HIGH POWER Magnetic Loop Antennas

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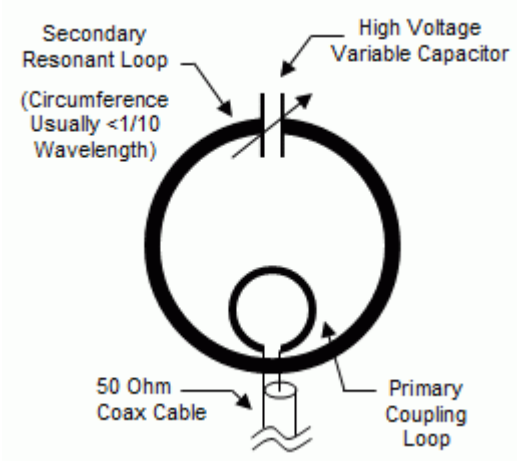


Magnetic Loop Antennas
for
The Radio Operator
with Limited Space
pt.2
Home Made HIGH POWER Magnetic Loop

 by Popeye

In **part one of this series**, I covered the use of one brand of commercially available, small transmitting loop antennas, also known as ‘magnetic loops’. For that article, I bought the very popular AlexLoop “WalkHam” antenna. It is designed to be highly portable, fit into a small case and is quick and easy to set-up. For the AmRRON operator, there are many UP sides of the AlexLoop and others like it, including very high efficiency on 20 meters and above, easy portability and excellent form factor.

Two mini-downsides to the AlexLoop and others like it:

1. They are designed primarily for communication only on the higher ham bands. This makes sense for hams who like “DX” contacts for hobby hamming and hunting ‘DX’ stations with very small, lite equipment. However, more than half of AmRRON HF communication and all of the regional communication happens on the 40 meter band and below. These commercially available loop designs are AMAZING from 30 meters upwards, but to keep them a handy

size, they are too small to have high efficiency down on 40 meters, though they are usable down there.

2. The AlexLoop and most commercial magnetic loops are designed for low power, usually limited to 10 CW/Digital or 20 Watts SSB voice. This is not a problem on the higher bands, where their efficiencies are in the 70-95% region and atmospheric noise is low. However, on forty meters, atmospheric noise, T-storms and etc. cause higher noise on the receive end. On forty meters, the AlexLoop has a calculated efficiency of only 13% meaning that for a ten Watt signal input, only 1.3 Watts is radiated. I've made good contacts at that level on forty meters in Morse and digital modes (including E-mail over radio) . However, because the small, lite and easily portable AlexLoop is optimized for the higher bands, I easily made several strong contacts on the high bands.

Because I was so impressed by the AlexLoop, it seemed a good idea to make a 'magloop' optimized for AmRRON home or camp radio operations divided between 20 and 40 meters, which is where we are most of the year. I designed in the option to operate on the 60 meter band as well, for excellent NVIS coverage, though with a little less efficiency, way down there. My BIG Loop is not an antenna optimized for hotel operation and rapid set-up/tear down, like the AlexLoop is. The BIG Loop is for those like me, who want an EFFICIENT antenna to use in a small space from 20 meters downward past 60 meters and with low chance of it being accidentally discovered.

Home Cookin' !

I do not intend this to be a step-by-step, a how-to article on building a magnetic loop: there are plenty of those on the internet already. However, I do want to show you what can be done on a budget for we AmRRON operators who – for various reasons- must hide the fact that we are operating a radio station. Most current-off-the-shelf (COTS) magloops are not available in packages optimized for 20 meters and below and those companies who DO make them are charging a HIGH price. So, let's make our own HIGH efficiency magnetic loop for the bands from 20 to 40 meters and below, where AmRRON and other EmCOMM organizations do the lion's share of the work.

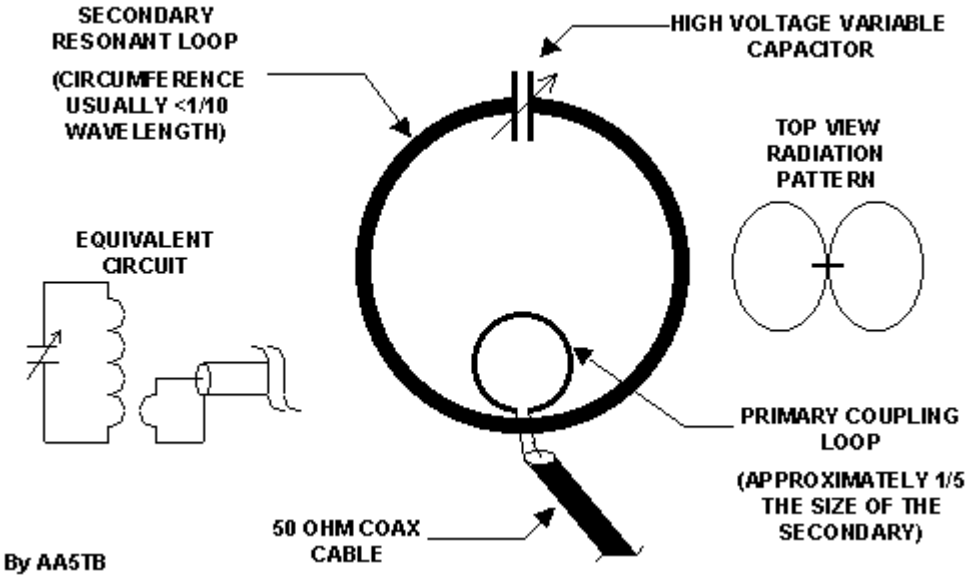
Because I live in a total HOA (read: COMMUNIST) community, I am not allowed any (known) ham radio antennas. Therefore, I make certain that I use only UN-known ham radio antennas. You see, I learned long ago that "It is better to beg forgiveness than to ask permission.". To a land lord, the default answer for ham antennas is usually 'NO!" and once it's known that you asked about ham radio antennas, you'll always be under suspicion for anything unusual happening with home electronics within a 5 mile radius. Do NOT mention ham radio to anyone who does not have the 'need to know'. Have a plausible explanation for nosy neighbors if they see something unusual about your "Unknown" antennas:

"Oh THAT ? It's an ultrasonic, giant scorpion attractant. Man! That thing has brought in dozens of them! They kill rats and stray cats in my yard. Come closer, and I will show you how it works – uh, you'd better put on some boots and really – watch your step and bring your rifle ! "

(Bore them or seem mildly ‘creepy’ and they’ll leave you alone.)

A magnetic loop antenna is electrically simple and looks like a two turn transformer with a tuning capacitor in the larger loop. The “primary” of this transformer is a small loop of wire, fed by standard 50 Ohm coaxial cable (coax) that goes to your HF transceiver. It feeds (“induces”) the radio signals to/from the BIG loop. The BIG loop is like a transformer ‘secondary’, large swings of high voltage and current in the big loop are radiated as a radio signal. This loop is usually made from copper tubing with a tubing diameter as small as ½”, up to an inch in diameter. The larger the tubing diameter, the less resistance and the MORE efficient that antenna is. However, copper is expensive and some-what heavy, so most hams limit the diameter to 1” or below. I HAVE been tempted to make a loop using FOUR INCH copper tubing, but I think it’s better to use the money to feed my family for a month instead. (Silly priorities)

Here is a drawing from the excellent AA5TB MagLoop Website.



for more information: http://www.aa5tb.com/loop.html

As a personal motivation to complete my home made BIG magnetic loop, I sold my super-cool AlexLoop to a friend who will put it to good use, because they travel a lot. With no more loop for me to play with, I was 'forced' to finished my BIG loop. I wanted my "clandestine" loop for home to be optimized for AmRRON use by being efficient on the 20 through 40 meter ham bands. It had to use readily available materials and be able to run at least 150 Watts. This way it would be over built, easily running a standard ham rig at 100 Watts and I could occasionally run my old ship's radio through it for old time's sake! I used the following website calculator to design my magnetic loop antenna:

http://www.66pacific.com/calculators/small_tx_loop_calc.aspx

My BIG loop was designed with a maximum frequency just above the 20 meter band. According to the above link, the diameter of the loop must not exceed 16.7 feet. I selected a length of 16.5 feet (I'd advise making it 16′ even, to ensure the loop is not too long to work well). Next is the tuning capacitor: it determines your loops' frequency range and your power limit. High voltage capacitors used to be a very common item in ham shacks during the age of tube radios. However, since the age of transistors in transmitters, the requirement for high voltage capacitors in normal ham radios has almost disappeared, making them somewhat difficult to find and a bit expensive.

For a 100 Watt transmitter I recommend the following:

16 feet of 1" tubing
(I used 7/8" Heliax 'hardline' with a copper outer conductor OD of 1 inch
for less than the price of hardware store tubing. E-Bay $30 + shipping). I

soldered the inner conductor to the outer at both ends.

For a frequency range of 14.5 – 7.0 MHz you need a variable capacitor of at least 30pF – 127 pF.

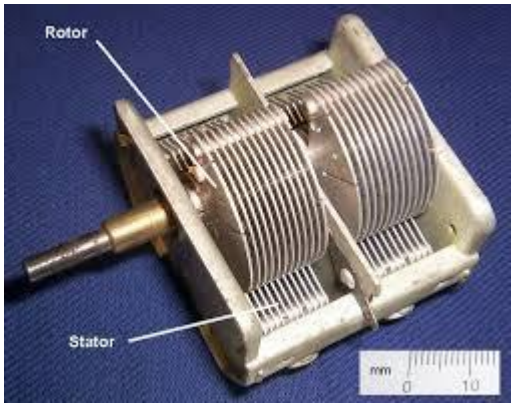
For a frequency range of 14.5 – 5.2 MHz you need a variable capacitor of at least30 pF – 230 pF.
If the tuning range of the capacitor is wider, it will work I/e 8pF to 350 pF is perfectly fine, but the wider the tuning range, the 'touchier' it is to tune, requiring very fine hand movements! Try to keep it no larger than 500 pF if possible. You don't need that extra tuning range, but it makes adjustment much touchier.

>>> At 100 Watts, the variable capacitor must be able to handle at least 4,700 volts, otherwise the high voltage will spark across the capacitor plates, causing a short circuit.

>>> At 50 Watts, the cap only needs to be rated to 3,300 Volts.

>>> At 25 Watts, the cap is a very reasonable 2,300 Volts.

>>> 10 Watts or under, you can use almost any old dual stator, variable capacitor from the tube radio days, if both halves (the stators) are the same or close to the same size. If you can slide a postcard through the plates, you should be good for at least 10 Watts CW/Digital.



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I ordered a “vacuum variable” capacitor from the former Soviet Union on E-bay. it was rated at 7.5 KV (7,500 Volts) with a tuning range of 8-350 picoFarad : perfect for over 150 Watts! According to the on-line calculator, it would tune from just above the 20 meter ham band, to below the 60 meter band. Efficiencies on the 60 meter band are enough that the signal should be usable, though 6 dB (one S-unit) lower than from a 90 foot long, dipole antenna. That’s fine! Unfortunately, the Soviet capacitor arrived damaged, so I was unable to use it.

However, in my junk box was a WW II surplus ‘junk’ tuning capacitor that would work! It’s not as cool as a Soviet high voltage, vacuum variable capacitor that might have been part of the old Radio Moscow radio stations – but it was ‘free’ and available and came with a 3:1 reduction drive, so that the very FINE tuning is easier. I HIGHLY recommend a reduction drive for using a non-vacuum capacitor on a magloop. Oh, and the vendor on E-Bay returned a full refund and his apology when he saw my e-mail with the picture of the dented product. A good, ethical fellow and I intend to order from him again when he has another.

For the GEEKS in the reading audience, here is how I used my random ‘junk’ wide spaced capacitor with two isolated ‘stator’ sections as a high efficiency, HIGH VOLTAGE tuning capacitor. It had a plate spacing between rotor and stator of roughly 1 mm. A rule of thumb is that 1 mm spacing will handle 2,000 Volts. Because I would be using BOTH stator sections in series, the total plate spacing doubles, resulting in 2 mm spacing which is 4,000 Volts capacity or about 100 Watts key down.

My recommended source for the high voltage tuning capacitor for HIGH POWER magnetic loops:

1st Choice: **http://www.mgs4u.com/RF-Microwave/vacuum-variable-capacitors-500.htm**
They are a ‘little’ bit more expensive than E-Bay, but very ethical and selling only TESTED products.

2nd Choice: E-Bay – review each vendors’ feedback carefully! Most cannot test their products nor understand how they work.

3rd Choice: **http://www.mfjenterprises.com/Product.php?productid=MFJ-23**
Limited tuning range, and physically large for what they do, but a fair price for a rare commodity.

Recommended Reading:

An Overview of the Underestimated Magnetic Loop, by Adam Curry
http://l.curry.com/9pz

AA5TB's Excellent website concerning magnetic loop developments and experiments
http://www.aa5tb.com/loop.html
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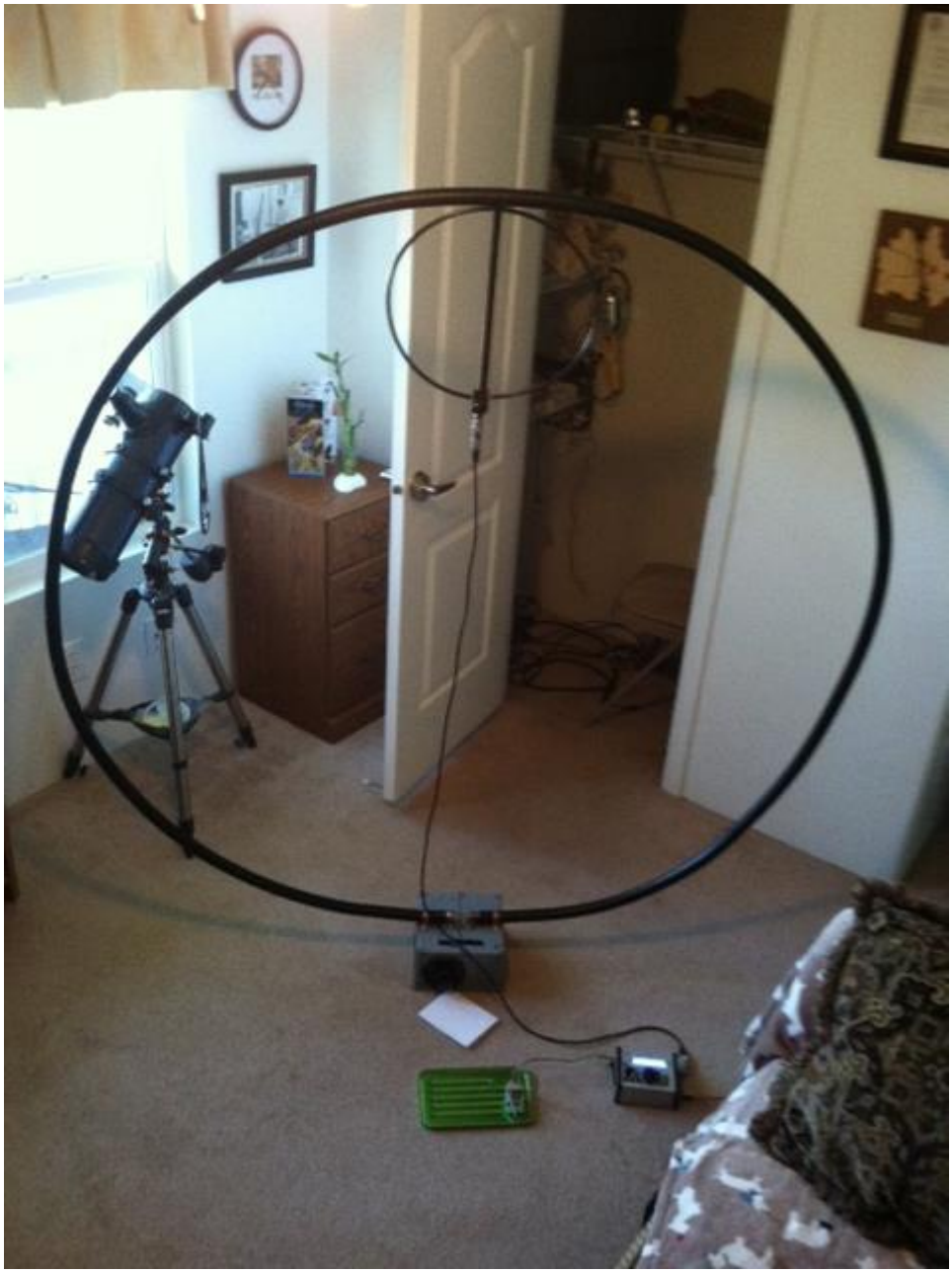
The feed loop design I chose was as simple and quick as I could make it: a small wire loop that is 1/5th (0.20) times the diameter of the big loop. I used #10 AWG single strand, put it into a piece of scrap plastic tubing (not necessary). For testing, I duck taped it to the top of the BIG loop and after some very delicate 'fiddling' with feeder loop distance and position I was able to get a 'low enough' SWR on forty meters to join the AmRRON CW net last Saturday. I was 'weak readable' into the net control station and loud & clear into other AmRRON operators two (western) States away. This is remarkable, considering my station:



> Home made magnetic loop,
> Duck-taped feed loop,
> using a WW II ‘junk’ tuning capacitor,
> Inside of my front room,
> Running only 5 Watts from a solar recharged battery.

Here is what the not-yet-completed magloop looked like during the AmRRON forty meter CW net.
A half wave dipole for the forty meter band would be 63 feet across and would need to be high and in the clear for best effectiveness. My home made magnetic loop is only 63 inches across (diameter). The calculated efficiency on 20 meters is over 90% and on forty it is 45%, which while it may sound bad, is a loss of only a HALF of an S-unit at the receiving station! Yes – my signal strength is only reduced by half of one of those little lines on the receiver s-

meter. I -might- be S-9, if I could put a full sized dipole high and in the clear; on the low magloop it's calculated to be S-8 ½. I'll take that – HAPPILY!

'Half an S-unit down on forty meters?'

Pretty good for something that I can hide
in a closet or a wooden storage shed!

On twenty, it's at least as good as a HIGH dipole, on forty meters, you can't hear the difference between S-9 and S-8 ½ in the real world. I cannot string-up a forty meter dipole, 63 FEET across, 30 to 70 feet high and in the clear; I'd be ratted-out by my neighbors in a heart beat! However, I have no trouble using a high efficiency magnetic loop only 63 inches across and I'm 'invisible' to the prying eyes of the communist HOA and their willing informers.