ANOTHER LOOK AT HF MOBILE ANTENNAS

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After reading NC0B's excellent article on HF mobile antennas in *Ham Radio*'s September 1989 issue,[1] I was inspired to look up some data I recorded many years ago on inductively loaded mobile antennas. I'd like to offer some additional thoughts on this subject.

Loading coils

It has long been stressed that HF antennas requiring inductive loading should use high Q, low loss coils. This concept is employed in the "bug catcher" type coil. The coil is perhaps 3 to 5 inches in diameter and space wound with no. 12 or no. 14 wire to give the optimum form factor for maximum Q. A length-to-diameter ratio of 0.4 to 0.5 results in the shortest length of wire and, therefore, the lowest RF resistance for a given inductance.

While this form of loading coil is generally an improvement over some commercial designs, it's not the optimum when used as part of the overall mobile radiation system.

Tests indicated that the Q factor of the coil is secondary to its *physical shape.* A long, narrow coil (still low loss) of lower Q consistently produced a stronger radiated signal than the short, fat, high Q coil when all other factors of the system were equal.

Shape versus Q

One theory for the superiority of the long coil was given by E.L. Gardiner, G6GR, in *Radio Communication.*[2] He pointed out that any radiated field in space must have both an electrostatic and an electromagnetic field which are correctly related. Neither field by itself will produce meaningful radiation.

In the typical loaded mobile whip, current in the lower section generates a magnetic field. This field won't be radiated unless an adequate electrostatic component is also present in the form of an RF potential difference between the ends of the conductor carrying the current; that is, the base and tip of the whip. These components will be in phase because the antenna is a resonant circuit. The major portion of the potential difference appears across the ends of the coil, as is normal in a parallel-tuned circuit. The electrostatic field strength setup is proportional to the distance between these two high potential points — namely, the length of the coil.

For example, 100 volts across 1 meter represents an electrostatic field of 100 volts per meter, while the same potential across 1 centimeter represents only 1 percent of this field. This leads to the conclusion that however strong the electromagnetic field component may be, it can be fully transformed into radiation instead of heat only if an adequate electrostatic field is present, and vice versa.

Practical considerations

From a practical standpoint, the optimum length for this type of loading coil is 14 to 20 inches for 160 meters and 10 to 14 inches for 75 meters, with corresponding diameters of 1 to 2 inches. The lower wind resistance of such a coil allows it to be located higher up on the vehicle. This places the radiated field away from the car body and reduces losses.

For maximum radiation and efficiency, the loading coil should be placed as high above the vehicle as possible. I have seen bug catcher type coils mounted on vans with a spacing of a foot or so from the metal body — a sure method of converting most of the RF to heat instead of radiation.

It isn't difficult to homebrew efficient mobile antennas. You can use any sturdy material for the bottom section. I use fiber glass wound with copper tape. I also use fiber glass for the top section. My loading coil forms are polyethelene bottles of the desired diameter. I remove the top and bottom of each bottle to produce a hollow form. I use foam tape on the fiber glass whip to build it up to a diameter which is a snug fit for the top and bottom of the form. For 75 meters, you may need two forms situated one above the other. After winding, cement the coil to the taped segments. Because the fiber glass whip passes through the coil, it receives very little physical stress. This method also eliminates the need for any large metal fittings near the field of the coil which would reduce Q. The only metal parts near the coil are two 4-40 brass bolts and nuts used to anchor the ends of the winding.

Coils are space wound with no. 18 wire for 75 meters and no. 16, 14, and 12 for progressively higher frequency bands. If you use fiber glass for the complete top section, make the segment conductive by slipping on braid from coax cable. Because you want maximum capacity above the coil, cover the entire surface of this section with the braid. A single piece of wire (no. 14, for example) taped to the fiber glass will work but the capacity will be lower, requiring more inductance on the coil.

After you prune the coil to frequency, give it a layer of PVC tape for weatherproofing and to eliminate "bug catching" between turns. Drill several holes through the layers of tape at the bottom to let the inside of the coil breathe and to prevent moisture buildup.

Please note that this is a single band antenna. I change bands by changing top sections, each of which is optimum for one band. The inconvenience of changing top sections is offset by the "home station" reports I receive.

Tuning the antenna

Commercial mobile antennas are generally close to resonance and require only slight adjustment of the top section to bring them on frequency. Homebrew antennas, however, can initially be megahertz away; this can pose a tune-up problem.

The usual method of finding resonance involves coupling a grid dip oscillator (GDO) to a one-turn loop connected between the base of the antenna and car body (ground). You then find the frequency of the GDO on a calibrated receiver.

If you don't have a GDO, you can get the same results with a 79-cent Radio Shack buzzer and some flashlight cells. Couple a loop from the buzzer-battery connection to the loop at the base of the antenna. Temporarily shield the buzzer by sticking it in a cake tin or wrapping it in foil. With the buzzer fired up, the antenna will be shock excited and radiate a weak, raspy signal at its resonant frequency. You'll be able to pick up this signal on your receiver. If the band is busy, you may need to run a piece of coax from the receiver to the vicinity of the antenna to pick up antenna radiation only. This system works best on the lower frequency bands where the Q of the antenna is higher, with buzzer noise peaking over a 20 to 30-kHz segment of the band.

After you fracture your rib cage laughing at this scheme, I'll tell you that I filched the idea from the broadcast industry. In the days before fancy instruments, the same system was used to determine the resonant frequency of scaled broadcast towers. If your library is as old as mine, you'll find this technique in *The Radio Engineering Handbook* by Keith Henney.[3]

After you determine the resonant frequency (hopefully at a lower than desired frequency) remove turns from the loading coil, one at a time, until you observe resonance on the high frequency end of the band you want. Turns must be removed, not shorted; a shorted turn will lower the Q of the coil.

On 160, 75, and 40 meters, it's easiest to retune to lower frequencies with a remotely controlled roller coil in the car trunk, as described by K9MLD in *Ham Radio*, October 1988.[4] I used this system back in the fifties running 35 watts AM on 75 meters and can vouch for its convenience. The secret of efficient operation is to peak the antenna alone at the high frequency end of the band and then use just enough roller coil inductance to restore resonance on lower frequencies. Because the roller coil is bottled up in your trunk, any radiation it produces isn't going anywhere, so use as little inductance as possible. The best resonance indicator for this system is a field strength meter at the driver's position; this will quickly tell you when the system is peaked to maximum output.

Some homebrewers use a sliding section type whip above the coil to tune. Unfortunately, the conventional auto type collapsible whip will quickly develop intermittent contact at the sliding joints, resulting in noisy reception and erratic loading on transmit. Sliding joints are recommended only if you devise some way of fastening them securely after adjustment via a set screw to ensure low loss continuity. Even a few watts of RF power will affect joints in this manner — they just aren't designed to pass RF current.

In lieu of a roller coil, you can make limited excursions lower in frequency using an alligator clip and a short (2 to 3 inch) piece of wire clipped above the loading coil to increase capacity. After a few trials, you can readily determine where to locate the clip in order to hit the desired band segment.

SWR

No story on antennas is complete without a discussion of SWR. I may shock the majority of you by saying that the usual obsession with a low SWR doesn't really apply to mobile HF antennas. Other than to satisfy a fussy solid-state rig, a low SWR isn't essential. In some cases it's actually detrimental.

Your objective is to obtain maximum radiation from an antenna system which is, by its physical properties, relatively inefficient. The fallacy of striving for a low SWR lies in the fact that you can doctor the antenna to produce a low SWR and, in so doing, actually reduce the effective radiation of the system. The best method of tuning a mobile antenna is with a field strength meter, adjusting for maximum radiation. Once you've done this, you can check the SWR. On the lower frequency bands it can be 2:1, or even 3:1. Because most transmission line runs on mobiles are short (less than 20 feet), the losses incurred from such ratios are negligible. If your sold-state rig doesn't like this condition, a simple "L" network at the rig will make things right.

It's entirely feasible to use inductive or capacitive matching devices at the feedpoint (base) of the antenna to improve the SWR. However, these are generally one-band devices requiring readjustment for each band. So, if you're an SWR fanatic, you can use base matching or an "L" network. But remember that each requires attention for a band change.

The interstate bonus

For the crowded 20-meter band, I built two top sections. For in-town use I have a shorter section with a total height of 9 feet. On the interstate, where most overpasses are at least 14 feet, I go to a longer top section with the loading coil 10 feet above ground and a total height of 13 feet. This begins to look like a full quarter wave, and with my 100-watt homebrew mobile, performance begins to approach home station efficiency. The real interstate bonus comes courtesy of the highway's construction. With their large masses of steel reinforcing bars under the concrete, these highways constitute an excellent ground system which improves mobile operation significantly. It's the next best thing to driving over salt water (using a bridge, of course), so don't be surprised to find that signals drop suddenly when you leave the interstate for a country road!

You can always improve your mobile antenna system by becoming a fixed mobile. When parked at an off-the-road site, clip a quarter-wave length of wire to the *bottom* of the loading coil and throw the other end up into a nearby tree. This is most effective on 75 and 40 meters where antenna efficiency is lowest.

One ham I know kept an important 40-meter sked with this system. Unfortunately, he was out in west Texas and there were no trees around, so he had his XYL hold up the far end of the wire with his fishing pole. Needless to say, the QSO was short. hr

REFERENCES

1. Robert Sherwood, NCØB, "HF Mobile Antennas," *Ham Radio*, September 1989, page 9.
2. E.L. Gardiner, G6GR, "The Practical Design of Mobile Aerials, *Radio Communication*, RSGB, July 1971, page 450.
3. Keith Henney, *The Radio Engineering Handbook*, 4th Edition, Chapter 14, page 613.
4. Joel Eschmann, K9MLD, "The Weekender: Remote Tuner for 75-Meter Mobiles," *Ham Radio*, October 1988, page 36.