A Small Loop Antenna for 160 Meters

Effective, low-profile 160-meter antennas present a formidable challenge. Here's one that answers the need.

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For amateurs with limited space, the loop antenna is ideal for 160 meters. Because loops have high Q, they exhibit very narrow bandwidth, suppress harmonics and give a significant receiving-noise reduction compared to dipoles. The loop's apparent simplicity is deceptive, however.

This article describes a practical loop antenna that has worked well for me on 160 meters for more than three years. The design is based primarily on information published by Ted Hart, W5QJR.[1,2]

Theoretical analyses of loop antennas appear in Kraus,[3] Stutzman and Thiele,[4] and Weeks.[5] These authors don't discuss efficiently constructing and coupling the loop to the transmitter, however, and these are not entirely trivial considerations. Practical and design considerations are discussed in David,[6] Hall and Schetgen,[7] Hart,[8] McCoy,[9] Morrow,[10] and Patterson.[11]

For distances of 700 to 1000 miles, my loop has performed interchangeably with my full-size inverted **V** antenna (62 feet high at the midpoint and fed with open-wire transmission line).

During several recent DX contacts with the loop, I've compared it to my inverted **V**. During a QSO with G3PQA, the strength of my signal from the loop was essentially the same as that from the inverted **V**. DL1RK found my signal from the loop slightly stronger than that from the inverted **V**. Both antennas are oriented to favor Europe. Also, the inverted **V** is more than 90% efficient, whereas the loop's efficiency is close to 50% (–3 dB).

Radiation Pattern

I quote from Hart (see "References"):

> The loop has one distinct advantage over conventional antennas due to its radiation pattern. If you envision the pattern to be the shape of a doughnut, and the doughnut is "standing" on the ground, the maximum gain occurs at both low and high angles. In fact, it radiates equally well at all elevation angles in the plane of the loop.

[1]Notes appear on page 34.

Table 1
Approximate Costs of Materials

Eight 10-foot × 1-inch sections of copper pipe—$50.

Eight 45° elbows—$10.

One PVC insulation section—$10.

One 15-foot, 6-inch × 5/8-inch copper inner loop—$15.

Support rope—$25.

Labor (plumber) to obtain, assemble and solder these components—$100.*

Total—$210.

The total does not include the costs of C1, C2, C3 and the feed line.

*With ingenuity, you may be able to obtain these parts and services for significantly less.

Fig 1, from Hart (see "References"), compares the vertical radiation patterns of the loop with those of a vertical and a dipole. The inner-pattern axis is perpendicular to that of the outer patterns. Note that the loop performs better at low angles, making it a good DX antenna. Fig 2 (also from Hart, "References") compares horizontal patterns at four elevation angles.

Physical Description

Fig 3 shows the antenna schematically and Fig 4 shows the base section of my antenna. The outer loop is made in the form of a hexagon with eight 10-foot sections of 1-inch copper pipe joined with 45° couplers. The inner loop is a circle, 15 feet, 6 inches in circumference, made from ⅝-inch copper pipe. Choosing values and ratings for C1, C2

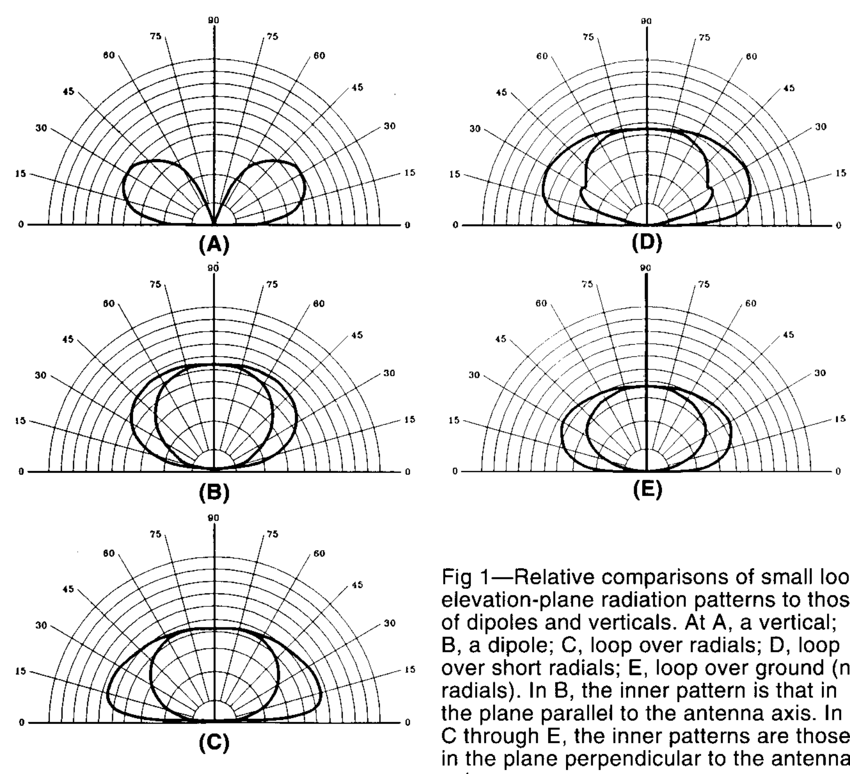

Fig 1—Relative comparisons of small loop elevation-plane radiation patterns to those of dipoles and verticals. At A, a vertical; B, a dipole; C, loop over radials; D, loop over short radials; E, loop over ground (no radials). In B, the inner pattern is that in the plane parallel to the antenna axis. In C through E, the inner patterns are those in the plane perpendicular to the antenna axis.

Table 2
Calculating capacitor ratings

$V_{C1} = 1800\sqrt{P}$
$V_{C2} = 18\sqrt{P}$
$V_{C3} = 17\sqrt{P}$
$I_{C1} = 2.2\sqrt{P}$
$I_{C2} = 0.21\sqrt{P}$
$I_{C3} = 0.15\sqrt{P}$

Example: if P = 100 watts, then V_{C1} = 18,000; V_{C2} = 180; V_{C3} = 170; I_{C1} = 22 A; I_{C2} = 2.1 A; and I_{C3} = 1.5 A.

and C3 is discussed later.

The antenna is mounted vertically, approximately a foot off the ground. I installed 12 quarter-wavelength radials under the loop. These radials are joined under the loop, but are not electrically connected to it. The radials act as a reflective screen to reduce ground loss. The use of radials is not necessary, but they do increase antenna efficiency and thus signal strength. As a compromise, the radials can be as short as twice the loop's height and should be parallel to the loop plane.

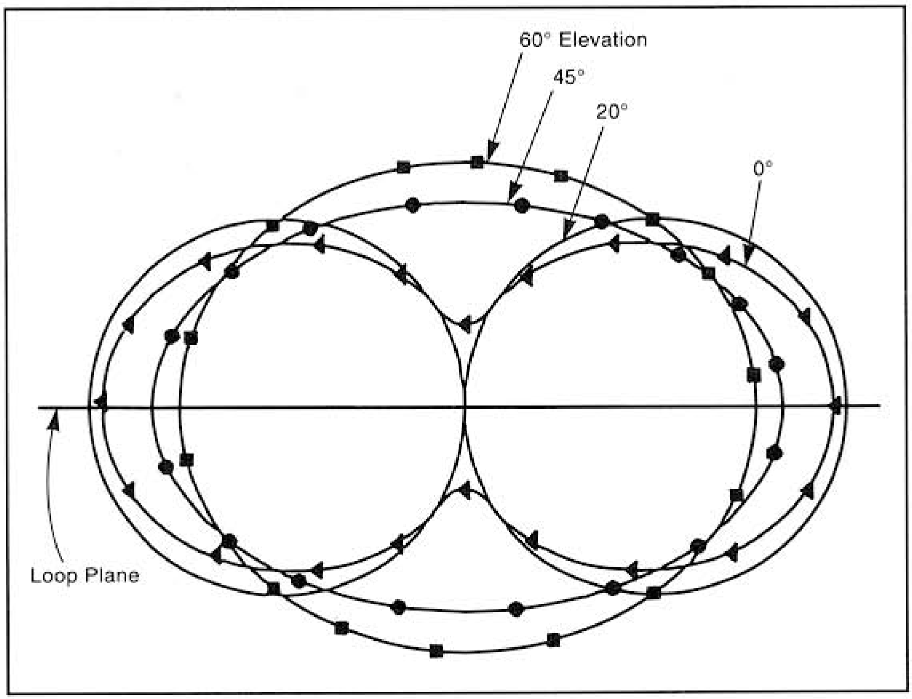

Fig 2—Electrically small loop antenna azimuth-plane radiation patterns at several wave angles.

Construction

Table 1 lists the bill of materials for my loop. Because the outer loop's radiation resistance is on the order of 0.1 Ω, every effort must be made to minimize losses. Antenna efficiency increases with the diameter of the pipe used in both loops. One-inch copper pipe is used as a compromise in the outer loop; larger pipe would provide better efficiency, but would weigh considerably more.

I support the outer loop with nylon rope strung between two trees. Smaller nylon ropes guy the lower section between trees and a fence. The inner loop is hung from the top of the outer loop with nylon rope, and nylon rope is used to guy and position the inner loop.

Solder all of the loop's joints with rosin-core tin/lead or tin/lead/silver solder. Do not use acid-core solder. Note that McCoy's loop (see "References") was built with aluminum tubing that was bolted together, which accounts for the poor performance noted there.

Capacitors

C1 is a 200-pF vacuum-variable unit. A split-stator capacitor should work in place of a vacuum variable; however, under no circumstances should a conventional variable capacitor be used at C1 because the loss in the wiper contacts is significant compared to the outer loop's radiation resistance. C2 is composed of ten 100-pF "doorknob" capacitors connected in parallel via copper straps, and C3 is a single 740-pF doorknob.

The outer loop radiates and the inner loop functions as a low-loss matching and coupling device. This type of antenna puts very high voltages across C1 and C2 and passes unusually high currents through them. The formulas in Table 2 give approximate currents and voltages for C1, C2 and C3, where P is the applied power in watts.

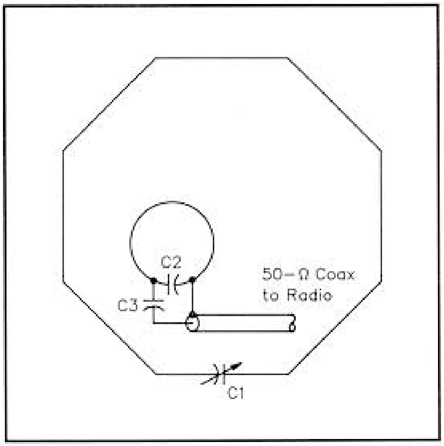

Fig 3—Schematic of the loop antenna.

Table 2's formulas are based on a steady-state analysis, under the assumption that the radiation resistance and the loss resistance in the outer loop are each 0.1 Ω. These resistances can differ significantly from this value depending on how the loop is constructed and located. Furthermore, substantial transient currents and voltages can occur under certain situations. Consequently, I recommend incorporating a safety factor of two to three after calculating the capacitor voltages and currents with these equations.

Tuning and Matching

To adjust the antenna to resonance at 1.85 MHz, follow this procedure:

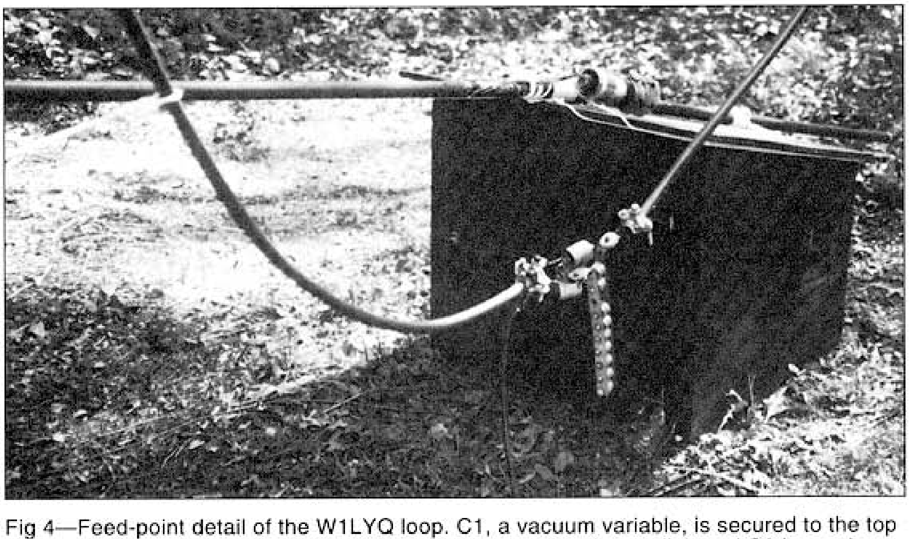

Fig 4—Feed-point detail of the W1LYQ loop. C1, a vacuum variable, is secured to the top of a wooden box. C2 is made of ten "doorknob" capacitors in parallel, and C3 is one large doorknob. The loops are tied off to nearby objects for support.

1) Place the inner loop in either lower corner area of the outer loop, *but not touching it*, in a plane parallel to the outer loop and approximately 20 inches from that plane.

2) Set the transmitter to 1.85 MHz.

3) Adjust C1 for minimum SWR.

By making minor adjustments in the loop position and C1's setting, you should easily get the SWR down to 1:1. Once a 1:1 SWR is achieved at 1.85 MHz, you need only adjust C1 for other frequencies between 1.8 and 2 MHz. The achievable SWR will be 1:1 from 1.8 to 1.85 MHz, and at 1.85 MHz the SWR will climb slowly but steadily to 2:1 at 2 MHz. Changing frequency by more than 2-3 kHz requires readjusting C1 for minimum SWR. Keep in mind that a change of 1 pF in C1 makes a change of 3-5 kHz in the antenna's resonant frequency. I therefore recommend that you use a motor drive with sufficient gear reduction.

For optimum performance, especially at low angles, C1 should be mounted at the top of the loop. Also, it is possible to eliminate C2 and C3 by a suitable choice of the size and position of the inner loop (see Hart, "References," for details). Consider this if you're planning to use high power with the loop.

Warning

Operating a loop antenna indoors or close to dwellings can raise the risk of interference to consumer devices and ham gear. Also, it's prudent to minimize RF exposure to people who may be near the antenna by using the minimum necessary transmitter power to carry on the desired communications. Whenever possible, mount your antennas as far as you can from people and dwellings.

Acknowledgments

I thank Ted Hart for several insightful criticisms of an early draft of this article, and for his permission to quote text and diagrams; and Professor Tom Neuhaus, WB2CLN, and Don Ridley, WT1I, for their comments and suggestions when I was building and testing my antenna. Professor Neuhaus additionally calculated the approximate formulas for the currents and voltages to which C2 and C3 are subjected. I also appreciate the insightful comments and words of encouragement from Vic Misek, W1WCR.

References

T. Hart, "Small High Efficiency Antennas: The Loop," W5QJR Antenna Products, PO Box 334, Melbourne, FL 32902.

L. McCoy, "The Army Loop in Ham Communications," *QST*, Mar 1968, pp 17-18.

Notes

[1]See "References."

[2]T. Hart, "Small, High Efficiency Loop Antennas for Transmitting," J. Hall, ed, *The ARRL Antenna Book*, 16th edition (Newington: ARRL, 1991), pp 5-11 to 5-16.

[3]J. Kraus, *Antennas*, second edition (New York: McGraw-Hill, 1988), pp 238-264.

[4]W. L. Stutzman and G. A. Thiele, *Antenna Theory and Design* (John Wiley and Sons, 1981), pp 99-107.

[5]W. L. Weeks, *Antenna Engineering* (New York: McGraw-Hill, 1968), pp 56-61.

[6]E. David, ed, *HF Antenna Collection* (Radio Society of Great Britain, 1991), pp 96-100.

[7]G. Hall and B. Schetgen, "Six Winners Emerge From the ARRL Antenna Competition," *QST*, Feb 1985, pp 44-47.

[8]T. Hart, "Small High Efficiency Loop Antennas," *QST*, Jun 1986, pp 33-36. Also see Notes 1 and 2.

[9]See "References."

[10]R. Morrow, "The Electromagnetic Antenna," *RadioScan*, Nov 1991, pp 10-13.

[11]K. Patterson, "Down to Earth Army Antenna," *Electronics*, Aug 1967.

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New Books

THE ANTIQUE RADIO BOYS AND THE GARRULOUS GREBE

By Stan Dryer

Published by Rainy Day Books, PO Box 775, Fitzwilliam, NH 03447. Black-and-white illustrations. Retail $6 postpaid First Class mail in the US.

Reviewed By Cynthia Wall, KA7ITT

Holy Hertz! Fans of the original Radio Boys series by Allen Chapman will be pleased to see that Stan Dryer has created their 1990s counterparts in the Antique Radio Boys. The first to be published of the new series is *The Antique Radio Boys and The Garrulous Grebe*.

Back in the 1920s, when radio communications was in its infancy, the Radio Boys solved mystery after mystery using home-built crystal sets, spark-gap transmitters and their uncanny sleuthing ability. Now 70 years later, Terry, Jim and Gary, members of Dryer's Antique Radio Club at Cartwright Junior High, retain their predecessors' talents, puns ("Holy Heterodyne—rectify the problem!") and fondness for old radios. Old to them means anything before 1950. In fact, a WWII SCR-5789 Gibson Girl emergency transmitter is featured in the climax of this 50-page story.

If the boys have a few more tools at hand than the original gang, they must still plot their wits against scurrilous Dr Artemisius Krull, thief of Grebe CR-4s. In addition to thievery, Krull is a father who will go to any length to make sure his atonal daughter wins a singing competition against the lovely Lucia Beaucart.

There are other 1920s-type characters who help mix in the action: Krull's accomplice, Verton Gridleak—a thug identifiable by the scar on his hand received in a soldering iron fight; Lucinda's father, Frank Beaucart, proud antique radio collector; and Dick Wood, a Secret Service agent who poses as a mild-mannered radio repairman.

Author Stan Dryer, aka Frank Bequaert, is retired from an electronics, computer and teaching career. He and his wife Lucia operate Rainy Day Books, which offers a wide selection of radio-related technical and historical books.

Reviewer Cynthia Wall, KA7ITT, of Salem, Oregon, is author of several Amateur Radio novels published by the ARRL, including Hostage in the Woods, Night Signals *and* Firewatch.

AMATEUR RADIO RV ANTENNAS

By Robert K. Benson, W2HZF

Published by Tiare Publications, PO Box 493, Lake Geneva, WI 53147. 1992. Softcover, 8½ × 11 inches, 61 pp. $14.95 plus $2 s/h.

Reviewed By Steve Ford, WB8IMY
Assistant Technical Editor

Recreational vehicles (RVs) seem ready-made for Amateur Radio mobile operating. They offer plenty of room for rigs and ample space for antennas. Properly equipped, an RV is an excellent platform for a complete Amateur Radio station.

In *Amateur Radio RV Antennas*, Benson concentrates on HF antennas for RV applications. He discusses vehicle types and antenna designs suited for each application. The discussion includes matching, grounding, single band versus multiband, and so on. (There's also an informative appendix chapter on maritime mobile operating.)

This book, however, isn't all that it could be. *Amateur RV Antennas* avoids detailed evaluations of commercial mobile antennas. Instead, the book speaks in generalities, pointing the reader in various directions, but never quite going the full distance. There are drawings in the book, but no photographs. (Photos of typical RV antenna installations would have been a definite benefit.) And where's VHF/UHF? Excluding antennas for VHF and UHF is a notable omission, considering the popularity of VHF/UHF mobile operating. I'd have even liked to see a few words about antennas for working satellites—an RV could serve as a super mobile OSCAR ground station.

If you're looking for a book that discusses mobile HF antenna *considerations*, you may find *Amateur Radio RV Antennas* worth the price. On the other hand, if you're trying to choose a specific antenna, looking for antenna designs to build yourself or interested in VHF/UHF operating, save your money. You're better off reading *QST* Product Reviews or buying one of the many antenna books on the market. The author knows his subject, but the lack of details leaves the reader hungry for more information.