Peter Dodd's

# antenna workshop

Peter Dodd G3LDO, investigates using a magnetic loop antenna on the h.f. bands.

Welcome to *Antenna Workshop* (*AW*). This time, I'm looking at the magnetic loop antenna, which would appear to provide an ideal solution for those wishing to operate on high frequencies (h.f.) from a restricted site. It can be hidden very conveniently in the loft, a balcony of a high-rise apartment or a rooftop.

Many of us, as Radio Amateurs, are facing the prospect of having to give up a much loved hobby due to strict rules against erecting outside antennas. In spite of these restrictions, a practical and viable solution to actively continuing the hobby may be the small magnetic loop antenna.

Unfortunately, the magnetic loop antenna has been the subject of some controversy in the past – with some experts claiming that the magnetic loop is very inefficient. Additionally, a conventional magnetic loop antenna requires a good quality low-loss split stator, butterfly, or vacuum variable capacitor of adequate r.f. voltage and current rating. This restriction imposed by the capacitor may be circumvented by using a capacitor arrangement using hinged plates, as described by **Martin Ehrenfried, G8JNJ**‡1. So, I'll now describe my experience constructing such an antenna.

## Loop Construction

Most designs seem to use a one metre-diameter loop for the bands 14 to 29MHz. However, if you are considering constructing a small transmitting loop antenna, there are a few interactive computer programs on the Internet. I used the one obtainable that's based on *ARRL Antenna Handbook* material‡2.
In view of the state of the sunspots at the time of writing, I used a larger 1.5m diameter loop to hopefully cover 7 to 22MHz. But the design didn't go quite to plan! – as I will describe later.

The loop is made from 22mm copper tubing in an octagonal configuration as shown in **Fig. 1**. Each section of the octagon is 580mm long. Almost all of the material used to construct this loop was obtained from a local DIY shop, although the eight 45° couplings used on my loop weren't available locally and had to be sourced from a plumbing supplies outlet. A T-coupler was used at the base of the loop to provide a short stub mast for fixing the loop to a support pole.

The small loop antenna has a very low radiation resistance order of 0.1–0.3**Ω**. This competes with the ohmic resistances of the loop conductor itself and the resistances from connections and soldered joints, including the tuning capacitor connection. This means that, depending on the frequency, every additional bit of resistance caused by a poor contact, will cost you in the loop's efficiency.

I checked the resistance of my soldered joints by passing 10A through each joint and measuring the voltage drop (in mV) across it. The current was provided by a battery charger charging a lead acid battery, with the joint in the charging path as shown in **Fig. 2**. (A current limited power supply would be a more convenient current source). Most joints registered 0.1mV but one faulty joint resisted 0.2mV until remade. My digital voltmeters have a resolution of only 0.1mV – but the readings were adequate to show up the faulty joint.

## Capacitor Construction.

The capacitor comprises two aluminium plates fixed on hinges at the copper loop ends with brass nuts and bolts. A drawstring and bungee cord arrangement is used to adjust the angle of the capacitor plates relative to each other. This, 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 r.f. resistance of the capacitance to loop connection. This arrangement is no exception – the hinge, although made of brass, would probably present a relatively high r.f.

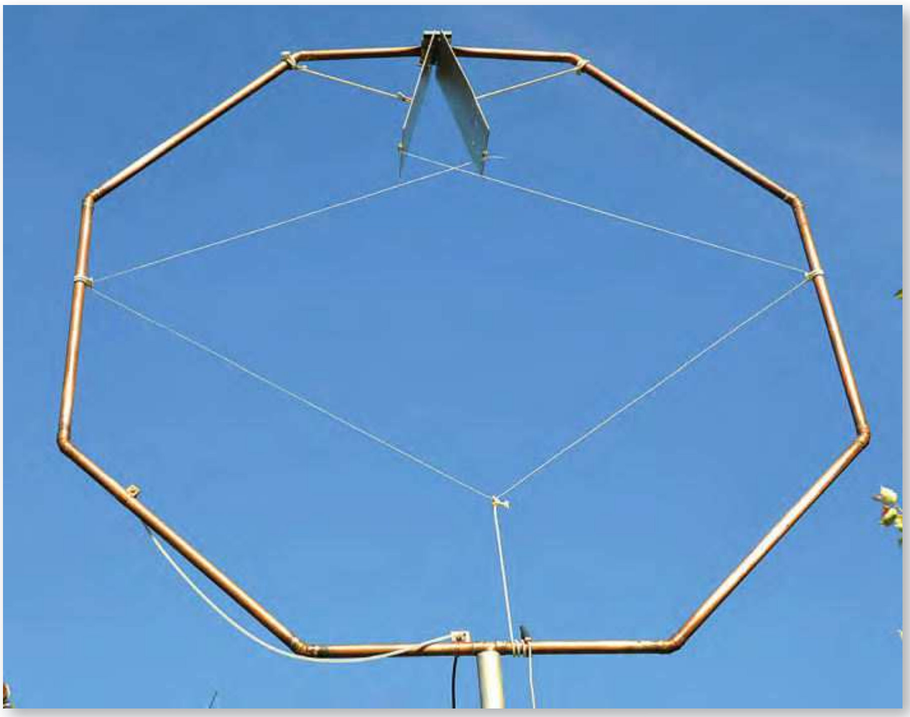


*Fig 1: The G3LDO magnetic loop antenna with mechanical capacitor tuning.*

resistance, which is circumvented using coaxial cable braid as shown in Fig. 2. Copper pads are used to make the connections to the aluminium capacitor plates.

The capacitor plates are held in the open position with 5mm thick bungee cord. Capacitor variation is achieved using strimmer and nylon cord to pull the capacitor plates together against tension created by the bungee cord, which is best seen in Fig. 1.

The tension in the bungee cords 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 Fig. 1. The strimmer cord runs through small holes drilled in these plastic clips.

I orginally constructed the loop with two rectangle aluminium capacitor plates 150 x 300mm. This gave a maximum capacitance with the plates 4mm apart of 100pF, which theoretically should have tuned the loop down to 10MHz. In the event the loop would not tune down to 10MHz, so I replaced the rectangle capacitor plates with larger elongated hexagonal plates to reduce the minimum and increase the maximum value of the capacitance.

*Fig 3: Detail of the capacitor with the coaxial cable braid to provide an r.f. bypass of the hinges.*

An insulation block is required to fix the distance between the two hinges. I used a block of 10mm thick dark coloured Perspex of unknown pedigree. The complete capacitor is shown in **Fig. 3**. Almost all loop

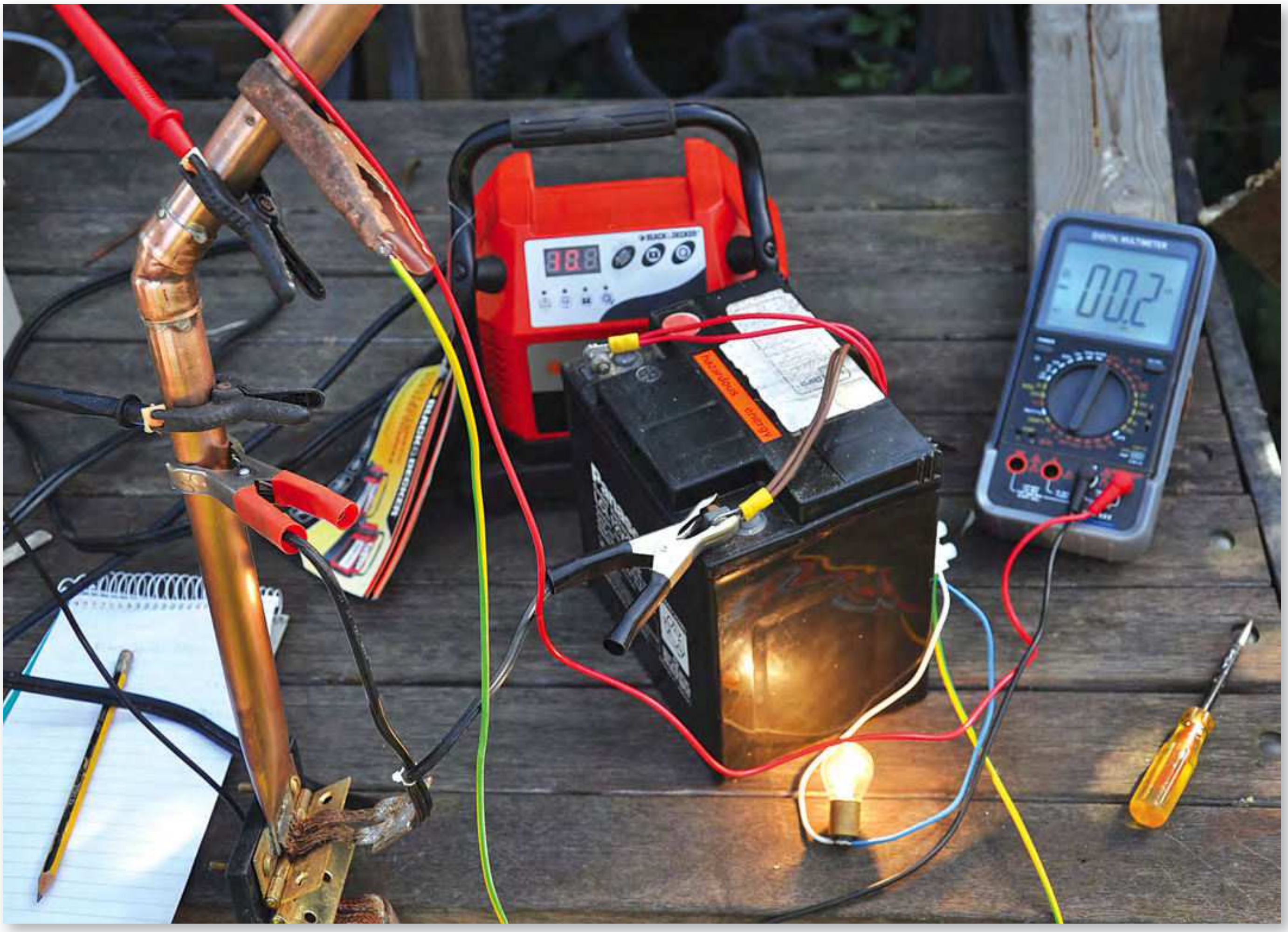
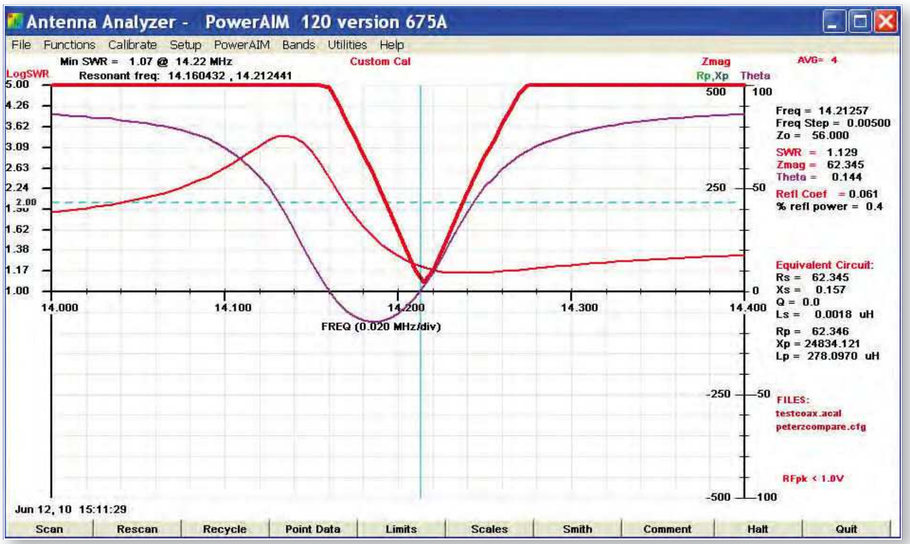


*Fig 2: Method of testing a copper pipe joint using 10A battery charger. The bulb provides a current limiting load to prevent the battery over-charging during the test.*




capacitor methods use a motor/gear box arrangement to vary the capacitor and tune the loop.

I used a simple arrangement where the lower part of nylon cord section was 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 although impractical as a usable loop. A small motor/gearbox with the nylon cord round a miniature winch would provide remote tuning of the antenna.

## Feed Method & Tuning

I chose the simple shunt feed (some call it a Gamma match) as shown in Fig. 1. I made a best guess, as to where to connect the shunt feed clip to the loop. Then I connected the MFJ 265 analyser (set to 14.2MHz) to the feed point and pulled the cord of the tuning mechanism.

The MFJ 261 dipped to an s.w.r. of 1.5:1 on the first attempt. A small position adjustment of the shunt feed clip to the loop reduced the s.w.r. to a much lower value. An s.w.r. and impedance plot of the antenna after adjustment is shown in **Fig. 4**.

## Operational Tests

Tuning the loop was quite straightforward, particularly with an active s.w.r. 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 s.w.r. 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 wasn't as great as I hoped and the practical range covered only the 10, 14 and 18MHz bands. The reason for this is that the minimum capacitance of the hinged plate capacitor is greater than I had thought. (Although it wasn't 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 the tuning arrangement adopted. Readers will no doubt – appreciate why when we consider that the difference in capacitance with plate spacings ranging from 4 to 8mm, results in a capacitance change of 60pF.

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 on the lower frequencies at the expense of loss of coverage on the higher frequencies.

I tried a short length of RG-213 coaxial cable 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 holding the hinges in place.

## Loop Tested

This loop was tested on the 10, 14 and 18MHz bands, though most of my tests were conducted on 14MHz. My initial impressions were that it performed very well for such a small antenna. The loop was mounted on the roof of the house extension around four metres high. The comparison antenna was multi-band rotary dipole 11m high on top of the house chimney.


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***Fig 4: Measurements of s.w.r., Z magnitude and Theta of the finished loop using the AIM 4710.***

There was very little difference between the two antennas on short skip contacts. Sometimes the loop gave the best results, at other times, the dipole performed better. On average the dipole was 2dB better, measured using the *WSPR* programme, than the loop on DX contacts with stations at a distance of over 6000km. (I hope to publish details of the comparative performance antennas using this method in a later *Antenna Workshop)*.

Unlike conventional antennas, compact loop mounting height isn't so important, as long as it is at least one loop diameter above the ground. It should mounted as far away as possible from electrical wiring. The ideal position for a loop antenna is on a raised flat roof or in a large loft with the loop above an earth mat of a dozen or so radials twice the loop diameter in length.

The coaxial cable feed to the loop should ideally be routed vertically down from the loop to the ground to get the best s.w.r. and to minimise common-mode currents on the cable.

## Reasonable Efficient

This design was investigated to gain some experience with small transmitting loop antennas and the good news is that it appears to be reasonably efficient. The down side of this capacitor arrangement is that it requires protection from the weather because any wind can move the capacitor plates. A frictionless arrangement for the strimmer cord at the sides of the loop, such as small plastic pulleys, would make tuning easier. Cheerio until next time! ●

**References**


[‡1] **http://g8jnj.webs.com/**

[‡2] **www.66pacific.com/calculators**
Then go to Magnetic Loop Antennas.