Build the Versa Loop

Two relay-switchable loops + a 41-foot mast = 360° 7-band coverage and gain over a ½-λ dipole at 20 through 10 meters.

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Do you long for a beam and tower, but cringe when you think of how your spouse and neighbors might respond? The easy way out is to just put up a vertical or dipole and keep dreaming. I did that at my last QTH, but this time I longed for something more—an antenna I wouldn't have to apologize for over the air. Somehow, I had to find a way to combine good performance, multiband operation and low visual impact. My goal was an antenna that

- pleases (or is at least nonrepugnant to) the eye
- performs well for DX *and* stateside contacts
- operates on multiple bands, with top performance between 20 and 10 meters, and useful performance on 40 and 30 meters
- covers 360°—no azimuthal holes allowed
- can survive high winds (it can really blow here)
- can be built at a modest cost

After scouring my antenna books and sifting through magazine articles (see the bibliography), I opted to use a pair of orthogonal wire loops. Because of the versatile way in which this antenna encompasses many bands and several modes of operation, I decided to call it the Versa Loop. Because of the way in which it performs, I decided to share it with you.

Versa-Loop Basics

The Versa Loop (Fig 1A) consists of two diamond-shaped wire loops that can be closed or opened at their tops by means of a relay (K1 in Fig 1B). Each loop is 1 λ long at 20 meters. One of the two loops is selected at a time by another relay (K2 in Fig 1C); the inactive loop is left open and floating. Because the inactive loop is symmetrically perpendicular to the active loop, the inactive loop does not affect the active loop's pattern. Because the Versa Loop is a balanced antenna and is not worked "against ground," it does not require the presence of a ground screen or radials for proper operation.

The Versa Loop is bottom-fed in its open- *and* closed-loop modes; thus, one transmission line can be used to feed the antenna through its seven-band operating range. (I currently use a relay [K3 in Fig 1C] to choose between two feed-line options, but this is not mandatory; more on Versa-Loop feeding later.)

Structurally, the two loops are suspended from a single common pole that is made as high as possible without sacrificing wind survival or rendering the Versa Loop visually unacceptable. (I managed to install a 41-foot pole on my suburban lot; this, mounted on a wooden deck 11 feet above ground, put the midsection of the loops at a height of about 39 feet.) The upper segments of both loops do double duty as part of my system's four guy wires. The fewer antenna lines that slice the sky, the better the sky looks—and the less obtrusive the system will be.

Constructing the Versa Loop

Mast

Since the antenna itself is relatively simple, the main challenge in constructing the Versa Loop is getting the antenna's slender mast (Fig 2) up as high as possible. (In my case, minimizing the visibility of the antenna's wires and guys was also an issue.) Luckily, my house has a wooden deck that serves well as a base for the Versa-Loop mast; the deck puts the mast base 11 feet off the ground and about 15 feet lower than the apex of the roof.

The lower mast section consists of about 24 feet (20 feet + 4 feet + coupler) of 1½-inch (ID) schedule-80 PVC pipe (actually 1-15/16 inches OD, with a ¼-inch-thick wall); machine screws secure the pipe sections to the coupler. The bottom of the mast is secured to the deck with a Radio Shack® no. 15-517

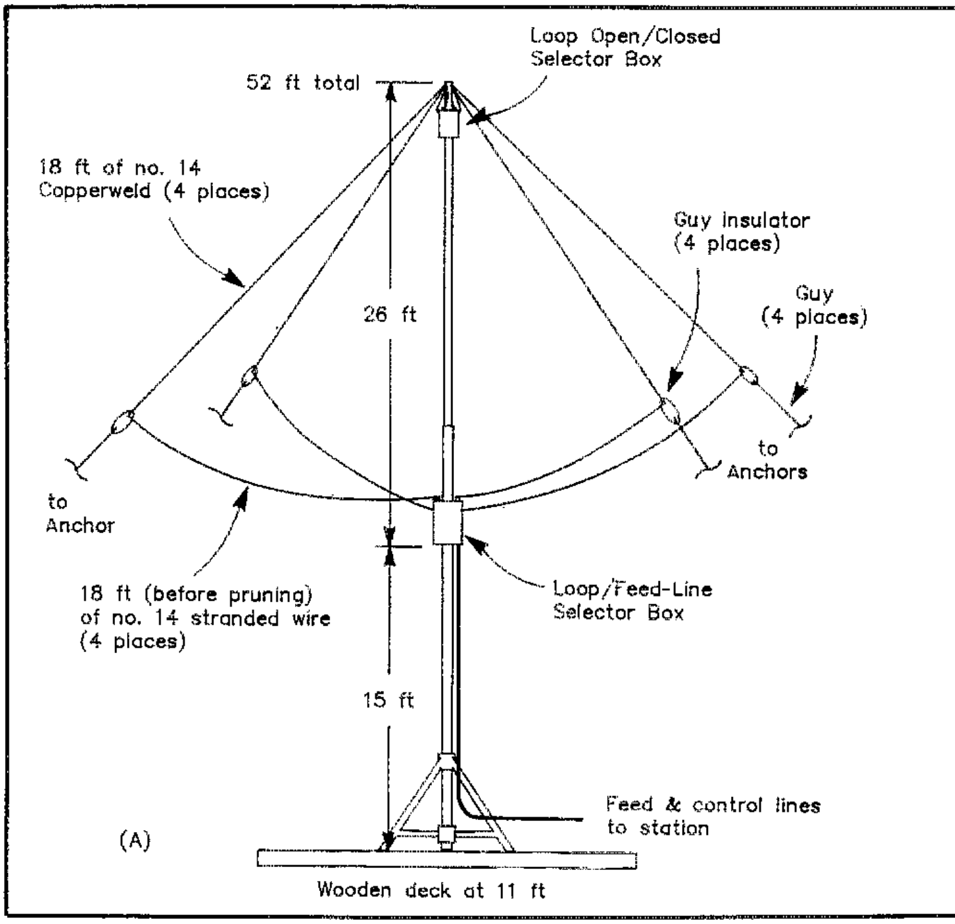


Fig 1—The Versa Loop (A), a simple multiband (40- through 10-meter) antenna, consists of two 14.15-MHz, 1-λ loops that bisect each other at right angles. The loops may be closed or opened at their tops by a remotely controlled relay (K1 at B). Directivity selection is performed by connecting one or the other of the loops to the feed line via another relay (K2 at C). An optional feed-line-selection relay (K3 at C) may also be employed.
The upper loop segments consist of no. 14 Copperweld™ copper-clad solid steel wire;

tilt-over, TV-antenna roof mount. Pipe clamps secure the mast to the house where it passes the eaves. If you decide to mount your Versa Loop's support mast on the ground, I recommend using a tilt-over mount to make raising the antenna easier.[1]

Despite the mast support that the house provides, the heavy-wall PVC pipe used for the lower mast section is too wobbly to use without additional stiffening. I solved this problem by strapping a 20-foot-long piece of 1-1/2-by-1/8-inch-thick steel angle stock to the pipe with stainless-steel hose clamps. The channel between the angle stock and the mast forms a convenient conduit for coaxial feed and relay-power lines.

The upper section of the Versa-Loop mast consists of a 20-foot length of 1-1/4-inch-OD, 1/8-inch-wall fiberglass irrigation pipe, 3 feet of which telescopes inside the lower mast section. The upper and lower mast sections are pinned together by means of a ¼-inch diameter stainless-steel bolt that passes through matching holes drilled through both sections. Although the fiberglass pipe was relatively expensive—$30—it worked so well, and is so strong, that in retrospect I almost wish I'd sprung $90 for larger-diameter fiberglass pipe to use in place of the cheaper PVC-and-steel-angle lower mast section (cost, $20 in all).

Loops, Guys and Relay Boxes

The loop-top relay, K1, is housed in a small plastic box that is U-bolted to the mast a few inches below the mast top. Small holes drilled through the mast just above the relay box pass the four 18-foot-long, no. 14 Copperweld™ wires that constitute the top halves of each loop (see Fig 3). The fiberglass serves well as a wire anchor and RF insulator. Short, flexible drop wires connect each piece of Copperweld to K1 through small holes drilled in the box. Small-diameter (0.1-inch) coax, run inside the hollow antenna mast, carries dc for K1A. I used RTV sealant to weatherproof the relay box before installing it on the mast.

At the side corners of the loops, the Copperweld upper loop segments terminate at insulators, and rope completes each of the four Versa-Loop guys between the insulators and the guy anchors. I used polyester rope because of its strength and its resistance to stretching and ultraviolet light. (I intended to dye the rope to decrease its visibility. Unfortunately, I discovered later—after dipping the rope into a pot of hot, blue fabric dye—that polyester rope won't accept dye!) The mast is not guyed between the peak of the house roof and the upper loop-mast junction—a 26-foot stretch of mast. *Don't try this if you don't use heavy-wall fiberglass pipe for your Versa-Loop mast; most other materials will require an additional set of guys.* (An all-metal mast is acceptable; the symmetry of the two loops to the mast should keep a metal mast from radiating.) I've watched my Versa Loop in 60-mi/h winds and, thanks to the steel mast brace and fiberglass mast material, it survived with gusts to spare.

Complete the loops by installing 18 feet of no. 14 stranded wire (with light-blue insulation, if you're striving for minimum visibility) as each of the bottom two segments of each loop. The total length of each loop, including the wires connecting the loop to the relays, will end up close to the theoretical 1005 ÷ f (MHz)—71.3 feet at 14.15 MHz—after pruning. Leave the bottom loop segments somewhat slack so that guying tension is applied only to the Copperweld top quarters of the loops. This assembly method produces a substantial Versa Loop, provided that the

[1]Notes appear on p 26.

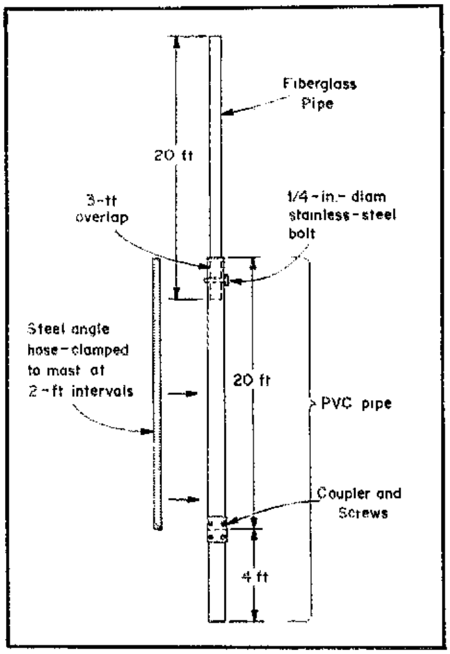
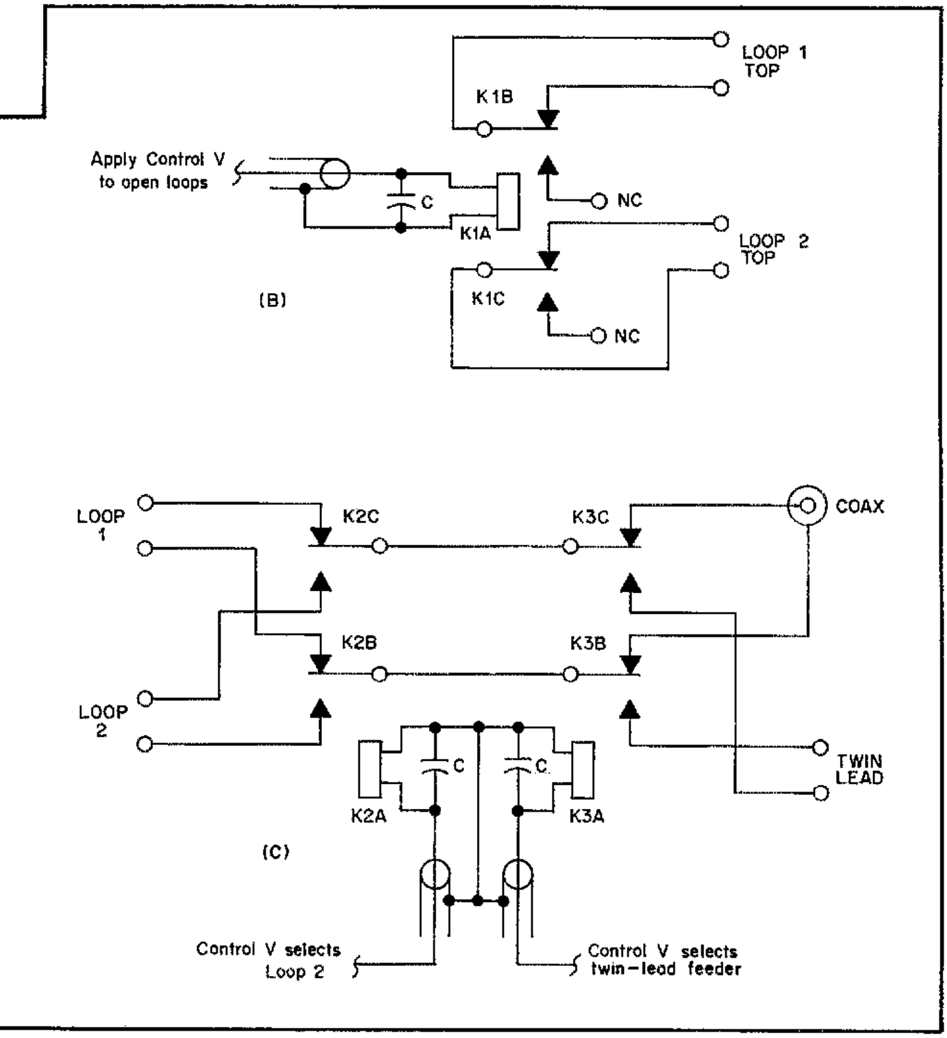


Fig 2—Diagram of AE6C's Versa-Loop mast. The upper mast section consists of 1-1/4-inch-OD, 1/8-inch-wall fiberglass pipe; the lower section is 1-1/2-inch-ID (1/4-inch wall) schedule 80 PVC pipe; the steel angle stiffens the mast. Guys are *required*; see text.



the lower loop segments are no. 14 stranded copper wire. The solenoid bypass capacitors, C, are 0.01-μF ceramic discs rated to handle the relay control voltage; the control voltage necessary depends on the relays used. K1 is a ceramic DPDT relay with wide-spaced contacts capable of handling the high voltages developed under open-loop conditions; K2 and K3 are ceramic DPDT relays. See the text for more on constructing, mounting, feeding and tuning the Versa Loop. Fig 2 details the Versa-Loop mast.

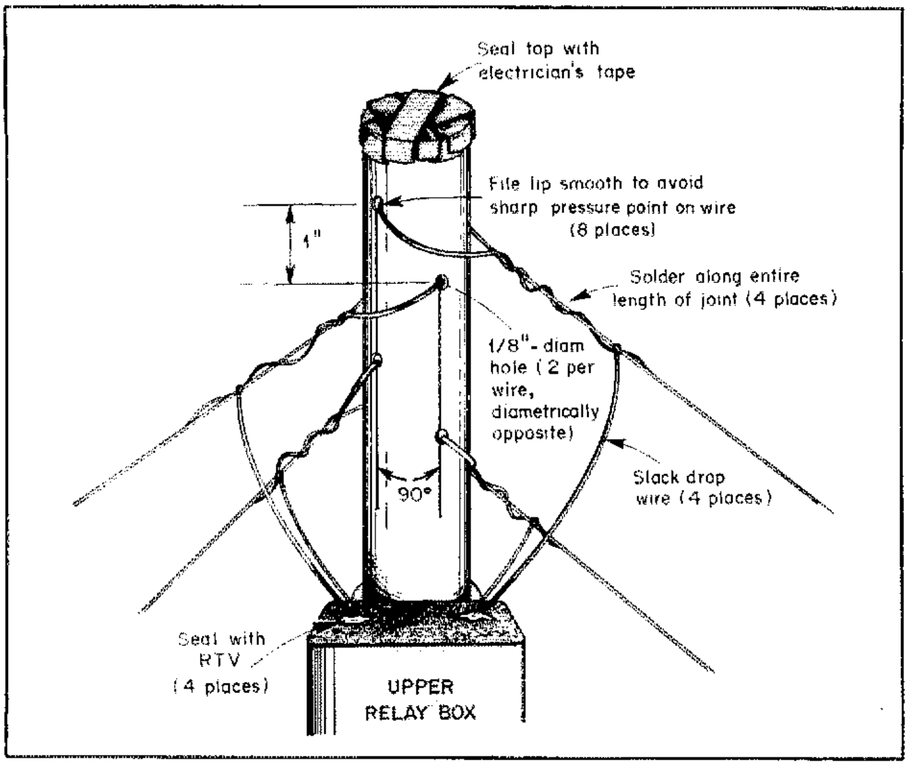


Fig 3—The Versa Loop's Copperweld upper-segment wires (which also serve as part of the antenna's guy system) are anchored to the fiberglass upper mast section as shown here. The mechanical strength of this arrangement should be sufficient for tubing wall thicknesses of at least 1/8 inch. Bend the Copperweld wires by hand to avoid sharp bends and nicks that might expose the Copperweld's steel core. Two drop wires enter the relay box through its top; the other two enter the box through holes on the box back.

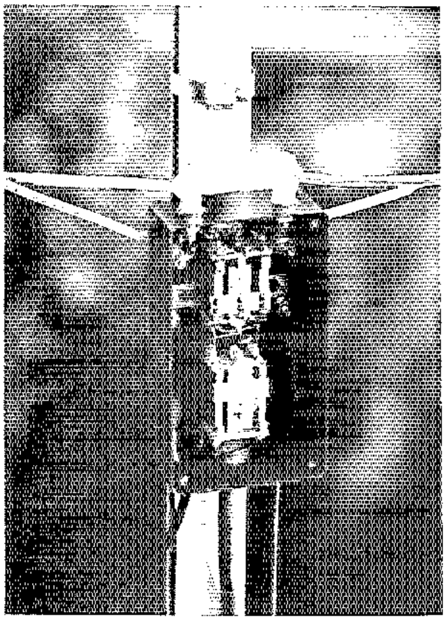


Fig 4—Close-up of the bottom relay box reveals the relays, their respective control wires, loop wires, and both balanced and coaxial feed lines. Below the box, eight ferrite sleeves slipped over the coaxial feed line act as a balun by keeping RF current from flowing on the outside of the coax shield. The lower mast construction and loop wire strain reliefs are also visible.

stranded loop segments can whip around a bit in the wind without breaking. (To improve the stranded segments' resistance to fatigue, keep flexing at each of the Versa Loop's stranded-wire-to-Copperweld junctions from occurring at a single point. You can do this at the Copperweld side of each joint simply by threading the wire through the insulator eye before soldering it. To distribute flexing strain where the loop wires enter the lower relay box, slip a few inches of snug-fitting, flexible plastic tubing over each of the wire ends as shown in Fig 4.

The lower relay box (Figs 1C and 4), a blue-plastic Radio Shack project case, contains two ceramic DPDT relays (K2 and K3) that handle loop and feed-line selection. Ceramic feed-through insulators bring the wires into the box; the box is weatherproofed and fastened to the mast with U bolts. The Versa Loop's coaxial feed line, and coaxial power lines for K2 and K3, run down the sides of the lower mast section. TV-style standoff insulators hold the Versa Loop's twin-lead feed line away from the mast.

Installation

Raising the Versa Loop into position is fairly simple and low-risk because of the antenna's telescoping, tilt-over design. Before you raise the antenna, however, plan exactly where the antenna's four guy ropes will be anchored. Each of the loops is bidirectional, of course, with maximum gain occurring perpendicular to the loop plane. Assuming that the loops bisect each other orthogonally and that there is no distortion of their patterns by nearby objects, switching between the loops results in a 90° azimuth shift. Considering the response of the antenna's switchable loops as a single, four-lobed pattern, there's about a 3-dB difference between maximum gain (perpendicular to the loops) and minimum gain (along lines 45° between the loops). If possible, position your Versa Loop to aim its pattern maxima in directions of interest.

For a given Versa-Loop height, there is an optimum set of guy-anchor locations for the best Versa-Loop shape. If you're lucky enough to be able to locate your guy anchors optimally, you'll be rewarded with two perfectly planar loops at right angles to each other, and an included angle of 90° at the bottom of each loop. Of course, few locations offer a *perfect* situation for a Versa Loop, but don't let this discourage you. Loops are pretty forgiving creatures, and this antenna is no exception. One of my loops does not lie entirely in one plane, and the top angle of both loops is a little sharper than 90°, yet my Versa Loop works like a champ. If you can allow for a little variation in the final height of your antenna, and vary guy-anchor locations somewhat to achieve the best loop shape, your Versa Loop will perform well.

Assemble and paint the antenna and mast on the ground. (My Versa Loop is the color of my house below roof level and sky-blue above.) Temporarily tape the wires and guys to the collapsed mast. Attach the assembly to the tilt-over base and walk it up against the house. (One person could do the whole job from the roof with a harness, but two people make the job easy—and safer.) Once the antenna is in place, bolt it to the house.

If you can round up some friends for 15 minutes, the antenna-raising phase goes fast. With four people tending guys, you can easily push the lightweight upper mast section up and slip the retaining bolt through the mast lap joint. Let the bottom-loop-segment wires slacken appreciably at this point; they'll sag less after pruning, and you'll be able to adjust their tension later by slightly adjusting the antenna height. Now secure the guys to their anchors and you're ready to prune the loops.

Feeding the Versa Loop

There are many ways to feed a loop, but if you want multiband operation with one feed line, the easiest feed method is to use open-wire transmission line in conjunction with a balanced matching network. Such a feed line, known colloquially as a *tuned feeder*, is the simplest and lowest-loss way of driving the Versa Loop in its open- and closed-loop modes with one feed line from 40 through 10 meters.[2] Balanced, high-impedance transmission line of various types works just fine. I used 450-Ω ladder line initially, and then switched to 300-Ω transmitting twin lead for a neater, cleaner look. Add a balun and Transmatch at the end of the feed line, and you're in business.[3] The Station Accessories chapter of *The 1989 ARRL Handbook* describes three suitable balanced-output Transmatches.

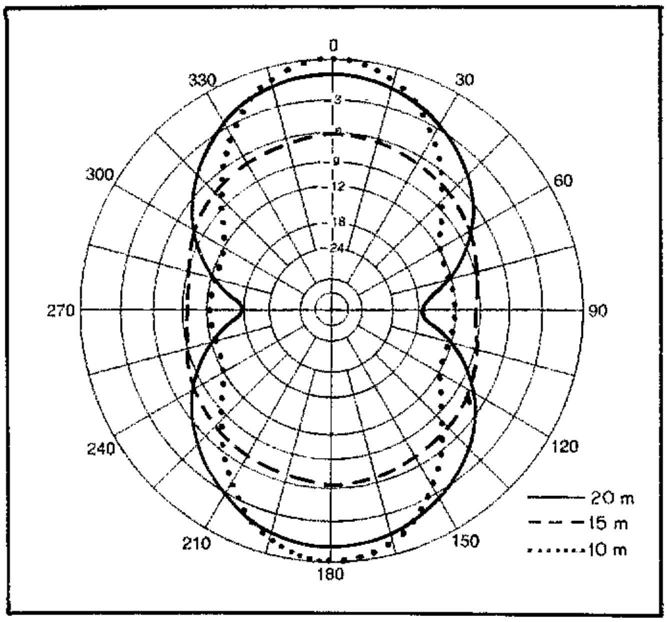


Fig 5—Azimuthal patterns at maximum response for a Versa Loop operating in closed-loop mode and centered at 39 feet above average ground (dielectric constant, 13; conductivity, 5 mS/m). The patterns are scaled to allow direct comparison of the Versa Loop's maximum gain in the closed-loop mode on 20, 15 and 10 meters; to find the actual gain represented by these patterns, add 9.59 dB to all values. Figs 7 through 9 reveal that the elevation angle at which maximum gain occurs varies from band to band. Table 1 lists the Versa Loop's gain at maximum response on 20, 15 and 10 meters.

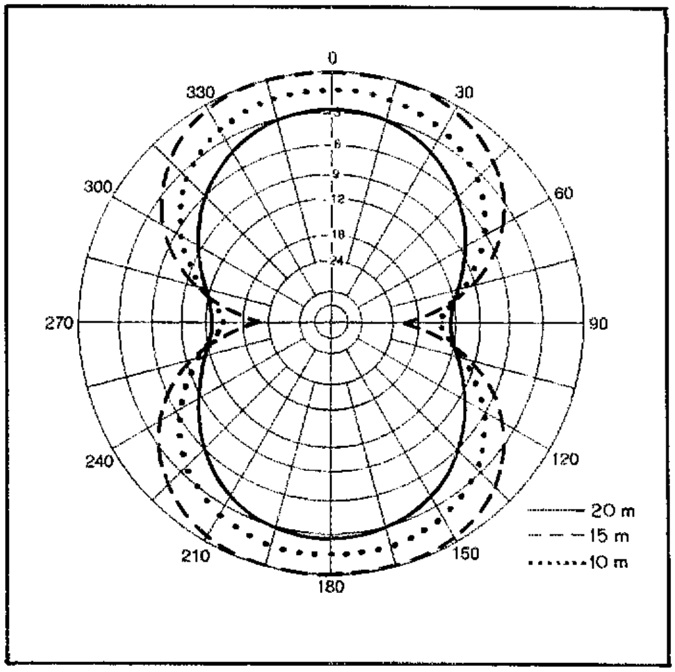


Fig 6—Azimuthal patterns at maximum response for a Versa Loop operating in open-loop mode and centered at 39 feet above average ground. The patterns are scaled to allow direct comparison of the Versa Loop's maximum gain in the closed-loop mode on 20, 15 and 10 meters; to find the actual gain represented by these patterns, add 9.75 dB to all values. Figs 7 through 9 reveal that the elevation angle at which maximum gain occurs varies from band to band.

Table 1

Versa-Loop Gain (dBi) at Maximum Response as Calculated by MININEC

	Mode	
Band	*Closed*	*Open*
20 m	8.49	7.11
15 m	3.61	9.75
10 m	9.59	8.37

Gains shown are for a Versa Loop 39 ft above real ground (dielectric constant, 13; conductivity 5 mS/m). For gains relative to a dipole (dBd) at the same height over the same ground, subtract 2.14 from the values shown.

If you're interested in using the Versa Loop only on 20 meters with the loop tops closed, you can feed the antenna via coaxial feed line without using an adjustable matching network. According to theory, the radiation resistance of a square 1-λ loop is about 120 Ω; using an R-X noise bridge, I characterized my Versa Loop as 122 Ω in parallel with a touch of capacitance (8.5 pF) that I attribute to K2 and K3. The most straightforward way of matching this impedance to 50 Ω is to insert an electrical-¼-λ section of 75-Ω cable between the Versa Loop and its 50-Ω feed line. Such a transformer, known colloquially as a Q section, is a type of series-section transformer.[4,5]

Pruning the Versa Loop to Size

Regardless of choice of feed, the pruning strategy is to match the impedance of both loops on 20 meters, with both loops closed. I did this by using RG-62 and my R-X noise bridge. (An SWR meter in 50-Ω line would accomplish the same thing.) Prune equal amounts off each stranded segment of Loop 1 until you obtain the desired center frequency (14.15 MHz in my case). Then, prune Loop 2 for an identical match at the same frequency. If you did a reasonably good job of making the loops identical, you'll find that their SWRs track well across the band, and retuning will be unnecessary as you switch between antennas.

If you forgo coax entirely and use a tuned feeder, size Loop 1 to 1005 ÷ f(MHz) right away and then trim Loop 2 until its SWR roughly matches that of Loop 1 at the same Transmatch settings.

Versa-Loop Performance

20, 17, 15, 12 and 10 Meters

Compared from band to band in a given mode (loops open or loops closed), the Versa Loop's gain generally increases with frequency. Table 1 lists the Versa Loop's MININEC-calculated gain at 20, 15 and 10 meters; Fig 5 shows a MININEC comparison of the antenna's closed-loop azimuthal patterns at maximum response on these bands; and Fig 6 shows MININEC's comparison of the *open-loop* azimuthal patterns at maximum response on these bands.[6] The relative sizes of the patterns in Figs 5 and 6 allow direct comparison of the Versa Loop's gain *and* pattern shape at 20, 15 and 10 meters. Space doesn't allow the publication of Versa-Loop patterns for 20 through 10 meters, inclusive; you can infer the antenna's 17- and 12-meter performance from Figs 5 and 6.

What Figs 5 and 6 *don't* show is that the Versa Loop's maximum gain occurs at different elevation angles on each band, and that opening and closing the loops significantly changes the elevation angle at which maximum gain occurs. Figs 7 through 9 show MININEC's comparison of the Versa Loop's open- and closed-loop modes at 20, 15 and 10 meters; you can use these patterns to infer what goes on at 17 and 12 meters.

Another antenna parameter not shown or implied in Figs 5 through 9 is the Versa Loop's polarization. Operating in its closed-loop mode at 20 meters, the Versa Loop radiates a horizontally polarized wave; operating in its open-loop mode at 28 MHz—as a *bi-square* antenna[7]—the Versa Loop is *vertically* polarized. On other bands and modes, the situation isn't so clear-cut. It's safest to say that the Versa Loop's polarization varies with the band of operation, and with whether its loops are open or closed!

Originally, I had somewhat fixed ideas about which loop mode would be optimum for each band. My experiences show that both Versa-Loop modes are worth trying throughout the antenna's operating range. For instance, I initially used the antenna in its closed-loop mode on 15 meters, but it didn't perform as well as I thought it should. (During the ARRL DX Contest, I actually had to *work* to pick up stations after having nabbed them easily on 20!) Unbeknownst to me, though, the loop-top relay's power supply failed, opening the loops. Other than an SWR increase, which in my haste I naively corrected, I had no idea what had happened. Suddenly, I nailed stations left and right.

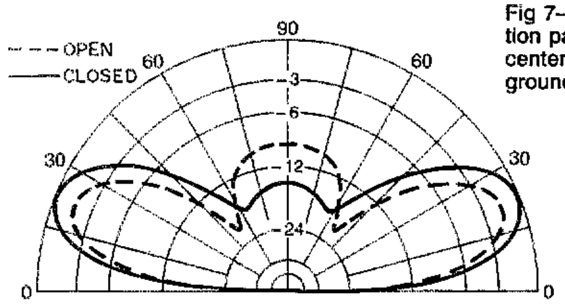


Fig 7—Open- and closed-loop elevation patterns for a Versa Loop centered at 39 feet above average ground at 20 meters.

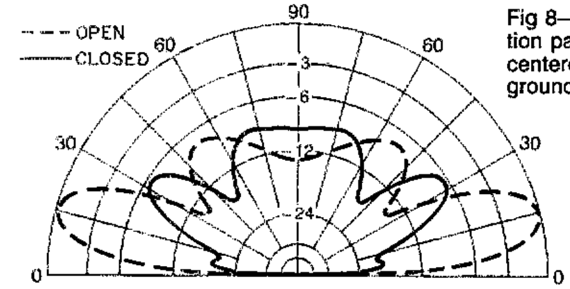


Fig 8—Open- and closed-loop elevation patterns for a Versa Loop centered at 39 feet above average ground at 15 meters.

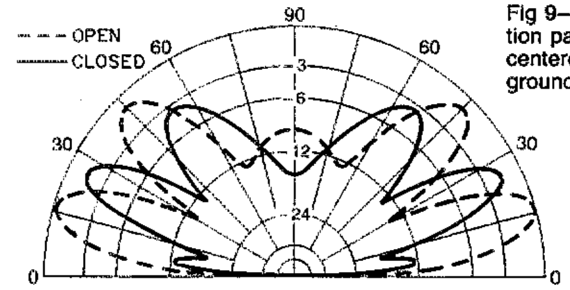


Fig 9—Open- and closed-loop elevation patterns for a Versa Loop centered at 39 feet above average ground at 10 meters.

(Now *this* was *fun*!) After the feeding frenzy was over, I did some detective work and discovered the relay problem. (Figs 5, 6 and 8, and Table 1, show why the open-loop mode is better on 15!) Moral: It's not called the Versa Loop for nothing! When you build yours, don't slavishly stick with one loop mode per band. Experiment! Remember also that loop selection is important even at the Versa Loop's 3-dB gain minima (where the loop patterns intersect). At these azimuth points, both loops have the same gain, but their null and maximum-gain directions differ greatly. A crafty operator soon learns to take advantage of these characteristics to dodge interference.

40 and 30 Meters

At 40 meters, the Versa Loop's elements are ½-λ loops; at 30 meters, they are square 0.7 λ loops. According to *The ARRL Antenna Book* (p 5-1), a ½-λ loop exhibits about 1 dB of loss relative to a ½-λ dipole (about 1 dBi gain), with a fairly omnidirectional pattern devoid of pronounced nulls. A square 0.7-λ loop can be expected to exhibit somewhat less than 3 dBi gain.

In practice, directional effects are hard to detect on 40 and 30 meters when switching between the two loops. I've had no problem working 30-meter DX with the loops closed, but closed-loop 40-meter operation is a struggle on the long haul because of the antenna's low gain and high radiation angle in this mode. Opening the loops made the difference: Contacts into Japan and Europe became routine on 40. (Opening the loops on 30 meters made no appreciable improvement in the antenna's performance.) Stateside contacts come easily on both bands.

Summary

I've been delighted with the performance of the Versa Loop on 20 through 10 meters, and its performance on 40 and 30 meters is acceptable. My DXCC total jumped by 50 countries (to 175) in just four months of casual operation with 100 W output. This antenna clearly beats the verticals and dipoles I've tried, and seems to be roughly on par with a low (30-foot) tribander. Compared to the roof-mounted tribander, the Versa Loop draws much less unwanted attention and covers four more bands. It can change direction instantly, is less expensive than the tribander, and is the quietest receiving antenna I've ever used. All in all, the Versa Loop is the best antenna I've ever had.

I look forward to hearing from other hams who build and test the Versa Loop. Its seven bands and two modes offer plenty of opportunities for experimentation, discovery and just plain fun.

Notes

[1]Fig 46 on p 37-20 of the 1989 *ARRL Handbook* shows a home-buildable mast of this type.—*Ed.*

[2]It's important to use low-loss feed line in tuned-feeder service because line loss increases with SWR—and because the Versa Loop's tuned feeder operates at a high SWR over much of the antenna's frequency range.—*Ed.*

[3]Use of a magnetic-core balun between the tuner and the Versa-Loop feed line is not recommended. Such cores generally function poorly in power-handling situations at impedances greater than a few hundred ohms; the impedance at the tuner end of the Versa Loop's open-wire feed line will likely be quite high (a few kilohms) on some bands. A balanced-output tuner is the best solution to this problem.—*Ed.*

[4]G. Hall, ed, *The ARRL Antenna Book*, 15th ed (Newington: ARRL, 1988), pp 26-14 and 26-15.

[5]I successfully tried an even simpler method of feeding the closed-top Versa Loop on 20 meters: I used RG-62 coax (93-Ω, 95 Ω in its foam-dielectric form) between the antenna and my TS-820 transceiver. The TS-820's adjustable output network matched the RG-62 well; transmitters that include SWR-dependent power-reduction circuitry and are designed for 50-Ω loads would probably require the use of a Transmatch to achieve full power output in this situation.

[6]MININEC (Mini-Numerical Electromagnetics Code) calculations for this article were done at ARRL HQ on an IBM® PC.—*Ed.*

[7]*The ARRL Antenna Book*, p 5-22.

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