How to Build High-Q Coils

Perhaps you are wondering why anyone is concerned about the Q (quality factor) of a radio coil. After all, isn't a coil a coil?

Not really! Certain types of circuits require coils with high Q in order to perform a given task properly. Such applications are associated with tuned, narrow-band circuits. For example, part of a receiver's selectivity is determined by the sharpness or rejection ability of the early stages (near the antenna) in the circuit. The higher the tuned circuit Q the better the "front end selectivity," as it is called.

High-Q tuned circuits in this part of a receiver help to reject strong signals that are near in frequency to the one you wish to monitor. The better the front-end selectivity the less chance for receiver overloading if there is a very strong signal near the one of interest.

Additional receiver selectivity is, of course, obtained at the IF (intermediate frequency) of the radio. Here we use IF filters that are of the ceramic, crystal or mechanical varieties. The IF filter is chosen to provide the *overall* bandwidth of the receiver. Our IF filter may be designed for AM, SSB or CW bandwidths—wide, medium or narrow, respectively. High Q is required also in the IF filter if it is to yield the desired narrow bandwidth or selectivity.

What Determines Coil Q?

Q is dependent upon (1) the effective ac or RF resistance of the length of wire used to wind the coil and (2) the quality of the coil form dielectric (insulating material) substance. There is also a third consideration with respect to Q: The form factor of the coil plays a role in the Q obtained. Form factor is the ratio of the winding length to the coil diameter. Generally speaking, a 1:1 form factor ensures the highest Q, although I have found form factors up to 2:1 quite satisfactory.

Finally, the coil should be spaced well away from conductive objects, such as shield cans, metal chassis and metal panels. Make certain that your coil is a least one coil diameter away from metal objects.

Getting back to the coil resistance versus Q, the greater the wire resistance the lower the Q, and hence the broader the response of the tuned circuit in which the coil is used. How may we reduce the effective ac resistance of our coils? The answer lies in the use of large wire diameters.

RF current does not flow in all of the wire. There is a condition known as "skin effect." The lower the operating frequency the deeper the penetration of RF current, but it never flows all of the way to the center of the wire. Therefore, the smaller the wire the greater the resistivity to RF or ac current. Increasing the wire diameter provides more conductor area for the RF current, and this reduces the effective resistance of the coil winding.

This is why some builders in the olden days used 1/4- or 3/8-inch copper tubing when they wound coils for their transmitters. Radio amateurs still use large diameter wire or copper tubing for the coils in high-power amplifiers and for loading coils that are used in mobile antennas.

We should acknowledge also that the efficiency of circuits is best when the tuned-circuit Q is high. In other words, the higher the Q the lower the circuit losses.

Most VHF and UHF coils are silver plated. This aids the conductivity of the coils, which lowers the resistance. The plating also discourages harmful oxidation, which can increase the resistivity of the coil wire—especially if copper or brass is used.

Coils that are wound on toroid cores of the correct material for the operating frequency (there are many core mixes or recipes) can produce very high values of Q. This is because the magnetic core material reduces the required number of coil turns and this, in turn, reduces the resistance of the winding. Irrespective of the type of coil used, toroidal or air wound, high Q may be thought of as 150 or greater. A low-Q coil may have a reading of only 10, 50 or 80, for

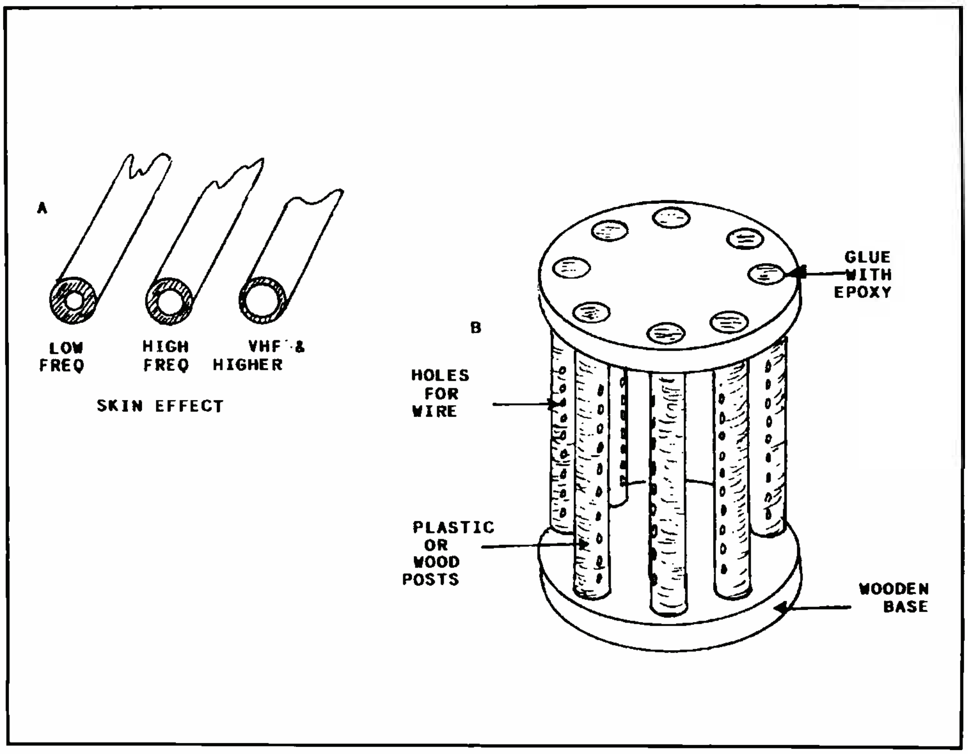

Figure 1: The illustration at A shows the relative penetration of ac or RF current versus operating frequency for wire of a given gauge. Note that the current flows deeper into the conductor at the low end of the frequency spectrum.

The drawing at B shows how you may build a coil form to obtain high Q. Although eight vertical posts are shown, you may reduce the number to six. The pillars may be drilled, as shown, to contain the wire used for the winding. An alternative method is to file notches in the posts, into which the wire is laid and glued.

example. Qs as great as 500 are not uncommon for well designed air-wound coils. Q may be measured with a commercial Q meter or while using a signal generator and an oscilloscope, as detailed in *The ARRL Electronics Data Book*.

Coil Form Insulating Material

Air-wound (self supporting) coils have the least loss and yield the highest Q. Commercial Miniductor stock, such as that manufactured by the B & W Company, has high Q. Ceramic or steatite coil forms, especially when glazed, are excellent for use when winding high-Q coils. Plastic materials such as polystyrene, Delrin, Teflon and fiberglass are suitable also. At the low end of the Q scale are coil forms made from wood, PVC tubing and paper-base phenolic.

How to Build a Large, Hi-Q Coil

I mentioned earlier that air-wound coils have high Q. We can approach the quality of a self-supporting air-wound coil by building a coil form with ribs. The major portion of the coil has air as the dielectric when this is done. Large coils of this type are often used for resonating short antennas. They may be used also in the tuned circuits for RF power amplifiers and antenna tuners. Figure 1 shows how to construct a coil of this type.

The vertical support rods may be made of plexiglass tubing or rod material. If you do not have access to a plastics dealer you can use wooden dowel rod for the supports. The doweling should be boiled for 15 minutes in canning wax or bee's wax to impregnate the wood. This keeps the wood from absorbing moisture and dirt, which would spoil the dielectric quality of the wood and degrade the coil Q.

Avoid using nylon rod or tubing for any RF coil. It will actually become hot and melt under high power at the upper end of the HF spectrum and in VHF or UHF circuits. PVC will act in a like manner under the foregoing conditions.

Wood is suitable also for the top and bottom plates of the coil depicted in Figure 1. The end plates should be treated with canning wax or finished with polyurethane lacquer or spar vanish. This will prevent the absorption of moisture.

The support rods are inserted into the end plates to provide a snug fit. The ends of the rods are abraded and coated with epoxy cement before they are inserted into the end-plate holes.

The vertical ribs can be notched to keep the coil wire in place. A drop of epoxy cement may then be placed at each anchor point to affix the wire to the ribs. Alternatively, you can drill holes in the ribs and thread the wire through them. Remember that the larger the wire diameter the greater the Q. The turns should be spaced one wire diameter from one another. Try to maintain the 1:1 form factor for the winding, as mentioned earlier.

In Conclusion

I have seen small coils that were made as shown in Figure 1. The builders used ordinary wooden house matches (heads removed) as ribs, after they were boiled in wax. Plastic knitting needles can be cut to suitable length for use as ribs, should you wish to make small coils.

Large coils with considerable inductance are handy for increasing the electrical length of short wire antennas. For example, if you do not have sufficient room for a full-size quarter-wavelength end-fed wire, you can resonate the antenna to 1/4 wavelength by placing the loading coil in series with the wire. The turns on the coil are shorted (from either end) until the signals peak in strength at the operating frequency.

Do not short circuit the coil turns at points other than the ends of the coil. If you do, the coil Q will be ruined. In other words, don't short turns along the midsection of a coil.

MT