A Tuneable Magnetic Loop Antenna for 7MHz made from Coaxial Cable

Background

The construction of a simple magnetic loop antenna for 7MHz is described that does not require a tuning capacitor. The antenna can be assembled and set up in just a couple of hours and it is hoped that this simple project will form the basis of a special 'buildathon' evening at a forthcoming CARC meeting to encourage further experimentation.

This is an experimental antenna. The idea was inspired by the large drum of low loss 75 Ohm coaxial at the CARC hut (unmarked but assumed to be RG11) in *the 'might come in useful one day'* storage area. Although the impedance is 75 Ohms, this is of little consequence in this application. The emphasis here is the diameter of the braid screen, which is used as the radiating element. The total length of cable required for the project is 6m. This includes an allowance for a short feeder as shown in the photographs. So here is a project that could make a large dent in that drum of cable while inspiring CARC members all to become antenna experimenters.

Introduction

The idea of using the outer braid of coaxial cable as the radiating element for a compact transmitting loop antenna is not new. Perfectionists rightly point out that copper braid is not the ideal low loss conductor for an efficient small loop antenna but the on-air performance has shown that this simple antenna can put out a very respectable signal. Using the Q measurement method proposed by G3LHZ (Prof. Mike Underhill), [ref. 1] the Q-factor of the prototype was measured as 216 which compares very favourably with the measured Q of 268.5 at 7MHz of a 1m diameter loop made from 10mm solid copper pipe, [ref. 1]. In his presentation, Mike showed that the measured efficiency of the solid copper version is 85%. Whatever your views on the controversy surrounding the efficiency of small loops, the comparison does indicate that this simple coaxial loop should radiate almost as well as the slightly larger solid copper version that uses an external capacitor. No claims are made that this is a DX antenna, but I believe you'll be pleasantly surprised at what can be achieved with just a scrap of cable, a few bits and pieces from the Pound Shop and some very rudimentary woodwork.

No Tuning Capacitor Required

The expensive high voltage tuning capacitor that is normally a prerequisite for a small transmitting loop is not required in this design. Rather, the capacitance between the inner and outer conductor of the coaxial cable forming the main loop is used to resonate the antenna. The antenna may be tuned over the 7MHz band by simply stretching or compressing part of the outer braid that makes up the main loop. The disadvantage of this simple arrangement is that the tuning cannot be carried while the PTT is pressed because the proximity of your hand will affect the tuning and more importantly, you risk RF burns to your fingers. The method is therefore to adjust the tuning braid first, then make the VSWR measurement and to repeat the process until a perfect match is obtained. The exposed polythene insulation below the tuning braid may be calibrated with tick marks if required.

Provision has not been made for remote tuning or weatherproofing since the loop is intended for indoor use only. Further development is left to the ingenuity of the experimenter. It is hoped that CARC members will be sufficiently inspired by the performance of this antenna to experiment with new ideas and report their activities through future editions of the CARC Newsletter.

High Voltage and Current

During initial testing, the prototype flashed-over across the open stub at the 'gap' when transmitting a test carrier of 100W. After cleaning away the burnt polythene and extending the polythene insulation at the open stub by 20mm or so, the antenna withstood the maximum power of 120W from my TS940 without further fireworks. The current in the outer loop at this power would typically have been 25A with about 3-4kV across the open coaxial stub at the gap.

A word of Caution

Despite the ability for this loop to handle 100W, it is recommended that less power be used in practice. The coaxial loop is an experimental indoor antenna that would typically be located on a table within a metre or two of the operator. Intense RF fields can be generated by an efficient loop running 100W and it would be sensible to treat this as a radiation hazard. A study to determine a safe power level is beyond the scope of this project and while I personally believe that the health risk at HF frequencies is negligible, I do not advocate high power operation. It is for the builder and user of this antenna to assess the health and safety aspects of the project and to act accordingly. Note also that 100W into this loop will test the EMC immunity of your nearby PC and more importantly, arching at high power is always a potential fire risk. Far better to adopt a QRP mentality when experimenting with this antenna. Making QSO's (*any* QSO) running a ten watts or so on HF into this novel antenna whilst stood on the table beside your rig can be very rewarding and every contact a savoured achievement.

Why 7MHz?

7MHz is an excellent band for inter-G and continental contacts where signals are radiated at high angles to exploit NVIS propagation. QRP activity in both the CW and phone sections of the band is also lively. The small transmitting loop radiates at high angles when the plane of the loop is vertical and near ground, so is well suited to 7MHz.

It is also fortuitous that the circumference of the outer loop happened to be a convenient 2.68m, (0.85m diameter) when resonant at 7MHz using the cable self-capacitance. 0.85m is a convenient diameter for further experimentation. For example, removing the inner-to-outer connection at the gap and connecting an external 40-140pF tuning capacitor should allow the 14MHz, 18MHz and 21MHz bands to be tuned in the manner of a conventional magnetic loop. Something to try.

Materials

- 5m coaxial cable, 75 Ohms, (from the CARC drum).
- 1-off MDF base, 140 x 330mm x ¾"
- 1-off MDF end upright, 140mm x 100mm x ¾"
- 1-off wood vertical support, 1m x32mm x 13mm
- Cross head, BZP chipboard screws, 2-off 2"x8 plus 2-off 1"x8
- 4-off spring clamps, 3" or 4" (Pound Shop)
- 1-off 10mm dia hose clip (optional)
- 1-off small tie-wrap
- 1-off clothes peg
- PVC tape
- PL259 plug (note, this cable is too large to fit a standard BNC plug)

Tools

The following list is compiled as a checklist to ensure that all necessary tools are taken to the CARC for the Buildathon evening:-

- Stanley knife or similar for cutting and trimming cable
- Junior hacksaw for cutting cable
- Wire cutters
- Tape measure, 3m minimum length
- Screwdriver to suit the wood screws
- Large pliers
- 'Workmate' bench
- Hot glue gun with glue
- Soldering iron and solder
- Scissors
- Electrical extension lead

Equipment for Test and Setting up

Essential Equipment

- 7MHz transceiver, (10W suggested)
- VSWR meter with interconnecting coaxial cable to the transceiver

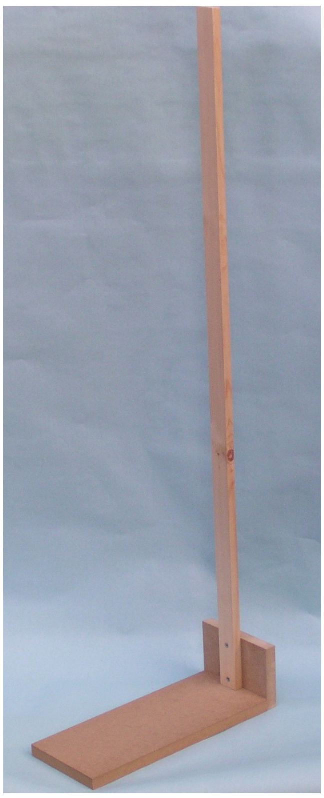
Optional Equipment

- MFJ 259 or similar Antenna Analyser (highly recommended).
- Field strength meter

Construction

1. The Stand

The base and rear support bracket in the prototype was constructed from ¾" MDF. The upright is softwood.



(i) Base:
330mm x 140mm x 19mm (3/4")

(ii) Rear support bracket:
100mm x 140mm x 19mm (3/4")

(iii) Upright support:
32mm x 13mm x 1m

(iv) Required tools

- Drill and the following drill bit sizes:
    1. 4mm for screw clearance
    2. 2.5mm for screw pilot holes in base
    3. 2mm for screw pilot holes in MDF end upright

2. The Main Loop

The dimensions are critical for the loop to tune over the specified frequency range of 7.000MHz to 7.100MHz and reflect the exact dimensions of the prototype after some extensive cut and try experimentation. Results should be repeatable when using cable from the same drum.

1. Start by cutting a length of cable, 2860mm which allows 50mm for wastage. Using a junior hacksaw and/or a Stanley knife rather than wire cutters to make a clean cut.

2. Square the end of the cable and remove 20mm of outer PVC jacket from one end of the coaxial cable, being careful not to nick the braid when cutting through the outer insulation.

3. Fold the exposed braid back on itself over the outer. Cut 80-90 cm of tinned copper wire and bind the exposed braid for about 10mm. It will be found easier to do this if the end of the cable is held in a vice (Workmate) and one end of the tinned copper wire is first tack-soldered to the braid where it exits the outer insulation. Tack-solder the other end when the winding is complete. Finally, solder tin the whole winding. This will allow a more satisfactory electrical connection to be made when soldering the inner conductor from the other end.

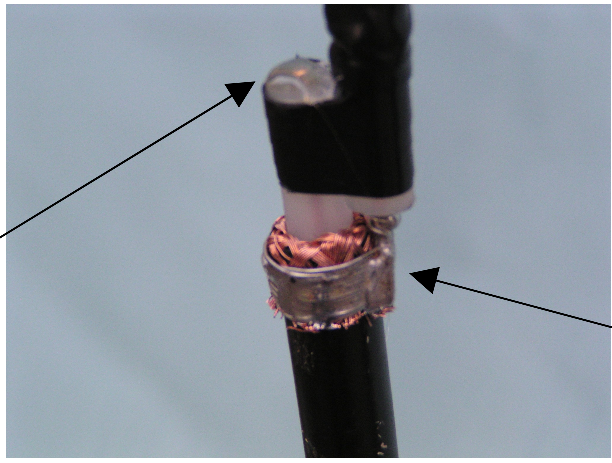
4. Seal the end of the protruding 20mm of coax inner with a dab of hot melt glue. This will help prevent flashover should you wish to experiment with higher power.

5. Now the critical part. Measure *exactly* 2810mm <u>from the end of the protruding inner insulation</u> from step 3 and make a clean cut using a Stanley knife. If steps 2 & 3 went well first time, then you will be cutting off 50mm, but it is strongly recommended that you measure the overall length of cable again to determine where to cut rather than measuring back 50mm. Discard the piece cut off.

6. Now, holding the cable longitudinally between the jaws of the workbench, make a shallow circular cut at 500mm from the end and lightly run the knife along the cable to the nearest end. Do not cut down to the braid. Once the first 10mm or so of insulation is peeled back from the end, you should be able to 'unzip' the rest by pulling the outer insulation away using pliers. The exposed braid is the tuning section of the loop.

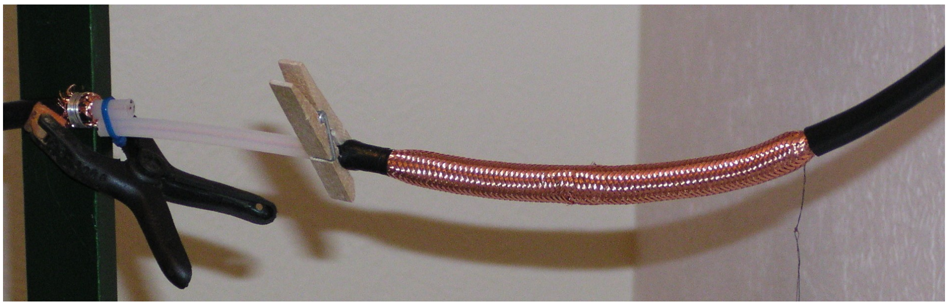
7. Carefully push back the exposed braid back a few cm and strip 20mm off the inner conductor.

8. Now close the loop by using a 10mm hose clip to temporarily make a connection. This will be removed and the joint soldered later after final setting up (see below).



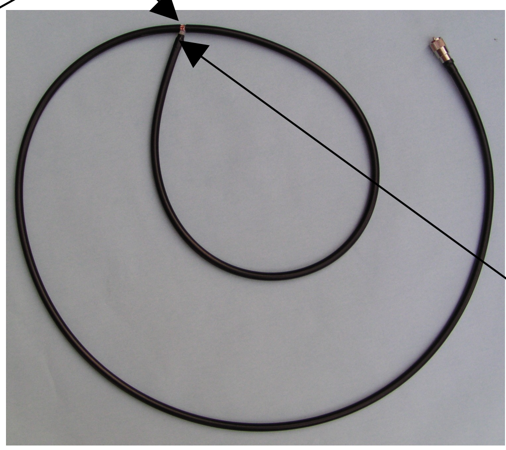
(The protruding inner that was sealed with hot melt glue in step 4 is a potential flash-over point and should be kept away from the braid that tunes the loop.

9. Tidy the end of the loose braid using PVC tape to prevent fraying while still allowing the end of the braid to slide along the polythene insulation. This is the tuning adjustment. In operation, the exposed braid is compressed or stretched over the polythene inner to tune the loop, then held in position using a clothes peg. DO NOT ADJUST THE BRAID WHILE TRANSMITTING, ELSE YOU RISK RF BURNS TO YOUR FINGERS.



3. The Coupling Loop

The dimensions of the coupling loop are less critical than the main loop and minor variations may generally be 'tuned out' by adjusting the position of the coupling loop relative to main during set-up. The coupling loop is fixed with plastic spring clamps in this simple design and is readily adjustable.



The coupling loop and feeder are made from a continuous length of coaxial cable. Again, 75-Ohm coax is used since this is available. Longer cable distances should use 50-Ohm coax for correct matching in 50-Ohm systems. However, manual tuning suggests that this antenna would normally be positioned within reach of the operator and consequentially cable lengths will be quite short.

The 2.5m length of cable specified below allows the VSWR meter to be inserted approximately 1 metre from the base of the antenna. The overall length of cable may be increased by 1 or 2 metres from that stated if required.

1. Cut approximately 2.5m (or as required) of 75 Ohm cable from the drum using a junior hacksaw to get a 'clean cut'.

2. Using a Stanley knife carefully cut around the circumference of the cable at 900mm and 905mm respectively from one end, avoiding any damage to the underlying braid. Call this 'end 'A'. Now cut longitudinally between the cuts and remove the circular ring of outer insulation. Call this point 'B'.

3. Remove 30-35mm of outer insulation and all the exposed braid at end 'A'.

4. Strip 20mm of the inner polythene insulation at end 'A'.

5. Tidy any braid whiskers that might be protruding from the outer insulation at end 'A', then wrap one or two turns of PVC tape to overlap both the inner and outer insulation.

6. Now close the loop by soldering the inner of end 'A' to the exposed braid at point 'B'. Note that the braid at end 'A' is not connected.

7. Fit a PL259 plug to the other end of the cable.

<u>Testing and Setting Up</u>

1. Clip the main loop to the support stand with 'gap' at the lowest point using plastic spring clamps top and bottom. A crosspiece may be added to support the sides of the loop to approximate a circle if required. However, the prototype allowed the cable to sag into a rounded corner triangle as shown in the photographs.

2. Now position the coupling loop using two more plastic spring clamps such that the top of the coupling loop is about 70mm below the top of the main loop.

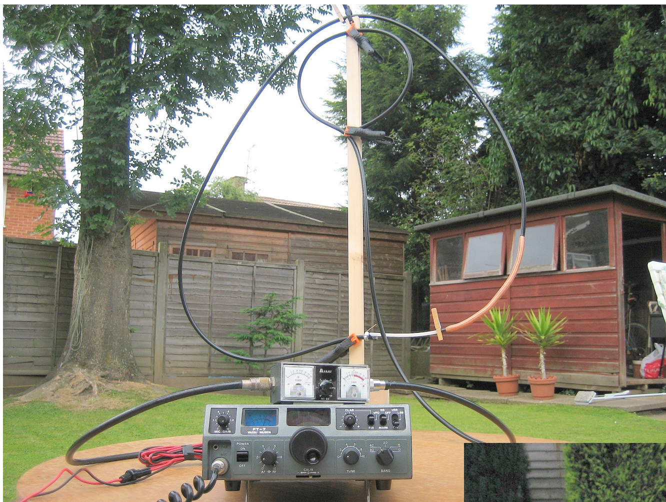
3. Move the tuning braid to roughly half of its adjustment range and fix with the clothes peg. If an Antenna Analyser is not available, connect to a low power transmitter via a VSWR meter and apply a few watts of CW carrier. Slowly tune the transmitter across the band until a sharp dip is observed in VSWR. The VSWR dip should occur somewhere near the centre of the 7MHz band and, provided the diameter of the inner coupling loop has

been cut correctly, minimum VSWR will coincide with a sharp peak on the Field Strength meter.

4. Cease transmitting and if necessary, adjust the height of the inner coupling loop in steps of 10mm or so until the match is exactly 1:1. The position of the coupling loop is now set and should not need to be moved again unless the antenna is physically moved to another location. Tuning is very sharp so tune slowly across the band when searching for the tune point.

5. Check the band limits for tuning and if low, trim a few mm at a time off the inner conductor that protrudes from the tuning braid to raise the frequency. If the tuning range is high, then the outer loop has unfortunately been cut too short.

<u>On the Air</u>



<u>On a low table, about 2ft above ground</u>

<u>A Perfect Match</u>

<u>First QSO</u>

Date	**Time**	**Freq. MHz**	**Mode**	**Power**	**Station**	**My Report**	**Report Given**	**Details**
3/7/08	**16:15**	**7.070**	**SSB**	**10W**	**M/PA1FM/P**	**5 – 5 -QSB**	**5 – 5 -QSB**	**Frank, Lake District. 50W to 8ft helical vert. with 5m ground wire**

Building and using the experimental loop antenna is fun but will be only the beginning if you are inspired like me to try some ‘cut and try’ experimentation. Here are just a few ideas to try:

- Adapt the antenna to work on different bands
- Try alternative feed methods (e.g. gamma matching, transformer matching, feeding with open wire feeder, remote ATU etc)
- Use the loop in conjunction with a longer horizontal wire loop as described by G3LHZ during his very informative talk on small transmitting loops [ref. 1]
- Try alternative shapes for the main loop including triangular and oval shapes, (this may require changes to the feed method as well).
- Design a version that collapses into a small case for portable operation

But if you do non of these things, you’ll still have a conversation piece for rag chews for years to come.

References

1. CARC Technical Lecture, 14 June 2006
A talk on “Small Loop Antenna Efficiency” by Prof. Mike Underhill G3LHZ