630m LOG experiments, Part 2

Rudy Severns N6LF June 2021

Part 1 of these notes gave details of some experiments with horizontal receiving loops lying on the ground (LOG) for 630m . The results were very positive, at least at my QTH, so I've taken the time to look more closely at these antennas. I found there is much more to be said.

2.1 **Open and closed loops**

To understand loop antennas it helps to start with a simple linear half-wave dipole like that shown in figure 1. If you open the center of the dipole and measure the impedance around the self resonant frequency (SRF) you'll find it behaves like a series resonant circuit, i.e. relatively low impedances near resonance. On the other hand if you were able to measure the impedance between ends of the dipole (not likely but as a thought experiment), with the center shorted, you would find very high impedance like a parallel resonant circuit.

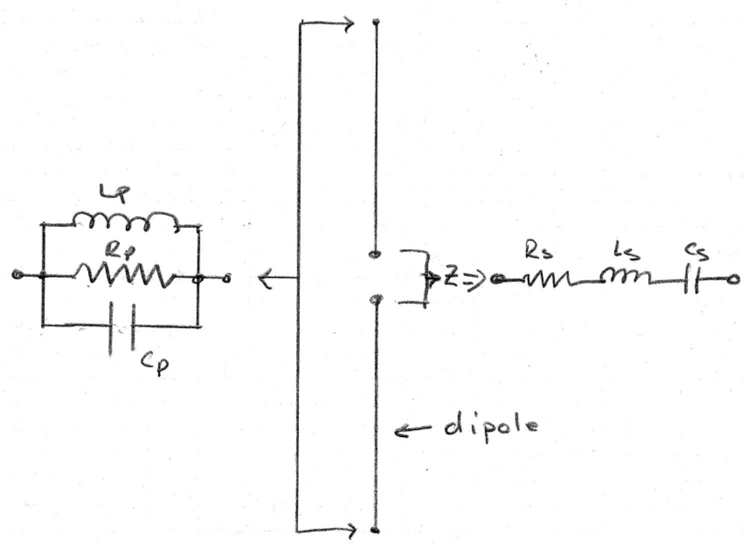

Figure 1 - dipole

As shown in figure 2 the dipole can be bent into a loop so that the opposite ends are now close together making an impedance measurement readily possible.

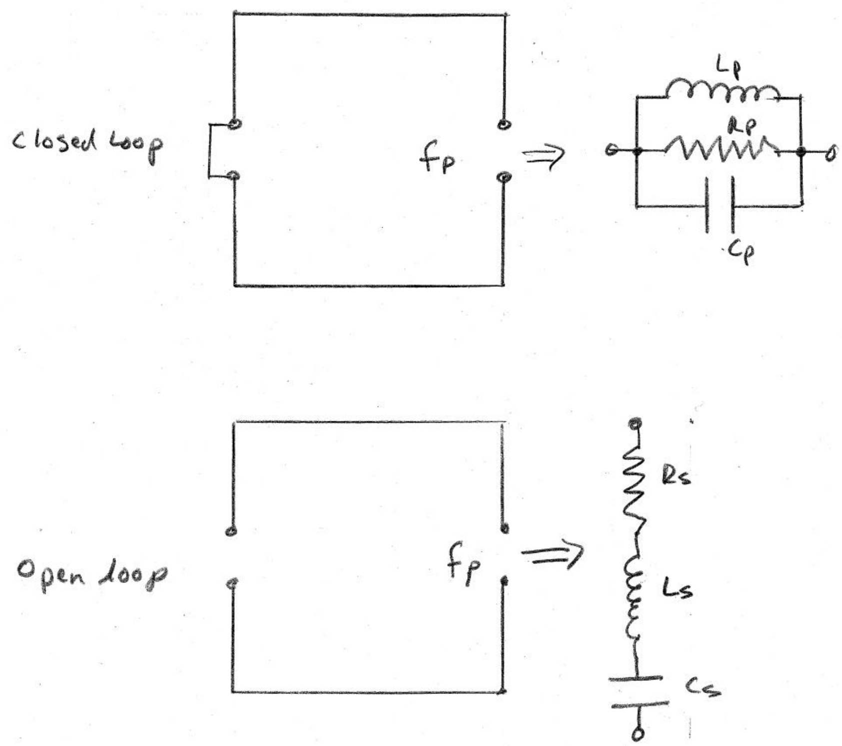

Figure 2 - Open and closed loops.

Two cases are shown, a closed loop with the center shorted and an open loop with the center open. In the closed loop version the feedpoint impedance behaves like a parallel resonant circuit. In the open loop version the feedpoint impedance behaves like a series resonant circuit. If you measure SRF in a closed loop and then simply open the opposite side, you'll find that the SRF doesn't change, just the character of the impedance. For the same loop antenna you can chose to have either a high Z or a low Z at the feedpoint whichever is most convenient.

Although most of this discussion concerns a single turn loop on the ground the basic ideas extend to a multi-turn loop as shown in figure 3.

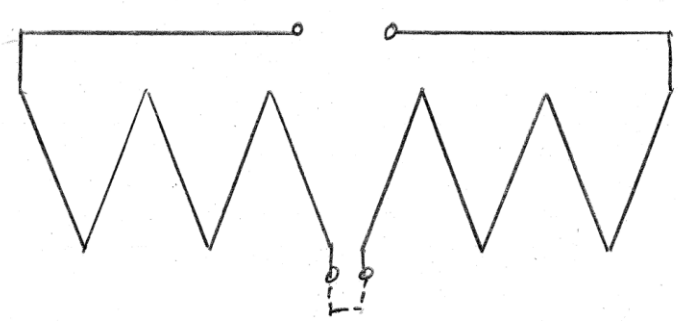

Figure 3 - Dipole wound into a multi-turn loop.

As shown in figure 4 a closed loop may be fed at any point in the loop with no change in feedpoint impedance. The only effect of shifting the feedpoint is to rotate the radiation pattern. The dashed lines indicate the direction of maximum vertical (V) and horizontal (H) polarized reception.

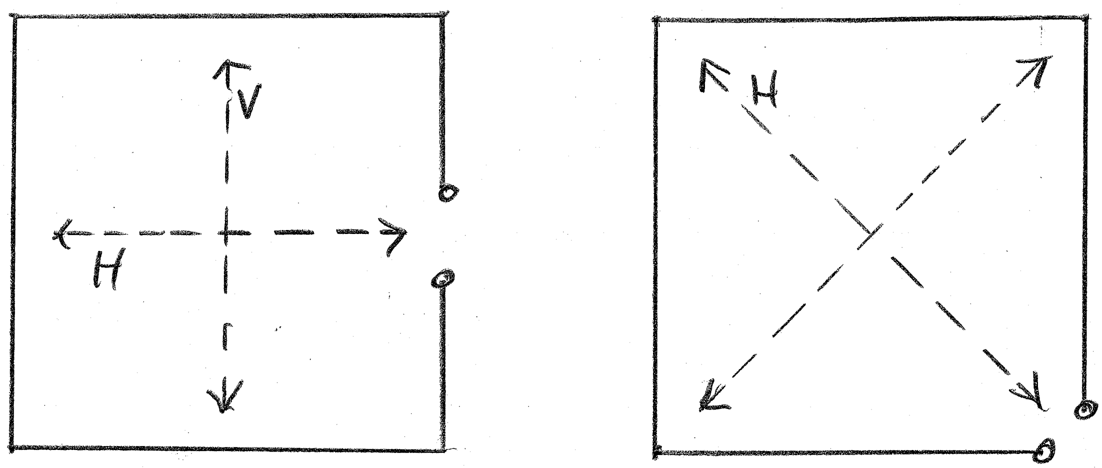

Figure 4 - Effect of shifting feedpoint on radiation pattern.

As shown in figure 5, the open loop behaves quite differently. If the open point is fixed and the feedpoint is shifted the only change is the impedance seen at the feedpoint. Moving the feedpoint away from opposite the open point gradually increases the feedpoint impedance as the feedpoint moves toward the open. The radiation pattern however, does not change, with one caveat. This is true when the loop is near resonance. Going away from resonance the radiation pattern shifts when the feedpoint is moved relative to the open point but near resonance the effect is very small. One comment, a matching transformer is shown in figure 5, it is also possible to insert a coupling loop within the outer loop which, depending on the relative areas, acts as matching transformer. The principle is the same.

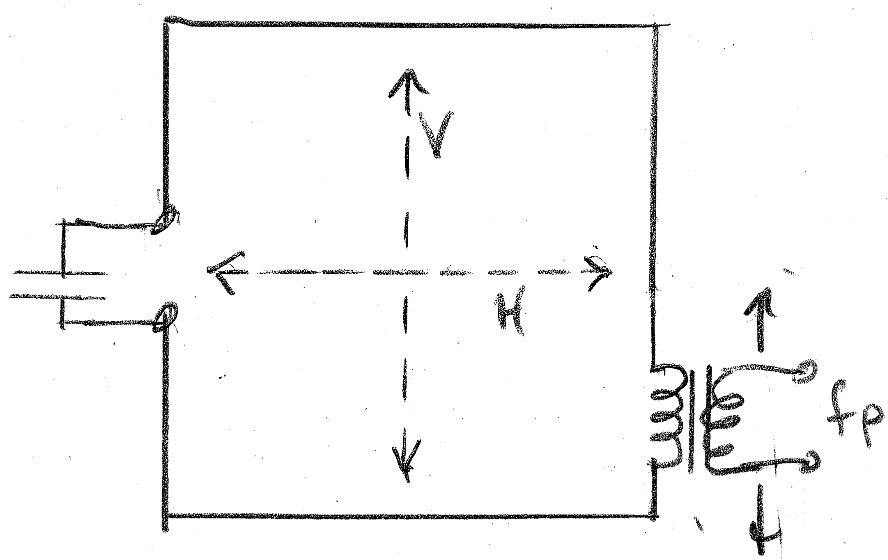

Figure 5 - Shifting the feedpoint in an open loop.

The ability to change the feedpoint location without changing the pattern can be very handy. I wanted the vertical pattern oriented E-W but the placement of the loop is fixed by the property lines. For the LOG described earlier in part one this meant I had to have the feedpoint located on the south side of the loop which put the feedpoint which included an amplifier and a common mode choke in a box in the middle of my neighbors field. That worked but was not ideal. For the latest antenna by opening the loop at the middle of the north side (small red box) as shown in figure 6, I was able to keep the loop the physically same but with a feedpoint (round circle) in the lower left (SW) corner. The new feedpoint was 80' closer to the shack and allowed the feedline to be fed away on a diagonal reducing coupling to the loop. In addition the impedance at the new feedpoint was low and allowed matching and isolation with a simple transformer.

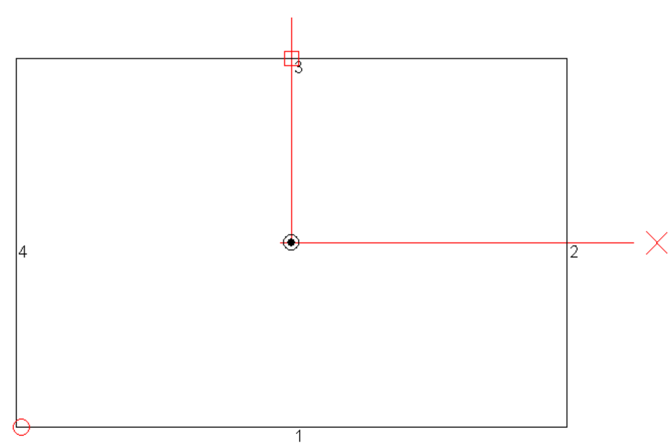

Figure 6 - New LOG at N6LF. The X direction points east.

This antenna is 146' E-W by 100' N-S. The small square at the top includes a series capacitance of TBD pF. Impedance measurements on the actual antenna, with and without the resonating capacitor, are given in figure 7.

{measurement yet to be made}

Figure 7 -

To obtain maximum signal output on a given band it is usually desirable for the loop to be resonant. However, at 630m and even more so at 2200m it may not be practical to make the loop large enough to be self resonant so as a practical matter some lumped reactive loading must be added. As shown in figure 8 there are several possibilities using capacitance. While inductors could also work most of the time a capacitor will prove simpler and more efficient, particularly if some tuning adjustment is wanted. At a high impedance feedpoint shunt C can be added for resonance (A). In the case of a low impedance feedpoint capacitance can be added across the normally open terminals (B).

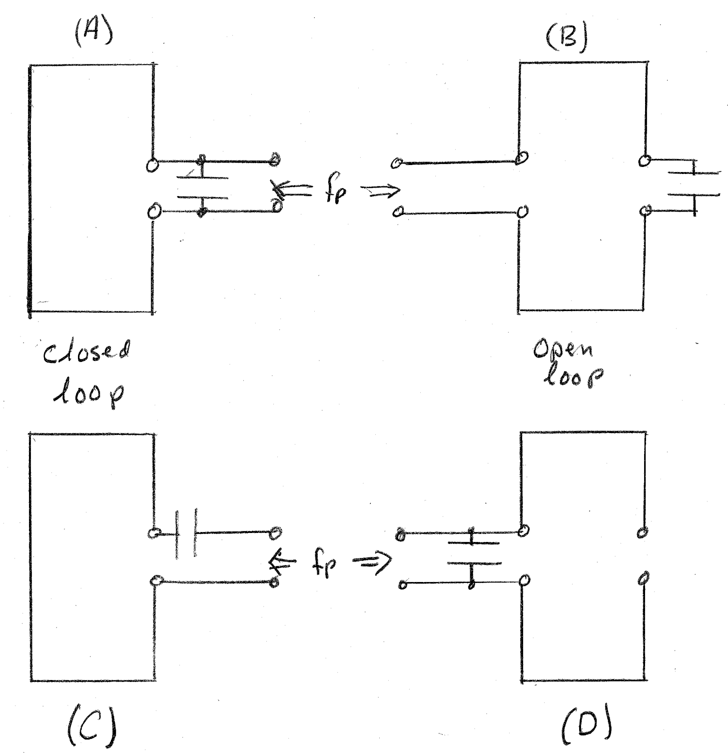

Figure 8 - Loop loading for resonance.

Figure 8 also show two other possibilities (C & D) which provide somewhat different results. Scheme (C) was used earlier in the LOG experiments with a closed loop.

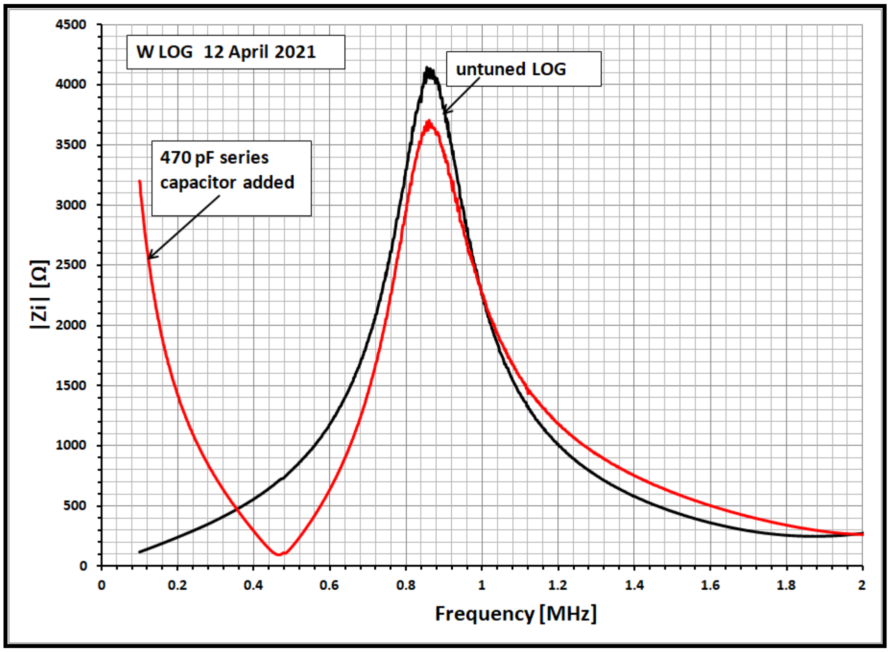

Figure 9 - Zi with and without series 470 pF capacitor.

Figure 9 is a graph of the feedpoint impedance (Zi) with and without series capacitance at the feedpoint. This scheme does not shift the SRF downward, instead it introduces a new series resonance at 475 kHz. Scheme (D) has a different effect, it leaves the series resonant impedance unchanged but adds a parallel resonance at a higher frequency. It's not obvious when this might be useful but was mentioned to complete the picture.\

2.2 Induced voltage in loop

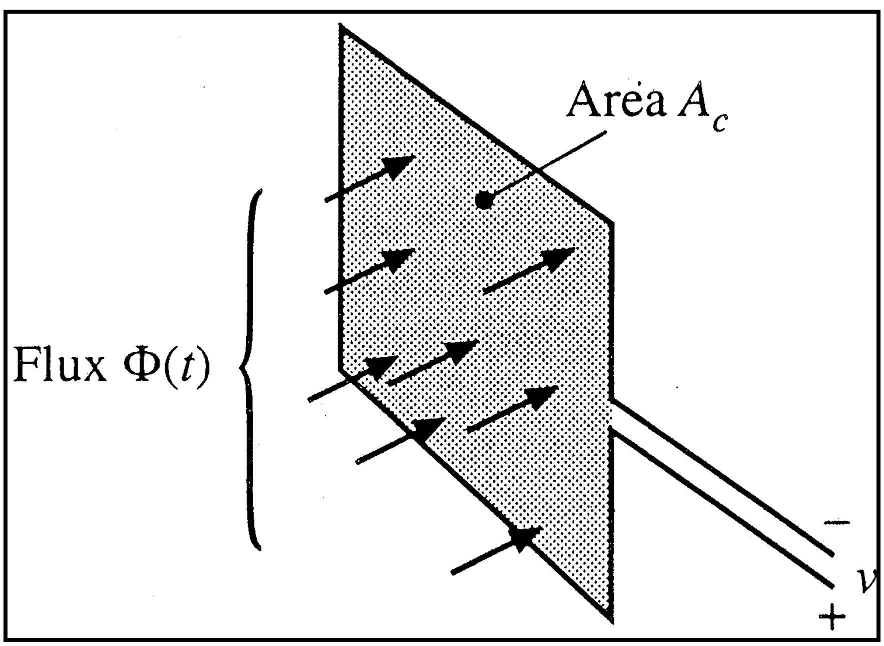

Figure 10 -Magnetic flux through an O/C loop.

Figure 10 is a sketch of an idealized loop. The voltage induced in the loop by the incoming signal can be expressed by:

$$\boldsymbol{v \propto \Phi N f = H_o N A_c f} \quad (1)$$

Where:

Φ=flux through the coil=H_oA_c , H_o= peak field intensity A/m, v= voltage at the feedpoint with no load (open circuit, O/C), N= number of turns, A_c= area of the coil and f= frequency.

Equation (1) is telling us it that for given signal (H_o) at a given frequency (f) if we want more voltage at the output we can increase the number of turns (N) and/or the area of the loop. Note, the shape of the loop has not been mentioned, only it's area.

2.3 Loop geometry

The shape of the loop is not critical, circle, polygon, etc can all work. Symmetry is also not required. For example the loop shown in figure 5 is a rectangle and works well.