

Five Bands – No Hands

A Small Transmitting Loop for 40 through 15 Meters

with Fixed Coupling

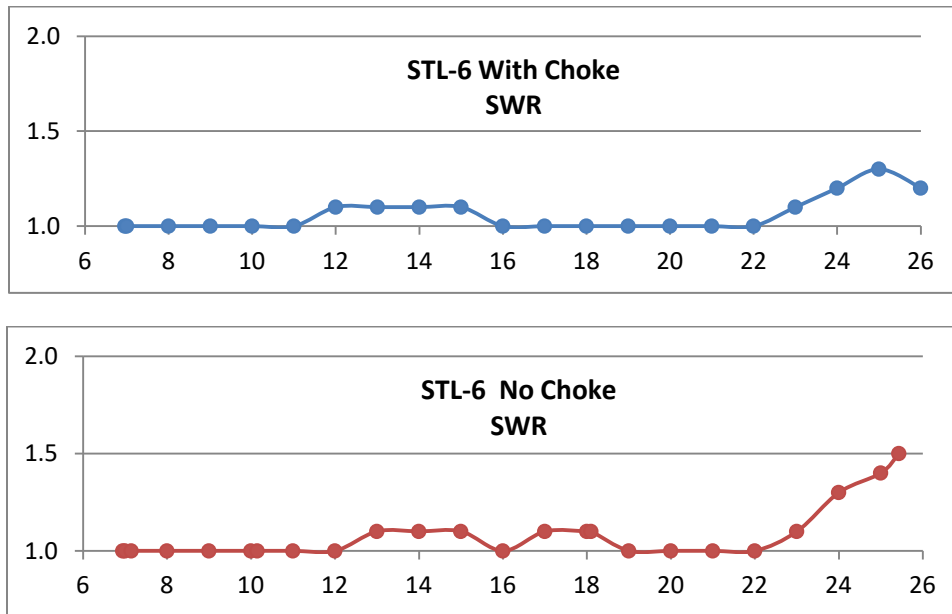
by Chris, K6NM, New Mexico, USA

Tired of hiking out to the backyard loop and fiddling with the coupling, when you just want to change bands? Well, read on.

Living in a community with HOA restrictions, my 4-year quest has been to build a multi-band small transmitting loop (STL) that would accept at least 100 watts, and be really easy to operate, especially when changing bands. And I wanted to use commonly available components and to be reasonably cheap – and I mostly succeeded.

Like any STL, a very high Q tuning capacitor is critical, and I bought a 5-250 pF vacuum variable capacitor off eBay for about 100 bucks. Also, I wanted to put the 10-foot length of copper pipe I had in the garage to good use, and I think I spent about \$40.00 on everything else. You can easily build one of these antennas, too. There's a list of materials at the end.

Here's the continuous-tuning SWR curve of my antenna over the 6 to 26 MHz spectrum, both with and without a common mode choke attached:



As you can see, this antenna delivers SWR's of 1.1 or better on 40 through 15 meters, and requires no adjustment, ever. When I change bands all I have to do is resonate the antenna from the shack, and I'm ready to transmit.

This is the sixth STL antenna that I've built over the last 5 years, so I cleverly call it STL-6. It's an octagonal copper tubing main loop, paired it with a pretty unconventional loop coupling system.

The main loop is made from a single 10-foot piece of 1/2-inch copper water line cut into 8 identical lengths, with a 14mm capacitor gap, and soldered together with 45-degree copper elbows using silver-bearing solder paste and a heat gun. This worked very well - no more torches for me. The loop has a measured DC resistance of 2 milliohms. The capacitor leads are copper strips soldered to the main loop. The coupling system is a dead simple loop of RG-8X coax, but formed into kind of a unique shape.

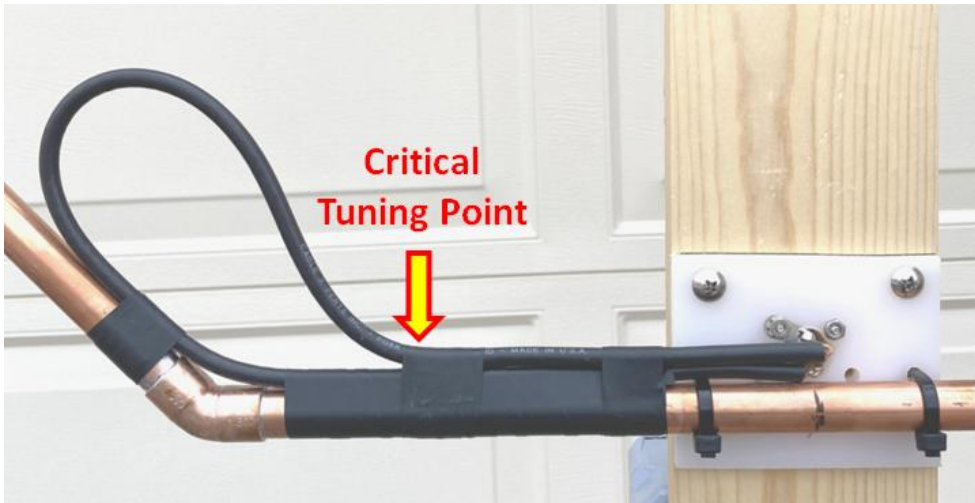
Here's the DTL-6. It has a surplus Soviet-era vacuum variable cap at the top, driven by a PVC shaft, with a stepper motor mounted below the loop, and limit switches to protect the capacitor shaft from over-travel, all mounted on a 1 x 6 inch pine board 8 feet tall.

The main loop is 1/2-inch copper water line, with each side measuring 15-3/8 inches (391mm) on centerline. The cable ties also show that this is a work in progress :-). To turn the stepper motor I use a DRV8825 board at 32 microsteps, and I use a length of Cat-6 ethernet wire as a motor control cable.

Except for the coupling system, the antenna components are well-known and have been discussed thoroughly, so I'll focus on detailing the coupling loop design here.



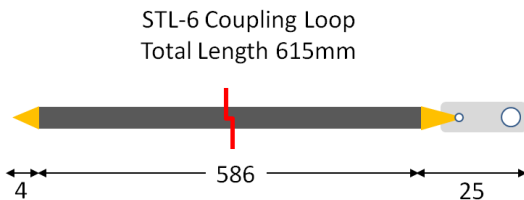
THE COUPLER



I call this asymmetrical coupler the "NM crush", after my home state of New Mexico. Its odd shape is the trial-and-error result of over 100 loop shape and length combinations, including gammas and toroids as well.

Truth be told, I just could not get any wide-bandwidth coupler to work with circular main loops. Maybe you can. This setup yields a 1.1 or better SWR from 6.3 to 23.0 MHz, and I can live with that.

Here's a diagram of the RG-8X loop before shaping, and connection to the SO-239:



The 615mm long loop has a solder lug on one end, which attaches to the body of the SO-239 connector. The SO-239 is located in the wood mast just above the center of the bottom tube of the main loop. The other end of the coax is soldered directly to the center conductor of the SO-239. I placed a 5mm thick piece of white HDPE in this area to insulate the main loop from the mast.



Only the coax shield braid is used as the loop conductor. I removed 4mm or so of the outer jacket at each end, clipped off the center conductor and insulator at both

ends, and then twisted the braid ends for the solder connections. The center conductor is not used.

The overall length of this coupling loop is 0.197 times the centerline perimeter of the ½-inch copper tubing I use for the main loop. Maybe a 0.200 factor would work, but this type of coupler seems to be picky about this length ratio, so I stick with 0.197, and ½-inch tubing. I'm not an engineer, just a tinkering ham radio guy, but my best guess is that the NM crush coupler acts as an inductive/capacitive matching network.

SHAPING THE COUPLER

I've found that it's key for best performance of this type of coupler to get its shape exactly right. As you can see in the photos, the coupling loop is being held in place for now by electrician's tape – very handy when making the many necessary tweaks to the loop's shape during construction.

The fixed leg of the coax runs away from the SO-239 center post and is taped down first, all along the top of the inside of the copper tubing, almost to the 45-degree bend. (Hint: I first solder a heavy copper wire into the SO-239's center post, to be able to keep the coax centered atop the tubing when it's soldered.) That leg of coax sweeps up the copper tubing past the angle, and is taped down further as seen in the photos.

The second or top leg of the coax has the solder lug, which is attached with a machine screw to the SO-239's mounting flange as shown in the photos. Then that coax leg is taped directly onto the top of the first leg for about 11.5 centimeters. Later you'll be moving this top leg for final SWR adjustment, so tape it in place so it can easily be re-adjusted. To start, I use multiple rings of tape spaced a few cm apart.

I couldn't have come up with this design without a graphic antenna analyzer to do the interactive SWR adjustments. I use a Youkits FG-01 antenna analyzer on an 8-foot length of coax, to constantly watch my SWR curve in real time as I adjust the coupler.

The entire coupling loop is centered in the plane of the big loop, and no twisting or angling of the coax away from the center plane is necessary. To adjust, simply pinch the top leg of the coupler coax closer or farther away from the bottom leg, observing the SWR at your target frequency. When you get to your desired SWR, tape the coax in place.

I usually start by adjusting for best SWR on 20 or 17 meters, my fave bands, and then check the higher and lower bands. Changing the open area of the loop tends to affect the higher frequencies, and pinching the top coax leg up and down tends

to affect the lower frequencies. In some cases you might need to introduce a couple millimeters of "daylight" between the two parallel coax legs.

Changes of only a few millimeters can alter your SWR significantly, so be patient. Even with practice, it takes me a half hour of fiddling to get the coupler shape just right. I'm looking for a more permanent method of stabilizing the coupler shape, but right now, it's just *more tape*!

An adjustment usually affects more than one band, so I re-check all bands after an adjustment. When all bands are close to their best SWR's, I connect a 40-foot coax feedline to get away from the antenna and eliminate any body capacitance, re-check the SWR curve, and commute back and forth to do any final tweaks. Usually there are not many corrections needed.

COMMENTS

I really like the convenience of this "set it and forget it" coupler, and I'll try using insulated copper tubing to replace the RG-8X coax for more physical stability. Then there's weatherproofing, as well.

Finally, this crushed style coupler seems to be scalable to other sizes of octagonal loops and deliver a 1.1 or better SWR over at least 3 to 1 frequency ranges. The STL-6's 1.1 SWR range is 6.30 to 23.03 MHz. The STL-5 that I built in 2018 had a range of 6.6 to 22.0 MHz.

Well, that's it - thanks for reading. Hope you've found something useful here!

Chris , K6NM

August, 2021

FINAL THOUGHTS

--- This antenna is usable on 12 meters I think, but I don't operate that band and so I can't all this antenna "Six Bands – No Hands". By the way, this antenna is dandy for Short Wave Listening, since it's continuous coverage between 6 and 26 MHz, depending on your capacitor's capabilities.

--- I always connect a common mode choke at the antenna's SO-239. STL's love to use the feedline as part of the antenna if you let them. My choke is a homebrew following the design of Peter on YouTube: <https://www.youtube.com/watch?v=P7wW4TtXmc8> (Channel TRXLab, video #105).

It has about 30 dB of common mode current attenuation from 40 through 10 meters. If I remove the choke, transmitter RF from the coax feedline leaks into the motor control cable and randomly activates the motor, changing the antenna resonance frequency. So I always use the choke.

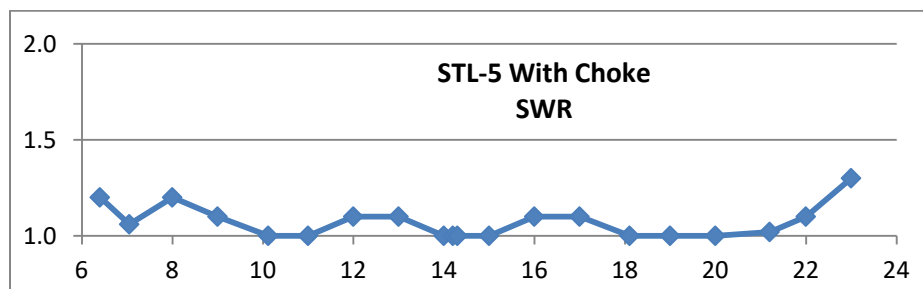


--- Here are my STL-6 bandwidth measurements for calculating Q. They're the 2.62:1 SWR points below and above resonance points (5:1 forward:reflected power on my Bird 43):

Center	Lower	Upper	Bandwidth
7102.17	7097.61	7106.83	9.22
7115.45	7110.54	7119.55	9.01
7137.21	7132.63	7141.64	9.11
14080.69	14066.97	14099.47	32.50
14106.75	14090.35	14122.54	32.19
21202.02	21174.63	21251.91	77.28
21249.89	21216.26	21293.73	77.47

--- In 2018 I built a larger loop which was a bit too heavy for me to lug around, the STL-5. It was another 1/2-inch copper octagon with 20-inch (508 mm) sides on centerline, and an 800mm overall length NM crush style coupler. It used the same capacitor and had a DC resistance of 2.6 milliohms.

Here's its performance:



STL-6 MATERIALS

Main loop:

10 feet of ½" copper water line, type "M" (.028" wall), capacitor gap 14mm

45-degree ½" copper elbow couplers

Silver-bearing solder paste (430 degrees F. flow, 650 F. reflow).

Heat gun

5mm thick HDPE pieces to insulate main loop from wood mast, sawn from a kitchen cutting board.

Coupling loop:

RG-8X stranded center coaxial cable, labeled "ABR High Flex RG8X" or "Cablexperts RG8X Mini 95% Braid", 6.1mm outside braid diameter

HH Smith/Abbatron #6 toothed lug 16mm long

Capacitor:

Soviet-era 7-250pF vacuum variable capacitor, 8.5kV, 20 turn shaft

13mm wide copper sheet strips, 1/32" (0.8mm) thick, for connecting to main loop

Stainless hose clamps for connecting copper strips to capacitor ring contacts

Motor/Driver/Controller:

NEMA 17 dual shaft 1.5A 1.8 degree stepper, DRV8825 driver board set at 32 microsteps, CD40106 hex Schmitt trigger gated pulser and switch conditioning, diode logic, and panel switches

Capacitor drive shaft:

¾" PVC pipe, Schedule 40, plus end caps and 8mm bolts

Flexible couplers for drive shaft ends

Capacitor shaft rotation limiter:

300mm 8mm T8 Lead Screw Set

Microswitch limit switches, placed along lead screw assembly to limit shaft rotation to 12 full turns