the reduced-size, full-performance, corner-fed delta loop

For broadband DX performance, try this one on for size

The full wave loop, whether in delta or quad form, has enjoyed popularity over many years. It forms the basis for the well-known and very effective 2-element quad antenna, the history of which can be traced back over 30 years.

A single loop in quad (diamond shape) or delta (apex up) has the following advantages: it requires only a single support, matches easily into low impedance coax, and offers broadband performance.

In May, 1974, L.V. Mayhead, G3AQC, published a very interesting article on the operation of loop antennas close to ground.[1] By modelling the antennas at UHF, he found that the angle of radiation of a delta loop close to ground could be significantly lowered if it were fed at either side corner instead of at the center of its base leg. This had important and useful implications for the use of such antennas on the lower frequencies.

The corner-fed delta loop has also been mentioned as an effective DX antenna by ON4UN in his book *80-Meter DXing*,[2] and references to it have appeared in many popular Amateur journals over recent years.

Space for a full-sized 7 MHz delta loop was not available at my station in North Sydney, Australia. However, previous experiments carried out in England showed very little deterioration in performance of two-thirds size, side-loaded quads at HF compared to full-sized quads. I decided, therefore, to see whether a corner-fed, reduced-size delta loop for 7 MHz could be made to perform as efficiently as a full-sized loop.

14-MHz model first compared

Instead of experimenting at 7 MHz, I chose to first experiment by reducing the size of a full-sized 14-MHz corner-fed delta loop so that a standard of comparison would be available. The 14-MHz loop had been in use for some time and had shown itself to be an effective antenna despite a base height of only 6 feet (1.8 meters). In comparison tests with a half-wave dipole at 30 feet (9.2 meters), it would generally give a 1 S-point improvement in Europe on long path, and seemed about equal to the dipole on the short path to Europe (from Australia). Both antennas were broadside to Europe on long and short paths.

It is worth remembering that even when the delta loop and dipole delivered equal results, the dipole had the advantage of being nearly a half wavelength high on 14 MHz. To achieve the same effective height for a dipole operating on 7 MHz or 3.5 MHz would mean heights of over 60 feet (18 meters) and 130 feet (40 meters), respectively!

current distribution determines polarization

In the original article on the corner-fed delta loop, the loop was not an equilateral triangle, but instead had sides in the ratio 1:1:1.4, where 1.4 represents the base of the apex-up triangle. This configuration means that the two sloping sides meet at a right angle to each other, and the vertical height of the triangle formed is not as great as it would be if the triangle were equilateral in shape.

The current distribution of a delta loop fed in one corner is shown in **fig. 1**. The phase of the currents in the two sloping legs is such as to make it resemble two vertical antennas fed in phase so that maximum radiation would take place in a plane broadside to the plane of the antennas. Although the sloping sides of the delta loop are at 45 degrees to the horizontal, the

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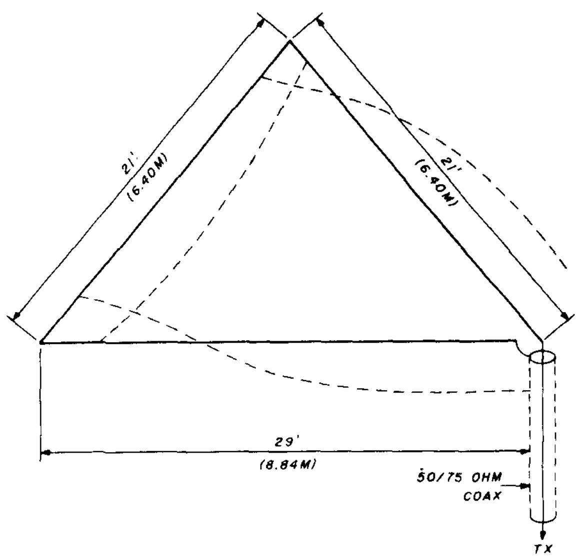

DIMENSIONS FOR FULL-SIZE CORNER-FED DELTA LOOPS

frequency (MHz)	total loop circumference (feet)	total loop circumference (meters)	length of each side (feet)	length of each side (meters)	length of base (feet)	length of base (meters)
3.600	279 ft. 2 in.	(85.09)	82 ft.	(24.99)	115 ft. 2 in.	(35.10)
7.075	142 ft. 0 in.	(43.28)	42 ft.	(12.80)	58 ft. 0 in.	(17.68)
14.150	71 ft. 0 in.	(21.64)	21 ft.	(6.40)	29 ft. 0 in.	(8.84)

fig. 1. Current distribution for a full size 14 MHz corner-fed delta loop. The inner conductor of coax connects to sloping leg.

phase of the currents in both sloping legs produces a predominately vertically polarized signal.

My objective with the smaller loop was to try to recreate a similar current distribution to that described for the full-sized loop.

A loop two-thirds the size of the normal 14 MHz loop was made. It had sides of 14 feet (4.27 meters), and a base of 20 feet (6.1 meters). However, before I made a serious attempt to load this loop to obtain the conditions of current distribution previously mentioned, I decided to simply series-load the loop with a coil at its feedpoint and observe the effects.

When the loop was loaded in this way, it was possible to lower its resonant frequency from 20.9 MHz to 16.5 MHz by adding small amounts of inductance. However, tuning the loop lower than 16.5 MHz required increasingly larger amounts of inductance, until finally a coil of 17 turns close wound on a 2-inch (5-cm) diameter form was needed for resonance at 14 MHz. This coil had a measured inductance of 17.1 microhenries, indicating that the antenna was 1500 ohms capacitive reactive at 14 MHz. The radiation resistance of the loop was too low to allow a good match into 75-ohm coax, and even with the feeder tapped into the coil to obtain a match, results were very poor. This was not really surprising, because by virtue of being placed at the feedpoint, the coil would have been carrying high current, introducing high loss into the system. The current distribution of the loop loaded in this way would not resemble the full-sized version. At best, then, the loop can be lowered in frequency by up to *20 percent* of its natural resonant frequency by simple series loading with a coil. This is probably not the best way to load the antenna, but it may still give useful results. To bring the 20.9 MHz resonant loop to resonance on 14 MHz represents a *33 percent* lowering of frequency.

the effects of base loading

The next experiment consisted of increasing the sides of the loop from 14 feet (4.27 meters) to 17 feet 9 inches (5.41 meters), but keeping the base at 20 feet (6.1 meters) and to try loading the base wire. If the base could be loaded, maximum current would appear in both sloping sides, with a voltage point at the top of the loop. The sides of 17 feet 9 inches (5.41 meters) represent a quarter wave each on the loop at 14 MHz, since the loop circumference in feet is given by 1005/frequency in MHz (bear in mind that there is no *end effect* on the wire of a loop).

The objective with the loop in **fig. 2** was to make the base look like an *electrical half wavelength*, with a voltage point in the middle of the base wire. This would then result in each leg carrying high currents in phase, and a low impedance point at each corner of the loop.

The loading of the base wire was quite easily achieved by connecting two five-foot (1.52-meter) lengths of 300-ohm twin ribbon feeder, shorted at their far ends, 5 feet (1.52 meters) in from each corner of the loop, as shown in **fig. 2**. The ribbon feeder was used instead of a coil because it was felt losses would be lower, and ribbon feeder proved easier to trim and was less bulky than a coil. A 3-foot 6-inch (1.07 meter) piece of stiff wire was connected at the voltage point midway along the base and brought the loop to resonance at 14.15 MHz.

The loop matched well to 75-ohm coax, with an SWR of less than 1.5:1 across the band. The performance of the loop compared well to the full-size version. However, the two hanging stubs would obviously present a problem when scaled up, so I decided to hang two wires from the middle of the base, and pull them back on themselves, as shown in **fig. 3**. This idea worked extremely well, and with each wire 9 feet 3 inches (2.82 meters) long, the loop was again brought to resonance at 14 MHz, but without the inconvenience of hanging stubs.

This method of loading has the advantages of low loss and ease of trimming. Performance was again similar to the full-sized loop.

reducing leg length

Now that the base had been successfully loaded so that it looked like an electrical half wavelength, an attempt was made to reduce the two sloping legs back to 14 feet (4.27 meters) by taking up the extra wire in the form of a closed stub at the top of the antenna. Various closed stubs using open wire line and 300-ohm ribbon feeder were tried, and although the antenna could be resonated each time, the radiation resistance at the feedpoint was too low to match into 75- or 50-ohm coax.

The stubs were dispensed with, and a single wire 7 feet (2.13 meters) in length connected to the apex of the loop, and hanging vertically brought the antenna to resonance. Although this proved to be a much simpler way of resonating the loop, the radiation resistance at the feedpoint was still too low.

A 4:1 matching transformer at the feedpoint connected in such a way so as to step up the impedance of the loop did provide a match, but the bandwidth of the loop was too narrow. It was felt that the introduction of a matching transformer would start to make the whole exercise rather cumbersome and introduce extra losses apart from the unacceptable bandwidth.

After some experimentation, the sides were increased to 16 feet (4.88 meters), with a 3-foot 6-inch (1.07-meter) wire hanging from the apex. This produced an SWR of less than 1.5 to 1 across the whole band even when the base of the loop was only 4 feet (1.2 meters) high.

Results with this loop were still comparable to the full-sized loop, and represented a reduction of the full-sized loop of 27 percent in terms of circumference, with a corresponding reduction in the perpendicular height of the triangle by 18 percent.

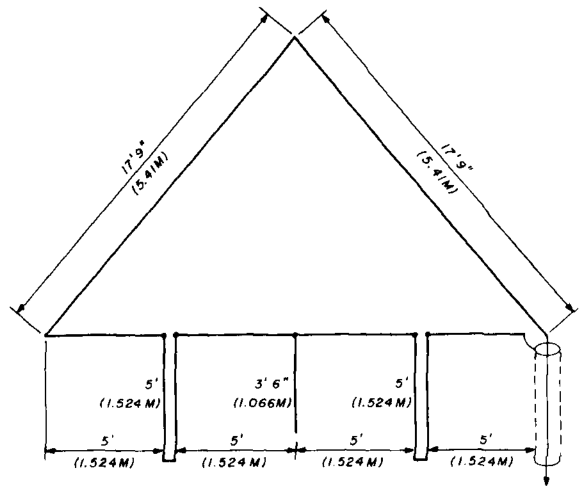

fig. 2. Initial method of loading loop using lengths of 300-ohm ribbon feeder shorted at far end.

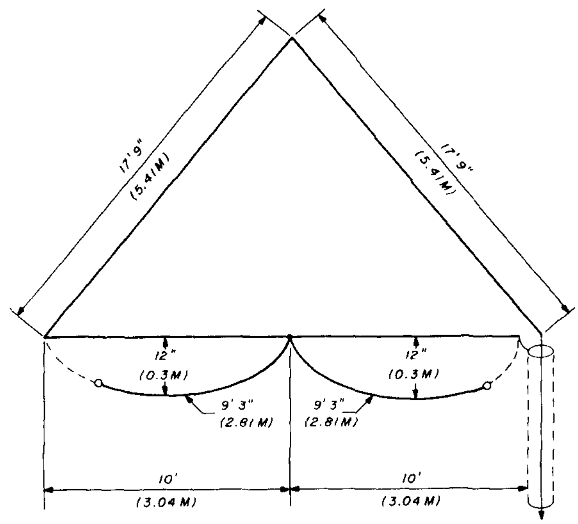

fig. 3. Improved method of loading using wires connected to center of base and pulled out as shown. Light nylon cord is used to secure their ends.

40-meter model

The final experiment was to double the dimensions for 7 MHz operation. This meant that the sides were each 32 feet (9.75 meters), base 40 feet (12.19 meters), apex vertical loading wire 7 feet (2.13 meters), and base loading wires each 18 feet 4 inches (5.59 meters). These dimensions resulted in resonance at around mid-band on 7 MHz with an SWR of no greater than 1.5 to 1 across the band.

A thin, light nylon cord was attached between the bottom of the apex loading wire and the midpoint on the base. This was necessary to keep the apex loading wire from blowing around and also to help prevent sag in the base wire, the latter which was also supporting the bottom loading wires. The loop was pulled slightly away from the mast so as to keep any interaction between the partially metal mast and itself to a minimum.

The results with the 7 MHz loop were good. I worked many continents—including America and Europe — with good reports.

It should be remembered, however, when assessing the performance of any antenna, there is no one antenna that will give excellent results on all paths, during all types of propagation, and over all distances. The corner-fed delta loop is a predominately low-angle radiator and as such should generally be at its best over longer distances. If one is only interested in working, for example, up to 1000 miles, a dipole with its higher angle of radiation could be expected to give better results. If a corner-fed delta loop is erected, this point should be remembered in any comparison checks.

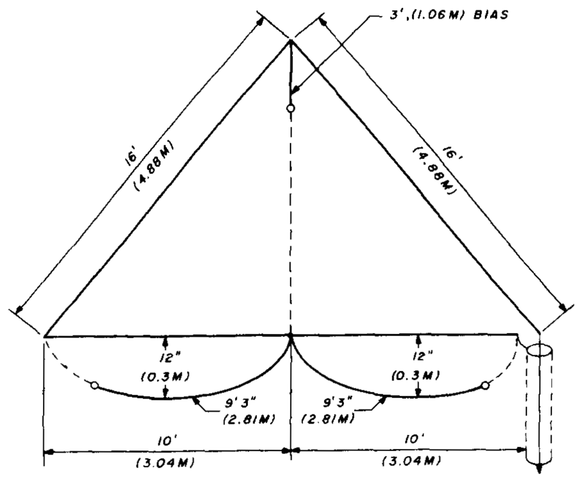

fig. 4. The final loaded loop for 14 MHz. All dimensions are doubled for operation on 7 MHz. Base loading wires are each 18 feet 4 inches (5.59 meters). The top loading wire is made taut by securing to base with thin light nylon cord.

how about 80 meters?

There is no reason those with sufficient space and mast height could not assemble a 3.5 MHz version of this antenna by simply doubling the dimensions given. A 3.5 MHz version would require a mast height of 56 feet (17 meters), which would allow the base of the loop to be 6 feet (1.8 meters) above ground. The horizontal distance taken up would be 80 feet (24.4 meters). These dimensions represent a considerable saving on the full-sized loop and are feasible for many Amateurs.

Final trimming of the loop should be done by adjusting the lengths of the bottom loading wires simultaneously so that their respective lengths are always equal. The top vertical loading wire should not be trimmed. Any trimming should be carried out with the antenna at its normal height, because bringing the base wire closer to ground tends to reduce the resonant frequency of the antenna. The base wire should preferably be a minimum of 6 feet (1.8 meters) above ground. While good results have been achieved with lower positioning than this, it is not recommended; in the original article[1] on the corner-fed delta loop, the base was 10 feet (3 meters) high and this, of course, would be a better height to aim for.

The radiation resistance of a loop antenna drops as it is reduced in size and also as its height above ground decreases. Consequently, 50-ohm coax is recommended for the feeder, although this is not critical. Good results have been obtained with 75-ohm cable.

further experimentation

I hope that by describing some of the experiments carried out, and results obtained, others might be encouraged to experiment further. There is no reason, for example, why those with a little extra space might not erect another similar loop 0.12 to 0.2 of a wavelength *behind* the driven loop, with this additional loop tuned to act as a reflector. To obtain reflector operation of this second loop, the bottom loading wires would have to be increased slightly to bring the loop to resonance some 5 percent lower in frequency from the driven loop.

It should be noted that any attempt to reduce the size of an antenna will be accompanied by a corresponding reduction in radiation resistance, bandwidth, and overall system efficiency. The corner-fed delta loop loaded in this way represents what I believe to be a reasonable compromise between these parameters and acceptable size.

references

1. L.V. Mayhead, G3AQC, "Loop Aerials Close to Ground," *Radio Communication*, May, 1974, page 298.
2. J. Devoldere, ON4UN, *80-meter Dxing*, Communications Technology, Inc., Greenville, New Hampshire, 1978.

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