# Homebrew Magnetic Loop

An experimental eight-shaped loop for HF

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[SK 2010; his website, where this article was published, no longer exist]

Some time has passed since I worked on the eight-shaped magnetic loop (by PA0FRI). Many experimental designs were tested and not all of them were successful. After all, all those experiments were meant to gain experience for building a double loop for HF with a reasonable chance of success.
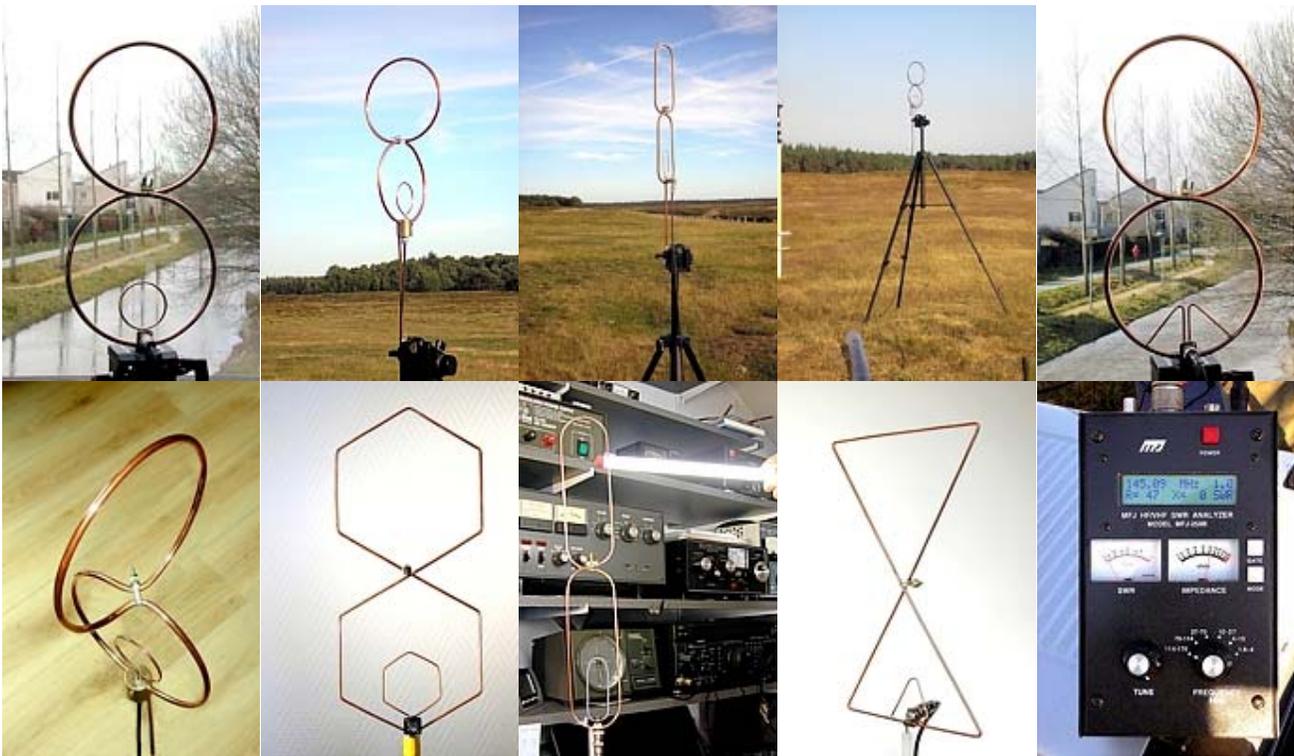
Why an eight-shaped magnetic loop antenna?

The idea behind the double loop is that two properly polarised magnetic fields enhance each other and because the two loops are in parallel, the impedance at the tuning point will be lower and the bandwidth larger compared to a single loop. The narrow bandwidth of a single loop, just a few Kc, makes tuning difficult. A loop's perimeter, in this case the sum of both perimeters, determines the antenna's inductance. This should be borne in mind when calculating the size of the coupling loop. The two loops, exactly equal in size and calculated for a certain frequency, are tuned to the frequency band by a capacitor. The loops are 180º out of phase relative to one another.

These were some fundamentals. The experiments with the small eight-shaped VHF loop have shown that its practical behaviour is in reasonable agreement with theory.

I do not claim to present a ready-to-apply project. This text is no more than an effort to give some suggestions and to show a few tricks that make it all a little easier. Conduct your own experiments and try to figure out improvements.

It's all experimental work and what can be nicer than being able to say in the end: *This I have designed and built myself*.

After having applied all my calculations, I still feel there must be yet another factor that should explain why an antenna with a perimeter less than ¼ lambda works better than one may expect from calculations based on theory.

The experience obtained from constructing the small double loop was a good reason to construct the HF magnetic loop described below. Initially a hexagonal loop was planned, because its construction from copper tube requires no precise bending and therefore is easier than constructing a circular loop. However, I got a generous gift of insulated tube, Ø 22 mm, made of soft copper and of a useful length. This implied a considerable reduction in cost. As a consequence, however, I had to venture on bending tube once again and this time it was tube of a relatively large diameter.

THE LOOP

The tube was made of soft copper with a diameter of 22 mm, which was covered by a protective layer of plastic. This kind of tube is usually supplied in lengths of 10 m on rolls of a diameter of 80 cm.

How does one know what loop diameter or tube length is needed for the required frequency? There are programs (loop calculator) that produce this information simply and quickly, but actually the basic calculation is of a convenient simplicity.

Here is an example for 14,200 MHz:
   Wavelength lambda = 300 / 14,200 = 21.13 m
   ¼ lambda = 21.13 m / 4 = 5.28 m
   Loop diameter = 5.28 m / 3,14 ≈ 5.28 m / 3.14 = 1.68 m

Of course, it is possible to use a loop calculator, for example if for some reason the loop size has to be a little smaller or if the desired tube length is not available. The applied material and the tube diameter also affect the result. This and much more is conveniently calculated by such a program. You may find a good calculator for HF by KI6GD.

I constructed a loop with a perimeter just below ¼ lambda, because such a loop radiates and receives a vertically polarised field if positioned vertically. According to the above calculation, a diameter of 1.68 m would yield a perimeter of ¼ lambda, so I reduced it slightly to 1.60 m. Thus, the perimeter will be 1.60 m x 3.14 = 5.02 m. Therefore, I took a tube length of 5.0 m, which had to be measured on the roll of 80 cm diameter. A simple trick did the job. I cut off exactly 5.0 m of rope with a negligible elasticity and fixed it to the outer side of the tube using small pieces of self-adhesive tape (see picture below). In this way the exact length of tube was obtained in a simple way. Two lengths of tube of exactly equal lengths were made in this way to construct the two loops that had to be stacked one on top of the other.
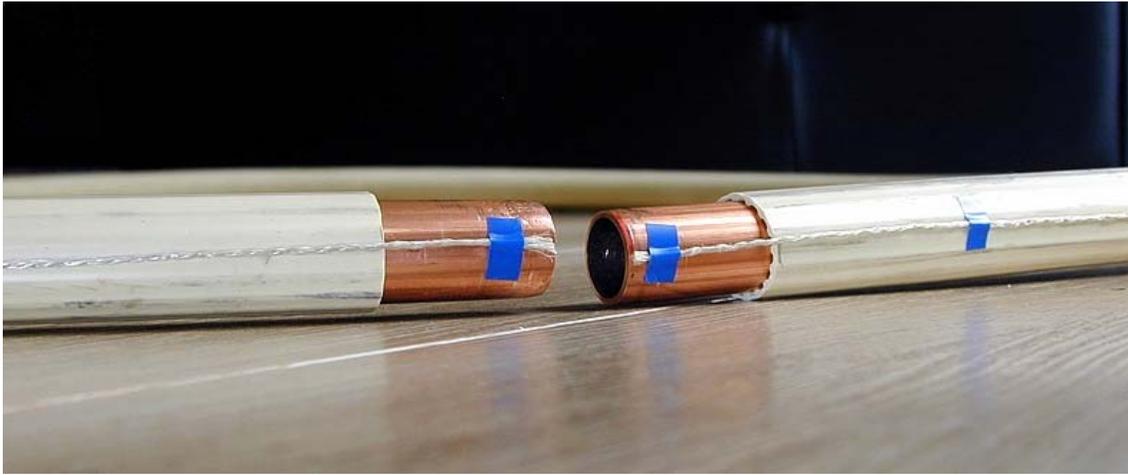
To obtain a real circle, I applied the following procedure. First the tube was bent into a smooth and approximately circular shape without causing sharp bends. Then a bending template was made from a plank of approximately the same thickness as the tube diameter. It was cut into two parts by removing a circularly curved strip (see picture). The width of the strip was equal to the tube diameter. With two clamps the two pieces of wood with a part of the tube in-between could be kept together, thus forcing the tube into a circular shape. The radius of the strip was slightly smaller than the radius of the planned loop, because after releasing the clamps the elasticity of the tube would cause the tube to spring back a little bit. For this reason, the tube should be bent a little beyond its eventual curvature in the process.
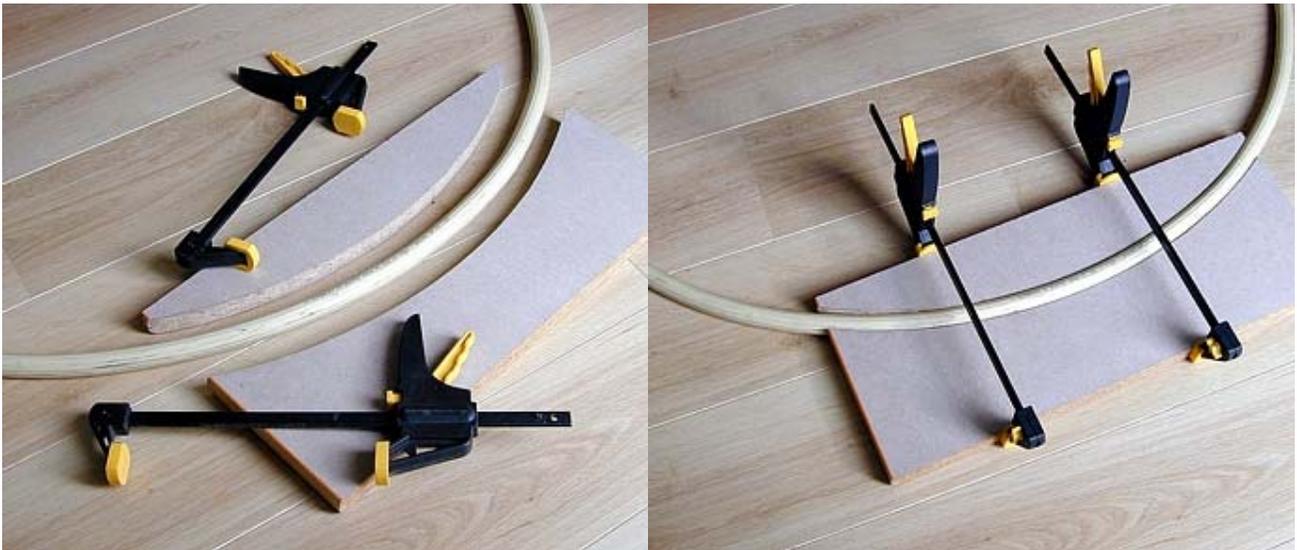
Now the clamps (see picture) were used to fit the tube snugly into the template. This goes without extreme force because of the soft copper. The clamps were released, the treated part of the tube was moved just out of the template and the entire procedure was repeated until the loop had become a circle and both ends met.

The result was a set of two identical loops (see picture).

Of course, both loops had to be connected. Two 22 mm brass or bronze compression fittings were be applied. Before connecting the loops, I modified the fittings a little. In the middle of one side of the hexagon I drilled a hole of 4.8 mm diameter and cut an M6 thread inside it.

A 6 mm brass stud was screwed in and brazed at both ends. The reason for this was that the plastic casing of the vacuum capacitor would be mounted at this point and at the same point both loops would be held together. The weight of the vacuum capacitor, the stepper motor and the stress on the connection of the two loops was expected to cause some strain on this point. Hence those who might wish to copy the system should pay careful attention to this connection and to using good quality material.

After this modification the loops could be connected. First the gland nuts and the rings of the compression fittings were put over the tube ends and the nuts fixed tightly. Now neither the nuts nor the rings could be removed from the tube anymore. However, with this construction it remains possible to separate the tubes from the respective fittings, but the rings will remain in position. This may be convenient in view of possible transport of the antenna.

Now a key (a wrench would also work) was put to the hexagon of the coupling piece and the nuts were fixed tightly using a second key. The nuts and the hexagon differ in size and hence the key sizes should differ accordingly. Those who copy the construction should make sure that the studs of both loops will end up opposite each other (see picture).

To fix the tubes and fittings firmly to the PVC casing that was to harbour the capacitor, a plastic ring of Delrin ® was inserted into its upper end. Delrin ® is a good insulator, does not absorb moisture and hence will not affect the capacitor. If the casing is really moisture proof, other materials such as nylon may be an acceptable alternative. Inside the white ring (picture) the studs with nuts and rings are visible. The leads to the vacuum capacitor were connected to these points.

The tuning capacitor

The vacuum tuning capacitor was from Jennings. It has a range of 10-500 pF and is rated for 15 kV and 65 A. This capacitor became available to me by chance. Both casing and mounting have been adapted to this capacitor.

Using an ordinary variable capacitor is also possible if the plate distance is sufficiently large to accommodate the high voltages across the capacitor. Preferably use a split-stator type because of the high currents that may develop. Because of the construction of the coupling ends, positioning of such a capacitor is a rather simple matter. The studs are simply positioned downwards and thus can conveniently accommodate the capacitor (see picture).

The casing for the capacitor was made of a 350 mm long piece of PVC tube with 115 mm diameter. To connect capacitor and stepping motor and to fix both inside the casing, it was necessary to use a lathe to make a properly sized adapter. Again, I used Delrin ® as a material. The connection between capacitor and stepping motor consists of a universal joint with a ceramic separation disc with steel springs that can compensate for any difference in moving direction. It also acts as a galvanic separator between motor and capacitor.
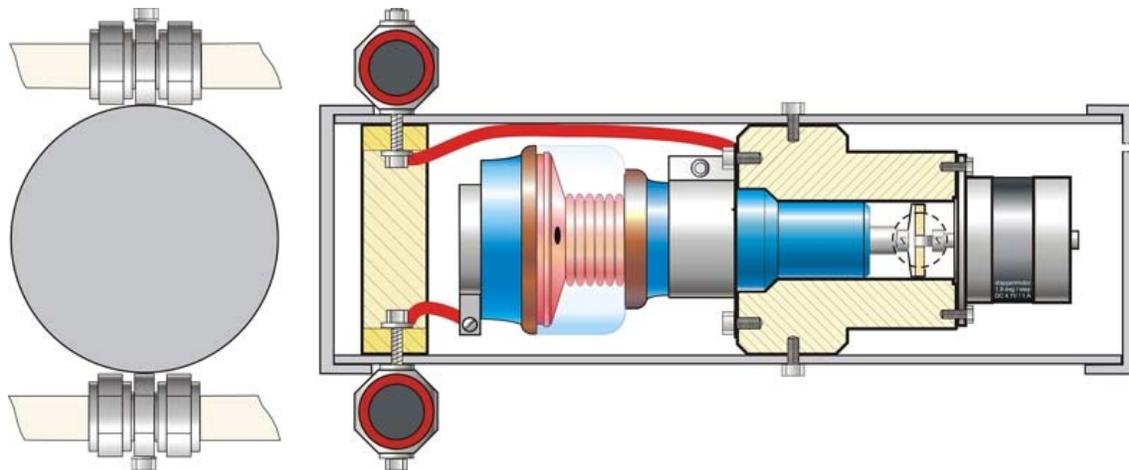
Cross-section of the casing of the vacuum capacitor, the adapter, the joint between drive shaft and capacitor, the stepping motor and other components.

The lower end with stepping motor.

The first test set-up (picture) in the shack shows the impressive size of the eight-shaped magnetic loop. On the picture it still lacks the coupling loop.

The coupling loop was bent from 8 mm soft copper tube, positioned inside the big loop and insulated from it.

Because two loops on top of each other are applied, the sum of the two perimeters is applied as a substitute diameter in calculating the size of the coupling loop.

Example:

Total perimeter = 5m x 2 = 10m
Substitute loop diameter = 10m / 3.14 = 3.18m
Coupling loop diameter = 3.18m / 5 = 0.64m

Observe that the diameter of the coupling loop is twice as large as for a single magnetic loop!

This eight-shaped magnetic loop, made from two lengths of tube of 3.70 m and 22 mm tube diameter resonated at 7.0976 MHz and 14.201 MHz with an SWR of 1:1.0 and an impedance at the feed point of at least 52 Ω. These two tube lengths are actually a bit too short to be used with 7 MHz but this was all I had and I really wanted to be able to work on this band. Surprisingly after the first CQ, CQ I immediately got a response.

Different test QSOs in the 40 meter band with the antenna in the shack with HB9, SP, DL and EA yielded reports ranging from 5.7 to 5.9. HB9ESS even gave me 5.9+. Thanks Chris.

Further testing, such as on working at various bands, bandwidth, capacitor value and radiation behaviour will follow.

To control the stepping motor I used a program with hardware developed by Lodewijk Baars, PA3BNX. This program that has many possibilities, runs on every notebook or PC and if necessary, even on a DOS machine.
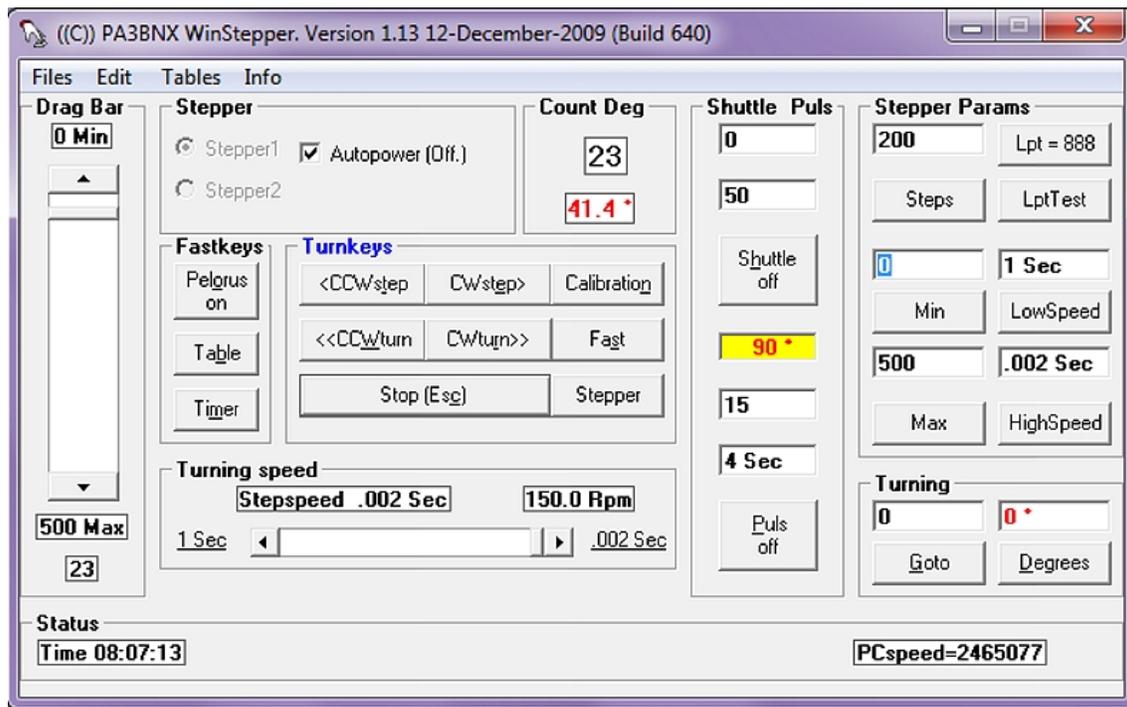
This program will control the stepper motor which is connected to the variable capacitor of the antenna. For CAT controlled transceivers a calibration table is included to lock the stepper. Pictures of the circuit diagram are included in the software. Click on info for more information after installation of the program.