A No Compromise Off-Center Fed Dipole for Four Bands

An easy to build single wire antenna for 40, 20, 10 and 6 meters.

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Many believe the off-center fed dipole (OFCD) is a compromise antenna, but that appraisal may not be deserved. When done right, these antennas can really perform!

Understanding the OCFD

Half wave ($\lambda/2$) dipoles are generally fed in the center, a point at which the driving resistance is low enough to provide a convenient match for coaxial feed line. Dipoles will, however, efficiently accept RF power at any point along their length as long as the source is matched to the load. The key to a successful OCFD design is finding that magic point where similar driving resistances appear for multiple bands. Opinions may vary about where that best point is, but most designers locate it roughly ⅓ of the way down the wire and transform it down to 50 Ω using a broadband transformer.

The trouble begins when builders try to cover multiple bands with the antenna too close to ground, or use matching transformers with incorrect ratios. After modeling various designs on *EZNEC* and evaluating a prototype, I found driving resistances tend to converge in the 120 to 140 Ω range at the 33% feedpoint location.[1] These values suggest a transformation ratio of under 3:1, which is significantly lower than the 4:1 or 6:1 transformers often encountered.

Building a 2.8:1 RF Transformer

The simplest way to achieve a suitable match to the OCFD may be with a conventional 2.8:1 transformer as shown in Figure 1. This device has a 3:5 turns ratio and provides a match at the secondary to 138 Ω. Mutually coupled transformers require more careful design than their transmission line counterparts and generally exhibit slightly higher insertion loss. Once the right combination of inductance and core permeability is found, however, construction becomes easy because you don't need to link multiple windings together through a labyrinth of phasing connections.

I made the transformer using a binocular core consisting of two 1⅛ × ¼ inch ID 43-mix EMI sleeves (Fair Rite 2643540002 or equivalent).[2]

The relatively high core permeability of 850 yields good performance over a wide frequency range with a minimal number of turns. The cores are relatively inexpensive and widely available since they are often used as feed line chokes for RG-8X and LMR-240 coax cable.

I used 16 gauge stranded wire covered with a Teflon jacket for the 3-turn primary because it provides a high dc breakdown voltage across the device. The secondary is wound with 5 turns of 18 gauge double coated enameled wire. I found it easier to install the solid wire secondary first, saving the slippery jacketed Teflon wire for when space becomes tight inside the cores. Note that EMI sleeves may have sharp mold seams that can scrape off enamel coating, so use caution when winding.

To test the transformer for SWR response, I attached two 68 Ω resistors in series across the secondary to make up a 136 Ω load. I then connected an analyzer to the primary winding and swept it from 1.8 to 50 MHz. The transformer delivered virtually flat SWR from 2.2 to 24 MHz. The SWR began to slowly creep up beyond that point.

In order to test for insertion loss and power handling, I wound a second identical transformer and connected it back-to-back to the first. Using a signal generator and spectrum analyzer, I measured approximately 0.2 dB of insertion loss per device through 14 MHz, with losses slowly increasing beyond that point. The plot shown in Figure 2 tracks the combined loss for the binocular transformer plus a tandem 1:1 current balun (described below). This small amount of attenuation should have negligible impact on real world signal strength or antenna performance.

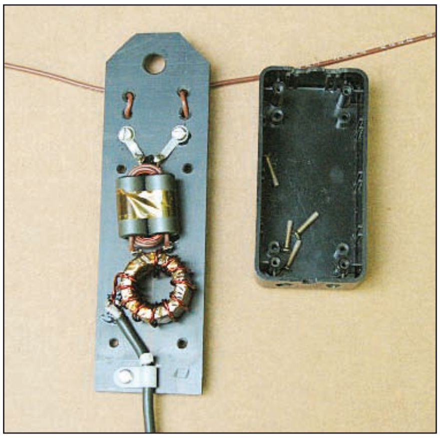

Figure 1 — The 2.8:1 transformer.

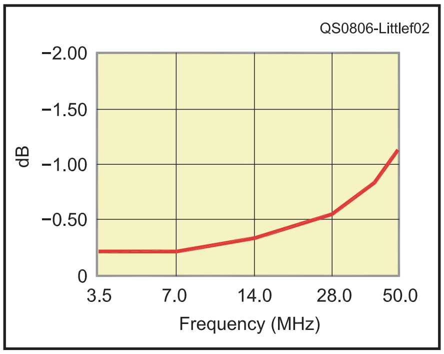

Figure 2 — Total loss of transformer and balun versus frequency.

Finally, to test power handling, I connected a dummy load to the transformers and applied a 14 MHz, 1000 W test carrier for a 10 second interval. The cores became quite warm to touch but never too hot to handle. More importantly, there were no telltale changes in SWR to signal core saturation. At 0.2 dB insertion loss, a 1000 W carrier will result in about 47 W of heat, or roughly three times what the transformer can safely handle over time allowing 7 W dissipation per core. Based on this finding, I use my AL-80A linear amplifier when I need to, but limit high power operation to casual SSB or CW contacts. I also avoid prolonged amplifier tune-ups.

The 1:1 Current Balun

Because OCFDs are fed asymmetrically, they are especially prone to radiate RF energy from the feed line. To prevent this undesired condition, I installed a 1:1 current balun in tandem with the balanced matching transformer. While the ferrite matching transformer may provide some limited blocking of the undesired common-mode path, it lacks sufficient cross sectional area to provide really good isolation. To enhance isolation, I added a

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[1] Notes appear on page 34.

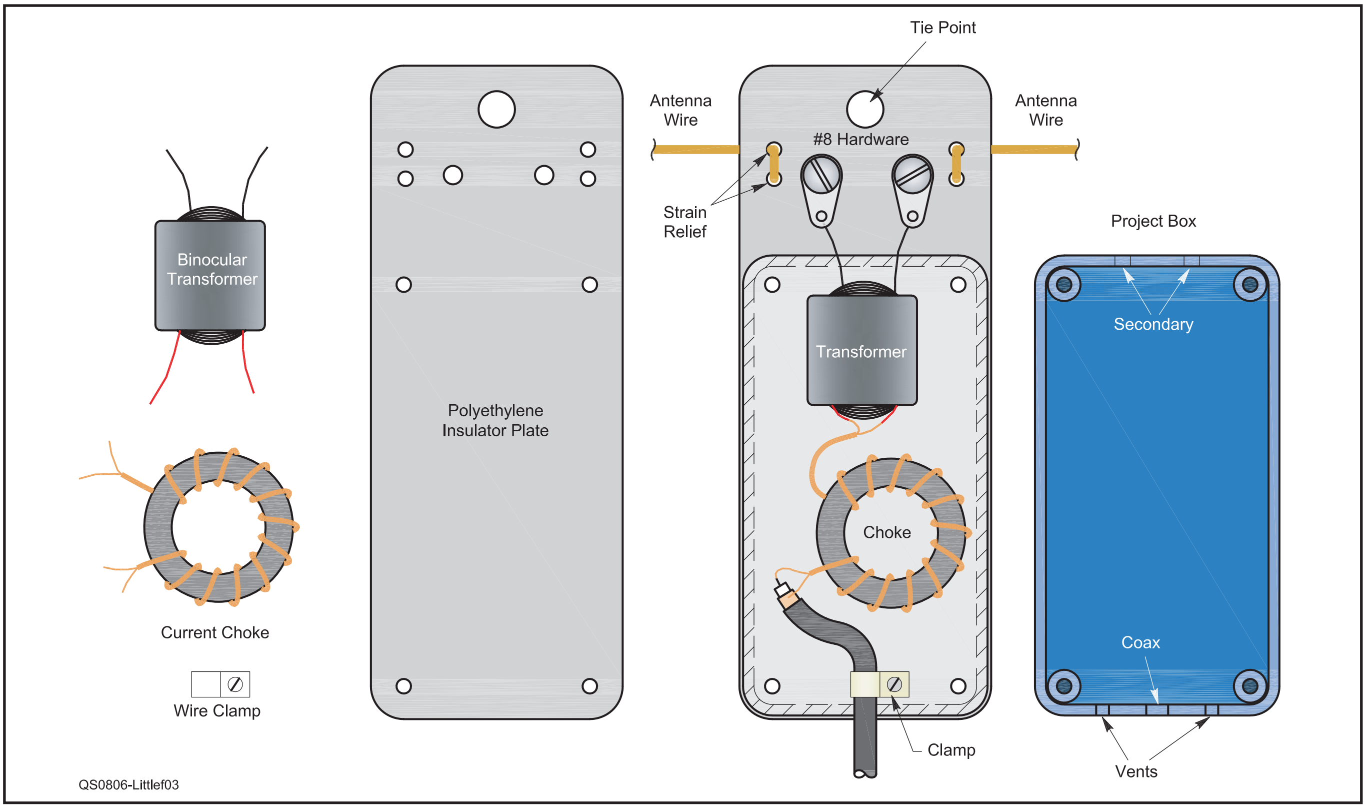

Figure 3 — Construction details of center insulator assembly.

lightweight 1:1 transmission line style current balun in tandem.

The balun core is made from two 1¼ inch outside diameter 43-mix toroids (Fair Rite 5943001601 or FT120-43) stacked together and secured with high-temperature Kapton tape. A light coating of 5 minute epoxy could be used to secure the cores if you don't have tape. The transmission line consists of 18 gauge high-temperature armature wire wound together at 4 to 6 turns per inch with an electric drill. I wound 12 turns of this twisted pair onto the form to complete the balun. Later checks with an RF current probe confirmed good common mode rejection along the feed line on all four bands. Construction details are shown in Figure 3.

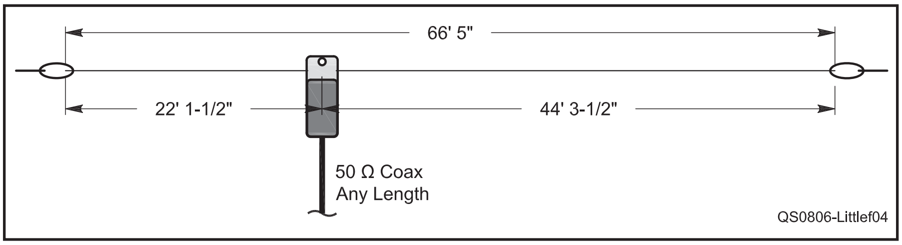

Figure 4 — Cutting dimensions for OCFD.

Center Block and Weather Enclosure

The center insulator was made from a ⅛ inch thick piece of black marine polyethylene. Other materials may be used, but this particular plastic is very strong and provides good UV protection. I mounted the transformer, balun, and feed line attachment directly onto the polyethylene base and covered it for weather protection with an inexpensive styrene project box. The box is attached via mounting holes normally used to secure its cover. The cover isn't used, but does provide a useful drilling template. I added two ¼ inch vent holes on the bottom side of the project box to permit air circulation and used a round file to create a mouse hole to admit the coax. I also added two small notches at the top to pass the secondary transformer lugs. A couple of dabs of sealant around the secondary leads at the top will prevent water from running in around the lugs.

Making the Antenna Flat Top

I used jacketed wire and, from mid-center block, cut the legs to 22 feet 1½ inches and 44 feet 3½ inches for a total span of 66 feet 5 inches (see Figure 4). If you use bare copper with a higher velocity of propagation, increase these measurements by roughly 2.5% for a total span length of 68 feet.

Note that the antenna wire is wrapped through strain relief holes and attached on the back side of the insulator block with solder lugs. The support tether at the feed point may be used to reduce stress across the span of the flat top. By shopping around, you may be able to locate some inexpensive Teflon jacketed wire that does a very nice job of shedding water and ice. For end insulators, I used two 6 inch strips cut from black polyethylene and ⅛ inch parachute cord for support.

OCFDs and Mounting Height — the Elephant in the Room

If the OCFD has been touted as a compromise antenna, it may be because builders fail to consider the profound impact of ground proximity on the lower frequency bands. With that caveat in mind, please resist the temptation to double the wire lengths for this project to add 80 meters! It's true that the OCFD is an even-harmonic radiator and that 160, 80, 40, 20 and 10 meter bands are all harmonically related. At normal backyard mounting heights, however, Mother Earth perturbs the fundamental response more than the harmonic responses (see OCFD mounting height data in Table 1). As a result, unless you have very tall trees, you can count on 80 meters resonating

Table 1

Antenna Height versus Resonant Frequency (MHz) and Load Impedance (Ω)

Height (feet)	*40 Meters*		*20 Meters*		*10 Meters*		*6 Meters*	
70	7.11	87	14.24	150	28.68	128	50.33	139
60	7.12	108	14.18	147	28.64	127	50.34	139
50	7.06	122	14.20	127	28.70	132	50.3	137
40	6.95	114	14.29	135	28.64	125	50.33	137
30	6.87	84	14.26	175	28.67	129	50.33	140
20	6.88	47	14.06	156	28.71	137	50.38	138
10	6.99	15	14.05	63	28.42	124	50.26	151

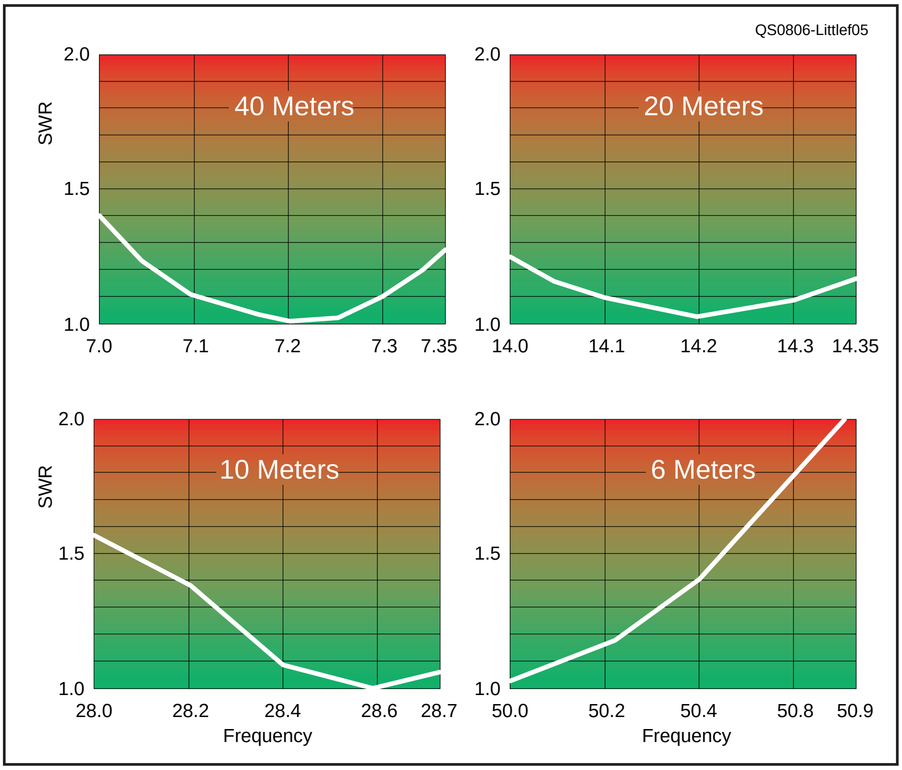

Figure 5 — OCFD SWR versus frequency plots.

below the edge of the band at well under the anticipated 130 Ω driving resistance.

What about Other Bands?

This antenna is not particularly usable on the 30, 17, 15 or 12 meter bands. The lowest modeled SWR I found was 23:1 on 17 meters. If the antenna is fed through 100 feet of RG-8X coax, the cable loss of almost 6 dB would result in an SWR at the radio of about 6:1 — likely usable with a wide range antenna tuner. There would likely be additional loss in the balun and transformer. Thus something less than 25% of the transmitter power would reach the antenna. On the other bands the mismatch is considerably worse.

Going on the Air

Figure 5 shows the measured SWR readings for my 45 foot high installation as seen through 100 feet of RG-8X. These favorable plots confirm *EZNEC*'s prediction that the 2.8:1 transformation ratio and 50 foot mounting height are a winning combination.

When it comes to on-air performance, the OCFD has the advantage of being electrically large, efficient and broadbanded. These qualities translate into having the ability to work almost any station you can hear — plus the freedom to hop from mode to mode or band to band without suffering power reduction from radio's final amplifier reducing power due to high SWR.

On 40 meters, the OCFD functions like any dipole with peak current occurring at mid element. As such, it models with 5.7 dBi gain at 42° elevation and works well for both domestic and DX contacts. On the harmonic bands, the radiation patterns develop progressively more peaks and nulls at higher octaves — much like a G5RV or a center fed dipole. As a result, the antenna will favor some directions with upward of 7.8 dBi gain on 20 meters and 9.2 dBi gain on 10 meters. Note that it is not omnidirectional and will exhibit weaker performance in directions at which nulls occur. The radiation angle on 6 meters is very low and SWR favors the bottom end of the band where horizontally polarized SSB, CW and AM signals prevail.

Finally, because this antenna has low visibility when tucked away among the trees, it might work well for hams living with covenants or apartment dweller restrictions. If you don't mind slitting turf and burying low loss cable in the dark of night, you could install the OCFD up to several hundred feet from your building. You'll lose a couple of dB to feed line loss on the higher bands, but you should suffer no additional transmission losses from high SWR. Best of all, the electrical racket from your complex as well as any consumer gadgets your signal might disable, will be several wavelengths away. Food for thought for the brave of heart!

Conclusion

This article presents a practical approach for achieving excellent multi-band performance and low SWR on its bands between 40 and 6 meters using a simple OCFD design. It doing so, it describes an alternative OCFD matching solution and raises awareness of the potentially negative impact of ground proximity on lower-frequency OCFD performance.

There have been many OCFD configurations described in the amateur literature. Serge Stroobandt, ON4AA, provides an excellent compendium of them on his Web site at **www.stroobandt.com** I also recommend reading the recent paper by L.B. Cebik, W4RNL, *The Isolated Off-Center-Fed Antenna: Some Less-Explored Facets*, available on his Web site at **www.cebik.com**. This comprehensive discussion of OCF behavior offers a wealth of new and useful information to OCF modelers and designers.

Notes

[1] Several versions of *EZNEC* antenna modeling software are available from developer Roy Lewallen, W7EL, at **www.eznec.com**.

[2] **www.fair-rite.com**.

Rick Littlefield, K1BQT, has an Amateur Extra class license. He was first licensed at age 13 in 1957. An avid builder and writer with over 100 technical articles in print, Rick especially enjoys designing antenna and low power projects and was an early inductee into the ARCI QRP Hall of Fame. His professional resume includes extensive work for familiar Amateur Radio manufacturers such as MFJ Enterprises, Ten-Tec and Cushcraft Corporation. He holds a master's degree from the University of New Hampshire and is currently employed as a product design engineer at Laird Technologies in Manchester, New Hampshire. You can contact Rick via e-mail at **k1bqt@arrl.net**.