The Capacity Tuned Folded Loop

A 1/3-wave, 7-foot, 20 meter antenna.

by Jim McLelland WA6QBU

The Capacity Tuned Folded Loop (CTFL) is a compact antenna that puts out a respectable signal on 20 meters and it will also let you tune other bands between 40 and 10 meters with a tuner. It is a wire loop that is inexpensive, simple to build, and you can hang it up anywhere. If you're like me and aren't allowed to put up an outside antenna, the CTFL may be a good HF option. The design is based on one of those brainstorms that come late in the night and haunt you until you try it out to see what will happen. (The XYL says I've been haunted for years, and points to all the strange noises that come from the shack when I'm in there.) Try it! You won't be sorry.

The Antenna

The CTFL is a small wire loop designed primarily for single-band HF operation. It is a folded dipole, shortened until the impedance drops from the typical 300 ohms to 50 ohms, then bent into a delta loop, with a capacitor between the ends to tune it back down to the original resonant frequency. It's then fed through a half-wave length of twin lead that terminates in a 1:1 balun at the tuner and SWR bridge. You could put the 1:1 balun at the antenna and use coax, but I wanted the option of using my tuner to resonate the CTFL on other bands and twin lead is more efficient in this respect. Although the CTFL is probably at its best on the design band, it will work on the others. But, if you can work it out, it's better to have one antenna for each band of interest.

With this system, you get a self-resonant antenna on 20 meters with a 2:1 SWR bandwidth of about 280 kHz and an impedance of 50 ohms. I found that I could easily resonate on the center of the phone band and run up and down the band without need of the tuner and stay below 2:1 SWR. Even moving to the bottom of the CW portion only required minor tuner touch-up. Another interesting point is that you *do not* need a good ground to make it work. Some kind of ground is always a good idea to help with RFI and RF feedback, but it is absolutely not required to make the loop work efficiently.

Construction

Take a look at Figure 1. All the lengths are based on the characteristics of Radio Shack 15-1153 5/16" twin lead (get two rolls if you want to feed it with twin lead). Other varieties will require somewhat different lengths, especially with the capacity tuning stub. Cut the 20 meter loop to 24' 8", short both ends together, and open one conductor halfway between the ends for connection of the feedline. Keep in mind throughout the project that all connections should be twisted and soldered. Further, you need to use shrink tubing everywhere possible for both added strength and insulation. A little planning here will save you a lot of grief later. Now solder a 24" open stub to the ends. Then, cut 27' 10", or some multiple of it, for your feedline (half-wave with a velocity factor of 0.80) and solder it on. Keep the loop end spacing constant at about 1" by attaching a short piece of rope with shrink tubing. Now all you need is a 1:1 balun on the rig end of the feedline and you're done. You can buy a balun, although they're easy to make. Ten to 15 turns of RG-58/U in a 6" coil will work fine, or you can wind some RG/174/U on an open ferrite form that Radio Shack sells. You can also use a 4:1 balun like the one that's probably in your tuner, but then you'll have to use the tuner to match the system.

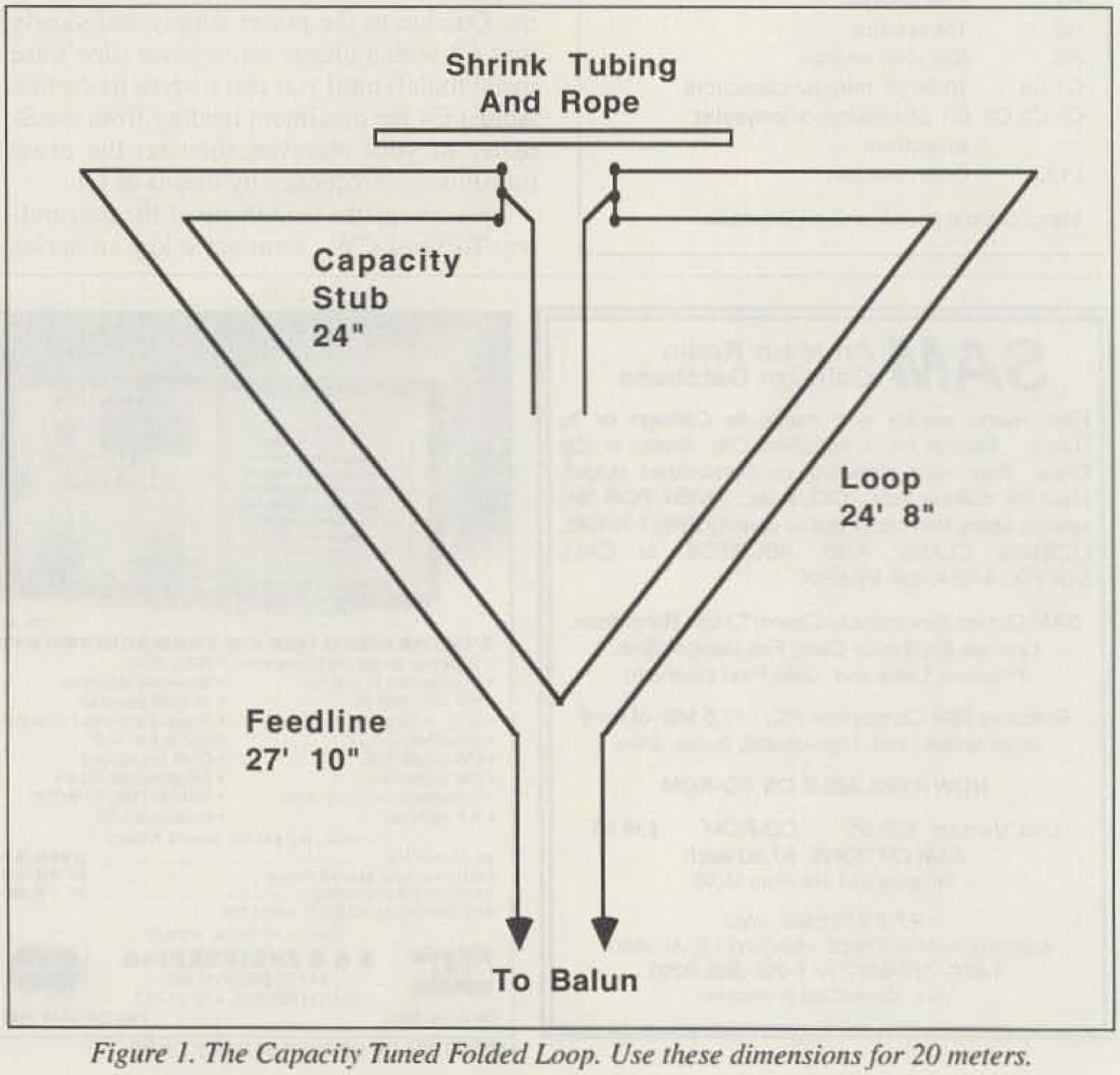

Figure 1. The Capacity Tuned Folded Loop. Use these dimensions for 20 meters.

Installation

If your loop is quite close to the ground, install it vertically. Keep in mind, however, that the loop has directivity perpendicular to its plane. Therefore, if you have a favorite direction and your space will permit it, point it that way. You can also reduce interference, if that's a problem, by positioning the loop sideways to the noise or stations you want to reduce. If you've got a two-story house, you can mount the loop horizontally in the attic. I've tried both at the same time and usually closer stations are better horizontal whereas I hear DX better when its vertical. Being able to easily switch back and forth between two antennas keeps the QSO going awhile longer. Install the loop as an equilateral triangle if possible.

Changing the feed angle tunes the loop up as the feed point angle gets wider and the impedance goes up also (60 degrees = 50 ohms and 90 degrees = 100 ohms), so it should be stable before trimming the stub. Stay away from metal objects and use insulating material for mounting purposes. If you mount the loop vertically, feed it from the bottom, and keep the line away from metal objects as well.

Tuning

Built as described above, the CTFL is probably resonant at the bottom of the band, depending on your loop angle and proximity to objects. Using an SWR bridge, find the dip near 14 MHz. To raise the frequency, just trim 1/2" pieces from the capacity stub until it resonates where you want it. If you don't want to bother, just use your tuner and it'll work fine. If you're a real stickler, use an antenna bridge and you can get it right on. That's what I did but I really don't think it matters that much with a tuner.

Testing

Does it work indoors? Yes—yes—yes! With no tuner on 20 meters, I've been able to work all over North America with the loop hanging on a door. Often, signals were the same as my reference antenna in the attic.

I think you cliff dwellers are going to like this one. Try hooking it to the XYL's hanging plants like I did and see what happens. Ha-ha.

Parts List

Twinlead—5/16"	100'
Shrink tubing—3/8"	1'
Shrink tubing—3/16"	1'
Banana plugs	2
Dacron line	50'
Double split twinlead insulators w/hardware	4

Note: All parts needed to build this antenna can be obtained by ordering the Compact Loop Experimenter's Kit. Introductory price w/shipping (40% discount for *73* readers): $24. Available from Antennas West, 1500 N. 150 W., Provo UT 84604; tel. (801) 373-842.

Notes on Impedance and Matching

A single wire loop of 1/3 wavelength has an impedance of about 13 ohms. This is typical of small loops and, in fact, many designs are down around 5 ohms. Since modern equipment is designed for 50 ohm antenna systems, some sort of matching is necessary. The "folded" design (multiple wires in parallel) was attractive because it is built into the antenna. Further, the impedance multiplying factor can be chosen, depending on how many "folds" are used. The final impedance is determined by multiplying the original impedance by the square of the number of wires in the antenna.

Expressed as a formula: Z(f) = Z(o) x N x N

Z(f) = Final Impedance

Z(o) = Original Impedance

N = Number of parallel antenna wires

For example:

	Z(f) ohms	=	Z(o) ohms	x	N # wires	x	N # wires	Antenna Configuration
1.	13	=	13	x	1	x	1	single wire
2.	52	=	13	x	2	x	2	twinlead x 1
3.	208	=	13	x	4	x	4	twinlead x 2
4.	468	=	13	x	6	x	6	twinlead x 3

The CTFL uses example #2. I settled upon it because it is simple; further, I felt that as I attempted to use the antenna at higher frequencies, the impedance would be less likely to go through the roof. However, I have experimented with example #3 as well and it worked just like the formula said it should. I merely made two identical loops and taped them together, connecting them at their shorted ends and using one capacitive stub and one feedline connected in one of the four wires that now forms the antenna. For a purely single-band antenna, this is a more elegant design and gives a good match with 300 ohm twin lead. One step further would be to use three loops as in example #4 and feed it with 450 ohm ladderlead (available from Antennas West—see the Parts List). Also, more folds should be more efficient since there's more total copper and less current per wire.

Using 300 ohm twinlead with a large mismatch on the line does not cause a loss problem, but some interesting things can happen that must be kept in mind. Let's look first at the CTFL's 52 ohm impedance (#2 above) as an example. When a feedline has a mismatch, it will act like an impedance transformer of some kind, depending on several factors. If it is exactly 1/2 wavelength long, it will act as a 1:1 transformer, *period!* You just have to make sure that you really have a half wavelength. To do this, you must divide 492 by the frequency in MHz, and then multiply by the Velocity Factor (VF) of the feedline to get the length in feet.

For example:

492 /14.14 MHz = 34.8 ft.

34.8 ft. x 0.80 = 27.8 ft. = 1/2 wave at 14 MHz

Furthermore, all of this happens regardless of the line impedance. (If you use coax and roll some of it up in a coil, you also get a balun—see below.) As a side note here, folded antennas do not work at their folded second harmonic. (Think about what your rig sees if the other end of a half-wave line is shorted: You got it, a short!) One leg of a folded loop or dipole is normally a 1/4 wavelength but at the second harmonic (frequency x 2) this equals a short circuit! With the loop described in the article, the second harmonic of the folded portion is about 32 MHz—safe on 10 meters.

Now we need to consider the other extreme, a 1/4 wavelength of feedline. This type of impedance transformer makes major changes and depends on both the line and antenna impedance to determine the final system impedance. System impedance equals line impedance squared, divided by the antenna impedance. To see how this works, look at the following formula:

$$Z(\text{system}) = \frac{Z(\text{line}) \times Z(\text{line})}{Z(\text{antenna})} = \frac{300 \times 300}{52} = \frac{90{,}000}{52} = 1{,}731 \text{ ohms}$$

As you can see, the system impedance suddenly went quite high, and that's one reason why I went with a half-wave line in the article.

Earlier I mentioned a balun. The reason you need one is to keep the feedline from radiating, and so you don't distort the radiation pattern. The latter may not be so important, but only the antenna should radiate and nothing else. On the higher bands, it doesn't take much coax to make a half-wave (27.8 ft. at 14 MHz) line and if you wind half of it, or more, into a 6" coil, you've got yourself a balun. However, it's frequency sensitive unless you use coax that matches the system impedance. For example, RG/58/U is 50 ohm coax and so is the antenna in the article. As the XYL would say, "Voilà." Now the length isn't even important but I'd stay with at least 1/4 wavelength as a minimum. Hollow ferrite cores made for coax also work well if you use enough of them, but I really like the little snap-apart ferrite core that Radio Shack sells. You can wind quite a bit of RG/171/U coax (that's the little-bitty 50 ohm stuff) on it and it makes a real small balun that you can put at the antenna or anywhere else. I wind as much as I can inside, and some more around the outside, and then tape the whole mess together. I suppose you could use a big piece of shrink tubing or put it inside some PVC pipe but I just use electrical tape and it works fine.