The Army Loop Antenna

A simple portable HF antenna that is easy to deploy, and ideal for NVIS propagation.

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Introduction

You may have heard all sorts of stories about the use of electrically small tuned loop antennae on HF, many of them erroneous. This essay plans to set the record straight, and also to describe a very effective portable antenna for 80, 60 and 40 metres which any ham can build.

There are two main types of loop antennae: they can be categorised by size: large, over one quarter wavelength circumference (for example a cubical quad); and small, less than a quarter wavelength circumference. It is the second type that is of interest here.

In order to achieve good matching to the transceiver, and high efficiency, a small loop needs to be tuned by a capacitor between its ends. High currents flow in the loop, hence it needs to have very low resistance. Since high voltages exist on the ends (several thousand Volts when running 100 W), the tuning capacitor needs a good voltage rating, as well as low resistance.

Types of small loop

There are broadly two types of small loop antenna, the inductively matched type, and the Army Loop type. Both have advantages. For the higher bands, the inductively matched type is probably better, as it offers remote operation and is easily rotated. Efficiency can also be high because the high voltages are at the top, well above ground. Unfortunately it is mechanically complex, not easily portable, usually requires a vacuum variable capacitor, and not suited (because of size) to the lower bands.

The Army Loop,[1] on which I will concentrate, suits the lower bands, and for convenience is best operated from close to the antenna, although once tuned up, the feed line can be any length. The tuner is at the bottom, where the high voltages will be. This type uses capacitive coupling and matching, and is mechanically simple and highly portable, as I will describe.

One of the major advantages of a loop antenna for portable use (holidays, Field Day, Emergency operation) is that it has a very small 'footprint' on the ground. An 80/40 Army loop occupies only about 16 square metres of real estate. An 80/40 trapped dipole requires nearly 400 square metres, a fan dipole even more, when you consider all the poles and guy ropes.

However (despite what you may have heard), effectiveness (signal strength at the other station, quality of reception) need not suffer if a few simple guidelines are followed. Experience has shown that signals from a well-deployed loop can be the same as, or at most a few dB weaker that from a full-sized, well elevated dipole over a good ground. Which is another way of saying that the small loop can easily hold its own with other portable antennae, which are frequently not well elevated, and are used over indifferent ground. Ground is not an issue with the Army Loop.

Construction and Assembly

The Army Loop which I will describe is roughly diamond shaped, sometimes in practice almost circular, with a circumference of 10 metres. It is supported by just one mast, about 5 to 6 metres tall, and with four guy wires. Figure 1 shows the layout.

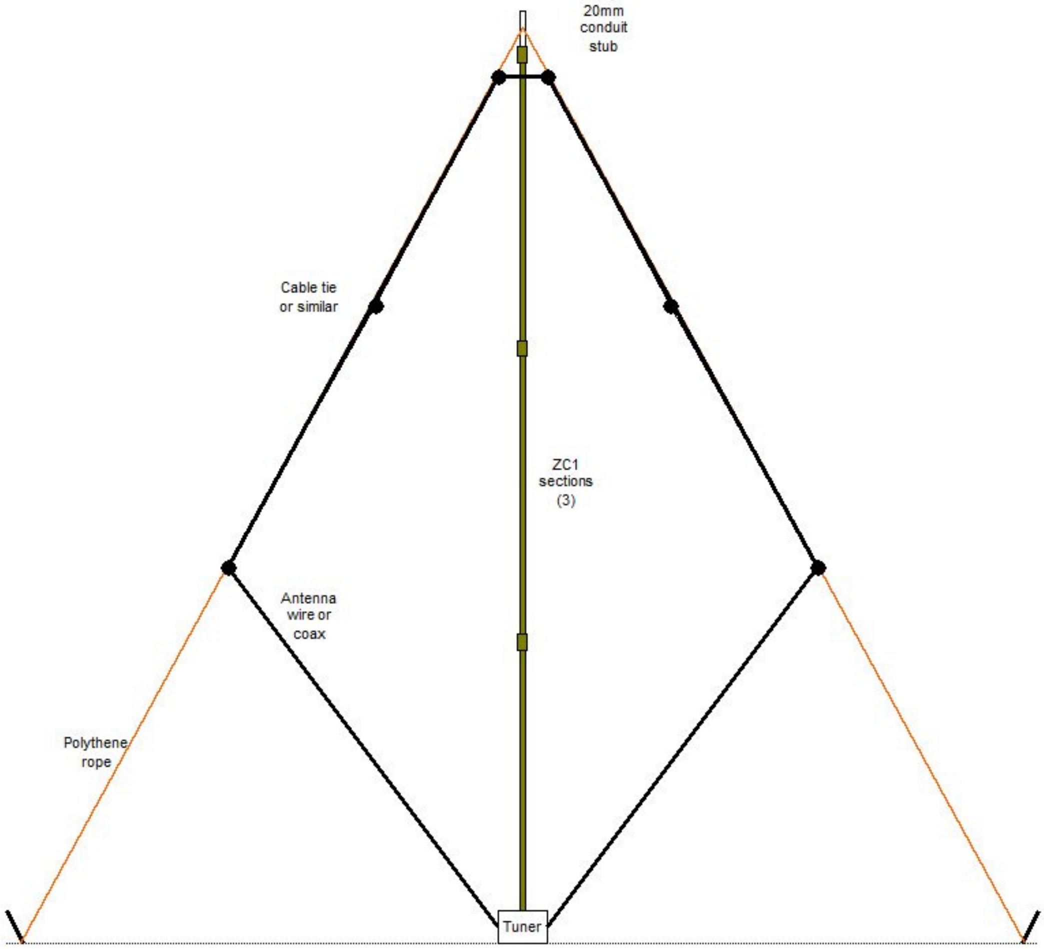


Fig. 1. A simple Army Loop

As you can see, I've used a mast consisting of three 1.8 metre steel poles (the well known ZC1 poles), although wooden, bamboo or fibreglass poles, such as tent poles, would be better. The mast needs to support a reasonable weight.

The actual antenna loop is made of a new 10 metre domestic extension lead, with the plug and socket discarded, and all three 1 mm stranded wires connected in parallel to robust crimped fork terminals. This is the cheapest way to buy cable: it cost me $10, the guy ropes a further $10.

The mast is supported by four 7.5 metre braided polypropylene ropes, in reality two 15 metre lengths, fastened at the centre over a small PVC conduit stub at the top of the mast. The antenna loop is carried on one of these 15 metre lengths, tied to it with tape or cable ties. You could add a second identical loop to the other guys, and in this way have a choice of radiation pattern direction (the loop has a roughly cardioid pattern). I don't recommend using a smaller loop for higher bands on the other guys, as it then becomes difficult to bring the ends back to the tuner unless the apex of the guys is lower down the mast. As described, the antenna will nicely tune from about 3 MHz to nearly 8 MHz, so covers 80, 60 and 40 metres.

Fig. 2. The loop erected in my garden

Mechanically, the loop is very simple in concept, and very easy to deploy. This type of mast can be erected in five minutes by one person. You mark a spot on the ground for the mast, assemble it, pace out 4.5 metres each way, place four tent pegs, connect the ends of the guys, raise the mast, then adjust the guys to keep the mast straight. Finally, untangle and connect up the loop.

Army Loop History
This type of antenna was developed by Kenneth H. Patterson for the US Army, and it was first described in *Electronics* in 1967.[2] The purpose was to provide a small, efficient, portable and quickly deployed antenna for use in difficult terrain where high-angle radiation (NVIS) was required. The idea wasn't new, but his design took great care to achieve the highest efficiency. Lewis McCoy's subsequent QST article [3] describes the antenna and tuner. McCoy was not able to achieve such good results as the Army, but we now know a lot more about this antenna than McCoy did in 1968.

The Patterson design used eight heavy loop sections fabricated from gold-plated Aluminium tubing. We have found that if you use a single continuous heavy wire loop, (appliance cable, not coax) you can achieve excellent results without the losses associated with joints, and also achieve a cheaper and more portable result.

The Loop Tuner
The Army Loop Tuner is unusual in that it contains no inductors. It is the loop itself which is the inductor. The loop is usually tuned by a split-stator capacitor, while match to 50 Ohm is provided by another smaller capacitor. Take a look at Figure 3.

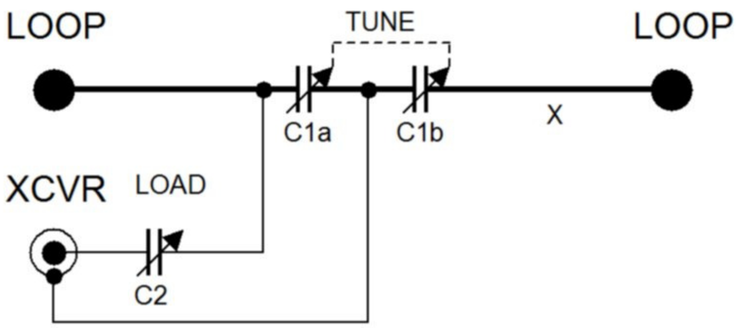


Fig. 3. The Loop Tuner Schematic

While the upper capacitor C1 (TUNE) is shown as a split-stator type, you could use a dual-gang variable capacitor of suitable voltage rating, as I did. Whatever you do, you must avoid having sliding or rotating contacts in the main current path (shown with heavy lines). For example, you should not use two coupled separate capacitors. There can be in excess of 10 A flowing in this path, and even the slightest resistance will cause loss. This capacitor should also be able to withstand 10 kV (for 100 W). In fact, the more efficient your antenna is, the more this becomes a problem. This capacitor should be at least 150 pF per section, preferably more if you hope to cover 80 and 40 metres with one loop. A high quality broadcast variable is quite suited to low power. Use a vernier or planetary drive for C1, as tuning will be very sharp.

The second capacitor C2 (LOAD) is the matching device, and also needs a good voltage rating. 150 pF should suffice. This capacitor needs to float above ground, as the input side (the rotor) is connected to the RF from the rig. I simply mounted mine on plastic stand-offs, provided plenty of clearance for the shaft at the front panel, and used a plastic knob.

The point marked ‘X’ in Figure 3 indicates where a current transformer or thermocouple ammeter could be added. While it is useful during development to know what current is being achieved, if your rig has a good SWR meter, or if you use one in the feed cable, it isn’t necessary to have a meter built in when the antenna is in use. You should avoid all unnecessary mechanical connections in the high current RF path.

Mechanical Assembly of Tuner

See Figure 4. This shows my actual tuner, with the TUNE capacitor on the left (it has an epicyclic drive), and the LOAD capacitor on the right. The capacitors are mounted off the front panel using plastic spacers. The LOAD capacitor fortunately had threaded bosses in the front ceramic plate, so insulating it from ground was easy.

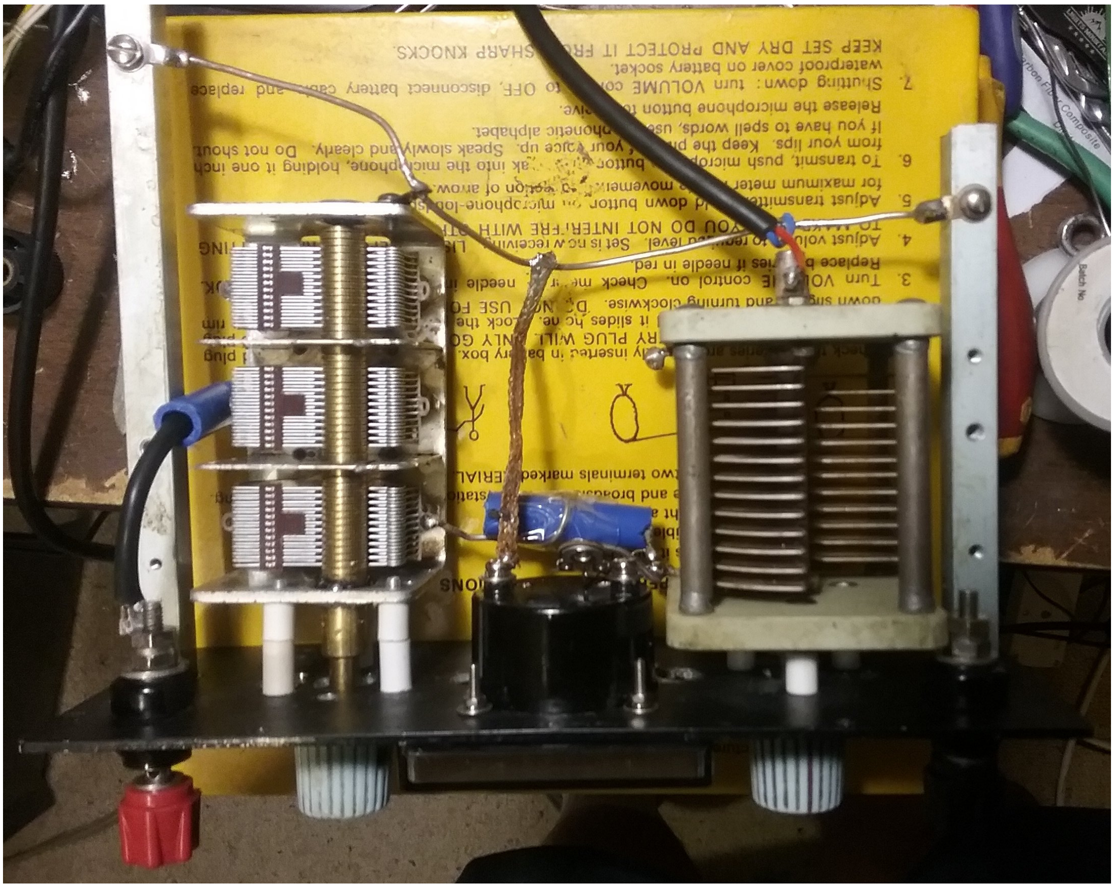


Fig. 4. Inside the Loop Tuner

Note the really robust antenna terminals. One side of the loop (the left) connects directly to one side of C1. Note the heavy cable and extra insulation where it goes past the side rail. The other side of the loop (the right) connects to the stator of C2 via a lug on one side, and from a lug on the other side connects to the other side of C1 via a heavy tinned copper wire, which is fashioned into a loop, one turn 15 mm diameter. This forms the primary of my current transformer.

The current transformer secondary has 22 turns, and is tucked inside the primary wire in a blue insulating tube, and wound on a smaller tube containing four paralleled 100 Ohm resistors. Note that my current transformer is NOT connected at the point marked ‘X’ in figure 1, but between the two capacitors, which is electrically equivalent, but mechanically more convenient. This works because C2 is silver plated and has stator lugs on both sides.

Input from the transceiver to the LOAD capacitor rotor is via the black cable at the rear of the capacitor. There is a UHF connector on the rear panel of the box. You might recognise the box in the photo – it is the case of an old 1960s AM radio-telephone, the AWA Teleradio 3 ‘butter box’.

The Current Transformer
As I described, the transformer secondary is wound on a small tube with four 0.1 W 100 Ohm resistors tucked inside. These form the 25 Ohm load of the current transformer. The rest of the circuit is pretty simple – just a Germanium diode, a pot and a bypass capacitor. There is sufficient sensitivity for QRP. See Figure 5.

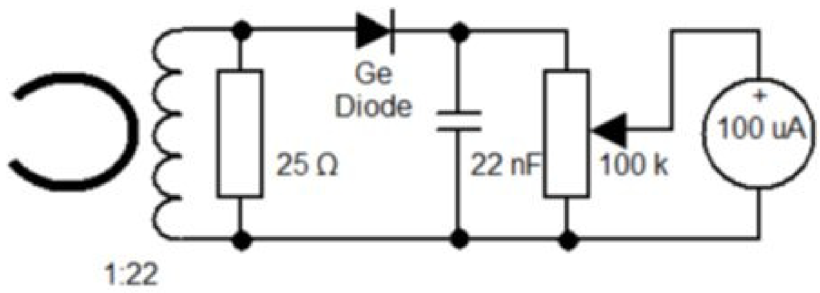


Fig. 5. Suggested current transformer circuit

By the way, there is *no ferrite core* required for the transformer, and it’s burden on the loop is also very small, about 0.05 Ohm, so probably less than the resistance of the primary wire itself. The meter should be flat up to at least 10 MHz, and you could calibrate it against a known RF Ammeter in the actual loop circuit. Aim for 10 A full scale.

Apart from improved robustness, there are several major advantages to using a current transformer, rather than an RF ammeter. It can be a lot more sensitive, is much faster responding, and will have less loss, so can be permanently built into the tuner. RF ammeters are quite non-linear, easily damaged by excessive current, and do not respond well to low power. They are also nowadays quite hard to find.

Tuning Up
First connect the transceiver to the tuner, and the tuner to the loop. Make sure the ends of the loop (which carry high voltage) don’t touch anything, especially the rig, the operating desk or yourself. Tune the rig to the frequency you want to use, set LOAD about half-way, then adjust TUNE until you hear the receiver noise peak.

Then transmit a few Watts on AM, and adjust TUNE and LOAD alternately for maximum loop current. There is some interaction, and TUNE will need adjusting as you move up the band. LOAD will probably then not change much unless you use a different loop or band. If you don’t have a current meter, watch your SWR meter in RFL mode, and carefully adjust the two controls until you achieve 1:1 SWR.

If you can't achieve 1:1 SWR, this will indicate serious losses, probably in the loop itself. Use heavy wire with no joins, keep the loop well above the ground (the base of the loop at least 1 metre above ground), and keep it well away from trees, shrubs and other structures, including parked cars and aluminium ladders.

Results

If you use a heavy wire loop, deployed as suggested, you should expect results on 80 metres at night that are equal to those of the average dipole. There is some directivity, and also some difference in the perceived fading, especially on local stations. The received signals are as strong as on a dipole, and you may experience lower interference and electrical noise, although the latter is affected by loop placement and orientation.

DX performance on 40 metres is perhaps more modest, because the antenna lacks a low take-off angle, but over shorter ZL or VK paths, and for all NVIS applications, the antenna won't disappoint. If you don't tell anyone you are using a loop, they won't know from the signal they receive!

Best of all, you will have a small, compact portable antenna for your next holiday trip, easy to carry and erect, and which will give excellent results.

The last photo (Figure 6) shows a front view of the completed tuner. It is simple and compact. The front panel underlay is plain yellow card. The overlay is OHP film, printed in reverse on a laser printer. It would also be quite practical to print onto the card, and use a plain library film overlay. The panel is held in place by the meter, terminals and knobs.

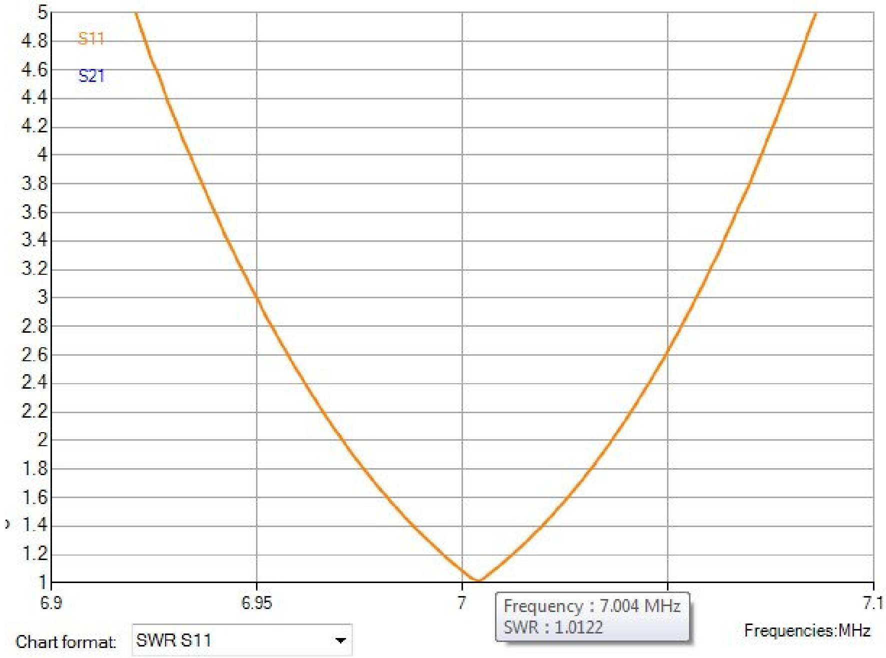
Fig. 6. The Army Loop Tuner

By the way, if you're not up to making your own tuner, MFJ make an excellent Loop Tuner, the MFJ-935B.[4] It has very high quality components.

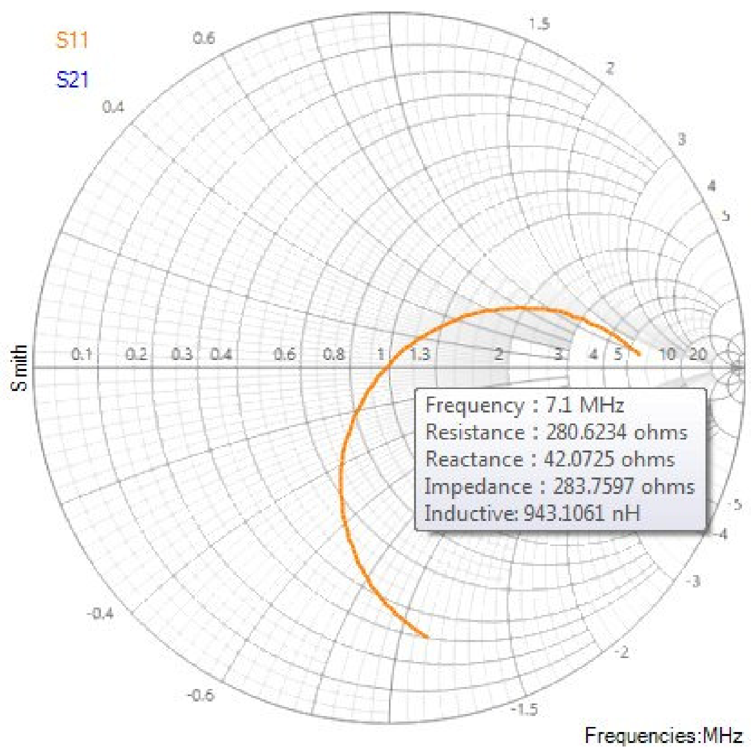
[1] https://owenduffy.net/blog/?p=3026
[2] http://webclass.org/k5ijb/antennas/Small-magnetic-loops-Army-loop.htm
[3] https://www.nonstopsystems.com/radio/pdf-ant/antenna-article-mag-loop-1ICP.pdf
[4] https://www.mfjenterprises.com/Product.php?productid=MFJ-935B

Appendix
The following charts illustrate results measured with a NanoVNA-H, for the frequency range 6.9 to 7.1 MHz, with the loop tuned to just above 7 MHz. The 2:1 SWR bandwidth is about 60 kHz. Expect 30 kHz on 80 metres.

Be aware however that a VNA cannot show the losses to the environment (ground proximity, trees, cars, ladders) which occur when operated at high power.



A.1 SWR of the Army Loop on 40 metres



A.2 Smith Chart of the Army Loop on 40 metres