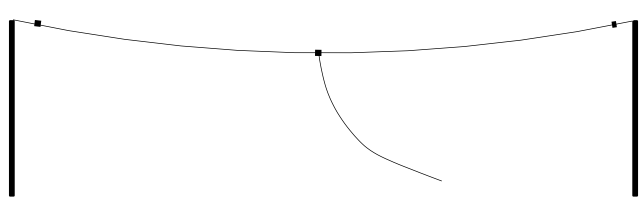
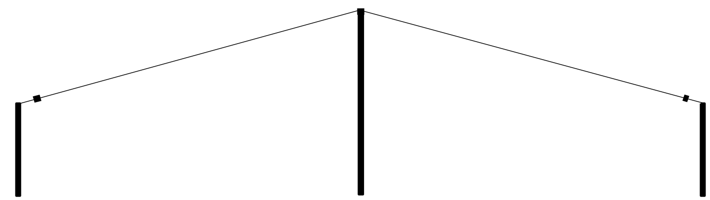
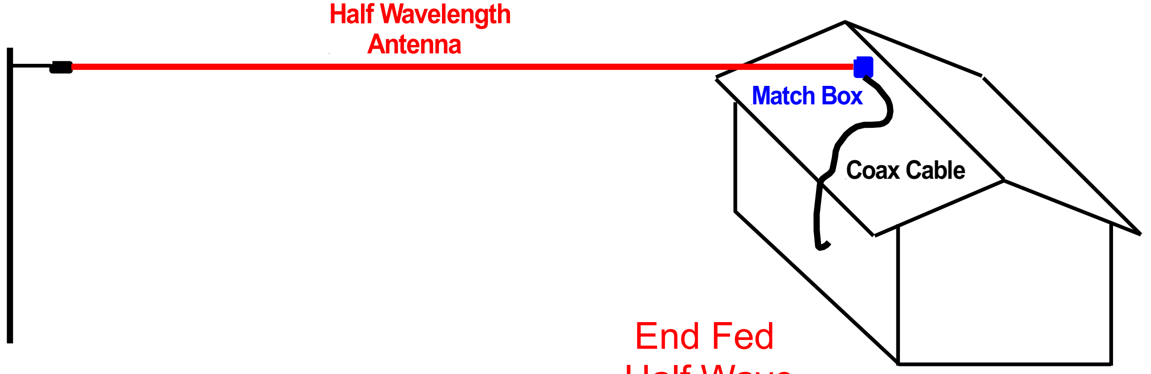
Easy Up Antennas



Horizontal Dipole



Inverted V

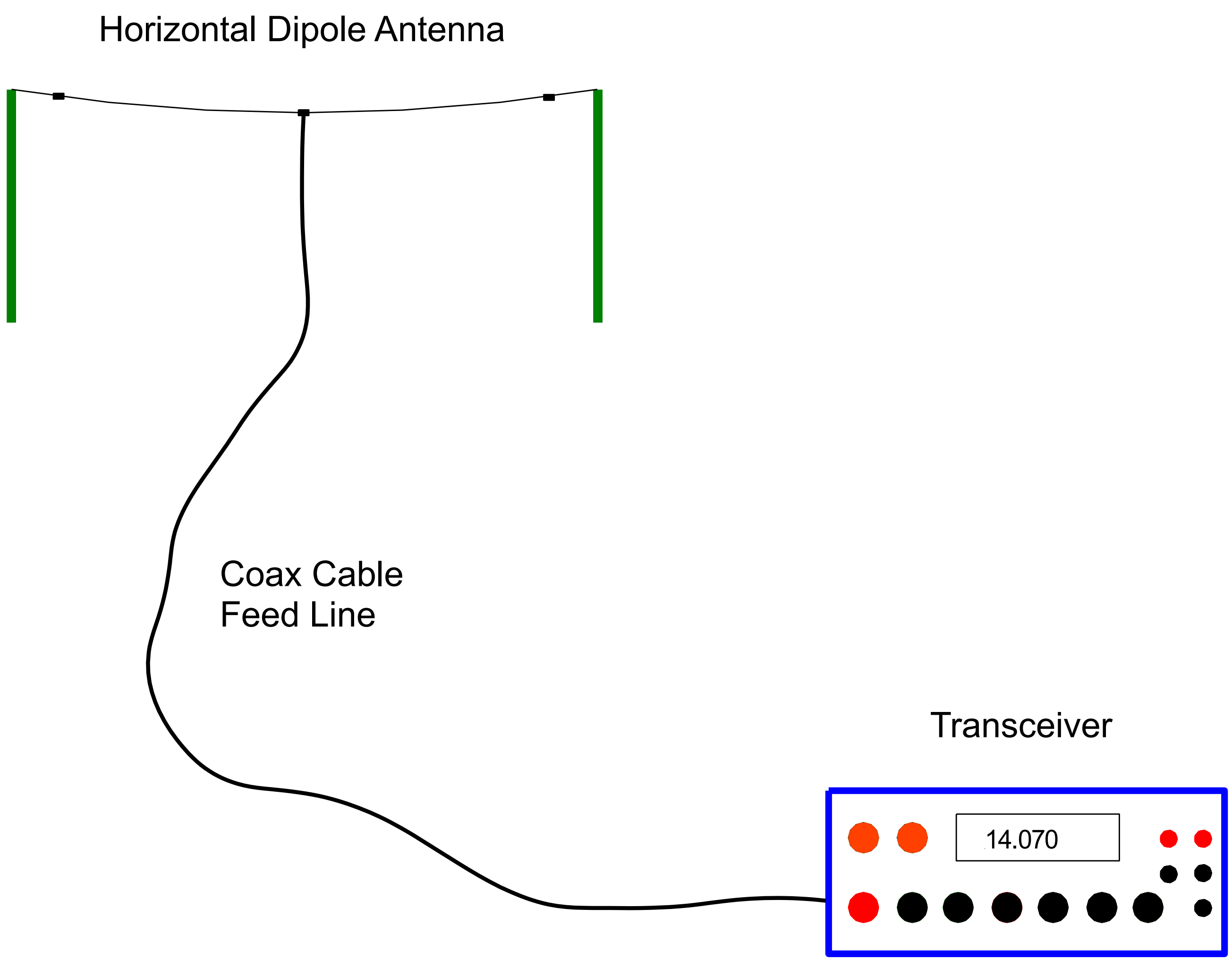


End Fed
Half Wave

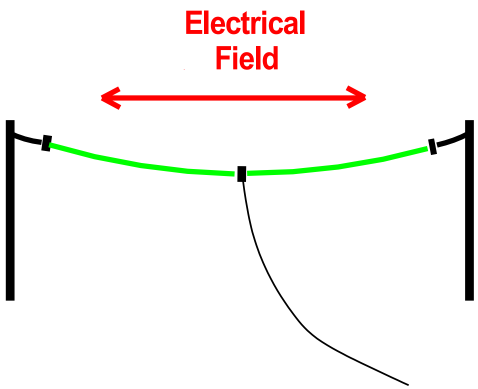
Ken Larson KJ6RZ
www.skywave-radio.org
January 2023

λ

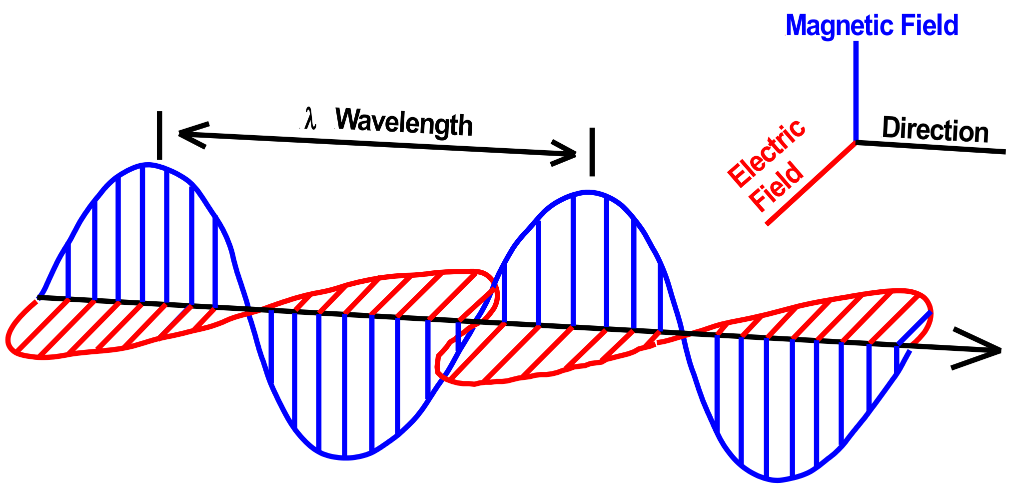
Center Fed Horizontal Dipole Antenna System



Polarization of a Horizontal Dipole

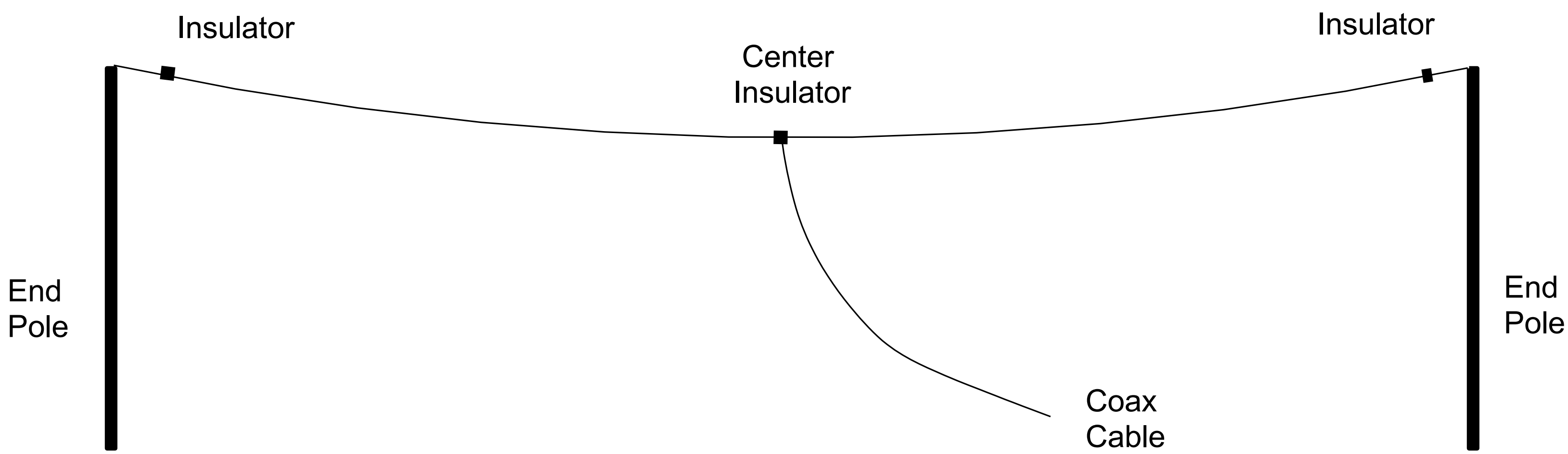


Horizontal Dipole Antenna



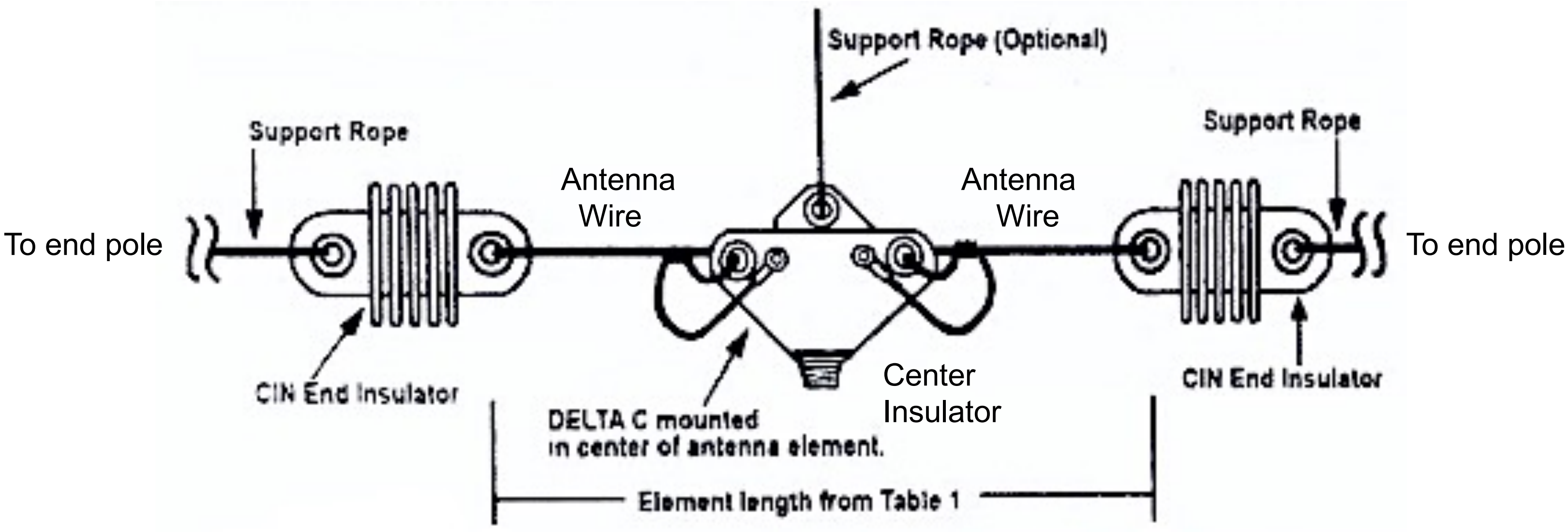
- A horizontal dipole antenna is horizontally polarized
- That is, the Electric Field component of the electro-magnetic wave radiated by a horizontal dipole is parallel to the Earth
- Notice that the Electric Field is in the same direction as the electrical current flowing in the antenna

Center Fed Half Wave Dipole Antenna



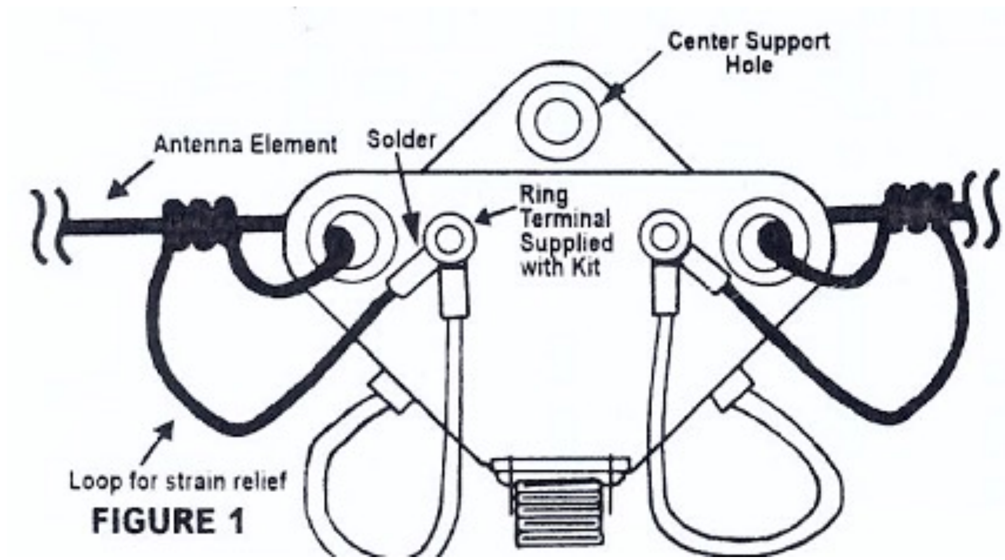
- A center fed horizontal half wave dipole is 1/2 wavelength long from one end to the other
- Insulators at each end isolate the antenna wire from the two supporting poles
- The center insulator connects a coax feed line to the antenna
- Each leg of the antenna is 1/4 wavelength long

Components Of A Center Fed Half Wave Dipole



- Coax Cable runs from antenna's center connector to radio shack
  - RG8X coax for typical HF installations
  - LMR400 low loss coax for long coax runs
  - Coax cable connector – Male PL-259
  - Antenna center connector – Female SO-239

Details of a Horizontal Dipole Center Connector



- Each antenna leg (black wire) feeds through one of the center connector's two strain relief eye holes & connects to the corresponding ring terminal
- A white wire connects the center pin of the SO-239 coax connector to one of the two ring terminals
- A second white wire connects the outer treaded part of the SO-239 connector to the other ring terminal

Half Wave Dipole Antenna Lengths

Band	Center Freq MHz	Length: 1/2 λ Feet	1/4 λ Leg Feet
		@ 0.95c / @ 0.9c	@ 0.95c / @ 0.9c
80	3.60	129.87' / 123.03'	64.93' / 61.52'
75	3.85	121.43' / 115.04'	60.72' / 57.52'
60	5.357	87.27' / 82.68'	43.64' /41.34'
40	7.15	65.39' / 61.95'	32.69' / 30.98'
30	10.12	46.20' / 43.77'	23.10' / 21.89'
20	14.17	33.00' / 31.26'	16.50' /15.63'
17	18.11	25.82' / 24.46'	12.92' / 12.23'
15	21.22	22.03' / 20.87'	11.02' / 10.44'
12	24.94	18.75' / 17.76'	9.37' / 8.88'
10	28.80	16.23' / 15.38'	8.12' / 7.69'

$$\lambda = \frac{vc}{f} = \frac{v \cdot 300\ Mm/sec}{f\ MHz}$$

$\lambda = wavelength$
c = speed of light
v = velocity factor
f = frequency

Antenna Wire

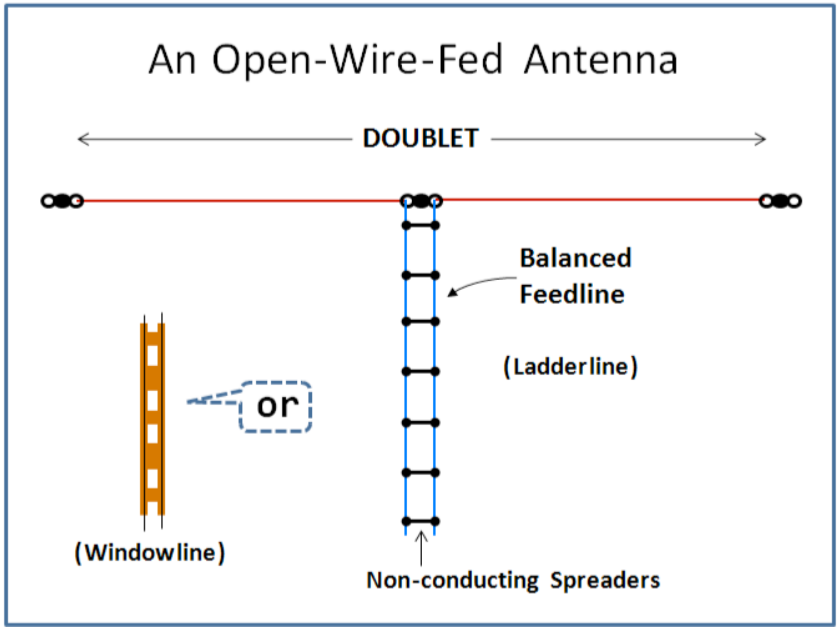
Bare Copper Wire velocity factor v = 0.95

Insulated Wire velocity factor v = 0.90

c = speed of light = 300 mega-meters per second

Insulated wire antenna a little bit shorter than bare copper wire antenna

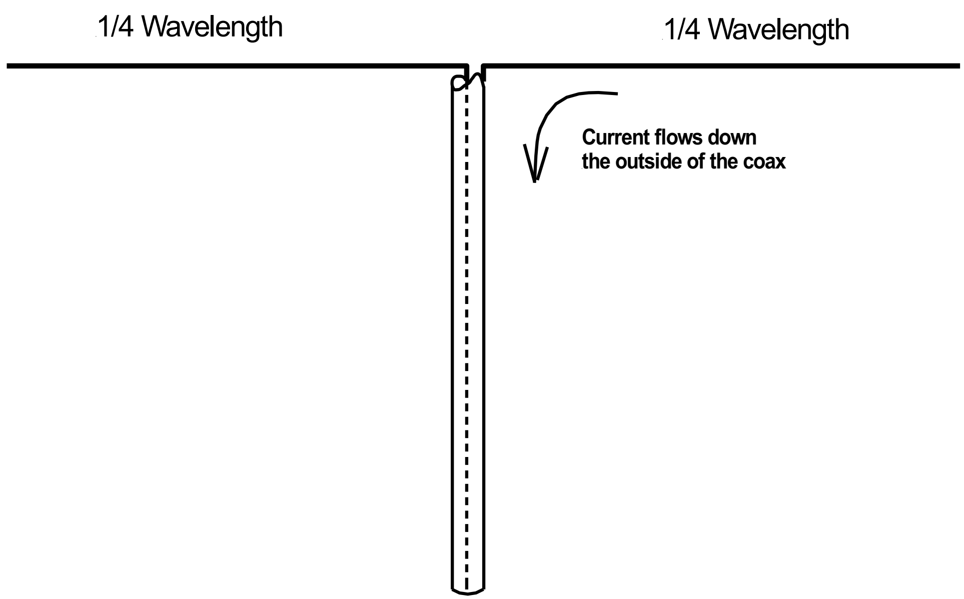
Feeding a Dipole Antenna

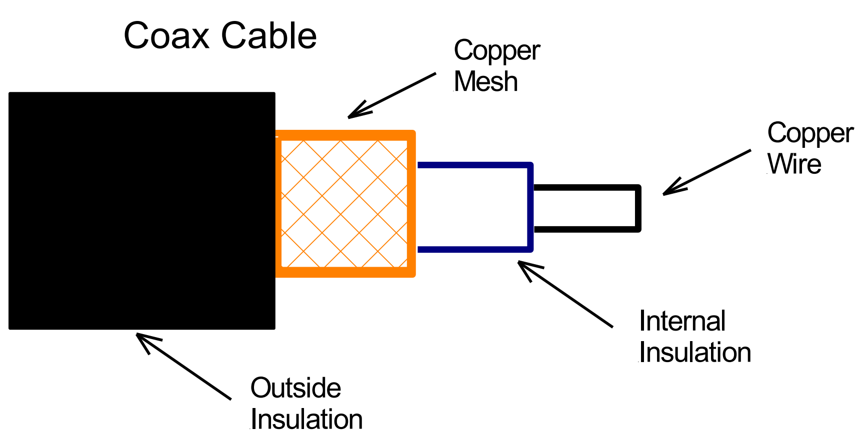


DJ0IP

- A dipole antenna is a balanced device with equal currents flowing in the antenna's two legs
- A dipole antenna is best fed by a balanced (open) feed line
- One advantage of a balanced feed line is that it does not radiate
- Instead, the two EMF fields produced by equal and opposite currents flowing in the feedline's two wires cancel each other
- To remain balanced, an open feedline must be kept away from surrounding objects (trees, house, etc.)
- Open feedlines are fairly difficult to use

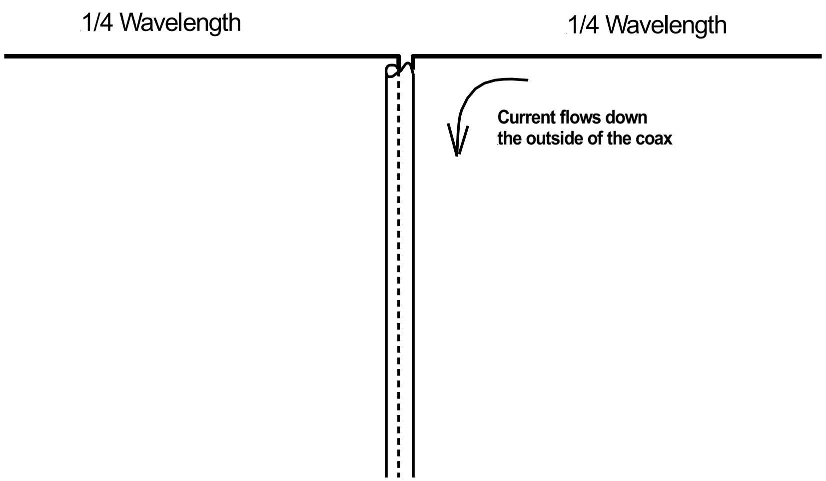
Coax Cable Feed Line

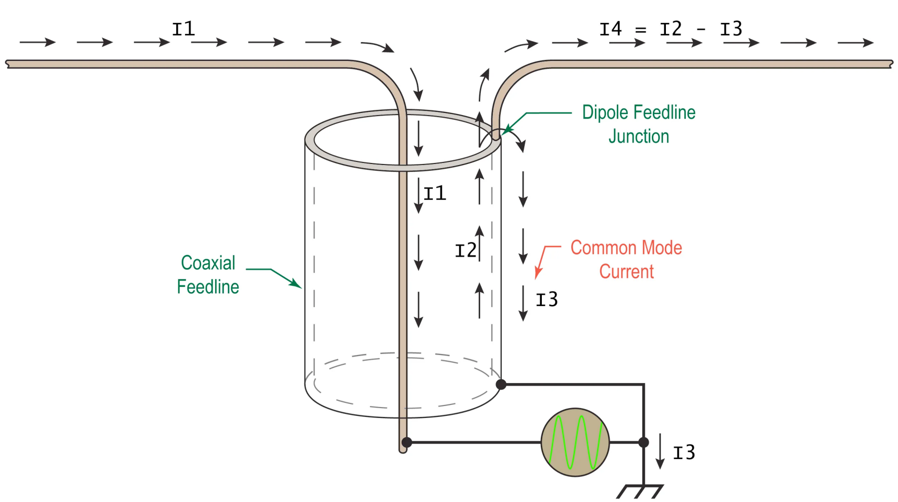




- Coax cable feedlines are easy to use
- A coax feedline is not affected by its surroundings
- However, a coax cable is not balanced.
- Unwanted current can flow on the outside of the coax mash (braid) causing the coax to radiate
- The unwanted current may distort the antenna's radiation pattern and even lead to RF in the radio shack

Why a Coax Feed Line is Unbalanced

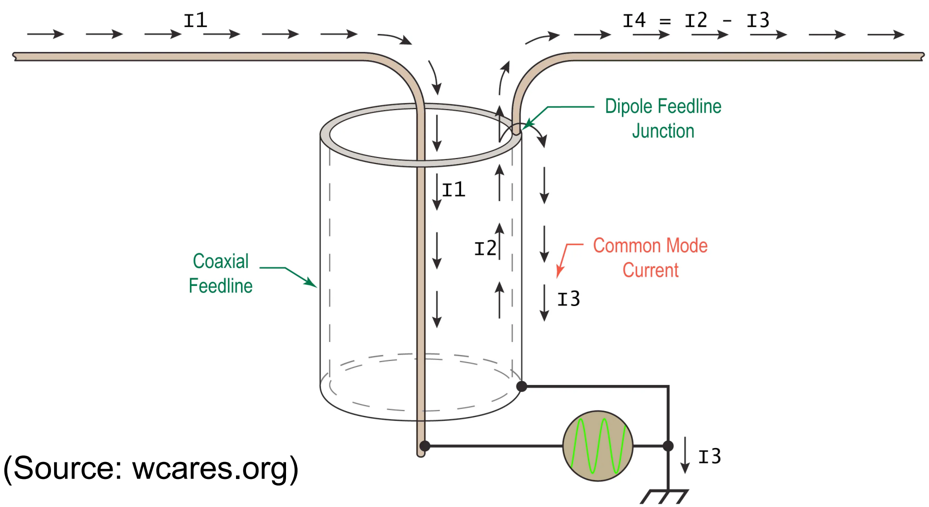




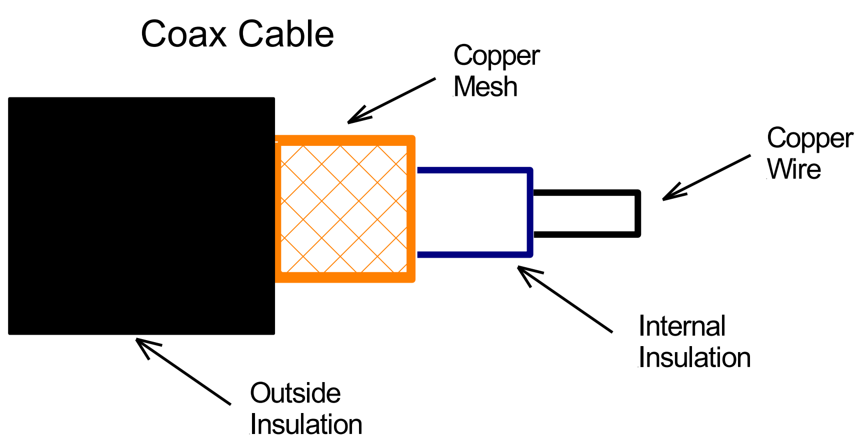
Source: wcares.org

- The current from the coax center conductor is delivered directly to the antenna (left leg in this case)
- The current flowing on the inside of the braid splits when it reaches the antenna
- Some flows into the antenna as desired (right leg)
- The rest flows down the outside of the coax braid
- The current flow in the antenna right leg is now different than that flowing in the left, unbalancing the antenna
- In addition the coax radiates

Current Flowing on Outside of Braid

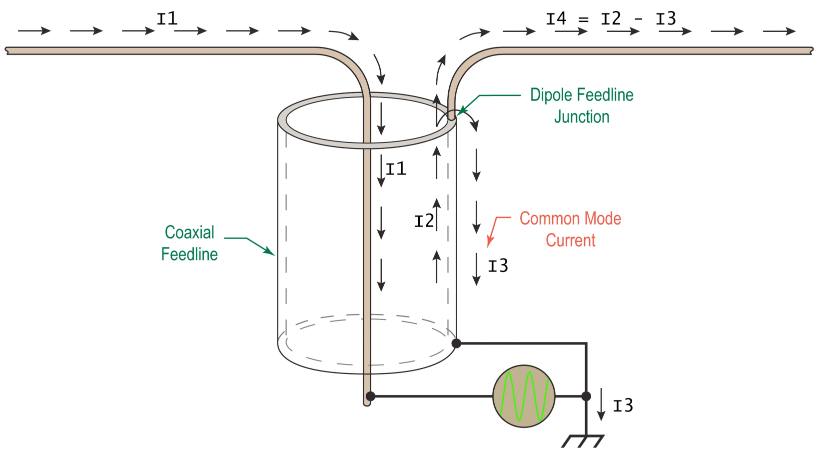


(Source: wcares.org)

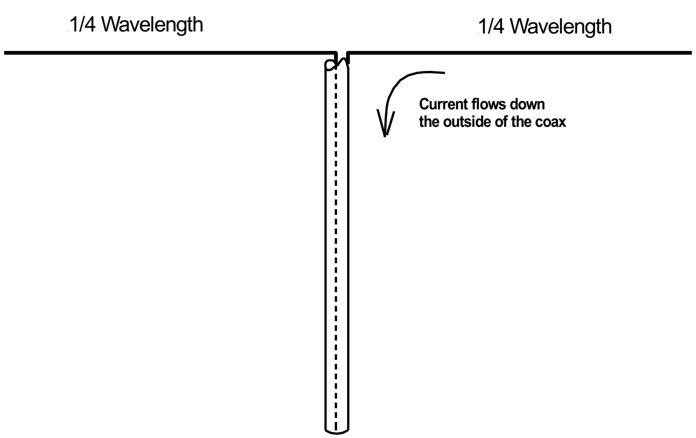


- The amount of current flowing on the outside of the braid depends on the braid impedance verses that of the antenna
- Most of the current flows into the antenna if the braid impedance is different than the antenna
- The braid impedance depends on two factors:
  - The length of the coax feedline
  - The orientation of the feedline relative to the antenna
- In most cases the coax braid impedance relative to the antenna is unknown

Do You Have a Problem?

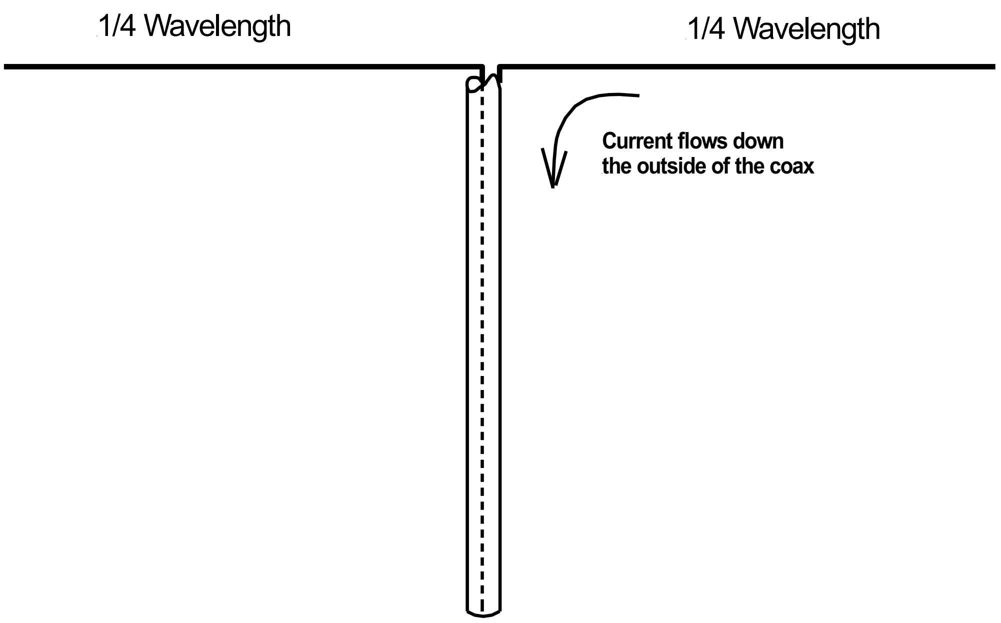


(Source: wcares.org)



- The chance that the coax feedline is just the right length to cause significant current to flow on the outside of the coax is rather low
- The coax outer braid is RF grounded at the station transmitter
- **If the coax is an odd number of 1/4 wavelengths long**, the impedance of the outer braid will be very high at the antenna feed point, little current will flow on the outside of the coax, and radiation will be small
- **If the coax is one or more 1/2 wavelengths long**, the impedance of the outer braid will be low at the antenna feed point, considerable current will flow on the outside of the coax, resulting in significant radiation

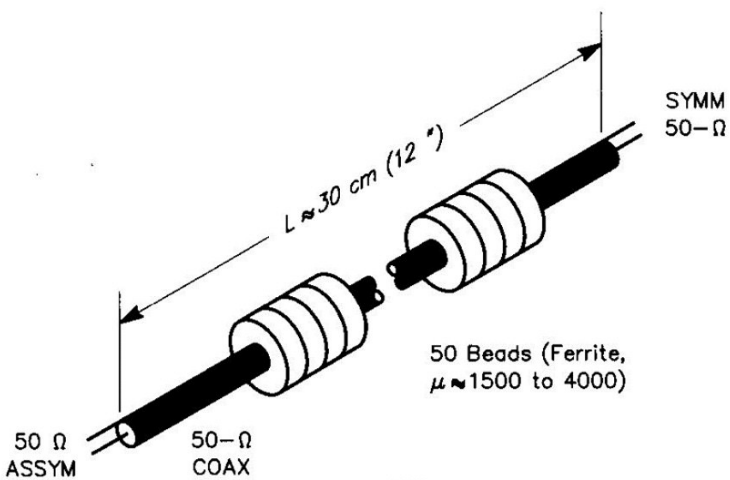
You May Not Have a Problem



- If the coax drops straight down from the antenna, any radiation from the coax will be vertically polarized
- This may actually be helpful on 80 and 40 meters causing the antenna to be more omni directional

RF Choke Balun

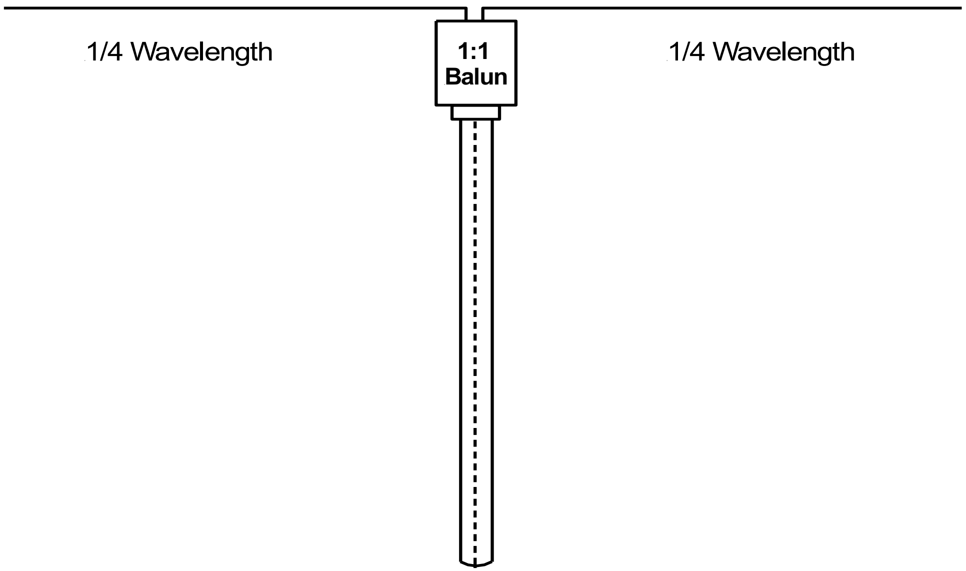
Part #: MFJ - 918



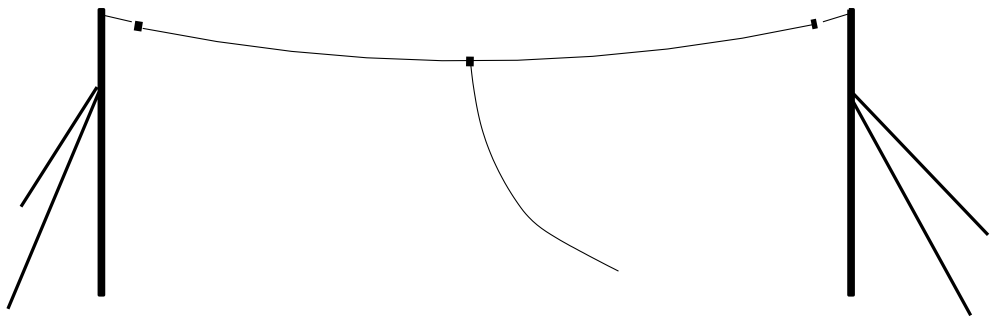
- An RF choke balun eliminates the uncertainty
- Balun means balanced to unbalanced
- The choke balun replaces the antenna’s center connector
- The balun causes the coax outer braid to have a high impedance relative to the antenna
- So no current flows down the coax
- All of the current flows into the antenna as desired
- A choke balun consists of a section of coax passing through a large number of Ferrite beads (> 50)

Choke Balun Is Recommended

- While not absolutely necessary, a choke balun
  - Serves as the antenna's center insulator providing a means to connect the coax feedline to the antenna wires
  - Prevents current from flowing down the outside of the coax
  - Helps maintain the antenna's desired radiation pattern
- A choke balun is an excellent choice for the antenna's center insulator

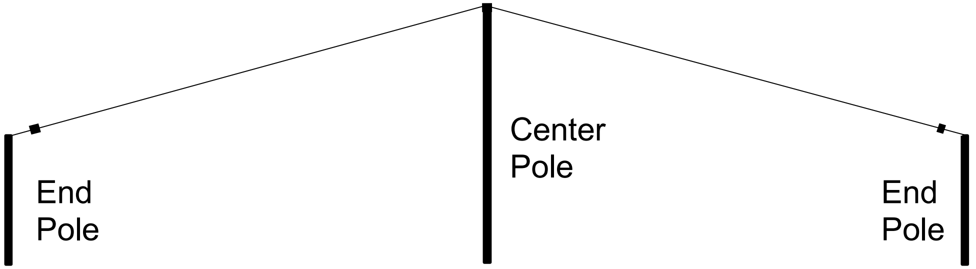


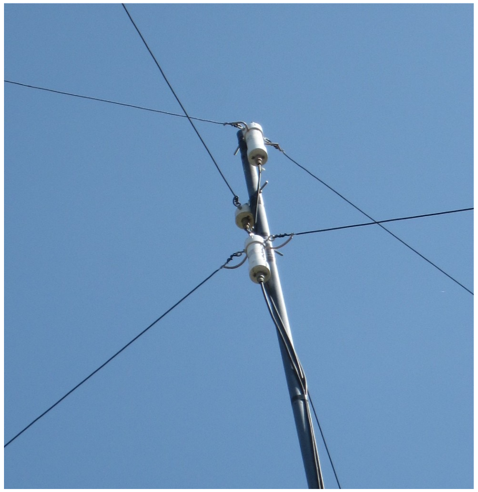
Dipole Installation



- Building a dipole antenna is relatively easy
  - The material needed is readily available, and
  - Assembly is straight forward
- Two long poles are required, one at each end of the antenna
- The poles must be strong enough to support the coax cable, center connector, and perhaps balun at the center of the antenna.
- Two guy ropes on each pole may be required
- Because of coax weight, AWG 14 antenna wire should be used so that the wire will not break (AWG 12 for long 80m antennas)

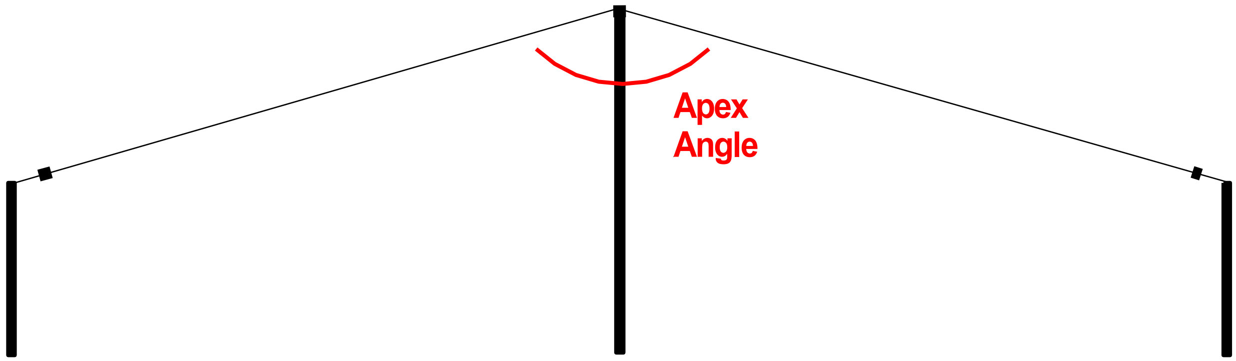
Inverted-V Antenna





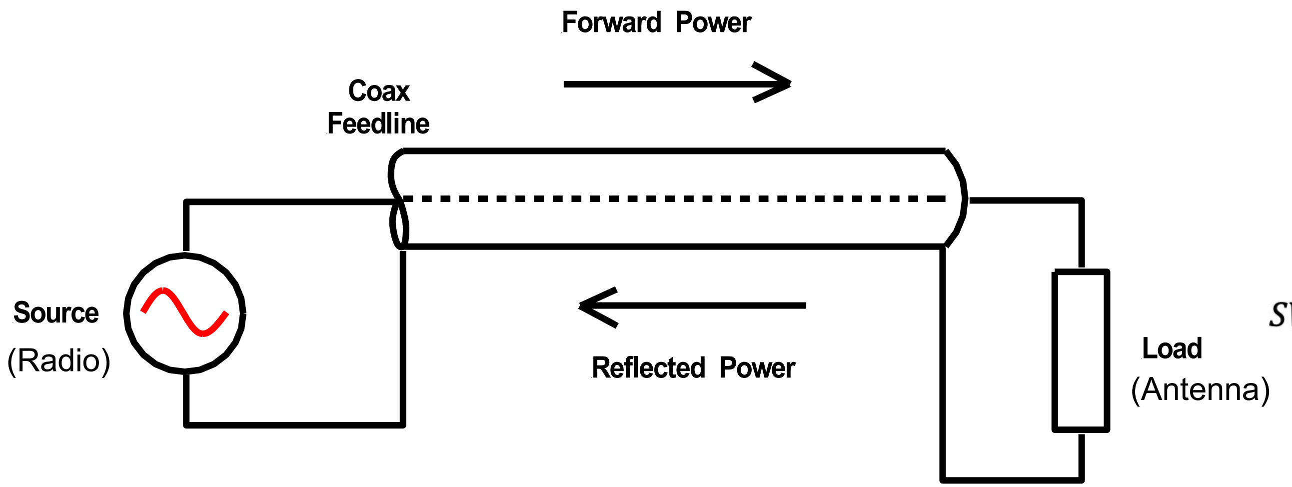
- An Inverted-V antenna simplifies dipole installation
- An Inverted-V consists of a center pole and two end poles
- The center pole determines the height of the antenna and supports most of the antenna’s weight (coax cable, center connector, balun)
- Each end pole supports only the end of the antenna wire and thus can be made of light material (aluminum swimming pool skimmer pole)
- Length of each end pole must be long enough (longer the better) so that the angle between the two antenna wires is greater than 90^{o}
- Antenna wires themselves becomes natural guy wires for the center pole

Inverted-V Apex Angle



- The apex angle, which is the angle between the two legs of the antenna, is a critical parameter for Inverted-V antennas
  - Apex Angle = 180 deg: Inverted-V becomes a flat top dipole (good)
  - Apex Angle = 90 deg: The smallest angle for acceptable performance
  - Apex Angle < 90 deg: Radiation severely impaired
  - Apex Angle < 20 deg: Antenna stops radiating all together

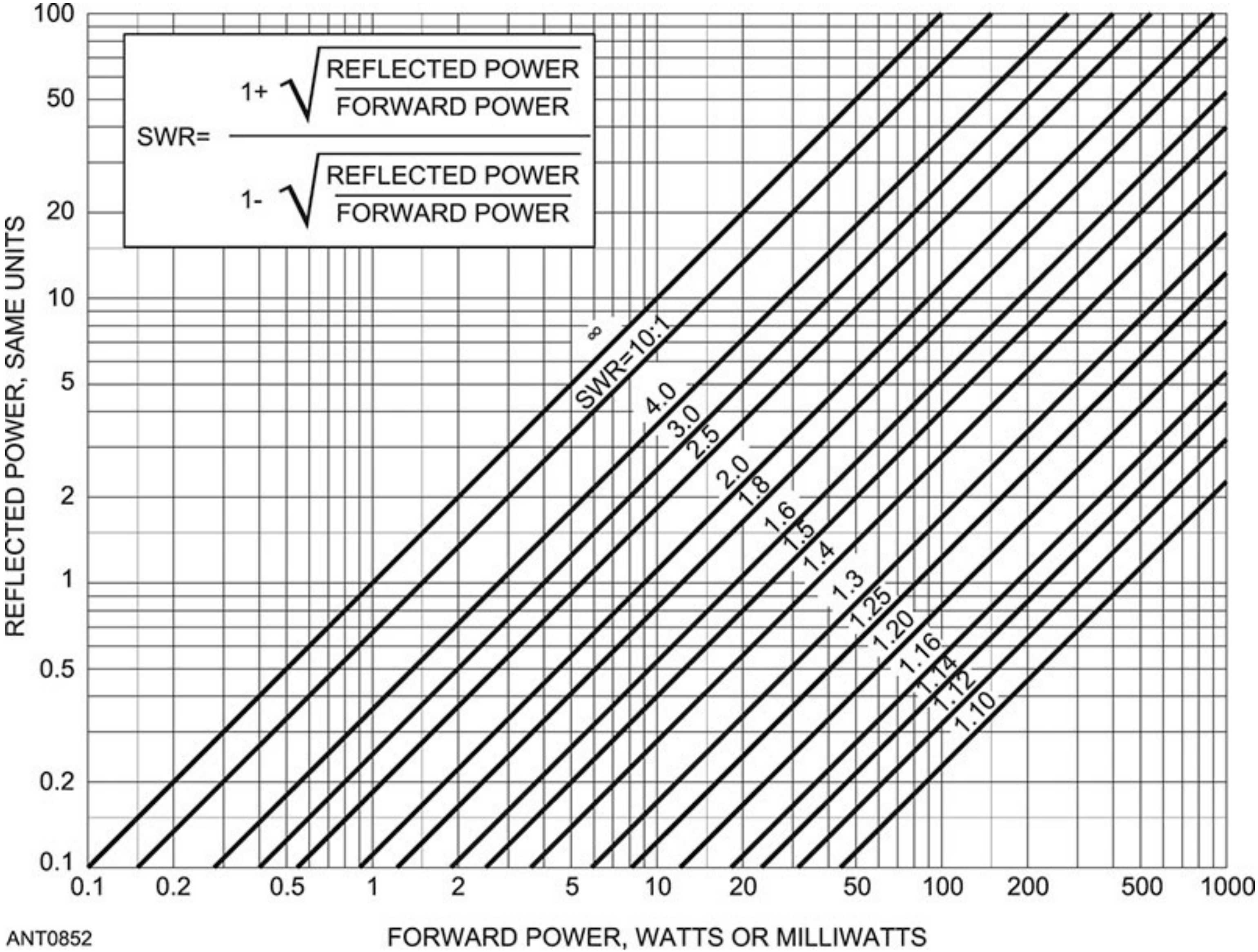
Standing Wave Ratio (SWR)



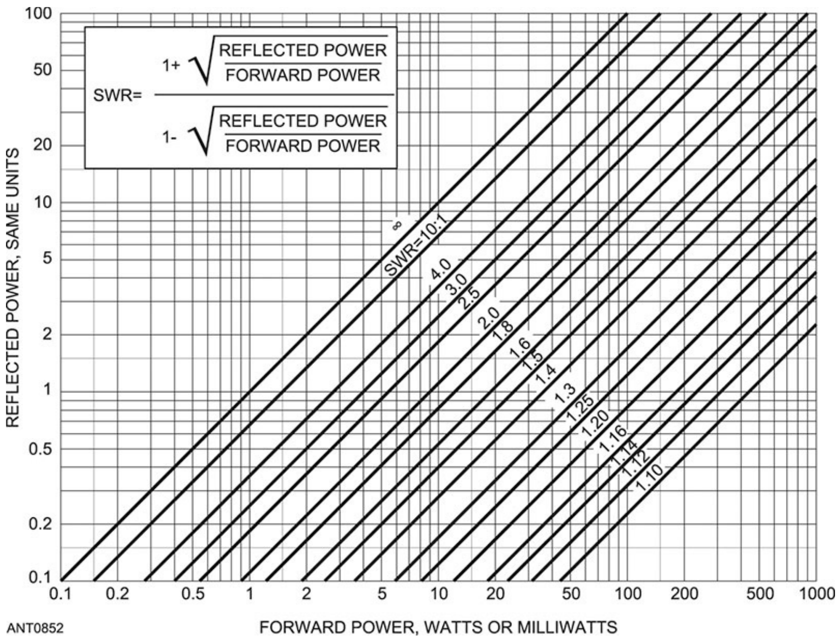
$$SWR = \frac{1 + \sqrt{\dfrac{Reflected\ Power}{Forward\ Power}}}{1 - \sqrt{\dfrac{Reflected\ Power}{Forward\ Power}}}$$

- All of the transmitted power (forward power) will be delivered to the antenna if the impedance of the radio, coax, and antenna are the same
- Part of the forward power will be reflected if the impedance of the antenna is different from that of the coax and radio
- The ratio of forward to reflected power, given by the above equation, is defined as the Standing Wave Ratio (SWR)

Standing Wave Ratio (SWR)



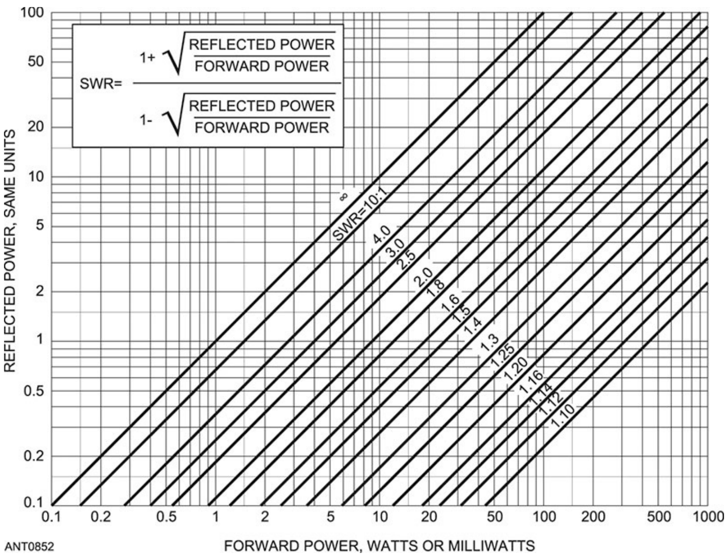
Standing Wave Ratio (SWR)



- With a relatively high 3:1 SWR 20% of the transmitted power will be reflected, a loss in radiated power of about 1db
- This loss will be completely unnoticed at the receiving station
- SWRs of 3:1, or even higher, were common place in the old days of vacuum tube radios

$$SWR = \frac{1 + \sqrt{\frac{Reflected\ Power}{Forward\ Power}}}{1 - \sqrt{\frac{Reflected\ Power}{Forward\ Power}}}$$

Standing Wave Ratio (SWR)



$$SWR = \frac{1 + \sqrt{\frac{Reflected\ Power}{Forward\ Power}}}{1 - \sqrt{\frac{Reflected\ Power}{Forward\ Power}}}$$

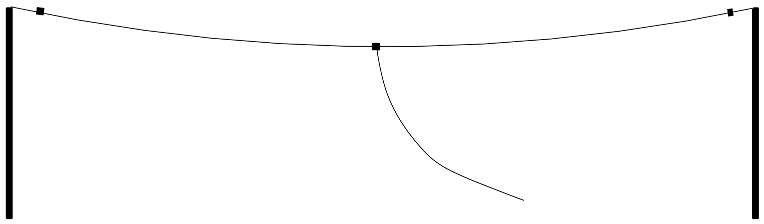
- While vacuum tube power amplifiers can handle an SWR of 3:1
- Semiconductor transmitters (or amplifiers) can not !
- For semiconductor equipment the SWR must be lower than 2:1
- In today's semiconductor world antenna's must be more carefully matched to the transmission line than in the old days, this is done by
  - Operating over narrower bandwidths
  - Using a tuner at the radio
  - Using a match box at the antenna

Antenna Tunning

SWR Meter

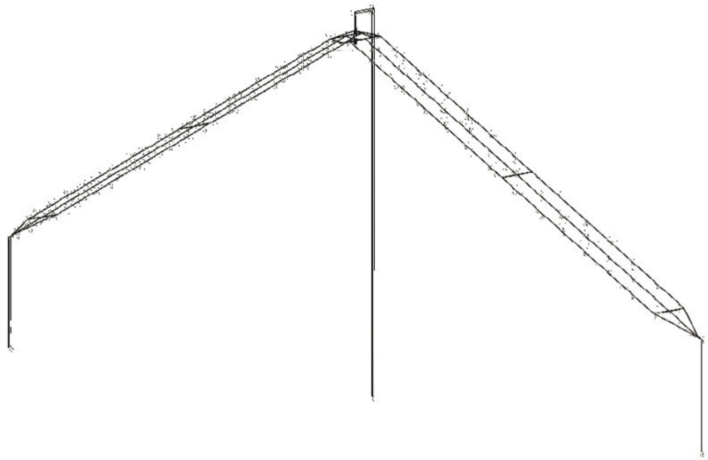
- An antenna is too long if the frequency with the lowest SWR is below the desired center frequency for the antenna
- For example, the antenna is too long if the frequency with the lowest SWR is 6.95 MHz and the desired center frequency is 7.15 MHz
- In this case shorten the antenna by cutting off shorts lengths of wire from each end of the antenna until the lowest SWR occurs at the desired center frequency
- The antenna is too short if the frequency with the lowest SWR is 7.25 MHz
- In this case lengthen each end of the antenna until the lowest SWR frequency drops to the desired center frequency

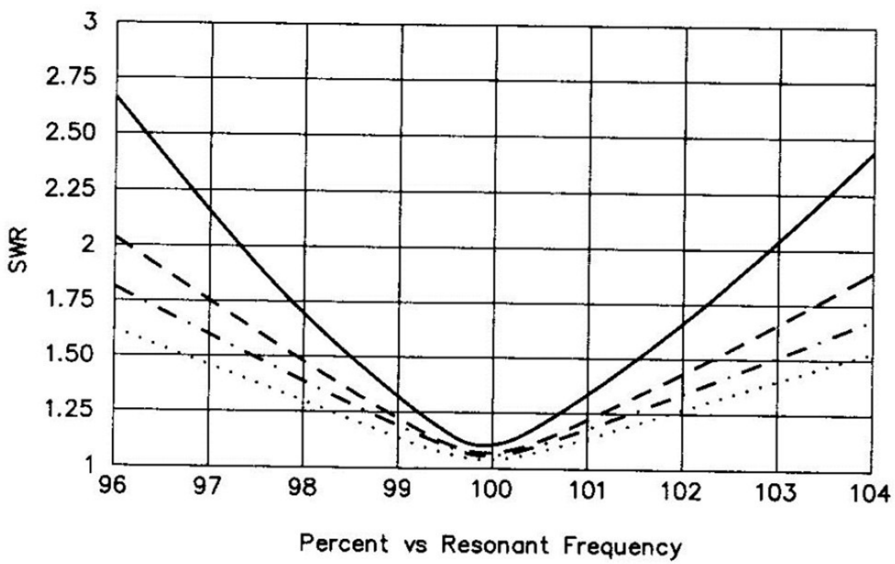
Antenna Bandwidth



- Antenna bandwidth is defined as the range of frequencies at which an antenna can operate with an SWR below a specified level
- Example: A 75 meter antenna tuned for a frequency of 3,850 KHz has a SWR = 1:1 at that frequency
- At 4,000 KHz its SWR = 2:1
- At 3,700 KHz SWR = 2:1
- Between 3,700 and 4,000 KHz the antenna's SWR < 2:1
- Its 2:1 SWR bandwidth is thus BW = 4,000 – 3,700 KHz = 300 KHz

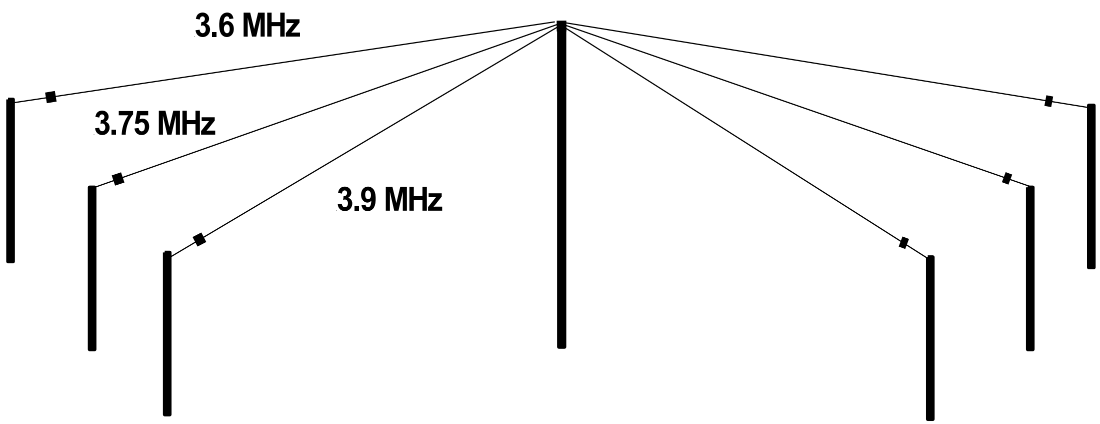
Broadband Antenna





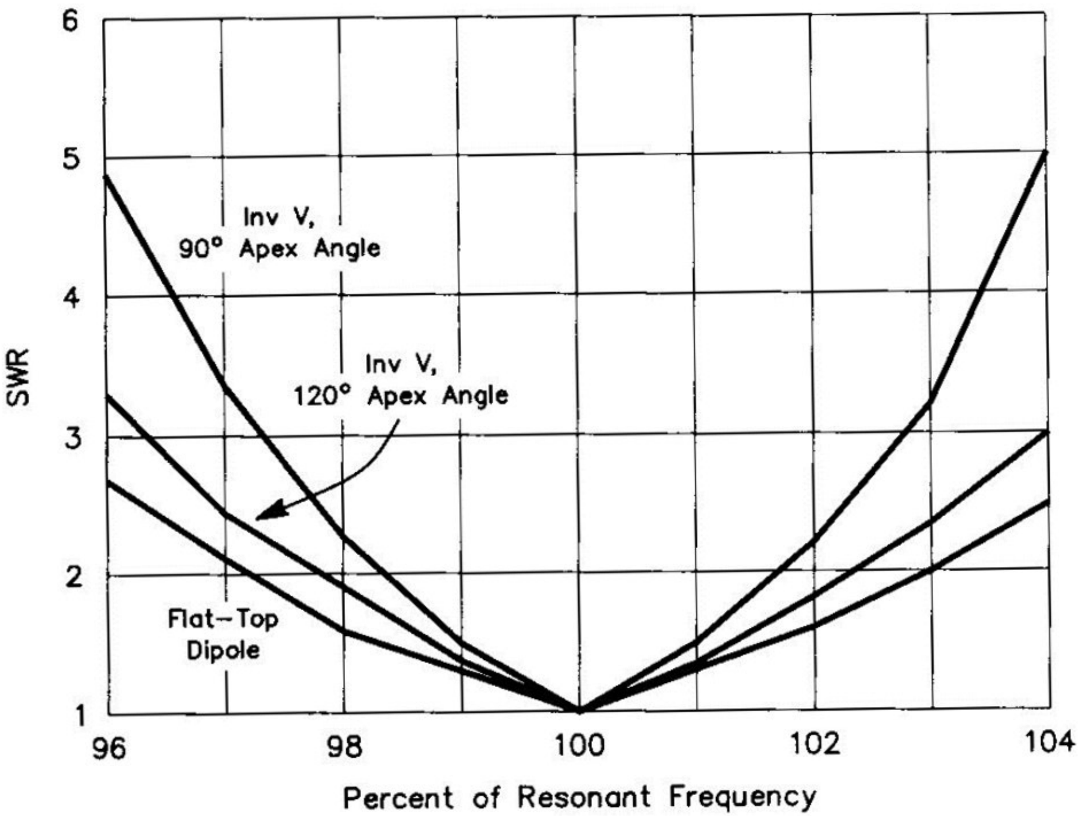
- The SWR bandwidth of a half wave dipole is determined in part by the diameter of the antenna wire
- Antenna built using thicker wire has a wider bandwidth
- Multiple parallel wires increase the effective diameter of the antenna wire & thus its bandwidth
- Solid = #12 wire
- Dashed = 3 wires spaced 4” apart
- Dotted = 3 wires spaced 12” apart

80 Meter Fan Antenna



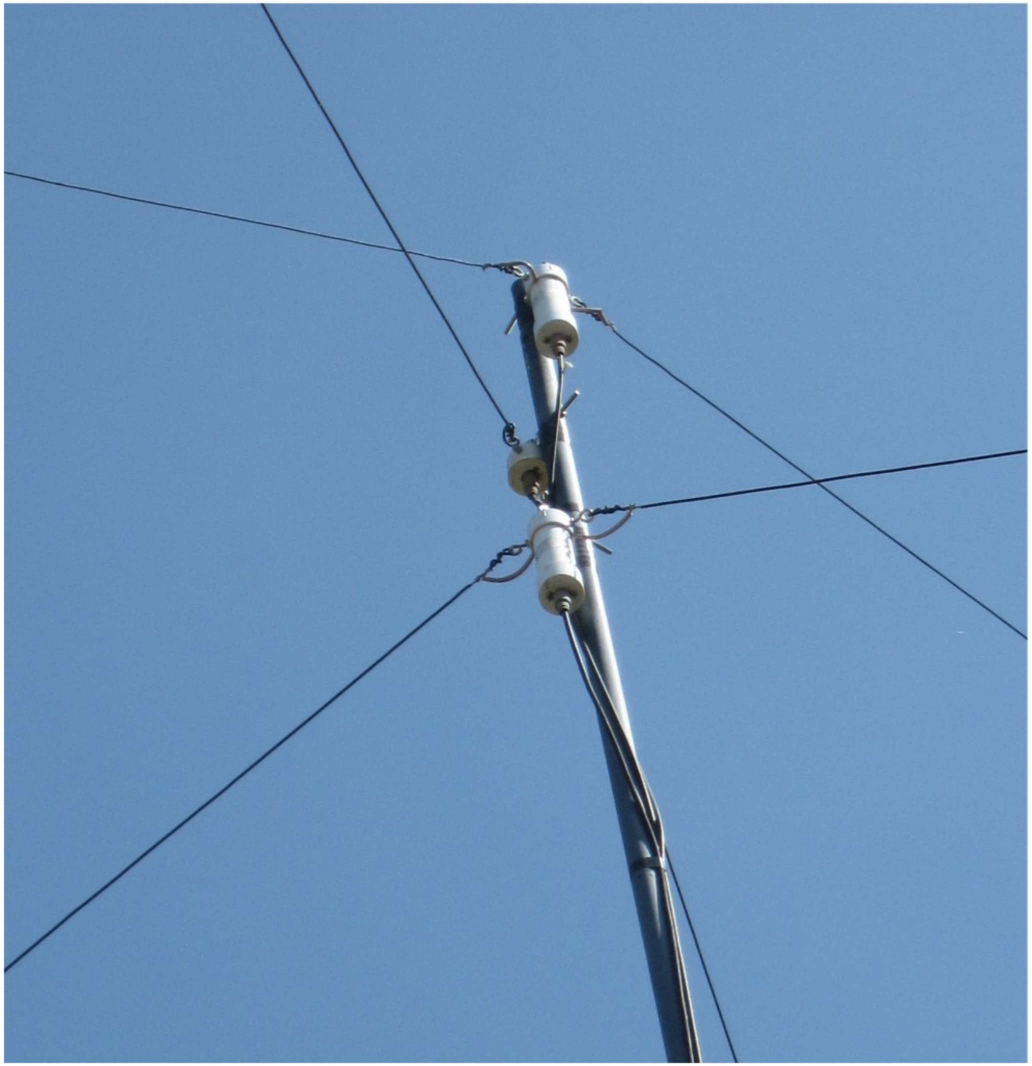
- The bandwidth of an 80 meter dipole generally does not cover the entire 80 meter band
- The problem can be solved by using 3 Inverted V antennas driven by a single coax cable
- One Inverted V antenna is cut for the bottom of the band
- Second antenna cut for the middle of the band
- Third antenna cut for the top of the band

Inverted-V Bandwidth



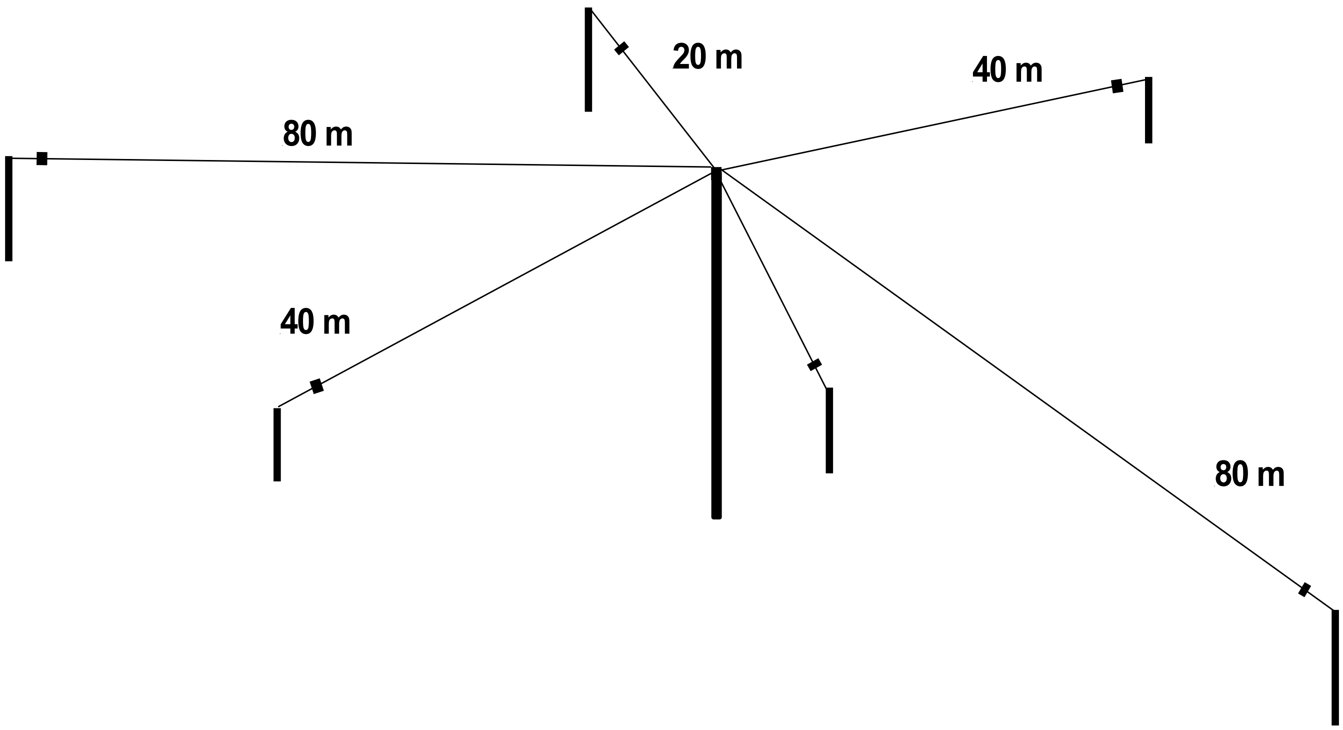
- SWR curves for three 80 meter Inverted-V antennas with apex angles of 90, 120, & 180 deg
- SWR bandwidth increases with increasing apex angle
- The bandwidth is greatest for an apex angle of 180 deg (for a flat-top dipole)

Simple Multiband Inverted V Antenna System



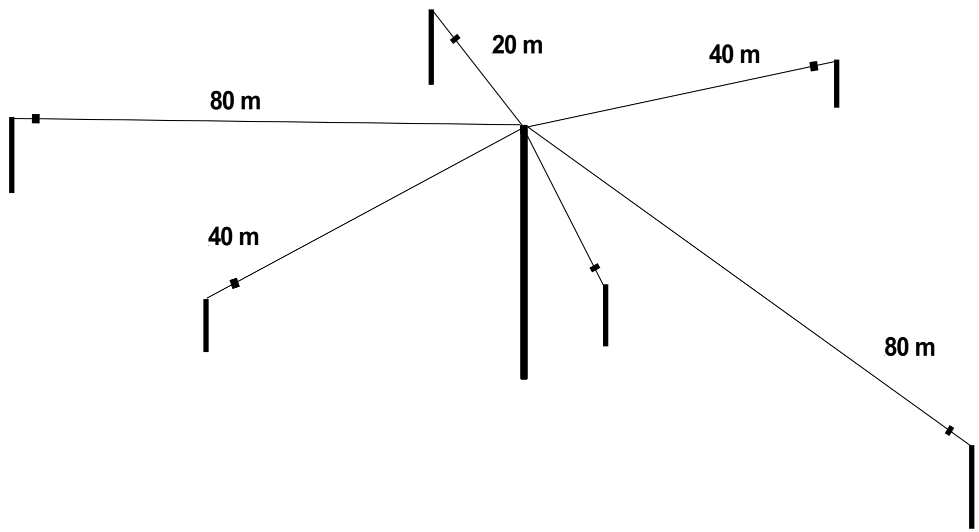
- Three Inverted V antennas, each with its own coax feedline, mounted on a single pole
- From top to bottom the antennas are 20 meters, 80 meters, and 40 meters

Multiband Inverted V Antennas



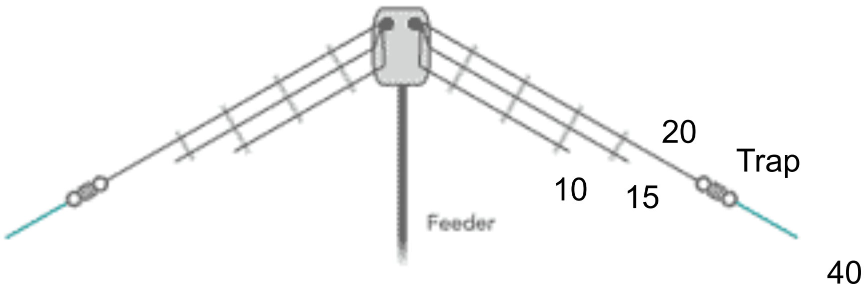
- A single coax can drive multiple Inverted V antennas, for example 80, 40, and 20 meter antennas

Multiband Inverted V Antennas



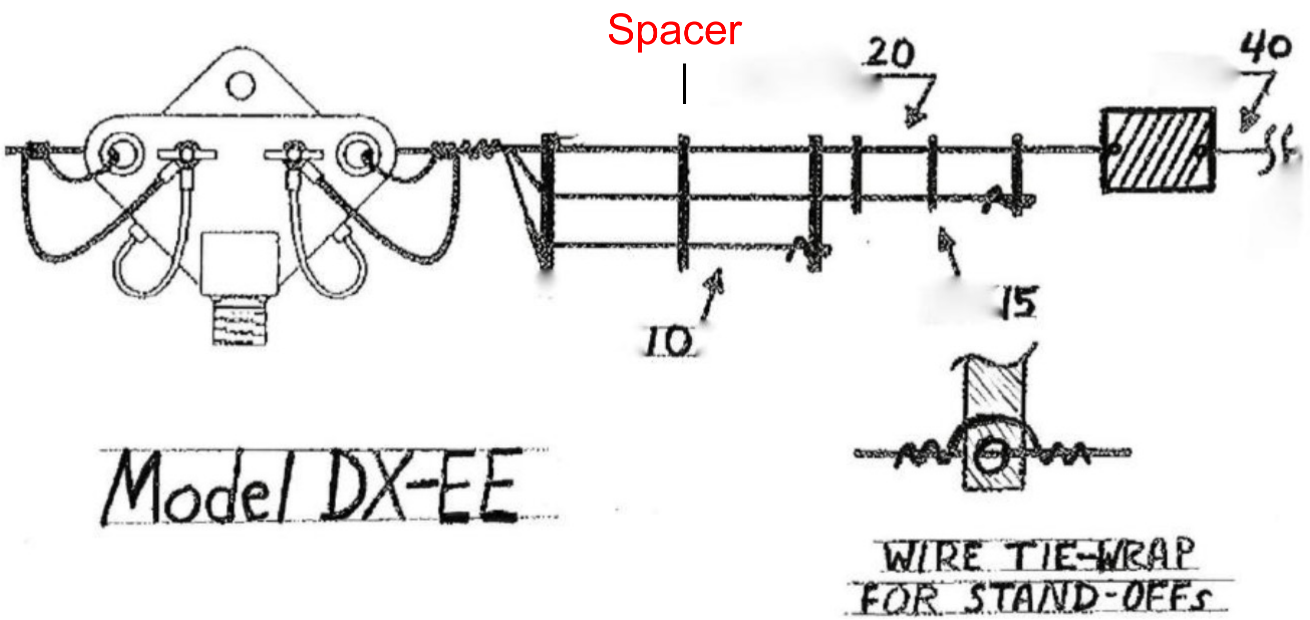
- When transmitting on 40 meters only the 40 meter antenna appears as a low impedance resistive load
- The 80 meter antenna is too long and appears as a high impedance inductive load
- The 20 meter antenna is too short and appears as a high impedance capacitive load
- Consequently the 40 meter antenna is the only antenna that radiates the 40 meter signal

Stacked Multiband Antennas



- In this figure spacers (spreaders) are used to build a multiband antenna with the elements for the various bands (40, 20, 15, 10 meters) stacked one above the other, all driven by a single coax feed line
- The top element is a 20 / 40 meter trap antenna
- A 20 meter signal travels down the antenna as far as the trap
- A 40 meter signal passes through the trap and continues down the length of the antenna
- However, the inductive trap shortens the physical length of the 40 meter antenna narrowing the antenna’s bandwidth

Stacked Multiband Antennas

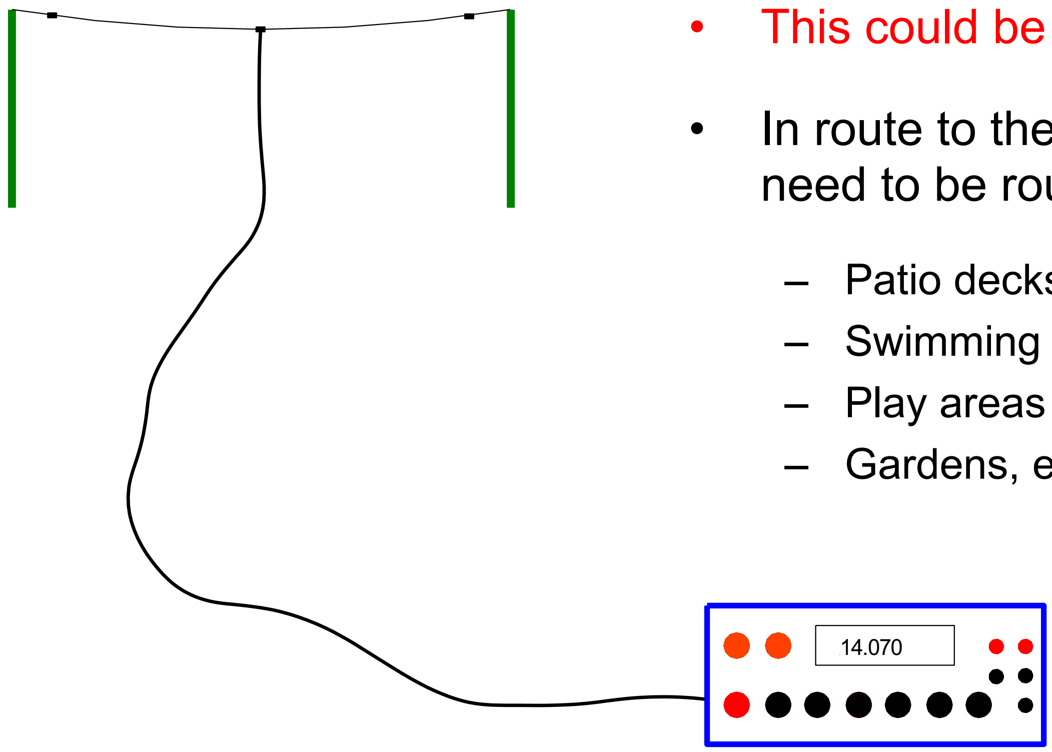


One half of
antenna shown

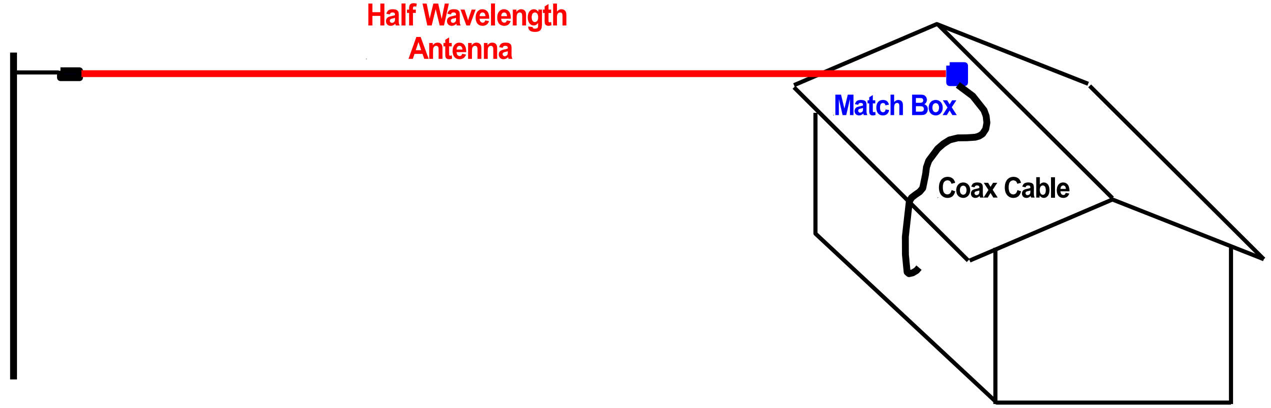
- Details of a stacked multiband antenna offered by Alpha Delta
- Insulated spacers separate the various antennas

Long Coax Runs

- A center fed antenna may have a long coax run from the radio shack to the center of the antenna
- This could be a problem
- In route to the antenna the coax may need to be routed around
  - Patio decks
  - Swimming pools
  - Play areas
  - Gardens, etc.



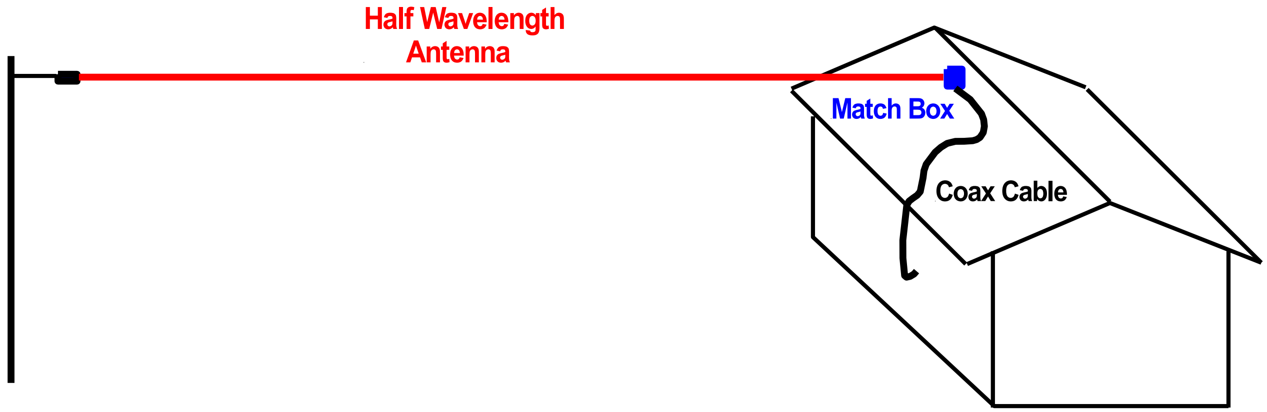
End Fed Half Wave Antenna



Manufacturers:
- PEZ EF-40-10-KW
- MFJ-1984HP

- An end fed half wave antenna (EFHW) is an excellent solution to the long coax problem
- The antenna can be installed as either a horizontal dipole or Inverted V
- In addition, an EFHW is inherently multi-band
- An EFHW cut for 7.0 MHz will also work on 20, 15, and 10 meters in addition to 40 meters

End Fed Half Wave Antenna



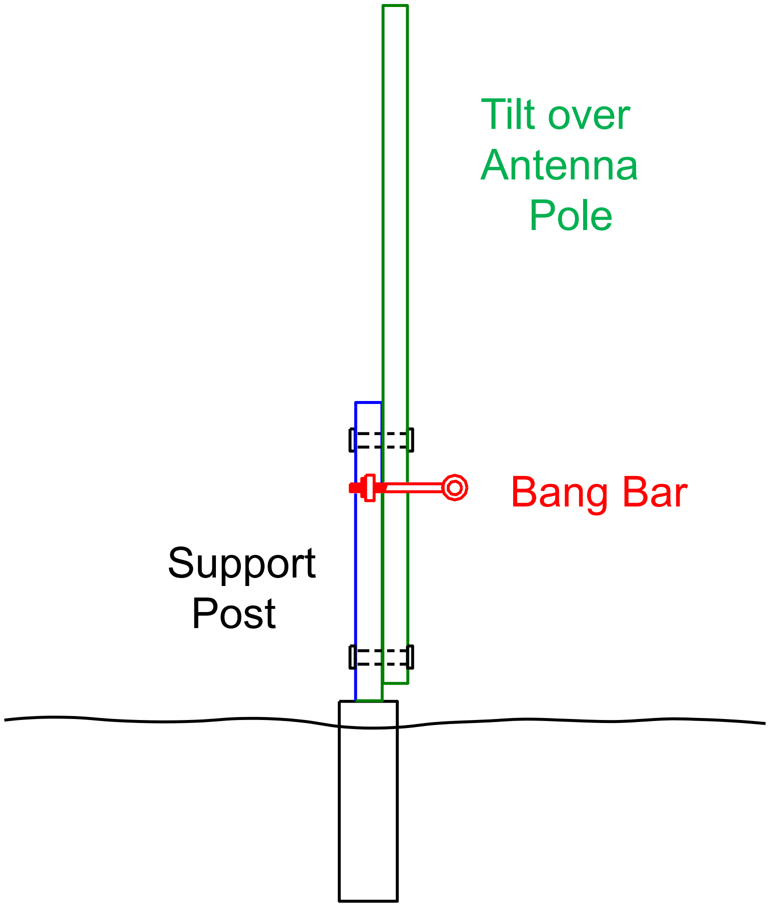
Manufacturers:
PEZ EF-40-10-KW
MFJ-1984HP

- The only difference between a conventional antenna and an EFHW is that the EFHW is fed at the end of the antenna instead of the middle
- But, the impedance at the end of a dipole or Inverted V antenna is very high
- A RF transformer (match box) is needed between the end of the antenna and the coax feedline to drop the impedance at the end of the antenna to 50 ohms
- Also a short counterpoise wire must be connected to the match box to tune out reactive impedance

Installing Antenna Poles

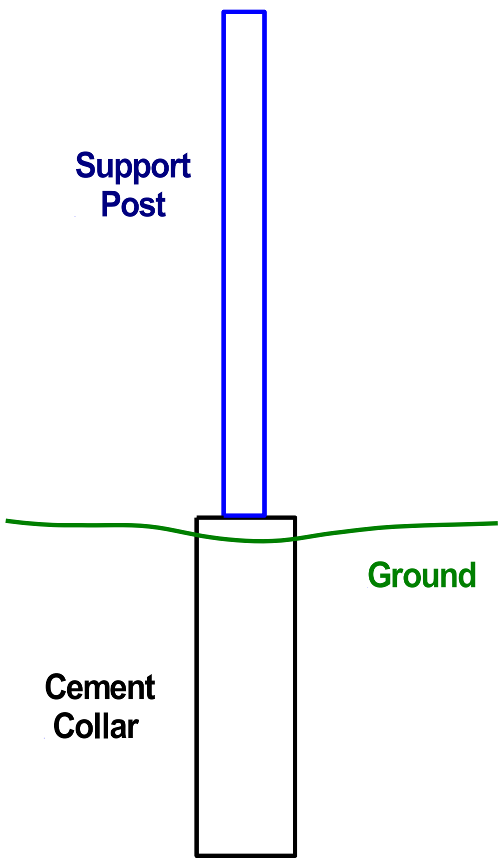
- There are many different ways to install antenna poles
- Here are a few ideas

Tilt Over Antenna Pole



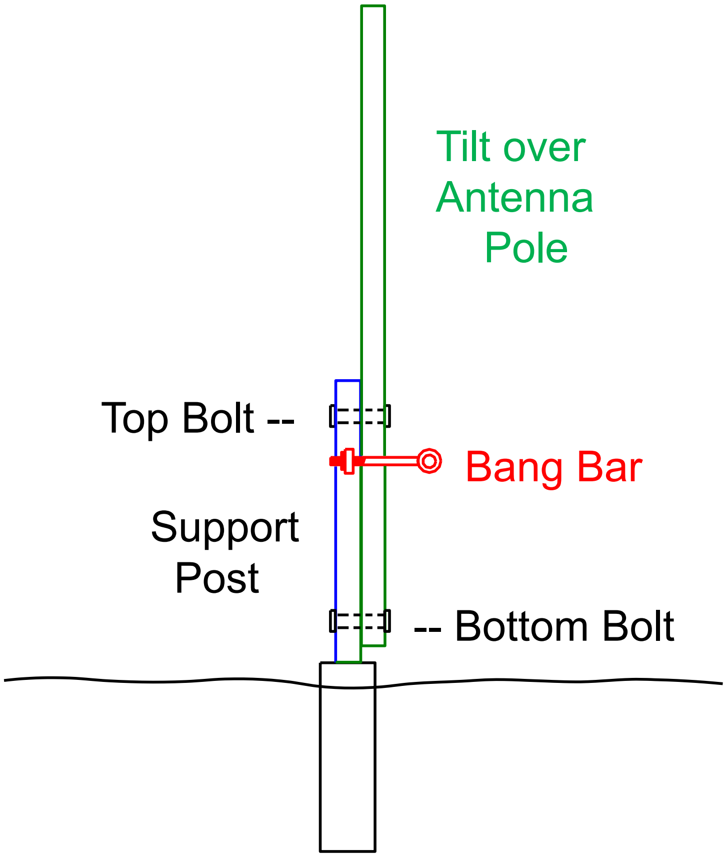
- A tilt over antenna pole is an excellent choice for the center pole of an Inverted V antenna
- A pair of tilt over antenna poles can be used as the two supporting end poles for a horizontal dipole antenna
- A tilt over antenna pole consists of three sections
  - Support post
  - Tilt over antenna pole
  - Bang bar

Antenna Support Post



- The support post is cemented in a cement collar
- The collar is formed by a 4” diameter 24” long plastic drainage pipe
- Bury pipe 18 inches in the ground
- The support post is held in the middle of the pipe while cement is poured in
- The support post is typically a galvanized 5 foot long fence post 2” in diameter
- Use a level to ensure the support post is exactly vertical
- This technique allows the support post to be easily removed at a later time by simply digging up the cement collar

Tilt Over Antenna Pole

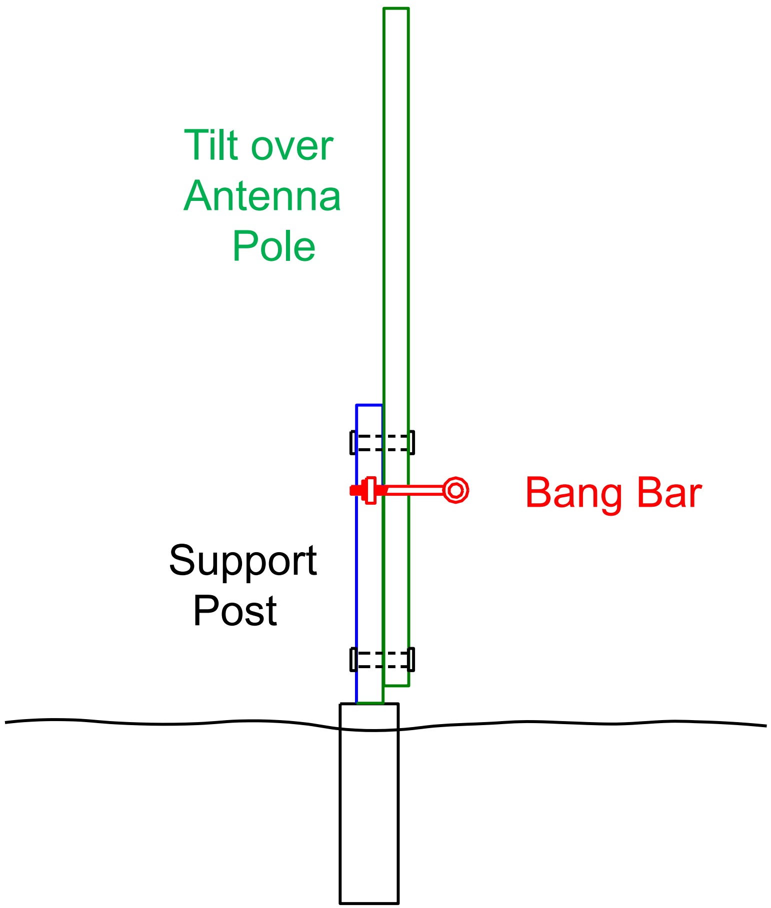


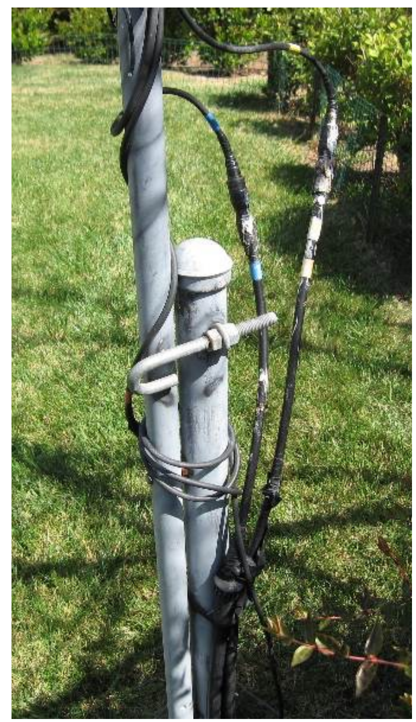
1/4" bolts are used which are long enough to pass thru both antenna pole & support post. Top bolt 3" down from top of support post. Bottom bolt 3" up from bottom of antenna pole

- Bottom of the antenna pole is bolted to the support post
- This bolt forms the antenna pole pivot point
- The bolt at the top of the support post secures the antenna pole in the vertical position
- This bolt is removed for lowering or raising the antenna pole
- For erecting the pole, the pole is rotated upward until it is vertical
- The top bolt is then installed securing the antenna pole to the support post

Bang Bar

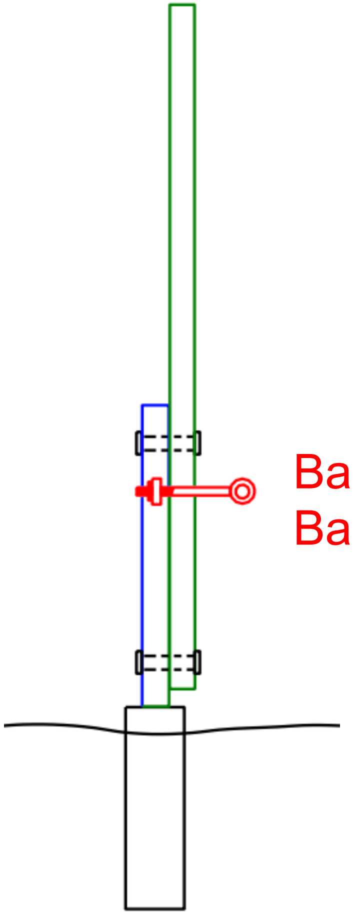
- The antenna pole becomes unstable, difficult to control, as the pole approaches the vertical position
- This problem is solved by using a “bang bar”





Using A Bang Bar

Bang Bar

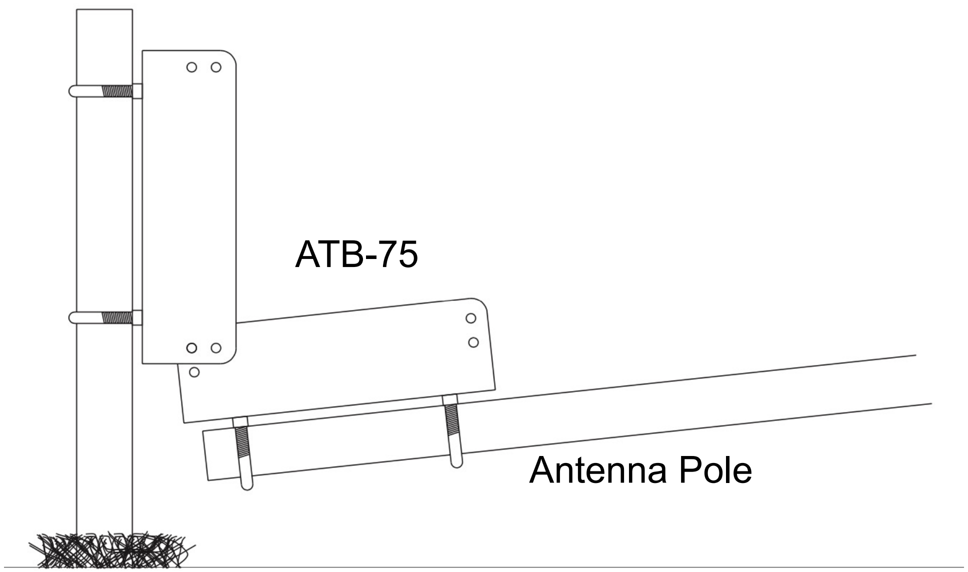


- The antenna pole is rotated upward until it contacts the bang bar
- It is then held in place against the bang bar while the top bolt is inserted thru the antenna pole and support post

Constructing the Bang Bar

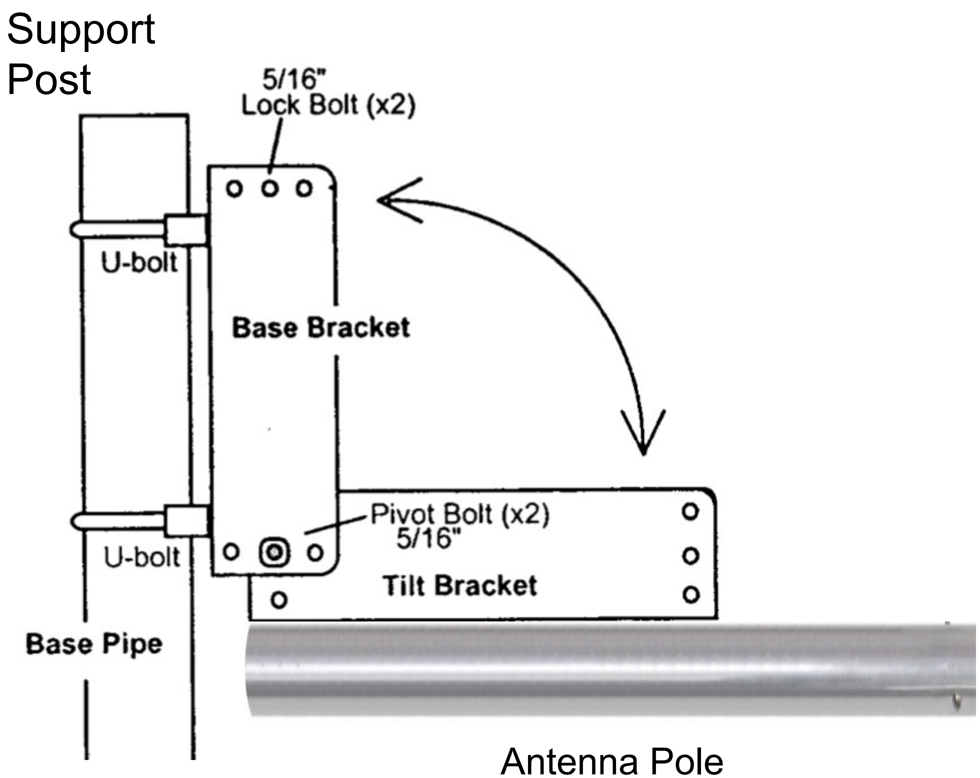
- The bang bar is constructed by installing a large eye bolt in the side of the support post
- A 1/2” x 6” long J bolt is then inserted through the eye bolt and bolted in place
- The J bolt is the bang bar
- The top 1/4” bolt holes in the antenna pole and support post must line up while the antenna pole is held against the bang bar so that the top bolt can be installed
- If necessary small adjustments in alignment can be accomplished by rotating the bang bar J bolt

Tilt Mount Brackets



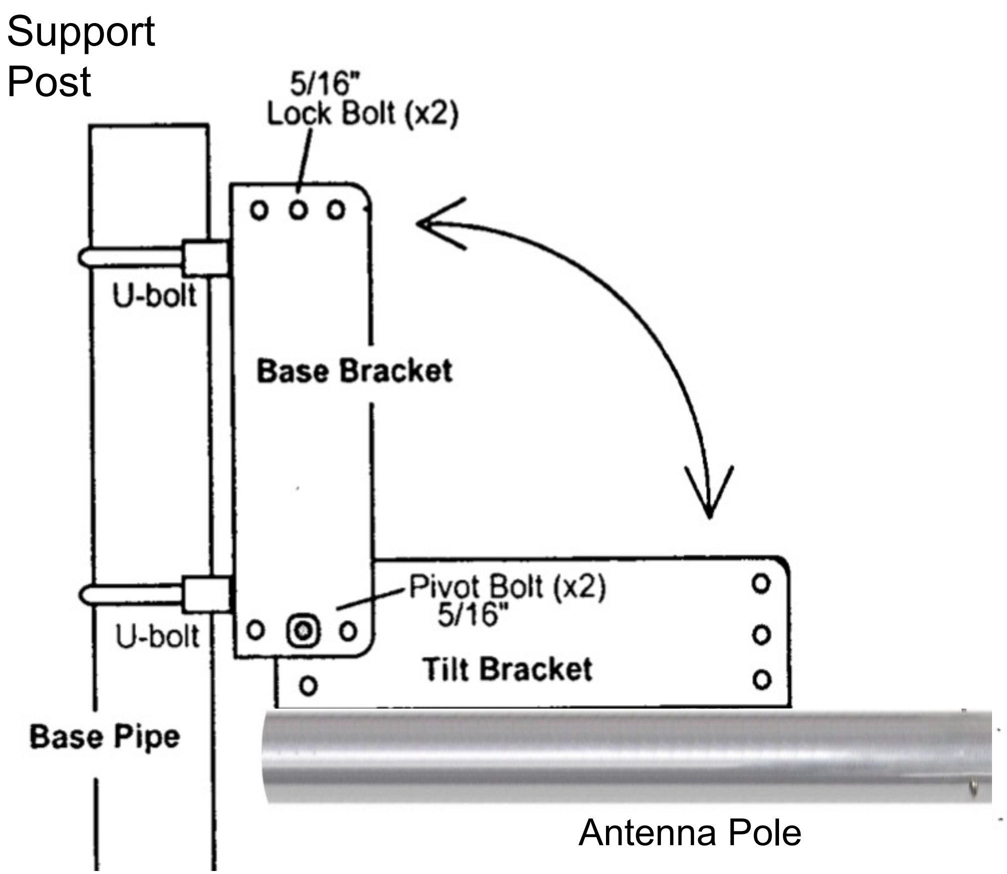
- An alternative to the tilt over antenna pole bang bar approach is to use a Hy-gain ATB-75 Tilt-mount to attach the antenna pole to the support post
- DX Engineering DXE-OMNITILT-1 tilt mount and Cushcraft R-8TB tilt base are also good choices
- These mounts do not require holes to be dilled in the support post or antenna pole
- Instead clamps are used to connect one component to another

Installing The Antenna Pole



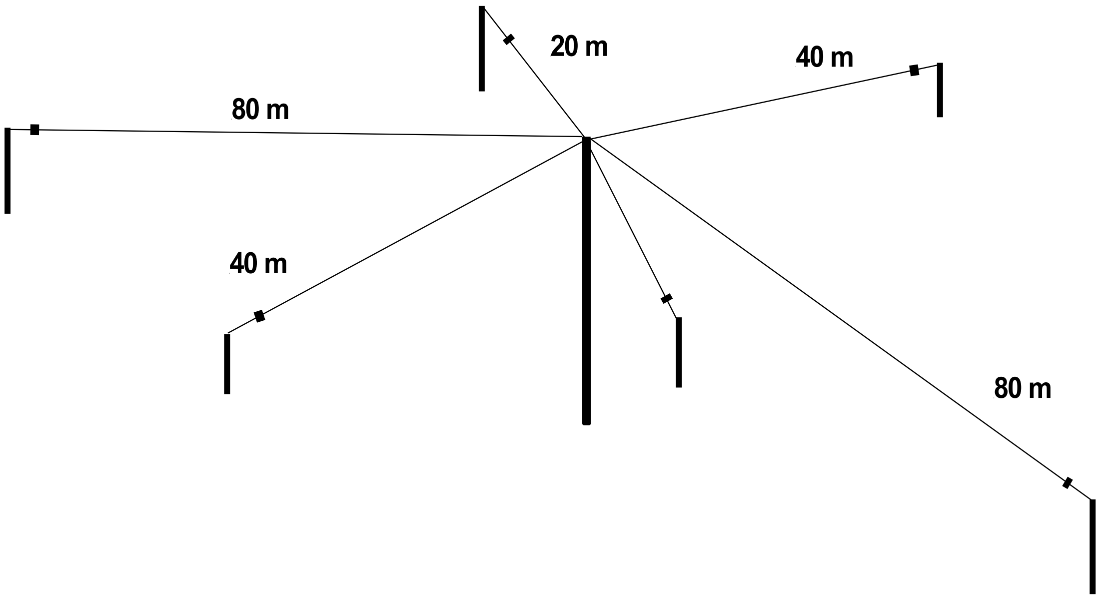
- Attach the ATB-75 Tilt-mount "Base Bracket" to the support post (Base Pipe)
- Place the "Tilt Bracket" in the horizontal position
- With the antenna pole horizontal and supported along its length on boxes, etc.
- Clamp the antenna pole to the Tilt Bracket

Raising The Antenna Into Position



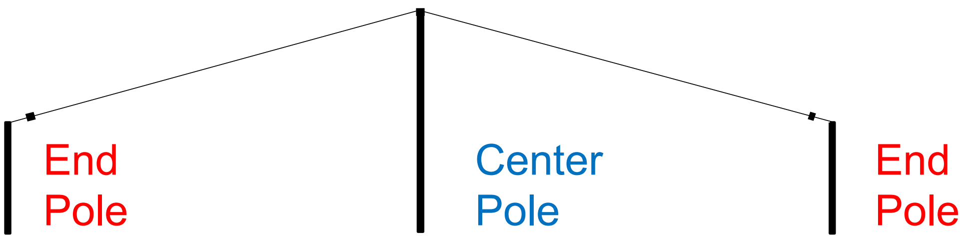
- Raise the antenna into position
- The Base Bracket bolted to the support post performs the bang bar function
- Raise the antenna until the Tilt Bracket rotates into the Base Bracket
- Insert the Lock Bolt through the Base Bracket and Tilt Bracket securing the antenna in the vertical position

Installing Guy Ropes

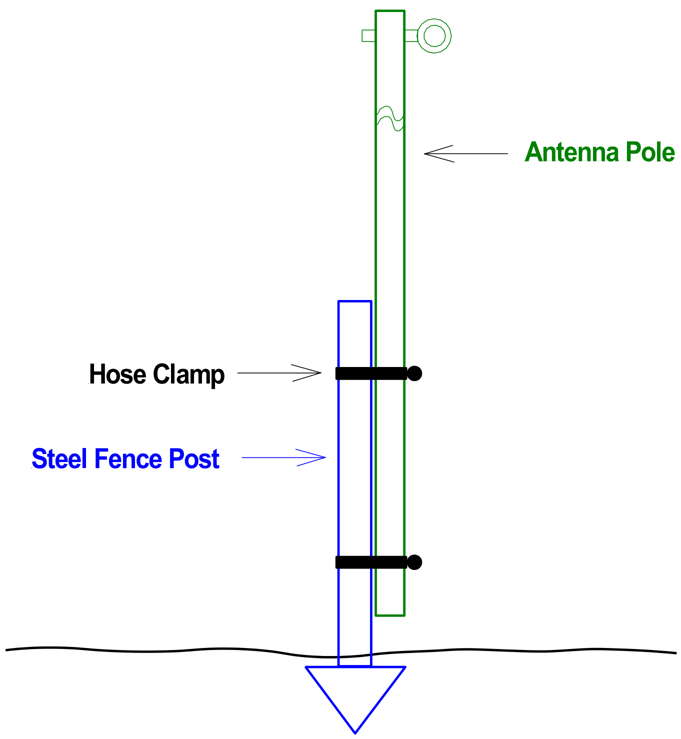


- In general 3 or more guy ropes are required to support an antenna pole taller than 20 feet
- Installing 2 or more Inverted V antennas at the top of the pole in a May Pole arrangement eliminates the need for guy ropes
- The antenna wires themselves serve as guy lines
- In essence, an additional 1 or 2 Inverted V antennas are FREE since the added antennas eliminates the need for guy ropes

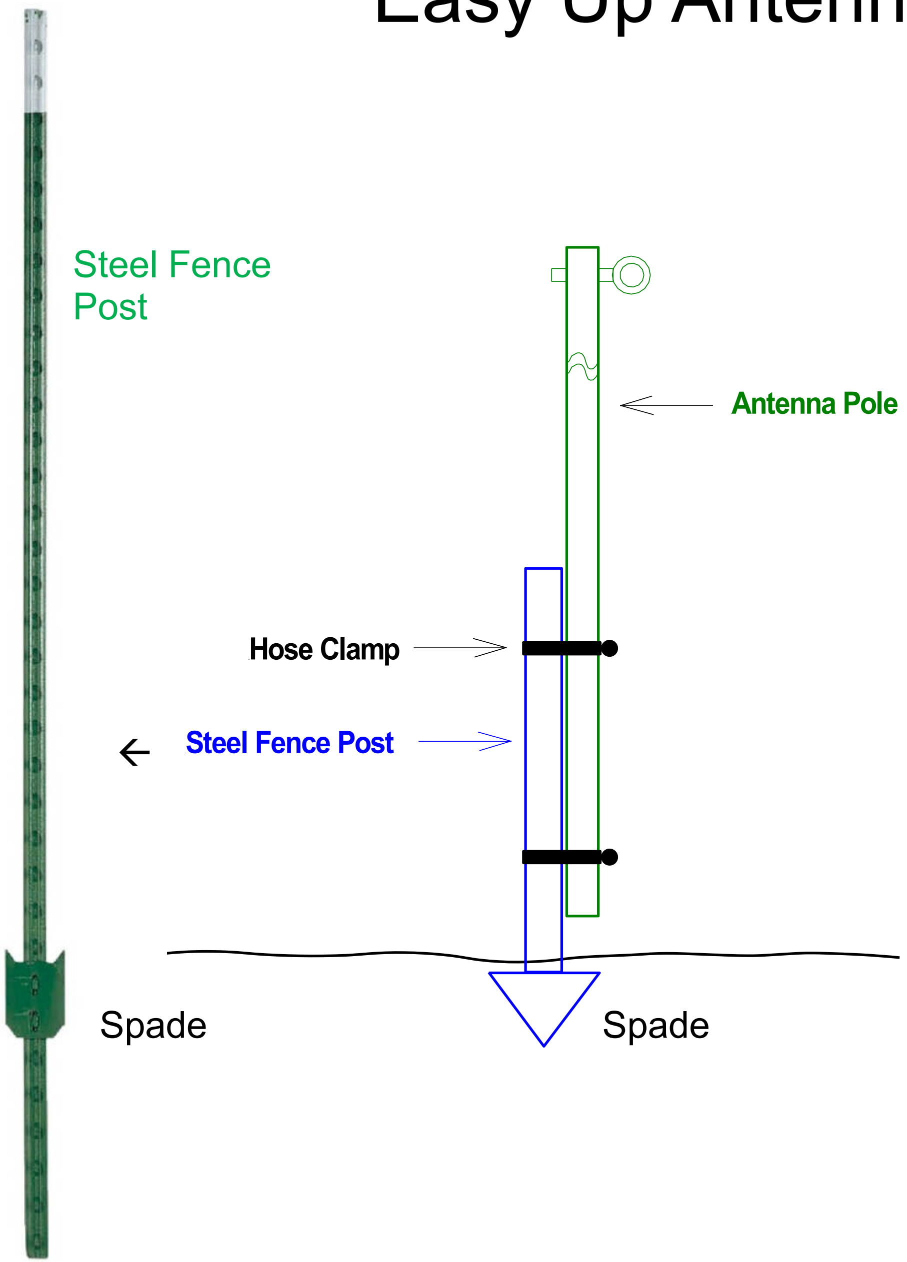
Inverted-V Antenna End Poles



- An Inverted V antenna requires two end poles
- End poles can be easily constructed using light aluminum swimming pool skimmer poles
- An aluminum pole up to about 20 feet in length can be installed by clamping it to a 6 foot steel fence post



Easy Up Antenna End Pole

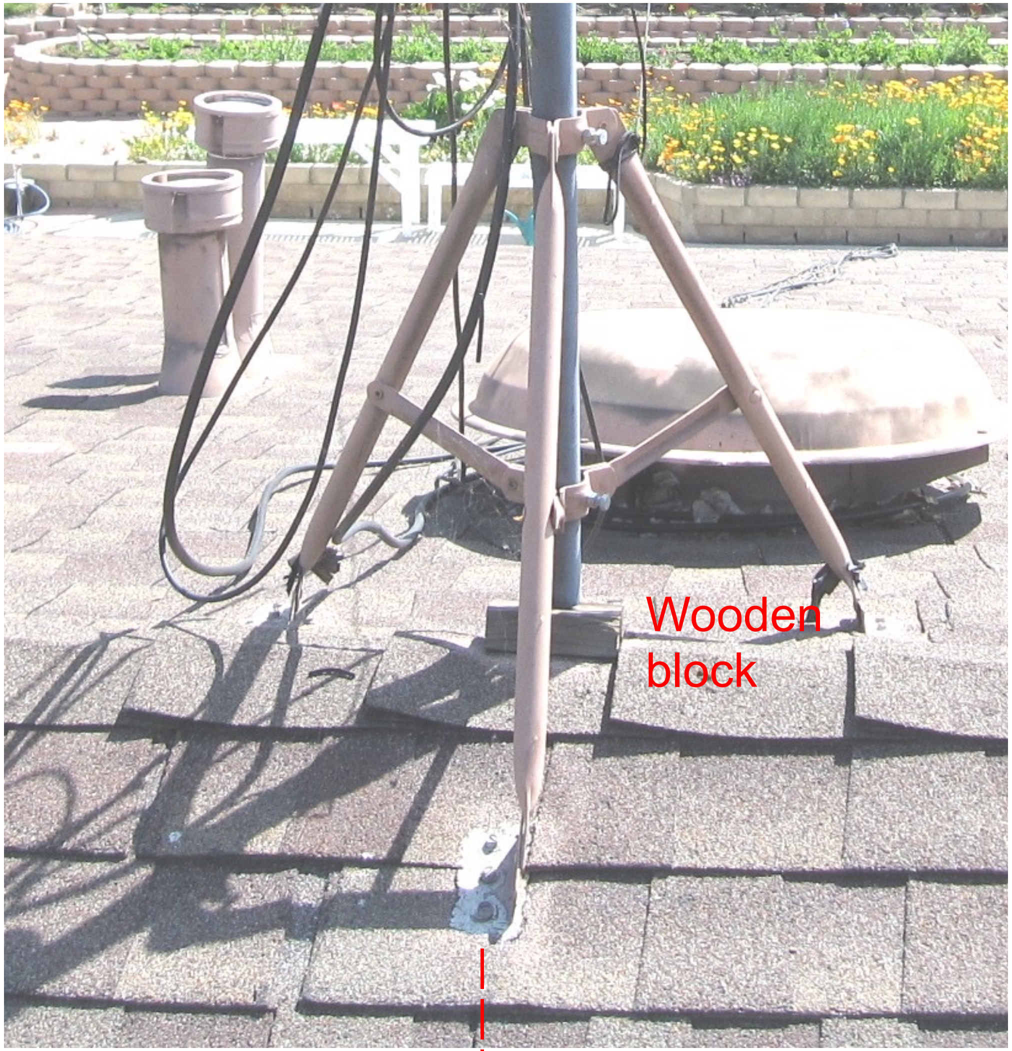


- Drive the steel fence post into the ground until the post spade is completely in the ground
- Stand the end pole up against the fence post
- Cross sectional shape of the post will cradle the end pole, keeping it from moving around
- Use hose clamps to clamp the end pole to the fence post
- This is typically a 2 person project
- One person holds the end pole in position while the second person attaches the hose clamps

Roof Mounting An Antenna

- An Inverted V antenna can be mounted on the roof of a house as well as at ground level

Mounting The Tripod

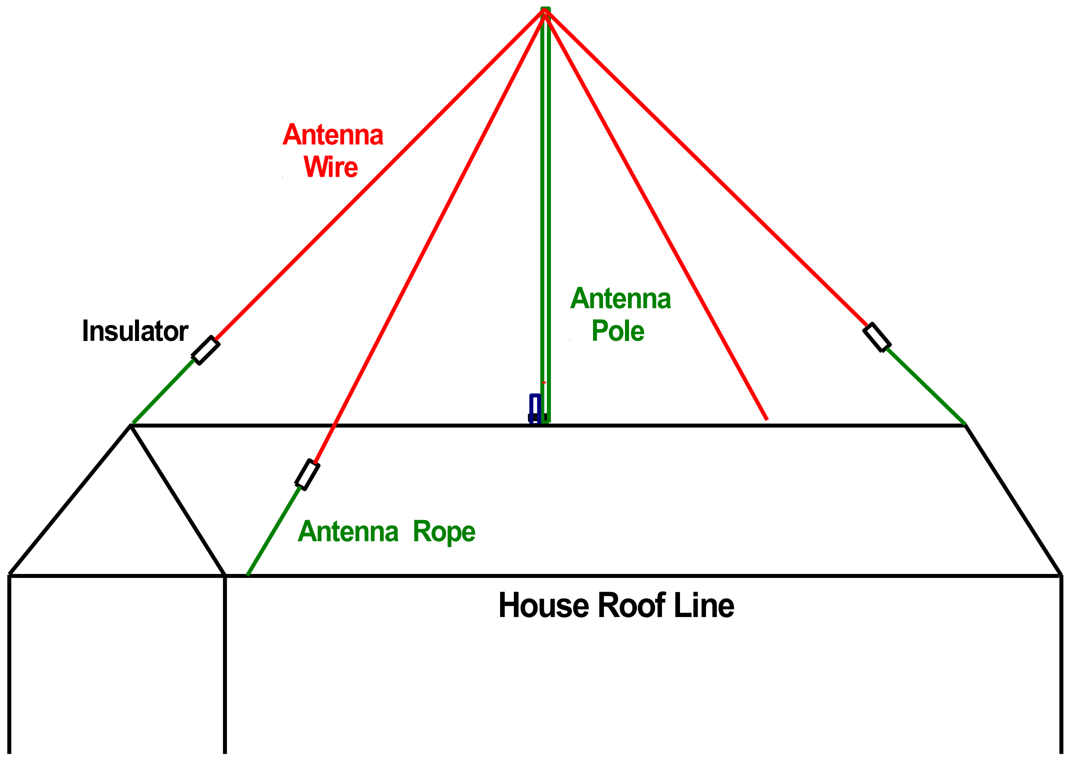


- For roof mounting, the support post is installed in a heavy duty tripod
- Bolt each foot of the tripod to the roof peak using 1/4” x 2-1/2” lag bolts
- Cover the bolts with high quality roofing tar to prevents water leaks around the bolts
- Bolts should be checked for cracks annually and more roofing tar applied if required

Installing The Support Post

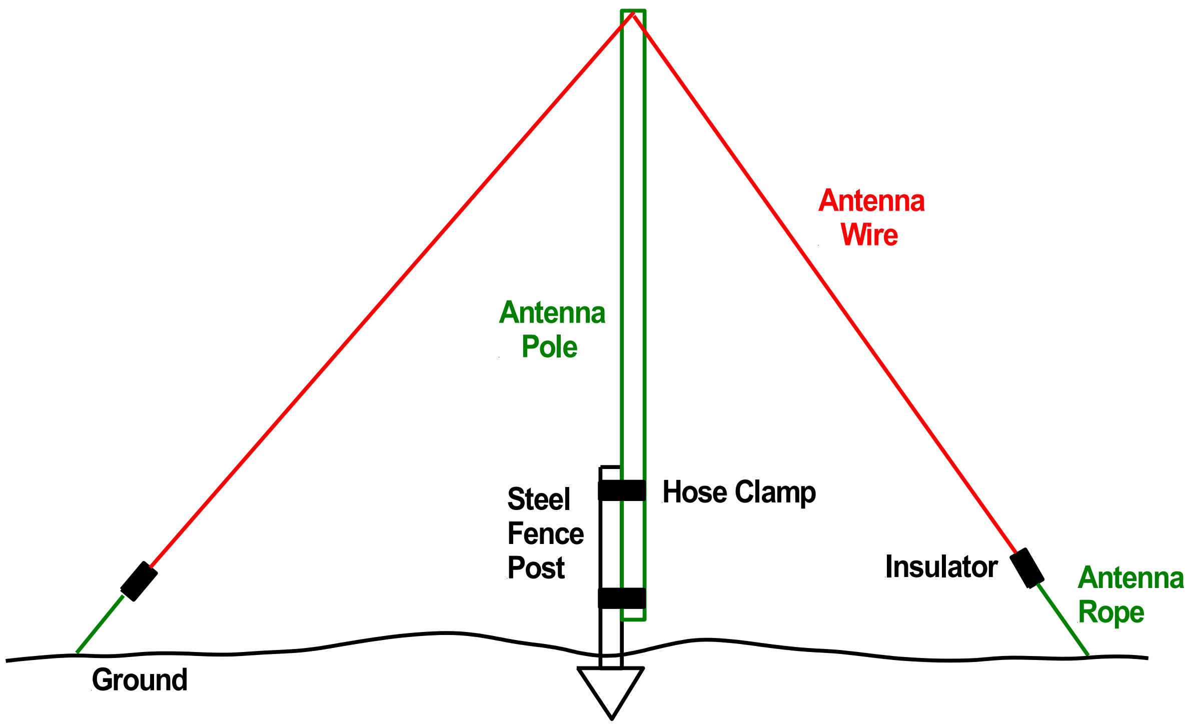
- Install the support post equipped with a bang bar into the tripod
- Place a 2 x 4 wooden block between bottom of the support post and roof to prevent post from "digging into" the roofing material
- Attach tilt over antenna pole to the support post using lower bolt
- Rotate the antenna pole up until it contacts the bang bar
- Install the upper bolt securing the antenna in place
- Alternately, a Hy-gain ATB-75 or similar tilt-mount can be used to attach the antenna pole to the support post

Attaching Ends Of Antenna Wires To Roof



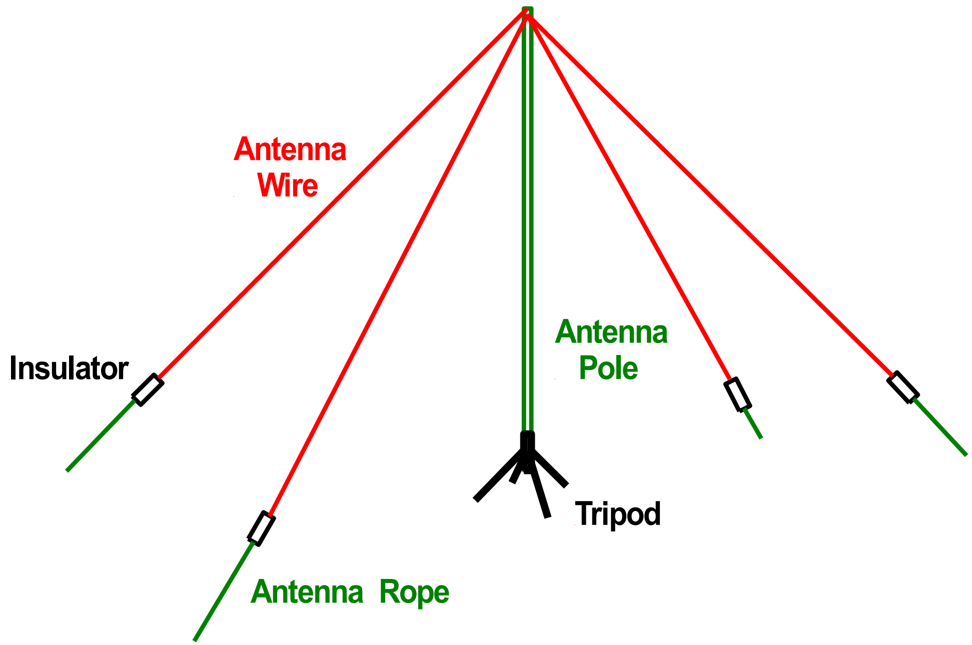
- Typically antenna ropes tied to the antenna wire end insulators are used to secure the antenna wires to eye bolts along the periphery of the roof
- Installing 2 or more Inverted V antennas at the top of the antenna pole eliminates the need to install guy ropes

Portable Light Duty Field Antenna Mount



- The 6’ long steel fence post used to install an end pole can also be used to install the center pole for a light weight Inverted V antenna
- The center pole should generally be limited to 20’ in length
- Poles longer than that can become difficult to handle and potentially unsafe

Portable Tripod Mount Field Antenna



- A tripod can be used to install a portable antenna in the field in the same way that a tripod is used to mount an Inverted V antenna on a roof top
- Instead of mounting the tripod to the roof, 8” long steel nails are inserted through the holes in each foot of the tripod nailing the tripod to the ground
- The rest of the installation is the same as used on a roof top