Antenna Workshop

Don't be an Alligator!

Geoff Cottrell G3XGC offers you a loop antenna designed to improve your station's capability on the 1.8MHz band.

In Top-band-speak, 'alligators' are 'all mouth' and have 'no ears'. It's a term thought to have originated in America.

When I moved to my present suburban terraced house in Oxford in 2000, I hadn't operated on-air since the late 1960s and gave no thought to the Amateur Radio potential of the site. But what pitched me back into activity was the loan of an old h.f transceiver and a curiosity to see how the bands sounded. However, the new QTH was not exactly ideal, with a garden 20 x 6m surrounded by (r.f. noise generating) houses in a densely populated area.

Then the bug bit, I had to get onto 1.8MHz from this location. I wasn't then aware of the high level of radio frequency interference (r.f.i.) that bedevils today's would-be 'Topbander' in suburban locations like mine. When I first tried listening using a simple wire antenna, all I heard was broadband noise, with the occasional very strong station breaking through.

The band noise comes from a number of different local sources, such as harmonics of the ubiquitous and often poorly suppressed switch-mode power supplies, computer monitors, plasma TVs and so on.

One day, I noticed a sudden drastic increase in noise level, which I eventually traced to one faulty and very noisy switch-mode power supply in my own house. Needless to say, it was immediately replaced! But there's not much that can be done about the multiplicity of failing or poorly specified equipment in surrounding properties. Problems with r.f. interference are worse on this band than any other, with the exception of 136kHz!

Some Research

I embarked on some research and experiments to see if matters could be improved. My sources were the Internet and useful publications (see references). For DX top band operation on 1.8MHz, the gurus generally deem separate receiving antennas to be necessary. This is because vertically-polarised transmit antennas pick-up much local noise in reception.

Many of the 'big' 1.8MHz stations seemed to have some very effective Beverage receiving antennas. But these require a lot of space - a typical Beverage can extend some 260m or more. Such large antennas were clearly out of the question for my limited space. However, there was a viable alternative in the 'small' loop antenna designs.

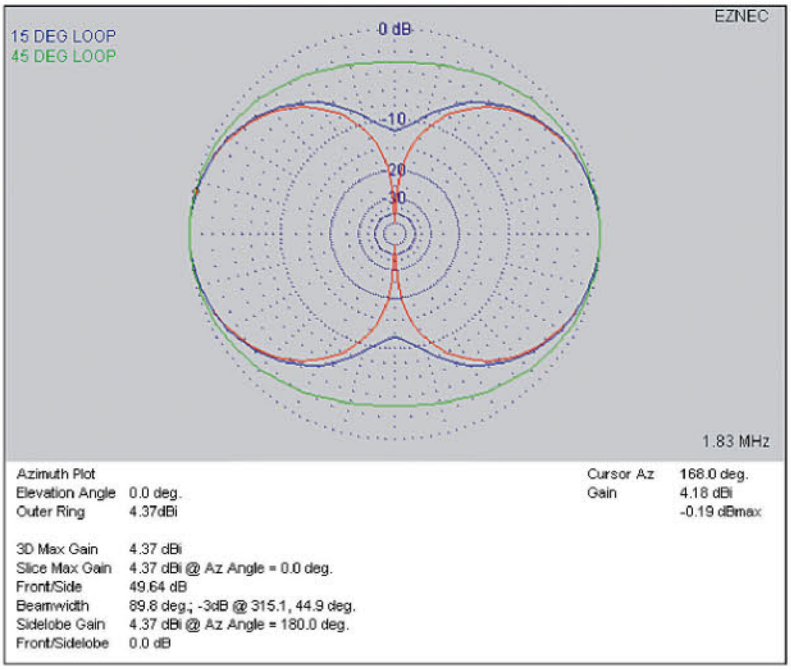

Fig 1: Azimuthal plots of the loop polar diagram seen from above with the plane of the loop lying along the horizontal axis and with the scale marked in decibels (EZNEC model). The red curve is for 0° elevation – note the two sharp nulls aligned with the central axis of the loop. The blue curve is for 15° elevation and the green curve is for 45° elevation. Note: the response becomes more omni directional for higher elevation angles.

Besides being small enough to fit in my garden, a really useful feature of a loop antenna is the existence of one or more deep nulls in the reception pattern at low elevations, **Fig. 1**. The idea is to use the directional nulls in the loop's pattern to attenuate local interference whilst having little effect on the wanted signal arriving at higher elevations. By rotating the loop, the nulls can be oriented in the direction of a local noise source and reduce it by some tens of dB, so giving an overall improvement in signal-to-noise ratio on the DX.

The loop described here is resonant in the 1.8-2MHz band. Incidentally, an additional advantage of having a tuned antenna is that strong out-of-band signals are attenuated before entering the receiver where undesirable intermodulation products could be generated.

Extensive Tests

After extensive tests, the most effective loop design that I've found (not to mention cheap!) is one made using some spare coaxial cable, **Fig. 2**. The antenna is electrically balanced and symmetric about its vertical axis. There is a braid-break in the coaxial outer conductor at the top and a simple matching circuit at the bottom feed-point. It is important to realise that this loop is not a purely 'magnetic' antenna - the coaxial cable outer conductor is not an electrostatic shield but forms an integral part of the antenna.

The loop works best when sited far away from local houses. This means putting it at the end of my garden where it feeds some 40m of RG58 coaxial cable running to the shack in the attic. Despite having only passive components at the feed-point, losses are minimal and the signal levels I get at the receiver are in general high enough for me not to need any additional pre-amplification.

The loop is a resonator. A parallel tuned circuit is formed by connecting the inductance of the loop (i.e. the two ends of the inner coaxial conductor) to the tuning capacitor C1, which can be varied to resonate the loop to any desired part of the band. I chose the c.w. end of the band. The bandwidth of the loop is about 50kHz, so the loop also covers the s.s.b. DX section (1.840-1.850MHz). In fact the loop also works well from 1.9-2MHz, although with reduced output.

Setting Up

To set up the antenna, I used an MFJ antenna analyser but peaking the noise on receive (at the required frequency) will do just as well. One side of the resonant circuit at C1 feeds a one-to-one isolation transformer (T1) via a matching capacitor C2. Naturally, there is some interaction between C1 and C2 but in practice it's easy to find settings that give both the required resonance frequency and a v.s.w.r of 1:1 in the 50Ω feedline.

You may ask, why is transformer T1 needed? The answer is that it's really a balun, matching the unbalanced coaxial feedline to the balanced antenna. If T1 is omitted the antenna will still work but (being unbalanced) there is a risk that the run of coaxial cable to the shack could pick up noise on its sheath. This noise will find its way into the receiver, degrading performance. I have tested loops with and without T1 fitted and believe that it makes a positive difference at my site.

How does the loop work? The loop diameter D is only 2m, which is very much smaller than 160m wavelength. Any interfering r.f. noise propagating towards the loop directly along either of the central axis directions, induce opposite and almost equal currents in the conductors on the left and right hand sides. These currents almost completely cancel resulting in no output.

For waves coming from any other direction, signal current cancellation doesn't happen and the loop is capable of good reception. There are, therefore, two narrow nulls aligned along the loop's axis. To reduce local noise, it is simply a matter of rotating the loop 'face-on' to the offending source. The higher angle waves arriving from the required DX stations suffer less signal cancelling and are much less attenuated. In fact, for higher elevation signals, the loop is almost omnidirectional. (Fig. 1).

Loop Construction

My loop has evolved from earlier designs (see refs). I do not intend to give a blow-by-blow account of the loop's construction as there are many ways to make one and I suspect that anyone contemplating making one will probably have their own ideas. However, a discussion of the critical aspects of the design, types of materials used and method of support may be useful. So, I give the main constructional steps of a circular loop that has been in service reliably at my QTH for several years (**Fig. 3**). These appear in rough order of assembly.

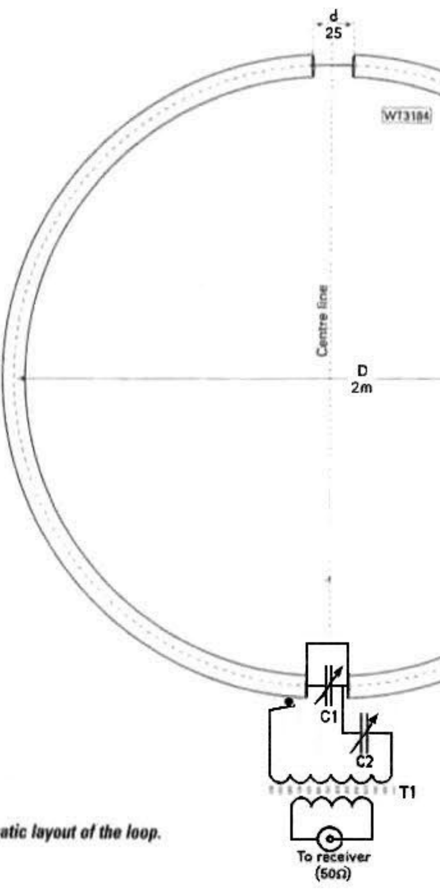

Fig 2: Diagrammatic layout of the loop.

Loop Element

The diameter, D, of the loop is two metres, which translates to a length of coaxial cable of roughly 6.3m (just over 20 feet). The exact loop diameter is not very critical but the geometry is. The element should be supported in such a way to keep it lying in as flat a plane as possible and with equal lengths between the left and right-hand sides measured from the two free ends at the base up to the centre of the braid break at the top. The length of the braid break, d, should be 25mm. Take care not to sever the inner conductor when removing the braid.

Self-amalgamating tape was used to weatherproof the joint. Carefully mark out the equal lengths of the element either side of the break. The coaxial I used was RG92, which has a lower capacitance per unit length (30pF per metre) than RG58, although there is no reason why the latter should not work in a loop of this size.

The Support Structure

In the antenna of Fig. 3, I used a circular support structure made from lengths of standard (and cheap) 22mm diameter pvc electrical conduit, together with some matching adaptors (joiners, a 'tee' piece, clamps and a box entry adaptor). The marked out cable element should be fed into the main pvc tube before attempting to form it into a circle.

The tubes were then joined and sealed from the weather using pvc 'pipe cement'. Be careful – this cement bonds very quickly indeed! The 'circularity' of the final structure was ensured by attaching the antenna tube to a single vertical piece of 50x25mm timber, using pvc screw-on clamp fittings.

Matching & Tuning

The two cable ends at the base pass through the pvc 'tee' adaptor, through a short length of pvc tube and enter an alloy box containing the tuning and matching components (C1, C2) via an entry adaptor. The removable box lid gives access for adjustment. The variable capacitors were 200pF 'Varicon' a.m. tuner types, mounted on a small piece of copper-clad board.

Note: Some fixed silver mica capacitors from the junk box were used to 'pad out' these variable capacitors to give optimum values, found by trial and error. At the base of the box is a BNC socket for the feedline and the box was grounded to the (joined) ends of the two outer sheaths of the two ends of the coaxial element.

The Transformer

A separate 1:1 transformer/balun (see **Fig. 4)**, in a pvc box, was added as an afterthought. With this arrangement, the sheath of the feedline is isolated from the ground of the tuning and matching box yielding good performance.

Transformer T1uses a type 43 material 'binocular' shaped ferrite core with: six turns of 22s.w.g. enamelled copper wire (primary) and six turns overwound (secondary). One complete pass of a wire through the core counts as one turn. With hindsight, I would recommend mounting all components in a single pvc box as suggested by Fig. 2.

Further Improvements?

The loop, as described, works well when it is sited far (e.g. more than one wavelength) from any other resonant metallic structures. However, if it is unavoidably positioned closer than this, near a resonant transmitting antenna (in my case a quarter wave inverted L there's interaction between the two antennas that can couple noise into the loop and degrade its performance. Fortunately, it's possible to 'detune' the transmitting antenna during periods of reception and regain the full hearing performance of an isolated loop.

Detuning is done by placing a relay (operated from the shack) in series with the feed point of the transmitting antenna. The relay contacts are closed during transmit and open (luring receive.

in the receive state, the resonant frequency of the transmitting antenna effectively doubles, and it can no longer resonantly couple noise into the loop. In practice I can obtain a noise reduction of up to two 'S' points (12dB) ' a huge difference)

Can the loop be improved (for example by making it bigger)? After all, the r.f. signal power coupled from the loop to the receiver is proportional to the loops enclosed area. A bigger loop will certainly sound 'louder' at the receiver but It won't necessarily provide a greater signal-to-noise ratio.

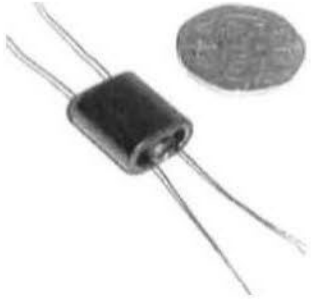

Fig. 4. The one-to-one transformer T1 ready for installation at the antenna. The binocular core is of type 43 material (At =2900) and part BN-43-202 (Fair rite part No. 28430000202).

Fig 3:The author with the completed 1.8MHz receiving loop in its final setting with its low-profile camouflage colour scheme!

Loop Larger

As the loop is made larger, the inductance Increases and so does the capacitance between the inner and outer conductors. The resonant frequency falls and C1 needs to be reduced to compensate and maintain the desired resonance.

Eventually, when the loop reaches a critical size, the loop self-resonates at the desired frequency and C1 has reached Its minimum value. Beyond this critical size it will not be possible to resonate the loop at the desired frequency. Use of a lower capacitance cable can however, recover the situation to some extent.

In practice, the described size is both convenient and gives very good results with the base of the loop about 300mm above ground (Fig. 3). Initially. I set my loop up on a rotator but quickly found that there was only one position that gave the best results. This position corresponded to the nulls pointing to the two nearest houses - mine and the one directly opposite. So, finally the loop has been set up in a permanent location. Over three years of operation, I have certainly heard (and worked) much 160m DX with this system. Although it is not a Beverage antenna, it is a lot cheaper than buying acres of prime real estate in suburbia)

References

A rich on-line resource of valuable information relating to antennas and so on is to be found at www.w8ji.com

ON4UN's *Low-band DX-ing* Fourth edition with CD-ROM, 2005, ARRL publications (ISBN. 0-87259-914.0)

DX-ing on the Edge: The thrill of 160m by Jeff Briggs, K1ZM. First edition, second printing, 1997.1998, ARRL publications (ISBN: 0-87259-635.4)