

# Multi-Band End Fed Antennas and much much more!



Bob Brehm, AK6R  
Chief Engineer  
[Palomar-Engineers.com](http://Palomar-Engineers.com)

Henderson ARC 8/22/2023

This presentation available on website  
Copyright 2013-2023 Palomar Engineers, Inc.



# Palomar Engineers Short History

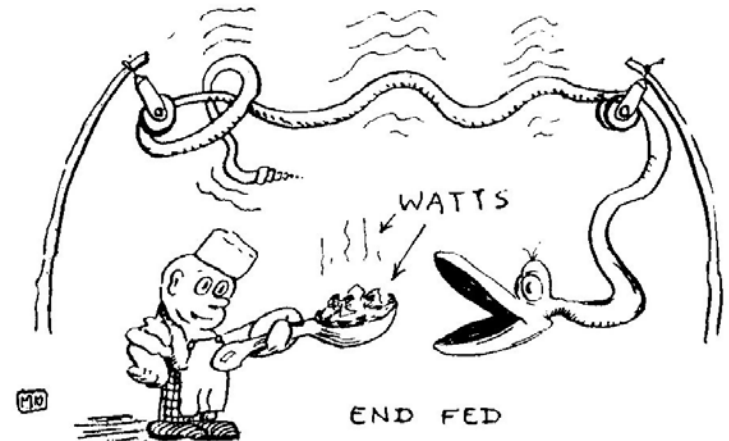
- Founded in 1965 by Jack Althouse, K6NY
- Reorganized in 2013 as RFI Solutions company
- **Objective:** Provide products that make radio communication more effective & enjoyable
- **Product Line**
  - Ferrite Core Products
  - Baluns, Ununs, Feedline Chokes & Coax Noise Filters
  - Antenna Systems (OCF, End Fed, Loop, Terminated)
  - RFI Solution Kits for Hams, Household, Marine/RV
  - Kurt Sterba Books/Free Downloads
- **Distribution:** Ham Radio Outlet, Direct, eBay
- **Markets:** Consumer, Commercial, and Military

Let's talk about End Fed Antennas

# End Fed Workshop Topics



- Short overview of antenna feed point options
- Dipole, OCF, Zepp, overview
- Popular End Fed Antennas
  - Resonant End Fed Half Wave
  - Non-Resonant End Fed Long Wire
  - Resonant End Fed Long Wire (OCF)
- Typical Configurations that work all the time
- How to choose an End Fed Antenna that fits your needs (bands, space, power)
- Feed Line Chokes, Antenna Switches
- A Special Topic
- Q & A



Thinking cap time.....

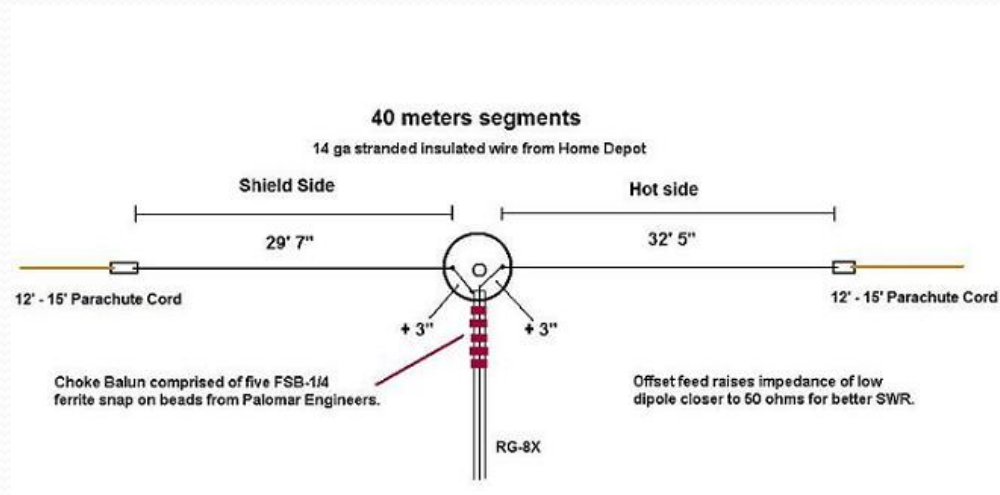
# Antenna Feed Options

CENTER FED

OFF-CENTER FED

END FED

# Resonant Dipole Examples



## Center Fed Single Band Dipole

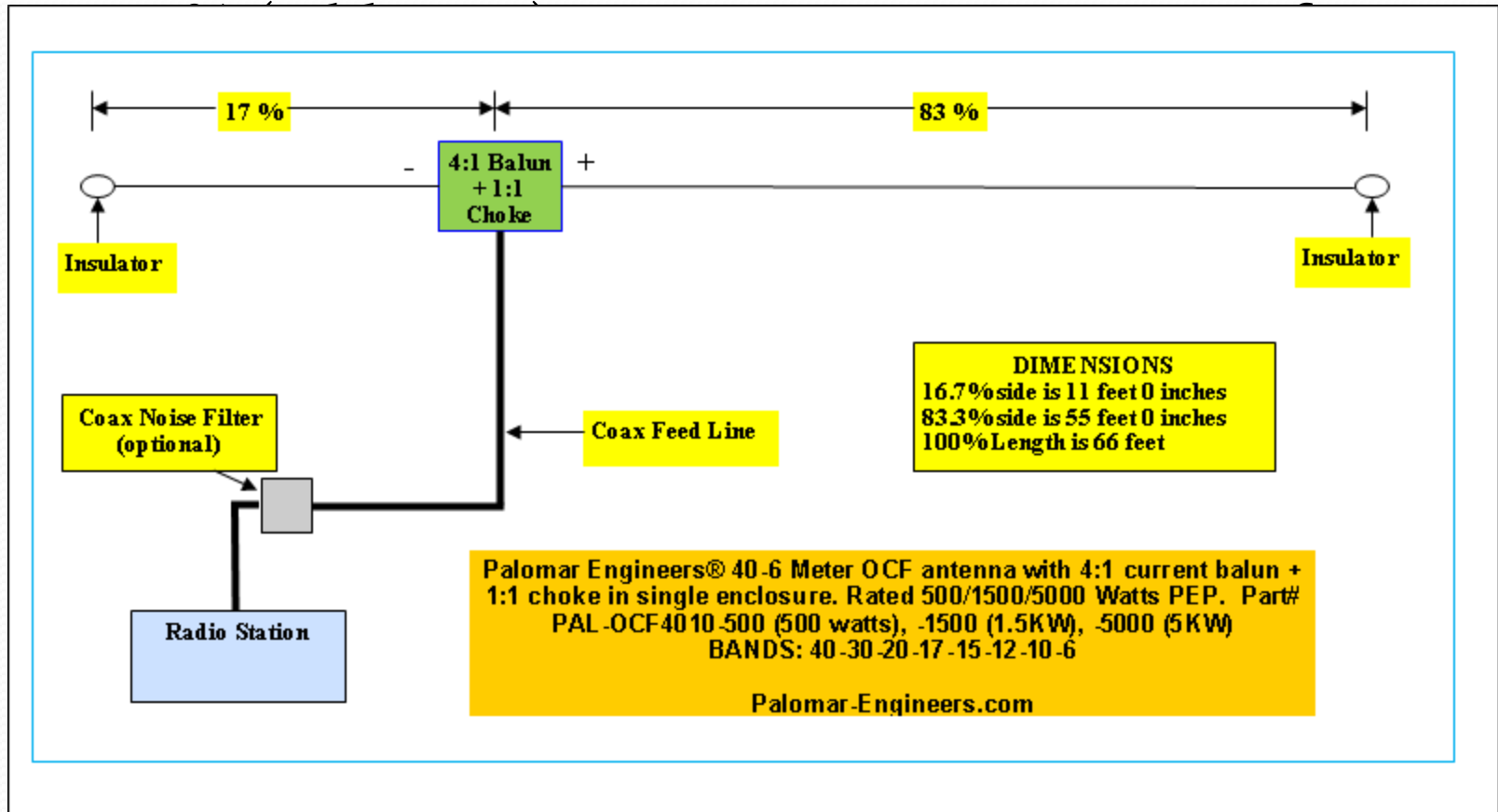
$Z = 25\text{-}120$  ohms depending on wave length height above ground

For very low dipoles center point  $Z$  is  $< 50$  ohms, so a trick is to feed slightly off center (one side longer) to raise the  $Z$  and lower the SWR

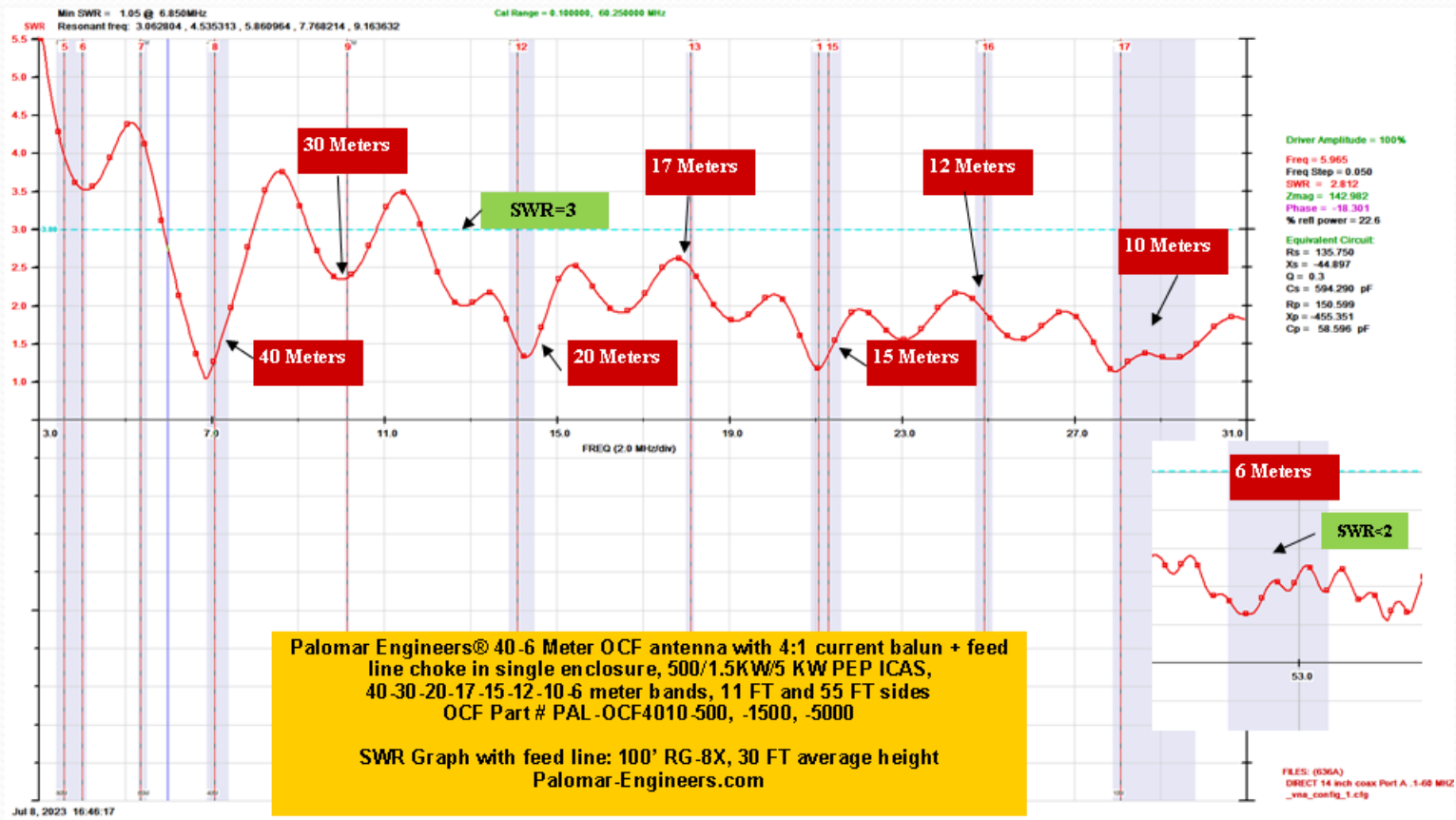
Total length =  $468/F$  (MHz)

# Palomar OCF Layout – 40-6 meters

## – 66 Ft (55' + 11')



# OCF SWR (40-6 Meters)



Very Popular > 1000 in use

End Fed Antennas

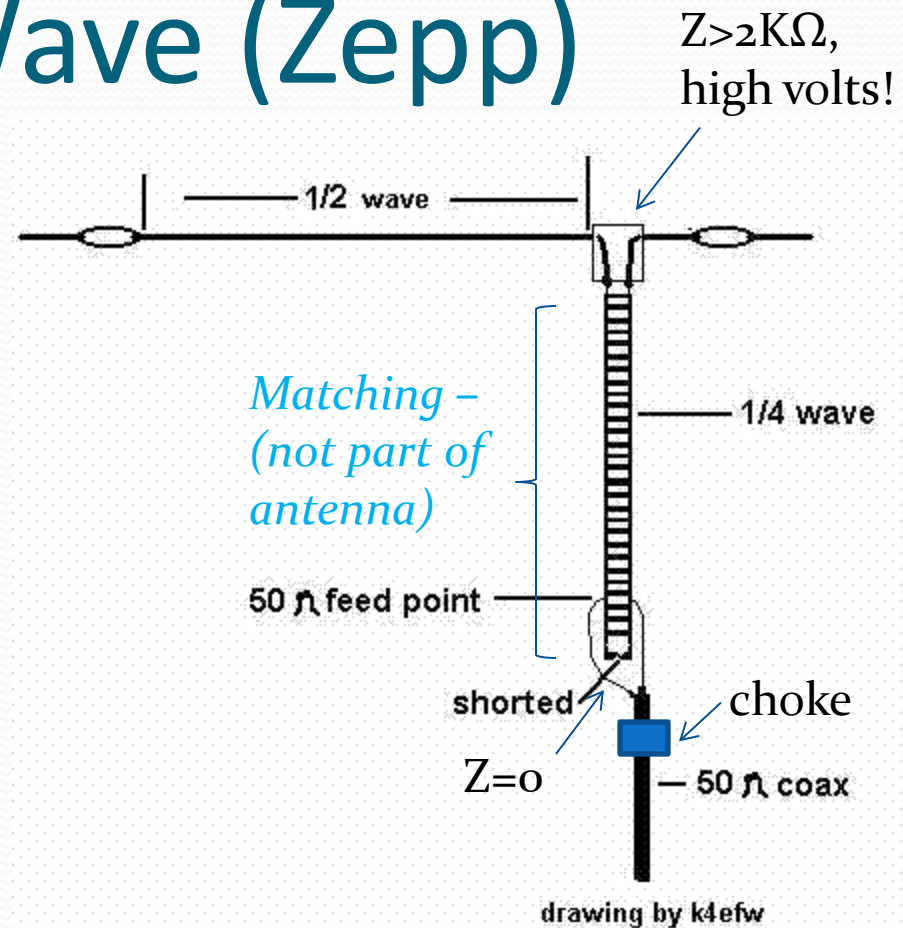
# End Fed Antenna Types

- End Fed Zepp (aka J-Pole)
  - End Fed Half Wave
- Non-Resonate End Fed
- Resonant End Fed (OCF)



# End Fed Half Wave (Zepp)

- Pros
  - Low loss
- Cons
  - Single band, odd harmonic w/o antenna tuner
  - High and long (66' & 33' feedline for 40M)
  - Needs feed line choke at coax feed point to prevent coax braid from radiating



#1 End Fed Half Wave

# Palomar EFHW Product

49:1 Unun



Feed line  
choke & wire



**PALOMAR**  
—ENGINEERS®—

**Bullet End Fed Half Wave  
Antenna System  
66 Ft Wire (40-10M) +  
Snap On Feed Line Choke  
300 W SSB/150 W Digital**

**Part#: PAL-EFHW4010-300**

Configuration

# Palomar EFHW Configuration

## Bullet™ End Fed Half Wave Wire Antenna Configuration

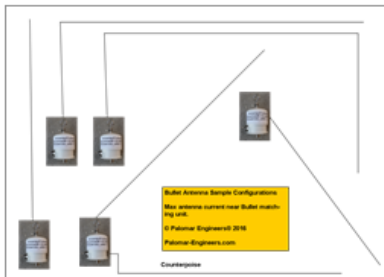
Max antenna current near center of antenna

Coax feed line length > 25 feet

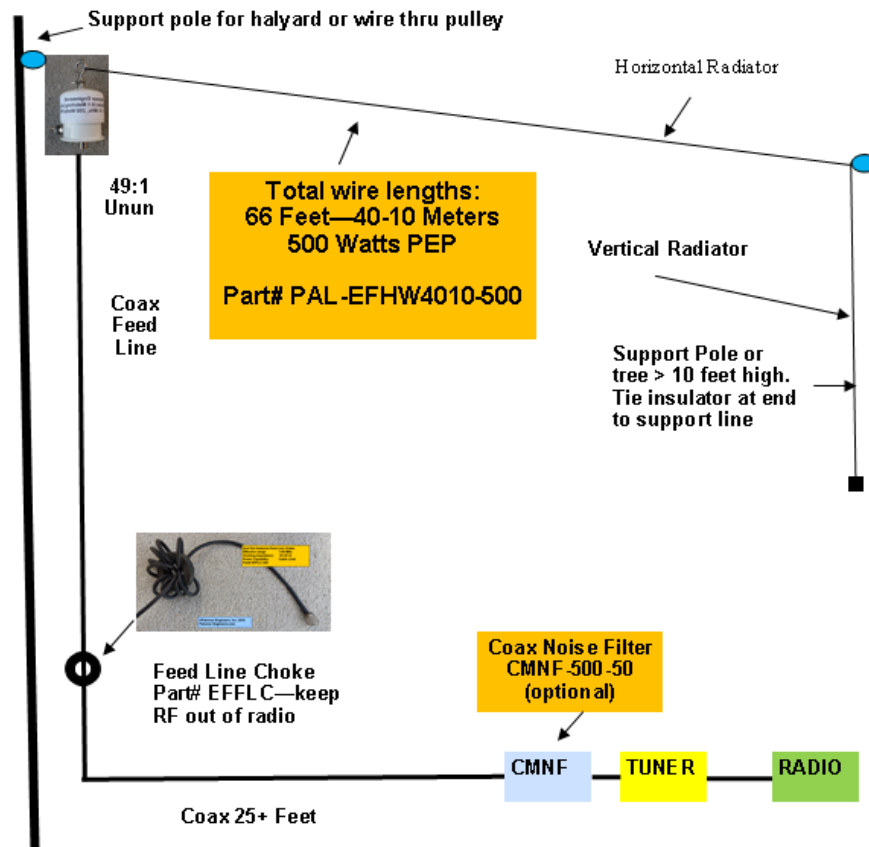
Feed Line Choke helps keep RF out of radio during transmit

© Palomar Engineers® 2016-2023

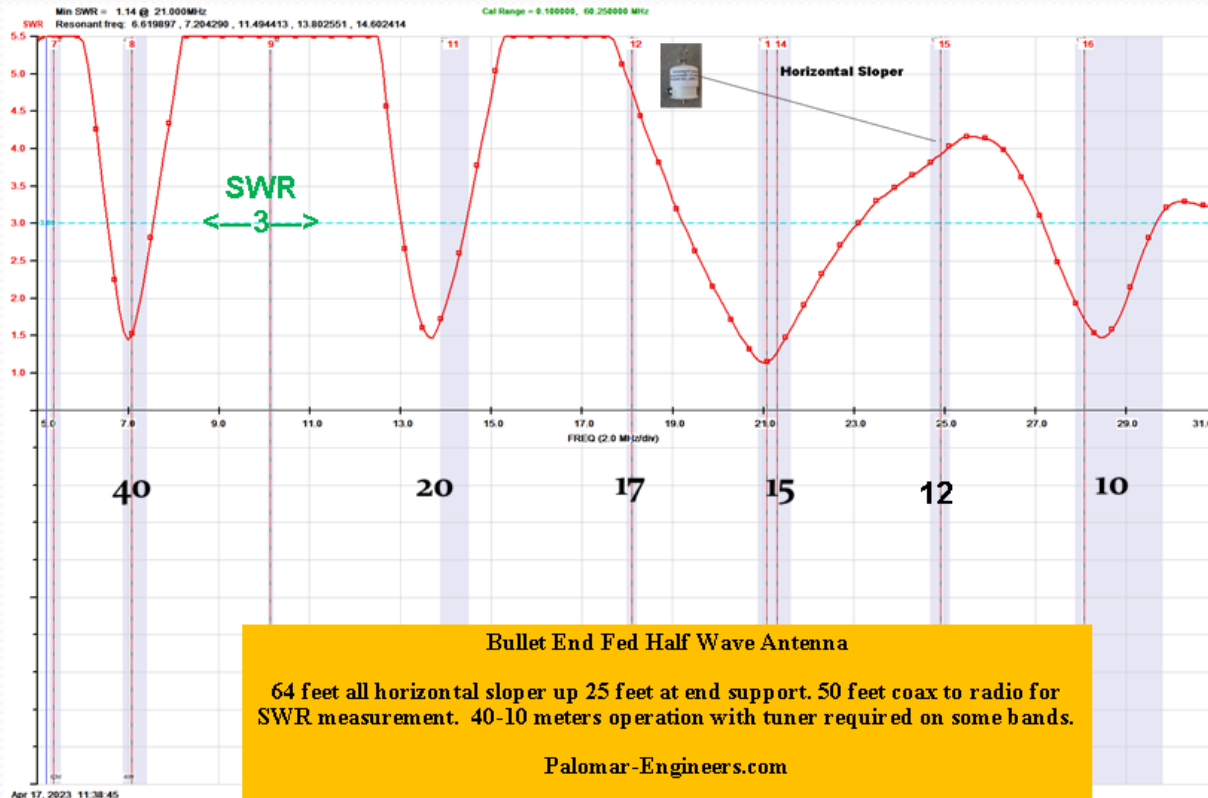
Palomar-Engineers.com



Other Possible Configurations



# Palomar EFHW-4010 (40,20,15,10)



**This configuration typical of most competing brands – 66 feet, only 4 bands! 49:1 high impedance unun, voltage fed with high voltage caution required! Note: 49:1 ununs have limited bandwidth!**

**Caution!!!**

# Caution: EFHW High Voltages

CU-49, CU-64 Unun for End Fed Antennas			
Output Terminal Voltage Calcs $E = \text{SQRT}(P \cdot R)$			
RATIO:	49:1	64:1	
Watts Input	Volts (r=2450 ohms)	Volts (r=3200 ohms)	
10	157	179	
20	221	253	
30	271	310	
40	313	358	
50	350	400	
100	495	566	
200	700	800	
300	857	980	
400	990	1131	
500	1107	1265	
600	1212	1386	
700	1310	1497	
800	1400	1600	
900	1485	1697	
1000	1565	1789	
1500	1917	2191	
2000	2214	2530	

**Keep feed point  
away from kids, pets  
& people due to high  
voltage which can  
kill or start a fire  
under the right  
conditions!**

**DISCONTINUED**

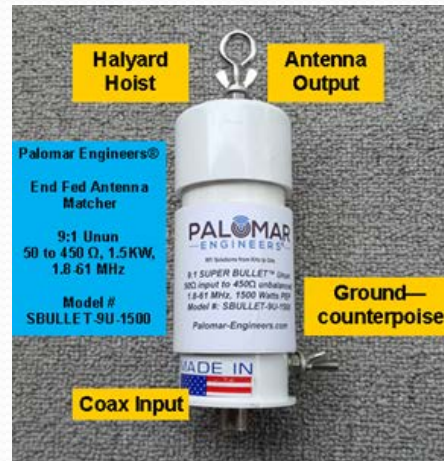
**This antenna has been  
replaced with the safer,  
shorter and far superior  
Resonant End Fed Long  
Wire**

**#2 - Non Resonant EFLW**



# Palomar Bullet-71 Antenna

9:1



**PALOMAR ENGINEERS®**

**500 Watts PEP**

**Bullet™ End Fed Antenna System**

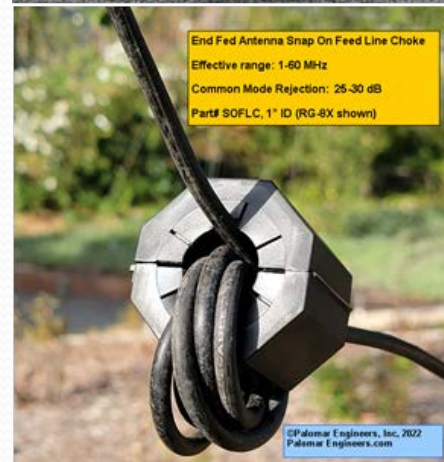
**71 Ft Antenna Wire (80-6M) +**

**BULLET-9U-500 Unun +**

**Snap On Feed Line Choke**

**Preassembled & Tested**

**Part#: BAS-71-500**



**PALOMAR ENGINEERS®**

**1500 Watts PEP**

**Bullet™ End Fed Antenna System**

**71 Ft Antenna Wire (80-6M) +**

**SBULLET-9U-1500 Unun +**

**Snap On Feed Line Choke**

**Preassembled & Tested**

**Part#: BAS-71-1500**

# Typical Non-Resonant End Fed Antenna Setup (like OCF)

**Wire = 71'**  
**Choke at 42'**  
**Length = 113'**  
**F = 4.14 MHz**

**Can work 80,  
60 with tuner**

**Coax braid  
radiates (down  
to choke) like  
wire**

**Bullet™ End Fed Long Wire  
Antenna Configuration**

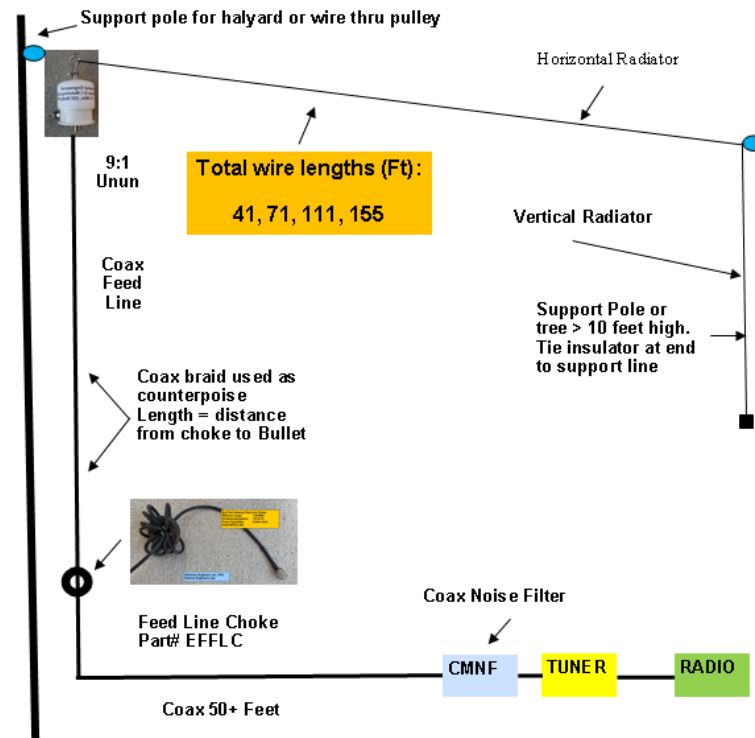
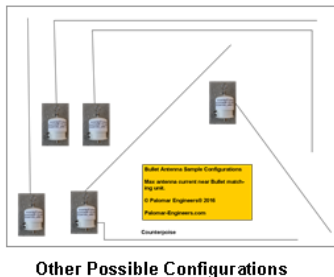
Max antenna current near Bullet  
matching unit.

Coax feed line length > 50 feet

Feed Line Choke required since  
counterpoise radiates

© Palomar Engineers® 2016-2022

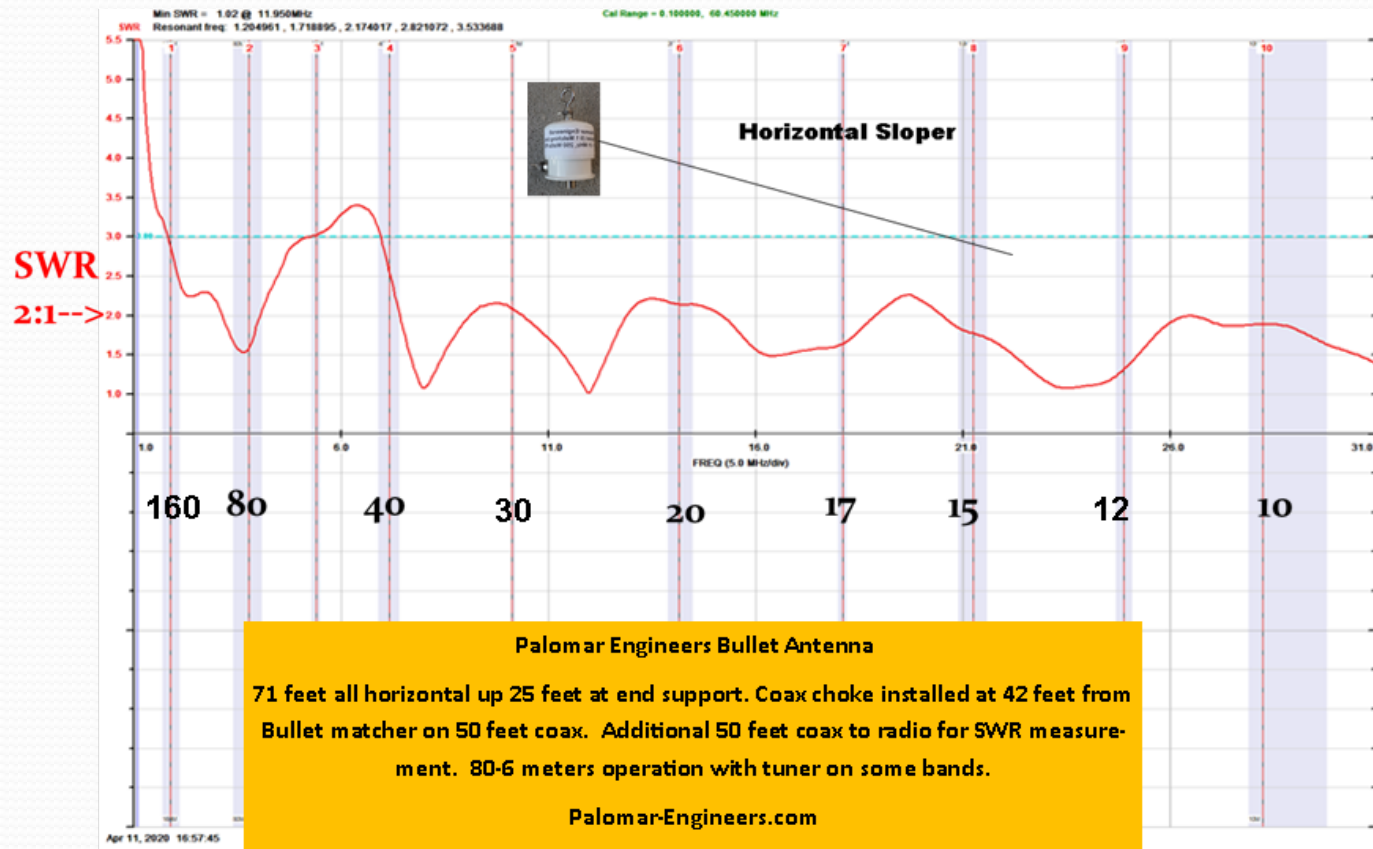
[Palomar-Engineers.com](http://Palomar-Engineers.com)



Bullet – 71 most popular length, 80-6 meters with  
tuner, over 4000 in use – at HRO or direct

SWR Factors

# Bullet-71'- SWR



All bands < 3:1, most under 2:1

#3 - Resonant EFLW



# Bullet-4006 – OCF End Fed



**Bullet OCF End Fed Antenna System**  
**40-30-20-17-15-12-10-6 Meters**  
**Wire: 55 FT, Choke at 12 FT**  
**500 Watts PEP/300 Watts Digital**

**Part# BULLET-4006-500**



4:1 unun



**Bullet OCF End Fed Antenna System**  
**40-30-20-17-15-12-10-6 Meters**  
**Wire: 55 FT, Choke at 12 FT**  
**1500 Watts PEP/750 Watts Digital**

**Part# BULLET-4006-1500**



4:1 unun

Config →

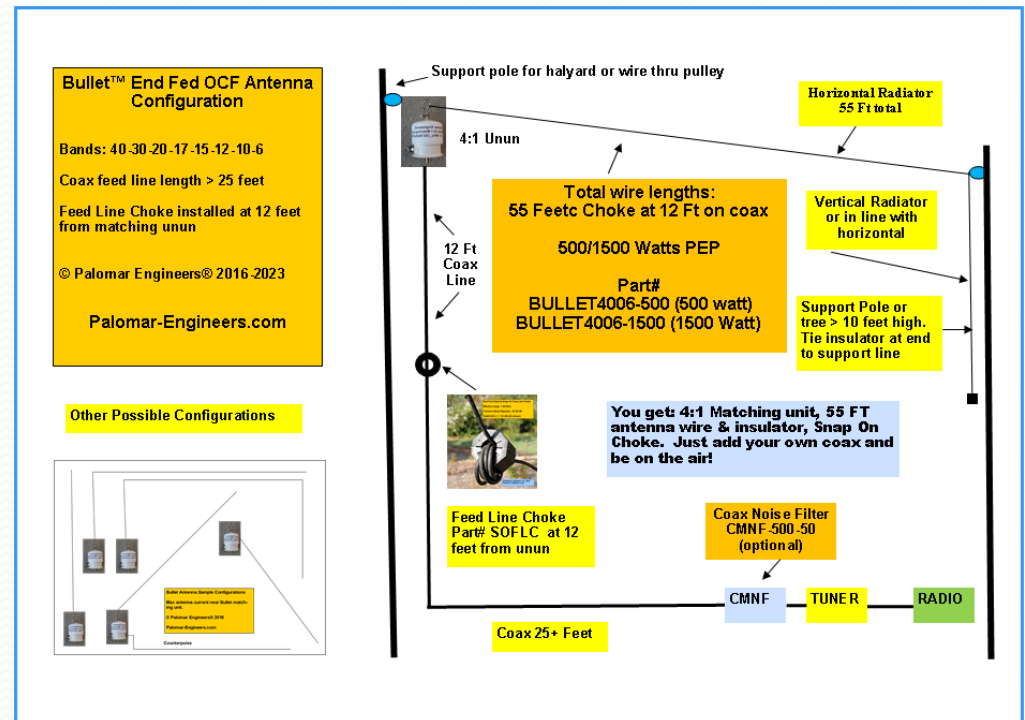
# Palomar Resonant End Fed Long Wire Antenna

## • Pros

- Wire length  $< \frac{1}{2}$  wave
- 40-30-20-17-15-12-10-6
- Stealth for HOA
- Ultra broadband 4:1 unun
- Total antenna is 55+12 = 67', but with lower SWR like OCF
- Safe & simple low voltage matching

## • Cons

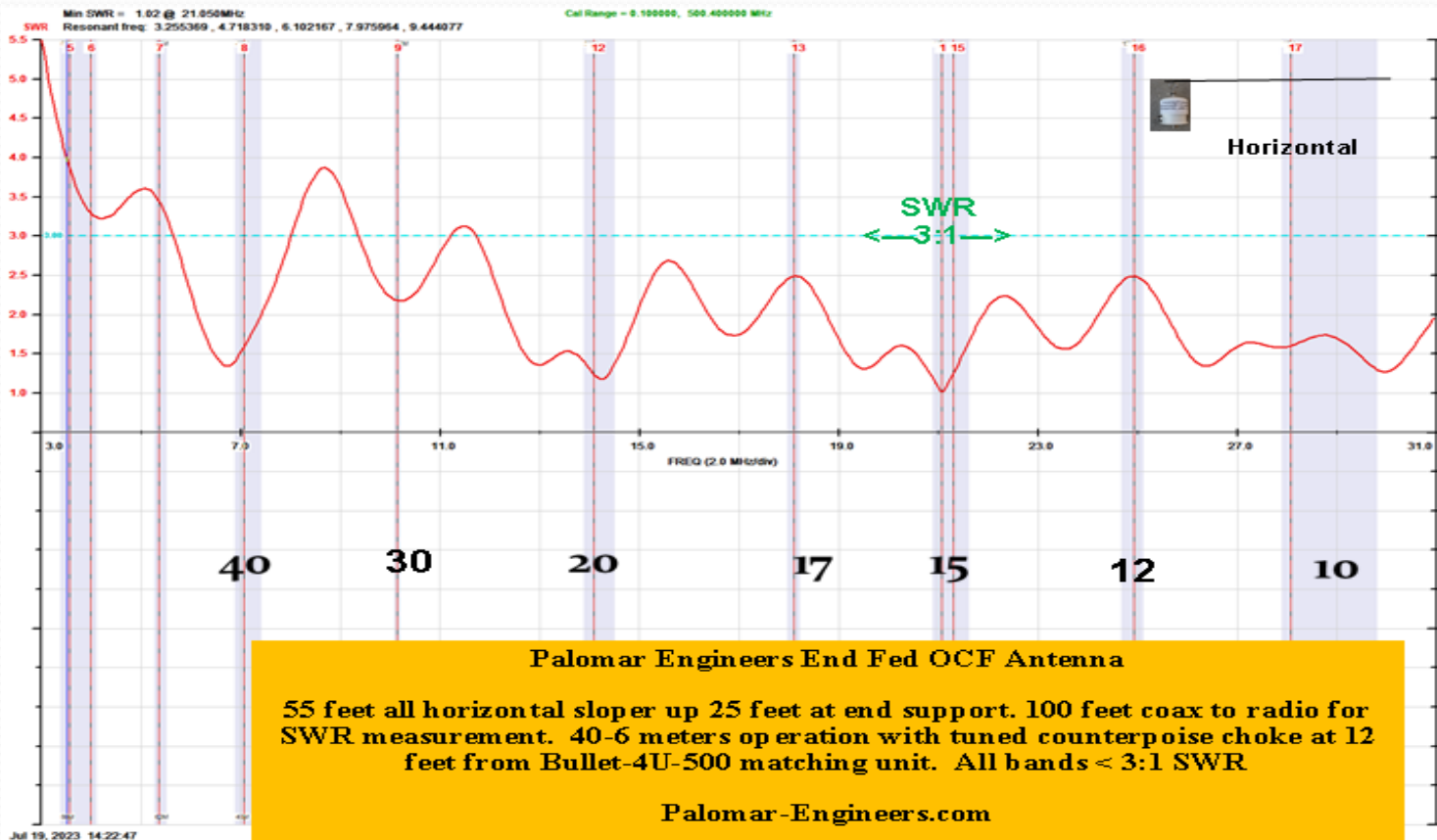
- Coax acts as counterpoise and radiates (OCF)
- Some bands may require antenna tuner in radio



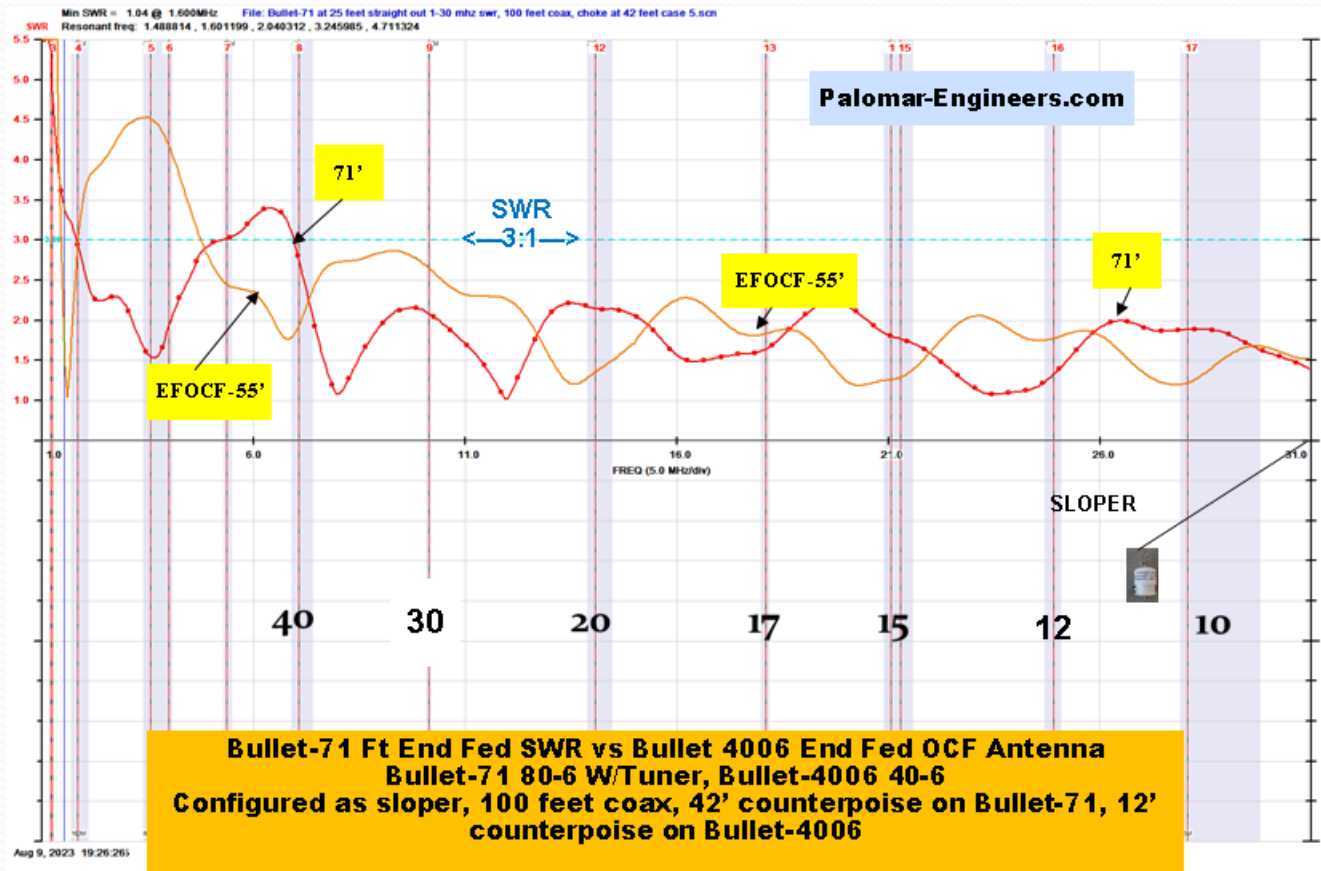
PART#: BULLET-4006-500/1500

BULLET-4006 SWR

# Bullet-4006 SWR 40-6M



# Bullet-4006 vs Bullet-71 SWR



55 feet Bullet 4006 has better SWR 40-6 meters, but no 80, 60 All Compared

Antenna:	EFHW-40	NREFLW	REFLW	OCF4010
Wire Length	66	71	55	66
Counterpoise (ft)	16	42	12	--
80M		✓		
60M		✓		
40M	✓	✓	✓	✓
30M		✓	✓	✓
20M	✓	✓	✓	✓
17M		✓	✓	✓
15M	✓	✓	✓	✓
12M		✓	✓	✓
10M	✓	✓	✓	✓
6M		✓	✓	✓
Min Coax	25	50	25	25
Unun Ratio	49:1	9:1	4:1	4:1+1:1
Other	Hi voltage feed point	Low volts, coax radiates, tuner	Low volts, coax radiates	Low volts, no coax radiation

# End Fed Antenna Choices Recap

- End Fed **Half Wave** –  $\frac{1}{2}$  wavelength at lowest frequency, harmonics only, requires high Z (49:1) matching unit, **high voltage** at feed point  
NO WARC bands or 6 meter coverage
- **Non-Resonant** End Fed  $< \frac{1}{2}$  wavelength at lowest frequency, uses simple matching (9:1), low voltage feed point, works all bands including WARC, coax radiates for additional band coverage
- ✓ • **Resonant** End Fed Long Wire  $< \frac{1}{2}$  wavelength at lowest frequency, uses even simpler 4:1 matching, lower voltage feed point, works all bands including WARC, 6M, excellent SWR similar to full OCF antenna

Most Convenient End Fed is the Resonant End Fed Long Wire Antenna followed by the Non-Resonant Long Wire

Question: So how do you set up end fed long wire antennas?



# Secrets of End Fed Antennas

**How to determine the wire length to use**  
(antenna, coax and counterpoise lengths)

**How to match the antenna to coax cable**  
(matching unit values and placement)

**Choosing a configuration that fits the location**  
(vertical, sloper, inverted L, horizontal options, zig-zag)

▪ **Choosing a feed line choke or noise filter**  
▪ (selection and installation)

How do these steps apply to your end fed use & location?

How long?

# Non-Resonant end fed antenna wire length options

- Antenna Wire – longer for better low band operation
- Coax Cable – used as counterpoise – place choke at suggested lengths from matching unit

Suggested non-resonant wire lengths for 1.8-31 MHz operation (measured from Bullet antenna wire terminal):

Bands Covered (meters)		Wire Length (feet)	Counterpoise Coax Length (feet)	Part#
40-30-20-17-15-12-10-6		41	16	BAS-41
80-40-30-20-17-15-12-10-6		71	42	BAS-71
160-80-40-30-20-17-15-12-10		155	95	BAS-155

Available at HRO and direct

Resonant EFLW



# Resonant end fed antenna wire length options

- Antenna Wire – choose for bands desired
- Coax Cable – used as counterpoise – place choke at suggested lengths from matching unit

Suggested non-resonant wire lengths for 1.8-54 MHz operation (measured from Bullet antenna wire terminal):

Bands Covered (meters)		Wire Length (feet)	Counterpoise Coax Length (feet)	Part#
20-17-15-12-10-6		27	7	BULLET-2006
40-30-20-17-15-12-10-6		55	12	BULLET-4006
80-60-40-30-20-17-15- 12-10-6		95	40	BULLET-8006

20, 40, 80

# BULLET-2006 (20-6M)

## Bullet™ End Fed OCF Antenna Configuration

Bands: 20-17-15-12-11-10-6

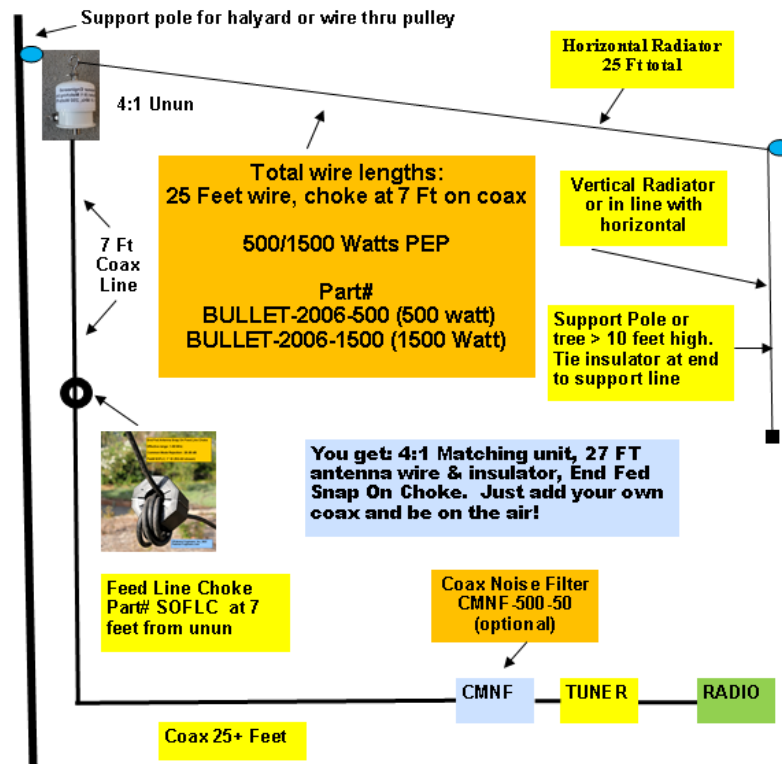
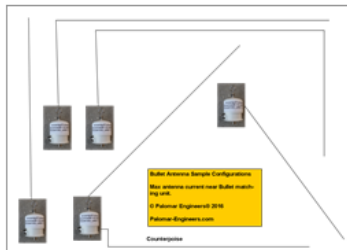
Coax feed line length > 25 feet

Feed Line Choke installed at 7 feet from matching unun, wire length 25 ft

© Palomar Engineers® 2023

Palomar-Engineers.com

## Other Possible Configurations



Great for portable operations—works on telescoping fiberglass pole—all vertical or inverted L

100, 500, 1500 watt options

# BULLET-4006 (40-6M)

## Bullet™ End Fed OCF Antenna Configuration

Bands: 40-30-20-17-15-12-10-6

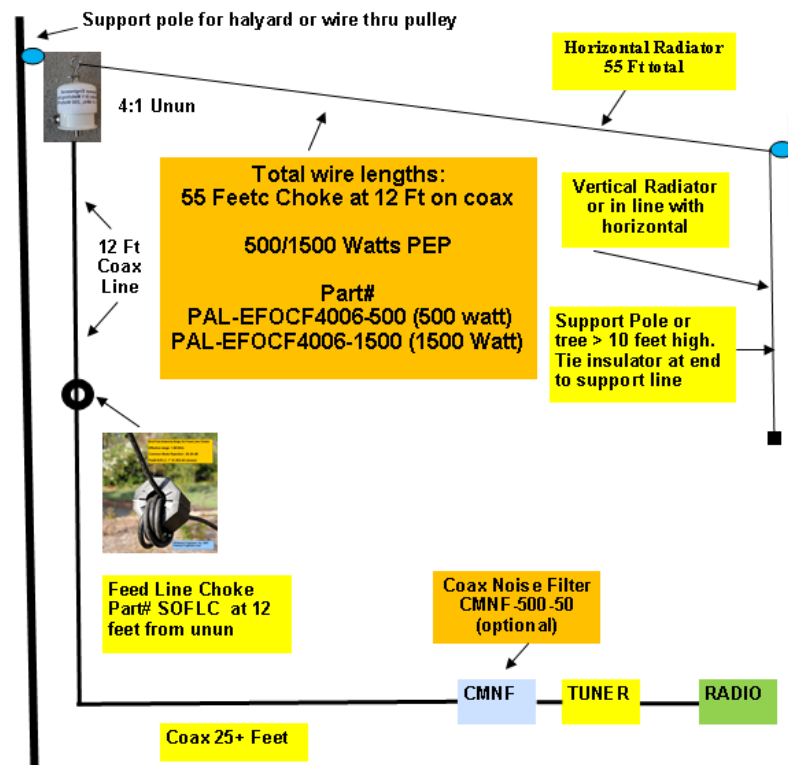
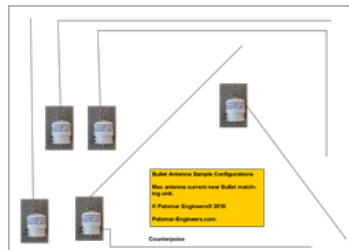
Coax feed line length > 25 feet

Feed Line Choke installed at 12 feet from matching unun

© Palomar Engineers® 2016-2023

Palomar-Engineers.com

## Other Possible Configurations



100, 500, 1500 watt options

# BULLET-8006 (80-6M)

## Bullet™ End Fed OCF Antenna Configuration

Bands: 80 40 30 20 17 15 12 11 10 6

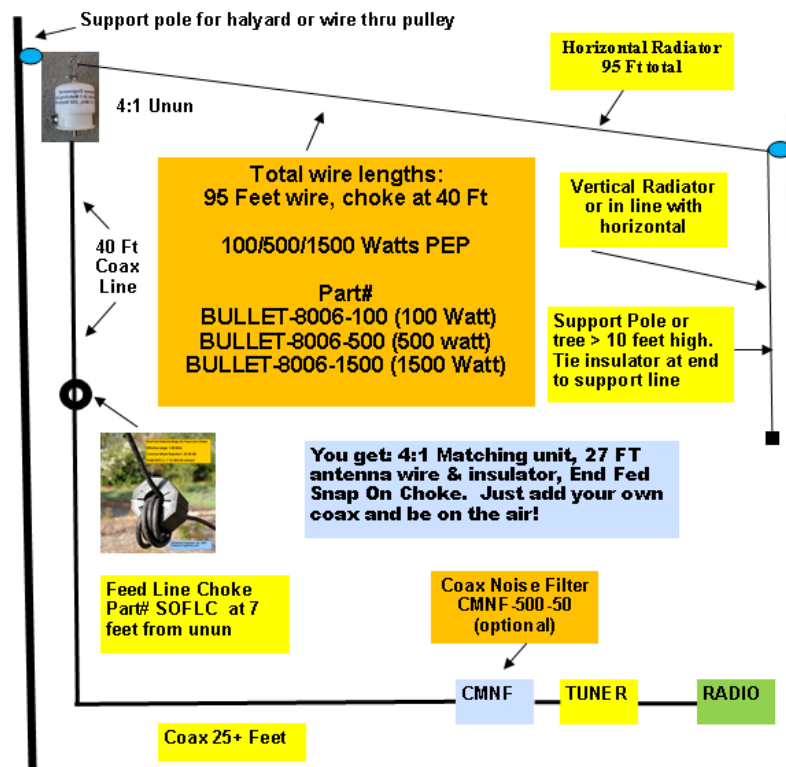
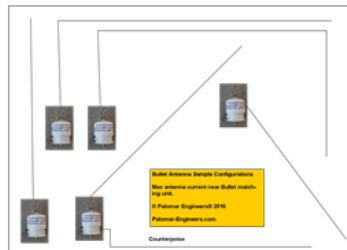
Coax feed line length > 50 feet

Feed Line Choke installed at 40 feet from matching unun, wire length 95 ft

© Palomar Engineers® 2023

Palomar-Engineers.com

## Other Possible Configurations

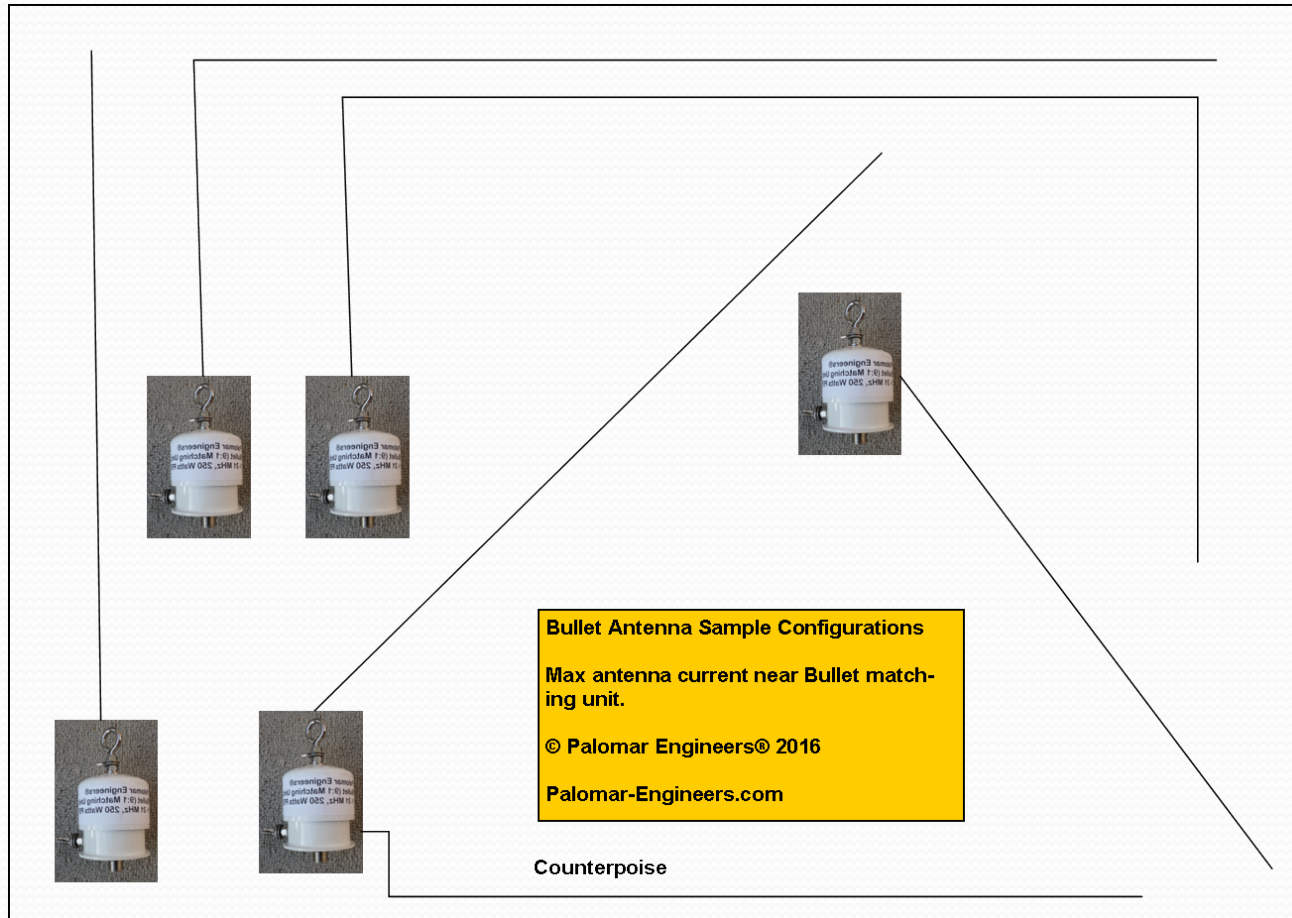


Work more bands than 80M EFHW, 40 Feet shorter wire with NO HIGH VOLTAGE at feed point!

100, 500, 1500 watt options

configs

# End Fed Configurations



## NOTES:

Slope up or down,  
Inverted L or N, Zigzag, all horizontal or vertical ok, 90 bend OK, counterpoise NOT under antenna, coax radiates so keep high, wind up if necessary

Keep antenna (wire & coax) as high as possible

SWR Factors

# End Fed SWR Factors

- Configuration shape (Inverted L, flat top, sloper, zig-zag)
- Feed line choke/noise filter placement – at radio end
- Top feed or bottom feed – feed sloper at top end
- Soil Conductivity – install over/near water
- Keep at least 3 feet from metal objects

Matching coax to antenna →

# Matching the end fed antenna to coax cable

- UNUNs are your friend
  - NREFLW Antenna feed point impedance: 100-900 $\Omega$ 
    - 9:1 unun = 33 to 100 $\Omega$  at coax (SWR < 2:1)
  - REFLW impedance is 100-400 $\Omega$ 
    - 4:1 unun = 25-100 $\Omega$  at coax (SWR < 2:1)
- Connections for coax, antenna feed point and counterpoise (NREFLW only)
- Power Ratings – PEP to match your station

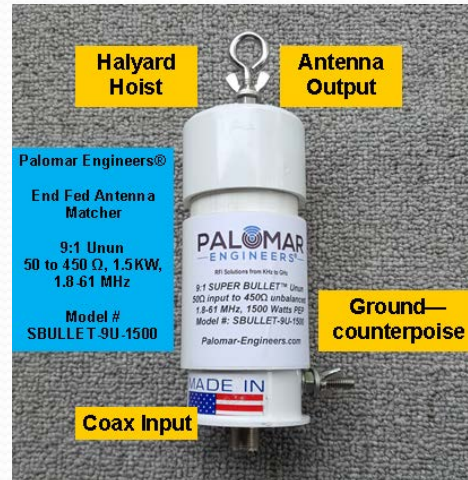
Unun examples



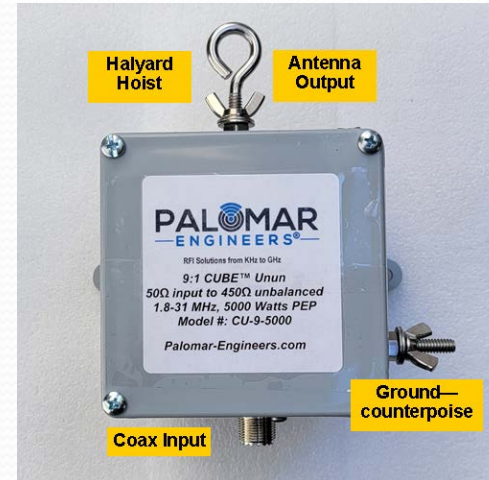
# 4:1/9:1 Ununs-100/500/1500/5000



**Bullet-9U-500 -500 Watts PEP**



**Super Bullet-9U-1500 - 1500 Watts PEP**



**Cube Unun – 9:1, 1.5/5KW Watts PEP**

**Bullet-9U-100 -100 Watts PEP/FT8**

**Bullet 4:1 Unun—100 Watts PEP/Digital  
Part# Bullet-4U-100**



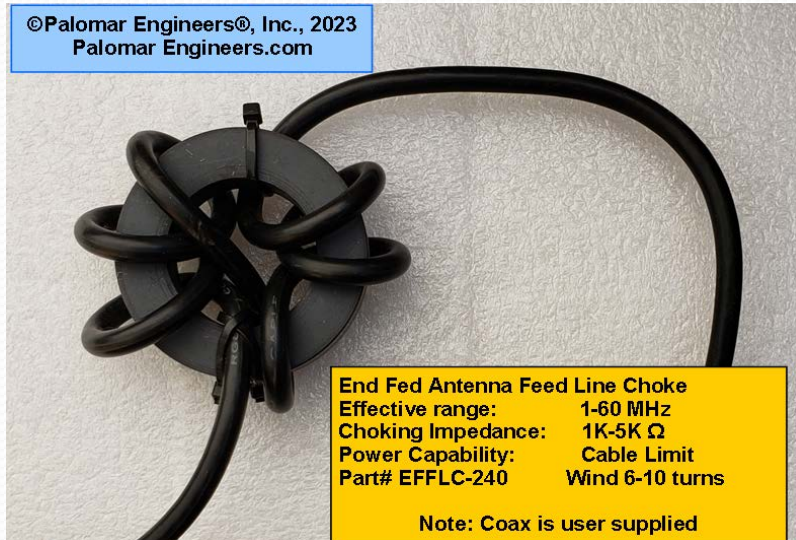
**Palomar-Engineers.com**

**These PEP values are accurate when used into a properly matched load**

**Feedline Choke Needed**



# Choosing an End Fed Coax Choke



Ring – 8-10 turns  
Higher Impedance - \$10

## Criteria to Consider

- Adequate Choking Impedance ( $Z$ ) > 500  $\Omega$
- Effective Frequency Range where  $Z > 500 \Omega$
- Sufficient Power Rating (PEP, Digital)
- Physical Size/Weight



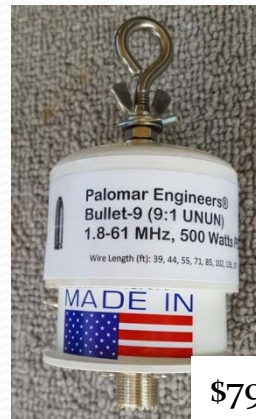
Snap on – 4-5 turns  
RG-8X or 3 turns  
LMR-400 size coax  
Easier to position - \$20  
Part# SOFLC

DIY Specials

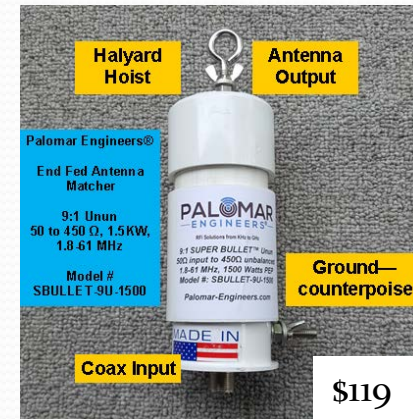
# Bullet Antenna Parts for DIY



\$130



\$79



\$119



\$69



\$69



\$20

What about antenna noise issues?

# Radio System Installation

## Bullet™ End Fed OCF Antenna Configuration

Bands: 40-30-20-17-15-12-10-6

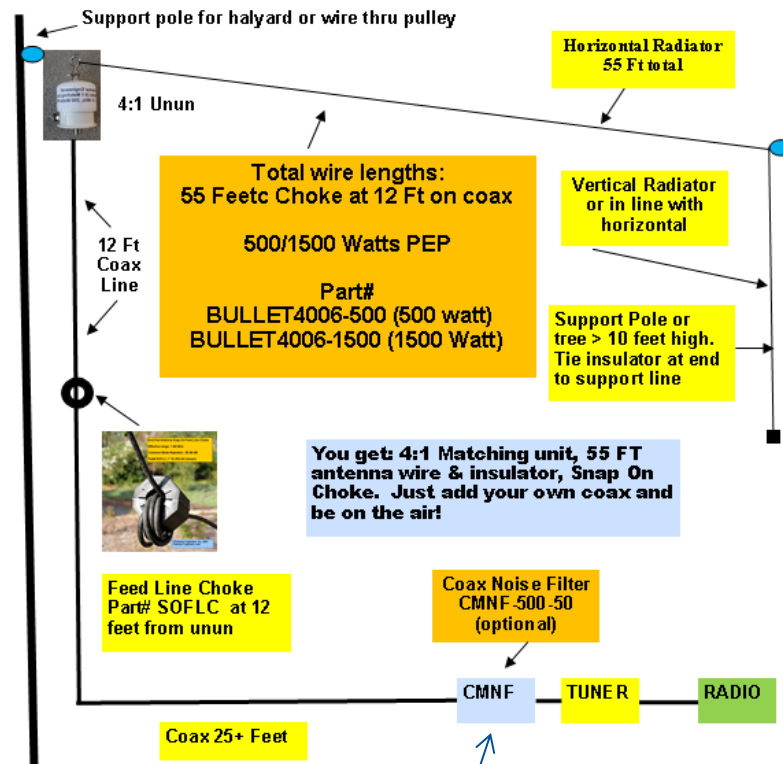
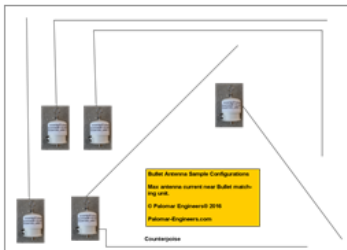
Coax feed line length > 25 feet

Feed Line Choke installed at 12 feet from matching unun

© Palomar Engineers® 2016-2023

Palomar-Engineers.com

## Other Possible Configurations



## NOTES:

If coax > 50 Ft or runs close to noise sources, consider a coax noise filter to reduce common mode noise received by coax braid.

Do a simple test.....

Coax Noise Filter

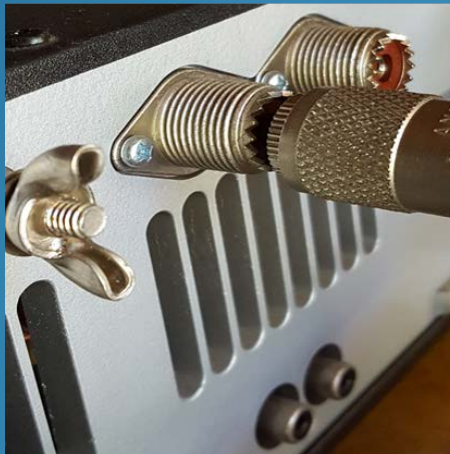


Receive RFI Solution

# Install Coax Noise Filter to Suppress RX RFI

Less common mode noise current (RFI) = More DX!  
How to select and install filters for maximum effect

Quick Test  
for Common  
Mode RFI



Coax Center Conductor Only—measure  
noise level



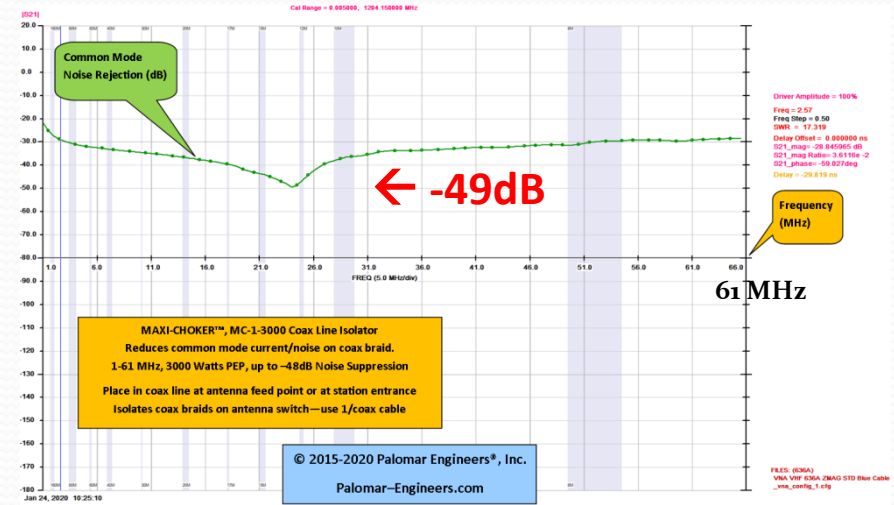
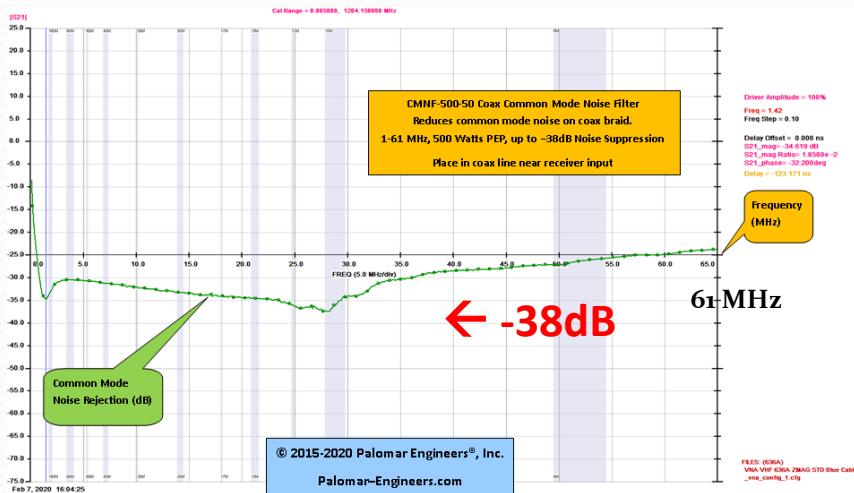
Coax Center Conductor and outer shield —  
measure noise level. If higher, then you have  
common mode noise

Power Options



# Choose choke with CMRR > 20 dB over frequency range used

CMRR =  
Common Mode  
Rejection Ratio



## Coax Noise Filter (CMNF-500-50)

1-65 MHz >2K  
500 Watts PEP, Up  
to 38 dB reduction  
(6 “S” units of  
common mode  
noise gone!



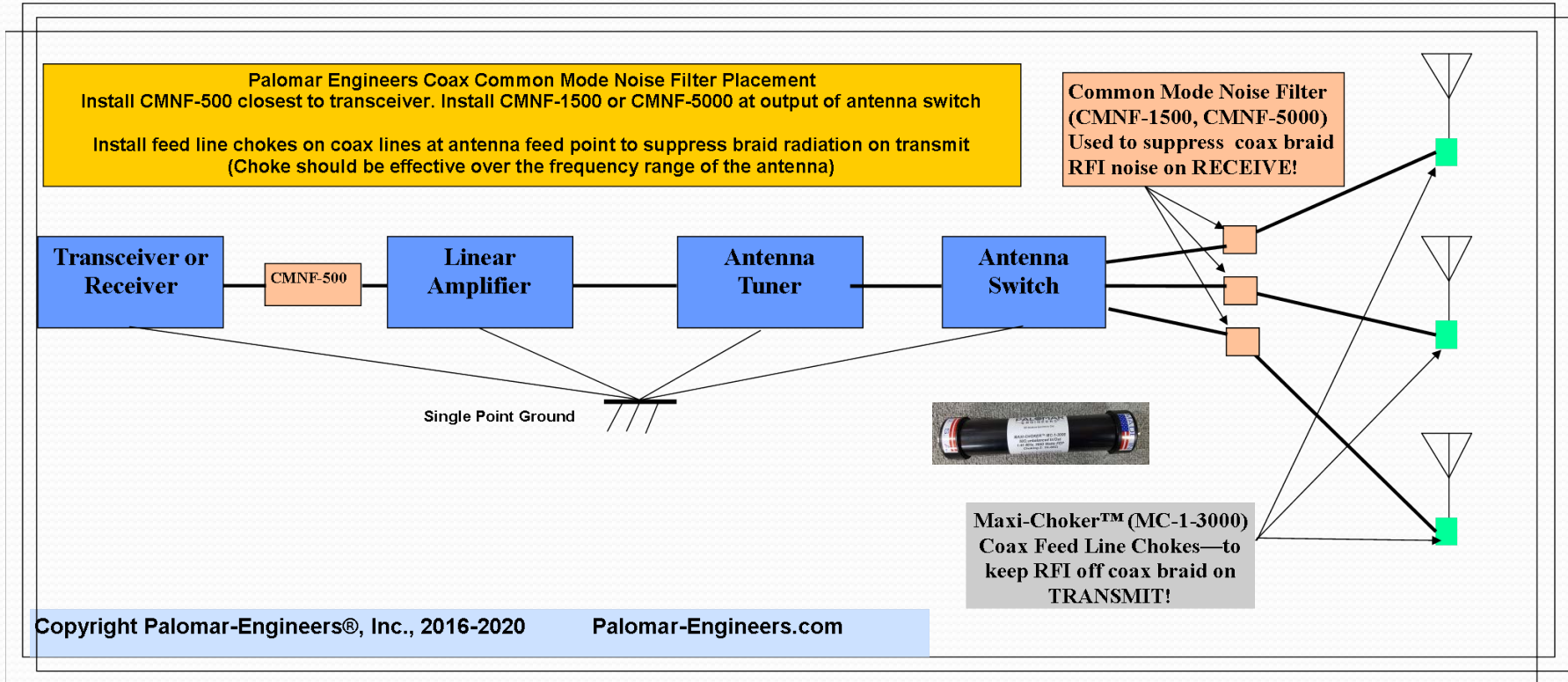
## Line isolator (part# MC-1-3000 - 3KW PEP)

1-61 MHz >2K, 3KW PEP, 1K-6K ZΩ, 1 pound. All coax lines,  
Optional ground, static bleeder, up to 49 dB suppression!

1 “S” unit = 6 dB, 36 dB = 6 “S” units

**DO NOT BUY CHOKES with NO SPECS!**

# Coax Noise Filter Installation



## Where to Install

- Choke at antenna for TRANSMIT RFI
- Noise Filter at Antenna Switch for RECEIVE RFI
- Between Transceiver and Amplifier
- Single point ground system

Antenna Switch Solution

# Antenna Switch Noise Solution

**ANTENNA SWITCH PROBLEM**  
During RECEIVE, you have 2 RECEIVE antennas per coax: the signal down the center of the coax + the signal picked up by the outside braid of the coax and they COMBINE at the coax connector unless suppressed by a coax noise filter! All coax braids are connected at the switch so you may be hearing noise from the braid of an unselected antenna! Use filters on each coax line before the switch!

**TRANSCIVER OR  
LINEAR  
AMPLIFIER**

**Antenna  
Switch  
(only switches  
center conductor)**

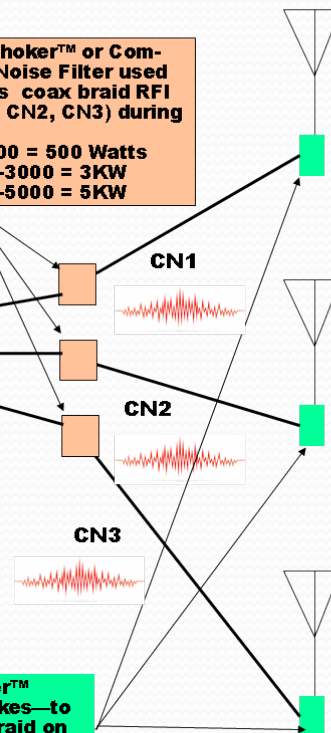
**If no common mode noise filters,  
noise = CN1+CN2+CN3 regard-  
less of antenna switch position!**

**You always have 4 antennas—1  
center and 3 braids!**

**CN1=common mode noise on co-  
ax braid 1, etc.**

**For common mode and  
RFI solutions contact  
Palomar-Engineers®.com**

**Mini/Maxi-Choker™ or Com-  
mon Mode Noise Filter used  
to suppress coax braid RFI  
noise (CN1, CN2, CN3) during  
RECEIVE!**  
MC-1-500 = 500 Watts  
MC-1-3000 = 3KW  
MC-1-5000 = 5KW



**Mini/Maxi-Choker™  
Coax Feed Line Chokes—to  
keep RFI off coax braid on  
TRANSMIT!**  
MC-1-500 = 500 Watts  
MC-1-3000 = 3KW  
MC-1-5000 = 5KW



500 watt Mini-Chokers



Coax Braid Isolators



# Solving End Fed Antenna RFI Problems

Stop Transmit RFI  
Reduce Receiver RFI noise





# Typical RFI Solutions

- Keep antenna (and coax) away from house wiring including AC power, Cable/Satellite feeds, telephone lines as these wires can act as receive “antennas” and overload attached electronics OR these “antennas” can transmit spurious signals (and noise) to your antenna and coax giving a high noise floor.
- Use Palomar RFI kits to solve RFI interference or noise issues in your own home or neighbor’s. See website for specific electronic device details.

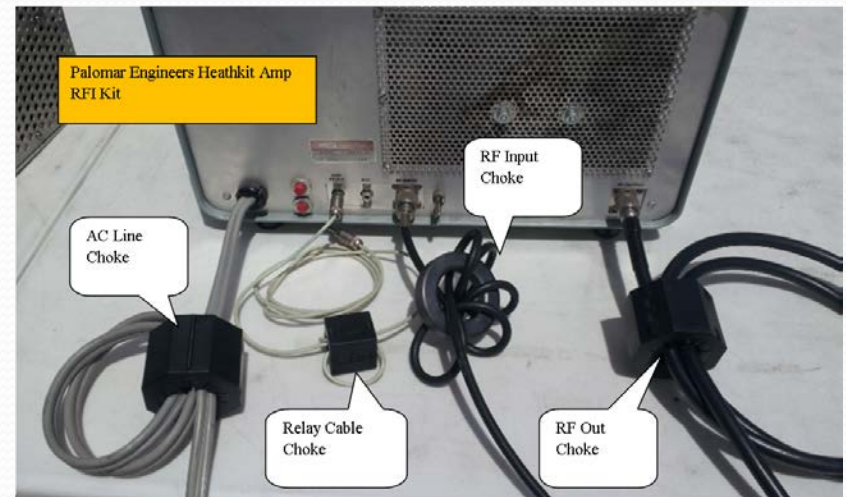
# Transceiver/Amp RFI Kits

Palomar RFI kits for all brands of transceivers and amplifiers

## Transceiver RFI Kit



## Linear Amplifier RFI Kit



**RULE # 1: Clean up your transmitter & amp RFI first!**

Neighbor's RFI

# Neighborhood RFI Solutions

## MY HOME or NEIGHBOR'S HOME



**ALARM SYSTEM RFI**



**HOME THEATER RFI**



**COMPUTER RFI**



**MISCELLANEOUS RFI**



**GARAGE DOOR**



**TELEPHONE/DSL RFI**

**Recommendation:** Use RFI kits for specific problems, have neighbor purchase and install – DO NOT make mods to neighbors equipment! MOST problems are RFI picked up by AC power/phone lines so ferrite filters work well.

Receive RFI Solution

Transmit RFI Solution

# Use Ferrite Combo RFI Kits for Newbies

Ferrite Combo Kits for Troubleshooting Multiple RFI Issues include multiple ferrite shapes and sizes

or

**½” ID snap-ons and 1.4” ID rings are the most popular sizes and can be used to solve most ham radio HF RFI problems**



**Buy 9  
Get 1  
FREE!**



Use Discount code “NEWBIE” – get 10% off orders thru 12/31/2023

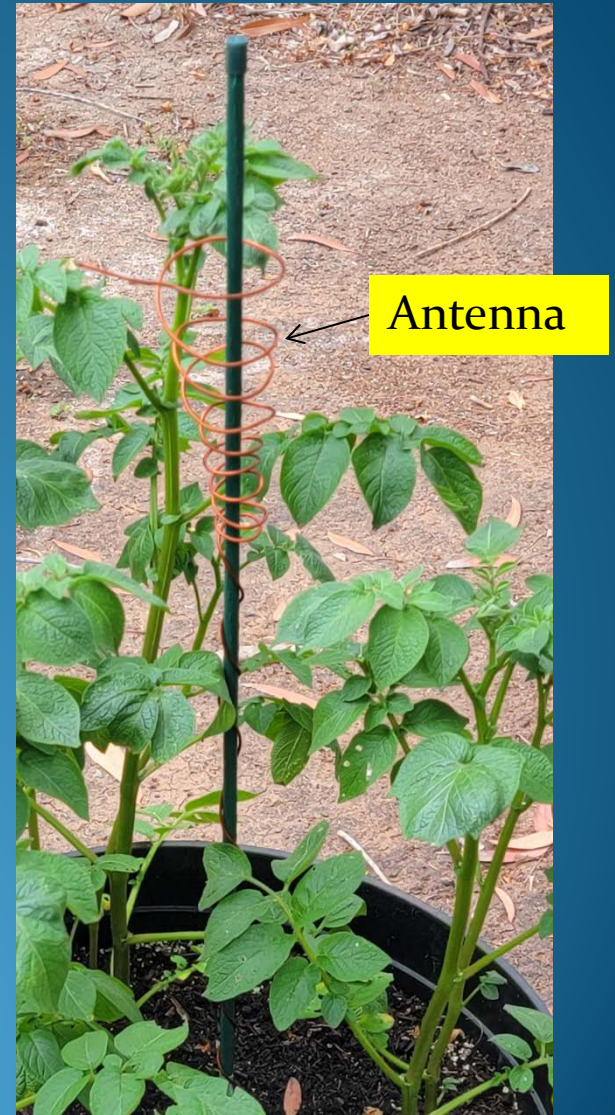
Surprise Topic



# Electroculture

## Antennas for Plants!

Faster Growth  
Healthier Plants  
Larger Fruits & Vegetables  
No fertilizer needed  
Easy DIY Project



# WHAT IS ELECTRO-CULTURE?

- **HOW DOES IT WORK?**
- Electroculture is “a method of applying atmospheric electricity to the fertilization of plant life”, which is said to increase and improve yields “utilizing certain materials to harvest the earth’s atmospheric energy”.
- Using a **conductive material** such as iron \*, copper, zinc or brass, it is possible to capture the atmospheric electricity of the air, the sun, the wind, the rain, the clouds, and the cold and frost, transform that into energetic electricity and transfer it into the soil. This energy has been shown to help soil fertility, plant growth and development, amplify yields, combat frost and excessive heat, reduce irrigation, protect plants from pests and diseases, and increase the soil’s nutrients.



# Sample Results



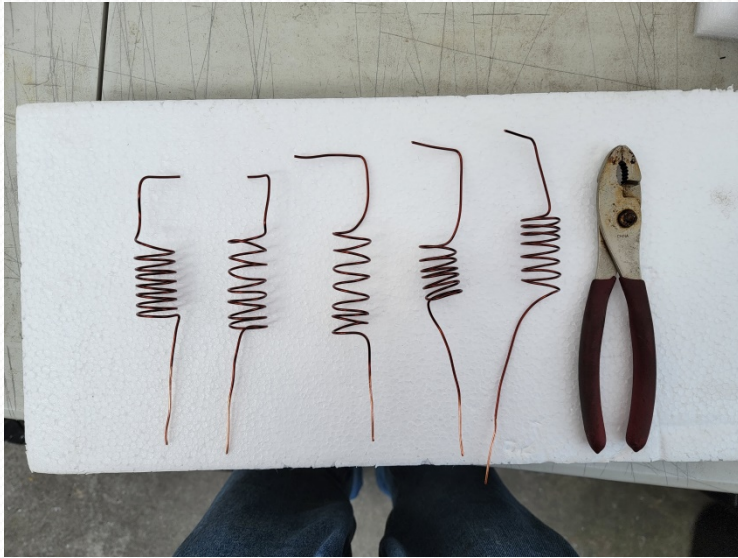
Potatoes at 2 weeks



Potatoes at 4 weeks – WOW!



# Simple to make & use



## Electroculture Antenna Installation

Place antenna south of the plant.  
Point straight wire at top of antenna  
toward magnetic north

Insert antenna 4-6 inches in soil.

Sit back and watch for additional  
growth – water as usual

The Plant Antenna Guru

**Do your own research** – technology an offshoot of Tesla science - early 1900's!

Check our website for more info

# RFI Solutions Experts



**RFI Solutions from KHz to GHz**

- Website: [www.Palomar-Engineers.com](http://www.Palomar-Engineers.com)
- Email: [Sales@Palomar-Engineers.com](mailto:Sales@Palomar-Engineers.com)
- Phone: 760-747-3343
- Bob Brehm, AK6R – Chief Engineer
- This presentation available on the website.