Handheld Direction Finding Loop Antenna for RFI Location

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A good way to locate radio-frequency interference (RFI) in the HF bands is with a small direction finding antenna and a portable radio. Here is a simple antenna design that is effective from 3 to 22 MHz. Based on a resonant magnetic loop, it has high transducer gain (high sensitivity), and also very good directionality. You can build it cheaply from junk box parts.

The basic design is a simple resonant loop with a smaller coupling loop. Since this is only for receiving, there is no concern about achieving very high efficiency nor are there any high voltages, so component selection is simplified. Figure 1 shows the complete handheld antenna and Fig. 2 is a schematic for a good reproducible design.

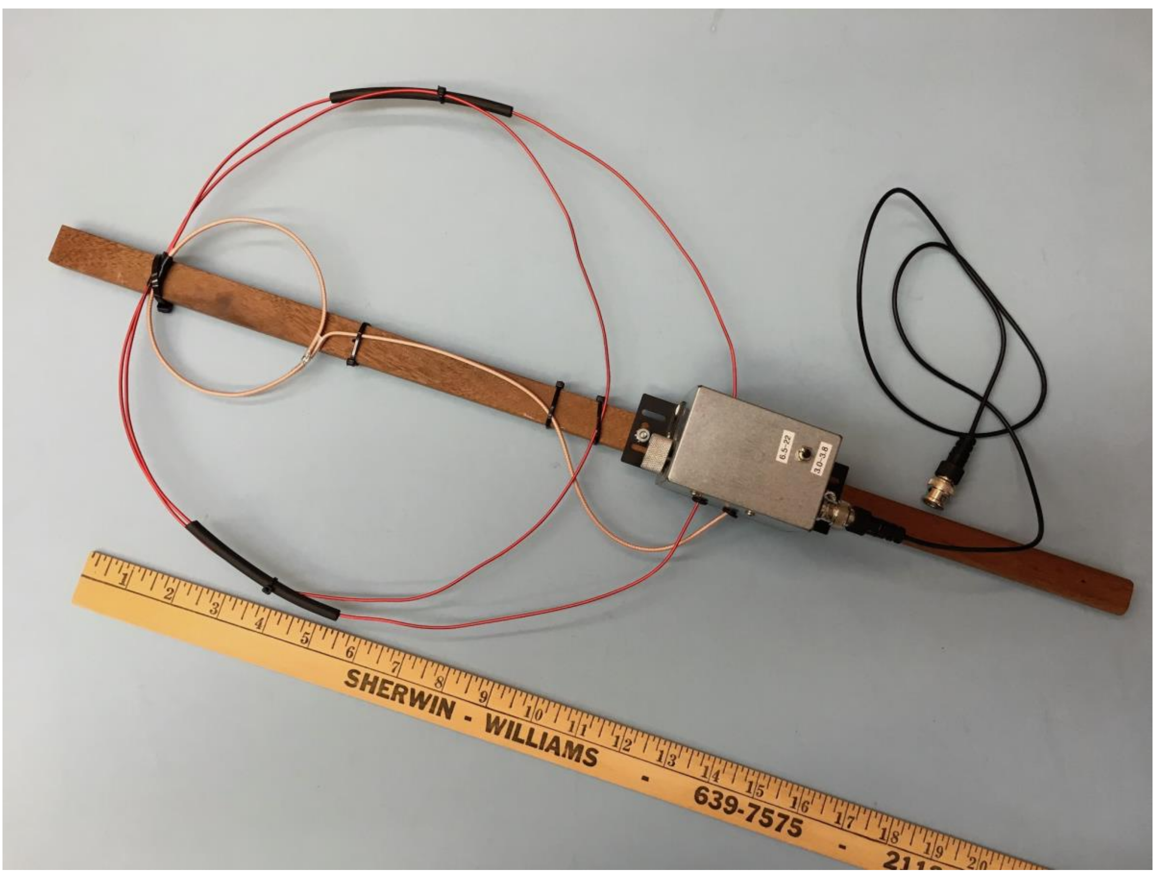

Figure 1. The complete antenna.

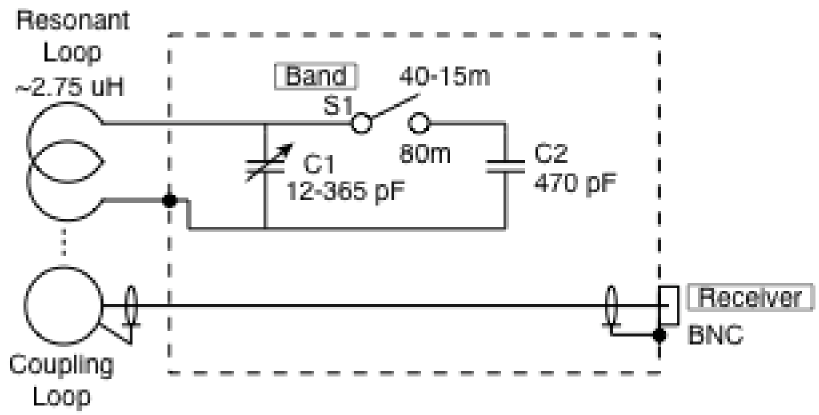

Figure 2. Direction finding antenna schematic.

Resonant Loop

The tricky part is finding a compromise loop diameter (wire length) that will cover the desired frequency range with reasonable capacitor values. This takes some experimentation. I ended up with 73 inches of 14 ga magnet wire (any insulated wire is fine), wound into a two-turn loop. The outer loop is about 12 inches diameter and is a bit egg-shaped to connect with the tuning box. Be sure the overlapping parts don't short to one another. Net inductance is around 2.75 uH.

Tuning Capacitors

The graph in Fig. 3 shows the approximate capacitance values for various frequencies. A single-section 365 pF variable capacitor will cover roughly 5-25 MHz. Then switch in a fixed 470 pF capacitor to cover 3-4 MHz. Something from an old transistor radio such as a plastic Polyvaricon will work, as will a common 12-365 pF air variable. Those are easy to find on Ebay or Amazon. If you can find one with gear reduction that will make tuning easier because the resonance is pretty sharp. (Or just use a larger knob.) The one I actually used was a rather different two-section variable but had a similar capacitance range. My band switched ranges ended up covering 3-4 and 6.5-22 MHz.

You could add additional capacitance to reach 1.9 MHz or even lower but the tuning range will be very limited. A larger loop and/or one with more turns would work better there. Similarly, if you are only interested in higher frequencies, a single-turn loop will let you reach 30 MHz or higher and will be easier to tune.

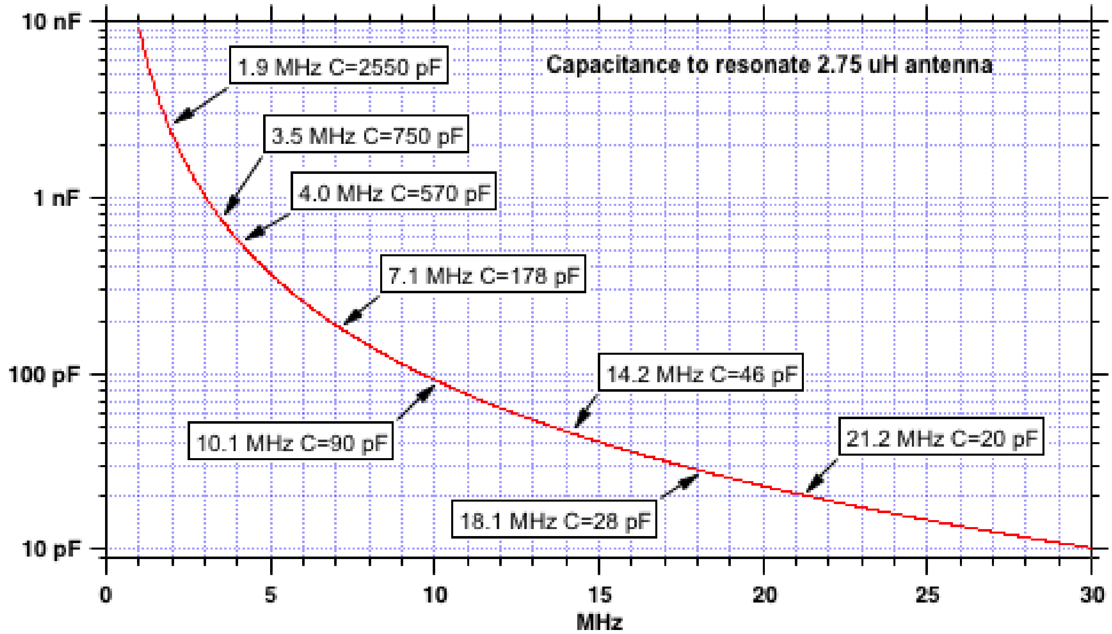

Figure 3. Approximate capacitance for various resonant frequencies.

Coupling Loop

Current flowing in the resonant loop can be picked up by several methods. I chose to use a coaxial coupling loop. Figure 4 shows the required shield and center conductor connections. I used RG316, a small Teflon coax, because it's easy to strip and easy to solder without melting insulation. RG58 will work fine. Loop diameter should be on the order of 20-25% of the resonant loop in order to obtain a match to 50 ohms, though that isn't terribly important in this receive-only application. Figures 5 through 7 show construction details. When working with small coax, use a sharp knife on the jacket and nip away the braid with diagonal cutters that have fine tips. Remember to install heatshrink tubing before soldering.

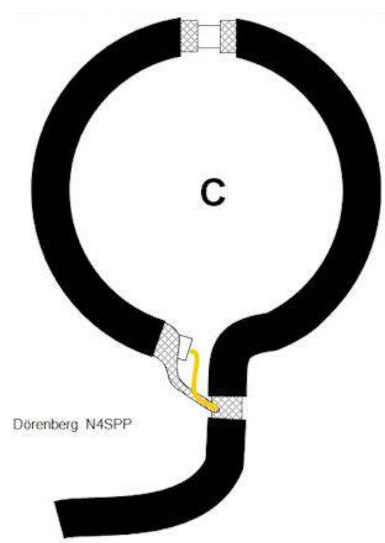

Figure 4. Detail of coupling loop connections [1].


Figure 5. Midpoint gap in the shield is covered with heatshrink.


Figure 6. Ready to solder the loop closed. Heatshrink is in position.

Figure 7. Completed pickup loop, about 3 inches diameter.

Enclosure, Assembly, and Testing
A metal enclosure is needed because hand capacitance will affect the tuning. I made my own from sheet metal (Fig. 8) but a single-gang outlet box is a possibility. Required size will depend upon the variable capacitor you have. The stator (fixed part) of the capacitor should be grounded to the enclosure. Then you can use a metal knob. If you don't have gear reduction, use a larger knob, at least 1.25 inches diameter. Run the resonant loop connections in through rubber grommets. Coax from the pickup loop can go to any kind of connector mounted on the enclosure. I used a BNC. Mount everything on a wooden stick or some kind of insulating support to make it easy to carry around.

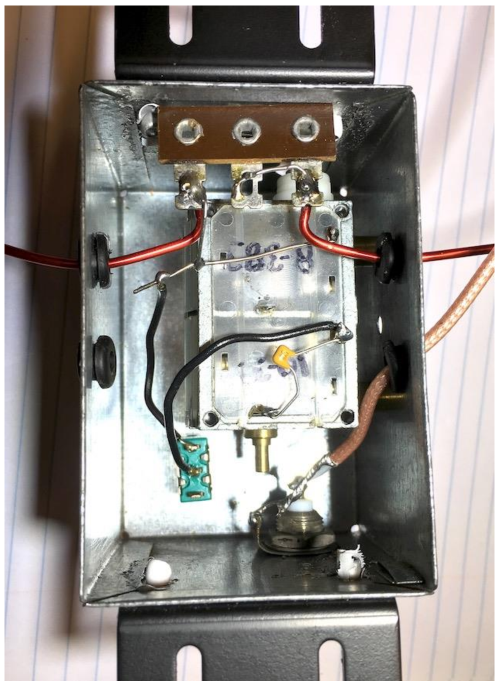

Figure 8. Inside my prototype tuning box.

If you have an antenna analyzer or VNA, connect it to the antenna output and look at the SWR as you tune the capacitor. You should see a very sharp dip in the SWR at resonance. My antenna had a very good match on 40-15 m with the SWR below 1.3:1. It was higher on 80 m, around 4:1, but this is perfectly acceptable.

Using the Antenna
You can use any kind of portable radio that covers the shortwave bands for RFI hunting. AM demodulation is preferred. I use an old Radio Shack DX-398 that I found on Ebay. If you have a portable spectrum analyzer or SDR with a waterfall display, that would be very useful. Because the antenna has narrow bandwidth, be sure to peak it up when you tune around. The noise level jumps right up at resonance.

Is it sensitive? Heck yeah. On 40m in the afternoon during a contest, I was standing in my back yard listening to the East coast with easy copy on CW. That is plenty of sensitivity for suburban noise hunting. The only time it may come up short is if you're trying to find some miniscule source of noise in an extremely quiet rural location. Some day I may try this as a QRP transceiving loop, just for fun.

My usual noise hunting procedure starts with a list of frequencies exhibiting RFI as detected on the station receiver. If the station has directional antennas, you might already know where to start looking. This antenna should exhibit a sharp null (looking thru the loop) and also a peak at 90 degrees to the null. It is most effective when the noise source is nearby, within a few wavelengths. If you walk right up to a noise source, the directionality often collapses but the relative signal strength can still tell you when you are getting closer. If the source is down the block somewhere, walk along with a Google Earth image of the neighborhood on a clipboard and draw heading lines from many locations. They will tend to intersect at some location. I easily found a problem in a nearby garage that way. Happy hunting!

References

1. Frank Dorenberg, N4SPP, "Small Magnetic Transmitting Loop for 80-20 Mtrs."
https://www.nonstopsystems.com/radio/frank_radio_antenna_magloop.htm