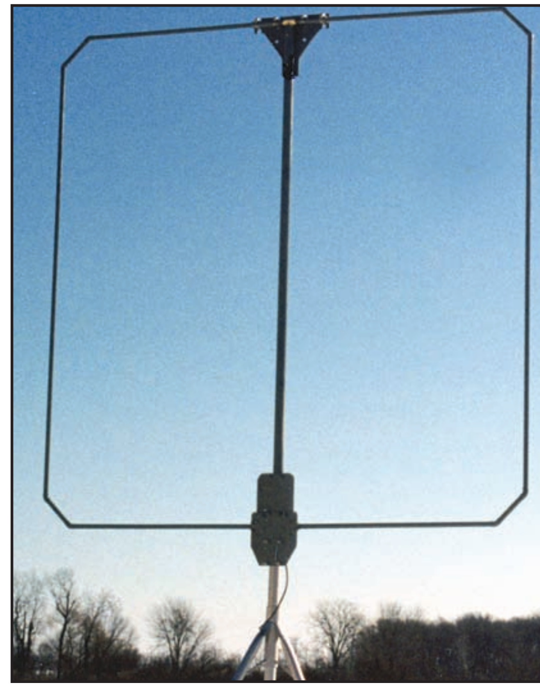
An Effective 160 Meter Receiving Loop

Use this antenna to hear those weak top-band signals by nulling out the noise and interference.

Dick Stroud, W9SR



If you would like to work 160 meter DX but don't have the space for a large receiving antenna, this small loop may be the answer. I was inspired to experiment with single turn receiving loops after attending a recent seminar on low band antennas by Ted Tahmisian, W9WT. A few such loop designs have been described over the years in various articles. A single turn receiving loop developed by Doug DeMaw, W1FB (SK), is shown in several ARRL publications and has been widely used.[1] A loop system made of solid shielded coax with an amplifier was later described by Barry Boothe, W9UCW.[2]

Design Considerations

The performance of several loop designs was evaluated using an 1830 kHz remote transistorized signal source and an Empire Devices NF-105 field intensity meter. I found that the null is typically 4 to 5 dB deeper with loops made of solid shielded coax compared to those made of standard RG-type cable.

Shielding coverage of standard cable can be as low as 85%, which will allow strong signals to pass through. Coax with a solid outer conductor provides almost complete shielding and thus can produce a deeper null. The larger single turn loops appear to be more sensitive up to the point at which mechanical constraints become the limiting factor. Shape does not appear to make any perceptible difference.

The accepted maximum perimeter of a directional single turn loop is 0.1 λ. Those made of standard coaxial cable, however, have been much smaller. With the high cable capacitance, the overall size must be kept small enough to allow tuning of the loop to resonance using an external capacitor.

With this type of loop the impedance of the cable is not critical and, with the loop described in Figure 1, the impedance of the home constructed coax is much higher than standard cable resulting in lower distributed capacitance. This allows a larger antenna to be used thus providing a stronger signal. The loop shown has a perimeter of 0.04 λ, which is a good electrical and mechanical compromise. The loop has an apparent inductance of 10 μH that can be tuned to resonance by 740 pF. The fact that the capacitance per unit length varies slightly within the assembled coax does not affect performance.

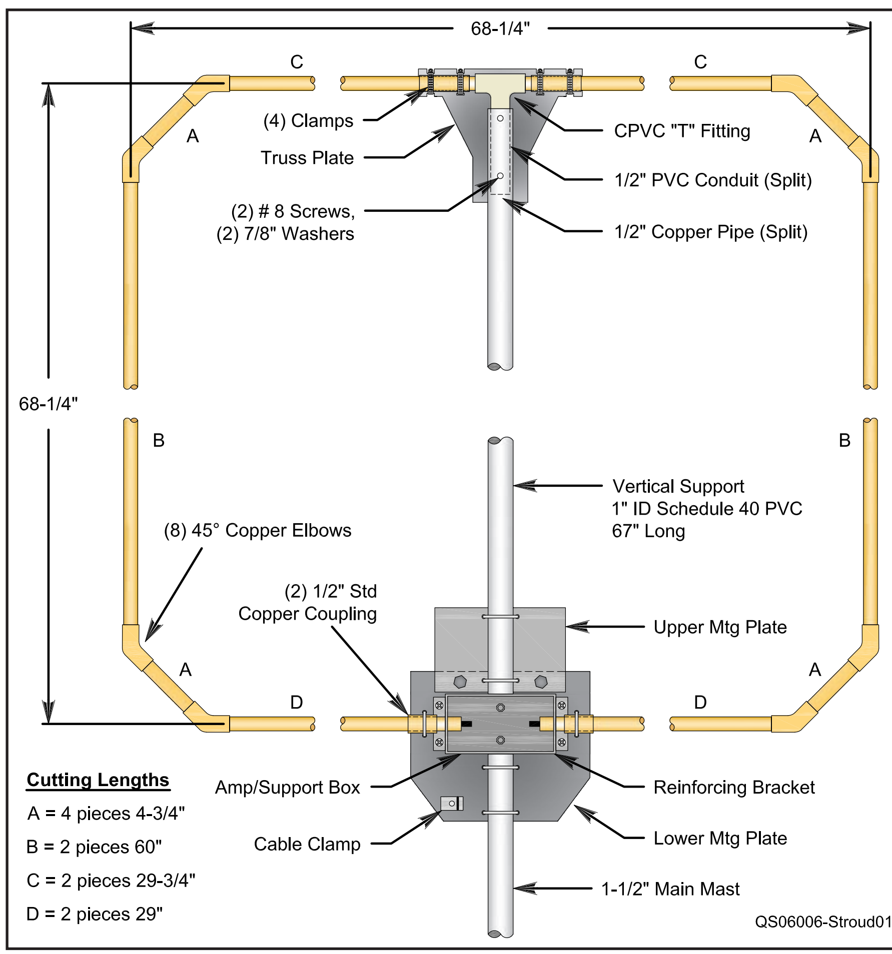


Figure 1 — Loop antenna configuration.

[1]Notes appear on page 38.

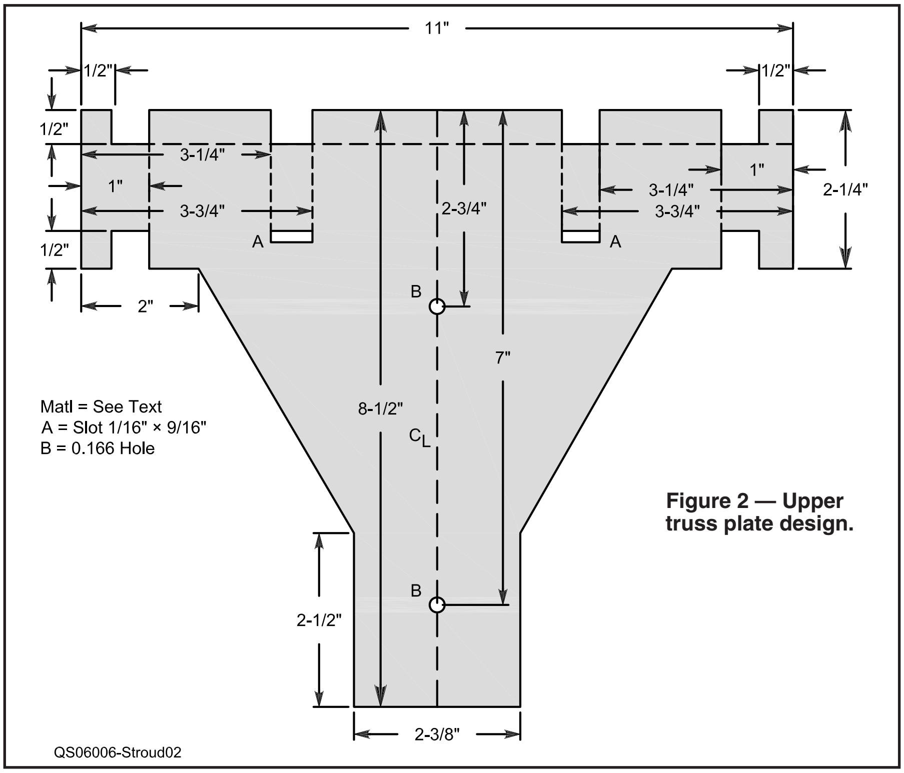


Figure 2 — Upper truss plate design.

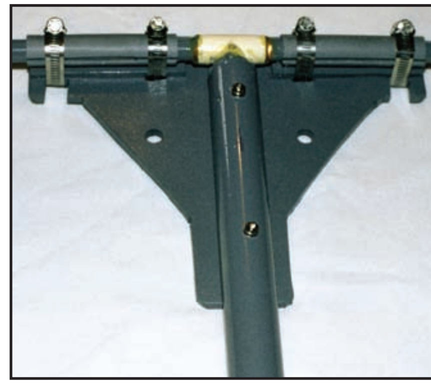


Figure 3 — Upper truss plate details showing T connector and element mounting.

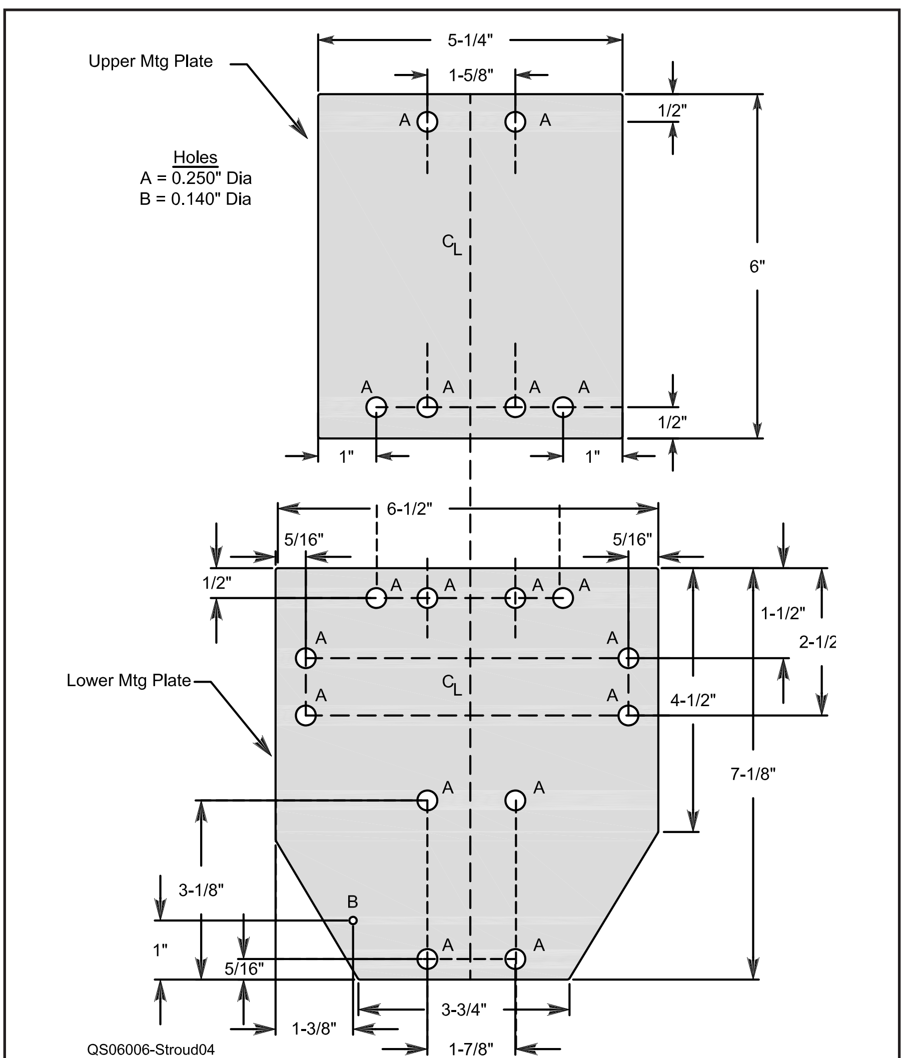


Figure 4 — Mounting plate construction. Use 0.125 inch aluminum.

Putting it All Together

This loop is very sturdy and can be built at reasonable cost. Most mechanical parts are readily available from home improvement outlets. All hardware is stainless steel. The main element is built of ½ inch copper water pipe and copper plumbing fittings. The center conductor is a single length (about 23 feet) of RG-11 foam dielectric cable with the outer jacket and shield braid removed. The two halves of the copper element can be soldered together on a flat surface, such as a garage floor, and later assembled into the "T" fitting at the top and to the aluminum box at the bottom. The design is octagon shaped, allowing the coax core to be easily threaded through the assembled pipe. A leader wire is soldered to the core conductor to aid in pulling it through the copper pipe.

The center vertical support for the antenna is a 67 inch length of 1 inch ID schedule 40 PVC pressure pipe. The upper truss plate is made from a Farberware 8½ × 11 inch, non-absorbing resin cutting board available at low cost from department stores (see Figures 2 and 3). This material is sturdy and has good RF characteristics at this frequency. The plate is notched and slotted, as shown, to accept the two stainless steel element clamps on each side. Two 4 inch lengths of standard ½ inch PVC electrical conduit are split and placed around the element under the clamps.

The center CPVC T fitting accepts the ½ inch copper pipe and has built-in stops so that when the element is inserted it will leave about a 1 inch electrical gap in the copper tubing. This is necessary for the loop to operate properly. Strips of fiberglass PC material (less copper) are used to shim the element to be in line with the T fitting.

To attach the PVC vertical support to the truss plate and T fitting another 6 inch length

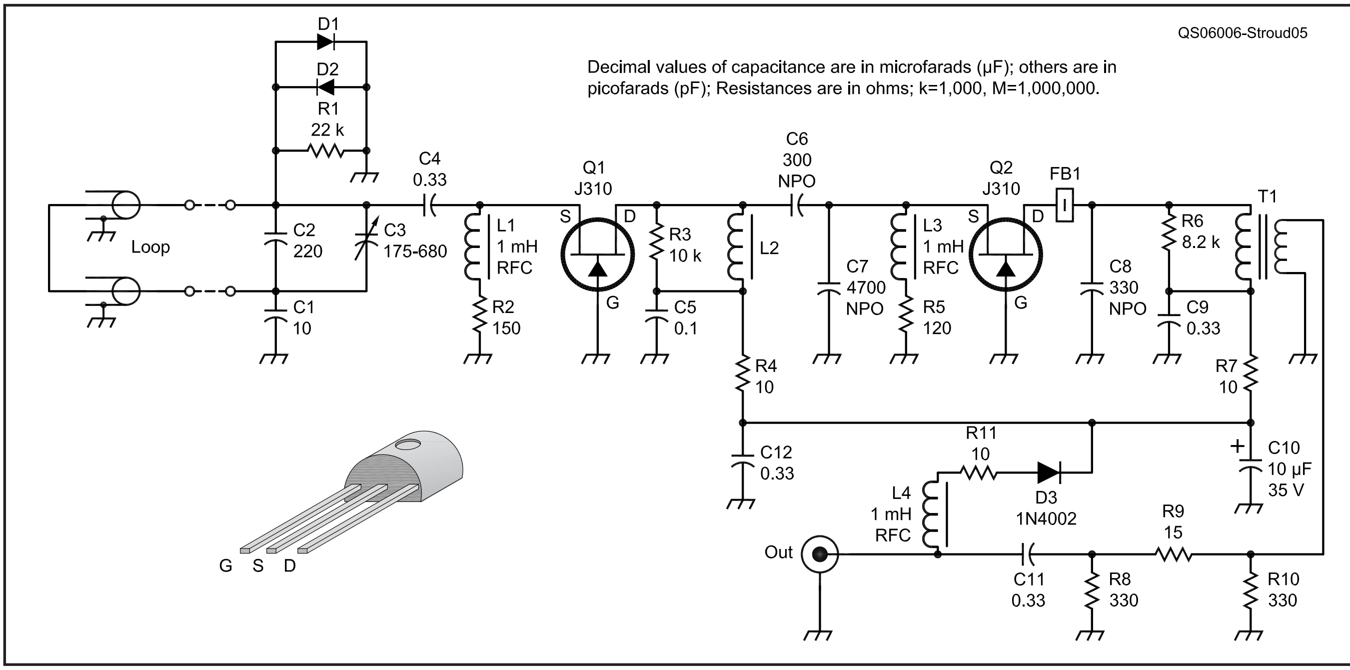


Figure 5 — Amplifier schematic.

C1 — 10 pF, 100 V molded mica capacitor, CM05.
C2 — 220 pF, 100 V molded mica capacitor, CM05.
C3 — 175-680 pF variable capacitor (Arco 468).
C4, C9, C11, C12 — 0.33 µF, 50 V ceramic capacitor.
C5 — 0.1 µF, 50 V ceramic capacitor.
C6 — 300 pF, 100 V molded mica capacitor, CM05.
C7 — 4700 pF, 100 V ceramic NPO capacitor.
C8 — 330 pF, 100 V molded mica capacitor.
C10 — 10 µF, 35 V electrolytic capacitor.
D1, D2 — Silicon small signal diodes, 1N4454, 1N914, or equivalent.
D3 — Silicon diode, 1N4002.
L1, L3, L4 — 1 mH miniature RF choke (J W. Miller 8230-92).
L2 — 75 turns #28 enameled wire on T37-2 form (see text).
Q1, Q2 — J310 low noise field effect transistor.
R1 — 22 kΩ, ¼ W resistor.
R2 — 150 Ω, ¼ W resistor.
R3 — 10 kΩ, ¼ W resistor.
R4, R7 — 10 Ω, ¼ W resistor.
R5 — 120 kΩ, ¼ W resistor.
R6 — 8.2 kΩ, ¼ W resistor.
R8, R10 — 330 Ω, ¼ W resistor.
R9 — 15 Ω, ¼ W resistor.
R11 — 10 Ω, ¼ W resistor.
T1 — Primary, 73 turns; secondary 7 turns, #28 enameled wire on T37-2 form; see text.

of conduit is split on one side and placed inside the upper end of the PVC center support. A 6 inch length of copper pipe is split for a length of about 5¼ inches and placed into the conduit. This leaves about ¾ inch of uncut copper extending out that will be later epoxied into the T fitting. Two 8-32 × 2 inch screws attach the truss plate to the vertical support and also go through the short length of conduit and split pipe. Fender washers, ⅞ inch in diameter, are used under the screw heads.

The aluminum center support box is a Pomona model #2906, available from **www.sales@xcess.com**. The box acts as a lower tie point for the copper element sections and also houses a two stage amplifier. The box measures 4¼ × 2⅝ × 1¾ inches with a ½ inch mounting foot on each side. Three 1⁄16 inch drip holes are drilled in the lower edge of the box before it is bolted to the main mounting plate. A U shaped reinforcing bracket is made of 0.063 inch thick aluminum and formed to fit inside against the ends and back of the Pomona box. The box and bracket are bolted by the same screws to the lower mounting plate. The box mounting feet are also bolted to the plate.

Holes are drilled on each side through the box and bracket to just clear the copper element. A standard straight copper coupling is placed over the element on each side to prevent crimping by the U bolts and the element is clamped to the base plate on each side. A 1 inch long section of ¾ × ¾ × ⅛ inch aluminum U channel is trimmed and placed under the element sections aligning the element with the holes drilled in the box. When the antenna is otherwise complete and square the element is cemented into the center T fitting with 5 minute epoxy and the clamps and U bolts are tightened.

The 0.125 thick aluminum mounting plate, shown in Figure 4, is made of two sections. The upper section is offset forward above the aluminum box and bolted to the lower plate section with ¼ inch bolts. This aligns the vertical center support with the centerline of the copper element. U bolts in the upper plate section clamp the PVC center support while U bolts in the lower section clamp to the main support mast.

The loop can be cleaned with steel wool and painted after assembly is complete, if desired. If you are anxious to try it you can operate without the amplifier by connecting C4 directly to the output connector and omitting C1. Capacitors C2 and C3 must be in place and C3 properly tuned. The full null depth will not be realized in this condition.

Amplifier Design

The amplifier, shown schematically in Figure 5, is built on a 2⅜ × 3¾ inch double sided PC board that is cut out to clear the small ribbed areas of the aluminum box as shown in Figure 6. It is also drilled for mounting on two ½ × ¼ inch diameter metal spacers fastened to the bottom of the box. The board on each end is notched to clear the ½ inch copper element sections that extend about ⅞ inch into the box. The center conductors should be approximately in line with the PC board surface. The output connector is mounted on the lower side of the

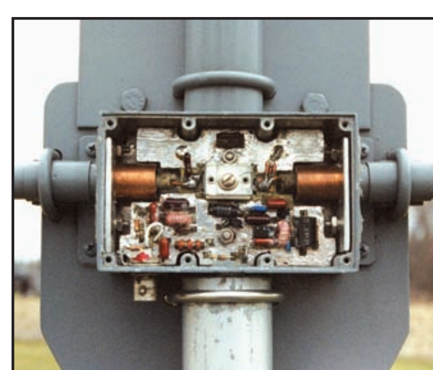


Figure 6 — Amplifier construction details.

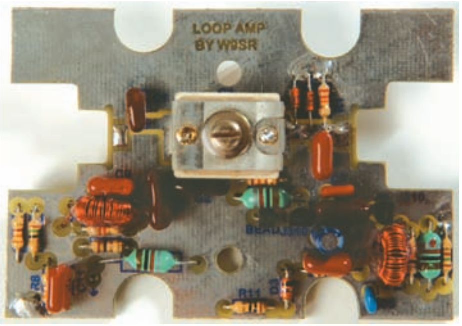


Figure 7 — Details of PC board construction.

Figure 9 — Loop amplifier power supply.

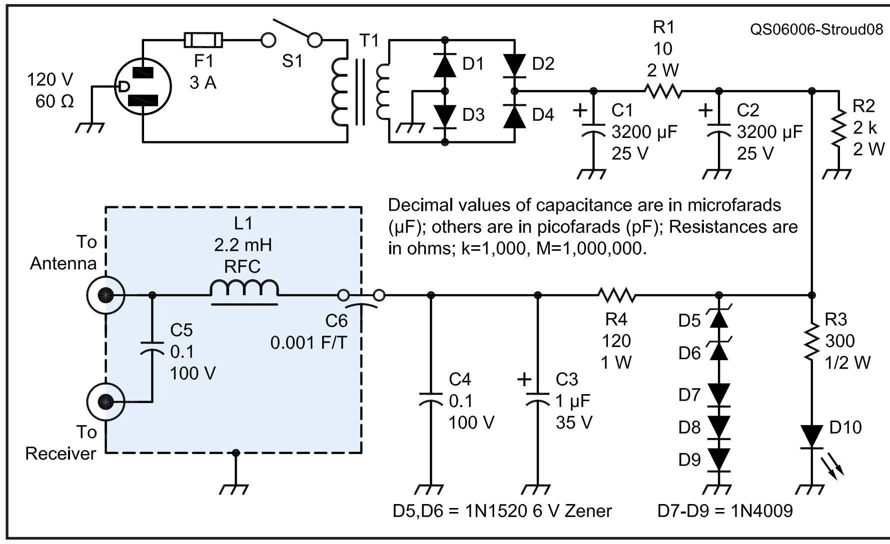


Figure 8 — Power supply schematic.

C1, C2 — 3200 µF, 25 V electrolytic capacitor.
C3 — 1 µF, 35 V electrolytic capacitor.
C4, C5 — 0.1 µF, 100 V ceramic capacitor.
C6 — 0.001 µF, 100 V feedthrough capacitor
D1-D4 — Silicon diodes; 1N4009, or 1 A, 50 V bridge rectifier.
D5, D6 — 1N1520, 6 V Zener diodes (see text).
D7-D9 — Silicon diode; 1N4009 (see text).
D10 — Light emitting diode (LED).
F1 — Fast blow fuse; 3 A, 120 V ac.
L1 — 2.2 mH miniature RF choke (J. W. Miller 9250-225).
R1 — 10 Ω, 2 W resistor.
R2 — 2 kΩ, 2 W resistor.
R3 — 300 Ω, ½ W resistor.
R4 — 120 Ω, 1 W resistor.
S1 — SPST toggle switch.
T1 — 120 V to 12 Vct, 450 mA transformer (RadioShack 273-1365 or equivalent).

box near one end to allow space against the box for the short 1½ inch main support mast. A close-up of the amplifier PC board is shown in Figure 7.

The amplifier consists of two cascaded, low noise, grounded gate stages using J-310 field effect transistors (FETs). C1 balances the sides of the loop against the amplifier input capacitance. This value was first determined with a variable capacitor and then a fixed unit was put in its place. C1 affects the null depth. Back to back signal diodes at the amplifier input protect the FETs from high signal levels generated by your local transmitter.

Inductor L2 is wound by winding one layer of 55 turns, then overwinding back in the same direction from that point to complete the required turns. T1 is wound in the same manner with the secondary wound over the cold end of the primary in the same direction. The pad in the output provides 2.2 dB of fixed attenuation with the resultant overall gain being 19 dB. The noise figure is less than 2 dB. With the values shown, the amplifier center frequency is 1.830 MHz and the –3 dB points are 1.764 and 1.896 MHz. The center frequency of the amplifier can be moved by changing the values of C6 and C8. Current drain at 12 V is 13 mA. The circuit board is available from FAR Circuits.[3]

All amplifier board parts except C3 are available from Dan's Small Parts and Kits. An on-line catalog can be viewed at **www.danssmallpartsandkits.net**. C3 is available from Communication Concepts at **www.communication-concepts.com**.

Power for the amplifier is routed through the output cable from a small power supply at the operating position.

There is no instability and no indication of overload or intermodulation products noted from the amplifier. The unit still performs well at 0°F in the Indiana winter!

The loop is not de-tuned by nearby objects and once it is tuned by C3 to 1830 kHz (or your favorite part of the band) in the shop, it will still be tuned when in the final position. Be sure your station control system will not allow you to transmit into the loop as the result would be catastrophic!

The power supply shown schematically in Figure 8 was built into a surplus Ten-Tec JW-7 cabinet and supplies 12 V dc through the coax to the amplifier. Construction is not critical and any stable 12 V at 13 mA supply can be used. The BNC coaxial connectors located on the power supply chassis should be shielded inside to prevent stray noise pickup. The 6 V Zener diodes were used because they were plentiful in the junk box; however, a 78L12 three terminal regulator would be a good substitute replacing the Zeners as well as the three diodes in series with them. The completed supply is shown in Figure 9.

Results

The null is through the center of the loop or into the page of Figure 1. The maximum signal is to the sides. It is important that the element and center box be waterproof. RTV can be used to seal any questionable area and a thin layer of RTV can be applied under the edge of the amplifier box lid as a gasket before final installation.

The receiving loop is mounted on a steel tower section, with a rotator, about 7 feet above ground. Results have been very gratifying. The peak to null varies greatly with the type of signal received and was measured at 38 dB using the test setup described earlier. The antenna is very effective in nulling out local power line noise, distant thunderstorms, broadcast band harmonics, computer hash and local interference. The null is not as effective on tumbling skywave signals but the loop still does a great job receiving them.

It is great for receiving low angle DX and often outperforms my larger antennas. The difference in gain is well compensated for by the on-board amplifier. I can instantly switch between receiving antennas from the operating position and am constantly amazed by the performance of the small loop. I am working many new European and Asian DX stations that I didn't know were around while I was listening on the transmitting antenna.

Notes

[1]D. DeMaw, "A Receiving Loop for 160 Meters," *QST*, Mar 1974, pp 38-41.

[2]B. Boothe, W9UCW, "Weak-Signal Reception on 160—Some Antenna Notes" *QST*, Jun 1977, pp 35-37.

[3]Send $9 plus shipping to FAR Circuits, 18N640 Field Ct, Dundee, IL 60118-9269.

Photos by the author.

Dick Stroud, W9SR, was first licensed in 1939 and received his Amateur Extra class license in 1952. Dick is a retired electrical engineer who spent over 30 years designing military electronics equipment. You can contact him at PO Box 73, Liberty Center, IN 46766 or at **dikw9sr@citznet.com**.