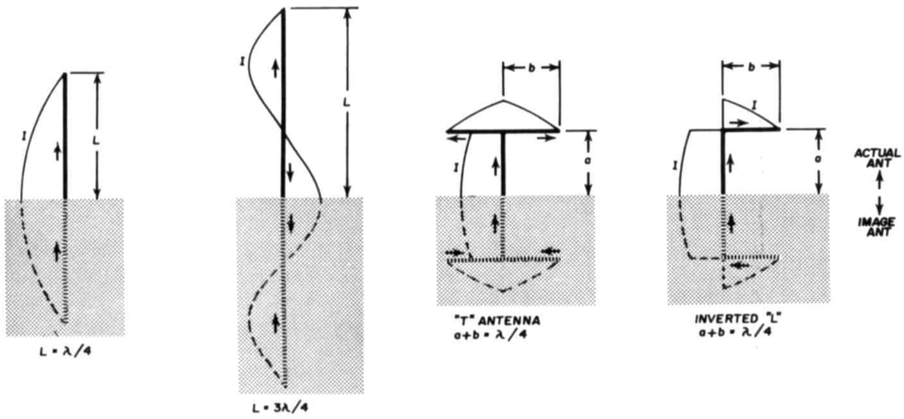
The electrical properties of a grounded vertical are shown in **fig. 1** and **2.** The common quarter wave is widely accepted because the feed point is not reactive and presents an impedance of suitable value. The lobe pattern of a half-wave antenna provides some gain, but the element end presents a current null that can't be matched directly to common transmission lines. A three-quarter-wavelength radiator is an ideal match for 50-ohm transmission line, but low-angle lobes are secondary. With more energy being directed toward the higher angles, direct-wave field strength, at zero elevation angle, is less than that of the quarter-wave antenna.

Most vhf amateurs recognize the five-eighths-wavelength antenna as the ultimate in a single-element radiator, but many don't know the true gain of the device. This is sometimes brought about by misleading literature that uses the dipole or isotrope as the reference source. The top curve of **fig. 2** is convenient for determining true zero elevation angle gain under ideal conditions (perfectly conducting ground).

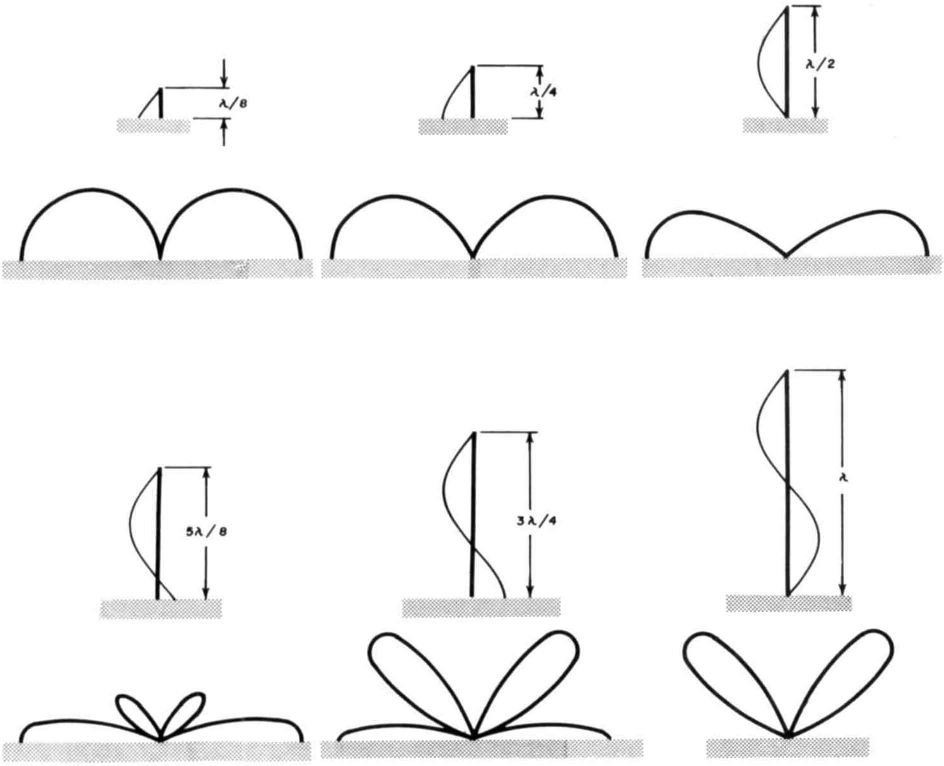
construction

These facts presented an interesting challenge. I wanted to evaluate some Motorola equipment in the fm portion of the two-meter band. However, the only permanent antenna system on the car was a quarter-wave six-meter whip, using a 232-Series Master Mobile tapered spring base. I couldn't see any way to utilize this system as a gain antenna in any conventional manner.

The only practical place to locate a matching network was at the coax terminal point inside the trunk of the car. As stated before, the purpose of the loading network is to extend the electrical length of the system to three-quarter wavelength. This means that the junction point of the



(a) CURRENT DISTRIBUTION



(b) VERTICAL PLANE RADIATION PATTERNS

fig. 1. Characteristics of grounded vertical antennas.

loading coil and the radiating element will exhibit a high impedance with a half-wave radiator, and the impedance will decrease as the radiator length is extended.

Seven-tenths wavelength appeared to be a good compromise. The zero elevation angle gain was better than that of a quarter-wave whip, and the impedance at the junction point approached minimum. The over-all length of the antenna (including base) is 52-1/2 inches for 147 MHz. The gain slope in this area is very steep (**fig. 2**), and a difference of one or two inches will alter the characteristics considerably.

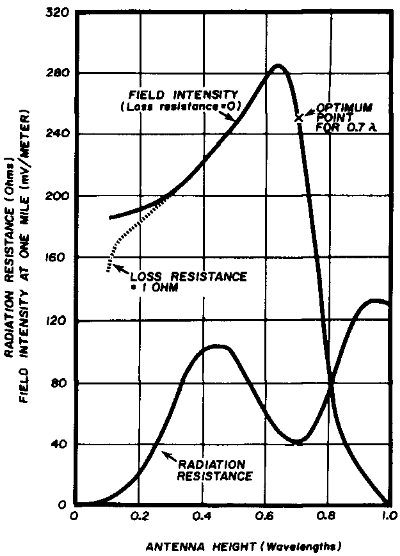


fig. 2. Radiation resistance and field intensity as functions of antenna height.

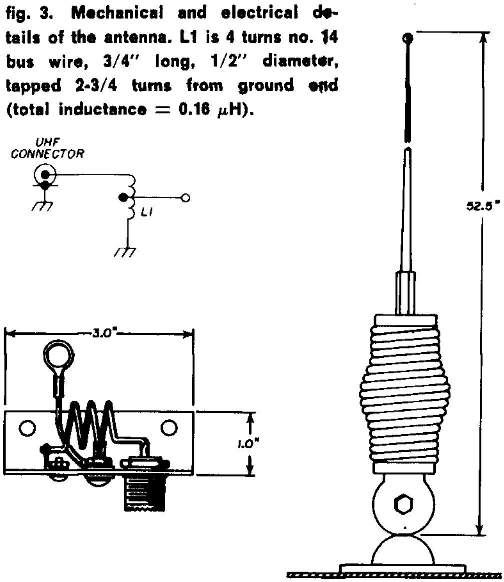
Fig. 3 shows the electrical and mechanical characteristics of the matching network. The device is built on a three-inch length of aluminum angle, with holes spaced to accommodate two of the mounting screws of the existing base. The coil is wound around a ½-inch form using number-14 bus wire. A teflon feedthrough, with a 6-32 screw, serves as the junction point for the coil tap and the antenna base coupling wire. This wire should be cut so the terminal lug center-to-center dimension is 1-3/4 inches. Typical solder lugs provide sturdy mechanical support of the coil at the tap point and ground end.

Electrically, L_1 supplies the requirement of two coils. The 1¼ turn between the uhf connector and the antenna is the series loading inductance. The remaining portion provides the shunt impedance required to cancel approximately 72.5 ohms of capacitive reactance.

Part of the capacitive component of this reactance is due to the mechanical structure of the Master mount and its relationship to the automobile body, when properly installed. This small amount of X_c can be overlooked at the lower frequencies but must be compensated for at vhf. Some additional strays are introduced with the installation of the matching network.

For a period of time, the development of the antenna overshadowed the original task of equipment evaluation. Practical problems had to be discovered and corrected by trial and error. A seven-tenths-wavelength antenna is not conventional, but it does have useful applications. The purpose in pursuing the project was to prove that it could be done.

fig. 3. Mechanical and electrical details of the antenna. L1 is 4 turns no. 14 bus wire, 3/4" long, 1/2" diameter, tapped 2-3/4 turns from ground end (total inductance = 0.16 μH).



references

F. E. Terman, "Electronic and Radio Engineering," McGraw-Hill, New York, 1955, p. 887.

J. D. Kraus, "Antennas," McGraw-Hill, New York, 1950, pp. 315, 316.

ham radio