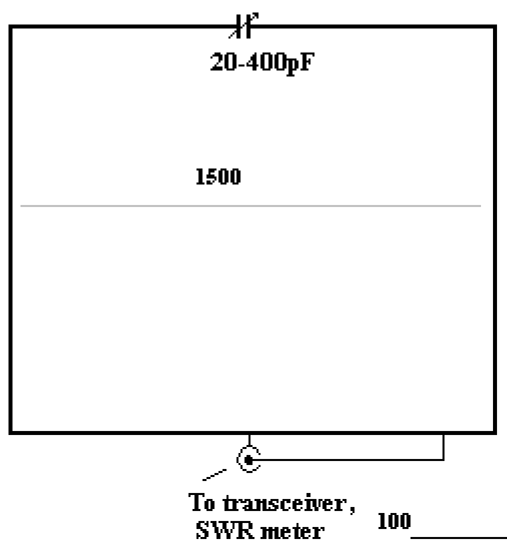
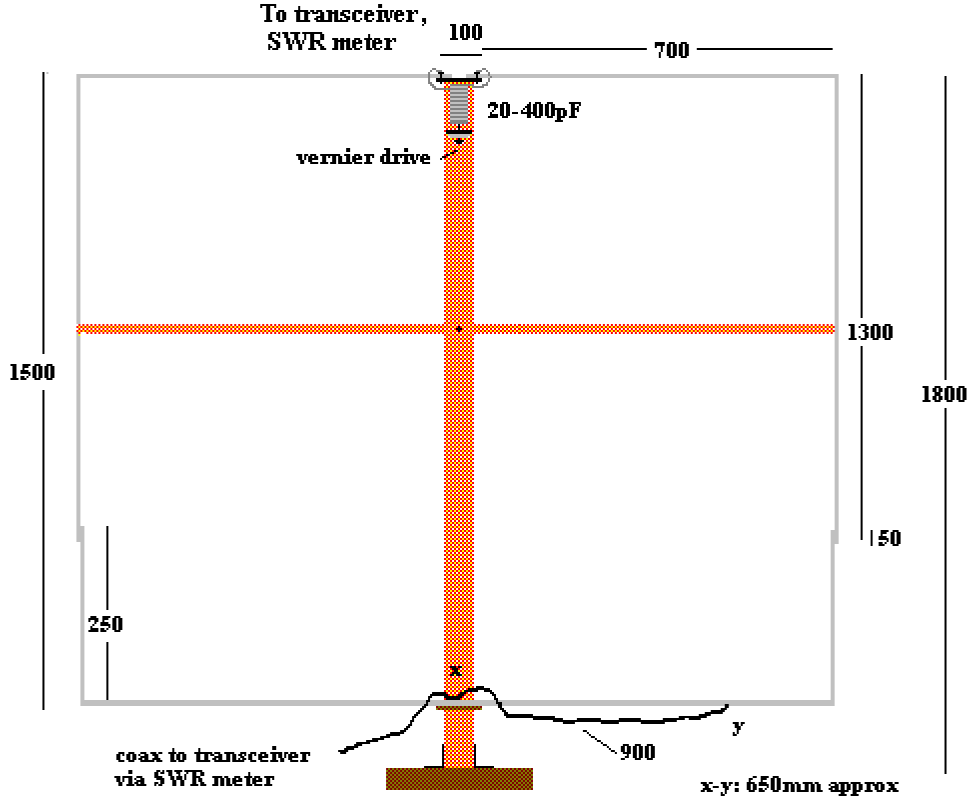
Magnetic Loop for 40 and 80 Metres

Dimensions in millimetres



Notes:

1. Use coaxial cable braid for connections to variable capacitor and between the feedline and point 'y'.
2. Use a good insulator at the top of the antenna (bakelite used in the prototype).
3. Ensure all electrical connections are low resistance. Sand aluminium and other surfaces at all connection points. Electrical conductive paste would be desirable at these points.
4. 3x20mm flat aluminium was used for the prototype. However 12 or 20 mm copper tube would be better.



by Peter Parker VK3YE - first appeared in Amateur Radio, December 1997

October 1997's Novice Notes looked at compact antennas that amateurs use to operate from confined locations. The smallest antenna described for 80 metres was a magnetic loop. This article provides all the details needed to build your own.

Description

Able to cover all frequencies between 3.5 and about 10 MHz, the loop described here is directional, does not require a radial system, and stands just 1.8 metres tall. Most parts needed can be purchased at a hardware shop. The antenna can be put together in an afternoon and requires only hand tools to assemble. It should cost less than sixty dollars to build.

Shown below is the schematic diagram for the loop. Note that the element is continuous except for a gap at the top across which the variable capacitor is wired. The feedline is connected to the bottom of the loop. Also shown is the physical construction of the antenna. The loop element is 1.5 metres square and is supported on a wooden cross. To minimise losses, thick aluminium strip is used for the element. At the top of the loop is a high-voltage variable capacitor. This is used for adjusting the antenna to the operating frequency. Because of its narrow bandwidth, the tuning is very sharp and a vernier drive has been added to make tuning easier. Dimensions are not particularly critical, provided it is possible to bring the loop to resonance on all operating frequencies with the variable capacitor used.

Parts needed

The following materials are required to build the antenna:

- 3 2m lengths of 3×20mm aluminium strip
- 1 1.8m length of 20×44mm pine
- 1 1.5m length of square (12×12mm) wood
- 1 polyethylene chopping board (medium or large size)
- 1 150 x 80×4 mm piece of stiff high-voltage insulating material (eg bakelite)
- 2 right angle metal brackets
- 1 20-400pF high voltage variable capacitor
- 1 6:1 vernier reduction drive (Dick Smith No P-7170)
- small length of coaxial cable braid
- RG58 coaxial cable (any length) and PL259 plug
- screws, nuts and miscellaneous hardware

Many of the above items can be bought at hardware shops. The main exception is the wide-spaced variable capacitor.

These are almost unobtainable commercially, though you could try Daycom in Melbourne. Other possible sources include old high power transmitting equipment, hamfests and deceased estates. The exact value of the variable capacitor is not particularly important, provided it is at least about 400pF. The capacitor used in the prototype was a two gang 200pF unit with 2mm spacing between the plates. The gangs were connected together to provide the needed maximum capacitance.

If your attempts to obtain a suitable capacitor fail, there is always the possibility of making one. Full construction details appear in DK1NB's magnetic loop design program (details later).

Construction

The first step in assembling the loop is to make the wooden cross that supports the aluminium element. This is done by bolting a 1.5m horizontal cross piece to the 1.8m vertical section. A white polyethylene chopping board is used for the antenna's base. The two right-angled brackets are used to attach this to the vertical section. The next step is to bend the three lengths of aluminium so that they form a 1.5 metre square loop able to fit on the frame when bolted together. As is visible in Figure Two, two pieces are "L" shaped, while the other is bent into a shallow "U". Note that the two L-shaped pieces are about 10cm apart at the top of the loop. These are physically joined by the bakelite insulation block that is attached to the top of the length of pine. The upper L-shaped pieces meet with the lower U-shaped piece at points 'v' and 'w'. The overlap is about 40-50 millimetres. Make the electrical connection at these points as good as possible. To achieve this, sand the aluminium at the point of contact and use two or more small bolts to hold the pieces together. Use special conductive paste if available.The variable capacitor is mounted on a home made metal bracket so that its shaft faces downwards. To the shaft is attached a vernier reduction drive. Use either small brackets, fishing line or glue to fasten the frame of the reduction drive to the 1.8 metre vertical section. Note the thick, low-resistance conductors between the end of the loop and the tuning capacitors. Braid from a length of coaxial cable was used in the prototype. Make these connections short to minimise losses.

The loop is fed at the bottom. The braid of the feedline connects to the centre of the lower horizontal element (see diagram, point 'x'). The inner conductor connects to the loop at point 'y' via a 900mm length of coaxial cable (inner and braid soldered together). At both 'x' and 'y', a small bolt, nut and eye terminal connector is used to make connections to the aluminium element. The distance between 'x' and 'y' and the length of the coaxial cable may both have to be varied for proper matching - this is discussed later.

Adjustment

The object of the adjustment process is to adjust the section between 'x' and 'y' until the antenna's feedpoint impedance can be made to equal 50 ohms on the bands of interest. The first step is to connect the antenna to an HF receiver tuned to 7 MHz. Set the receiver's RF and AF gain controls to near maximum and the antenna's capacitor to minimum capacitance (plates fully unmeshed). Then gradually increase the capacitance. Not much will happen at first, but the noise from the receiver should gradually start to increase. Further adjustment of the capacitor will result in the received noise falling. Turn the capacitor back to the position where the noise peaks. Depending on the value of your capacitor, the plates should be around a quarter meshed at this point. This test confirms that the antenna can be tuned to 7 MHz.

Repeat the process for 80 metres. This time, the noise should peak when the capacitor is near maximum capacity. If it is not possible to obtain a peak, try setting the receiver to a higher frequency (4 or 5 MHz) and tune for a peak. If a peak is obtained there, but not on 3.5 MHz, it is likely that the variable capacitor's maximum capacitance is too low for eighty metres. Possible remedies include substituting a larger capacitor, connecting high voltage fixed capacitors in parallel with the variable capacitor or making the loop larger.Having confirmed that noise peaks can be obtained on all frequencies of interest, it is now time to ensure that the antenna's impedance is 50 ohms at these frequencies. This entails making adjustment to the antenna's feed pont.The use of a resistive antenna bridge is recommended so that you can make antenna measurements without radiating a signal. If all you have is a conventional SWR bridge, make adjustments during the day to minimise the risk of interference to other stations. Position the antenna near its final operating position (which should be out of other people's reach). Set your transceiver to about 3.580 MHz. Adjust the variable capacitor for maximum received noise. Transmit a steady carrier and note the reflected power or SWR. Adjust the transmitter up and down 40 or 50 kilohertz to find the precise frequency where the SWR is lowest. Note the reading at this frequency. If you are lucky, the reflected power should be nearly zero. Otherwise, adjust the length and position of the 900mm lead joining the feedline to point 'y' and/or the spacing between points 'x' and 'y'. You will find that there is some interaction between these adjustments and the setting of the variable capacitor.

Every time a change has been made, adjust either the transmitting frequency or the antenna's variable capacitor for the point where reflected power is lowest. Repeat these procedures until reflected power is either zero or close to it.

When making these adjustments, there is a temptation to leave the transmitter keyed while making changes to the antenna or adjusting the variable capacitor. This should not be done for two reasons. The first is that the voltages at the top of the antenna element can be quite high (hundreds or even thousands of volts) even with quite low transmitting powers. The second is that the loop is detuned when people are near it. Thus any adjustment made when you are near the loop will not be optimum when you move away. This effect is particularly pronounced on higher frequencies, and applies to metal objects as well as humans.

Once a length and position for the 900mm coaxial cable has been found, along with an appropriate spacing between 'x' and 'y', all further adjustments can be done with the antenna's variable capacitor. Operating the antenna is described in the next section.

Operation

The Q of this antenna is very high. This means that it can only operate efficiently over a narrow frequency range (5-10 kHz typical). Almost every time you change frequency, you will have to change the setting of the variable capacitor.

As mentioned before, this is done by peaking the capacitor for maximum received noise at the desired operating frequency. If the reflected power is high, make further adjustments until it is acceptable. Again the use of a resistive-type bridge (rather than a conventional SWR meter) is preferred because of the ability to tune up without causing interference.

Note that the loop is directional, with a sharp null when the element is facing the direction of the incoming signal. This makes its behaviour different to that of full-sized quad elements, where the null is off the sides of the loop. This directivity can be useful when nulling out interference. It is also useful to remember when other stations report difficulty in hearing you - turning the loop may improve your signal.

Results

This loop has been used extensively on eighty metres. Most contacts have been made with the antenna indoors. Though performance is well down on a dipole, contacts into Western Australia and New Zealand have been made with it. The power used was twenty watts. Lower powers have been tried, but results have not been good. Contests are always good events to test the effectiveness of new antennas. During July 1997's hour-long 3.5 MHz Australasian CW Sprint, twelve contacts were made with the loop. This was despite the added handicap of having to retune the antenna with every significant frequency shift. As would be expected, the loop's disadvantage when compared to full-sized antennas falls with increasing frequency. On 7 MHz for instance, the theoretical difference between the loop and a half-wave dipole is barely one s-point. Tests have confirmed the effectiveness of the loop on 40 metres, though all contacts have so far been within VK/ZL.

Improving the loop's efficiency

The antenna described is capable of good results on 80, 40 and probably 30 metres. However, it is a compromise, designed for low cost and easy construction with basic tools. Doing any of the following will increase its efficiency and/or usefulness.

1. Use copper rather than aluminium. Copper is more conductive (but more expensive) than aluminium. This means that a version of this antenna using copper rather than the specified aluminium is likely to be more efficient than the prototype. Copper water pipe (the thicker the better) should be suitable.
2. Soldering the loop element directly to the variable capacitor will also improve performance and long-term reliability, especially if the antenna is used outdoors. The reason why this wasn't done in the prototype was due to the difficulty in soldering to aluminium.
3. Use a single piece of metal for the conductor to reduce resistive losses. Where this is not possible, either solder/weld pieces together, or use conductive paste to minimise losses.
4. Make the loop a circle or octagon instead of a square. Square loops are the easiest to make, but cover less area for a given perimeter than other shapes. This lowers efficiency.
5. Make the antenna rotatable. The loop's deep nulls can be used to advantage in nulling out interference from power lines, TV sets and other stations.
6. Use a larger loop. Efficiency increases rapidly with loop size. Even a 2 or 2.5 metre square loop should be noticeably more efficient than the 1.5 metre antenna presented here. The use of magnetic loop simulation software (see elsewhere) allows one to estimate the improvement possible by making this and other changes suggested above.
7. Use more reduction on the variable capacitor to make adjustment easier. The first prototype had only one vernier drive on the capacitor's shaft. With this arrangement, getting the antenna tuned to the desired frequency was tedious because the tuning is sharp. If you routinely change frequency, a second drive is well worth the cost, particularly if 40 and 30 metres are the main bands of interest.

To perform this modification, install the two vernier drives in tandem, as shown in Figure Two. If the front drive contains a 0-100 dial, you may find that the knob is limited to three turns and the back part restricted to 180 degree rotation. To overcome this, remove the knob, unscrew the 0-100 dial, and remove the c-shaped bracket that is restricting movement.

Information about magnetic loops

All information used in the construction of the prototype came from the following Internet sites:-

http://ourworld.compuserve.com/homepages/csl/magloop.htm
http://www.gqrpclub.demon.co.uk/ants.htm
http://www.cdrom.com/simtel.net/msdos/hamradio.html

Hans Joachim Kramer, DK1NB has developed a DOS computer program useful for those who design magnetic loops. Able to calculate efficiencies and bandwidths, this freeware program also contains much useful constructional advice (including pictures) to assist those who experiment with magnetic loops. This excellent program (mloop31.zip) is available from the last mentioned site on the list above

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