Portable HF Transmitting Loop Antenna

Por N5IZU enquanto HF antenas não são normalmente conhecidos por seu tamanho pequeno, loops magnéticas podem oferecer um desempenho bastante respeitável, ao custo de alguma eficiência e extremamente de banda estreita. Esta antena sintonizável laço magnético é minha contribuição para a arte de bem estabelecida de fazer loop amador. É pequeno e leve o suficiente para carregar durante a operação, desmonta em pedaços pequenos mas robustos que cabem facilmente em uma bolsa, mochila ou no ginásio, e pode ser ajustado de 14 MHz a 30 MHz.Specs in Brief

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Frequency coverage: 14-30 MHz
Efficiency: 32%@14, 54%@18, 66%@21, 78%@25, 87%@30 MHz
Bandwidth: 12k@14, 20k@18, 30k@21, 50k@25, 100k@30 MHz
SWR: 1.0:1 where tuned
Power Handling: tested at 20W PEP
Tamanho: 21 polegadas quadrado mais identificador
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Peso: 4,5 kg Theory of Operation

Para aqueles não familiarizados com antenas de laço magnético, o princípio por trás deles é simples. Um pequeno loop realizando (muitas vezes na ordem de 1/10 de comprimento de onda) é quebrado e um capacitor preenche a lacuna. Indutância do loop, combinada com a capacitância adicionada, forma um circuito tanque alto-Q. Um loop de acoplamento ou outra rede correspondente proporciona a potência de um transmissor, emocionante o circuito do tanque em sua freqüência ressonante. Alterando a capacitância, a antena pode ser ajustada sobre uma gama bastante ampla de freqüências.For any given tuning, bandwidth is very limited, due to the high Q of the circuit. Eficiência é limitada pela resistência do condutor. Enquanto a resistência do tubo de cobre é muito pequena, a resistência de radiação de um radiador tão pequeno muitas vezes é ainda menor. Meu loop, por exemplo, tem uma resistência de radiação de 20 milliohms em 14 MHz, mas sua resistência ôhmica é milliohms mais de 40! O poder perdido (dois terços neste caso) faz pouco para comunicação global, embora ela possa contribuir sempre tão ligeiramente para o aquecimento global.

Enquanto uma eficiência de 32% em 14 MHz não pode soar terrivelmente convidando, sou grato por ser capaz de transportar uma antena pequena, luz que executa um terço, bem como um dipolo de 33 pés acima de 16 pés no ar. Se é possível trabalhar o mundo com 5 watts em um dipolo, 15 watts neste loop deve fazer igualmente bem.

Construction

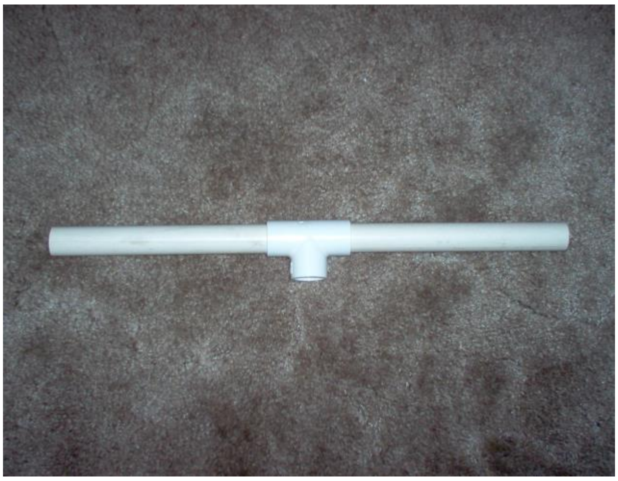
Except for the coupling loop, which is made from RG-58 coax, the entire antenna is made from hardware store parts.

Parts List

- 1/2 inch copper pipe (approx. 5 feet)
- 3/4 inch copper pipe (approx. 1 foot)
- 1/2 inch copper repair coupling (12 inch long)
- 3/4 inch copper repair coupling (12 inch long)
- 3/4 inch schedule 40 PVC pipe (approx. 5 feet)
- 3/4 inch "PEX" polyethylene pipe (approx. 1 foot)
- 1/2 inch copper elbows (3)
- 3/4 inch to 1/2 inch copper reducing elbow (1)
- 1/2 inch copper unions (4)
- 3/4 inch PVC cross (1)
- 3/4 inch PVC tee (1)
- 1 inch to 3/4 inch PVC reducing tees (2)
- foam insulation for 1/2 inch copper pipe (approx. 5 feet)
- RG-58 coax (approx. 6 feet)

Building the Main Loop

The main loop consists of the five pieces shown here. First, the pieces are built without soldering or cementing, to ensure that they fit correctly. Once a good fit is verified, soldering can be done. It is not necessary to cement any of the PVC parts.

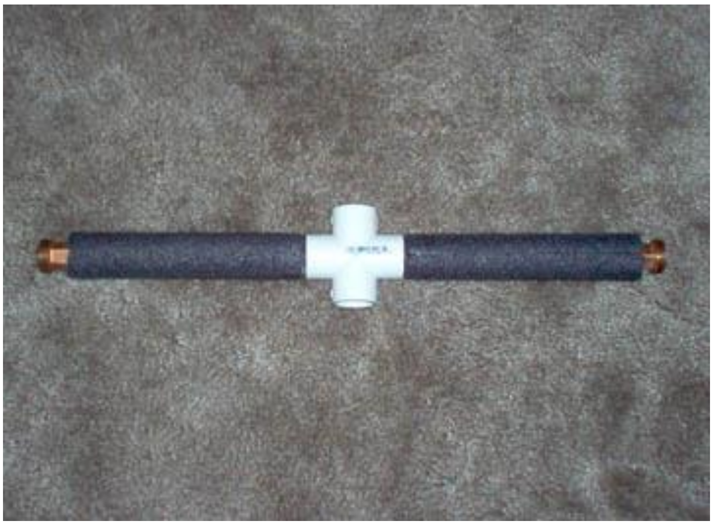


The PVC Cross Bar

The PVC cross bar is very easy to make. Two 8.375" lengths of 3/4" PVC are inserted into the 3/4" PVC tee. As a double-check that the lengths are correct, and that your PVC parts are the same as mine, temporarily attach the two PVC reducing tees to the ends, as they appear in the picture of the assembled main loop. The centers of the reducing tees (and thus the centers of the copper pipes which will later pass through them) should be exactly 21" apart.

The PVC Vertical Support

This piece will later contain the coupling loop. For now, simply cut a piece of 3/4" PVC pipe 14.75 inches long.



The Bottom Conductor

This piece forms the bottom of the transmitting loop. Underneath the pipe insulation and PVC cross is a single, straight piece of 1/2" copper pipe terminated in the threaded ends of two unions.Cut the copper pipe as needed to place the ends of the unions 17.75" apart. Do not solder anything yet. The foam insulation and PVC cross can be added later.

The Left and Right Side Conductors

In my design, these two pieces are very nearly the same size, but not quite. The loop is not quite symmetical, due to the asymmetry of the variable capacitor. It would be possible to modify the design slightly, so that the two side conductors are the same size. All that would be necessary is for one of the variable capacitor pieces (the stator assembly) to be made slightly taller to compensate. I welcome you to make this change if you wish, but I have chosen to only document what I have actually done.

The two side conductors are made from a straight length of 1/2" copper pipe with the threaded end of a union on one end, and a 1/2" elbow and the nut end of a union closely attached to the other. It will be necessary to cut a short "filler" piece of 1/2" copper pipe to attach the elbow to the union. Be sure to leave enough of that piece exposed for soldering (about 1/8").

When assembled, the left side conductor's length is 19.125 inches, measured parallel to the long pipe, from the center of the *nut* union-end to the end of the *threaded* union-end. The right side conductor, measured the same way, is 18.75 inches. Hold off on soldering anything for the time being.

Verifying a Good Fit

Slide the 3/4" PVC cross over the bottom conductor and the reducing tees over the tops of the side conductors, screw the unions together, carefully assemble the pieces, and see if they form a nice looking letter "U" shape.

The side conductors should be parallel and 21 inches apart, measured center to center. Attach the PVC vertical support and PVC cross bar, verifying that these support pieces will fit comfortably over the pipe when later centered over each piece by the insulation material.

The tops (threaded union-ends) of the side conductors should be 21 inches apart, measured center to center and parallel to the bottom conductor. Since the side pieces are of slightly different lengths, the left side of the "U" shape will be 3/8" longer (taller) than the right side (unless you've chosen to make them the same, as described earlier).

If everything checks out at this stage, in theory you could now start soldering. However, it is a good idea to make sure that the variable capacitor fits on the loop well, and the solder all the copper parts at once. Also, in the soldering step I will make suggestions as to how to get the PVC cross where it is needed (it won't slide over the union-ends), how to apply the insulation, etc. So for now, let's set these parts aside and start on the variable capacitor.

Building the Variable Capacitor

The variable capacitor is made up of the four pieces in this picture.

The Stator Assembly

The stator assembly is comprised of a 9 inch length of 1/2" copper repair coupling, a 1/2" copper elbow, and the nut end of a union. A short piece of 1/2" copper pipe must be used to attach both ends of the elbow. Cut these "bullet" pieces long enough to leave approx. 1/8" of copper exposed in each joint. (Add an additional 3/8" on the union side if you chose to deviate from my design and make the left and right side conductors the same length.)

Don't worry... it's almost time to begin soldering. Hang in there!

The Dielectric Sleeve

This is a 10 inch length of 3/4" *PEX* polyethylene pipe. Resist the temptation to use CPVC, which actually fits more easily here, because it is a lossy dielectric. When you transmit, CPVC sucks up a substantial portion of the energy by getting hot. PEX remains cool as a cucumber, letting your power go out over the air where it belongs.

As it comes from the hardware store, the PEX pipe's inner diameter is a little too small to fit over the copper repair coupling. If you have a lathe, great! I didn't, so I used a 11/16" speed bit (spade shaped) to bore out the pipe from both ends. It was necessary to move slowly and to let the drill bit rattle around in the pipe quite a bit after I was finished. Nonetheless, the copper repair coupling is only ever so slightly thicker than 11/16", so the PEX sleeve fits over it nicely once bored. You want it to be a snug fit as it is not supposed to slip during operation, and it is not normally disassembled.

Caution: Avoid allowing the repair coupling to become completely engulfed by the dielectric sleeve at this point, as it will be difficult to remove.

Check to see if 3/4" copper repair coupling can slide over the dielectric sleeve while it is partially installed over the 1/2" copper repair coupling. In my case, I found it to be difficult, and turned it down a little. I did this by sliding the PEX sleeve over a small hole saw that just happened to have the right outer diameter, then used my drill to turn the sleeve against a file (rasp). PEX pipe is stretchy, which is why it does such a good job of surviving when water freezes in it. However, this stretchiness means that a piece of PEX pipe that slides easily into the 3/4" repair coupling won't slide nearly so easily if at all, once it is installed on the 1/2" repair coupling.

For now, just try to make it possible to fit the pieces together, even if it is difficult. You can always remove more material later. You want some resistance so the antenna will stay put once tuned.

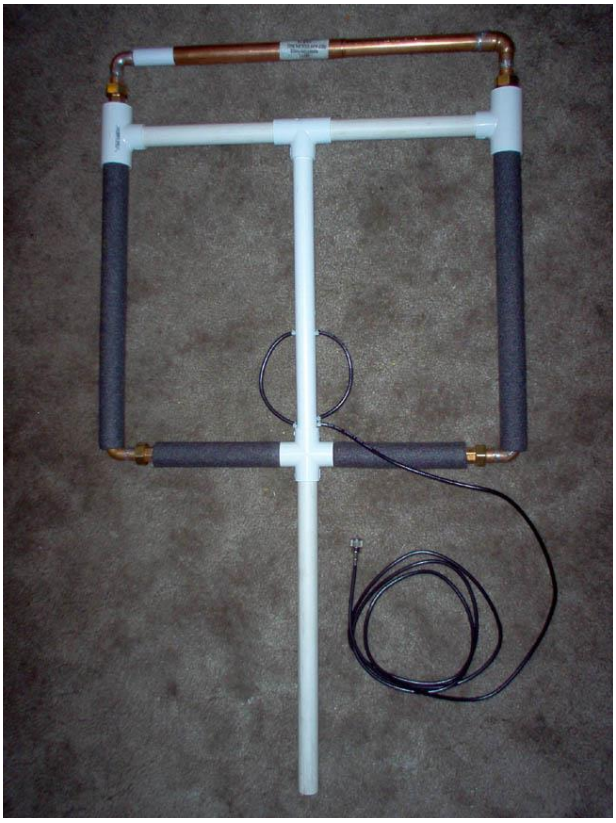
The Rotor

The rotor is easy! It's just a 9 inch piece of 3/4" copper repair coupling, lovingly deburred so it can slide easily over the rotor contact and the dielectric sleeve.

The Rotor Contact Assembly

The rotor contact assembly looks vaguely like a mirror image of the stator assembly. It consists of a length of 3/4" copper pipe, a 3/4" to 1/2" copper reducing elbow, and the nut end of a union. The length of the 3/4" copper pipe is approx. 8.375 inches (exactly 8 inches should be exposed, the rest fits inside the elbow). Use a short length of 1/2" copper pipe to attach the elbow to the union. Leave about 1/8" of this piece exposed for soldering.

Like the rotor, the rotor contact should be carefully deburred, as it needs to slide freely into the rotor.



Final Verification Before Soldering

As before, assemble the main loop for verification, only now, also attach the stator and rotor contact assemblies. These two capacitor parts do not touch at the top of the loop, but it should be possible to align their centers. Don't worry if the whole thing is very loose right now. The union joints are very flexible and forgiving. So long as it seems that the loop is square shaped and the capacitor pieces are co-axial in the middle, you're in great shape.

Soldering

It is now time to solder together the five copper assemblies: the bottom conductor, the left and right side conductors, the stator assembly and the rotor contact assembly. I'll just list a few soldering tips.

1. Undo the unions and solder each piece separately.
2. It is important to solder each joint completely, to minimize electrical resistance. Due to the extremely low radiation resistance of this loop, even a few milliohms have an impact on antenna performance.
3. There is no "trick" to the right and left side conductors. Simply solder the copper parts together. About the only advice I'll give here is that you should avoid getting solder in the threads.
4. The bottom conductor looks so simple, and it is, but there is one catch. The threaded union ends don't fit through the 3/4" PVC cross. My solution was to solder anyway, and use a dremel tool to remove material from the cross until it fit. Another solution would be to solder one end, allow it to cool, then install the PVC cross, taking care to keep it far away and as cool as possible while soldering on the other end.
5. Avoid getting solder on the outer surfaces of the stator and the rotor contact, since the dielectric sleeve and rotor fit snugly and must slide freely. If you accidentally get a tiny bit of solder farther from the joint than you had intended, you can always file it off, but it's best to keep these surfaces pristine if possible.

Once the parts have cooled, try screwing them together again and see if everything still fits as before. If not, make any necessary adjustments.

Adding the insulation

Install pipe insulation material over the two side conductors, leaving room to access the unions. Slide the PVC reducing tees over the insulation to complete assembly of the side conductors.

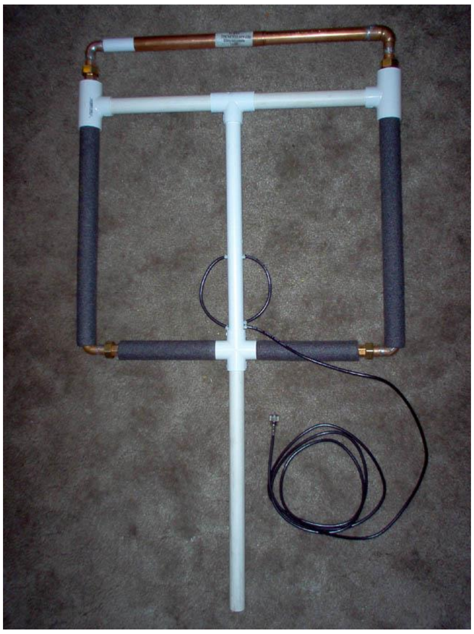
For the bottom conductor, use two pieces of insulation material, shoved into the PVC cross as far as possible and cut to size. I found it helpful to use an aggressive twisting motion to force the insulation material into the PVC cross.

Final Assembly of the Capacitor

Slide the dielectric sleeve over the stator, all the way to the joint. The sleeve is an inch longer than the stator, to prevent any possibility of shorts or arcing.

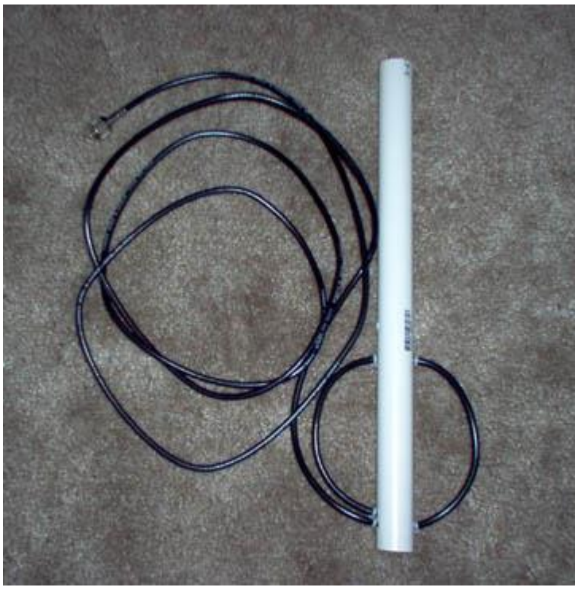
Now slide the rotor partway over the sleeve. Some resistance is normal, but if you find you are using excessive force, use the procedure mentioned earlier to turn down the sleeve until a comfortable fit is achieved.

Complete the capacitor assembly by inserting the rotor contact assembly into the rotor. The union centers should be exactly 21" apart. If they aren't, slide the dielectric sleeve onto or off of the stator to adjust the overall length of the capacitor.



The Complete Loop At Last

We're still missing a coupling loop and a 3/4" PVC handle, but other than that, it is now possible to assemble the entire loop, capacitor and all. It should look like the picture, other than the missing coupling loop and handle.



Adding the Coupling Loop

The coupling loop is a 15 inch (in circumference) loop. A simple heavy wire or thin pipe, bent into a circle, open at the bottom and connected to the 50 ohm coax, can do the trick. 1/4" copper line worked quite well when I tried it.

For my antenna, I chose to use a faraday shielded loop, to reduce the antenna's response to E-field interference (certain types of power line noise, for example). I also decided that the flexible coax loop was less likely to be damaged when transporting the antenna.

Here is a web site that shows how to make a faraday shielded loop from coaxial cable. It also has some good notes on magnetic loop antennas.

Testing the Antenna

Caution: Even at fairly low power levels, the RF voltages at the top of the capacitor become quite high. For example, a 20W power level will develop almost 2,000V across the capacitor. Also, check this RF Safety web site to make sure your exposure to RF is within acceptable limits.

Connect your radio and tune to a frequency near 14 MHz. Somewhere near 2/3 to 3/4 of full capacitance, the antenna should exhibit a sharp response peak. You might find it useful at first to leave the antenna alone and explore its tuning with an analyzer or your transceiver, moving the capacitor and testing it again. You will have to move your hands away from the antenna for each trial.

If everything is working properly, it should be possible (though sometimes difficult until you are practiced and you have the dielectric sleeve perfectly shaped) to achieve 1.0:1 SWR on any frequency from 14 to 30 MHz.

Tip: use a marker to write on the capacitor so you can find favorite frequencies again.