Multiband Wire Antennas & Phased Dipole Wire Beams

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www.ocfmasters.com

The Multiband HF Antenna Challenge

- Design for less than 3:1 SWR on all bands
- Dipoles
- OCFs
- End Feds
- Harmonic resonances don’t occur on integer multiples of the fundamental
- 40M Dipole tuned to 7.15 MHz – Third Harmonic should be 21.45 MHz
- BUT - actual resonance is 22.1 MHz
- WHY?

Bands Not Aligned

Looks Good!
Do you operate at bottom of Band?

1st Harmonic	80M	3.5 MHz
2nd	40	7.0
4th	20	14
6th	15	21
8th	10	28

Not Good!
REALITY

1st Harmonic	80M	3.75 MHz
2nd	40	7.5
4th	20	15
6th	15	22.5
8th	10	30

The Second Culprit - End Effect

- Electrical ***lengthening*** by current flowing from high voltage at the ends to the ground.
- Closer to the Ground – Lower Resonant Frequency as Electrical Length Grows
- A half wavelength in free space without end effect: L = 492/F (F= frequency in MHz)
- However, for a dipole on earth, L = 468/F. (We find 470/F more accurate.)
- A dipole operating on a harmonic frequency is complicated by these two CULPRITS
  - Harmonic Mismatch & End Effect

Example – 40M & 15M Dipole: 15M = 3rd Harmonic

- On 15M - there are three collinear dipoles along the wire, only ONE sees end effect!

There is no end effect on interior dipole ends - where collinear dipoles join

- Of three dipoles, 2 do not experience end effect (L= 492/F) and one dipole does (L = 470/F)
- 15M on a 40M dipole only experiences 1/3 the End Effect
- Must be made physically longer to compensate – lowering the resonant F on 40!
- Length for resonance on the n^{th} harmonic $L = (470 + (n\text{-}1) * 492)/F$

The Length Dilemma

- Cut length for 7.15 MHz *L = 470 / 7.15 = 65.73 ft.*
- Places 15M resonance at 22.1 MHz – above top of band
- Cut length for 21.225 MHz, *L = (470 + 2 * 492) / 21.225 = 68.5 ft*
- Places the 40 m resonance at 6.86 MHz – below the bottom of the band!
- What are us poor boys from the Western Suburbs of Boston to do?

Getting to Resonance

- *Simple Rule to make a non-resonant length antenna resonate:*

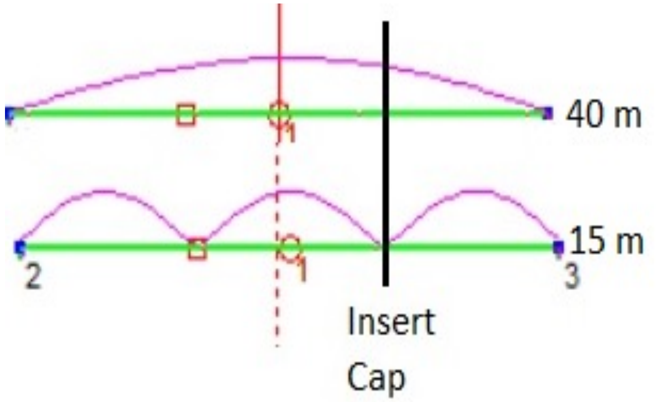
  Too short - Insert and Inductor

  Too long – Insert a capacitor

- *Solution: Cut length resonant mid-15M & electrically shorten for 40M*
  - *Insert 330pF capacitor at low current point on 15M at L/3*
  - Invented by Serge Stroobandt, ON4AA

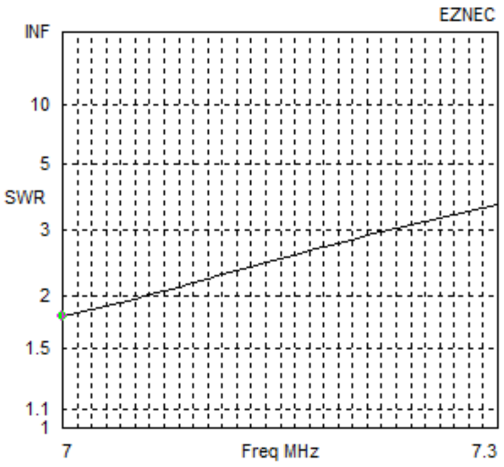
- *WHY 330pF and Why at L/3?*

Cap at one-third

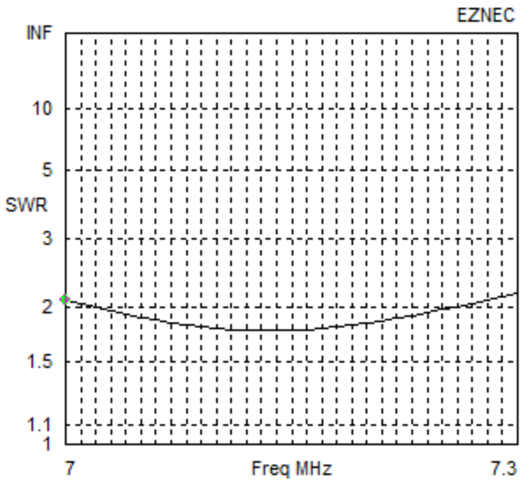


- Low current point for 15M impacts 40M but minimally affects 15M

- 330pF Cap Moves Minimum 40M SWR to mid-band



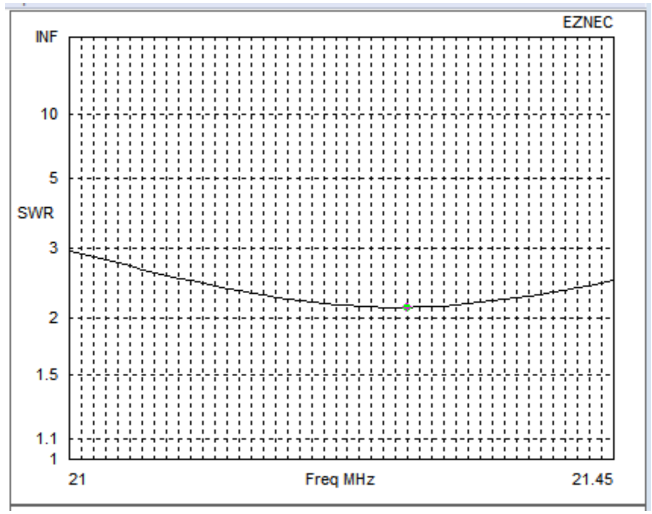
40M Without Cap



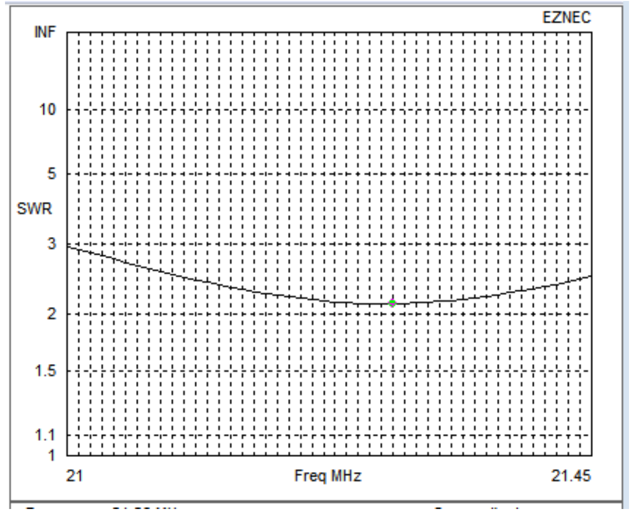
40M With Cap

SWR on 15M

- 330 pF at one-third total length. SWR curve is unchanged

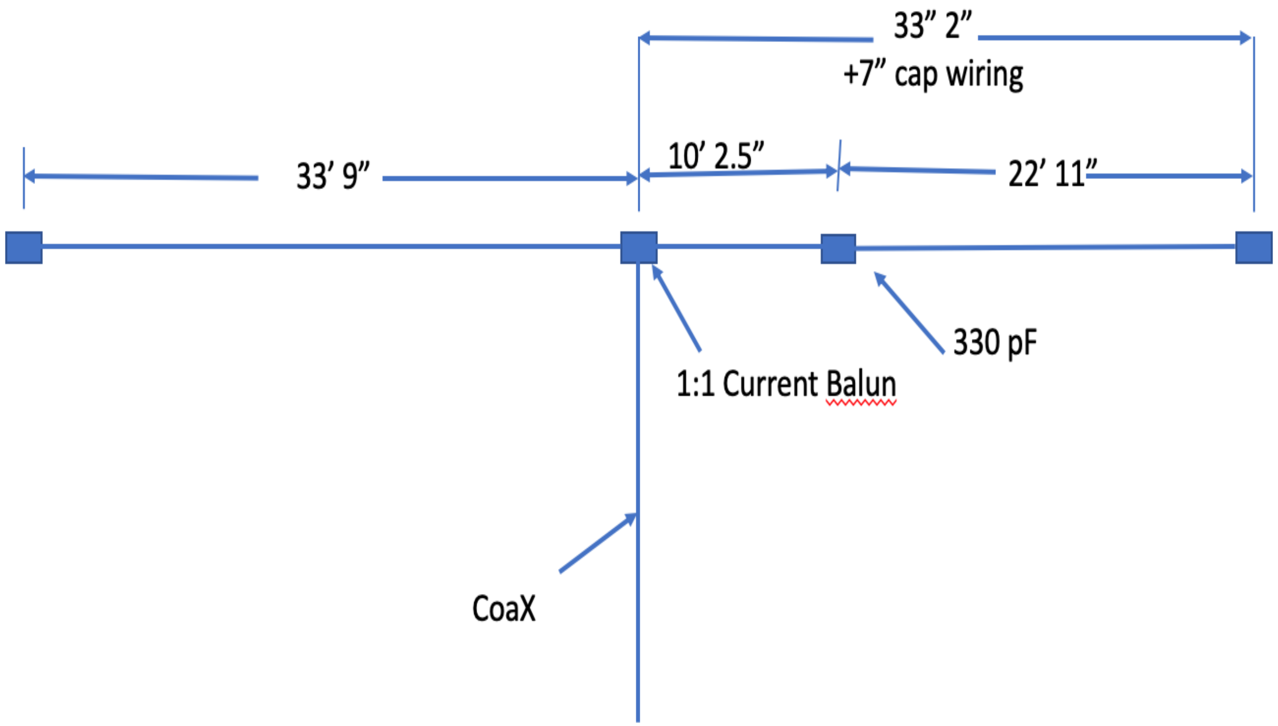


15 M Without Cap

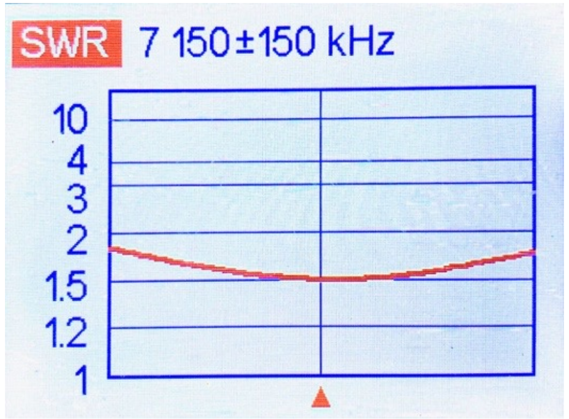


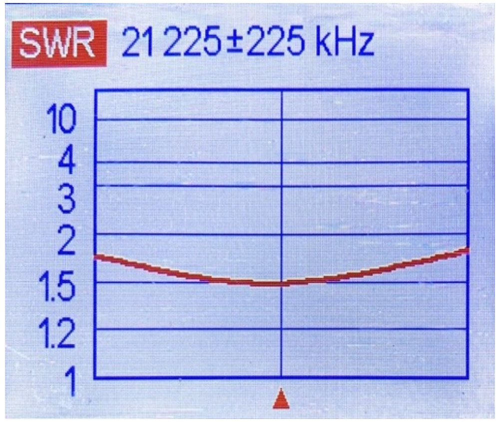
15 M With Cap

40-15 Dipole
(CQ Dec 2020)



Field Truth





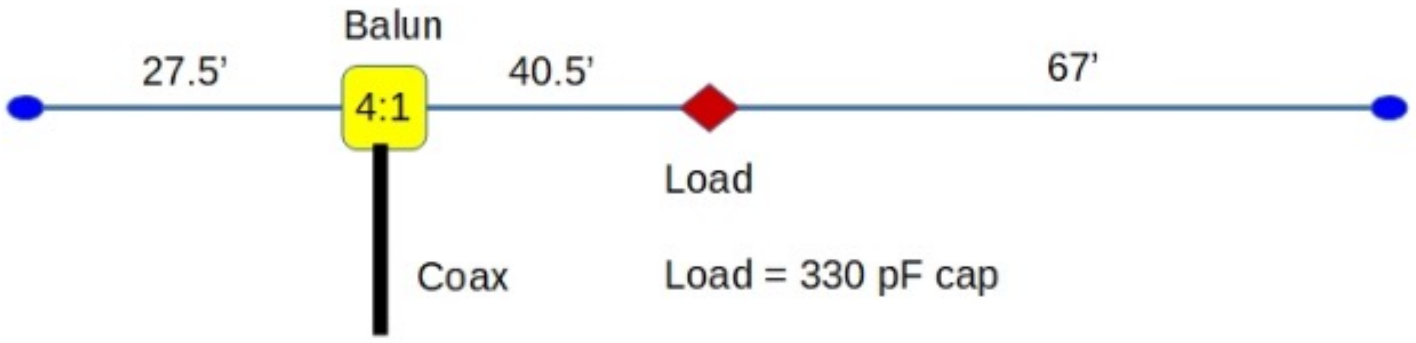
OCFs, aka Windom

- Higher impedance ~200 ohms – need 4:1 balun
- Offset feed makes antenna very unbalanced
  - Susceptible to RF on Feed Line
    - Detuning – Feed line becomes unwanted part of the antenna
    - RF in Shack
- Degree of Offset affects bands covered
- 80M 1/3 offset – 80,40,20, & 10M
- 80M 1/5 offset – 80,40,30,20,15,12,10 & 6M <3:1 SWR
- Similar better coverage 1/5 offset for 160M version

OCF & End Fed Design Methodology

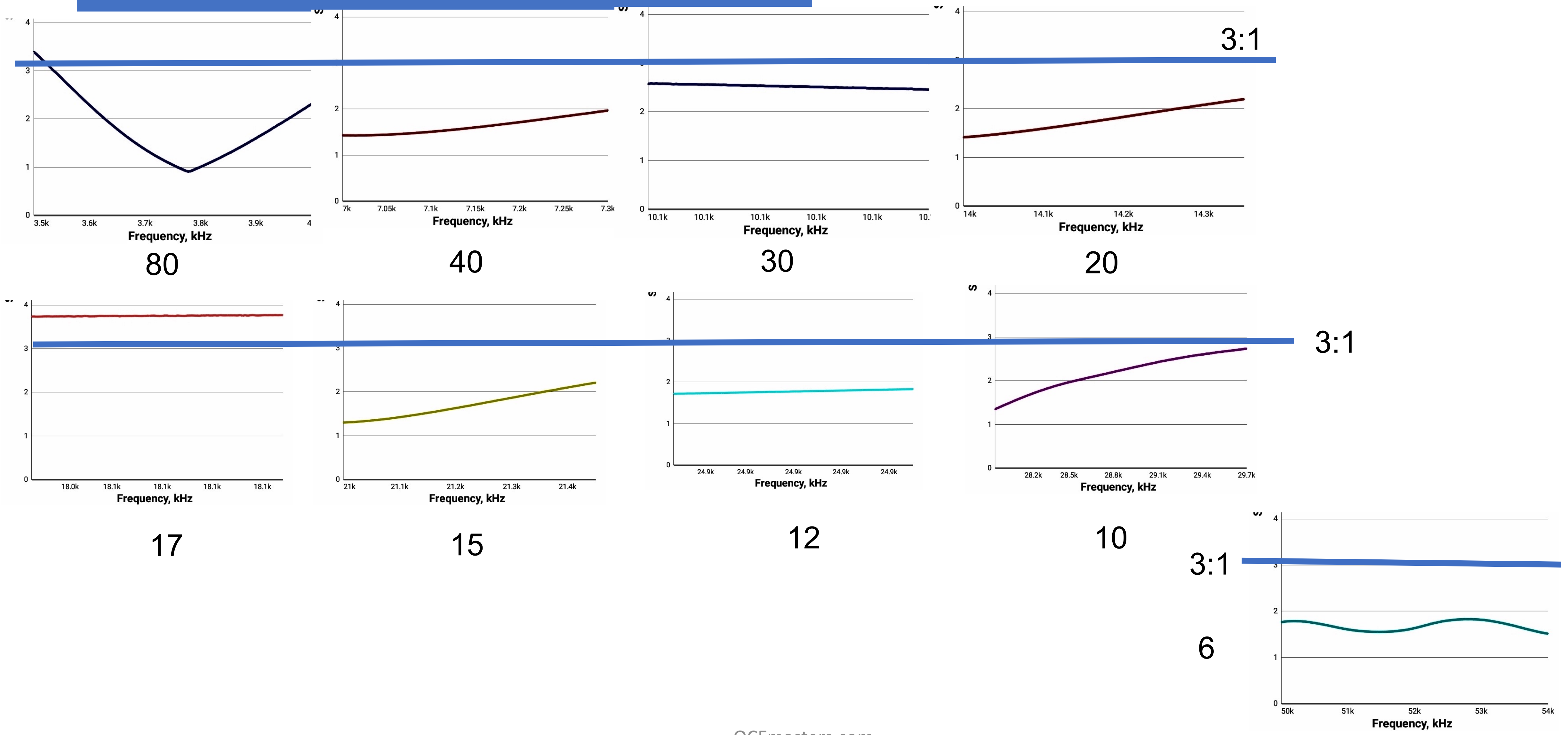
- Typically tuned to Low End/Lowest Band to match higher band's SWR
- High band resonance depends on harmonics & number of dipoles w/o end effect.
- Choose Length to optimize the higher bands 20, 15, & 10M
- Fix Lowest Band resonance to mid-band with Capacitor
- Transformer Balun & Choke Balun critical for OCF & End Fed Antennas

80M OCF
(CQ, June 2020)

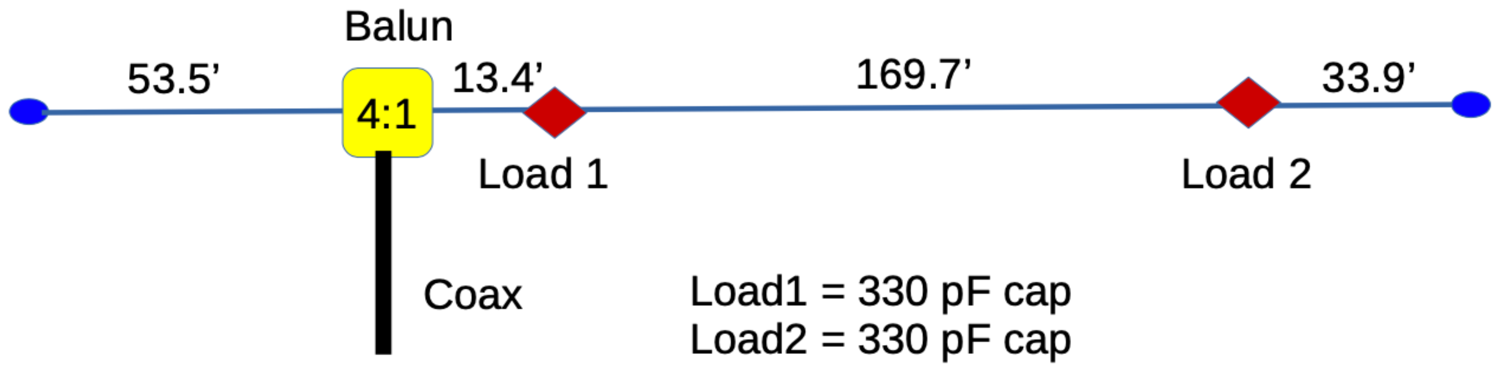


- Antenna length for upper bands 15M up – Length = 135ft ~ 3.45 MHz on 80M
- Load Capacitor moves resonance and 80M low SWR frequency to 3.75 MHZ

80M OCF SWR (KC1DSQ Antenna)

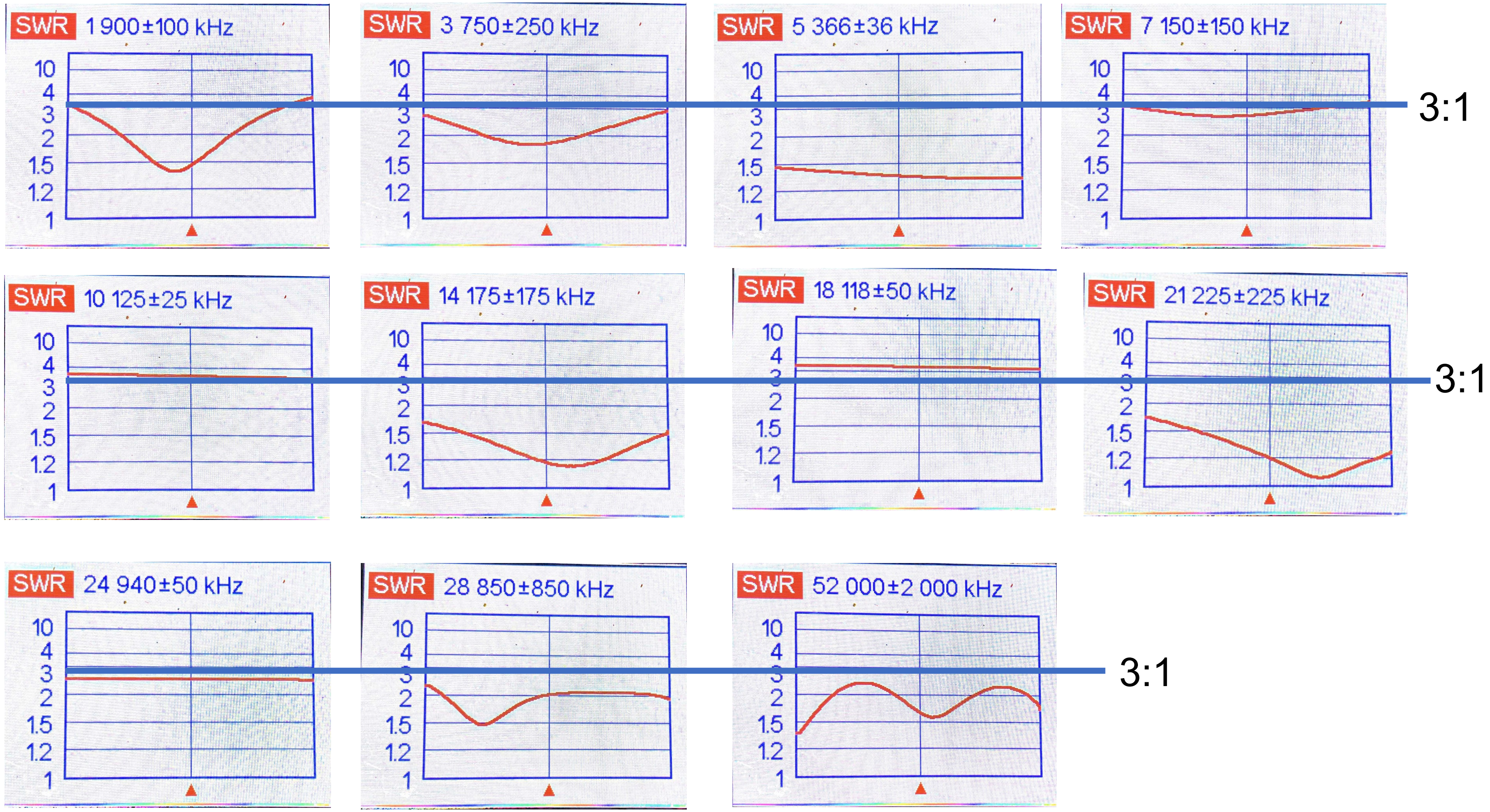


160M OCF
(CQ Magazine June 2020)



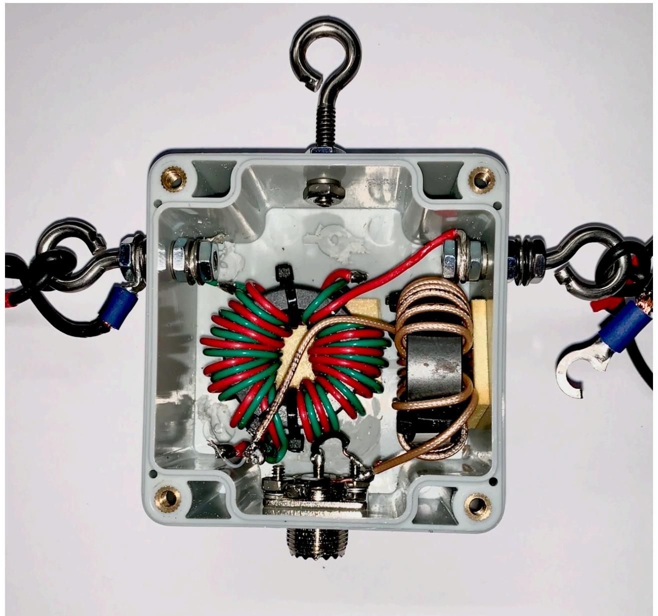
- Length for upper bands 15M up L =270.5 ft. BUT Low SWR@1.73MHz on 160M
- Cap in middle helps 160M but no help 80M or 40M
- Solution – Cap at 80M current peak, Load 1, & Cap at 40M current peak, Load 2
- Load 1 raises resonance 80 and 160, Load 2 raises resonance 40, 80, and 160

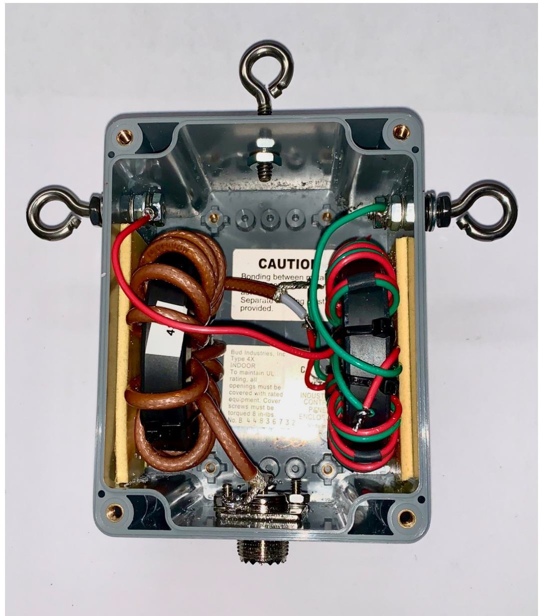
160M OCF SWR (W1IS Antenna)



Balun – Hybrid Balun
(CQ, Jan 2021)

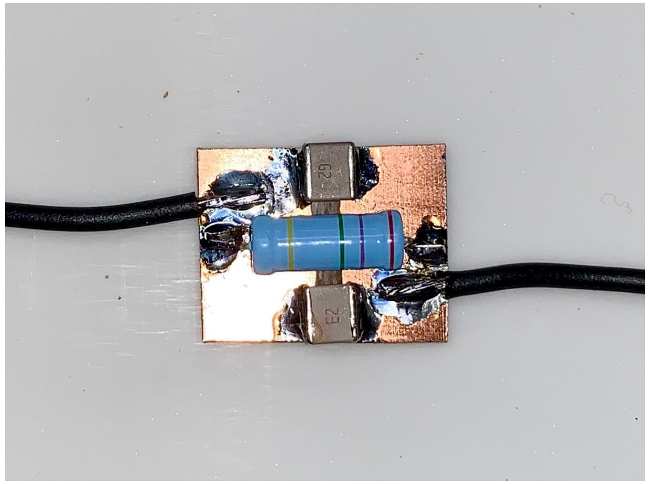
- Balun 4:1 Guanella with *isolated* 1:1 Balun/Choke
- Leakage Inductance easily couples between 4:1 & 1:1,
- Need to isolate the 4:1 from the 1:1.
- Mount at 90 degrees or leave at least 1 inch between them

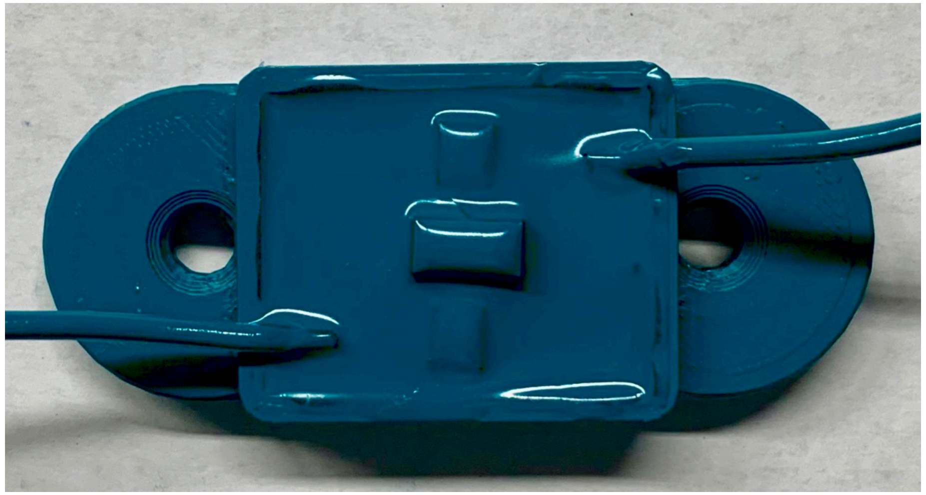




Load

- Capacitor in parallel with 1-4.7M Ohm non-inductive resistor
- Resistor prevents static charge build up



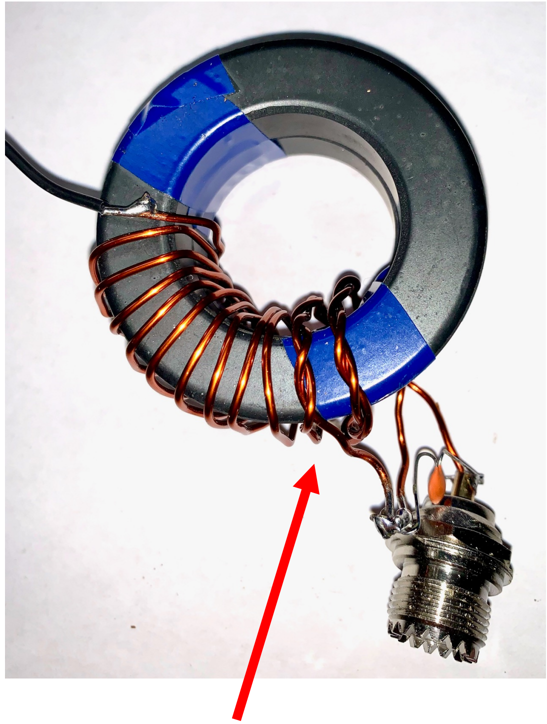


End Feds

- End Fed is an OCF with a Small Offset Ratio
  - Sometimes Called a Counterpoise
- Same issues as 40-15M & OCF Antennas
- Same solution - ”Choose Length for High Bands – Capacitor fixes Low band/s.”
- New Problem – Have we been winding EF Transformers Correctly?

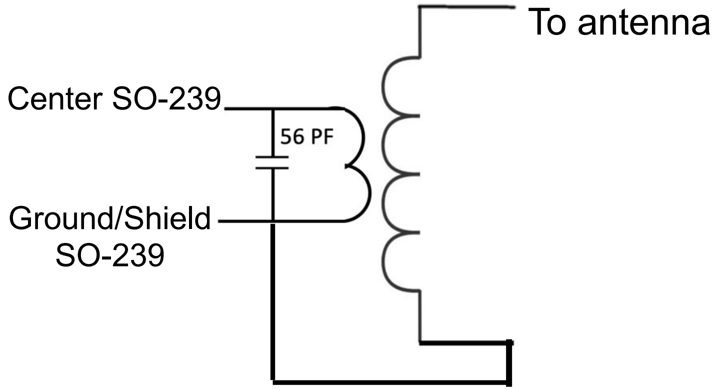
Conventional 49:1 End Fed Xfmr

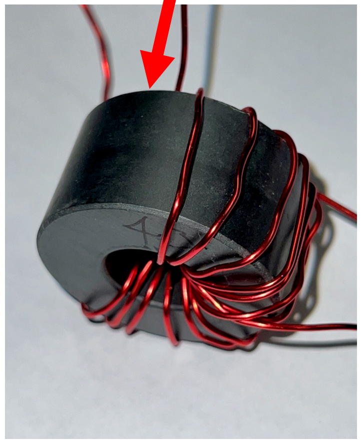
- 49:1 Impedance ratio
- High Impedance requires Longer Wire
- Gimmick Cap Loads Secondary – Low Pass Filter
- Narrows Transformer BW
- Requires 150pF Leakage Compensation Capacitor

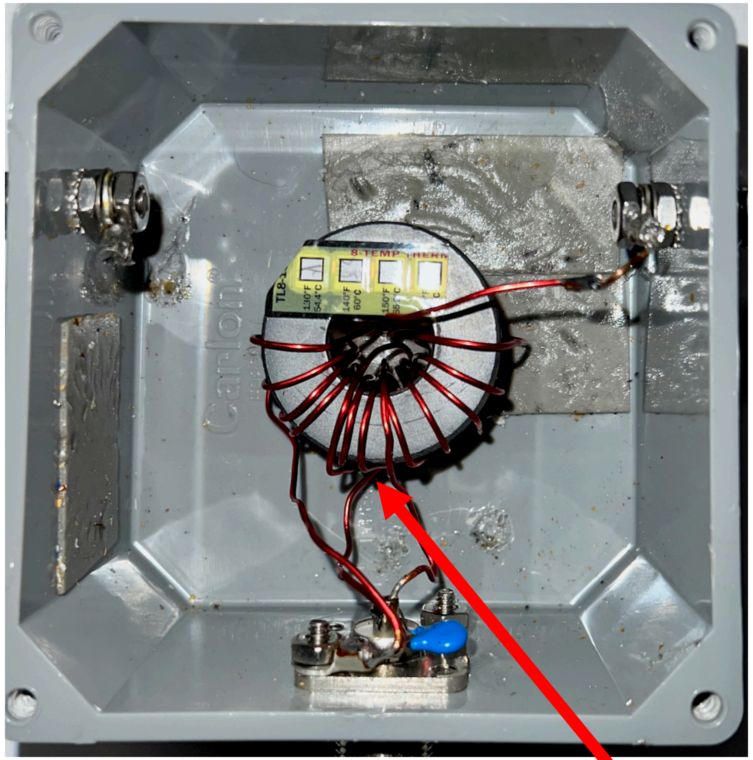


- Primary wrapped over & wrapped around High Z secondary
- AKA Gimmick Capacitor

36:1 End Fed Xfmr

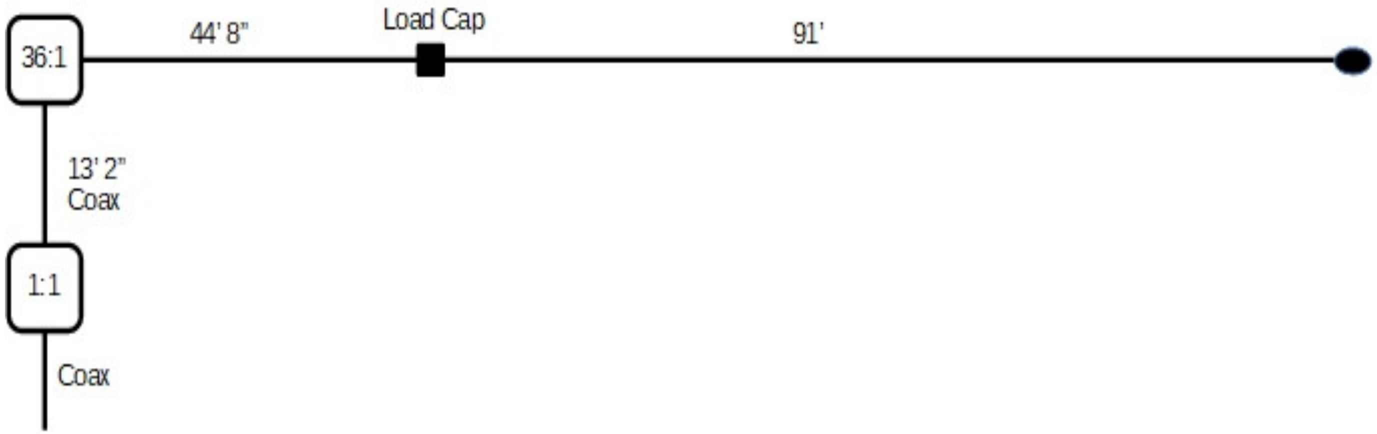






- Primary at Center of Secondary, No Capacitive Loading = No LPF
- 36:1 = Low Reactance, Lower SWRs. Wider BW
- Smaller Leakage Compensation Cap (56pF vs.150pF)
- 150W & 800W 36:1 Xfmrs & EF Capacitive Loads at BalunDesigns.com

80M End Fed



- 150 pF Capacitor at 32% places 80M resonance at 3.75 MHz Coax shield is counterpoise ~ .05x(Wavelength) = 13’2”
- Many designs and commercial end-feds falsely claim no counterpoise needed.
- There will always be a place for RF to return. RF will find it.
- Random or Controlled? Your choice!
- *Random* - Feed line becomes part of the antenna, detuning, RF feedback
- *Controlled* -1:1 balun/choke isolates counterpoise (RF on shield) from feed line
- Control where RF goes, don’t bet on being lucky.

1:1 Balun/Choke/UNUN for End Feds

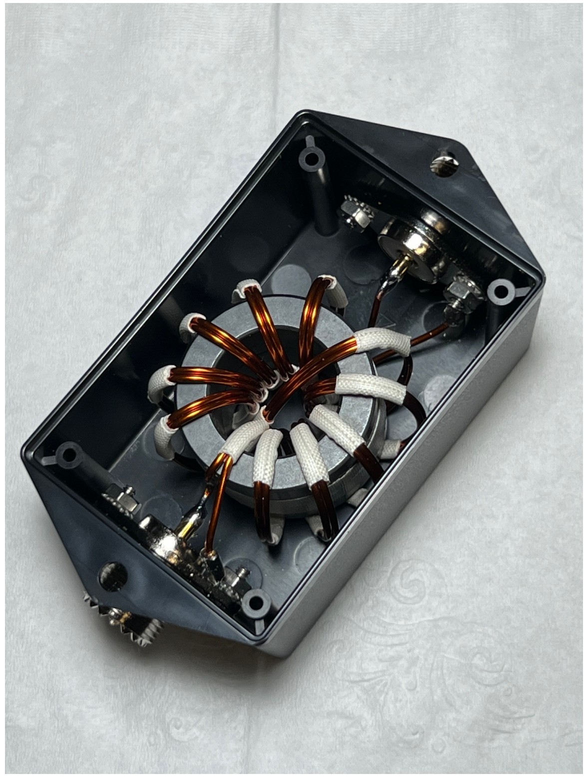
At end of Counterpoise Coax

High Voltage at end of Coax at Connector

Needs Sufficient Isolation to:

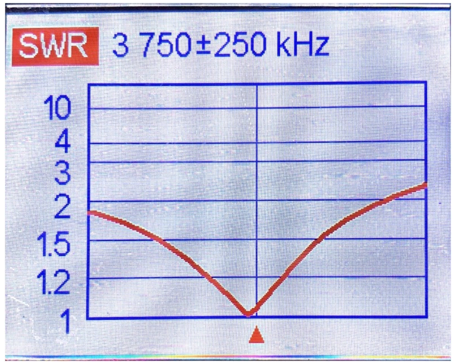
Make Antenna work properly on lowest frequency/band
Keep RF off Feed Line to Shack

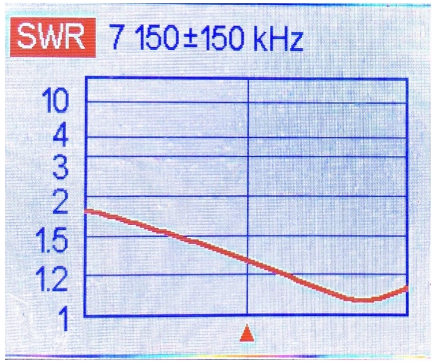
Spec 30 dB Isolation across Bands

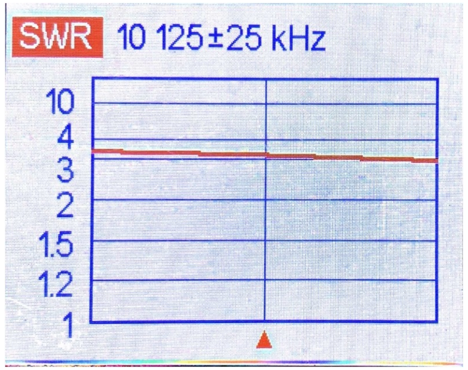


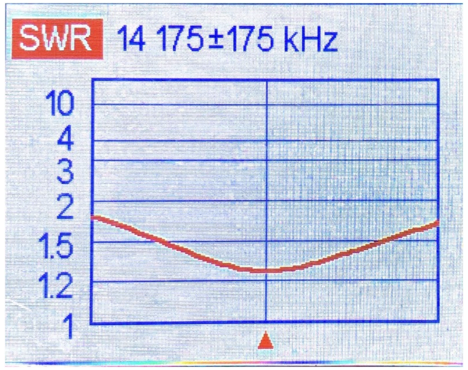
Balun Designs Prototype
End Fed Isolation 1:1 Balun/Choke

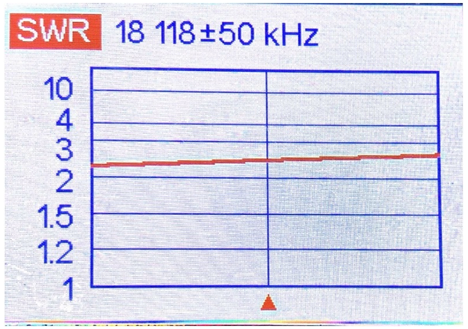
SWR 80M End Fed (W1IS antenna)

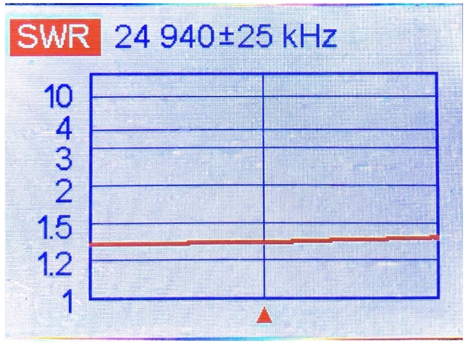


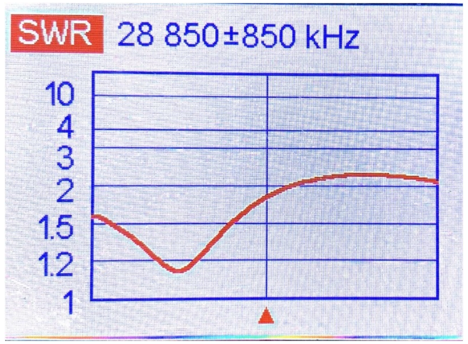




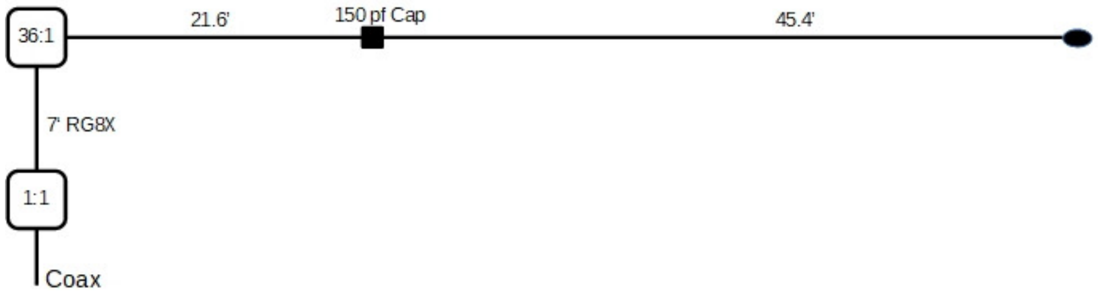


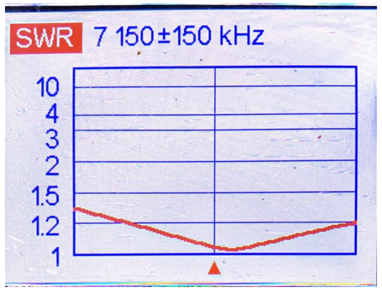


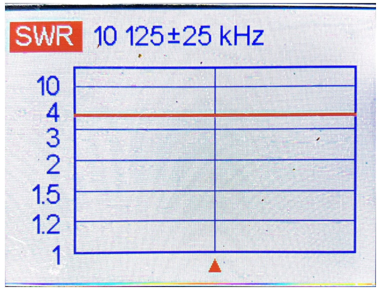


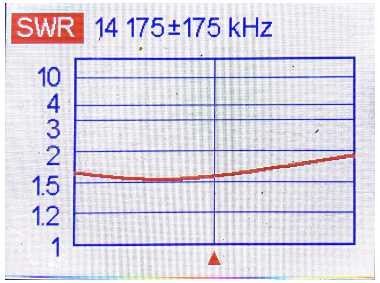


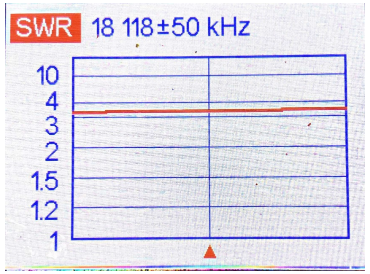
40M End Fed

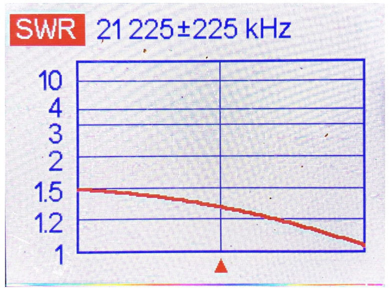


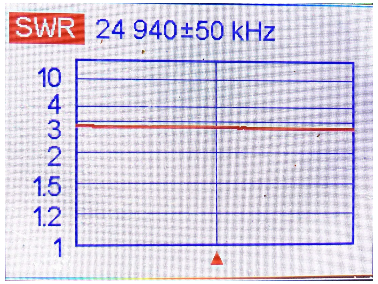


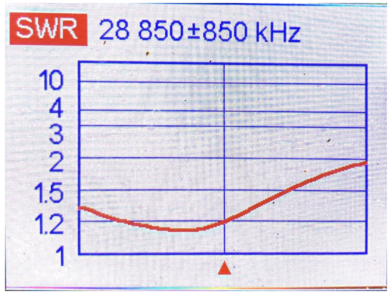


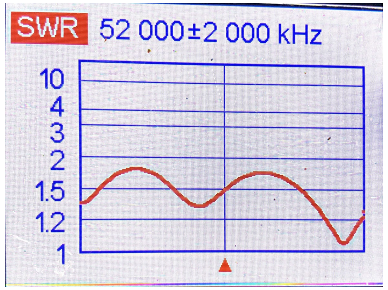










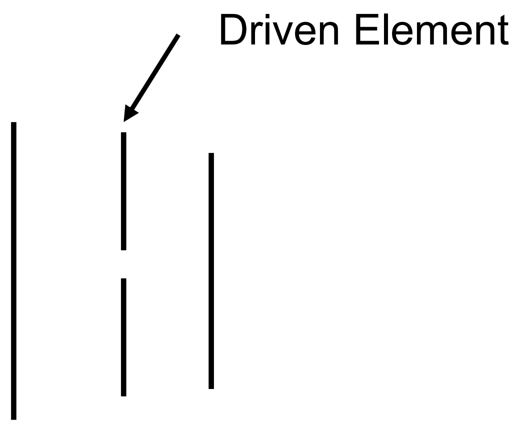


6M – Low Power Transformer 50% power.
High power transformer – losses too high on 6M

Phased Dipole Wire Beams

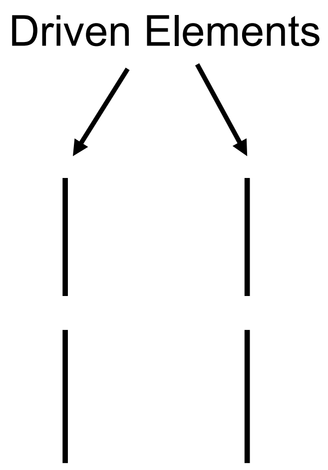
Conventional Yagi

- Driven by a single dipole
- Minimize rear radiation with reflector/s
- Maximize forward radiation with director/s



Phased Dipoles

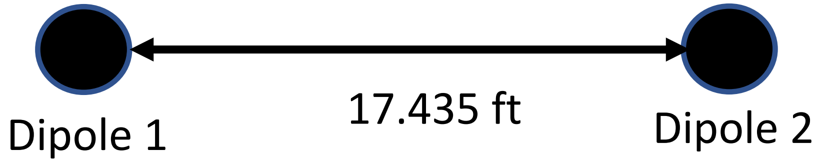
- Two driven dipoles phased to obliterate rear radiation
- Forcing most radiation in one direction.

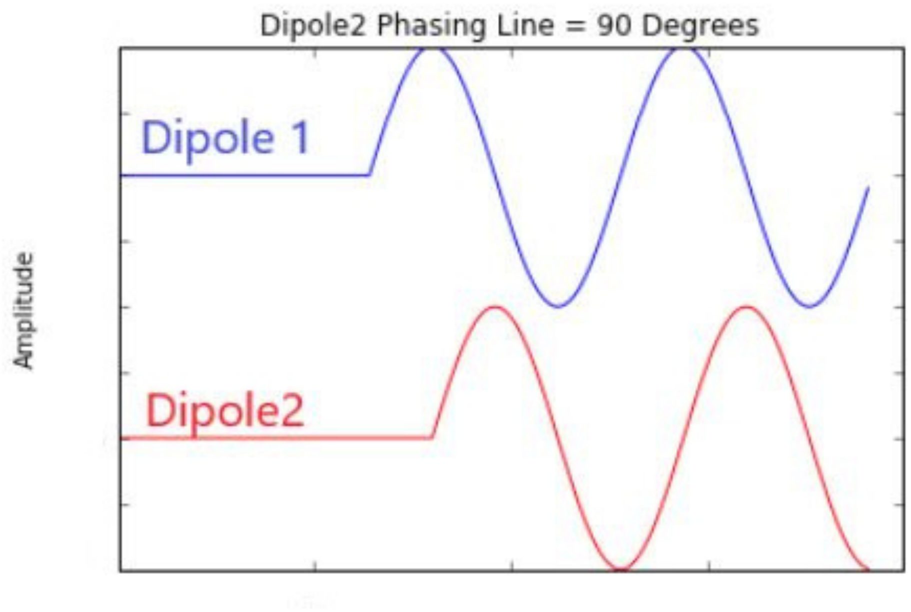


@14.175 MHz - Conventional 90 deg. Spacing

RF from Dipole 1 arrives at Dipole 2 90 degrees or 17.3 nanoseconds later

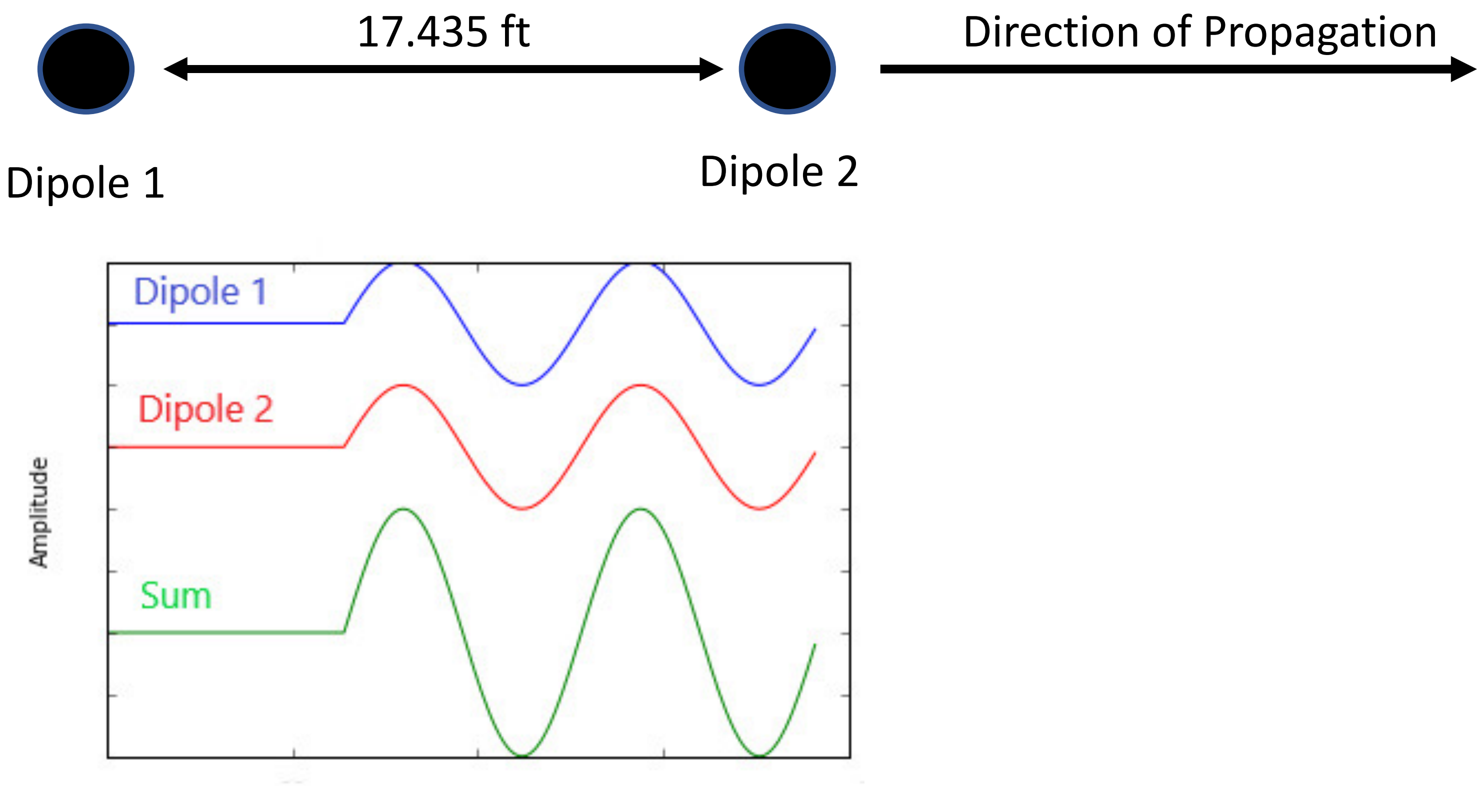
Dipole 2 is driven 90 degrees lagged from dipole 1 – Waves Add





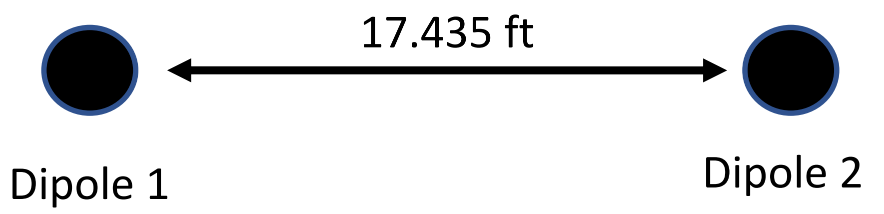
Add delay ~ 17.3 nS – coax delay line

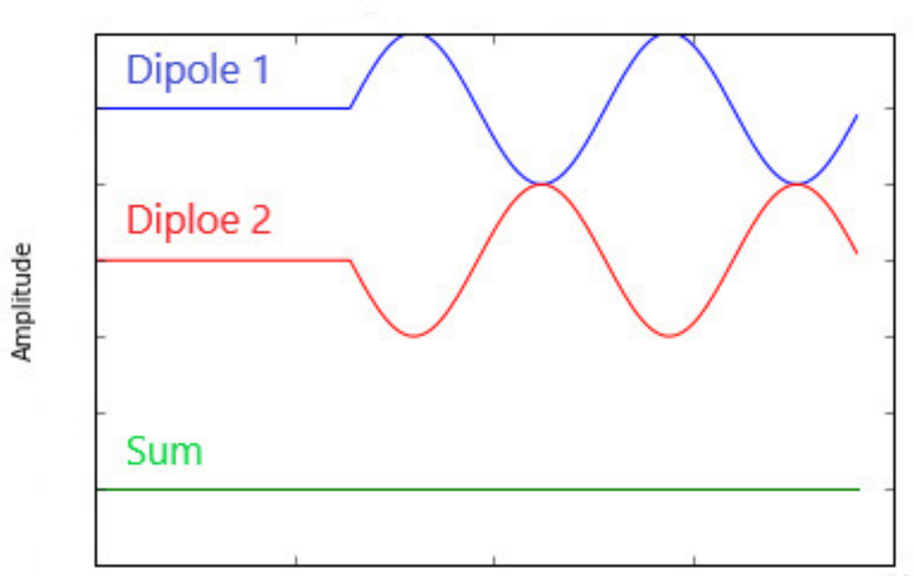
- Dipole 1 wavefront arrives in phase with Dipole 2



Signals Cancel in Reverse Direction

Dipole 2 wavefront arrives out of phase with Dipole 1



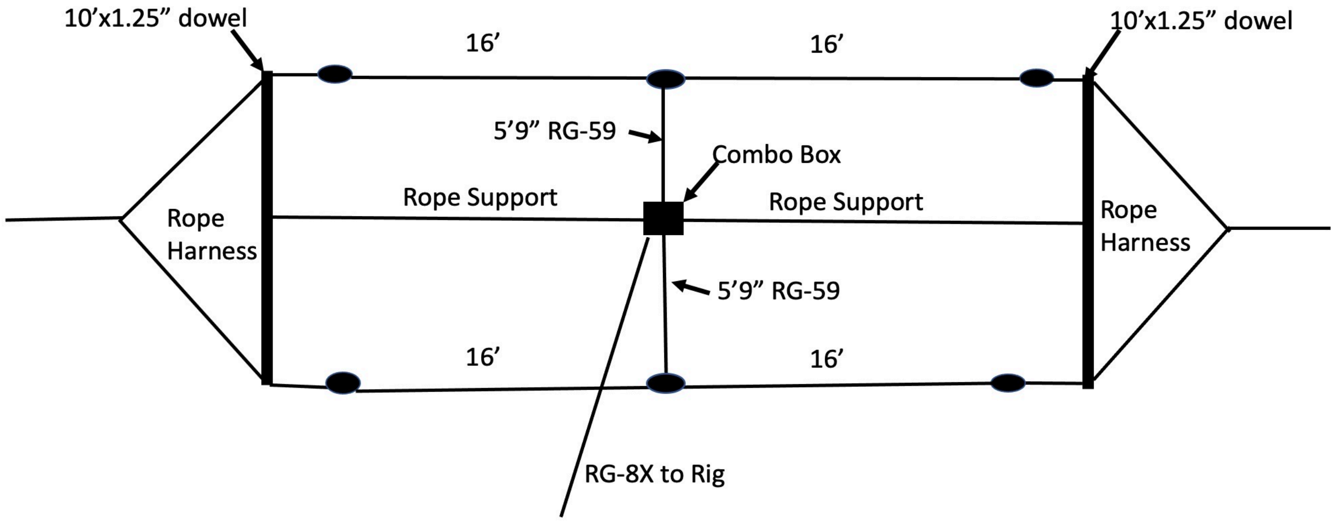


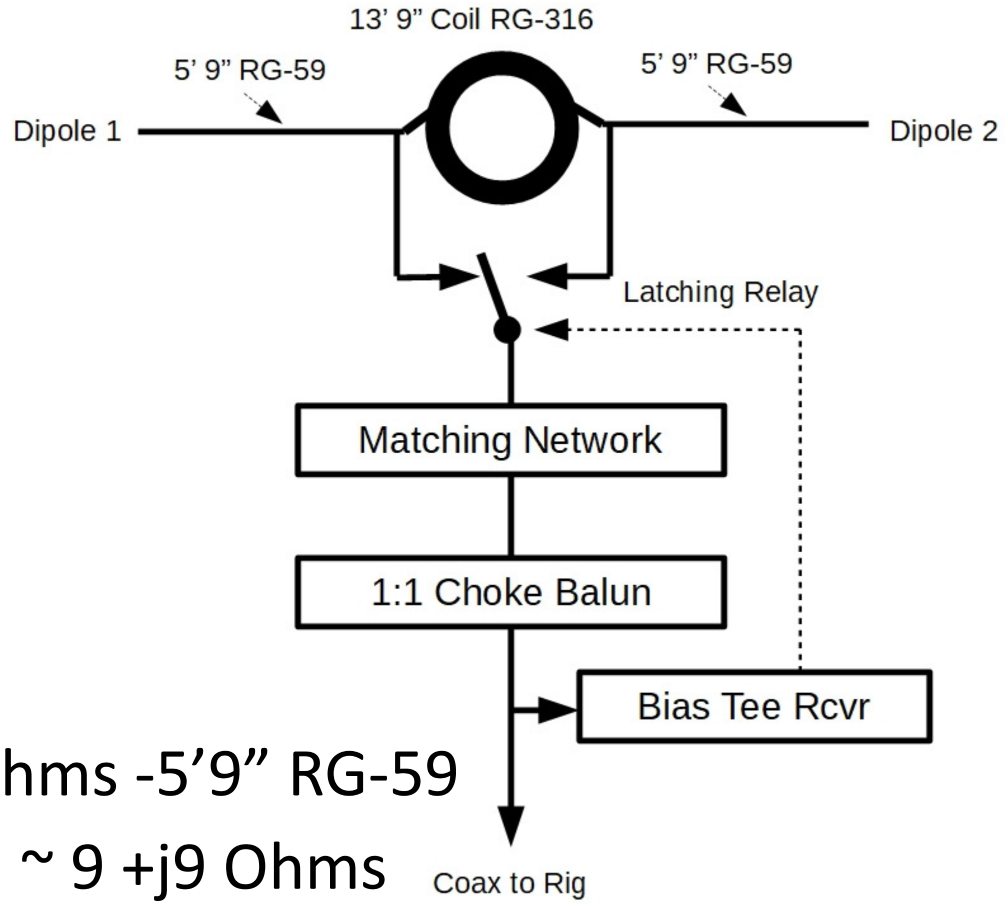
Reality Sets In

- Goal - build a phased dipole using 10 ft easily transported spacers
- The 10 ft problem: Determining the Phase Delay
- ¼ wavelength is about 17.3 ft but we have 10 ft or 52 vs. 90 degrees!
- Two Approaches
  - Maximize Forward Gain (Usual Approach - not simple for short span)
  - **Minimize Rearward Radiation for Best Front-to-Back Ratio**

Minimize Rear Radiation = Max F/B

- Adjust the phasing line to achieve 180 degree phase difference
- Spacing only 52 degrees
- Phasing line must be 180 – 52 = 128 degrees
- Squeezing the rear radiation forces energy forward for More GAIN





- Impedance of each dipole is transformed to 50 ohms -5’9” RG-59
- Combined Impedance of interacting dipoles 20m ~ 9 +j9 Ohms
- Low Q Pi Network transforms 9 + j9 ohms to 50 ohms to feed RG-8X
- 13’9” RG-316 50-ohm coax supplies phase delay = 128 degrees
- Latching Relay – Selects which dipole is fed directly, other by Phase Line
- 1-1 Choke/Balun isolates antenna and matching system from Feed Line

On the Air

- Using KX3, 5 W, worked several Eu stations with 55 or better signal reports.
- Pointing towards Europe, heard FEW US stations weakly
- Pointing towards US, heard NO European stations
- Forward Gain = 11+ dBi
- Measured 2 - 5 S units F/B with help from several PART members Steve, W1KBE, Colin, W1DJR, Bonnie, AC1IY, Frank, KC1HSC, Allison, KB1GMX, and Greg, N1DAM
- FD – Great F/B eliminated major noise source east of our site!

Summary

- Capacitive loads make Multi-band HF antennas effective - low SWR on all bands
- Built & tested Phased Dipoles for 20-6m with similar Gain and F/B.
- Yes, we built and tested ALL these antennas
- Yes, we are using or have used all of them ourselves.
- Details on building baluns & matching transformers on website & our book
- 36:1 Transformers & End Fed Loads available at BalunDesigns.com
  - 1:1 Balun/Choke/UNUN available soon.

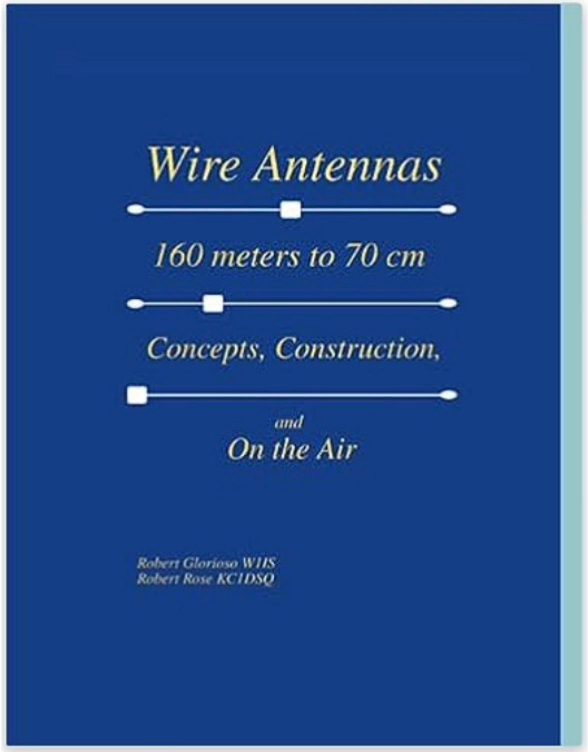
Thank You & 73

Bob^2

(Bob)^2 Latest Publications

- “A 70-cm ”Kitchen Array” CQ Magazine, August 2023, pp77-81
- “Wire Antennas 160 meters to 70 cm, Concepts, Construction and On the Air,” available at OCFMasters.com, Ham Radio Outlet Salem, Amazon

OCFMasters.com



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