convert an inexpensive CB mag-mount antenna into a superb 2-meter whip

In mounting mobile antennas, position is everything

Radio Shack sells an inexpensive CB mag-mount whip antenna (Model No. 21-1005A, shown in **fig. 1**) that can easily be converted to hamband use. It's a rugged unit with a chrome-plated disc-shaped base housing the magnet and a 16-foot length of RG-58/U cable attached. The necessary modifications don't alter the external appearance of the antenna in any way.

From the tip to the bottom of the conical aluminum base, it measures 37-1/2 inches — close to the 1/2-wave resonant length at 146 MHz. It's tuned at CB frequencies by placing an inductor between the base of the whip and ground that resonates with the short monopole capacitive reactance. Tapped a short distance up the coil from the grounded end, it produces a 50-ohm resistive impedance.

modifying the base

Dismantling the base is easy. The conical aluminum base unscrews by hand from the black plastic housing, separating the aluminum base from the disc-shaped magnetic mount below. The plastic housing is then pulled gently from the magnetic mount, revealing the matching assembly: a tapped-inductor tuner! The only damage to the assembly caused by taking it apart is to a ring of caulking compound (probably silicone rubber) that breaks loose from the base of the black plastic housing. Weatherproofing can be restored — even improved — by replacing this and adding more caulking compound to the periphery of the hole where the RG-58/U cable emerges from the plastic housing.

matching network design

The existing matching system for the Archer antenna is ideally suited for modification into an L-network. The coil form, measuring 5/8 inch in diameter, is made of solid plastic. The No. 18 wire of the existing coil is entirely satisfactory. Even the mounting terminals on the coil form can all be conveniently used. A small variable capacitor is the only component that must be added. I used a compression mica capacitor from my junk box (the screw-adjustable kind, mounted on a little white rectangular ceramic base). Since the capacitance required will be in the order of 5 pF, I recommend one that's ad-

fig. 1. Mag-mount whip antenna after modification and installation.

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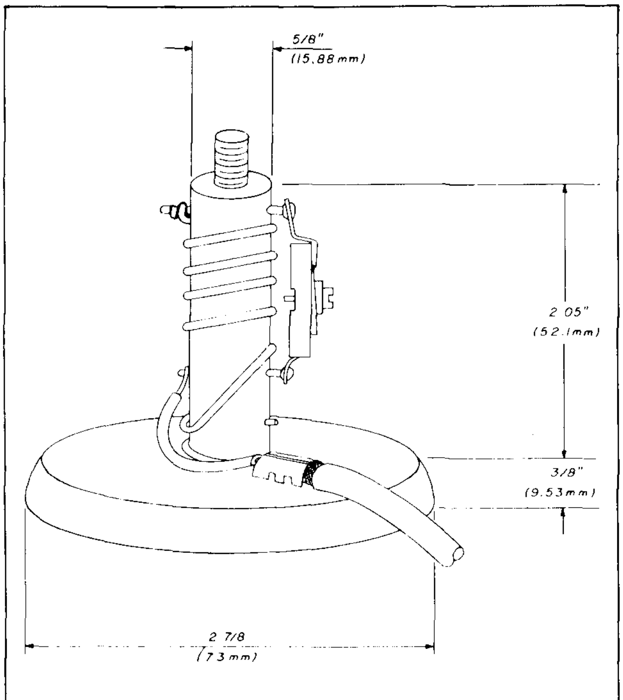

fig. 2. Details of the modified tuner.

justable in the 3- to 10-pF range. The ceramic-based compression mica type should handle powers of up to 100 watts.

I achieved a practically perfect match at 146 MHz by using the usual cut-and-try methods. My final coil had exactly five turns, from a bottom pin on the coil form (which is internally grounded to the magnetic base) to the pin directly above it at the top of the coil form, which is internally connected to the 1/4-20 screw onto which the aluminum base of the antenna is threaded. Since the spacing between the bottom and top pins to which the coil is attached is slightly over 1-1/2 inches, the turns are considerably spread out. In my final version, the top four turns are spaced about 1/4 inch apart; the bottom turn descends more steeply to reach the bottom pin. Three pins are on the coil form, each one extending horizontally through the plastic form so as to be accessible from either side.

The finished L-network is shown in **fig. 2**. The terminals on the capacitor have been bent out flat so that they can be soldered directly to the pins on the coil form. One terminal of the capacitor is soldered to the other end of the pin to which the center conductor of the coaxial cable is already soldered, and the other terminal of the capacitor is soldered to the opposite end of the pin to which the top of the inductor is soldered (that is, the base of the antenna). Nothing has to be done to the outer braid of the RG-58/U cable because it's already securely grounded to a lug under the coil form.

Figure 3 shows the schematic diagram of the final L-network. For those unfamiliar with the operation of these simple matching sections, they are ideally suited for transforming primarily resistive impedances from one value to another. Resistance *R*, the input resistance presented to the base of the whip and ground at the whip resonant frequency, will have a value in the neighborhood of 1000 ohms. The load resistance is shunted by the inductor so that the parallel combination is equivalent to a resistance of 50 ohms, in series with an inductive reactance. This reactance is then tuned out by the capacitive reactance of the adjustable capacitor. Assuming that the antenna represents a pure resistance of 1000 ohms at 146 MHz, calculated values for the L network are: $L = 0.25\ \mu H$ and $C = 5.0$ pF.

measured results

The final tuning of the antenna should be done with the antenna mounted at the selected location on the vehicle. It can be done with the black plastic covering of the matching network removed and the whip screwed to the top of the coil form. With a reflected power meter in series with the coaxial line, the capacitor is adjusted with an insulated tuning tool at a frequency near the center of the band. A deep minimum in the reflected power should be obtainable. I used a Bird Wattmeter; on the 25-watt scale, using 25 watts of transmitted power, my reflected power between 144 and 148 MHz did not exceed 0.3 watt. This corresponds to a maximum VSWR of 1.25. When the plastic cover is put back in place, the tuning is hardly affected. From past experience, I know that with a more sensitive directional coupler and a little more tweaking, I could reduce the reflected power at the center of the band to practically zero. However, at present, it's close enough.

positioning mobile whip antennas

A monopole antenna is really an abstraction implying a single conductor extending out from an infinite conducting plane. Its most familiar practical implementation is a broadcast antenna tower, in which an RF voltage is applied between the base of the tower and the earth. Even here, one could regard the antenna as a very unbalanced dipole, one side being the tower and the other the earth. In mobile whips, the dipole consists of the whip

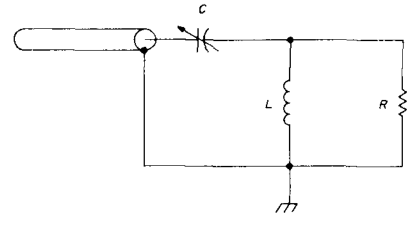

fig. 3. Schematic diagram of L-network tuner.

and the car, between which RF drive is applied.

It's a common mistake to think that the radiation pattern of a given antenna, such as a 1/4-wave, 1/2-wave, or 5/8-wave whip, is the same when mounted on a vehicle as when it's mounted above an infinite conducting plane. At 146 MHz the car's roof is a small ground plane elevated about 3/4 wavelength above the earth ground. This elevation affects the whip antenna radiation pattern.

When VHF antennas are mounted on cars, the main differences between antennas show up in the lack of symmetry of their respective radiation patterns in the horizontal plane. The most circular pattern is always obtained with the whip mounted at the center of a metal-topped roof. Contrary to popular belief, little gain differences are noted between 1/4-, 1/2-, and 5/8-wave whips when they're mounted on finite ground planes (car roofs), certainly not the 3-dB improvement realized when comparing a 1/4-wave to a 5/8-wave vertical working against an infinite-conductivity, infinite-extent ground system. (*This is related to the fact that at low take-off angles, as in mobile-to-mobile contacts, none of these antennas produces a maximum field component. It would be necessary to tilt the car and antenna system as a unit, adjusting the incline for each antenna/ground optimum take-off angle, in order to properly compare maximum developed field strengths. — Ed*)

feedpoint currents

At very asymmetrical locations, such as at one side of a trunk lid, or on one side of the hood, rather large differences between different antennas may appear. This is because of the different levels of current that emerge from the feedpoint at the bases of different antennas and spread out over the surface of the car. Of the three lengths of whips popularly used, the 1/4-wave whip spreads the most current; the current from the 5/8-wave whip is about 70 percent of the value of the 1/4-wave whip, and the current from the 1/2 wave is the lowest, being in the order of 20 percent of the value of the 1/4 wave (depending on the diameter of the whip). These differences in current spreading out over the car have little effect when the antenna is placed at a point of symmetry. However, when the whip is in a highly asymmetrical location, the patterns can be drastically affected.

radiation intensity measurements

Some years ago a group of professors at the University of Washington (including myself), who were also licensed Amateurs, made a series of measurements of the radiation intensity in the horizontal plane from 2-meter whips mounted on vehicles. The cars were mounted on a rotator, flush with the ground, and the radiation intensity was measured using a distant pick-up antenna in conjunction with a Scientific Atlanta pattern recorder. The best antenna location, as expected, was the center of the roof, where the maximum variation in intensity throughout 360 degrees of rotation was about 3 dB. The worst case was for a 1/4-wave whip mounted at the side of the trunk of a sedan, just forward of the hinge. In this case, the pattern was very irregular, showing a 17-dB hole in one direction. The most surprising result was in the case of a 1/2-wave whip mounted on the centerline of the top at the rear end, just above the tailgate window of a station wagon. The pattern for this case had a maximum-to-minimum variation of only 3 dB in 360 degrees.

There seems to be little doubt, then, that the 1/2-wave base-driven whip is the most tolerant of mounting location. It is therefore an excellent choice for a magnetically mounted antenna, especially when placed beside the trunk lid or to one side of the hood, just ahead of the windshield. Since maximum current occurs halfway up the whip, the 1/2-wave antenna can "see" over the car top better than a 1/4-wave whip at the same location.

acknowledgment

I want to thank my friend and colleague, Eric Lindahl, WN7WNL, who first noticed this antenna, bought one, and converted it for 2-meter use.

references

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2. W.L. Stutzman and G.A. Thiele, *Antenna Theory and Design*, McGraw Hill,

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