ANTENNA MUSINGS ON SIMPLE WIRE ANTENNAS

PRESENTED ON
FIELD DAY, JUNE 24, 2023
HOUSATONIC ARC,
GREATER NORWALK ARC,
GREATER FAIRFIELD ARC,
WESTPORT ASTRONOMICAL SOCIETY ARC

STEVE DICK, K1RF

In search of the Holy Grail

- A simple wire antenna that is low cost, easy to build, and easy to deploy, with great performance, from single band to multiband.

Narrowing down which simple antenna(s) to use

- Operation dependent
  - Home use – semi-permanent installation, available real estate and mounting options, bands and operating modes
  - Field Day – moderately quick deployment, available mounting provisions, co-located setups where interference is an issue
  - POTA – portable/lightweight with very quick deployment and limited mounting provisions
  - SOTA – very portable/lightweight and very quick deployment and limited mounting provisions
  - DxPeditions – Good performing antennas with moderately quick deployment, easily transportable

Choose the right antenna for the application

Thoughts on Building efficient antennas

- Goal: for dipoles, mount it as high as it is wide for good gain and elevation angle. For all horizontal antennas, “the lower the antenna as a fraction of a wavelength, the lower will be the overall gain and the higher the elevation angle of the radiation.” – L. B. Cebik W4RNL (SK)
- Goal: For efficient doublets, minimum length = 1.25 X band in meters (I.E. 80 meter doublet should be at least 80X1.25 = 100 ft long. –W8JI
- For OCFD (Off-Center-Fed-Dipole) antennas, use a 4 to 1 hybrid balun for the balun – extensive work by Rick Westernam, DJ0IP. (4 to 1 Ruthroff cascaded with 1 to 1 Guanella for high common mode rejection. Requires 2 cores or core stacks.). Some OCFD splits include 15 meters.

Hard to believe but …

- First a definition: dBi = dB with respect to an isotropic antenna – a conceptual one that radiates equally in all directions (spherical pattern). 3dBi = 2X power, 6dBi = 4X power, 9dBi=8X power of isotropic antenna
- Gain of quarter-wave vertical with 16 quarterwave ground radials over average ground: **0.22dBi** at 22 degrees (**1.052X**)
- Gain of a dipole in free space: 2.15dBi (1.64X)
- Gain of a dipole half wave above average ground: **7.9dBi** at 28 degrees (**6.17X**)
- Gain of an extended double Zepp (88 foot long doublet on 20 meters, 35 ft high): with average ground: **10.49dBi** @28 deg (**11.2X!!!**)
- Gain of 560 ft long horizontal loop 70 ft high on 20 meters: **12.9dBi** at **12 degrees** (**19.5X!!!!**!)

Some Antenna comparisons – Pros and Cons

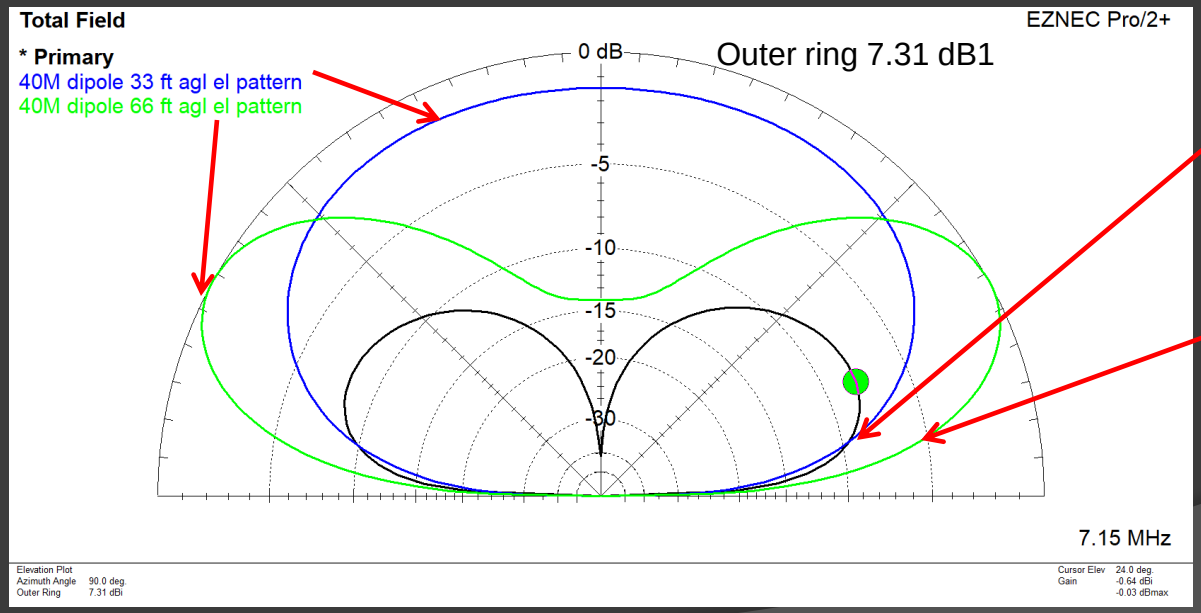
- Dipole vs Vertical
- Multiband Dipole-Doublet vs Multiband Broadside Doublet (L. B. Cebik)
- End Fed Half Wave vs Off Center Fed Dipole

Dipole vs vertical

- Dipole:
  - Pros:
    - Inexpensive and easy to build
    - Excellent gain when mounted at half wave height **(7.9dBi** at 28 deg elevation angle.)
    - Suppression of even harmonics helps for co-located antenna interference
    - Inverted V variant - easy deployment at the expense of slightly lower gain and broader azimuth pattern
  - Cons:
    - Monoband
    - Hanging coax at center
    - Difficult to get adequate height on 80M,40M
- Vertical (Quarterwave):
  - Pros:
    - Inexpensive and easy to build
    - Half the height of properly mounted dipole
    - Low angle of radiation (~22 deg) good for DX
    - Easy deployment for portable use, small footprint
    - No hanging coax
    - Suppression of even harmonics and vertical polarization helps minimize co-located antenna interference
  - Cons:
    - Monoband (without adjustable coil)
    - Low gain compared to properly mounted dipole(**0.22dBi** at 22 degrees elevation angle.)
    - Tripping hazard of radials

Dipole vs. Vertical – cont'd

- So how can a vertical still work well, especially for DX, if it's peak power is ~6dB or 4X weaker than a dipole? Well, read on.
- It's all about Elevation angle. Elevation angle, Elevation angle! Many backyard dipoles are mounted too low with NVIS elevation pattern! A 40M dipole mounted 35 ft high will lose to the vertical at elevation angles below about 12 degrees!



40M Quarterwave vertical beats 33 foot high 40M dipole below 12 deg. elevation angle!

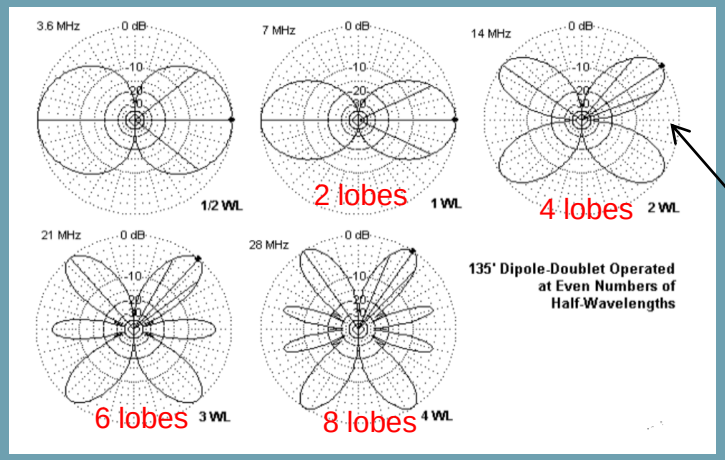
…but 40 meter dipole mounted 66 feet high kills quarterwave vertical at all angles!!!!

Dipole Doublet vs Broadside Doublet

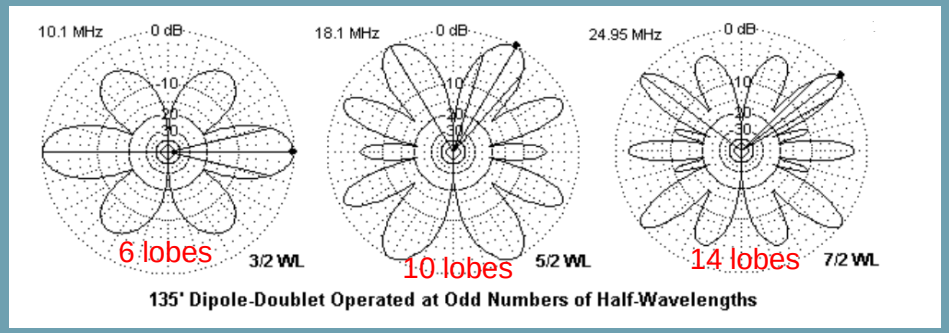
- The Dipole-Doublet (Cebik definition)
  - Antenna length is selected to be a <u>half-wave on the lowest frequency of operation</u>.
    It chief advantages are simplicity and the ability to cover all of the HF bands above the frequency for which the wire is a 1/2-wavelength dipole
  - But length greater 1.25 wavelengths on a given band will result in radiation no longer broadside to the wire with multiple lobes. As frequency goes up, number of lobes increases.
- The Broadside Doublet (Cebik definition)
- Length is determined by <u>highest band and set to 1.25 wavelengths on that band</u> (it is a.k.a an extended double Zepp!)
- Lowest band is set to 4X lower than the highest band
- Radiation is always in the same direction on all 4 bands, off-broadside rejection is in the same direction on all bands.

Doublet antenna patterns

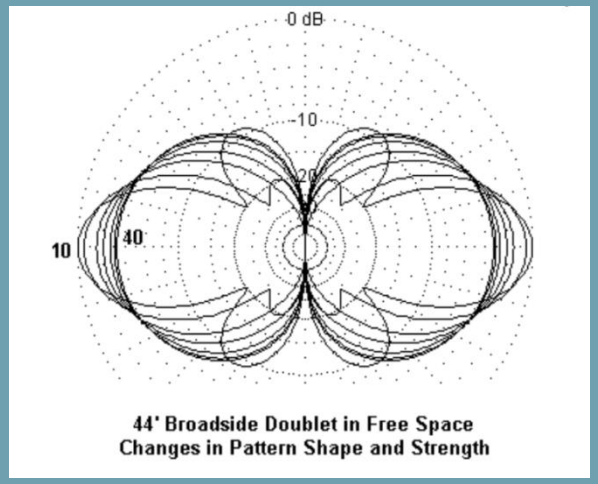
Dipole Doublet Az patterns*



*20M lobes no longer broadside to antenna!



Broadside Doublet Az patterns



Figures courtesy L. B. Cebik W4RNL (SK)

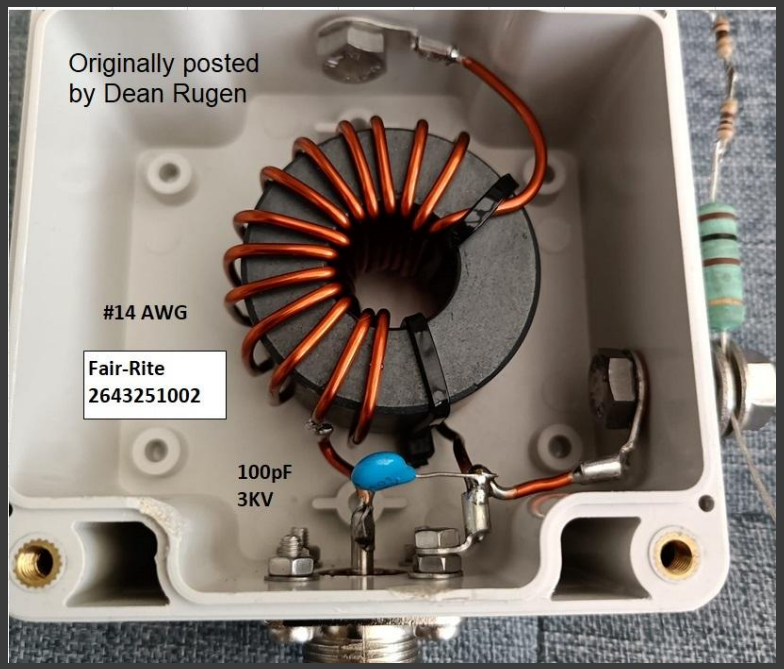
* "Over the years, I have discovered that many multi-band wire-antenna users remain unaware of the patterns produced by their antennas on different bands"
– L. B. Cebik, W4RNL

End Fed Half Wave vs. Off Center Fed Dipole

- End Fed Half Wave
  - Pros:
    - Coax feed at end provides more deployment options
  - Cons:
    - Transformers are more costly and less efficient than OCFD transformers in general
    - Very difficult to implement high power efficient transformer
    - Sometimes requires an additional common mode choke (recommended) for RF in shack due to transformer close to ground and near shack
    - Transformer needs a high voltage compensation cap
- OCFD
  - Pros:
    - Hybrid baluns are lower cost and higher efficiency than EFHW transformers for a given power level as they are transmission line transformers. ~97-98% efficient
    - Easy to implement efficient high power baluns
  - Cons:
    - Hanging coax
    - Coax + transformer often require support at center
    - Many commercial transformers have sub-par common mode current rejection

Antenna patterns are not that different! AN EFHW is basically a very offset OCFD!

Efficient EFHW transformer for 100 watt rigs, 80-10M



Toroid cost $8.13 at Digikey
$8.43 at Mouser

- A single FT240-43 with 2T/14T conventially wound has a loss of ~ 1.1-1.7dB. (77.6% to 67.6% efficient)
- The Toroid shown has a loss of <0.45dB (90.1% efficient) across 80-10 meters.
  - - >50 watts input continuous, >100W CW, >250W SSB

On 80m OCFD Antenna Splits

- Rick Westerman, DJ0IP, offered the following Comments: “The sweetspots have been known for almost 8 years now. It depends on which bands you want to use it on.”

80m OCFD: "Typical" SWR by Band, by Feedpoint Split

Feed Point	80	40	30	20	17	15	12	10
20.0%	*		4:1		26:1			
29.3%	*		9:1				10:1	
29.7%	*		12:1				6:1	
33.3%	*		26:1			17:1		

SWR:	<2:1	<3:1	<4:1	<7:1	>7:1

Values shown are approximate, and vary from QTH to QTH.

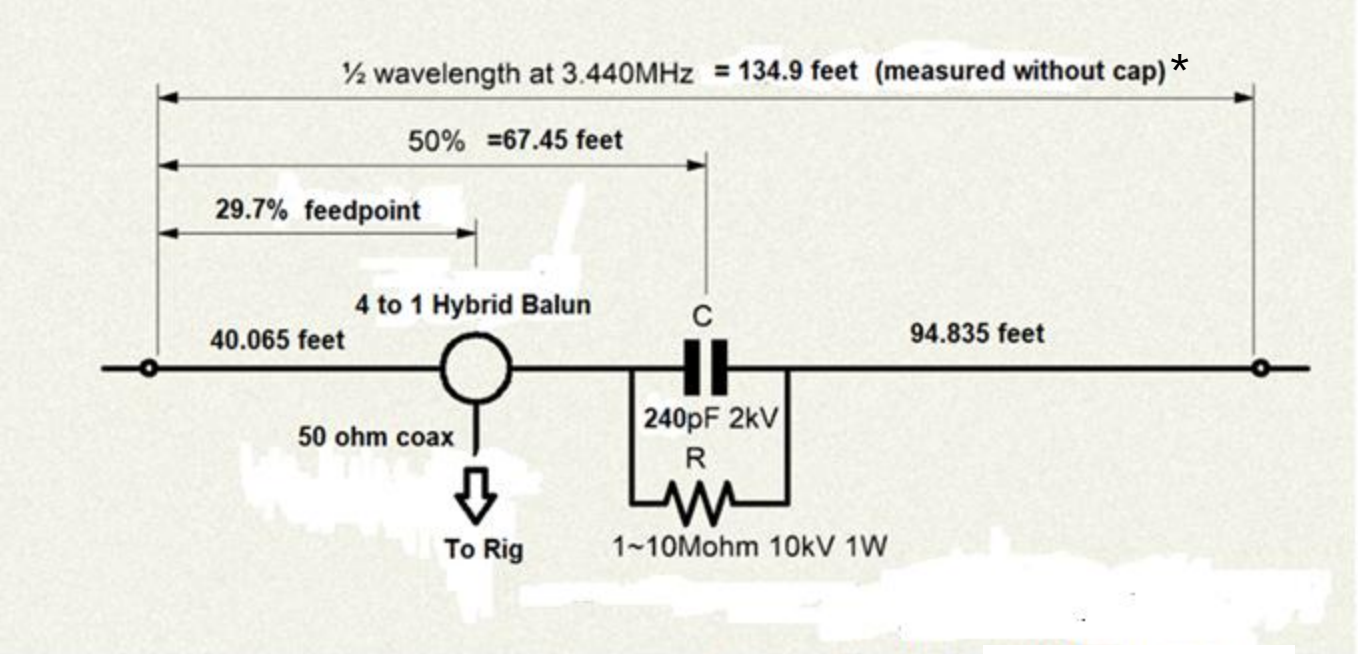
DJ0IP *ATU required to cover the whole band. ¦ Modelled for 200 Ω 3-JAN-2023

On 80m OCFD Antenna Splits -cont'd

- "Use either 20 percent or one of the two 29 percent feedpoints. I have personally built about 20 of the ones that use the 29.7%, hung them in many different locations, with various lengths and angles of the inverted V. They ALWAYS work on those 5 classic ham bands. Most of the time I don't even need an antenna matchbox."

  – Rick Westerman DJ0IP

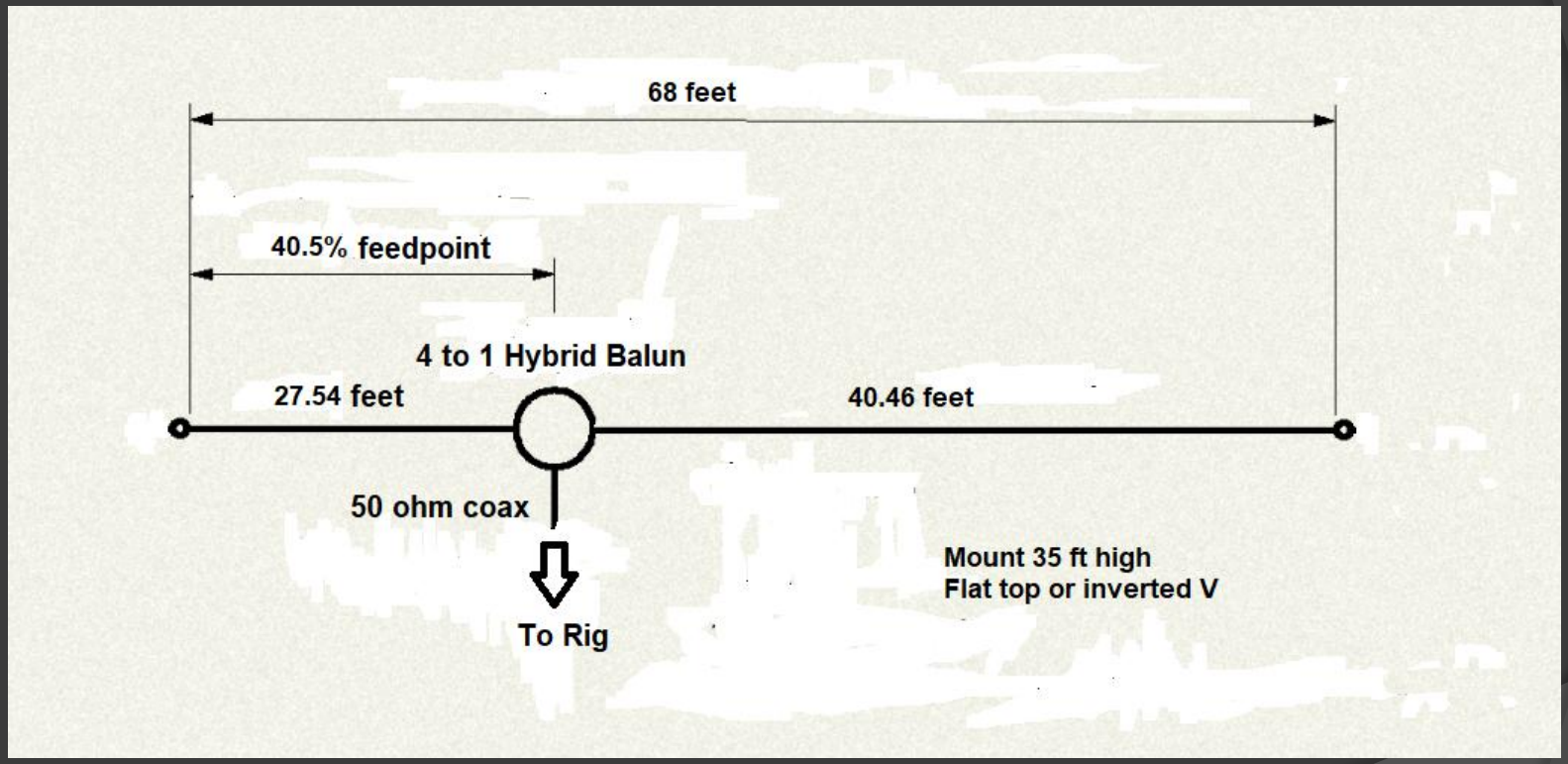
80m-40m-20m-15m-10m 29.7% feedpoint, recommended configuration



Courtesy ON4AA, DJ0IP,N4CY

* Cut below 3.5MHz to allow upper bands to line up. Adding C moved 80M resonance up without affecting higher bands. Use a doorknob cap for C or 3 paralleled ceramic high voltage “blue caps” from eBay. Three paralleled 100pF caps will work.
none ~ 3.45 MHz, 500pF ~ 3.6MHz, 300pF ~ 3.7MHz, 100pF ~ 4MHz

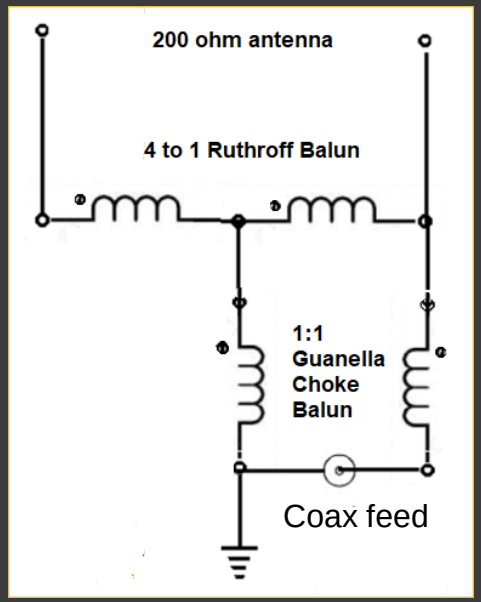
40m-20m-15m-10m low VSWR OCFD
68 ft long, 40.5% feedpoint value from ON4AA recommended configuration



On OCFD Baluns

- RF current flowing on the outer surface of the coax needs to be addressed for the asymmetric OCFD. The larger the feedpoint offset, the worse the problem becomes. If not managed, the coax becomes part of the antenna, skewing many of the antenna's characteristics, including resonance points. Worse yet, the characteristics then change with changes in length of coax.
- The larger the feedpoint offset, the larger the common mode problem increases
- The common mode current rejection of the balun is extremely important!

OCFD 4:1 Hybrid Balun (Recommended)



Low power Hybrid Balun Construction Courtesy N4CY

- K1RF recommended parts (Mod of N4CY balun) for 100W rigs (50W+ continuous, 100W+ CW, 250W+ SSB)
- Ruthroff balun:
  - Fair Rite P/N 5961001201 (tall version of FT114-61) ($2.76 qty 1, $2.38 qty 10 at Mouser)14 bilifar or twisted pair turns #20 awg, teflon insulated
- Guanella Balun
  - Fair Rite P/N 5943001201 (Tall version of FT114-43) ($1.78 qty 1, $1.19 qty 10) 36” length of RG-316, 17 turns

Resources

- Component sources – Rick Westerman DJ0IP
- OCFD Antennas Revisited – Steve Dick K1RF
- De-mystifying Dipoles and Doublets – Steve Dick K1RF
- The End Fed Half Wave Antenna – Steve Dick, K1RF
- For additional info join Facebook or groups.io user groups for the OCFD, EFHW, Wire Antennas for HF, Baluns Ununs and Tuners