Flagpole Antenna

Designs
For
The Villages

Dennis  W4DIH
Brad  KN9B

Feb. 15, 2011
Practical Considerations

Safety
Restricted Community Standards
Appearance
On Air Performance
Antenna Element Options
Tuner Options
Ground System
Cost Breakdown
Construction
Safety

Prevent direct contact with radiating element
Control Zone = 2+ Feet
Uncontrolled Zone = 4+ Feet
• Assumes; 100 W Transmitter, CW, 50 Feet RG-8X, VSWR 1.5, 10 M

Worst Case cited
most installations will
be ½ these distances
Design for Safety

Radiating element inside PVC pipe to prevent direct contact
Control Zone established by planter
Operator monitors site during transmissions
Restricted Community Standards

Located on private property
Not allowed in easements
Less than 22 Feet Tall
Requires Architectural Review Committee approval

• Application Form with Site Plan indicating location
Community Friendly Design

Location astatically pleasing on private property not in easement
Less than 22 Feet Tall
ARC application Form with Site Plan indicating location (kiss)

Installing Flagpole

Feb. 15, 2011
Appearance Considerations

Look and function as a flagpole
Withstand the neighborhood inspector review
External Pulley, Rope, Ring & Cleat
Include compatible planter suggestions
Appearance Details

Flagpole with flag, rope, pulley, cleat, etc.

- Flagpole parts can be purchased separately or as kits

Paint flagpole to color desired

Include planter control zone and hide tuner
Performance

Flagpole Antennas provide:

80 M to 10 M >>>> VSWR less than 2
80 M to 10 M >>>> Better than 90% Efficient

Ground Plane quality is biggest factor in DX reach
TVARC Project Objectives

80 M to 10 M operation *
Best at 40 M and 20 M
Tuner solution
Interface to a wide range of Ground Plane options

* No one requested 160 M
Antenna Element Options

Two approaches were developed for the ¼ WL Vertical
Both are 22 Feet Tall
Both can be painted to desired color

• DIY using PVC Pipe
• Purchased 2 Inch Aluminum Flagpole Kit
Antenna Element Options

DIY using PVC

- 2 ½ Inch Sch 80 PVC
- 2 Inch Sch 80 PVC
- 3 Inch Sch 40 PVC

Ground Level

- 1 Ft
- 2 Ft
- 5 Ft
- 10 Ft
- 22 Ft

Gray Electrical Conduit
Antenna Element Options

DIY using “longer” 33 Foot inside PVC

- **Main Element**
  - #10 or 12 AWG
  - ~ 22 Feet

- **Design based on**
  - “Linear” or “Bazooka”
  - Vertical ¼ Wavelength for 40 M
  - (~22 Physical Feet = ~33 RF Feet)

- **PVC Pipe**
- **Twin Lead, Ladder, etc.**
  - Length ½ Main Element
  - #14 or 16 AWG

- **Ground Plane**
- **Tuner**
- **Coax Feed 50 Ohms**
Antenna Element Options

Purchased 2 Inch Aluminum Flagpole Kit

- 22 Ft Pipe Support with Isolated Core Rod
- 18 Dia X 24 Inch Concrete
- 2 Ft Pipe Support with Isolated Clamps
Tuner Options

Three approaches were considered for the tuner
Two are located at the antenna and require power
One did not require equipment at the antenna

• Indoor tuner with isolation BALUN at antenna
• Purchased remote tuner
• DIY tapped load coil with remote control

The 40 M ¼ WL antenna design presented is dependent on the coaxial feed length
Use COAX lengths of 40-50, 70-80, 100-110 or 130-140 feet
Do NOT use COAX lengths of 30, 60, 90, 120 feet
Tuner Options

Indoor match was **rejected** due to high losses

Mono-band and 3rd Harmonic are 80% & 40% efficiency

Five-band resulted in most bands at 5% efficiency

![Graph showing VSWR values for different frequencies with 1:1 VSWR and High VSWR noted]
# Tuner Options

ANY purchased remote tuner *(here is a sample)*

<table>
<thead>
<tr>
<th>Vendor</th>
<th>SGC</th>
<th>MFJ</th>
<th>CG</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model</td>
<td>SG-230</td>
<td>MFJ-927</td>
<td>CG-3000</td>
</tr>
<tr>
<td>Power Input (PEP watts)</td>
<td>200</td>
<td>200</td>
<td>3-100</td>
</tr>
<tr>
<td>Input Capacitance maximum</td>
<td>6400pf</td>
<td>3961pf</td>
<td>6300pf</td>
</tr>
<tr>
<td>Inductance maximum</td>
<td>64µH</td>
<td>25µH</td>
<td>64µH</td>
</tr>
<tr>
<td>Size Overall (inches)</td>
<td>16Dx12Wx3H</td>
<td>7Dx6Wx9H</td>
<td>10Dx12Wx3H</td>
</tr>
<tr>
<td>Weight (pounds)</td>
<td>8</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Case Construction</td>
<td>Plastic ABS Waterproof case</td>
<td>ALUM Base with Plastic ABS Cover Rainproof</td>
<td>Plastic ABS Waterproof case</td>
</tr>
</tbody>
</table>

Paint SCG Remote Tuner

Camo Painted

Naked in front yard
Tuner Options

DIY using a tapped load coil with remote control

Coax Feed 50 Ohms

Ground Plane

Tapped Load Coil Remotely Controlled by Relays

1:1 BALUM or Choke

Remote Control & Status Panel in Shack to Select Band

Coax Feed 50 Ohms
# Tuner Options

DIY using a tapped load coil with remote control

- **80 M taps** have 200 KHz BW set at 3.6, 3.7 & 3.9 MHz
- **40 M tap** has 330 KHz BW set at 7.15 MHz
- **20 M tap** has 700 KHz BW set at 14.20 MHz
- **15 M tap** has 1,100 KHz BW set at 21.00 MHz
- **10 M tap** has 1,700 KHz BW set at 29.00 MHz

## Table

<table>
<thead>
<tr>
<th>22 Foot Element</th>
<th>33 Foot Element</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Freq</strong> MHz</td>
<td><strong>Match Eff %</strong></td>
</tr>
<tr>
<td>3.6</td>
<td>96.5</td>
</tr>
<tr>
<td>3.9</td>
<td>96.5</td>
</tr>
<tr>
<td>7.15</td>
<td>98.3</td>
</tr>
<tr>
<td>14.2</td>
<td>99.7</td>
</tr>
<tr>
<td>21</td>
<td>99.1</td>
</tr>
<tr>
<td>29</td>
<td>99.5</td>
</tr>
</tbody>
</table>

Example for 80, 40, 15 & 10 M

**BW based on 2:1 SWR**

**Taped load coil performance equals remote tuner BW based on 2:1 SWR**
Ground System

Guidance for your Ground Plane
- Local soil resistance is high & more than a rod is required
- Use 16 or more radials
  - Length is more important than Number
  - cut to ¼ WL for lowest frequency
  - Radials can be “bent” around house if needed
  - Connect radial ends

DIY using 14 AWG
- Copper, Galvanized or Aluminum
- Cut slit in grass with edger
- Electrical “Main” Panel Ground Buss

Purchased
- Hidden Dog Fence vendor will charge $150 to $200 for 16 Radials
- Ground Radial Plate Kit
Why your Ground Plane is Important?

Your typical 100W T/R on 40 M shown above with four different antennas:

- **Dipole** is less than 20 Feet above ground level
- **Theory** is a computer model perfect ground plane
- **Sea** is a $\frac{1}{4}$ WL Vertical Antenna measured over Sea Water the best Ground Plane
- **Typical** is a $\frac{1}{4}$ WL Vertical Antenna measured over ground much better than our sandy soil

DX Range 2 to 3 Hops

EIRP dBm

1st Hop in Miles

Elevation Angle
Multi-band Ground Plane

Shape is “Freeform”
Long & More are better
Connect ends as practical

Theory

Good

Better

QST March 2010 P. 30-33
Ground Plane what can I do?

DX openings are few above 15° Elevation, improvements can be realized by;

- Increasing the height of the antenna
- Raising the ground plane 1 to 5 Feet above ground
- Use a Vertical Dipole or J-Pole that do not require Ground Plane, but are 2X, 3X taller
- Put in 16 (or better 32) Radials if not an attic dipole will be a better DX antenna choice
- Increasing the height of the antenna using a balloon

Antenna Response Versus Height
14 MHz, Boston to Europe

QST March 2010 P. 39 -40
Antenna Height and Communications Effectiveness
By R Dean Straw, N6BV, and Gerald L. Hall, K1TD
Ground Connections

Bond mechanically and electrically
Use anti-corrosion paste
Keep dry

Main Ground Buss sold as repair parts
Ground Plate sold as kit
Split Bolt used for cable slicing
Power Panel w/o Cover
## Cost Elements

<table>
<thead>
<tr>
<th>Item Description</th>
<th>ALL DIY</th>
<th>ALL Buy</th>
</tr>
</thead>
<tbody>
<tr>
<td>US Flag</td>
<td>$20</td>
<td>$120</td>
</tr>
<tr>
<td>PVC, Rope, HW</td>
<td>$40</td>
<td>na</td>
</tr>
<tr>
<td>Concrete Base &amp; HW</td>
<td>$15</td>
<td>$60</td>
</tr>
<tr>
<td>RF Element</td>
<td>$10</td>
<td>na</td>
</tr>
<tr>
<td>Tuner</td>
<td>$40</td>
<td>$300</td>
</tr>
<tr>
<td>Ground Plane</td>
<td>$25</td>
<td>$175</td>
</tr>
<tr>
<td>Planter</td>
<td>$50</td>
<td>$150</td>
</tr>
<tr>
<td>100 Feet Coax</td>
<td>$75</td>
<td>$75</td>
</tr>
<tr>
<td>100 Feet Control Wire</td>
<td>$15</td>
<td>$50</td>
</tr>
<tr>
<td>Total</td>
<td>$290</td>
<td>$960</td>
</tr>
</tbody>
</table>

### Trade Space to Consider

- **PVC vs. Alum Flagpole Kit**
  - $70 vs. $120 = Δ of $50

- **DIY vs. Purchased Tuner**
  - $40 vs. $300 = Δ of $260

- **DIY vs. Purchased Ground Plane**
  - $25 vs. $175 = Δ of $150

**Quote from Hidden Dog Fence Installer**
PVC Flagpole Construction

A gathering of materials for TVARC Flagpole Antenna Project. I started with an assortment of stainless steel fasteners. 2 snap hooks, a rope cleat, stainless eyehook, a pulley, rope and of course a Flag.

Most all items purchased at Home Depot

Swivel ring = $2.98
Snap rings = $1.94
Rope Cleat $1.98
Eyebolt = $1.98
Rope = $4.24
Flag = $5.00*

*Marion flea market
PVC Flagpole Construction

The real Antenna

I used solid #10 copper wire

My first prototype used ladder line. This was changed later

This was excess wire from my collection which my XYL calls junk
PVC Flagpole Construction

Pipe Galore

I used 2- 10’ lengths of electrical 2” schedule 80 PVC conduit. Schedule 80 is thick walled and sunlight resistant. There is 1 length of 2-1/2” schedule 40 conduit.

A piece of scrape 1-1/2” plumbing PVC pipe
A piece of scrap 3” plumbing PVC pipe
The schedule 80 2” pipe was $6.47 per 10’
The 2-1/2 schedule 40 was $7.04 per 10’
The 3” and 1-1/2” plumbing pipe will cost about $6.00  (Home depot sells 3’ shorts)
PVC Flagpole Construction

- Main Element: #10 or 12 AWG, ~22 Feet
- Design based on "Linear" or "Bazooka" Vertical ¼ Wavelength for 40 M (~22 Physical Feet = ~33 RF Feet)
- PVC Pipe
- Twin Lead, Ladder, etc.
- Length ½ Main Element: #14 or 16 AWG
- Ground Plane
- Coax Feed 50 Ohms
- Tuner
PVC Flagpole Construction

The # 10 solid wire is 22’.
The Ladder Line is 11’.

I soldered together the both sides of the ladder line at the top.

One side of the bottom of the ladder line is soldered to the # 10 wire.

I soldered a piece of # 14 stranded copper wire on the other lead of the bottom ladder line to serve as the connection point to the tuner.
PVC Flagpole Construction

Close up of solder joints.
PVC Flagpole Construction

I used a 2” pipe cap on the top of the antenna. I painted this a bright gold.

I was going to couple the 2 pieces of 2” together but used the bell end on the conduit instead.
PVC Flagpole Construction

I positioned the 2 pieces of 2” conduit and about 2’ of the 1-1/2 pipe. The 1-1/2 will serve as a sleeve to strengthen the coupling of the 2 pipes.
PVC Flagpole Construction

I marked the center of the 1-1/2” to insure that there would be equal lengths in each side of the joint.
PVC Flagpole Construction

I drove the 1-1/2” into the bell end of one piece of 2” and the slide in the other side. I did use PVC glue on this joining.
PVC Flagpole Construction

I attached the screw eye taking care to be just below where the PVC cap will rest. I then attached the pulley to the screw eye.
PVC Flagpole Construction

This the top end of the coax. The shield and the center wire are soldered together. Be careful when you solder. I now have a large patch on one of my golf shirts.
PVC Flagpole Construction

This is the assembled antenna stretched out, ready to be assembled.
PVC Flagpole Construction

Approximately 1-1/2’ of the bottom 2” will slide into the 2-1/2” conduit for extra support. Measure your cuts with care.
PVC Flagpole Construction

The total length of the Antenna is 22’. You must allow for the slide in length.
PVC Flagpole Construction

Approximately 30” of 2-1/2” conduit will slide into the 3” pipe. The 3” will be encased in concrete.
PVC Flagpole Construction

Again. Please measure and mark your cuts accurately. 30 Inches of 2-1/2” pipe slides into the 3” pipe.
PVC Flagpole Construction

32 Inch Length of 3 Inch Sch 40 pipe. Home Depot sells 3 Ft. shorts in the plumbing department.
PVC Flagpole Construction

This is the finished flag pole cut to the proper length
PVC Flagpole Construction

Drill a ½” hole at approximately 22-1/2” from the bottom of the flag pole. Fish a piece of twine in the hole and out of the bottom of the 2-1/2” pipe. Tie the twine to keep it in place and to prevent it from disappearing when you pull in the antenna.
PVC Flagpole Construction

Push the solid #10 and the attached coax up the pipe. You may need to run a fish line to do this.

Tie the antenna lead (24” of 14 stranded wire) on to twine and when the antenna is at the top of the flag pole, pull the antenna lead out of the hole.
PVC Flagpole Construction

Attach cap and pulley. The rope goes through the pulley and down to where the cleat will be mounted. Leave about 4” extra in this loop.
PVC Flagpole Construction

Attach the cleat with (2) 3” 1/4- 20 ss bolts. Make sure that the bolts pass through the 2-1/2” and the 2” conduit. If you need to detach the pipe, this will be of great value.
PVC Flagpole Construction

Time for Erection!

It is a wise idea to enlist the help of friends to install the finished antenna.
PVC Flagpole Construction

View of the finished antenna from Lake Sumter.
PVC Flagpole Construction

Antenna on a very windy day.
(15 to 20 MPH winds)

The antenna will flex in heavy winds. It is best not to fly your flag under these conditions (as with all flag poles) you will not harm the antenna and it will stand straight in light winds.
Flagpole Construction

Light it up!
A solar powered light cost $19.95 at Home Depot.
It gives just enough light and last about a year.
Flagpole Construction