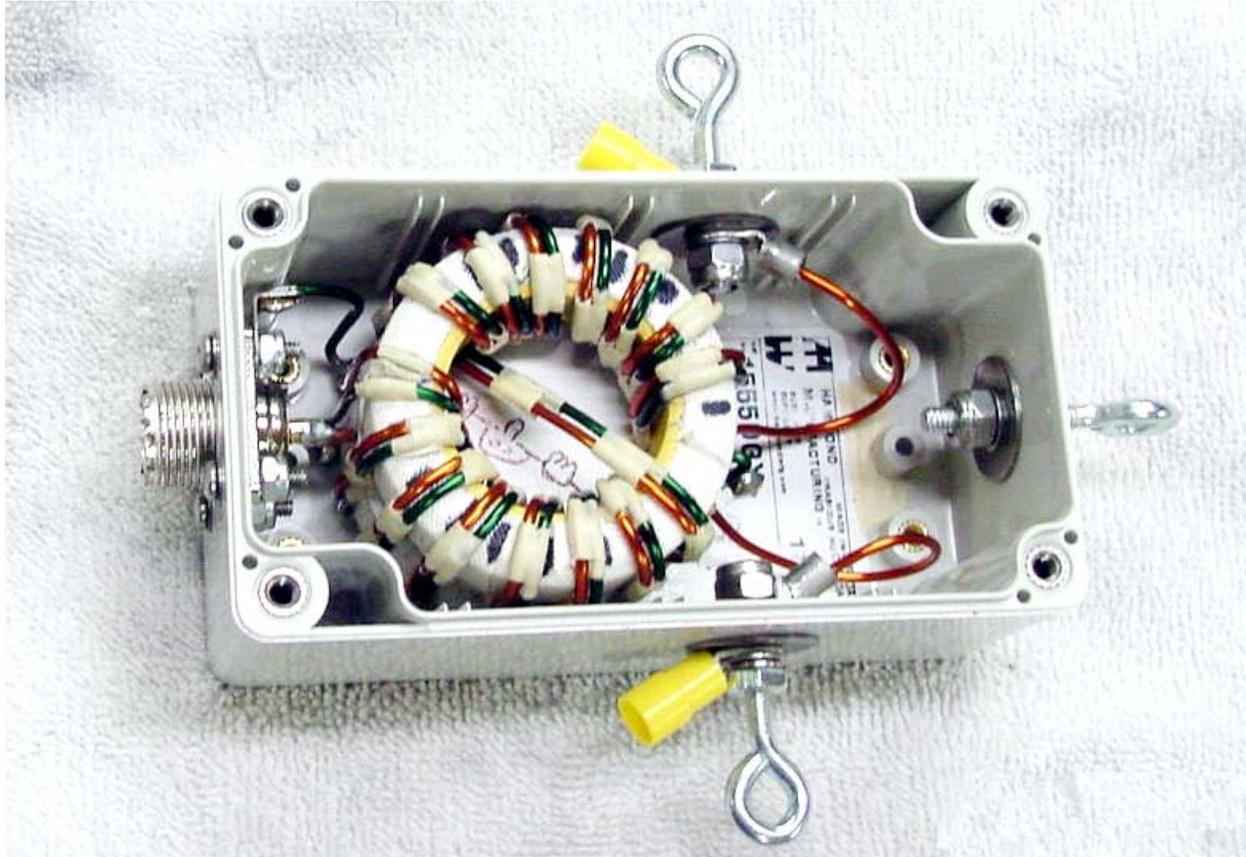


CVARC 4:1 Balun Project Kit by AE6YC

New to the amateur radio world or have been around long enough to be considered an *old timer*, whichever you will never forget the first kit or *homebrew* project you built. For me it was a 'cat-whisker' crystal radio receiver before I was a teenager. The balun project is a great introduction to what old timers in the hobby refer to as *home-brewing*. Our club has put together 35 kits and will schedule two work shops at the ECSS. Elmer's will be available to help with soldering, transmission line winding, schematic reading and testing to assure everyone leaves with their completed balun kit up and running.



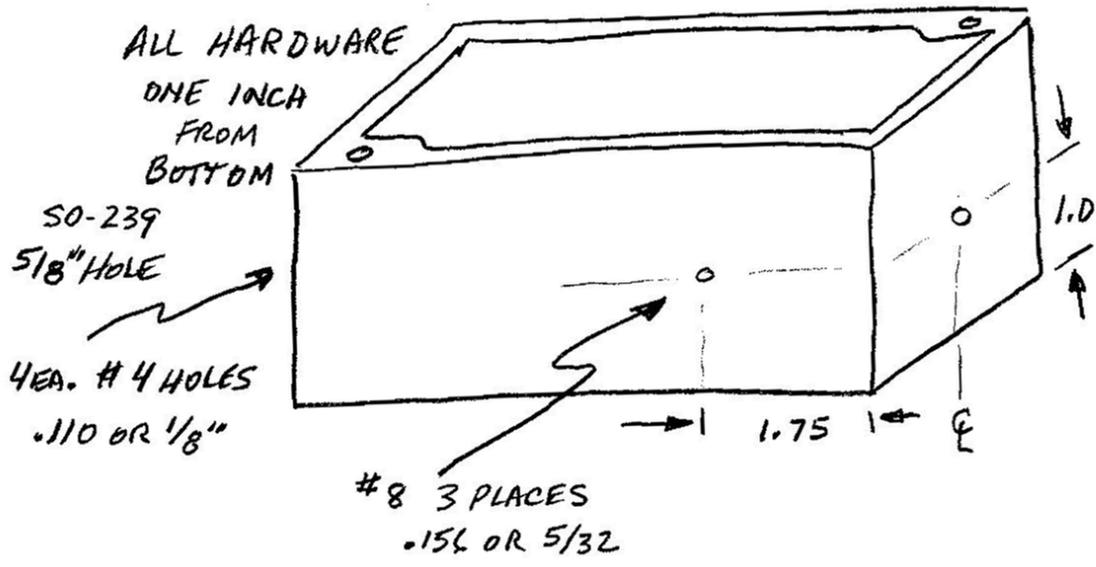
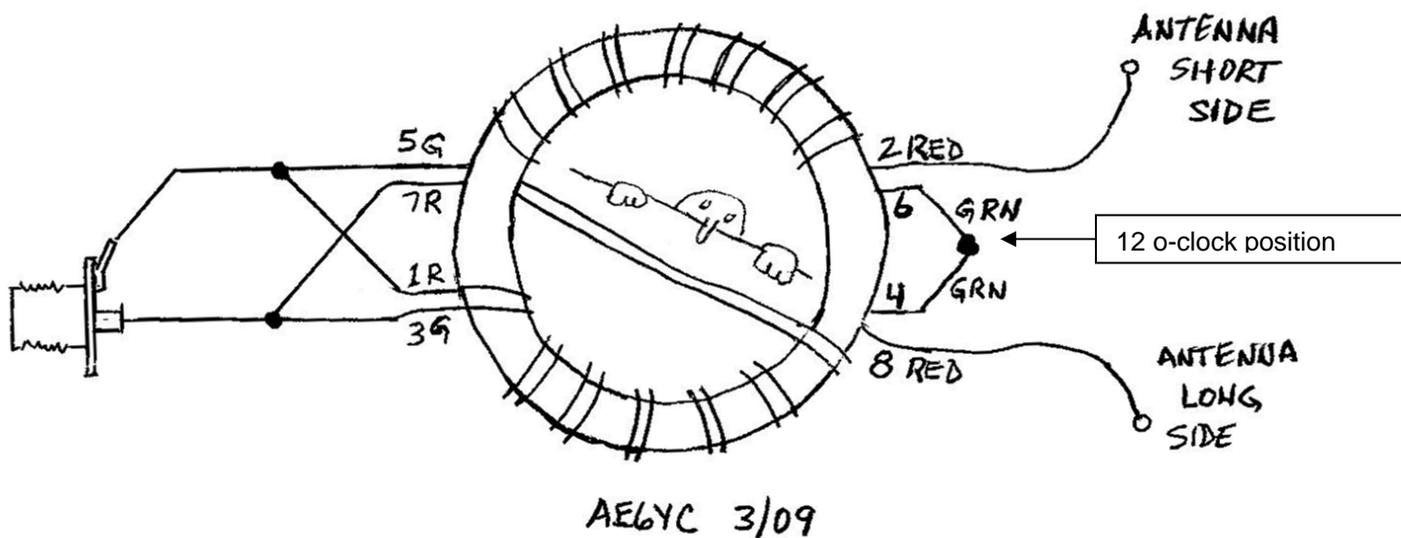
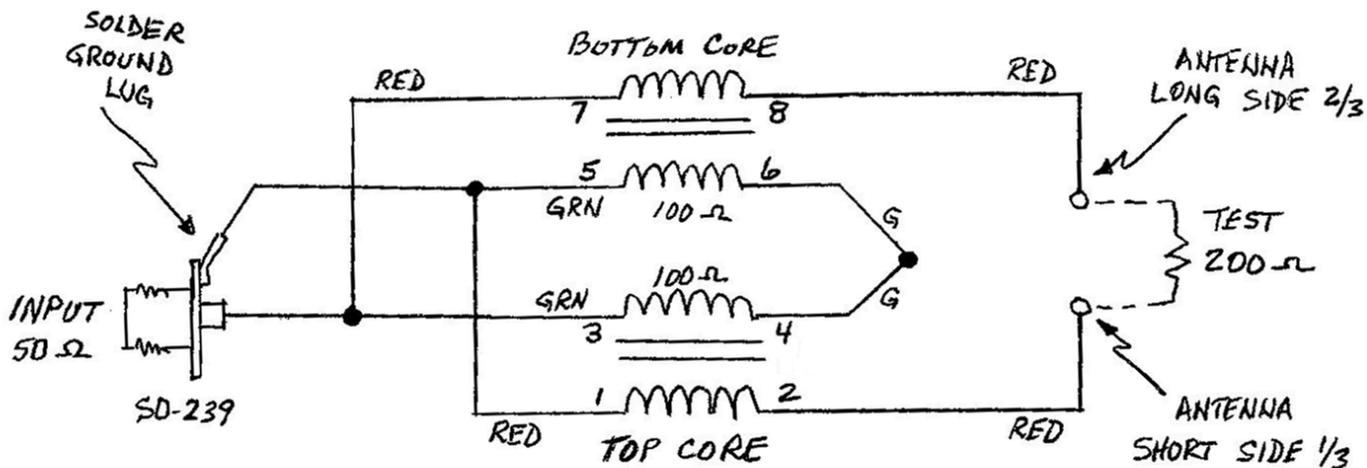
Why a balun - what's it used for

The most basic of antennas for ham radio is the dipole. Dipoles are both economical and easy to construct, the conventional dipole is limited to a single band of operation. The conventional dipole antenna is center fed meaning equal lengths of wire on each side of the feed point, and the overall length of the antenna wire is determined by the band or frequency you wish to operate on. Coaxial cable is generally used between the output of your radio and the center feed point of the dipole antenna.

However, by *off setting* the feed point at the antenna and building an impedance conversion device you can build a modified dipole antenna that will operate on several of the HF bands. This antenna is referred to as an OCF dipole, or off-center-fed dipole. OCF dipoles have much higher impedance(s) than conventional dipoles. The impedance conversion device, you guessed it, is the balun. Balun stands for *balanced - to - unbalanced*. The balun matches the impedance of the antenna to the output impedance of your radio. The balun is placed at the *off center* feed-point of the antenna wire, and coaxial cable is run from the balun to your radio. The balanced part or side of the balun is connected to the OCF dipole antenna wire, and the unbalanced side connects (via coax) to the antenna connector on your HF radio.

Whatever your situation - limited space, basic radio without tuner, budget, just upgraded to HF privileges, or just want to brew your own. Our balun project is just the ticket to get on several HF bands with a single antenna. The OCF dipole can be put up in a straight horizontal configuration - some times called flat top, inverted 'V', or inverted 'V' with drooped ends to fit on the smallest of city lots.

Schematic, core winding layout, and enclosure drill locations



Kit components

As pictured above the kit includes all components to build a complete balun assembly -

Hammond NEMA polycarbonate enclosure, 1555DGY, includes cover (not shown)
Powered iron 2 inch core (mix 6), Micro Metals T200-6
3M glass tape to wrap the core
Masking tape for wire spacing
Insulated magnet wire 14 gauge, green and red
#8 ring terminals
Various #8 hardware, eye bolts, washers, lock nuts
All hardware is stainless steel except eye bolts and #4 lock nuts
#4 solder lug, and 4-40 screws, washers and lock nuts
SO-239 connector, RFU-521 from RF Industries

Work shop tools

Long nose pliers, smooth and rounded jaws
Diagonal cutters, light and heavy duty
Measuring stick, rule or caliper, and awl for marking drill locations
Phillips #1 and #2 screwdriver
Wrench, 1/4 and 11/32 inch (#4 and #8 hardware)
Knife to scrape magnet wire insulation off
Scissors, we'll be cutting a lot of tape strips
Towel to protect the tables at ECSS, and catch small parts

Only a few of the following are required at each workshop sessions -

Soldering iron and solder

Drill and bits

- starter drill and for water drain holes, 1/16 inch
- .110 or 1/8 inch for #4 screw hole
- .156 or 5/32 inch for #8 eye bolts

Antenna analyzer and 200 ohm non-inductive resistor for testing the completed balun



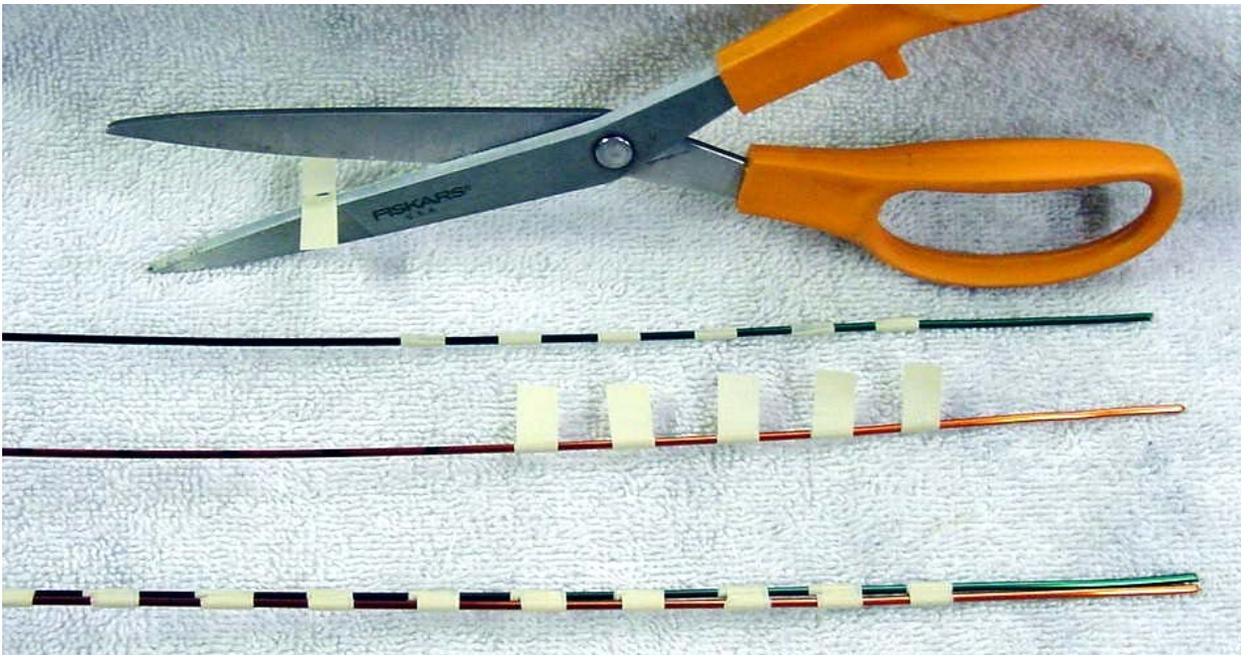
Workshop and assembly tidbits - in no particular order

All parts except the glass tape, magnet wire, and masking tape are in the project box. The tape(s) and green and red 14 gauge magnet wire will be cut to length at the workshops. The 5/8 inch diameter mounting hole for the coax connector has been predrilled by the author in all of the project boxes. To complete the connector mounting insert the connector with its mounting flange on the outside of the box into the 5/8 inch hole and match drill the four #4 screw mounting holes using a .110 or 1/8 inch drill, hint - after drilling each hole insert a #4 screw to keep the connector aligned.

Preparing the two transmission line windings is the most tedious and time consuming construction step. The two wires that make up each winding must be spaced .024 inches apart. This spacing determines the impedance of the transmission line windings (100 ohms).

Free space parallel wire transmission line impedance can be calculated using $Z_0 = 276 \log 2s/d$, with s being the center to center spacing of the wires, and d being the diameter of the wire (ARRL antenna book). However when winding transmission lines around a core the impedance is only about 80% of free space. Spacing the wires .024 of an inch yields a Z_0 of 122 ohms in free space. When we adjust this to 80% for winding our transmission line on a core, the net impedance is close to 100 ohms.

The magnet wire insulation is .002, and the masking tape we had left over from the tent pole project is .005 inches thick. By wrapping each wire with two layers of tape we achieve the .024 spacing of the transmission line for our 4:1 balun. Two of the windings are in parallel (50 ohms) to match the output impedance of our transmitter, and the other two windings are in series and present an impedance of 200 ohms to the antenna.



To prepare the transmission lines we start with 40 inches of wire. Starting 2 inches from one end apply the *spacing tape* for 31 inches on 3/4 centers.

Taping detail - starting with one of the wires and using 1/4 inch masking tape strips wrap each piece of tape two turns along 31 inches of one wire (red/orange wire in the above picture). For the other wire cut a 1/4 tape strip and then cut the strip in half (green wire). These half strips are just enough for two wraps on the second wire

Then place the green wire parallel and touching the red wire and snugly tape the wires together using the tape *flags* sticking out from the red wire.



A thin cardboard spacer between the two cores will prevent damage to the magnet wire insulation. I used a separator from a 36 pack soft drink carton; cardboard from the back of a writing tablet is fine as well.

Make sure the glass tape has been applied to the outer diameter of the core before winding the transmission lines. The core coating is slippery and the glass tape adds a little *cushion* for the wire to bite into and keep the winding turns in place. I found marking the winding start, cross over, and stop positions helpful. The fourteen turn winding starts at about the 5:30 clock position, verify the orientation of the wire colors are correct, red left, and green on the right.

CAUTION - as you wind the core keep the wires as tight as possible against the outside of the core. If the wires protrude too far the core assembly may not fit into the project box.

I wound my core using clockwise turns. Using the 2 inch tape free end of the transmission line you just prepared start winding from the top of the core at the 5:30 clock position, and strive for equal spacing for each of the 7 turns to reach the 12:30 position. Then cross over and under to the 6:30 position and complete the remaining seven turns coming off the bottom of the core at the 11:30 clock position. Wind the second core in a like manner.

To complete the core assembly invert one core and place the 2 inch tails at 6:30 and place the cardboard insulator on top of it. Now place the other core on top of the insulator with the 2 inch tail at the 5:30 position. The core assembly can be temporarily taped together to keep things aligned until you complete the wire forming, insulation removal, and soldering.

Install the coax connector and torque the mounting hardware except the screw holding the solder lug. The ground solder lug screw will be tightened after you connect and solder wire number 5. The eye hooks and ring terminals can be installed now or latter, only finger tighten the hardware until all soldering is completed.

The 2 inch winding tails get interconnected per the schematic and get wired to the coax connector and grounding solder lug. The longer red wires get *formed* to line up with the eye bolts and get ring terminals installed, and the long green wires are cut off and spliced. Take some time at this point to review the schematic, core layout drawings and compare them to the photos below.

Workshop courtesy - ask before borrowing. Tools can be ruined in a heart beat, please ask and discuss what the borrowed tool is going to be used for. Pliers are not wrenches, and small diagonal cutters are not used to cut 14 gauge wires to mention a few!



When clearance is required for scrapping insulation off a wire, gently bend/move the other wire out of the way - and remember to use smooth or rounded nose pliers. If you do not have smooth jaw pliers wrapping the tips with a few layers of tape will help to prevent nicking the insulation when forming the wires. Holding the core just above the project box will help you judge the positioning, length, and forming of the wires.

I found it easiest to start with the long green wires (# 4 and #6) near the 12 o'clock position. Cut them down to about 2 inches and scrape their insulation off. Form the wires and cut to length. Then wrap a few turns of buss wire to join the wires together, and then solder.

Interconnecting the wires that connect to the coax connector is not as straight forward. Refer to the photos and scrape a section of insulation off green wire #5, and red wire #7 coming off the bottom core. Scrape the insulation as close to the bottom core as possible. You only need to remove between 1/4 and 3/8 of an inch of insulation for the solder connection of wires #1 and #3 respectively. Wire 1 and 3 can be bent down to judge/mark where to start the insulation removal and then bent away from the core to facilitate scraping of the insulation. Then connect wire 1 to wire 5, and wire 3 to wire 7. Trim the excess and solder the two connections.

Now form wires 5 and 7 to line up with the SO-239 connector and the solder ground lug. After soldering allow everything to cool before any hardware is torqued down.

I prefer solder over crimping for the ring terminals. The terminal is large enough for two wires for those that would prefer to bring a pigtail from inside to connect to their antenna wire. If built as shown, double over the end of the 14 ga. magnet and it will snugly fit the ID of the terminal.

Testing and Science Project

Testing of the 4:1 balun kit is straight forward. Two dual core 14 turn prototypes build by the author and were tested using a MFJ-269 digital antenna analyzer and two 100 ohms metal film resistors wired in series. One balun was built per this document with the inverted core method. The only exception for the second balun was that the cores were not inverted. The test results were identical.

We will have a broad range of folks building the 35 kits, from newbie non-techies to elmers with decades of experience in the electronics industry. There is bound to be variations in building technique. How tolerant is the design of these mechanical variations and what is the impact on SWR performance. The author would be pleased to summarize the test results from each assembled kit. After the workshops the summary will be appended to this document.

Prototype Test Results

Your Test results

| SWR | Band | Frequency | SWR |
|--------------|------|-----------|--------|
| 2.2 | 160 | 1.9 MHz | |
| 1.4 | 80 | 3.9 | |
| 1.1 | 40 | 7.2 | |
| 1.0 | 20 | 14.2 | |
| 1.1 | 17 | 18.1 | |
| 1.3 | 12 | 24.9 | |
| 1.3 | 10 | 29 | |
| 1.8 | 6 | 52.5 | |
| Call - AE6YC | | | Call - |

Antenna Dimensions and Tuning

Work in progress

OCF 80 meter antenna dimensions (operate on 80/40/20/17/12/10/ and 6 meters)
 OCF 40 meter antenna

SWR and tuning chart/work sheet/cutting instructions

Comments/instructions on antenna trimming, antenna support, and antenna configurations
 Inverted V, flat, drooped ends, L, etc.