PALOMAR ENGINEERS®

RFI Solutions from KHz to GHz

Ham Radio Antenna Application Notes

BULLET End Fed Long Wire Antenna

Antenna Tip Sheet 2024

Need a high performance, multi-band, stealthy antenna system that is easy to setup and use? Get the Bullet-9 matching unit, the antenna wire and insulator all in one convenient package (great for HOA restricted areas, camping and portable operations) and remember to add the feed line choke.

One of the most popular antennas today is the end fed long wire due to its ease of installation, portability and stealth in various installations. It can be a condo dweller's only access to the world of ham radio or the best alternative for a backpacking SOTA (Summits on the Air), NPOTA (National Parks of the Air), mountaintop expedition, field day or portable outing. Excellent performance for permanent installations.

The antenna is simple to deploy, folds up easily for transport, and weighs under a pound, yet, with the 71 foot included wire, can work the 80-10 meter bands easily with the built in antenna tuner of most current day transceivers.

The 41 foot Backpacker Bullet antenna is super compact, uses a coax counterpoise allowing 40-6 meter operation and the whole antenna kit fits in a small bag! Get the longer 155 or 173 foot antenna to work the 160 meter band too!

The key to the antenna's success is the very efficient proprietary antenna matching unit between the long wire antenna and the coax feed line to the transceiver. The Bullet-9U-500 antenna matcher employs a dual core broadband transformer for wide bandwidth (1.8-61 MHz), a conservative 500 watt PEP rating, an easy on/off antenna wire connector, a connection for an optional wire counterpoise, and a SO-239 female coax connector for easy attachment of 50 ohm coax cable. Note: Bullet may naturally rattle when shaken due to an internal frequency compensation bead on the output lead to the top eyebolt.

BULLET-9U Matching Unit

Our antenna matching network is called the "Bullet" because of it shape and its effectiveness at taking down or contacting distant (DX) stations all over the world under the right conditions.

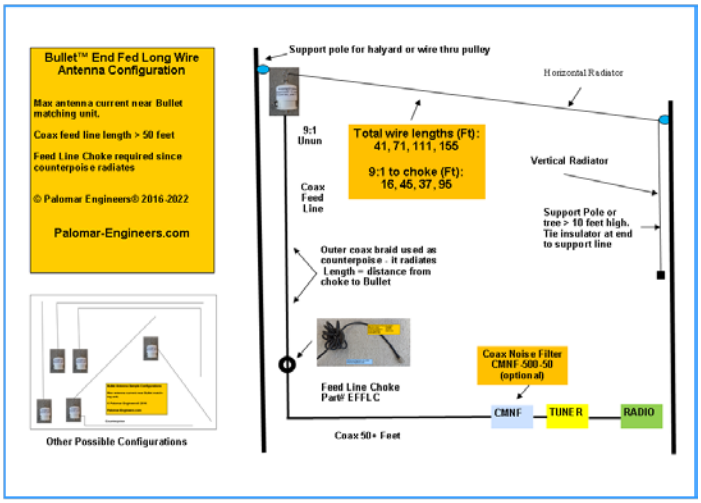
We sell the Bullet matching unit separately as the Bullet-9U (1.8-61 MHz) or 9LF (.02-30 MHz) for VLF use down to 200 KHz. Simply add you own wire (see table of suggested lengths below) or you can purchase a complete antenna system including Bullet, antenna wire, end insulator and required coax feed line choke. The matching unit is available in 100/500/1500/5KW PEP.

For best results we recommend the suggested minimum coax feed line lengths on the next page since the coax braid is used as a radiating counterpoise in addition to any external counterpoise off the side terminal on the matching unit. DO NOT GROUND THE RADIATING COUNTERPOISE OR THE SIDE TERMINAL! The coax feed line choke can be a simple ferrite ring (Part# EFFLC) with 8-10 turns of RG-8X coax line or a large diameter snap on choke (Part# SOFLC) with 5 turns of RG-8X for power levels of 1500 watts or use the F400-31 4" ring for ½" coax cable. Choke distance is measured from the Bullet-9U per the table in this report. We also recommend a coax noise filter (Part# CMNF-500-50 for 500 watts) at the radio end of the coax feed line to suppress RFI common mode noise in the radio.

Installation

The Bullet antenna wire can have many configurations. For best results, extend the antenna wire horizontally or as an "L" (horizontal "tail" with vertical matching unit end drop). The antenna may also be deployed as a sloper with the Bullet matching unit at the top (best) with the wire sloping toward the ground (with the end high enough to avoid contact by humans or animals), or at the bottom of the sloper with the antenna wire rising to a higher point. A typical setup which has proven successful in many portable installations is shown below:

Typical Antenna Configurations:



Antenna Length Modifications

For best results, chose a length from the table below as these lengths will form a non-resonant antenna for the mid-point of the amateur bands indicated. The antenna length should NOT be ¼ or ½ wavelength on any frequency that you transmit as the impedance will be very high (or low) and will not transfer through the matching unit at favorable impedance (high SWR) to your antenna tuner. The theory of the antenna length is to make the antenna non-resonant on any amateur band so that the impedance at the antenna side of the matching unit is in

the range of 400-600 ohms and when divided by 9 will be under 3:1 and easily in range of your transceiver antenna tuner.

Any length of 52 ohm feed line ok (50 feet minimum for 80 meter operation) but longer feed lines over 50 feet may show reduced SWR on some bands due to soil conductivity, nearby objects, etc. Due to local ground conditions, antenna height and feed line length, SWR may vary and an antenna tuner may be required or some bands to bring SWR at end of feed line to acceptable levels. 100 feet coax needed for 160M.

Use a good quality 50 ohm cable adequate for the power level of your station. The Bullet-9U-500 matching unit is conservatively rated for 500 watts PEP for SSB or 375 watts CW/digital. If the matching unit becomes warm to the touch after transmitting at high power, reduce the power output or the internal matching unit may be damaged.

NOTE: The matching unit output is DC grounded to bleed off static electricity, however it is not RF grounded as the RF signal (at the coax connector) will see approximately 1/9 of the antenna impedance on the antenna terminal of the matching unit. DO NOT CONNECT THE BULLET-9U SIDE TERMINAL TO GROUND!

Suggested wire lengths for 1.8-61 MHz operation (measured from Bullet wire terminal):

Bands Covered (meters)	Wire Length (feet)	Counterpoise Length (FT)	Minimum Coax Length (FT)
40-6	41	16	25
80-40-30-20-17-15-12-10-6	71	42-50	50
80-60-40-30-20-17-15-12-10-6	111	37	50
160-80-60-40-30-20-17-15-12-10-6	155	95	100
AM, 160-80-60-40-30-20-17-15-12-10-6	173	80	100

For those operators who like to experiment, the following lengths of wire can also be used: 49, 55, 77, 92, 102, 141-148, 203, 218, 268. You will also have to adjust the counterpoise lengths in proportion.

Extending wire length of antenna. You have two choices: extend the current wire length with additional wire or take off the existing wire by loosening the wire nut on the halyard hoist and slipping out the fork spade lug from between the washers and replace with a new length of wire as needed. Make sure you choose one of the lengths shown in the above table so as not to have a resonant point in any of the ham bands which will cause a mismatch for the 9:1 unun. **DO NOT UNSCREW THE TOP HALYARD HOIST EYEBOLT FROM THE BULLET CASE AS YOU WILL NOT BE ABLE TO SCREW IT BACK IN!!**

Counterpoise Required

Ideal: In almost all cases you can use the outside braid of the coax feed line as the single counterpoise for this antenna. The counterpoise radiates just like the wire since it is "other part" of the off center fed dipole. See required coax lengths in the above table. You will need a feedline choke at the suggested length measured from the matching unit to tune the antenna for as many bands as possible as well as stop the flow of RF on the braid and prevent it from reaching your radio. You can tune the antenna by adjusting the position of the feedline choke on the coax cable.

In some cases a single counterpoise may not be sufficient to tune in one or more bands and an additional counterpoise can be added at the stud on the matching unit. Do not ground the counterpoise stud when using a counterpoise(s). Counterpoise wire(s) close to or laying on the ground may detune the antenna and require repositioning of the coax choke. Use of one or more random length counterpoise(s) connected to the counterpoise post of the matching unit may also improve antenna efficiency and reduce SWR on certain bands. The counterpoise should not be installed under the horizontal portion of the antenna for best results. Suggested counterpoise lengths are 20-100 feet depending on length of antenna (see table above). Counterpoises can be straight or zig-zagged but do not run directly under the antenna and do not ground it. Remember that the counterpoise radiates like the other half of a dipole, so raised counterpoises work better than low or ground mounted counterpoises. If your coax length is too short to act as a full counterpoise, use a separate counterpoise wire kit attached to the side stud of the matching unit and adjust the length by folding back any excess for best SWR on the bands.

Feed Line Choke Needed

Many different types of feed line chokes will work with the end fed antenna. The purpose of the choke is to stop the RF current on the outside of the coax braid at a specific distance which optimizes the total length of the antenna (counterpoise + wire portion = total length) for lowest SWR on as many bands as possible. **DO NOT FORGET TO USE A CHOKE AND DO NOT GROUND THE COUNTERPOISE OR THE ANTENNA WILL NOT TUNE CORRECTLY!**

Configurations

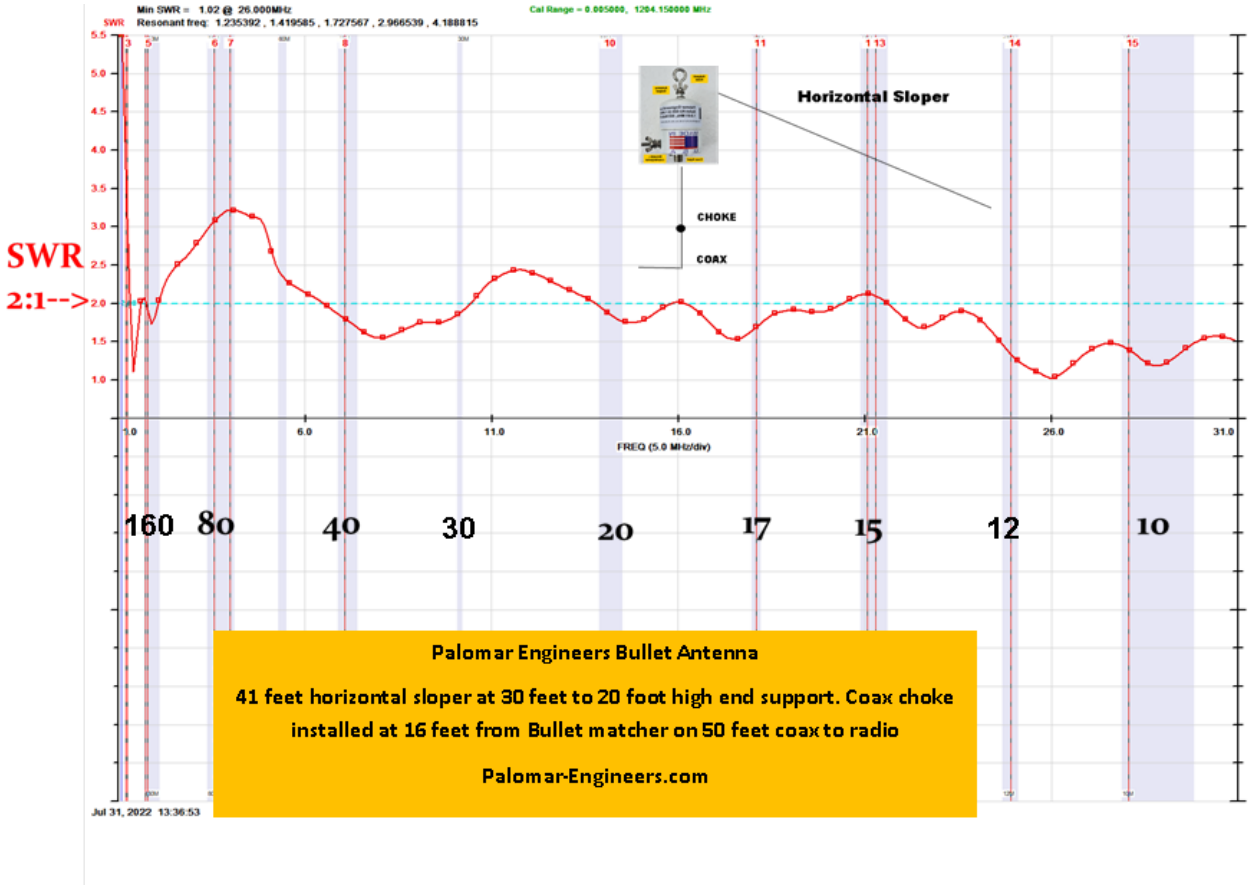
This antenna can be installed in a number of different configurations including vertical, high or low matching unit sloper, inverted L, inverted U. In general it is better to get the matching unit as high as possible since the antenna current is highest near the matching unit. Horizontal antennas and sloper antennas with the matching unit at the high end work particularly well since the radiating coax is also above ground. Radiation will be perpendicular to the wire on some bands and in-line with the wire on others depending upon the frequency of operation. Have fun and experiment with different configurations! Many different configurations and measured SWR curves are shown on the following pages.

Coax Noise Filter (500, 1500 and 5000 watts models available)

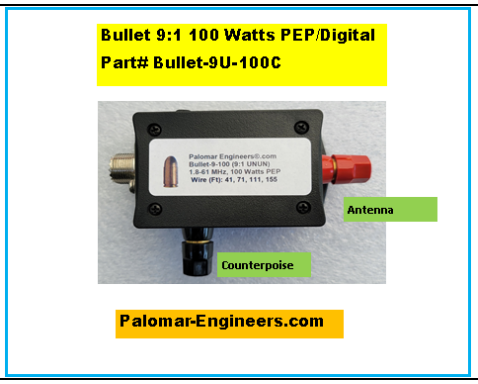
If the distance from the coax feed line choke is over 50 feet, it may be beneficial to use a coax noise filter which suppresses common mode noise picked up on the coax outer braid during RECEIVE operation. You hear this "noise" as a higher than normal noise floor when you connect the outside of the coax connector to your radio. Vertical antennas in general have a higher noise factor due to the vertical polarity nature of noise sources in the neighborhood.

A simple 500 Watt PEP, Common Mode Noise Filter (Part# CMNF-500-50) is pictured here. To install, simply connect the coax line from the antenna to one connector and add a small coax jumper from the other connector to your radio. You will still need a feed line choke at the appropriate distance from the matching unit unless the noise filter is installed at the correct distance. Coax noise filters are available in 500, 1500 and 5000 watt versions.

Bullet Backpacker 41 – all horizontal slope down from 30 feet to 20 feet. Coax choke at 16 feet from matching unit, coax noise filter installed at radio end of coax. No external counterpoise. May need tuner on some bands. Feed point at 41/(41+16) = 72% of total length.

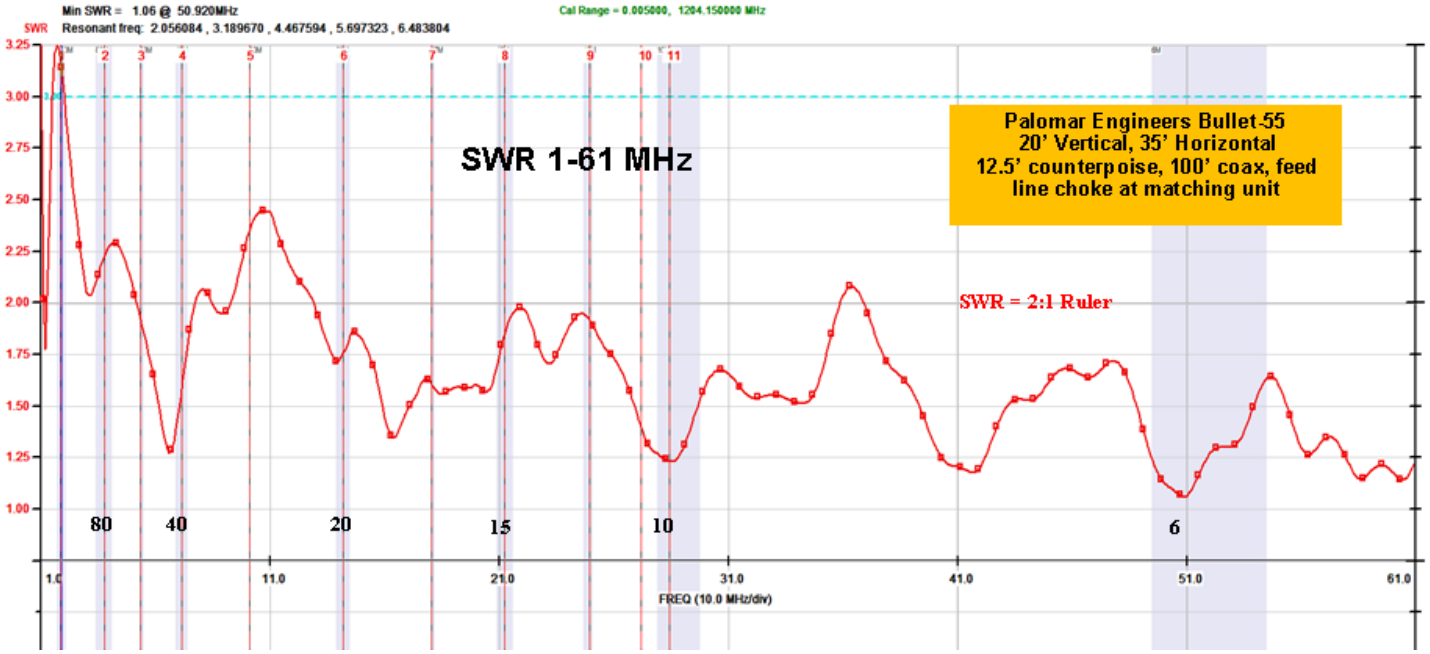


Bullet-41 application note: AK6R has used this antenna to work many countries on FT8 on all bands from 40-10 meters. Works very well as sloper and I am amazed how well it works on 30 meters into Europe from California during late afternoon into nightfall. I have used up to 280 watts on FT8 with this antenna for extended periods, but have also worked many contacts under 100 watts to test its effectiveness and I am very pleased with the configuration and simplicity of this installation between two trees. Great antenna for portable operations like NPOTA, SOTA, Field Day, etc., or for permanent installations like installing in an attic, under the eaves of a house, along a fence, etc. This is a short, effective and easy-to-hide antenna which gives a good account of itself on 40-6 meter bands.

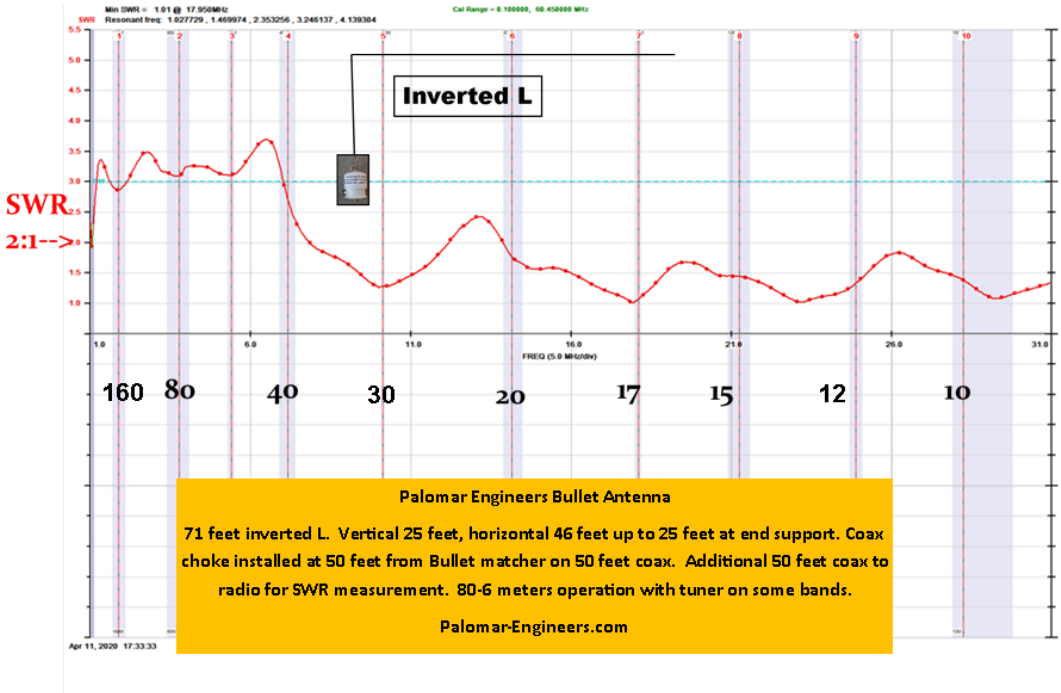


Revised 3/12/2024

Bullet 55 Inverted L - Vertical 25 feet, Horizontal 35 feet – 100 Feet coax, choke at matching unit (Bullet), Two 12.5 foot counterpoises wires – 180 degrees apart – you can adjust SWR response curve by adjusting length of counterpoise wires or their relative position to each other. Total antenna length = 55 + 12.5 = 67.5 feet. Feed point at 55/67.5 = 81% of total length.



Bullet 71 Inverted L (vertical 25', horizontal 46', Bullet-9U (2 feet above ground) – 100 Feet coax, choke at 50 feet from antenna feed point only – no separate counterpoises wires. Total antenna length = 71 + 50 = 121 feet. Feed point at 71/121 = 59% of total length



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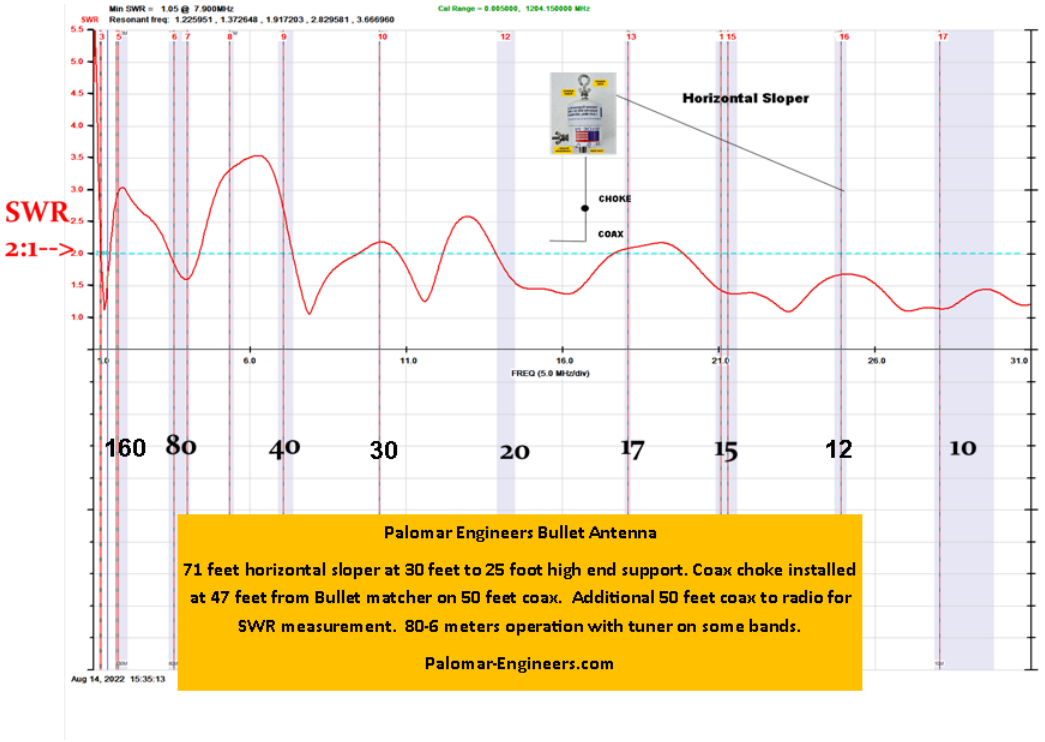
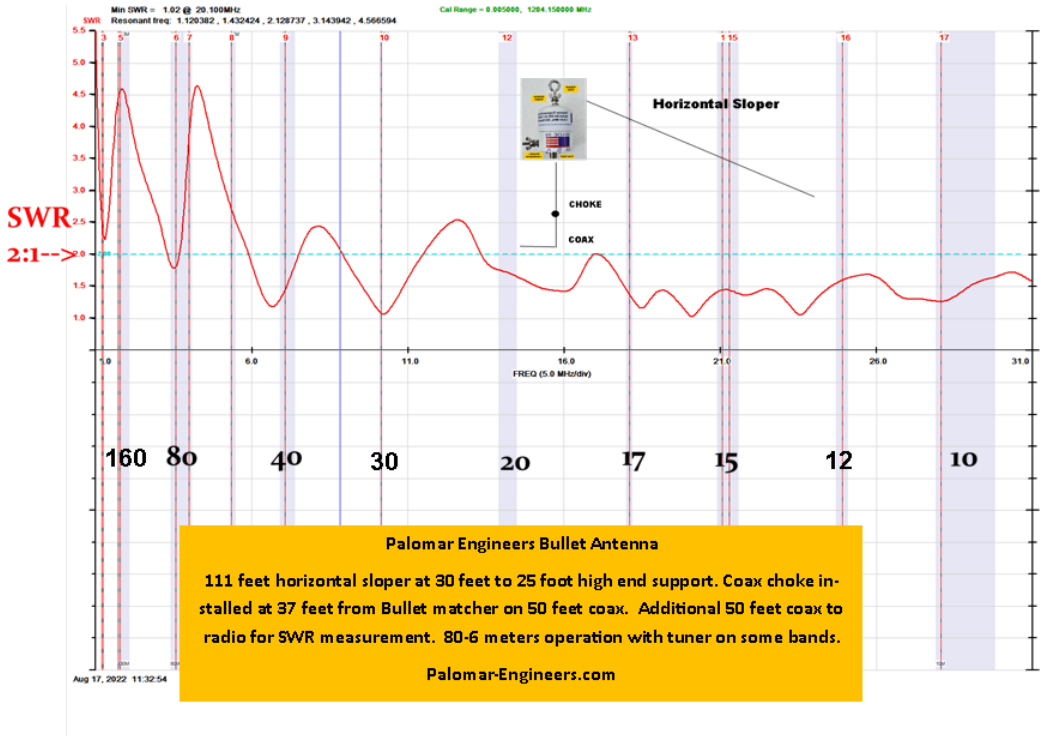
Bullet 71 all horizontal up 25 feet – 100 Feet coax, choke at 42 feet from antenna feed point only gives better 80 meter SWR – no separate counterpoise wires. Total antenna length = 71 + 42 = 113 feet. Feed point at 71/113 = 63% of total length

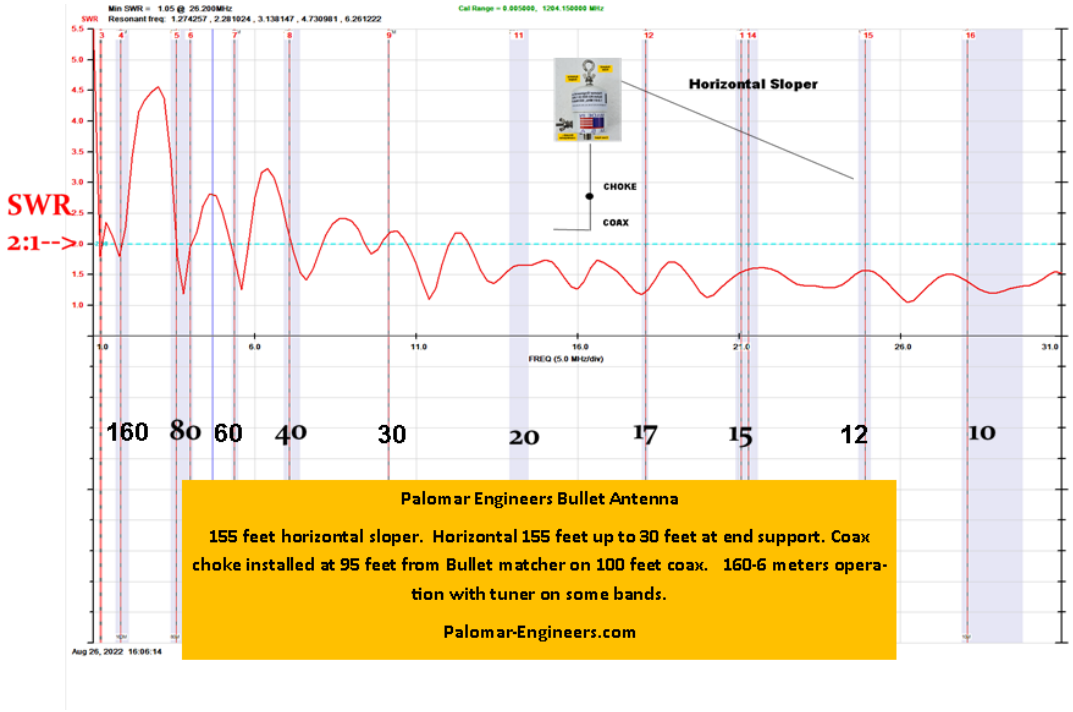


Bullet 111 horizontal sloper – 100 Feet coax, choke at 37 feet from antenna feed point only – no separate counterpoises wires. Total antenna length = 111 + 37 = 148 feet. Feed point at 111/148 = 75% of total length; coax braid counterpoise length is 25% and adjustable to fine tune with SOFLC.

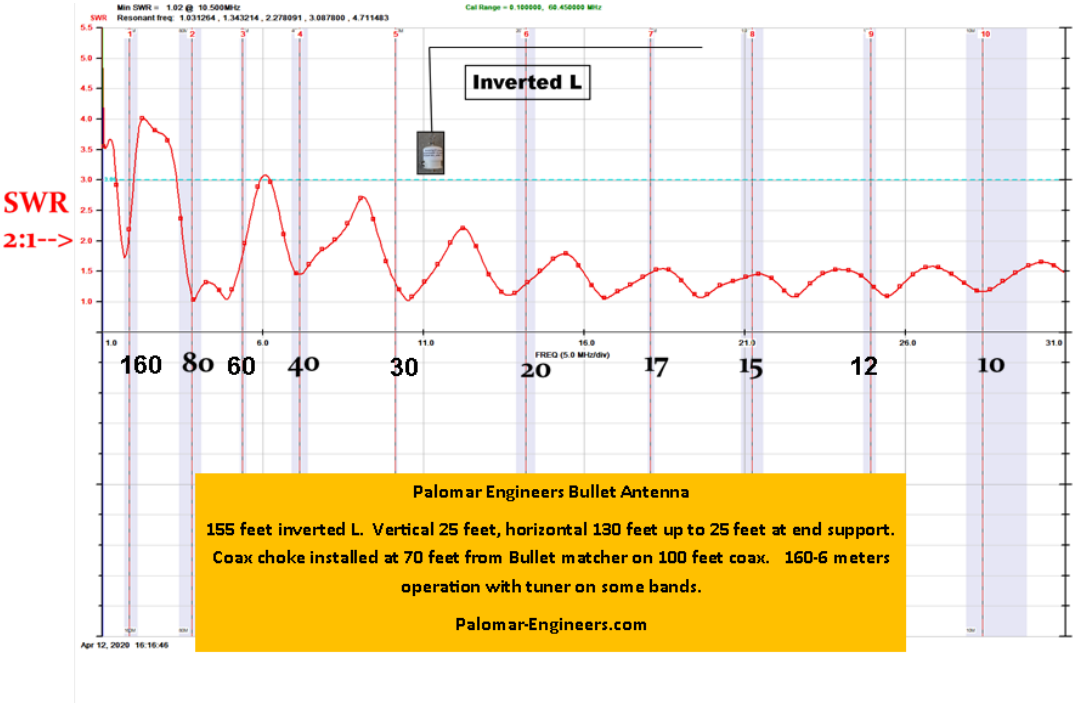


Revised 3/12/2024

Bullet 155 Horizontal Average height 30 feet – 100 Feet coax, choke at 95 feet from antenna feed point only – no separate counterpoises wires. Total antenna length = 155 + 95 = 250 feet. Feed point at 155/250 = 62% of total length; coax braid counterpoise length is 38%.

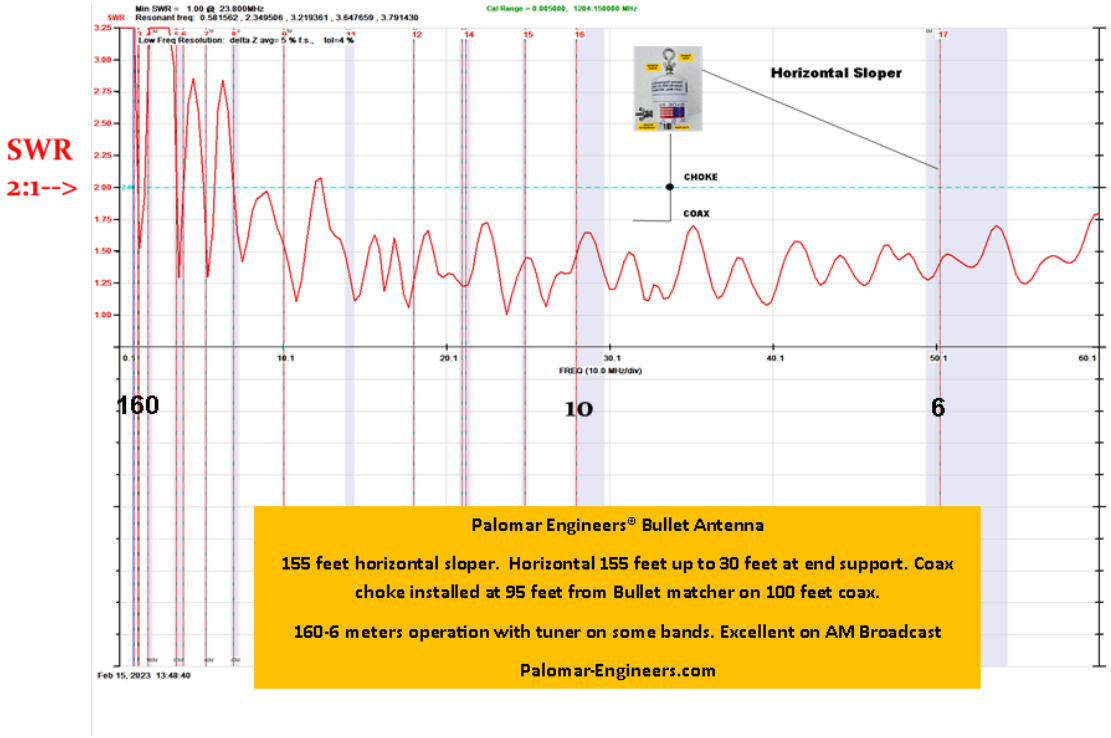


Bullet 155 feet inverted L. Vertical 25 feet, horizontal 130 feet up to 25 feet at end support. Coax choke installed at 70 feet from Bullet matcher on 100 feet coax. 160-6 meters operation with tuner on some bands.

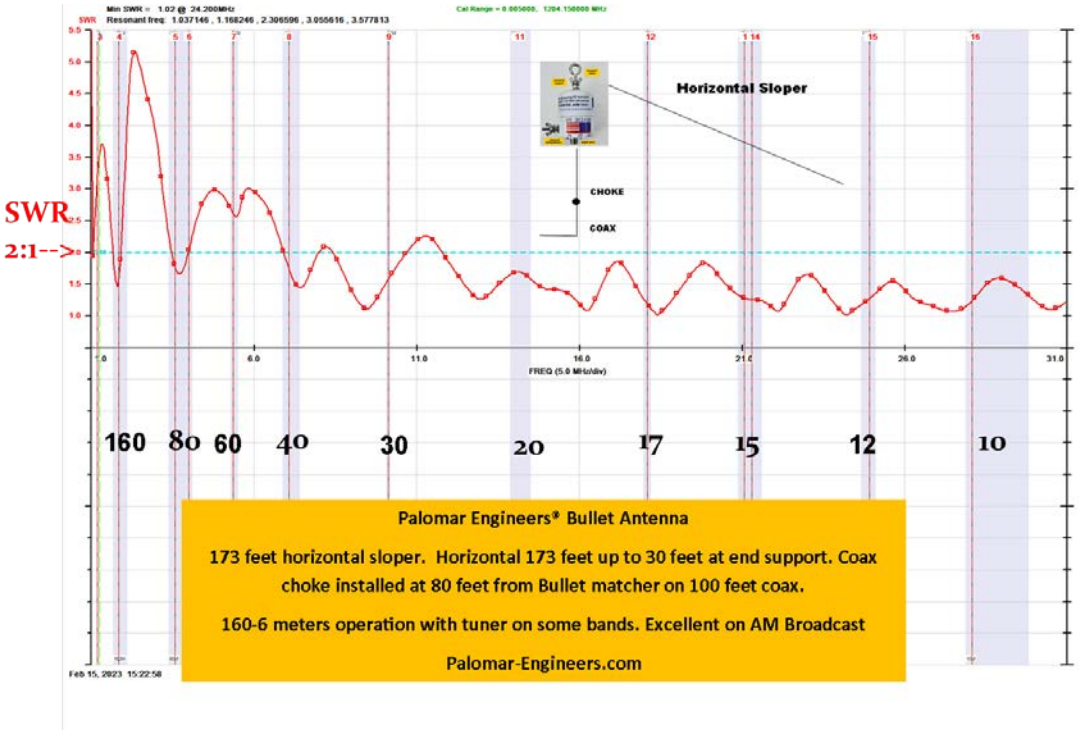


Revised 3/12/2024

155 feet horizontal sloper. Horizontal 155 feet up to 30 feet at end support. Coax choke installed at 95 feet from Bullet matcher on 100 feet coax. 160-6 Meter SWR



Bullet 173 Horizontal Sloper Average height 30 feet – 100 Feet coax, choke at 80 feet from antenna feed point only – no separate counterpoises wires. Total antenna length = 173 + 80 = 253 feet. Feed point at 173/253 = 68% of total length; coax braid counterpoise length is 32%. AM Broadcast reception very good.



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General Notes

For antennas over 71 feet, use 100 feet coax minimum and place choke in a position as shown in table below. This choke position will be a good starting point for tuning your antenna on the bands you want to operate. Here are some examples of actual antenna wire length and choke placement for the antenna SWR plots shown (units are in feet and % of total antenna length including counterpoise):

Antenna Wire length (feet/%)	**Antenna feed point to choke length (feet) starting point – fine tune distance for best results for your configuration(*)**	**Optional Wire Counterpoise Part#**	**Total Antenna Wire + coax length (feet)**
41 (72%)	16 (28%)	Bullet-CPK-41-20	57 (100%)
71 (63%)	42-50 (37%)	Bullet-CPK-71-50	113-121 (100%)
111 (75%)	37 (25%)	Bullet-CPK-111-50	148 (100%)
155 (62%)	95 (38%)	Bullet-CPK-155-100	250 (100%)
173 (68%)	80 (32%)	Bullet-CPK-173-100	253 (100%)
203 (72%)	80 (28%)	use 37 Ft CPK to fine tune some bands	283 (100%)
65% Avg	35% Avg		100%

(*) - Choke measurement is from antenna feed point at 9:1 unun coax connector to choke.

The “Bullet” End Fed Antenna Optional Counterpoise Kit

The counterpoise kit contains 1 pre-assembled counterpoise wire which easily attaches to the counterpoise connector on the BULLET matching unit for 500, 1500 and 5KW PEP. Improves performance on 1 or more bands. Black/Gray/Blue wire is standard.

Application Note: This kit is typically used with only with Bullet Antenna systems like the 41 foot, 71 foot and 111 foot or 155 foot when you DO NOT USE the coax braid as the counterpoise (such as when you coax is too short). This counterpoise radiates just like the other half of a dipole so DO NOT GROUND IT! It is used to fine tune particular bands (by varying the length to get the lowest SWR reading on as many bands as possible. Multiple length counterpoises can also be used if needed for a particular band) if your particular antenna geometry doesn't show a low enough SWR on a particular band.

Suggested coax braid length to choke or optional wire counterpoise lengths are as follows:

41 foot antenna wire needs a 16 foot counterpoise (20 feet of wire supplied - adjust as needed by folding back on itself)

71 foot antenna wire needs a 42-50 foot counterpoise (50 feet of wire supplied - adjust as needed by folding back on itself)

111 foot antenna wire needs a 37 foot counterpoise (50 feet of wire supplied - adjust as needed by folding back on itself)

155 foot antenna wire needs a 95 foot counterpoise (100 feet of wire supplied - adjust as needed by folding back on itself)

173 foot antenna wire needs a 80 foot counterpoise (100 feet of wire supplied - adjust as needed by folding back on itself)

Note: you can use multiple counterpoises to fine tune multiple bands – just attach additional counterpoises to the side stud on the matching unit (**WHICH IS NOT TO BE GROUNDED or BURIED**). Keep counterpoises away from metal objects for best results.

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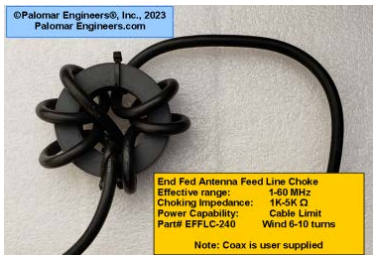
Feed Line Choke Options

Use Feedline choke EFFLC or SOFLC for RG-8X size cable or choke F400-31 for larger ½" coax. Coax position of feed line choke is measured from the 9:1 matching unit back to the radio station. Use of snap on chokes makes initial position adjustment easy and fun. If you use ½" size coax, get at least 6 turns through the large F400-31 ring to ensure enough choking on the 80 and 160 meter bands.



EFFLC (RG-8X coax shown not included) – wind 6-10 turns with cross over – up to -30 dB suppression, 1.5KW PEP

SOFLC - Snap On Feed Line choke (works on RG-8X (6 turns) or RG-8 (3 turns) up to 38 dB suppression, 1.5KW PEP

Super-Choker™ SC-1-5000 (5KW PEP) – up to -48dB suppression or Order F400-31 Ring and use your ½" coax

Coax Noise Filters

<u>Do you have common mode noise on your coax?</u>

Make this simple test to find out.

Coax Center Conductor Only—measure noise level

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

1. Remove the coax connector and measure the noise level.
2. Now insert the coax connector CENTER CONDUCTOR ONLY into the SO-239 antenna input and measure the noise level (it should be higher and include possible signals)
3. Now connect the OUTER SHELL of the coax connector to the antenna input and measure the noise level. If it is higher you have common mode noise and the common mode noise filter will help suppress this noise which is carried on the outside of the coax braid (acting as a second receive antenna).

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Common mode noise suppression with the CMNF series of filters is typically 25-36 dB which is equivalent to 4-6 “S” units on radios with 6 dB/”S” unit or may be more on radios with 3dB/”S” unit.

Note for antenna switch users, perform the above test on each antenna coax lead separately to determine if that particular antenna braid is contributing noise to the receiver – use a coax noise filter on the antennas that have common mode noise.

 Mini-Choker™ MC-1-500-50 (500 watts PEP) – up to -38 dB suppression	 CMNF-1500 (1.5KW) – wall mounting– up to -38 dB suppression	 CMNF-5000 (5KW) – wall mounting – up to -38 dB suppression

INSTALLING THE ANTENNA

	**Split wire pulleys are very useful for installing free running antenna wire. Use a halyard hoist on first pulley carabiner and free run the wire from the matching unit thru the first and any additional pulleys. Support the wire every 50-75 feet thru a pulley (and separate halyard hoist/support attachment to the carabiner part of the pulley) and the antenna will be much easier to raise and maintain in the future.** **Part#: Pulley-1.75**
	**Parachord – use continuous large loop with drop loop for pulley carabiner connection. You can get the parachord up into a tree by first using a fishing pole and fishing line and sinker to rerach a limb. Then attach the fishing line to the parachord and reel it over the branch and back down to ground and tie together using a square knot or other secure know. Then add a drop loop and attach the carabiner and pulley after securing the wire thru the split pulley. Raise the pulley and let the wire free flow thru the pulley. Attach the insulator at the end of the wire to another piece of parachord and and situate it at the desired location.** **Note: Picture showns antenna attached as downward sloper.** **Paracord Part#: Paracord-1/8-100 (100 feet)**

Modifying the Wire Length of the Antenna

You can add wire to the wire portion of your antenna to increase its length to a larger size. In addition to the wire length change, you will also have to change the counterpoise/choke position on the coax cable to match the corresponding length of wire (see table for specifics). For the wire you can add an additional wire and tie the wire and solder and cover with shrink wrap of tape. The coax cable can be extended with an additional 50 foot piece of cable and a double female barrel connector – both available from the company if needed.

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Tuning Your Bullet Antenna

The Bullet antenna configurations shown in this manual have been used successfully by many radio amateurs around the world, however your installation geometric shape, height, soil conditions, and coax cable length may be different and your SWR results may not match the ones shown or you may have a higher then wanted SWR on a particular band or bands.

So how do you tune the antenna for your installation? First start off with the suggested dimensions for the antenna wire and the choke placement distance from the matching unit and measure the SWR's on the various bands. This antenna is tuned by adjusting the placement of the choke (or length of the counterpoise wire used). Move the choke a couple feet at a time and see if the SWR for the band or bands improves. You can also add one or more parallel counterpoise(s) off the side stud on the matching unit for a particular band (s). to fine tune the antenna for particular frequencies.

Do not change the length of the main antenna wire, but rather change the position of the choke on the coax and/or add counterpoises as needed. They don't have to be straight just the correct length. Keep them away from the horizontal portion of the antenna so that the antenna radiation does not couple to the counterpoise lowering the radiation efficiency.

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

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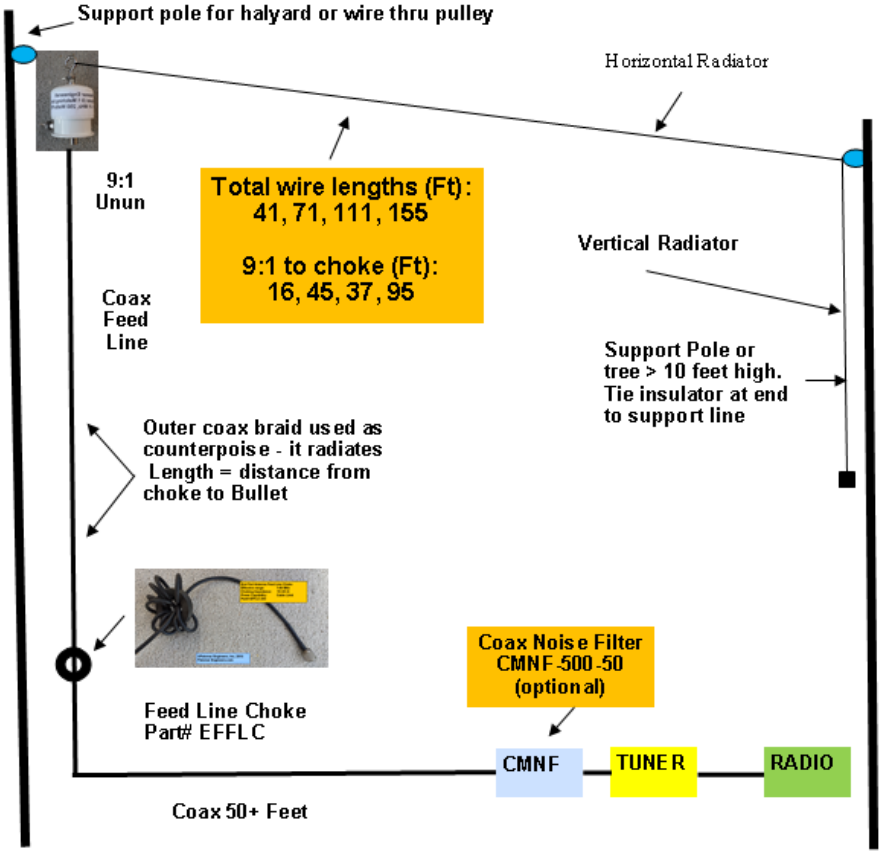
Other Possible Configurations



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Bullet Antenna Individual Components

PEP Power Rating	100 Watt (*)	500 Watt (*)	1500 Watt (*)	5000 Watt (*)
Feed Line Choke	EFFLC	EFFLC or SOFLC	SOFLC MC-1-1500	SC-1-5000
41' Wire + Insulator	BWK-41	BWK-41	BWK-41	BWK-41
71' Wire + Insulator	BWK-71	BWK-71	BWK-71	BWK-71
111' Wire + Insulator	BWK-111	BWK-111	BWK-111	BWK-111
155' Wire + Insulator	BWK-155	BWK-155	BWK-155	BWK-155
173' Wire + Insulator	BWK-173	BWK-173	BWK-173	BWK-173
Use Coax	RG-8X-50	RG-8X-50	RG-8X/RG400/RG-8/213/LMR400	RG-8/213/LMR400
Transformer (9:1)	Bullet-9U-100	Bullet-9U-500	SBullet-9U-1500	CU-9-5000 (5KW)
9:1 Unun Transformer Picture				

(*) Power rating are for SSB PEP, Digital (CW/FT8) rating are 50% of PEP ratings

Complete Bullet Antenna Systems

Item	100 Watt	500 Watt	1500 Watt	5000 Watt
Antenna Length (FT)	Part #	Part #	Part #	Part #
RG-8X-50	✓	✓	✓	
RG-400/-8/-213				✓
Transformer (9:1)	Bullet-9U-100	Bullet-9U-500	SBullet-9U-1500	CU-9-5000
Feed Line Choke	SOFLC	SOFLC	SOFLC	CU-1-5000SO
Order Part # (XX=41, 71, 111, 155, 173)	BAS-XX-100	BAS-XX-500	BAS-XX-1500	BAS-XX-5000

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