helically wound mobile antenna

Improved performance over a manufactured whip is claimed for this antenna design

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This article describes a helically wound whip antenna for mobile operation. The final design evolved over a period of about five years. An antenna was desired that performed better than those available on the market; tests have indicated that this objective has been achieved.*

The antenna has flat response at resonance and frequencies above resonance, with pronounced fall-off at frequencies below the design frequency.

Design data and construction details are given to enable you to duplicate the antenna, either as a single-band design (1-150 MHz) or as a 4-band amateur antenna covering 10-80 meters.

Construction procedures, dimensions, and winding instructions must be followed explicitly, otherwise the antenna may not perform as claimed. After you've built the antenna from the instructions provided here, *then* try your own variations. But it's important to "stick to the script" to start with.

*A copy of the test report is available from *ham radio* for $1.00 and a self-addressed stamped envelope. editor.

During the 1964/65 period, I conceived an idea to build a single-band helically wound whip into a two-band antenna while also trying to improve the coupling to space by the production of a near-sinusoidal current and voltage distribution over a short antenna. The results have been very satisfactory.

Having made many single-band helically wound whips, I noticed that a second resonance was apparent around 18-19 MHz on most antennas, using rod about 3/8 inch in diameter for the dielectric. While developing the technique to wind single-band whips for frequencies from 3.5 to over 100 MHz, trends were noted, and an antenna for the 40- and 20-meter bands was attempted. My first attempt, which was pure luck, was a helically wound antenna similar to the present multiband antenna. After rewinding and making adjustments, the first design was born. It worked on 40 and 20 meters, so I tried it on 10. It loaded and worked, but as this was done during the quiet period of 10 meters, only local results were obtained. Finally the antenna was tried on 15. It worked on that band also. Subsequent results have been most satisfactory. Tests on 20 showed 3 dB gain over a Hustler at a distance of 14,500 miles.

The form factor was a compromise, producing a near-sinusoidal distribution of voltage and current similar to that of a ¼-wave atnenna.

single-band design

Experimentation has resulted in a formula for determining the approximate length of wire for a helically wound antenna for one frequency. The formula is at best an approximation as shape, dielectric rod length, and wire gage affect the formula. To find the approximate length of wire for a helically wound whip for one frequency, use

$$L = \frac{840}{F}$$

where

L = wire length (ft)

F = frequency (MHz)

This formula will result in a little more wire than required providing the top third of the antenna length is close-wound. If less than one-third is close-wound, more wire will be required; conversely, if more than a third is close-wound less wire will be required.

The dielectric rod must be of constant diameter. Tapered rods will result in a different configuration than that specified, which may affect performance.

The rod length represents a quarter wavelength or 90 electrical degrees. Divide the rod length into nine sections, each of which represents 10 electrical degrees. To find the percentage of turns required at each 10-degree segment, use the data in **fig. 1**.

wire gage and length

Consider now one-third of the rod length. From **fig. 1** note that 71 percent of the total turns, or wire length, (using a constant-diameter rod) must occupy that space. From geometry the rod circumference is πD. Therefore, dividing 71 percent of the wire length by the rod circumference will give the approximate number of turns to be closewound. From the wire table in the Handbook, find a suitable gage of enamelled wire. The wire diameter should not be less than 0.028 inch.* If the wire table gives a size smaller than 0.028 inch, use a larger-diameter rod and recalculate.

Helically wound mobile whip for 10-80 meters used by ZE6JP.

Using the formula above, a 3/16-inch-diameter rod, 18 inches long, was used to build an antenna for 10 meters. The antenna was mounted on the car and tuned. An input of 22 watts was used. Good reports were received across town, but after one minute of operation the antenna was too hot to touch because the wire gage was too small.

winding procedure

Mark off the rod into 9 sections. It will be easy to determine the number of turns in each section as the rod circumference is known; also the total length of wire. Divide the circumference into the length to obtain the total number of turns. Divide each section into inches. Note that a change of turns per inch

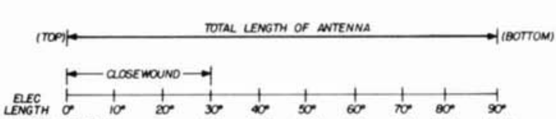


fig. 1. Diagram showing percentage of wire turns as a function of antenna length in electrical degrees. Approximately 70 percent of the total number of turns must be close-wound over the top one-third of the antenna.

*The ARRL Handbook shows this wire diameter as No. 21 B&S gage. The current-carrying capacity of No. 21 B&S gage, at 1500 circular mils/ampere, is 0.54 amp. **editor.**

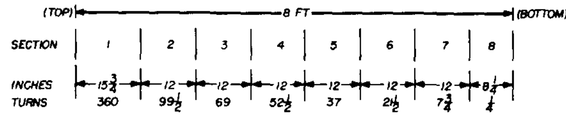
exists, section-to-section. Mark each number of turns in each progressive inch to accommodate the change of turns per inch. The winding then will have a constant change in pitch, and no sudden change of pitch will be obvious. Indelibly mark the position of each turn. Anchor one end of the wire, then secure the other end to the "loose-wound" end of the fiberglass rod and wind on. After completing the winding lock the top end with tape, then adjust the turns to smooth out any uneveness in the winding. Secure the entire winding with epoxy.

Mount the antenna in its operational position. Make certain the car has an open space of at least 20 feet around it. Use a two-turn loop to ground the bottom end of the antenna. Couple a gdo to the two-turn loop. Check the gdo frequency with an accurately calibrated receiver. The frequency should initially be lower than that required. Remove turns from the close-wound (top) end, turn-by-turn, until the gdo dips at the low end of the band. The antenna will load over the band by adjusting the transmitter tank circuit.

multiband design

This is an extension of the single-band design, but by its size and shape it will operate satisfactorily on the 40-10 meter bands. The multiband version behaves like an hf choke. As frequency is increased, resonances occur at different frequencies. These resonances are governed by the antenna shape, wire inductance, and distributed capacity. The low-impedance feed conditions at resonance are not normally harmonically related; however, this antenna does have this property. The resonances occur in the ham bands, and the feed impedance allows the antenna to be loaded by the conventional mobile pi-section tank circuit. By adding approximately 60 μH in series with the antenna base most of the 80-meter band may be covered. Similarly, the antenna will tune 160 meters with suitable inductance added at the base.

From band-to-band, the feed-point impedance at resonance varies but is generally between 15-50 ohms. No difficulty has been experienced when feeding with RG8/U about 15 feet long. Forget swr so long as the antenna can be loaded – improving swr adds very little to the radiation. In general, the usual pi section is adequate, unless in certain manufactured transceivers the 50-ohm termination is restricted.



SECTION	WINDING DATA	
1	360 TURNS CLOSE WOUND	
2	/9½/9/9/9/8½/8½/8½/8/7½/7½/7½/7/	(TURNS/IN.)
3	/7/6½/6/6/6/5½/5½/5½/5/5/5/	(TURNS/IN.)
4	/5/5/5/4½/4½/4½/4½/4/4/4/4/3½/	(TURNS/IN.)
5	/7/7/6½/6/5½/5/	(TURNS/2 IN.)
6	/4½/4½/4/3½/3/2/	(TURNS/2 IN.)
7	/2/2/1½/1½/[illegible]	(TURNS/2 IN.)
8	¼ TURN OVER LAST 8¼ IN	

fig. 2. Winding details for a 4-band amateur antenna. No. 18 AWG enamelled wire is recommended.

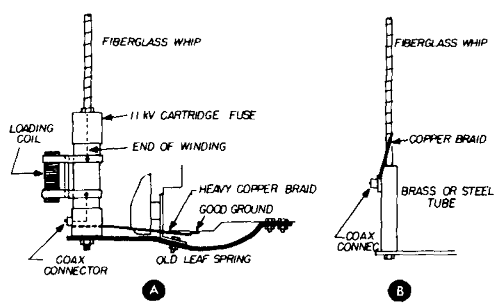


fig. 3. Suggested mounting arrangements. A shows author's mount, which includes loading inductance. A simplified version is shown in B.

The rod is of fiberglass with a diameter of ¾ inch, from 8 to 8 ft. 3 in. long. Lay the rod on a bench or table. Mark off the turn positions along the rod **(fig. 2)**. Scratch the marks so they won't rub off when winding. Mark off from the top end as in **fig. 2**. Wind as previously instructed and terminate in the same way. Use only 0.040-inch enamelled wire (18 AWG). A suggested antenna mounting is given in **fig. 3**.

tuning

All previous instructions apply except as follows. Remove turns from the top of the antenna until it resonates in the low end of the 40-meter band. Check resonances on the other bands with the gdo. An increase or decrease in rod diameter will change the resonant frequency.

Note that after each adjustment of the antenna a check over the band, on each band, should be made. A compromise may be necessary in some cases, but this was not found to be so in my experiments. While testing, the antenna must be in its normal operating position. Changing from mobile to mobile may require some readjustments. Removing turns from the top has a profound effect on 40 and a lesser effect on 15; less still on 20 and 10.

80- and 160-meter operation

The antenna may be used for the two lower amateur bands by adding a suitable loading coil. The antenna should be resonated, as before, at the lowest frequency of the band you intend to use. Again, check loading across the entire band. The antenna should take power if your transmitter output circuit is not too restricted.

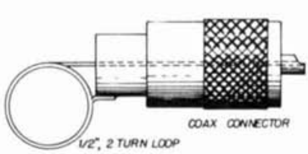


fig. 4. Loop with coax plug can be coupled to grid-dip oscillator to check resonant frequency of the antenna.

conclusion

I am informed by ZS6U that he has designed a 40, 20 and 15-meter single section, which screws onto a Hustler in place of the loading coil. Changes of wire gage are used for this antenna, but details are not available. Performance is at least equal to the single-band arrangements.

Close-up of ZE6JP's mount. Details are shown in fig. 3.

Additional resonances have been noted but no attempts have been made to use them. Typical resonances are (in MHz): 3.62, 7.05, 14.2, 21.1, 28.28, 31.8, 37.42, 44.5, 56, 67, etc. I don't know what the polarization really is, except it is mainly vertical by response on vhf. There is less decrease in signal strength when the antenna is moved from vertical than that measured from a base-loaded vertical antenna under the same conditions.

It's nice to change bands inside the mobile simply by reloading or by switching a relay to remove the short across the 80-meter coil.

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