### **Vertical Antennas**





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### Polarization of a Vertical Antenna



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

#### 1/4 Wavelength Vertical Antenna



.90 60 - 3 db - 6 db P P<sub>0</sub>

Vertical radiation pattern over perfect ground

- 360<sup>.0</sup> 315<sup>°</sup> 45<sup>°</sup> 270<sup>°</sup> 90<sup>.0</sup> 135<sup>0</sup> 225<sup>°</sup> 180<sup>o</sup> Horizontal Radiation Pattern
- - Vertical Antenna

- The radiation patterns of a vertical 1/4 ٠ wavelength antenna
- Mounted over a very large horizontal ٠ metal surface
- Looks the same as •

#### Center Fed Vertical Half Wave Antenna



• With the large metal surface removed

#### Adding The Large Metal Surface Back





Vertical radiation pattern over perfect ground



• From a distance, the large metal surface looks like the missing half of the antenna

#### **Radials Improve Ground Conductivity**





- Ground is a crude version of a large metal surface
- However the conductivity of ground is much less than that of a metal plate
- Radials (wires buried in the ground and radiating out from the antenna base) improve the ground's conductivity

#### How Many Buried Radials?

- Use as many radials as possible up to about 60
- Space radials evenly in a spoke pattern
- Bury each radial about 1" below ground
- Make each radial about 1/4 wavelength long
- Length is an economy issue
- Making the radials longer than 1/4 wavelength cost more in copper wire but does not significantly improve performance.



#### Length and Number of Buried Radials



#### **Buried Radials – Practical Considerations**

- Try to install 20 or more radials
- If objects get in the way, like your house or yard fence, cut radials to fit, but maintain as many evenly spaced radials as possible with most radials 1/4 wavelength long



#### **Elevated Radial System**



- Radials can be elevated above ground
- For safety purpose they must be high enough so that they can not be accidently touched
- In this case each radial must be exactly 1/4 wavelength long
- This is a resonant system
- The vertical 1/4 wavelength element plus each radial forms a resonant 1/2 wavelength antenna



#### **Roof Vertical Antenna**

- A vertical antenna with an elevated radial system can be mounted on the roof of a house
- An even number of 1/4 wavelength evenly spaced radials must be used so that
  - The antenna is resonant &
  - The radiation from the individual radials cancel out
- This is necessary to obtain an omni directional vertically polarized antenna pattern
- Try to install 16 radials if possible



- In some cases the vertical element can be very tall (64' for 80 meters)
- A loading coil can be used to shorten the length of the vertical element
- However, the loading coil will reduce the bandwidth of the antenna
- The antenna may not cover the entire frequency band

#### Center Fed Vertical Half Wave Dipole



- A center fed vertical half wavelength dipole is a very effective antenna
- In this case radials are not used since the antenna is a resonant 1/2 wavelength long antenna



#### "Short" Vertical Dipole Antenna

 The antenna shown is a short center fed vertical 40 meter antenna



- It is easy to build a vertical antenna that does not require radials
- Simply use a horizontal end fed half wave (EFHW) dipole and stand it on end
- Such an antenna is inherently multiband
- A 40 meter EFHW antenna will also operate on 20, 15, and 10 meters

Match Box

- As with all EFHW antennas, an RF transformer (match box) is needed at the base of the antenna to convert the antenna's high end impedance to that of a 50 ohm coax feedline
- The problem is that such an antenna for 40 meters is 64' tall





- The height problem is solved by installing a loading coil to shorten the length of the vertical element
- As before, the loading coil will reduce the antenna's bandwidth
- The loading coil will also eliminate the antenna's inherent multiband capability
- The spokes below the match box are the antenna's counterpoise elements designed to reduce the reactive impedance at the base of the antenna (each spoke is about 0.05 wavelength long)



#### Multiband Shortened No Radial Vertical Antenna

- Antenna manufacturer's install all kinds of "plumbing" on the vertical element to:
- Create a short electrically half
  wavelength (EFHW) vertical antenna
- That achieves multiband capability
- In truth, this is a compromise antenna since it does not perform as well as a full height 1/4 wavelength vertical with an appropriated radial system
- But it is an excellent compromise when a suitable radial system can not be installed
- Notice the RF transformer match box at the base of the antenna

## Installing A Ground Mounted Vertical Antenna



# Ground Mounted Vertical Antenna Material





- The following items from DX Engineering are recommended for installing a ground mounted vertical antenna
  - DXE-RADP-3 Radial Plate and associated components
  - DXE-VA-BASE vertical antenna Tilt Base





- DXE-RADW-32RT set of 20 radial wires, each
  - 32 feet long
  - Stranded 14 AGW insulated wire
  - With a 1/4" ring terminal on one end
- DXE-STPL radial wire anchor pins
  - Staple height 6", width 1-1/2"
  - Qty: 100 or 300 piece package
- Steel guy rope (tent) stakes
- Antenna Support Rope
  - Synthetic Textile Industries, or
  - Mastrant
- JTL-12555 Jet-Lube SS-30 for protecting mechanical assemblies of aluminum tubing, general hardware and copper grounding systems.

# Antenna Support Post



- The first step in building a ground mounted vertical antenna is installing the Support Post
- Most of the antenna components are either directly or indirectly attached to the Support Post
- The Support Post consists of a standard 1-1/2" galvanized water pipe (OD 1.9") 5 feet in length which can usually be found at local home building supply stores
- Notice in the following procedures that all attachments of one component to another are performed using clamps
- Holes are not drilled through any pipes. Drilling holes would be difficult given the heavy duty pipes being used

# **Installing 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 the collar 24 inches in the ground so that the top of the collar is at ground level
- The post is centered in the middle of the pipe while cement is poured in
- Use a level to insure that 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

## Installing The Radial Plate



- The Radial Plate is attached to the Support Post by means of a clamp in accordance with the manufacturer's directions
- The Radial Plate is positioned so that it is 1 to 2 inches above ground level
- This spacing provides room for installation of the radial wire hardware
- The Radial Plate has holes for installing 60 radial wires (15 radials per side)

# **Installing Radials**



Radial wires stretched out in a uniform manner from the square Radial Plate

- Radials can be laid out on the surface of the ground or up to 6" below ground
- Attach the radials to the Radial Plate and stretch them out uniformly
- An often used approach is to lay the radials on the lawn and allow the grass to grow over the radial wires



# Installing Radials on Lawn





- Mow the grass short, but don't scalp it
- Bolt a radial wire to the Radial Plate and stretch it outward from the plate
- Starting from the Radial Plate, about every 3 to 4 feet insert an anchor pin to hold the radial wire down while pulling the radial outward from the Radial Plate to keep it taut.
- Push the anchor pin all the way in to force the radial wire into the grass roots so that the grass will grow over the radial wire
- Continue until all radials are installed
- The grass will eventually grow over the radial wires completely burying them

### **Operation of the Tilt Base**



- When completely installed, that is
  - Tilt Base bolted to the Support Post, and
  - Antenna clamped to the Tilt Base
- The antenna is rotated to the horizontal position by following the steps shown
- Look carefully, lifting and sliding refer to lifting the top two pins of the antenna bracket out of the mounting plate top slots and sliding the the antenna to the right

# Installing The Tilt Base



- Bolt Tilt Base to the Support Post according to the manufacturer's directions
  - At this point the bottom section of the vertical antenna (shown in the diagram) has not yet been attached to the Tilt Base
- When the antenna is installed it will be insulated from the grounded Support Post

### Attaching Antenna to Tilt Base



- Assemble the vertical antenna on the ground according to the antenna manufacturer's directions
- Place the Tilt Base in the horizontal position
- With the antenna horizontal and supported along its length on boxes, etc.
- Clamp the bottom section of the antenna to the Tilt Base (not the antenna's grounded base tube, but the bottom of the active antenna itself, the grounded base tube is not used)

# **Guy Ropes**



- A minimum of 3 guy ropes will be required to hold the antenna in a vertical position, particularly during strong winds
- The antenna manufacturer will specify the point at which guy ropes are attached to the antenna (at a distance h1 from the bottom of the antenna)
- Due to the Tilt Base, the bottom of the antenna will be a distance h2 above ground
- When the antenna is in the vertical position the guy ropes will be attached to the antenna a distance of H = h1 + h2 above ground

# **Installing Guy Ropes**



- Install 3 guy rope ground stakes symmetrically around the antenna with each ground stake a distance H from the antenna base
- Each guy rope will be 1.4 H in length when the antenna is securely installed in the vertical position
- Cut each guy rope a couple feet longer than 1.4 H to provide sufficient rope for attachment to the antenna, ground stake, and for lengthening or shortening the rope to hold the antenna in a vertical position
- Tie the 3 guy ropes to the designated attachment point on the antenna
- Do not connect the guy ropes to the ground stakes

# **Tunning The Antenna**



- Rotate the antenna into the vertical position
- A coax cable connector assembly (DXE-UHF- FDFB-KIT) is available for the Radial Plate that simplifies connection between the antenna system and the radio shack
- Install the coax cable to the radio shack and test the antenna
- The antenna will need to be raised and lowered several times in order to tune the antenna to the desired frequency bands
- Once the antenna is tuned and in the vertical position, attach the 3 guy ropes to their associated ground stakes
- Lengthen or shorten each guy rope as needed to align the antenna in the vertical position

## Installing A Half Wave No Radial Vertical Antenna



## Antenna Support Post



- The first step in assembling a no radial half wave vertical antenna is installing the Support Post
- Most of the antenna components are either directly or indirectly attached to the Support Post
- The Support Post consists of a standard 1-1/2" galvanized water pipe (OD 1.9") 6 feet in length which can usually be found at local home building supply stores

# **Installing 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 the collar 24 inches in the ground so that the top of the collar is at ground level
- The post is centered in the middle of the pipe while cement is poured in
- Use a level to insure that 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

## No Radial Vertical Antenna Mounting Height



- The base of a no radial vertical antenna must be at least 8 feet above ground so that a person walking below the antenna will not accidently be "poked in the eye" by one of the antenna's counterpoise spokes
- In this picture the counterpoise spokes are located just above the black transformer/matching box



# Mast Requirements

- Because of the antenna mounting height requirement
  - An 8 foot Mast must be bolted to the Support Post, and
  - The base of the antenna bolted to the top of the Mast
- The Mast consists of a standard 1-1/2" galvanized water pipe (OD 1.9" OD) 8 feet in length
- This is a heavy antenna system with the weight of the
  - Antenna itself, plus
  - The Mast
- Do not use thin walled conduit, aluminum tubing or "TV" mast

## **Tilt Mount Brackets**



- Use a Hy-gain ATB-75 Tilt-mount to attach the Mast to the Support Post
- DX Engineering DXE-OMNITILT-1 tilt mount and Cushcraft R-8TB tilt base are also good choices

## Installing The Mast



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

## **Assembling Antenna**



- Assemble the vertical antenna on the ground according to the antenna manufacturer's direction
- Place the Tilt Bracket and Mast in the horizontal position



## Antenna Mounting

- With the antenna horizontal and supported along its length on boxes, etc.
- Clamp the bottom section of the antenna to the top of the Mast using U-bolts and mounting plate provided by the antenna manufacturer
- Attach the antenna coax cable to the bottom of the transformer/match box (partial black box shown in drawing)

# **Guy Ropes**



- A minimum of 3 guy ropes will be required to support the antenna, particularly during strong winds
- The antenna manufacturer will specify the point at which guy ropes are attached to the antenna (at a distance h1 from the bottom of the antenna)
- Due to the Mast and Tilt Base, the bottom of the antenna will be a distance h2 above ground
- When the antenna is in the vertical position the guy ropes will be attached to the antenna a distance of H = h1 + h2 above ground



# Installing Guy Ropes

- Install 3 guy rope ground stakes
   symmetrically around the antenna with each ground stake a distance
   H from the antenna base
- Each guy rope will be 1.4 H in length when the antenna is securely installed in the vertical position

# **Installing Guy Ropes**



- Cut each guy rope a couple feet longer than 1.4 H to provide sufficient rope for attachment to the antenna, ground stake, and for lengthening or shortening the rope to hold the antenna in a vertical position
- Tie the 3 guy ropes to the designated attachment point on the antenna
- Do not connect the guy ropes to the ground stakes

### **Raising The Antenna Into Position**



Raise the antenna into position

Insert the Lock Bolt through the Base Bracket and Tilt Bracket securing the antenna in the vertical position

# Adjusting Guy Ropes



- The antenna will need to be raised and lowered several times in order to tune the antenna to the desired frequency bands
- Once the antenna is tuned and in the vertical position, attach the 3 guy ropes to their associated ground stakes
- Lengthen or shorten each guy rope as needed to align the antenna in the vertical position

## **Upper Support Bracket**



- After the antenna has been tuned and raised into its vertical position, a support bracket can be added to strengthen the antenna
- The bracket is fabricated from a 12" long section of 0.125" x 2" x 2" angle aluminum (available on-line) that bridges horizontally from the top of the Support Post to the Mast

### Saddle Clamps



The support bracket is held in place by two DXE-OTMC-250P Double - V Saddle clamps



### **Roof Mounted No Radial Vertical Antenna**



# Mounting The Tripod



- A no radial vertical antenna can be mounted on the roof of a house as well as at ground level
- 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 Roof Mounted Support Post**



- Install Support Post into the tripod
- The Support Post is the same as for a ground mounted no radial vertical antenna (6 ft in length)
- Place a 2 x 4 wooden block between bottom of the Support Post and roof to prevent post from "digging into" the roofing material
- The rest of the installation is the same as for a ground mounted no radial vertical antenna except that a 6 ft mast is used and the guy ropes are longer



- A minimum of 3 guy ropes will be required to properly support the antenna
- The antenna manufacturer will specify the antenna attachment point for the guy ropes



- It is best for roof integrity to make the guy ropes long enough so that they can be anchored to the periphery of the roof
- Tie the 3 guy ropes to the designated attachment point on the antenna
- Do **not** connect the guy ropes to the roof anchor points



## Adjusting Guy Ropes

- The antenna will need to be raised and lowered several times in order to tune the antenna to the desired frequency bands
- Once the antenna is tuned and in the vertical position, attach the 3 guy ropes to their associated anchor points along the edge of the roof
- Lengthen or shorten each guy rope as needed to align the antenna in the vertical position
- Install upper support bracket the same as for the ground mounted antenna

### **Roof Mounted Quarter Wave Vertical Antenna**



## Roof Mounted Quarter Wave Vertical Antenna



- A quarter wave vertical antenna with radials can also be installed on a house roof
- A roof top is often an excellent location to install a quarter wave vertical if, as in the picture, there is not adequate space in the yard to install radials,

# 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

## **Support Post Installation**



- Install the Support Post into the tripod
- The Support Post is a 1-1/2" galvanized water pipe (OD 1.9"), 5 feet in length
- Place a 2 x 4 wooden block between bottom of the Support Post and roof to prevent post from "digging into" the roofing material

## **Tilt Mount Brackets**



- Use a Hy-gain ATB-75 Tilt-mount to attach the antenna to the Support Post
- DX Engineering DXE-OMNITILT-1 tilt mount and Cushcraft R-8TB tilt base are also good choices

# Antenna Mounting



- Attach the ATB-75 Tilt-mount Base Bracket to the Support Post (Base Pipe)
- Assemble the vertical antenna on the ground according to the antenna manufacturer's direction
- Lift the antenna up to the roof
- Place the Tilt Bracket in the horizontal position
- With the antenna horizontal and supported along its length on a saw horse, etc.
- Clamp the grounded bottom section of the antenna to the Tilt Bracket



- A minimum of 3 guy ropes will be required to support the antenna, particularly during strong winds
- The antenna manufacturer will specify the point at which guy ropes are attached to the antenna



- For integrity of the roof, it is best to install eye screws at the roof periphery as the guy rope anchor points
- Cut guy ropes much longer than needed
- Attach the 3 guy ropes to the antenna

## **Raising The Antenna Into Position**



- Raise the antenna into position
  - Insert the Lock Bolt through the Base Bracket and Tilt Bracket securing the antenna in the vertical position

### **Multi-Band Radial**



- This installation is an elevated radial system in that the radials are not only above the roof, but also a considerable distance above ground
- Consequently, all of the radials must be **exactly** the same length, that length being a quarter wavelength long for each frequency band
- Butternut offers a tuned radial kit (BUT-STR-II) consisting of 4 tuned radials each radial covering 40, 20, 15, and 10 meters as shown in the diagram
- Or you can build your own radials

## Installation of Radial Wires



- A minimum of 4 radials (per band) equally spaced around the antenna is required, 8 or more radials per band is desirable
- Connect the radials to the bottom of the antenna at the same point that the coax braid is connected to the antenna
- This point is around 5 to 6 feet above the roof
- A single STR multiband radial is shown connected to the antenna



# Connecting Multiple Radial Wires

- Connecting a significant number of radials to a single bolt on the antenna can be difficult
- It is recommended that 2 sections of 1/8" angle aluminum each 1" x 1" x 6" be bolted to the antenna at the point designated for the coax braid (one section on each side of the antenna pole)
- Drill 4 holes in each section for attaching radial wires plus the coax braid
- This arrangement allows up to 32 radials to be easily connected to the antenna



- Typically eye screws installed along the periphery of the roof are used for radial wire anchor points
- An antenna rope tied to a radial wire insulator is used to complete the distance from the insulator to the anchor point

## **Tunning The Antenna**



- Connect the coax cable from the radio shack to the antenna
- The antenna may need to be raised and lowered several times in order to tune the antenna to the desired frequency bands
- Initially loosely tie the radial ropes to their anchor points
- The guy ropes do **not** need to be anchored during the tunning process
- Once the antenna is tuned securely tie the radial ropes and guy ropes to their anchor points