Small Loop Design for HF QRP

A practical approach.

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It's nice to be able to make perfect small loops using metal tubing and motorized split stator capacitors, and to be able to weld everything neatly together, but not everyone wants or needs such elaborate antennas. In fact, for QRP operation, the weight and complexity of the very efficient loops is often not desirable. A wire loop, on the other hand, is a light, simple, device that can be built quickly and easily and can be repaired with a few basic tools. It needs only an ordinary variable capacitor, and it's easy to take in the car.

For the QRPer in an apartment, a manually-tuned wire loop hidden behind a wardrobe is more appropriate than a heavy monstrosity that must be operated by means of a control box even though the antenna is only a few feet away. Also, a wire antenna can be put together for just a few dollars—even less if you have a junk box and some leftover furring strips.

It works both ways

To design and build small wire loop antennas, I had to come up with a quick, easy way to estimate the inductance of a wire loop where the length is known. On the other hand, if a specific inductance value is known, the required length would be easy to calculate using the same formula. The range of the formula would have to include loops with a circumference of seven feet to 38 feet. In this range, "small" loops are still small relative to the size of a room or an attic space. Of course, 38 feet may be hard to accommodate, but it is still possible.

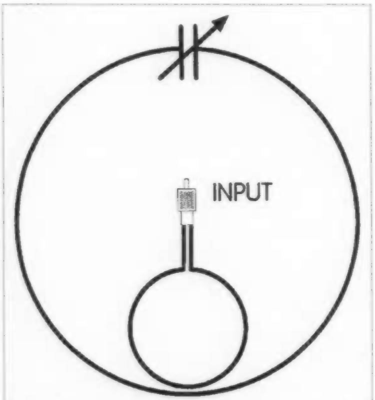

Fig. 1. Circuit diagram.

The simplified formula is a linear approximation of a more complicated formula which can be found in *The ARRL Antenna Handbook*. The more complete formula (slightly modified) is:

$$L = .019S\ (7.353 \log_{10} \frac{96S}{\pi D} - 6.386)$$

where S is the perimeter of the loop in feet, D is the diameter of the wire used in inches, and L is inductance in µH. This formula can be used for values outside the range given for the shortcut formula.

The simplified formula is L=.45S - .5, where L is the inductance in µH and S is the perimeter in feet. Solving for S in terms of L, we get S=2.22L + 1.11. These formulas are approximate but easy, and close enough for practical use. They assume an AWG #12 wire size but would work for wire slightly larger or smaller. The wire recommended for this purpose is #12 stranded, insulated house wire, cheap and readily available.

More numbers

Given the size of a loop and a capacitance value, the inductance can be calculated for a particular band, or for several bands using the extreme frequencies, L=.45S - .5 and the formula:

$$f = \frac{10^6}{2\pi\sqrt{LC}}$$

where f is the frequency in kHz, L is the inductance in µH, and C is the capacitance in pF. Some useful versions of this basic formula are the following:

$$C = (\frac{10^6}{2\pi f\sqrt{L}})^2$$

$$L = (\frac{10^6}{2\pi f\sqrt{C}})^2$$

The formula that solves for L is appropriate when you have a good variable capacitor and want to determine what size of loop you need for certain frequencies. You simply substitute the L value in the length formula (S=2.22L + 1.11).

Beside the formulas, some rules of thumb are helpful in making small loops. The size of the loop should be large enough to be relatively efficient and large enough to tune easily. For easy tuning, you don't want to be tuning at the extreme values of the capacitor. For efficiency, experience has taught me that a 10-20 meter loop works well if its length is no smaller than seven feet. A 20-40 meter loop should be no smaller than 11 feet. A 30-80 meter loop should be no smaller than 22 feet. For indoor use, a vertical loop is the best choice.

Impedance matching

Small loops require an impedance matching device. The simplest approach is a small input loop placed inside and very near the main loop (**Fig. 1**). In practice, using insulated wire, the lower part of the input loop can be taped to the bottom of the main loop. This allows for fairly close coupling and for added mechanical rigidity. The coax is attached to the input loop and is placed so that it comes away from the plane of the main loop at a right angle. The input loop should be about one-fifth the size of the main loop or smaller, but experiment for your own best results.

Try a project

To show the use of the previous information, let's design a 20 through 40 meter loop for use in an apartment, a home, or even outdoors (an outdoor antenna would require weatherproofing, however).

Assuming that you have an eight through 100 pF air variable capacitor available, the required inductance can be calculated using:

$$L = \left(\frac{10^6}{2\pi f\sqrt{C}}\right)^2$$

Using the lowest frequency to be used (7,000 kHz) and somewhat less than maximum capacitance (say, 90 pF), the inductance turns out to be around 5.74 µH. Using S=2.22L + 1.11, the length is approximately 13.9 feet or about 167 inches. This would be a square approximately 41.7 inches on each side. A circular loop, using D=C/π, would have a diameter of about 53 inches.

At the higher end of the frequency range, C=18 pF (somewhat more than the absolute minimum). Then, using the formula for f, specifically,

$$f = \frac{10^6}{2\pi\sqrt{LC}}$$

we come up with 15,700 kHz. This means that the antenna should easily accommodate 20 through 40 meters.

Finally, the input loop length is 167/5 inches or about 33.4 inches.

Testing the loop

First, the wire for the two loops should be cut to the calculated lengths and laid out on a wooden floor (or somewhere that won't involve a lot of metal mass). Temporarily mount the variable capacitor in a plastic box or the like and connect it to the main loop. Connect some 50 ohm coax to the input loop and place the loop very close to the main loop.

Now, connect the plug of the coax to a receiver set first at 7,000 kHz. By adjusting the loop capacitor, you should be able to find resonance points. If you have resonance, the background noise will maximize and signals should be easily heard on the band. Note that the resonance points are sharply defined, so tune slowly. If the loop doesn't tune the band, pruning or adding some length should fix it depending on which band is missing. Repeat this procedure for the highest frequency desired—in this case the top of the 20 meter band. If the SWR is too high, try pruning the input loop.

If the size of the loop is satisfactory, then you can design a framework to hold it. Almost any polygon will do, although a circle or an ellipse can be managed by using solid house wire, #12 or larger, which will hold a curved shape. A single mast can support the loop, but a spreader will make it more rigid.

If you think this particular loop is too large, get a larger capacity variable and design another loop to fit it.

Another approach

Another way is to begin with the size of the loop you prefer. Knowing the size, you can compute the approximate inductance. With the inductance and the frequencies, you can determine the size of the variable capacitor you need. There are variable capacitors available from several places including Surplus Sales of Nebraska, Mouser, Ocean State, or Antique Electronic Supply. Ocean State Electronics has some excellent trimmers that can be used. Trimmers give you a wide choice of capacitance ranges and breakdown voltages, and they are harder to tune, even with an alignment tool—but they *are* relatively cheap.

Capacitors obtained from an old tuner work well as long as the power levels don't exceed 10 or 15 watts. Capacitors with higher breakdown voltages are required for QRO.

Don't make the loop too small!

I recommend (from experience) that loops should be 8% of the wavelength of the lowest frequency you intend to use or more. About an eighth of a wavelength is better, but the antenna gets rather large, especially for 80 or 160 meters.

Finally, here is a warning: Don't forget that an antenna should not be touched while it is in operation. Even at low power levels, not to mention high ones, there is danger. Please take safety precautions. A loop sitting on the floor in your house is very accessible to pets and people.

On your own

You have enough information now to design, test and build your own small loop antennas—the best way to learn about them. This way you can get exactly the kind of small antenna you want. 73