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Rebuilding a Receiving Flag Antenna for 160 Meters

Try this excellent receive antenna for the "Top Band."

Steve Lawrence, WB6RSE

My 160 meter flag antenna has proven essential for chasing Top Band DX from a small city lot on the West Coast of the US. So it was with more than just a little disappointment that I looked up one day to see the top length of antenna wire dangling from the end of one of the spreaders. I knew immediately what had happened. The #14 AWG stranded copper wire that I had wound through and around a small diameter eyehook broke after the fiberglass mast and spreaders flexed in the wind for 4 years. The rebuilt antenna (seen in the lead photo) incorporates improved stress relief for the antenna wire across the top at the corners, and a heavy-duty aluminum mast.

Construction

Figure 1 shows the mechanical details of the antenna. I used a ¼-inch thick × 16 × 10-inch 6061-T6 aluminum plate to attach the element spreaders to the mast. For the U-bolt and saddle mounting holes, I scribed two lines through the center of the plate, parallel to each side. I then scribed two more lines through the center of the plate — one to the left and another to the right — at an angle of 25.8° measured from the 16-inch horizontal line. I scribed additional lines parallel to and equidistant from both sides of the first four lines, spaced to match the separation required for the U-bolts. I had to make sure that the holes for the spreader and coax support arm U-bolts were outside the vertical center area of the plate, roughly 3 inches wide, to avoid interference with the mast. I spaced the spreader and coax support arm U-bolts 3 to 4 inches apart, separated the mast U-bolts by 7 to 8 inches.

The feed point transformer and termination resistor were each housed in small black plastic project boxes approximately 5 × 2½ × 1½ inches (see Figure 2). I drilled two holes several inches apart into the 6-inch antenna end insulators, with matching holes in the box covers. I used screws and locknuts to attach the covers to the insulators, then screwed the covers onto the boxes after the components were mounted inside. The termination box is identical to the transformer box except that there is no SO-239 coax connector. The antenna end insulator provides stress relief for the wire with a service loop that connects to the box via ½-inch long #6 hexagonal standoffs. Solder lugs under the screws that hold the standoffs from inside the box connect to the secondary of the feed point transformer, or termination resistor. The hex shape of the standoff allows it to be held without twisting when the antenna wire's crimp/solder lugs are tightened to the standoffs, assuring the integrity of the connection inside the box. I tightened the wire crimp/solder lugs with a screw and lock washer, and covered the standoffs with Coax Seal™. I then sealed the boxes with #33 electrical tape along the edges at the cover seams.

I made spreaders from telescoping sections of ⅛-inch wall thickness fiberglass tubing. Starting at the mounting plate, I inserted an 18-inch length of 1-inch O.D. solid fiberglass rod into an 8-foot section of 1¼-inch O.D. tubing. The solid rod prevents crushing by the U-bolts. I inserted a 1-inch O.D. 8-foot section of tubing into the other end of the 1¼-inch O.D. section, overlapping by one foot, and drilled a hole through both pieces of tubing, securing the sections with a #8 machine screw and locknut. I inserted

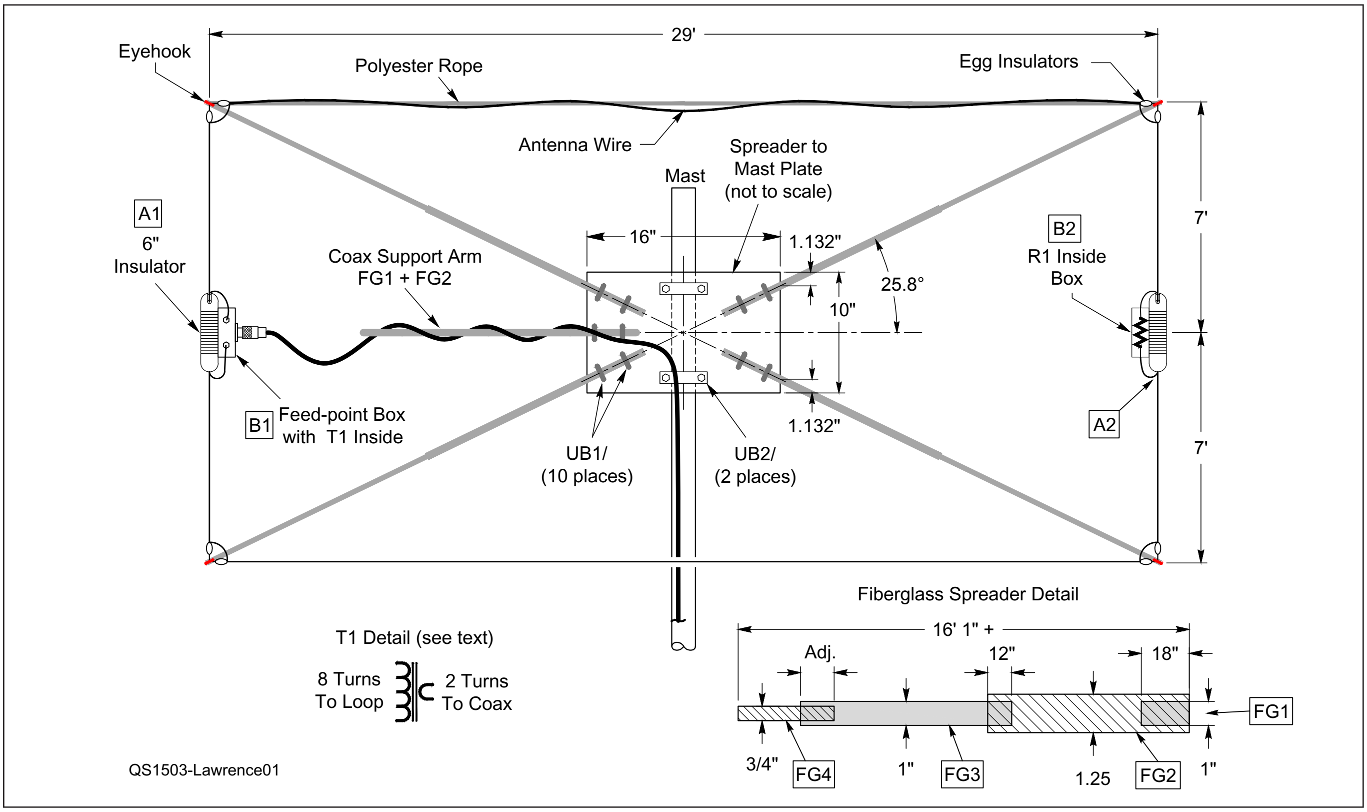


Figure 1 — Antenna mechanical details. (Fiberglass tubing and solid rod from Max Gain Systems **www.mgs4u.com**.)

A1, A2 — End insulator, Unadilla (**www.unadilla.com**)
B1, B2 — Black plastic project box, approximately 5" × 2.5" × 1.5"
FG1 — Solid fiberglass rod 18" 1" O.D., 5 pieces
FG2 — Fiberglass tube, 8' 1¼" O.D. ⅛" wall, 5 pieces
FG3 — Fiberglass tube, 8' 1" O.D. ⅛" wall, 4 pieces
FG4 — Fiberglass tube, 2' ¾" O.D. ⅛" wall, 4 pieces
Mast — 6061-T6 aluminum ¼" wall tubing, 10' to 12' long
R1 — Two 470 Ω 2 W 5% metal film resistors in series
Spreader to mast plate — 6061-T6 aluminum ¼" thick 10" × 16"
T1 — Two turns primary on eight turns secondary, BN73-202 binocular core (**www.amidoncorp.com** or **www.thepartsplace.k5nwa.com** or **kitsandparts.com/**)
UB1 — (10 places) U-bolts and saddles, SAD 125A (**www.dxengineering.com**)
UB2 — (two places) U-bolts and saddles, SAD 200A (**www.dxengineering.com**)

a 2-foot piece of ¾-inch O.D. tubing into the other end of the 1-inch O.D. section, and drilled a hole near the far end of this section to accommodate a #8 eyehook and locknut. The eyehook is a tie point for the tensioning rope and the egg insulators used for wire strain relief at each corner (see Figure 3). See the *QST* in Depth web page for an alternate method of assembling the antenna corners.[1]

I tied the polyester antenna rope to the eyehooks at the ends of each of the top spreaders with non-slip knots so that the total rope length was slightly longer than the top wire.[2, 3] I wrapped the top wire around the rope once approximately every 2 feet. With the wire and tensioning rope in place, I then adjusted the upper spreader lengths for tension on the rope, not on the wire. I adjusted the wires to the feed point transformer and termination resistor boxes so that the boxes sat at the midpoints of the 14-foot vertical sections. The spreader lengths will likely be slightly longer than the 16-feet 1-inch measured from the center of the spreader to mast plate. It's important to adjust all of the spreaders for an overall rectangular loop shape, but without excessive stress on the side and bottom wires. I secured each section with a screw and locknut, using plastic caps to seal the ends of the upper spreaders to prevent water accumulation. Quick-Clamps can be used to adjust the

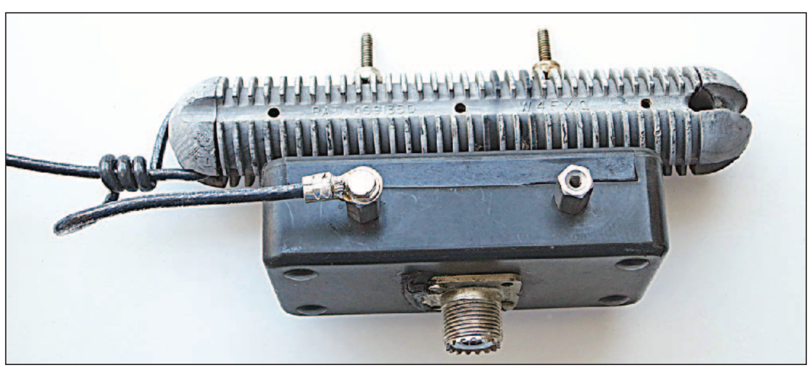


Figure 2 — Feed point transformer box showing one antenna lead connected with a strain relief.

Figure 3 — Corner strain relief uses antenna rope and egg insulators.

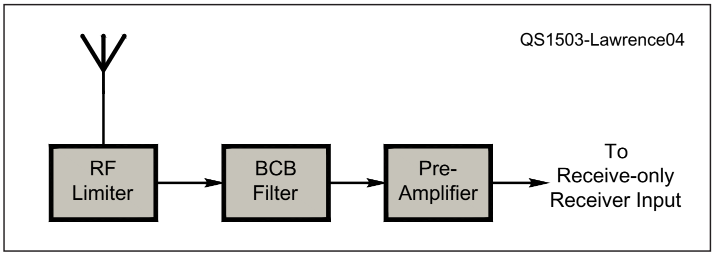


Figure 4 — The receiving lineup includes an RF limiter, BCB filter, and a pre-amplifier ahead of the receiver.

Broadcast Band (BCB) filters — Array Solutions W3NQN BCB Receive-only filter, or Clifton Laboratories Z10020 or Z10023A
Preamplifiers — Clifton Laboratories Z10046A, or DX Engineering RPA-1 or SV-160 or SV-DB
RF Limiters — Array Solutions AS-RXFEP, or DX Engineering SV-FESSS

spreader lengths before drilling the holes for the pinning screws and locknuts.

I connected one end of a 25-foot 50 Ω coax cable (with PL-259 connectors at each end) to the feed point coax connector, wrapped the connector with electrical tape and covered it with Coax Seal™. I then looped the coax around the box for strain relief, and secured it with a cable tie and electrical tape. Allowing the cable to droop slightly, I wrapped it around the 8-foot, 1¼ inch fiberglass support arm, and held it in place with tape and cable ties. I then routed the cable down and taped it to the mast. Once the mast and antenna were in place, I mated the cable to an SO-259 coax barrel near the rotator for attaching the cable run to the receiver, and sealed the PL-259 connectors and barrel with electrical tape. The 8-foot support arm also uses an 18-inch solid 1-inch O.D. fiberglass rod inserted in the end closest to the spreader-to-mast mounting plate, to prevent crushing by the U-bolts.

The Transformer

The feed point transformer is the critical component of the electrical design of the antenna. I wound the transformer on an Amidon BN73-202 binocular core, with an eight-turn secondary of #26 AWG enamel wire first, followed by a two-turn primary of #26 AWG Teflon® coated wire. When you wind yours, count a single turn as one loop through a core hole and back through the adjacent hole so that the ends of the wire extend out from the core in the same direction, shaped like a U. Bench test the transformer and termination resistor boxes before installing them. Using clip leads, connect each of the transformer box standoffs to one of the standoffs on the termination box and the coax connector to an antenna analyzer such as an MFJ-259B. You should see a fairly flat SWR of 1.2 or less and a nominal impedance of 50 Ω along with a very small reactive component to well beyond 14 MHz.

Caution!

Installing an antenna can be hazardous and can result in serious injury. Keep clear of power lines. Ensure that you have adequate manpower for the job, and inspect all equipment including belts, pulleys, ropes, and tool tethers. You can follow how I installed the antenna on my roof in a previous article.[4]

Cutting fiberglass produces a fine dust. Avoid inhalation or contact with the eyes. The 1-inch O.D. solid rod used to prevent U-bolt crushing only needs to be long enough to cover the area where the U-bolts are tightened. These pieces can be ordered precut to avoid generating hazardous dust.

Assembly Notes and Options

The mast is 6061-T6 ¼-inch wall 2-inch aluminum tubing. My mast is 12 feet long. I wrap tape around the top of the mast to provide a snug fit for a 2-inch PVC cap to keep debris out. All my hardware is stainless steel. Fiberglass degrades with prolonged exposure to UV light. One supplier recommends cleaning with acetone or methyl ethyl ketone (MEK). Then paint a primer coat, allowing it to cure for at least 2 days, followed by a topcoat of flat black paint. One hundred feet of #12 AWG stranded copper Thermoplastic High Heat Resistant Nylon (THHN) coated wire is sufficient to make the loop.

Alternate methods of winding the transformer and enclosing it and the termination resistor can be found on the W7IUV website.[5] I used two 470 Ω 2 W 5% metal oxide resistors in series. This resistor combination works for both 160 and 80 meters.[6]

A common mode choke can reduce noise coupled via the coax line to the receiver. A choke can be built into the box at the feed point during the initial construction, or if the antenna is already in place, in a box at the end of the 25-foot coax section at the rotator. Another can be inserted at the input to the RF limiter, shown in Figure 4. An effective common mode choke can be made with 17 turns of RG58 coax wound on an Amidon FT240-31 core.[7] An extensive discussion of common modes chokes is published on the Yankee Clipper Contest Club web page.[8]

Operating

The antenna is most effective when it can be rotated. The front of the antenna is in the direction of the transformer. The antenna provides directivity, not gain. The optimum direction is not necessarily towards the heading of interest but rather oriented to reduce noise and strong signal sources to achieve the best signal to noise ratio. To check that the antenna is performing as designed, rotate the antenna for a signal peak towards a local AM broadcast station. Note the signal strength. Rotate the antenna

180 degrees and the signal should drop approximately 25 dB.

Figure 4 shows a typical receiving lineup for a dedicated receive antenna — an RF limiter, AM broadcast band (BCB) filter, and a preamplifier — all used ahead of the receiver. The RF limiter, sometimes called a front end saver, is essential to protect the receiver front end when transmitting at high power close to a receive antenna. The BCB filter can be effective if a strong local AM station is overloading the external preamplifier. Overload can result in severe intermodulation distortion (IMD). A fixed or variable gain external preamplifier (18 to 20 dB gain) can be useful for weak signals. It may also be useful to turn off the external preamplifier and "ride" the receiver RF gain. You want to achieve the best possible signal to noise ratio when listening for weak signals. The receiver Automatic Gain Control (AGC) can also be turned off but beware of sudden strong signals. Be sure to keep the receiver audio level reduced accordingly. Some preamplifier designs incorporate an RF limiter and preamplifier in a single unit. In that case you can place a BCB filter (if needed) ahead of the combination unit.

This receiving flag antenna made a significant difference in enabling me to add new DXCC entities to my 160 meter log. It's an excellent performer on 80 meters as well. If you have room for just one Top Band antenna, this design is well worth the effort.

Notes

[1]**www.arrl.org/qst-in-depth**

[2]Polyester antenna rope, 3⁄16 or 5⁄16 inch, Synthetic Textiles, **www.synthetictextilesinc.com**.

[3]Instructions on tying non-slip knots can be found at **www.animatedknots.com/nonslipmono**.

[4]S. Lawrence, WB6RSE, "A Roof Mount for a Rotatable 160 Meter Receiving Loop," *QST,* Mar 2011, pp 40 – 42.

[5]L. Molitor, W7IUV, "Rotatable Flag," from his website **w7iuv.com/flag.htm**.

[6]E. Cunningham, K6SE, "Flag, Pennants and Other Ground-Independent Low-Band Receiving Antennas," *QST,* Jul 2000, p 34.

[7]S.E. Hunt, G3TXQ, Common-mode Chokes, from his website, **www.karinya.net/g3txq/chokes/**.

[8]C. Counselman, W1HIS, "Common-Mode Chokes." **www.yccc.org/Articles/W1HIS/CommonModeChokesW1HIS2006Apr06.pdf**.

ARRL Life Member Steve Lawrence, WB6RSE, was first licensed in 1959 with the novice call sign WV2GWG. He now holds an Amateur Extra class license and received his current call in 1965 after moving to the West Coast of the US. He holds a BS in Physics from UCLA and an MSEE from USC. Steve retired from Hughes Electronics/Boeing Satellite Systems as an engineering manager and Director of Quality in 2002. He coordinates the annual Top Band Dinner at the International DX Convention each April in Visalia, California. He's at the top of the mixed and phone DXCC Honor Rolls and needs just P5 to have worked them all on CW. He has over 200 confirmed DXCC entities on 160 meters from his West Coast city lot. You can contact him at 3642 Coolidge Ave., Los Angeles, CA, 90066-3310 or at **wb6rse1@mac.com**.

For updates to this article, see the *QST* Feedback page at www.arrl.org/feedback.

New Books

Ten Essential Skills for Electrical Engineers

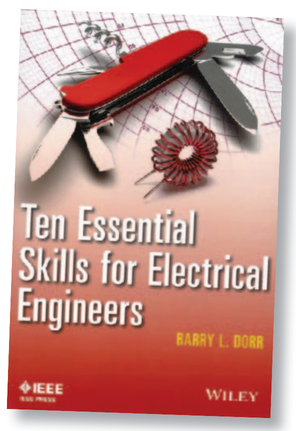
Barry L. Dorr, KC6QJR

Reviewed by Rick Lindquist, WW1ME

I readily confess my own severe limitations in reviewing a book such as *Ten Essential Skills for Electrical Engineers*. In short, I'm no engineer, but I've played one on Amateur Radio — so to speak. After all, aren't we *all* engineers at some level of the technology continuum?

Dorr's compact guide is a tome for the times. As he points out in a "Note to Instructors," in a job climate like today's, even graduate engineers now must hit the ground running. There's quite often little or no honeymoon for workplace newcomers to acclimate to the vicissitudes of a position, not to mention the corporate climate. Even as a candidate you're up against experienced applicants. Time to bone up!

Dorr has cast a wide net to encompass learners as well as doers. His book could make a great classroom text and not break the bank, as textbooks often can. Dorr suggests integrating it into the sophomore year of an undergrad electrical engineering curriculum or using it as a supplement. He suggests that student obtain *MATLAB* software (from MathWorks) to help them puzzle through the examples in the nine "How to" technical chapters. It struck me that someone with a talent for math (in other words, *not* me) could use this book for a self-study program, although it presupposes more than a modicum of engineering knowledge. Each chapter contains problems, and an answer key is at the end of the book.



Which brings us to the point: Just what are those 10 skills anyway? Well, just to get in the front door here, your mathematical skills had better be up to par. Dorr starts out simply, with "How to Design Resistive Circuits," covering coupling and attenuator circuits and — something new to this non-engineer — design of a "resistive Thévenin source." He shows how to do this with just three resistors — no fuss, no muss, no op amps. (This and other topics he expands upon focus upon typical engineering job interview questions.) As Dorr says in a footnote, "If it *doesn't* make sense, don't worry. You'll pick this up with time."

My brow wrinkled a bit when I saw that Chapter 2 discusses "How to Prevent a Power Transistor from Overheating." As Dorr notes, though, "Most experienced engineers have seen good electrical designs get scrapped because they were thermally impractical, so it is common for them to ask candidates to solve simple heat transfer problems during interviews."

Other chapters examine "How to Analyze a Circuit," "How to Design Digital Filters," and "How to Work with RF Signals," among other job interview grist. Dorr's approach throughout is to reinforce what that job-hunting BS degree holder (should have) learned in the college classroom and laboratory.

Dorr logically saves the best for last: "Getting a Job — Keeping a Job — Enjoying your Work." If only, right? But this is where the previous chapters lead. Dorr discusses preparing for an interview, getting one, getting through one, and even "Selecting the Right Offer." You can't say he's not optimistic. *Bottom line*: Dorr, who now has his own consulting business, parlays his 30 years of engineering experience and that of several reviewers to benefit budding engineers who soon may be knocking on the door of his — or your — workplace.

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