By Dave Benson, K1SWL

Taming the Trap Dipole

A self-supported dipole for 10/15/17 meters can be a fine thing—if it's designed right.

After our recent move from a city location to several acres of wooded bliss, it was only natural that a young man's fancy would turn to thoughts of . . . antennas! I've experimented with any number of antenna configurations over the years, but multiband operation always seemed to involve tuners used to press non-resonant wires into service. With the "clean slate" afforded me with the new location, I decided I wanted to pursue the "hook up the coax and forget it" approach. I'm also reluctant to spend my limited discretionary funds on commercial antennas when the homebrew approach works well.

One approach to a multiband dipole design is the so-called "fan dipole" wherein a separate electrical half-wavelength of wire is added in parallel at the feedpoint for each band of interest. This can become mechanically cumbersome after the first several bands and interaction between bands becomes noticeable, at least with close wire spacings. I elected instead to pursue the trap approach. This article describes the development of a self-supported 10/15/17 meter trap dipole.

This project moved from the back burner to the "gotta try it" category when I found that the local home-improvement emporium carried 8-foot lengths of 3/8-inch aluminum C-channel stock. This material has one important advantage: all surfaces are flat, which eases a number of construction details. The joints between the element sections need to be an insulating material and of sufficient strength to carry the weight of the outboard sections. The ideal material for this application turned out to be 3/8-inch square black Delrin (plastic) stock, which has good tensile strength properties.[1] This material is also available in sizes up to 4 inches square (at daunting prices) for applications where higher strength is required.

Figure 1 shows the dimensions of the trap antenna. The innermost dipole section (10 meters) is decoupled from the rest of the antenna by a pair of traps tuned to 28.1 MHz. The next pair of sections is decoupled from the outer wires by a pair of traps adjusted to 21.1 MHz. Although the dimensions shown are for the 10/15/17-meter bands, there's nothing to prevent you from developing other combinations.

The traps themselves are quite simple—a parallel-resonant tuned circuit adjusted to the center of each amateur band of interest. I constructed each of these from iron-powder toroidal cores and a pair of silver mica capacitors. Each trap uses two 1 kV-rated capacitors in series and T94 cores, the largest that would fit in the "low-profile" trap enclosures I chose. I used Serpac C-series enclosures available from mail-order distributors, and a number of choices are also available through RadioShack. Figure 2 shows the construction details—a pair of machine screws exits through the rear wall of the trap enclosure and passes through holes drilled through the insulator stock and the aluminum C-channel.

The traditional tool for adjusting traps has been a grid-dip meter, and this has been supplanted more recently by antenna

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[1] Notes appear on page 30.

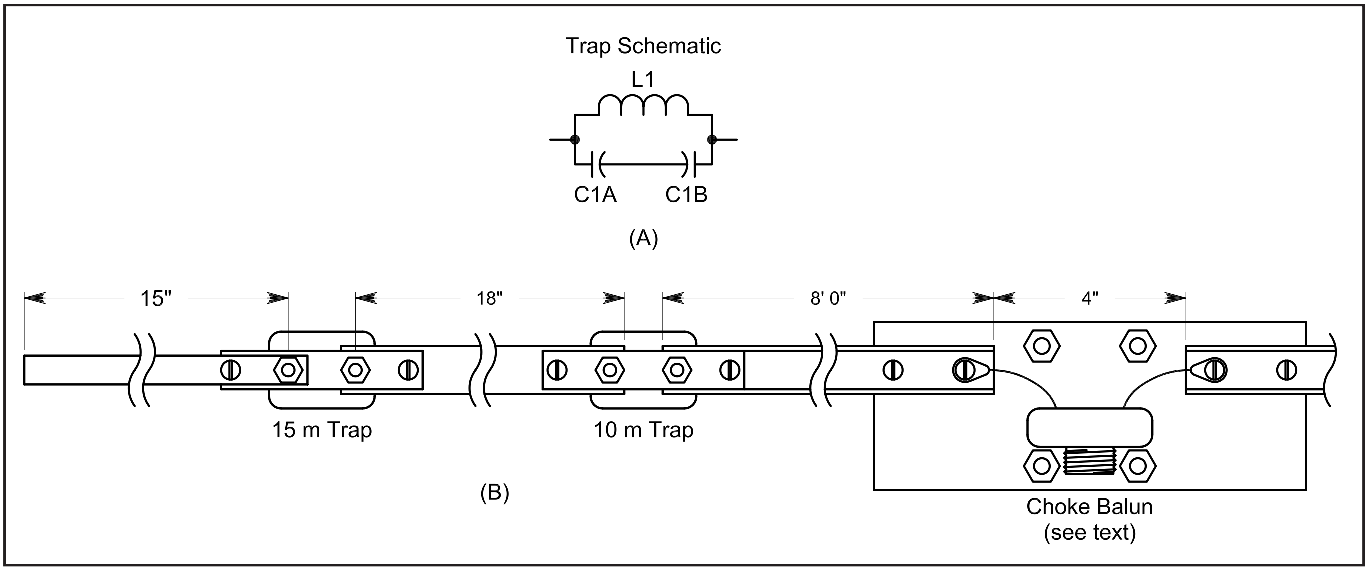


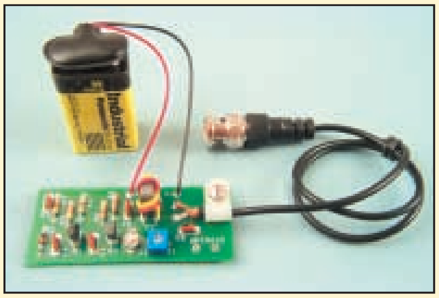
Figure 1—The dimensions of the trap antenna. Other dimensions can be devised for bands other than 10, 15 and 17 meters. At A, the schematic of the trap. At B, dimensions for one side of the dipole antenna.

C1A, C1B—100 pF, 1 kV silver mica capacitor.

L1—*10 meters*: 9 turns on a T94-10 toroidal core; *15 meters*: 11 turns on a T94-6 toroidal core. The coils must be tuned to resonance.

The Noise Bridge

Diode D1 is a source of broadband noise. This noise is amplified to useful levels by the two-stage circuit comprising Q1, Q2 and associated components. Although there's no attempt made to frequency-compensate this noise source, there's plenty of signal for our purposes—its output level ranges from S9+20 dB at 1.8 MHz to S7 at 30 MHz. In practice, when the impedances connected to points B and U are equal, this "bridge" circuit is in a balanced condition and output to the receiver is at a null. The only "tricky bit" in this circuit consists of the trifilar winding T1. [The circuit board project offering uses color-coded wire for this toroid, so hookup is pretty much foolproof.]



So Now What?

Let's put this to practical use: Connect a 100-Ω ¼ W resistor across the "unknown" terminals and connect to your receiver with a length of coax. Apply dc power (8-15 V) to the noise bridge circuit and you should hear a loud rushing noise in the receiver. Adjust control R1 for minimum S-meter indication and then C1. Once these are both adjusted carefully, the noise level in the receiver should drop to its internal noise level alone. The noise bridge is now adjusted for a null—the impedance presented by the 100-ohm resistance and stray capacitance is now balanced by the bridge's R1 and C1 settings.

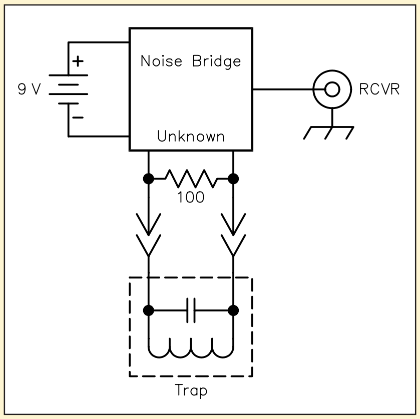


Figure B—How to hook up the noise bridge.

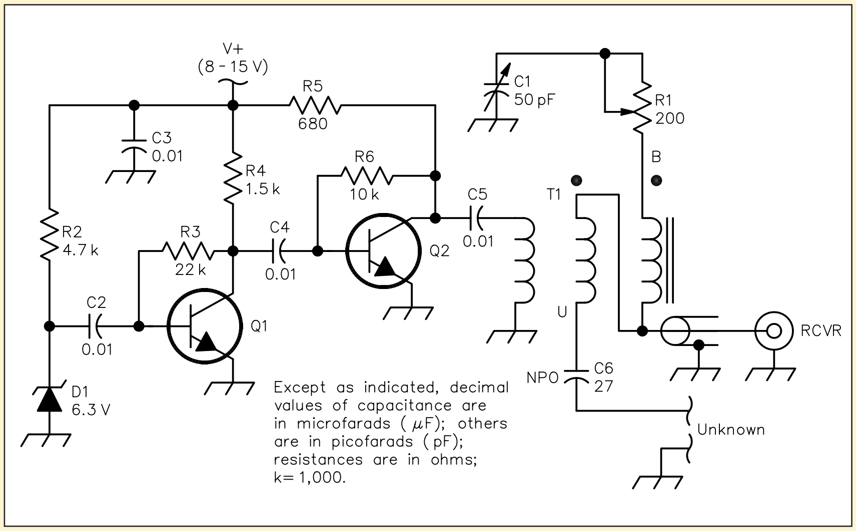
Putting it all Together

If you add the trap—a parallel L-C circuit—at its resonance frequency across that 100-ohm resistor, there'd be no disturbance to the null since its impedance at the intended operating frequency is theoretically infinite. Away from the resonance frequency, the noise level will rise as the receiver is tuned off to either side. Finding the trap's resonant frequency amounts to tuning your receiver until you've located the noise null. This null will be fairly broad; however, it should be easy to locate using 1-MHz and then 100 kHz tuning steps.

Once you've found the null, bunch the toroid turns together to lower the trap resonance frequency or spread the turns apart to raise the resonance frequency. There's a fair amount of adjustment possible without resorting to changing the toroid turns count—the 21 MHz traps, for instance, could be tuned in this manner to cover a range of 19-22 MHz.

Caution

My initial attempts at repeatable resonance measurements were inconsistent—the "casual" approach using clip leads yielded well over a MHz of variation in resonance frequency at 25 MHz! It's critical to make the leads from the "unknown" terminals on the bridge to the traps as rigid as is practical. I used 2-inch lengths of no. 20 magnet wire to the 100-Ω parallel load and installed solder lugs outboard of that resistor. This allowed the traps to be added and removed with a minimum of change in stray capacitance, which affects the resonance measurement significantly. Once these precautions were taken, the measurements became reassuringly repeatable. *Note: Once these trap hookup connections are ready to go and prior to adding the traps, be sure to readjust C1 for a noise null—this effectively tunes out the test setup stray capacitance.*



Except as indicated, decimal values of capacitance are in microfarads (µF); others are in picofarads (pF); resistances are in ohms; k= 1,000.

Figure A—The schematic diagram of the noise bridge, based on a design that appears in *The ARRL Antenna Book*. All resistors are 5%, ¼-W carbon composition.

D1—6.3-V, 0.5-W Zener diode, 1N753A or equiv.
Q1, Q2—High-speed NPN switch, PN2222A, 2N4401 or equiv.
T1—4 turns trifilar-wound on FT37-43 toroid; observe phasing.

analyzers. If you don't have access to either of these tools, though, despair not! If you have an HF transceiver with general coverage capability, you've already got most of what you need.

The remaining piece of equipment required is a noise bridge. Despite the arcane-sounding name, this is a simple circuit that is easily duplicated. The sidebar shows the schematic diagram for this circuit, and this is taken largely intact from *The ARRL Antenna Book*.[2] A printed circuit-board kit was developed as a club project and is available to interested builders.[3]

Antenna Adjustment

This antenna was developed by starting with the innermost (10-meter) section and working outward one band at a time. With a 4-inch spacing between the ends of the 8-foot channel sections, the 10-meter antenna simply worked on the first try. Resonance for this dipole was at 28.1 MHz and SWR characteristics were fairly broad due to the element thickness.

Upon adjustment of a pair of 10-meter traps, these were added to the element

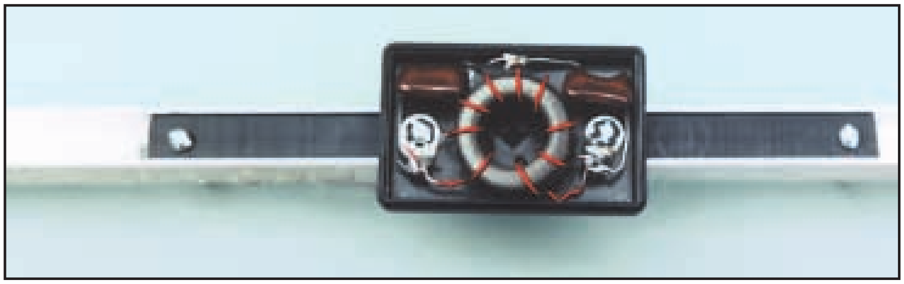


Figure 2—Construction details of the trap. See text.

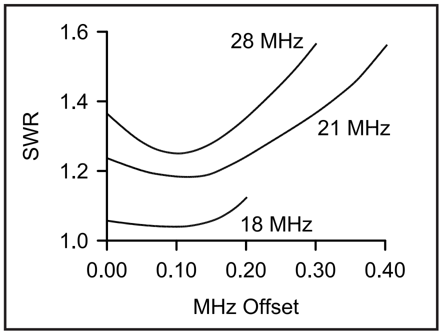


Figure 3—The SWR characteristics for the trap dipole. Since the author operates primarily CW and data modes, the lengths are optimized for the lower end of each band.

ends and outboard sections for 15 meters were added. Rather than use the C-channel material on the initial adjustments, I found it much more convenient to install outboard sections of ¼ inch aluminum rod stock. This material proved to be quite easy to trim to length with a pair of bolt-cutters! Tune-up was done at an initial height of 20 feet. Element lengths are adjusted using an SWR bridge and transmitter to determine the frequency at which SWR is minimum and adjusting accordingly. *A gentle suggestion: It's much easier to start "long" and subtract material rather the reverse!*

You'll find that the outboard lengths for each additional lower-frequency band do not meet the familiar formula for computing dipole lengths. The traps themselves present a very high impedance at their design frequency but below this frequency are inductive. This has the effect of shortening the resonant length of the antenna. [It has a modest effect in lowering feedpoint resistance as well, but is not significant within the context of this application.] With the trap components I chose, each outboard section length was shortened by 30-35% over the expected values for a dipole. For the adventurous, this length may be estimated by calculating the effective impedance of the trap at the lower band and applying it to any of several tools. This information is found in graphical form in *The ARRL Antenna Book*[4] or by use of *EZNEC*.[5]

With the length of the 15-meter section under control, I replaced the temporary rod sections with C-channel and added a pair of 15-meter traps. With the addition and adjustment of the outer 17-meter sections, this completed the design for my applications, so I elected to leave the outer antenna ends in the form of ¼-inch rod stock to reduce weight and lower the antenna's visible "profile."

The center insulator/mounting block is constructed from a 3/8 × 3 × 12-inch block of Delrin plastic. This provides sufficient rigidity for this antenna, although if the concept is extended to lower bands you'd probably want thicker plastic material. A small plastic box at the feedpoint contains a choke balun. I constructed this using a short length of RG-174 coax looped three times through a group of six FT37-43 ferrite toroids. There's nothing magical about this approach—any of a number of other methods can be used to achieve the same goal.

Construction

All fastening hardware for the trap dipole should be of stainless steel, and toothed lock washers are needed to maintain integrity of the tightened joints. Once the traps are adjusted to the desired resonance frequencies, the trap enclosures are sealed shut with an edge-bead of model airplane cement and resonance was re-checked. This final check ensures that adding the enclosure covers has not disturbed the trap frequencies—a possibility given the tight quarters afforded by the enclosures I chose.

Results

The SWR characteristics for this antenna are shown in Figure 3. I operate primarily CW and data modes, so my interest is in the lower end of each band; the lengths in this article reflect that preference. Whatever frequency you choose, you know you've done a careful job tuning the traps if the addition of these traps and outboard sections has no effect on resonance frequency of the inner antenna portion. Their presence, though, will narrow the effective SWR bandwidth as you move away from resonance—the trap-antenna bandwidths are lower than for that of a "plain-vanilla" dipole.

Trap Losses

Although I normally operate at 5 W output or less, that's not everyone's "cup of tea." I've tested this antenna at 100 W without incident. *EZNEC* analysis using the published "Q" values for the toroid trap material shows antenna gain at 28 MHz to be 0.8 dB down from the expected free-space values, and 0.9 dB down at 21 MHz. At 18.1 MHz, the loss is approximately 0.25 dB. These values would be somewhat improved with the use of higher-Q inductors. This design has traded "compact" and "low-profile" for modest gain penalties—proof indeed of the old adage about "no free lunch."

A point of interest—I calculate the peak voltage across the traps at that power level to be over 1 kV. This is no place for junkbox capacitors of questionable pedigree! A high-quality NP0 capacitor type is a "must"—the types typically available from your local electronics emporium may be quite lossy at high frequencies, and this will translate into considerable component heating and disappointing performance. The 500-V silver mica capacitors available from the large distributors are sufficient for lower-power (QRP) operation.[6]

I installed this antenna at the 35-foot level above my roof and have been very pleased with its performance. After years of "low-profile" QRP operation, my success rate snagging contacts on the first call has improved markedly. To a large extent, the old maxim of "Put it up high and in the clear" applies here! As a final "food-for-thought" consideration, the trap-construction scheme I've described would lend itself nicely to multiband vertical and ground-plane antennas.

Acknowledgments

Special thanks to Seabury Lyon, AA1MY, for his assistance with the noise bridge project.

Notes

[1] Delrin plastic may be purchased in small quantities from McMaster-Carr, **www.mcmaster.com**; see "raw materials."

[2] *The ARRL Antenna Book*, 19th Ed., p 27-24.

[3] A noise bridge kit consisting of double-sided/silkscreened printed-circuit board, on-board parts and RG-174/U cable with BNC connector and instructions is available from the New England QRP Club for $17 ($20 overseas) postpaid. Checks or money orders payable to S. Lyon, AA1MY, 99 Sparrowhawk Mtn Rd, Bethel, ME 04217.

[4] Dean Straw, N6BV, Ed., *The ARRL Antenna Book*, 19th Ed., p 6-28.

[5] *EZNEC* is available from Roy Lewallen, W7EL, **www.eznec.com**.

[6] Toroids are available from Amidon Associates (tel 714-850-4660) or Palomar Engineers, **www.palomar-engineeers.com**. 1-kV silver mica capacitors are available from RF Parts Co (**www.rfparts.com**; tel 800-737-2787).

Dave Benson, K1SWL, is a frequent contributor to QST. *He can be reached at* **dave@smallwonderlabs.com**.