Antennas

G3LDO's experiences with a small transmitting loop antenna

PHOTO 1: The G3LDO loop antenna with mechanical capacitor tuning.

SMALL TRANSMITTING LOOPS. I have talked about loop antenna several times but all this has been the work of other people. I had never actually built a small transmitting loop so I felt that it was high time this omission was rectified. This column is devoted to my experiences with this antenna.

The limiting factor in homebrewing a small transmitting loop is the tuning capacitor. You need a good quality two-ganged or butterfly transmitting capacitor or a fairly rugged vacuum capacitor. It also has to be well engineered into the loop. Because the bandwidth of the antenna is so small, a method varying the capacitor also has to be built into the system.

For the purposes of just trying out the transmitting loop I used a capacitor arrangement using hinged plates, as described by Martin Ehrenfried, G8JNJ **[1]**. I will describe its construction later.

COMPUTER MODELS. My first step was to make a computer model of the loop using EZNEC 5. I had heard that EZNEC did not model a transmitting loop accurately but this suggestion may have been propagated by someone whose theories on the loop did not match the modelled data. Part of this loop-building project was to investigate the suitability of a computer model.

The free-space model of a 1.5m diameter hexagonal loop made from 22mm diameter copper tube is shown in **Figure 1**. The model was brought into resonance with a 24pF capacitance load, giving a 2:1 SWR bandwidth 24kHz as shown in **Figure 2**. The model predicted a maximum gain of 1.34dBi (including 22mm copper losses) compared with 2.2dBi for a loss-less free-space dipole. This loop model predicts that my loop will be around 80% efficient compared with a dipole.

If you are considering constructing a small transmitting loop antenna, there are a few interactive computer programs on the Internet. The 66Pacific.com magnetic loop antenna calculator **[2]** shown in **Figure 3** is based on *ARRL Antenna Handbook* material and is the one used to calculate the parameters of the loop I intended to build.

LOOP CONSTRUCTION. The loop is made from 22mm copper tubing in an octagonal configuration as shown in **Photo 1**. The loop described by G8JNJ also used 22mm copper tubing but in a square loop and for this he used four 90° elbow soldered couplings to form the square.

Almost all of the material used to construct this loop was obtained from a local DIY shop except the eight 45° couplings that were not available locally and had to be sourced from a plumbers outlet. A Tee coupler was used at the base of the loop to provide a short stub mast for fixing the loop to an antenna support.

FIGURE 1: EZNEC 5 free space model of the proposed loop antenna.

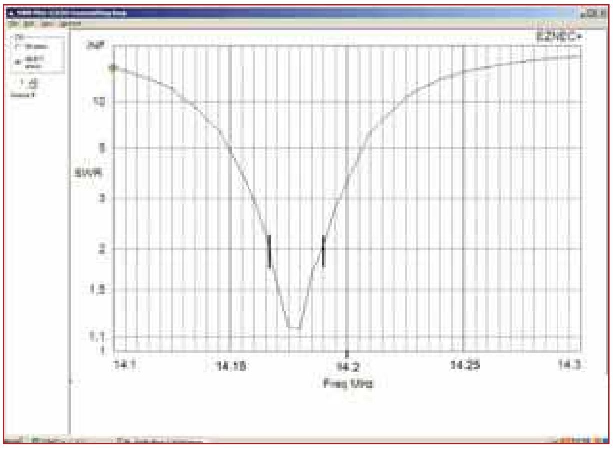

FIGURE 2: SWR curve the loop predicted by EZNEC.

Most designs seem to use a 1m diameter loop for the bands 20 to 10 metres. In view of the state of the sunspots at the time of writing, I used a larger loop of 1.5m diameter loop to hopefully cover 7 to 22MHz.

CAPACITOR CONSTRUCTION. The capacitor is made from two aluminium plates fixed on hinges at the ends of the copper loop. I used 6 x 12in plates because that is what I happened to have to hand. A drawstring and bungee cord arrangement is used to adjust the angle of the capacitor plates relative to each other, which in turn adjusts the value of the capacitance. The ends of the loop were flattened, which made a convenient point onto which to solder the brass hinges.

All descriptions of small transmitting loop construction emphasise the importance of overcoming the RF resistance of the capacitance to loop connection. This arrangement is no exception – the hinge, although made of brass, would probably present a relatively high RF resistance, which is circumvented using coax cable braid as shown in **Photo 2**. Copper pads are used to make the connections to the aluminium capacitor plates.

The capacitor plates held in the open position with ¼ in (6mm) bungee cord. Capacitor variation is achieved using strimmer line and nylon cord to pull the capacitor plates together against tension created by the bungee cord, which is best seen in Photo 1. The bungee tension is found by trial and error. The strimmer cord is connected to the ends of the aluminium capacitance plates in a cross-diagonal manner using 22mm plastic tube clips as shown in Photo 1. The strimmer cord runs through small holes drilled in these plastic clips.

I calculated the maximum capacitance with the plates 4mm apart as 100pF, which

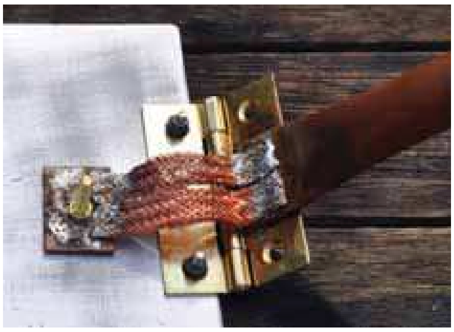

PHOTO 2: Detail of the capacitor hinge.

PHOTO 3: Construction of the variable capacitor with an additional parallel fixed lower frequency capacitor made from a short length of RG213 (see text).

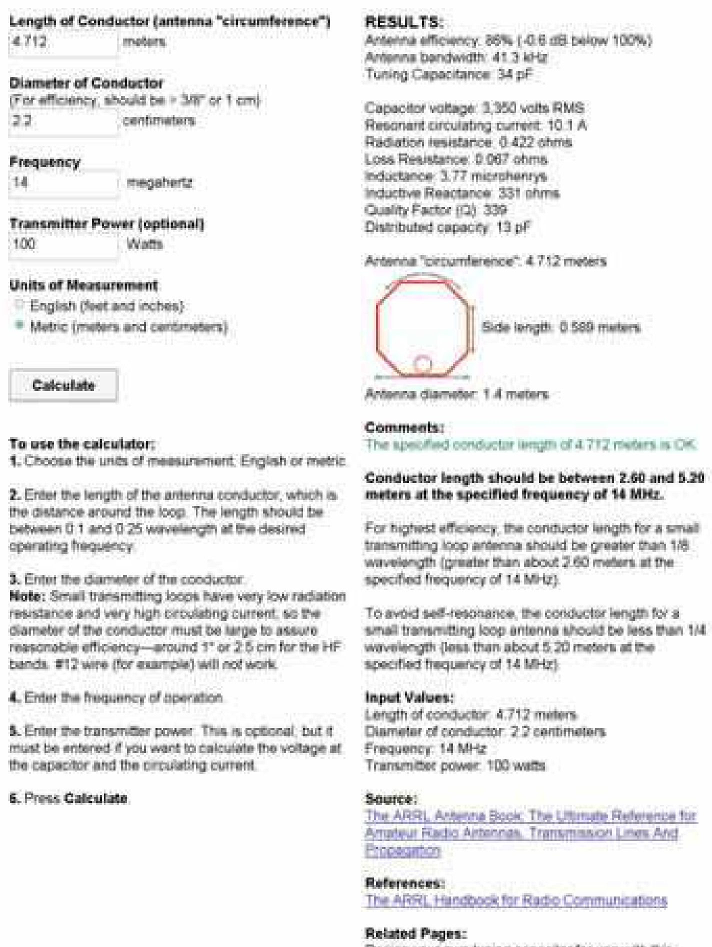

FIGURE 3: Calculations of the proposed loop antenna.

theoretically should tune my loop down to 10MHz. An insulator block is required to fix the distance between the two hinges. I used a block of dark coloured Perspex 10mm thick of unknown pedigree.

The complete capacitor is shown in **Photo 3**. A coax fixed capacitor stub shown in the photo was used during the experiments with this capacitor arrangement – I will describe the reason for this later.

Almost all loop capacitor methods use a motor/gear box arrangement to vary the capacitor and tune the loop. I used a simpler arrangement where the lower part of nylon cord section is wrapped around the lower part of the loop and secured with a plastic clip when the tuning point is found. This method of tuning was fine for testing the viability of the loop and was adopted because a suitable motor/gearbox was not available.

FEED METHOD AND TUNING. I chose the simple shunt feed (some call it a Gamma match) as shown in Photo 1. I made a guess as to where to connect the shunt feed clip to the loop, connected the MFJ 259 analyser (set to 14.2MHz) to the feed point and pulled the cord of the tuning mechanism. The MFJ 259 registered an SWR dip of 1.5:1 on the first attempt. A small position adjustment of the shunt feed clip to the loop reduced the SWR to a much lower value.

I also tried the G3LHZ 'twisted gamma' match described in my July Antennas column, using the centre conductor and insulation of a section of 75Ω coax (1mm conductor with 2.3mm thick insulation). The SWR and impedance matching results shown in Figure 3 showed no discernable difference between the short and long twisted gamma matches. G8JNJ is of the opinion that these gamma matches are a sort of loop rather than a shunt feed.

OPERATIONAL TESTS. Tuning was quite straightforward, particularly with an active SWR meter such as the MFJ 259/269 type of instrument. Otherwise you can tune for maximum noise and signals on receive and fine tune on low power transmit with an SWR meter. The tuning arrangement performed reasonably well with just a bit of friction where the strimmer cord goes through the plastic pipe clip holes.

The tuning range was not as great as the model suggested; the practical range covered only the 10, 14 and 18MHz bands. The reason is that the minimum capacitance of the hinged plate capacitor is greater than expected, although it was not possible to measure this capacitance with it connected to the loop. Adjustment of the capacitance at the lowest frequency range proved to be rather critical with this tuning arrangement. You can appreciate why when you consider that the difference in capacitance with plate spacings from 4 to 8mm results in a capacitance change of 50pF.

The solution is to add a fixed capacitor in parallel with the variable one when using the antenna on the lower frequencies. This has the effect of 'bandspreading' the tuning. I tried a short length of RG-213 coax as shown in Photo 3 and this worked quite well up to 100W; however, it flashed over at 200W. A better arrangement would be a fixed capacitance made from two aluminium plates fixed to the brass bolts and nuts seen in Photo 3. The minimum capacitance could be reduced by cutting off the two top (hinge) corners of each of the variable plates.

This loop was tested only on the 14 and 18MHz bands. My initial impressions were that it performed as well as a very good mobile antenna. The loop was mounted 2m above the ground well away from the house via a feeder comprising 43m of RG213 and 10m of RG58. The comparison antenna was an 11m high multiband rotary dipole on top of the house, fed via 15m of RG213.

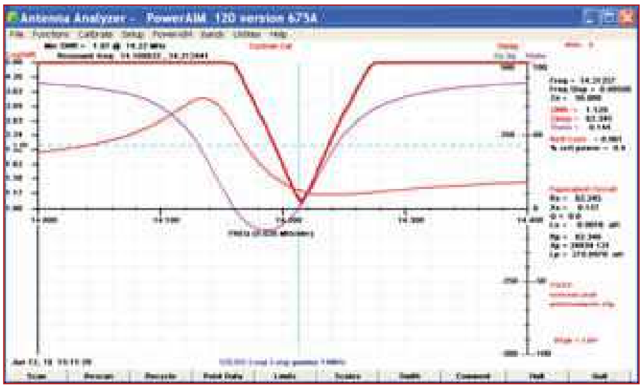

FIGURE 4: Measurements of SWR, Z magnitude and Theta of the finished loop. Compare the SWR with that predicted in Figure 2.

There was very little difference between the two antennas on short skip contacts. Sometimes the loop gave the best results, other times the dipole did best. DX signals were a different matter, with the dipole 2 to 3 S-points ahead of the loop. On the other hand, the loop was often better on receive because it was so quiet.

REFERENCES

[1] http://g8jnj.webs.com
[2] www.66pacific.com/calculators/small_tx_loop_calc.aspx