NVIS Antenna Design & Construction

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W5IFQ

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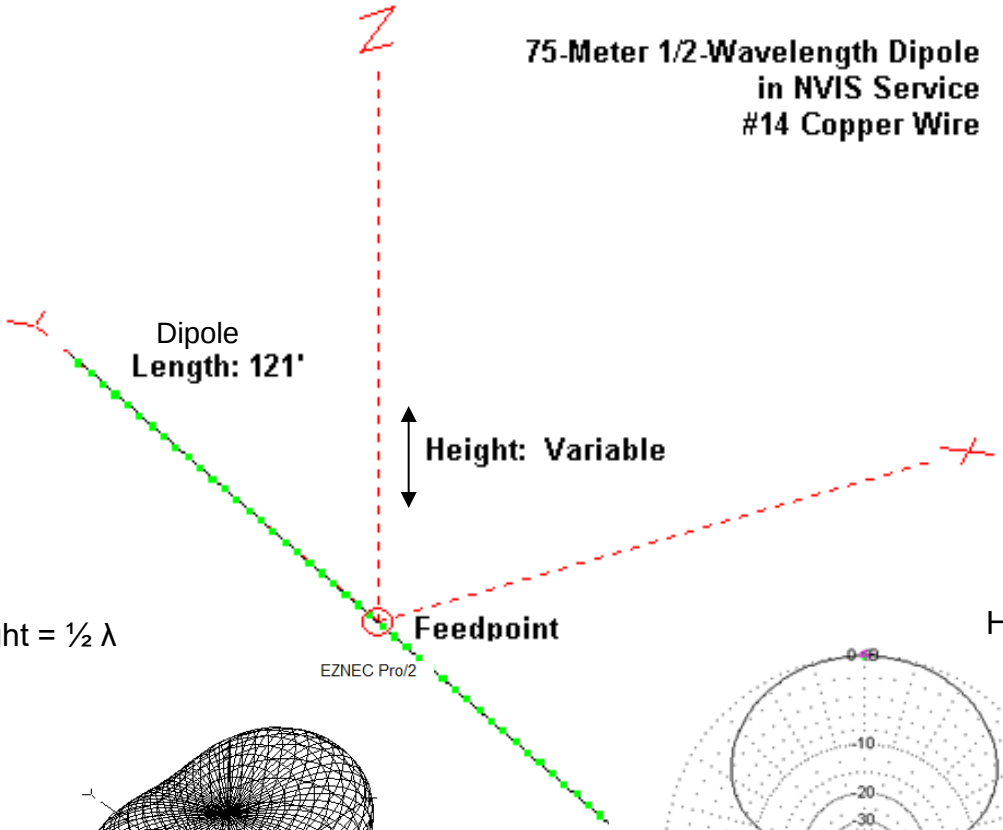
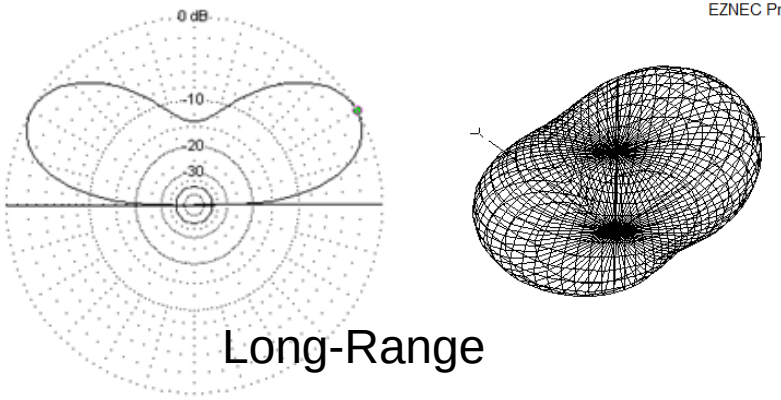
Objectives

- Introduce practical antenna designs for NVIS operations. This will include:
  - Various design shapes with efficiency comparisons.
  - Various mounting options including free standing masts and house supported antennas.
  - Antenna tuning techniques.
- Member examples will be provided
- A collection of antenna construction hardware is provided in Appendix.

Dipole Directivity versus Height
(1/2 Wavelength Dipole)

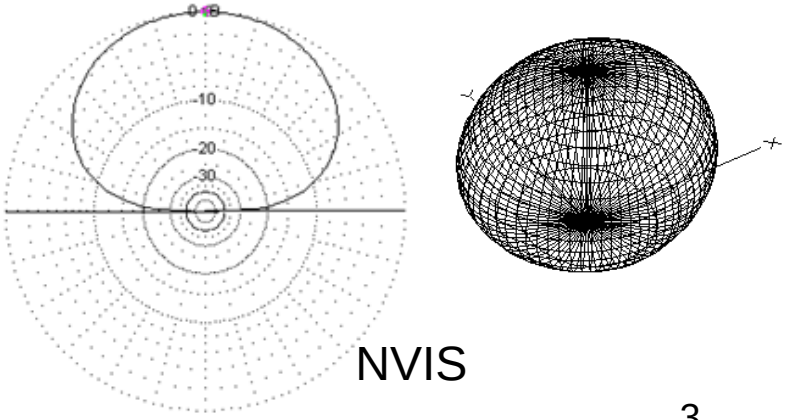


Height = ½ λ



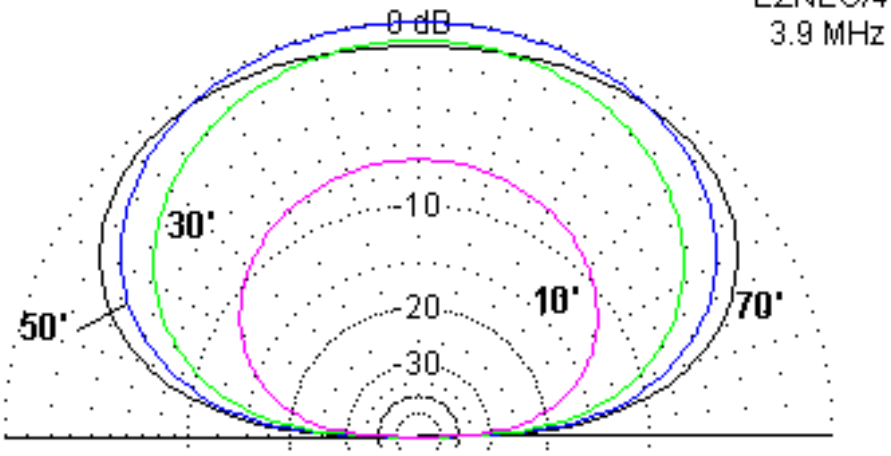
Long-Range

Height = .15 λ

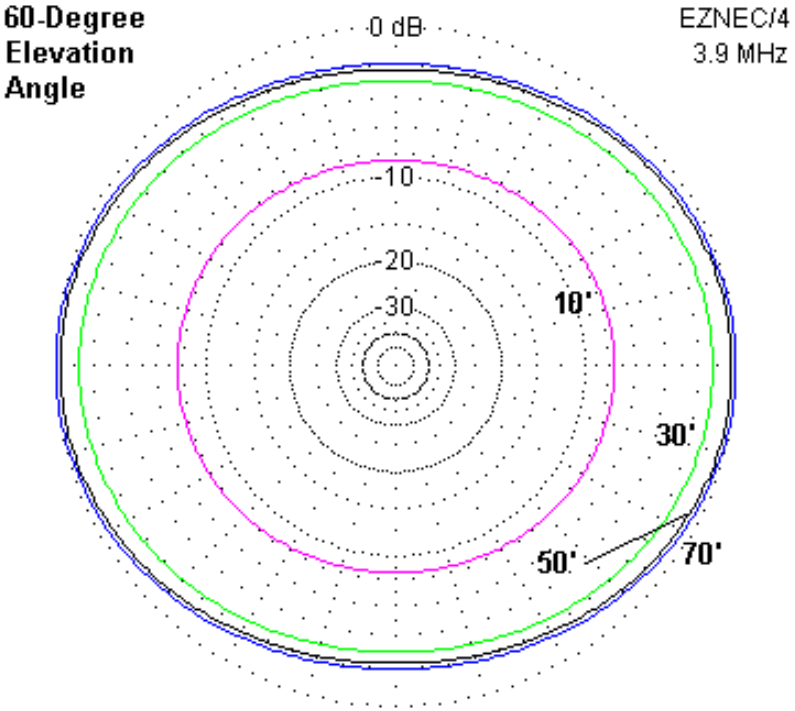


NVIS

NVIS Resonant Dipole Patterns Versus Height – 3.9 MHz



Elevation Patterns of a 75-Meter Dipole for NVIS Service at 10, 30, 50, and 70 Feet Above Average Soil



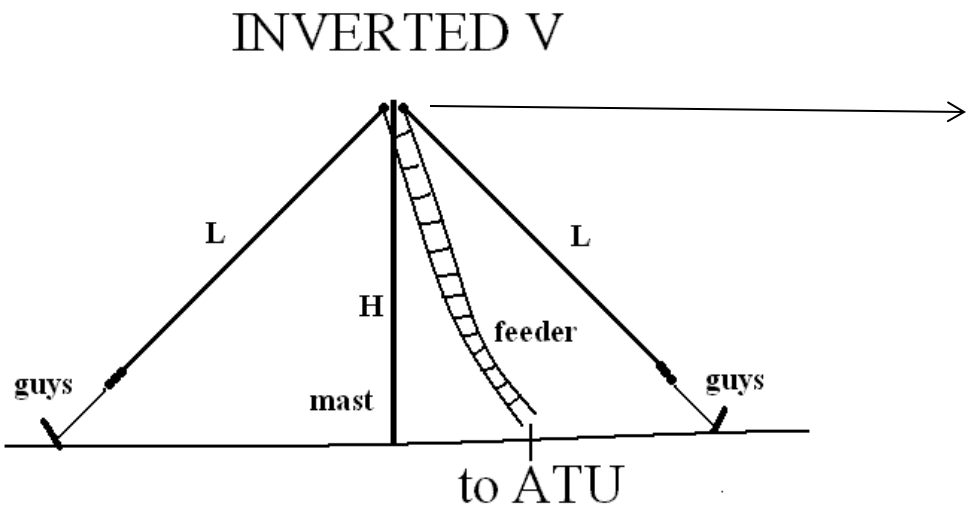
Azimuth Patterns of a 75-Meter Dipole for NVIS Service at 10, 30, 50, and 70 Feet Above Average Soil

50 ft. = 0.2λ
30 ft. = 0.12λ

Dipole Geometry Options

- Total length (both legs) between 100 ft. to 140 ft.
- Average Height to not exceed 40 ft.
- Either Horizontal or Inverted-V
- Can use OCF – Off center feed
- Horizontal wire angle can change but should not exceed 90°
- Wire elevation can change but vertical components do not contribute to NVIS pattern
- Need to model to evaluate performance trade-offs.

Generic Non-Resonant Dipole Driven by Tuner



WA1FFL Ladder-Loc

L = 65 ft. – 75 ft.
H = 30 – 50 ft.
Angle = As large as possible

Use 4:1 balun between ladder line and coaxial cable for rig mounted tuner.
Best to mount tuner at base of mast.

Non-Resonant Long-Wire Antennas

Auto-Tuner

Counterpoise
To Gnd.

20-40 ft.

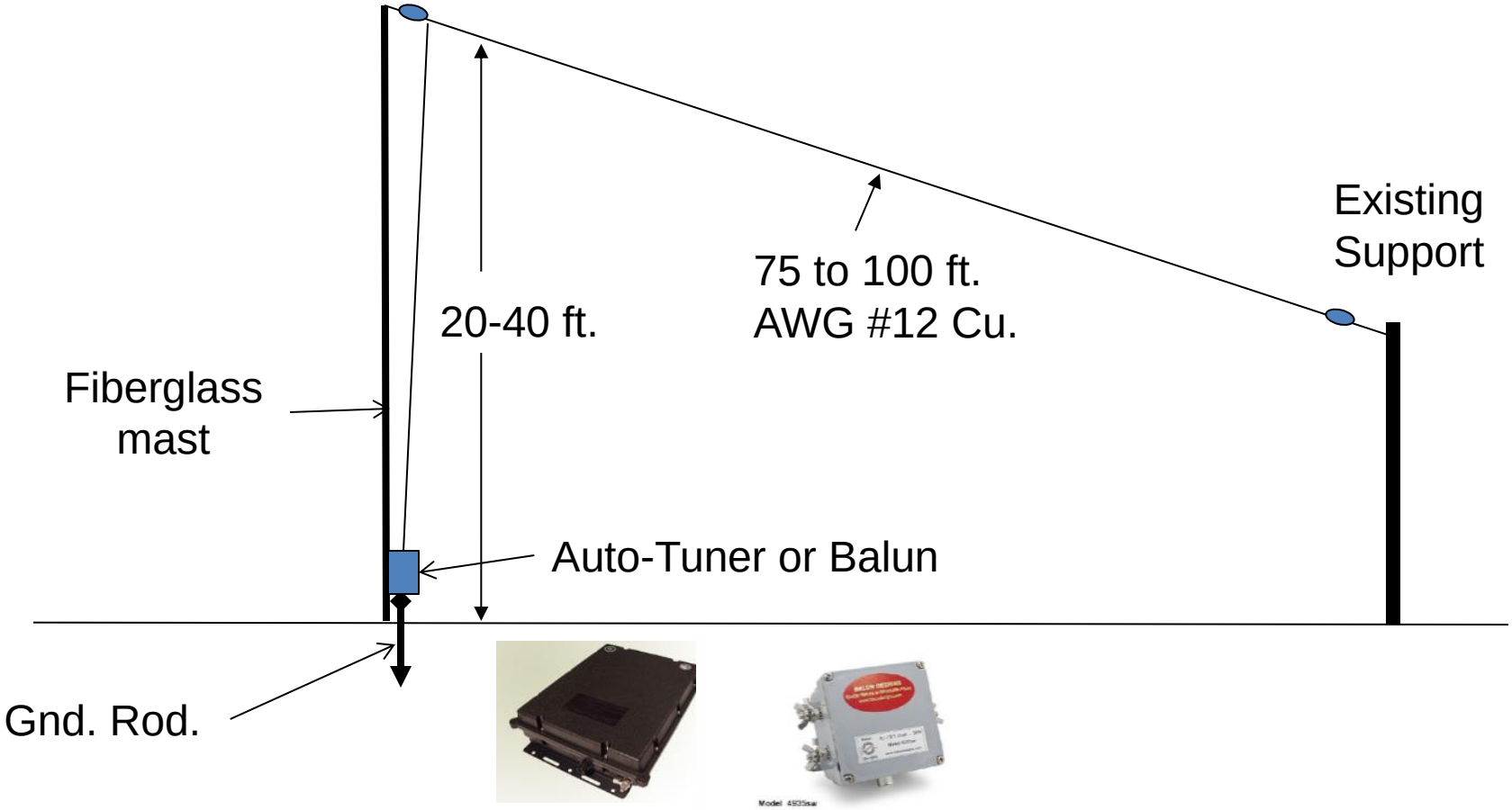
75 to 100 ft.
AWG #12 Cu.

Existing
Support

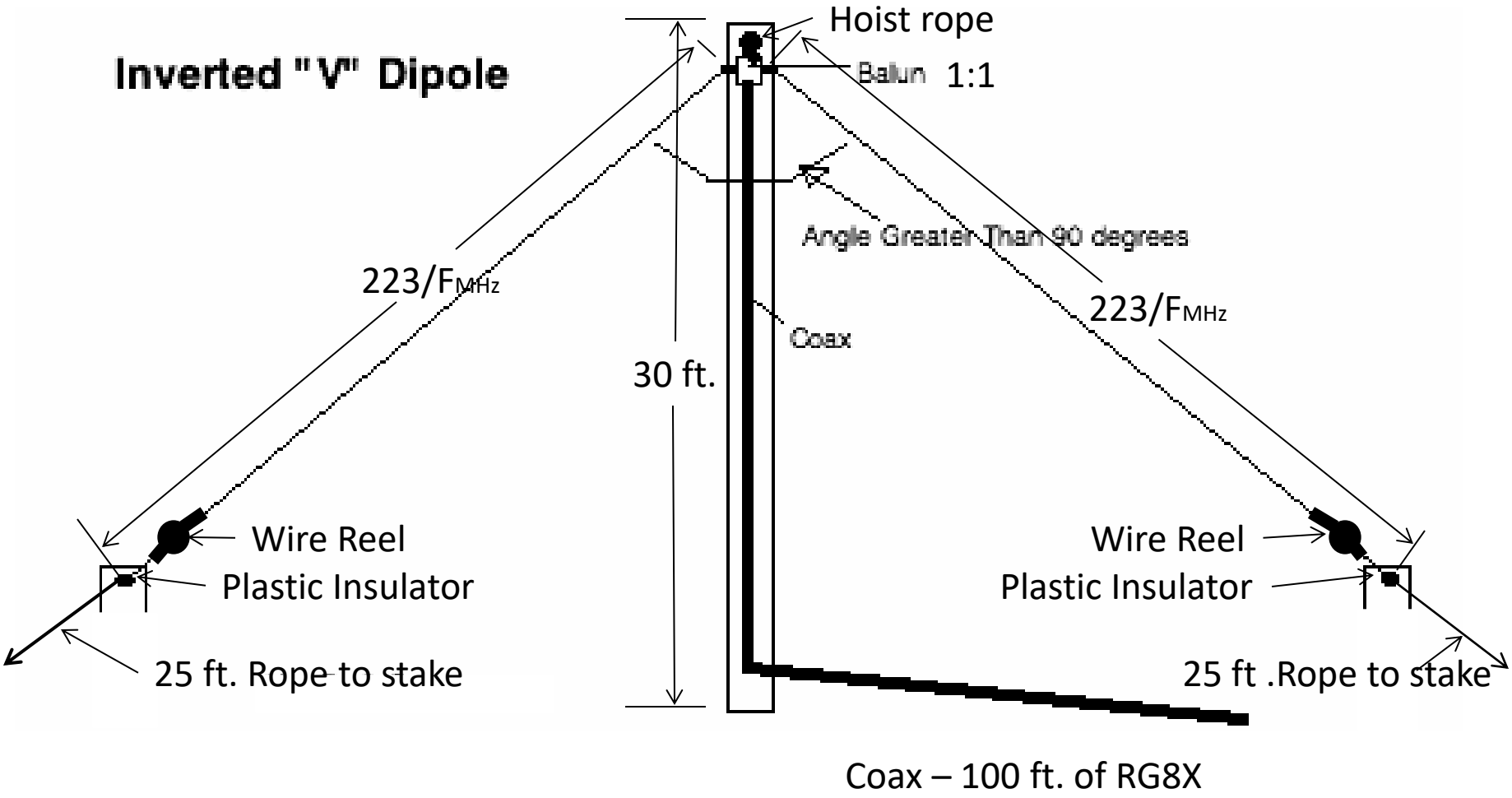
Mast,
Chimney
Tree?

Gnd. Rod.

Non-Resonant L-Shaped Long-Wire

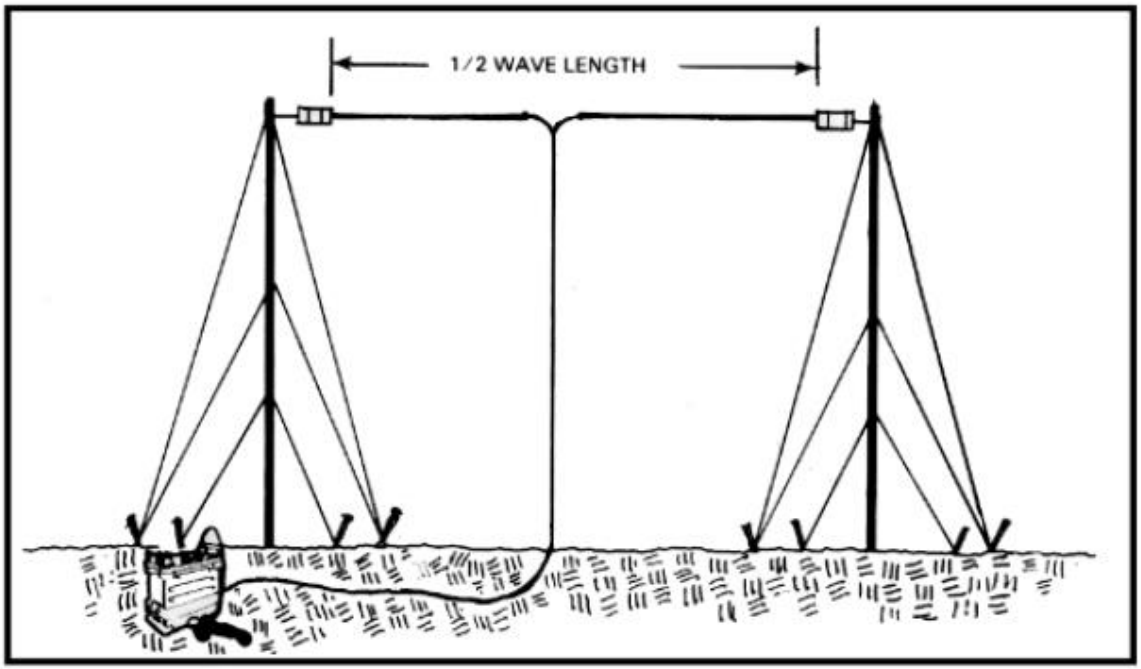


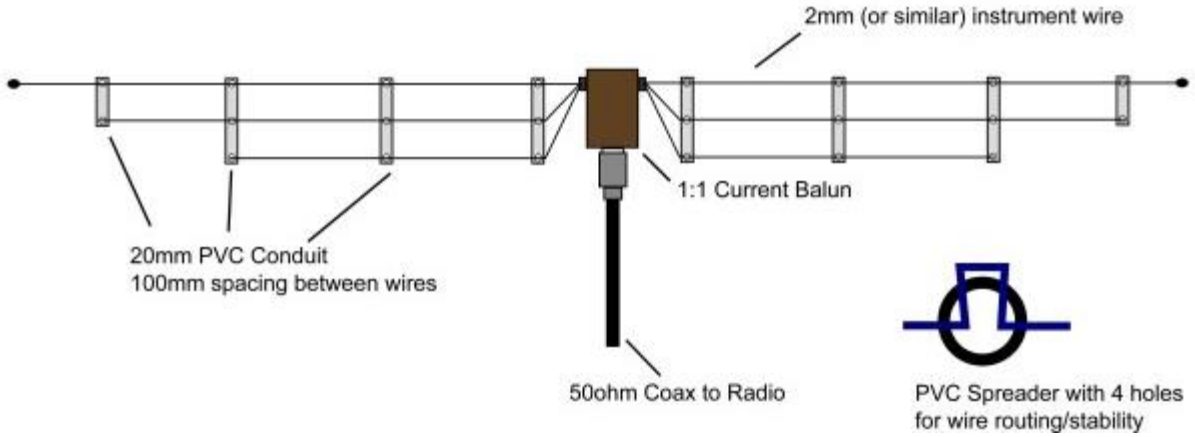
NVIS Resonant Inverted-V Dipole



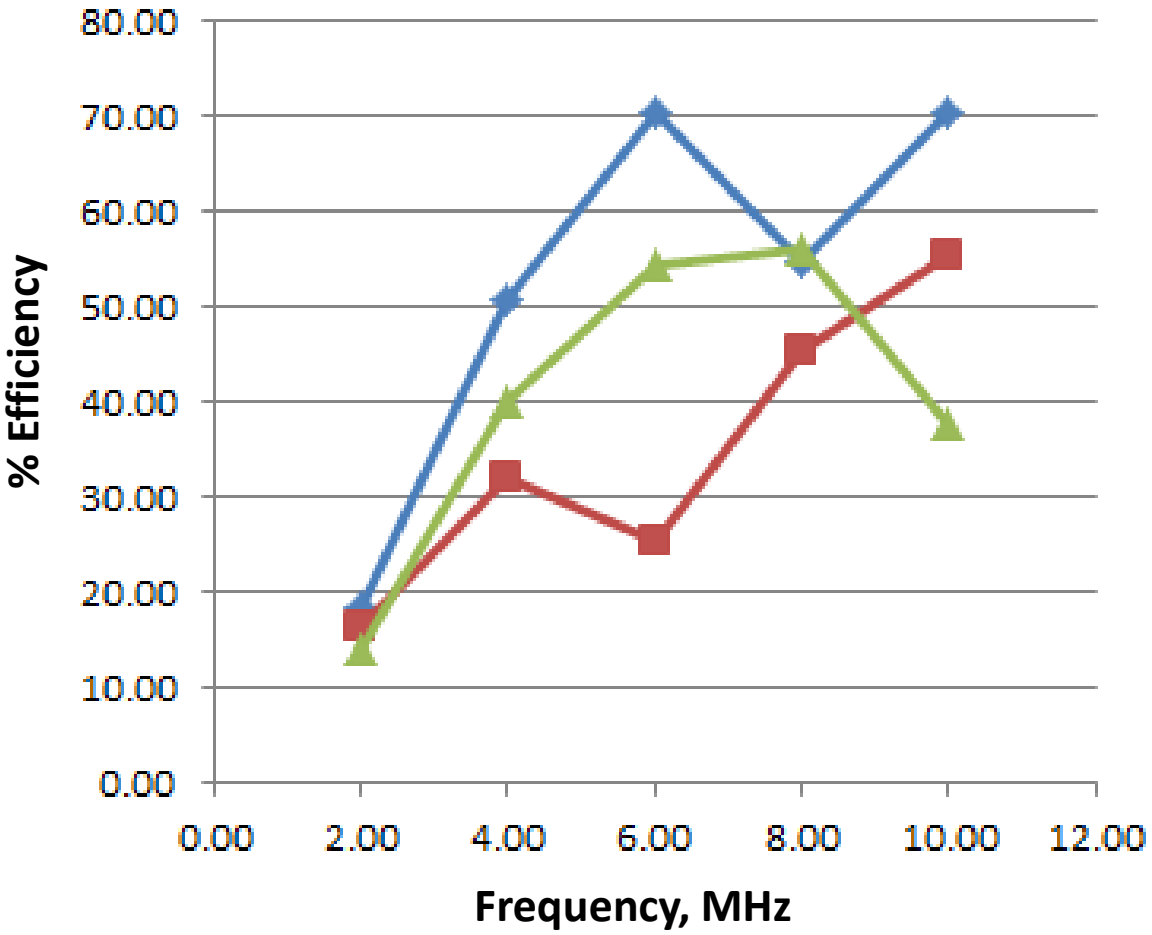
Resonant Dipole(s)

(80m, 60m, 40m)





Antenna Efficiencies



Note: LW height-21 ft.

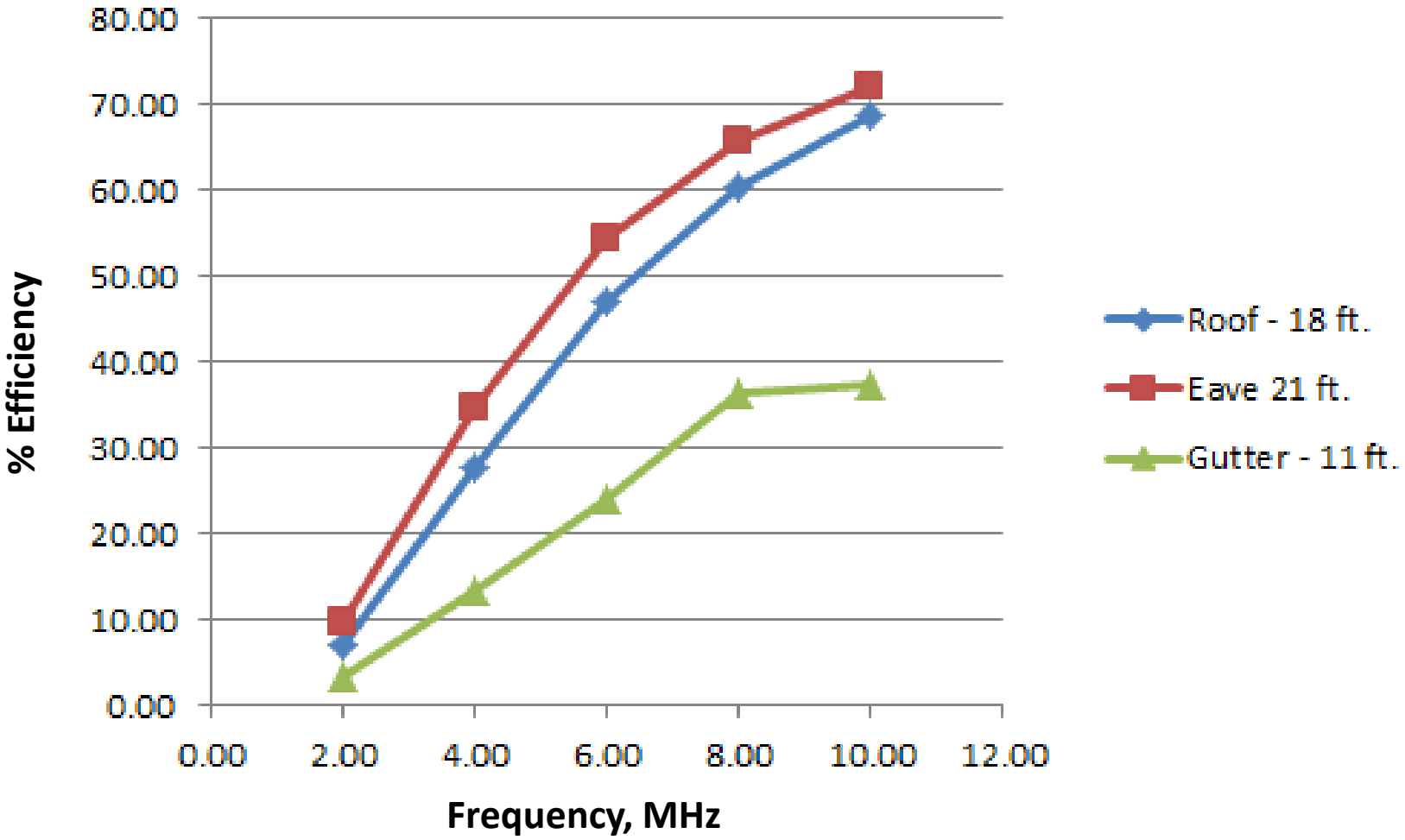
House Mounted Antennas

- Roof Ridge-line
- Eave
- Gutter

Ridge, Gutter & Eave Antenna Details

- Avoid these solutions if possible.
- Should be dipole not long-wire
- Total length should be greater than 100 ft.
- Can be OCF (off center feed)
- As high as possible
- Unknown effects of house components (AC wiring, air conditioning ducts, etc.).
- Attic radiant barrier foil will reduce efficiency of antenna.
- Potential human RF Exposure issues.
- Will probably trigger burglar alarm.
- Models assume antennas are located on an open field supported by dielectric masts.

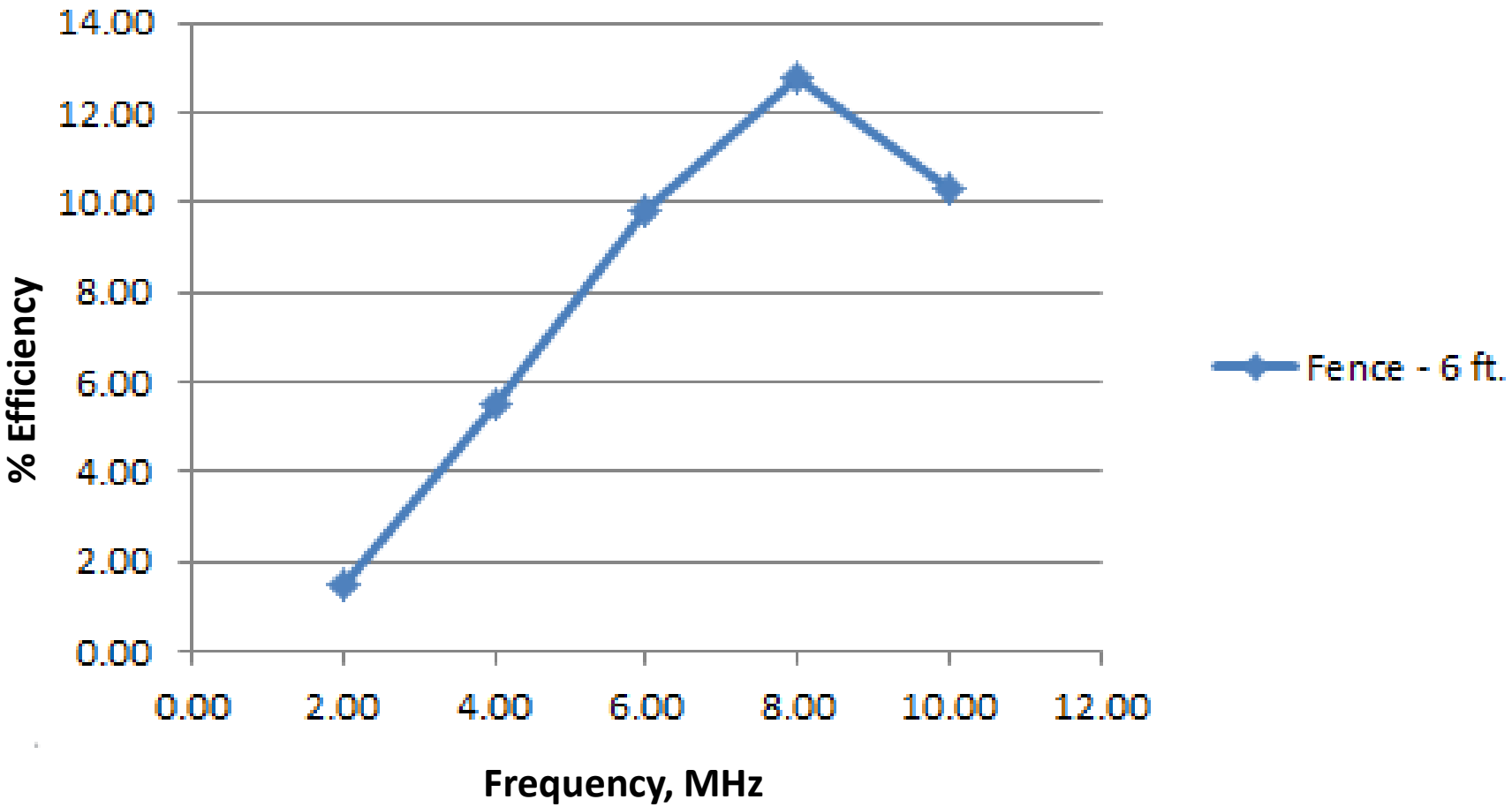
Antenna Efficiencies



Fence Mounted Antenna

- Use stranded, insulated wire
- Must mount auto-tuner at wire junction
- OCF generated more uniform directivity patterns.
- Definitely the worst case

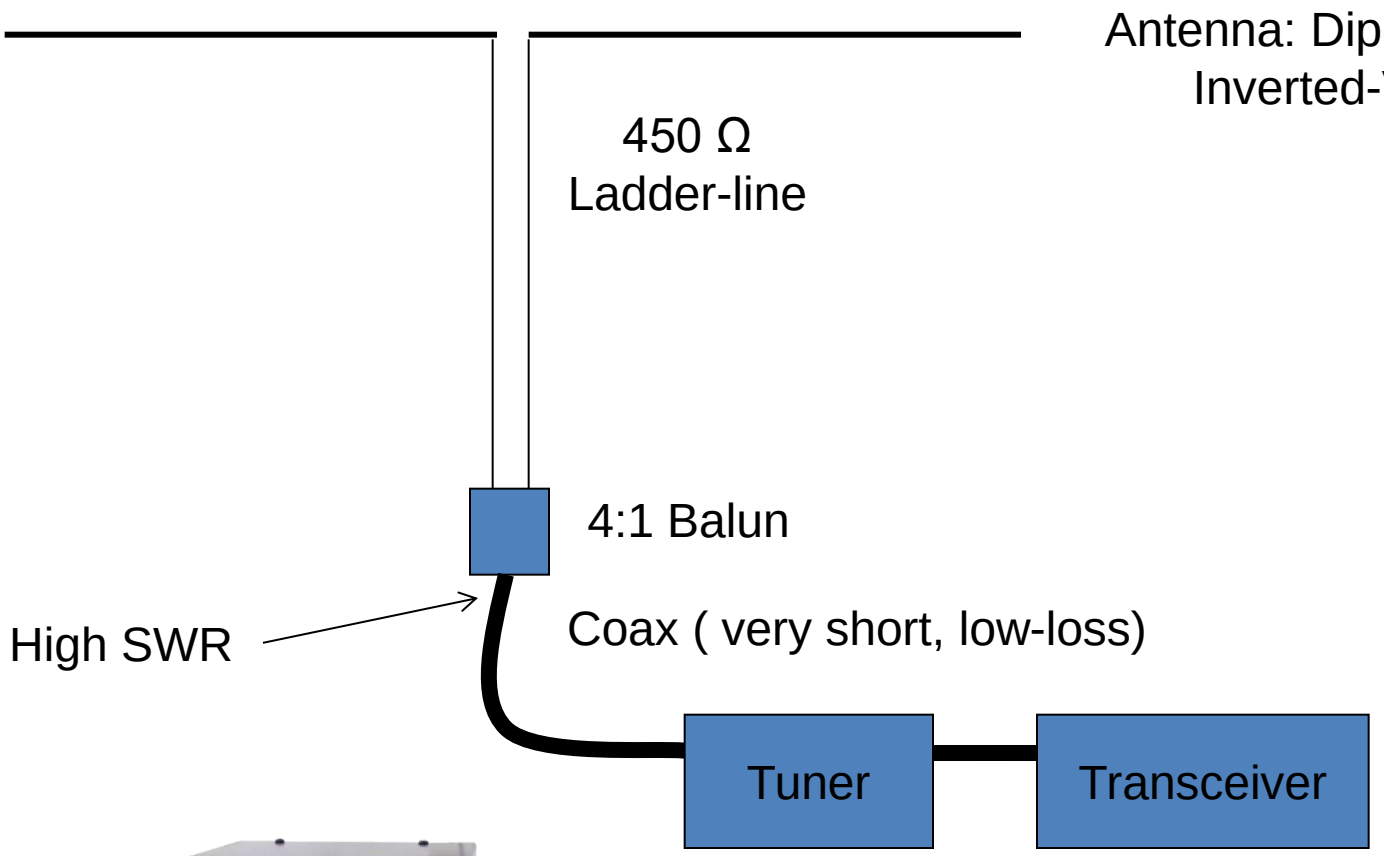
Antenna Efficiency



Tuner Locations

- At transceiver location
  - Convenient (can be a manual tuner)
  - Can disconnect for lightning and EMP mitigation
  - Potential for creating highest transmission line losses
- At base of Antenna mast/tower/Chimney
  - Accessible for service
  - Requires Lightning/EMP mitigation at tuner
  - Efficient if driving ladder line to antenna
- At antenna
  - Very efficient
  - Requires Lightning/EMP mitigation at tuner

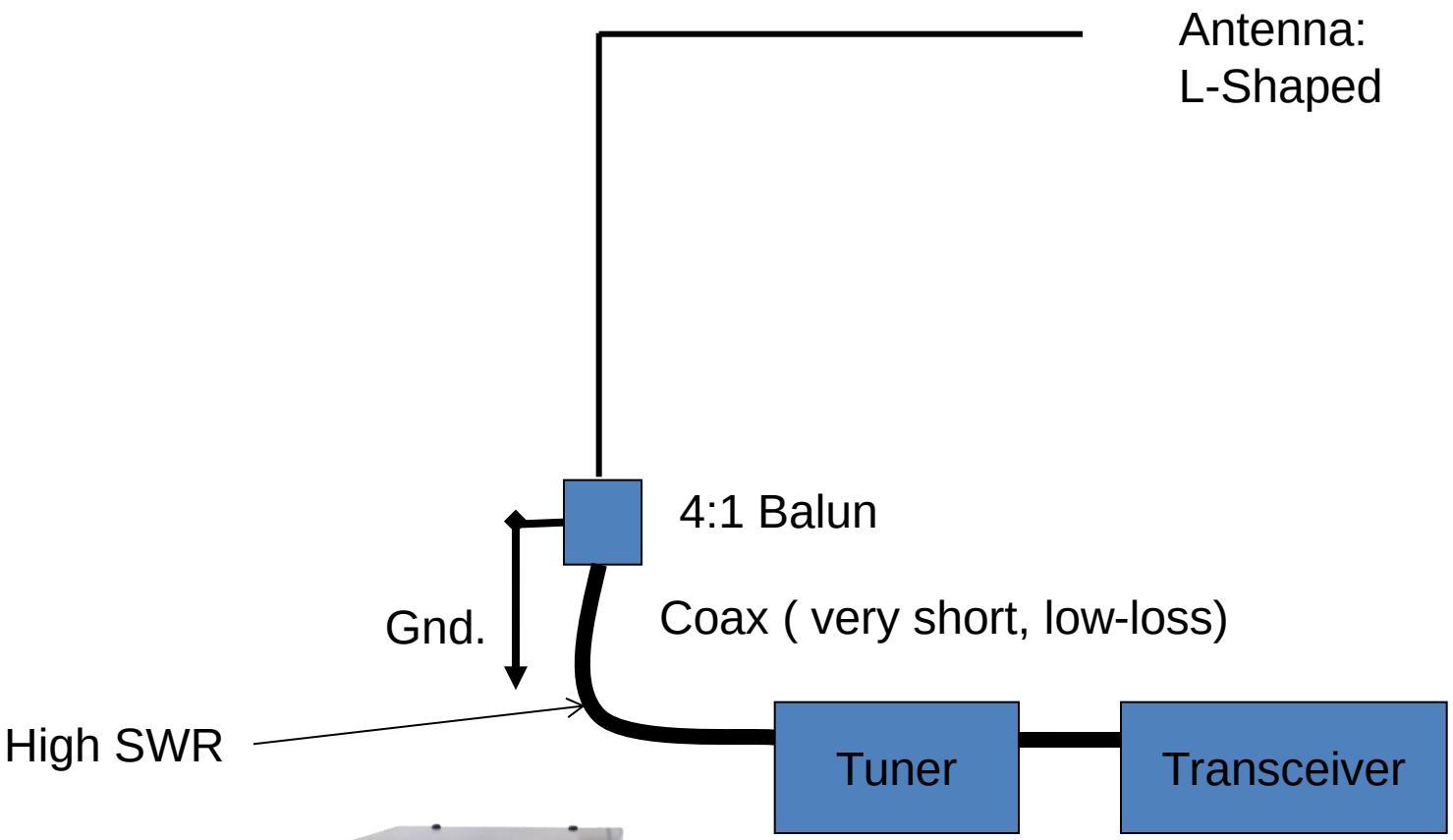
Tuner at Rig



MFJ-929

MFJ – 949E

Tuner at Rig



MFJ-929

MFJ – 949E

Remote Tuner at Mast Base

SGC-SG-230

ICOM AH-4

Dipole Antenna

450 Ω
Ladder-line
(30 - 50 ft.)

Auto-Tuner at
Base of mast

Choke Balun

Transceiver

Long coaxial
Cable run
(600 ft. +)

Remote Tuner at Antenna (Dipole or Long-Wire)

SGC-SG-230

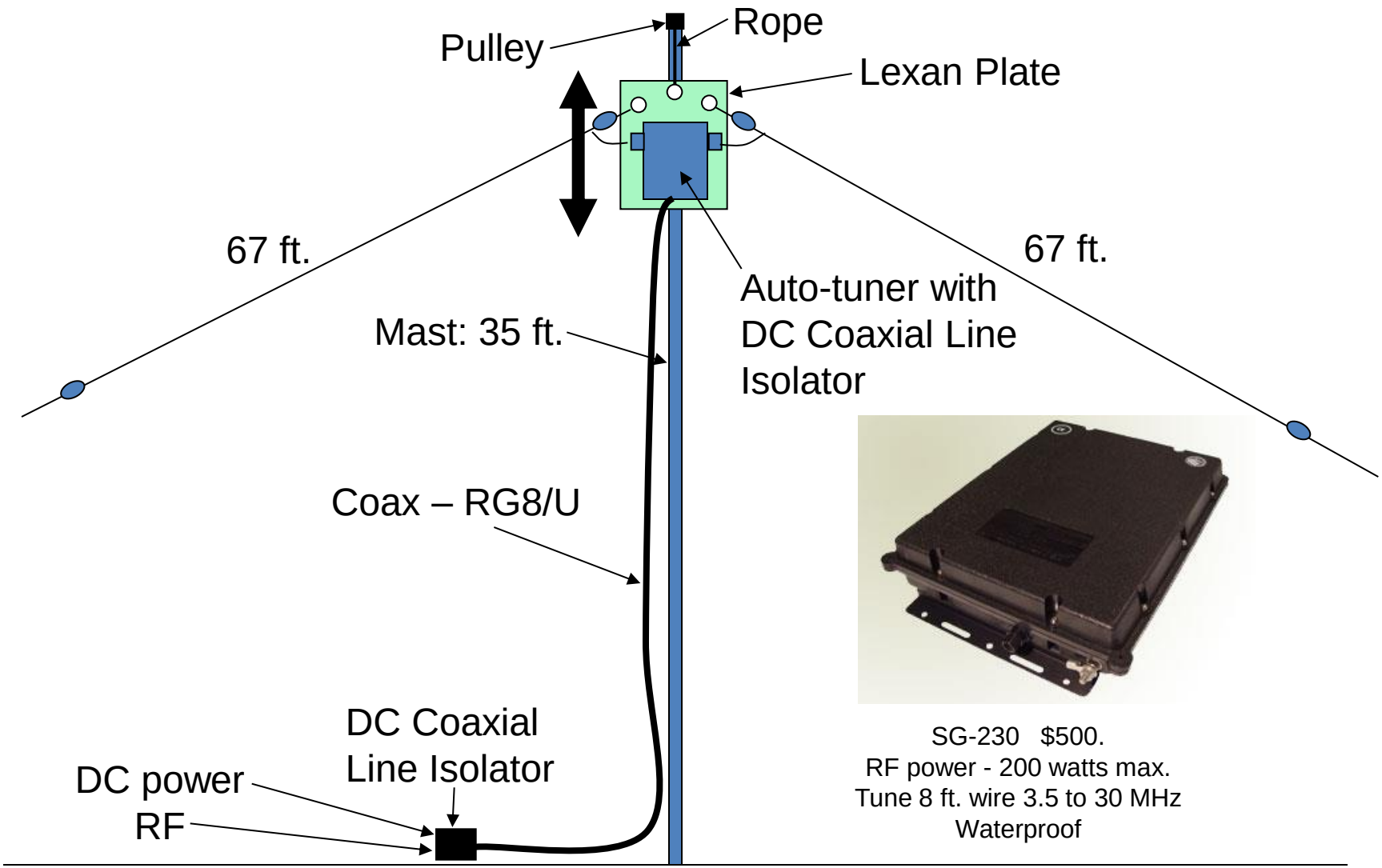
Wire Support Options

- Pole(s) – Aluminum, steel or fiberglass
- Tower – use “hanger” to get LL away from metal
- Trees – may need motion absorption
- Chimney
- Roof eave
- Rain gutter
- Fence
- Combinations of all the above

ANTENNA EXAMPLES

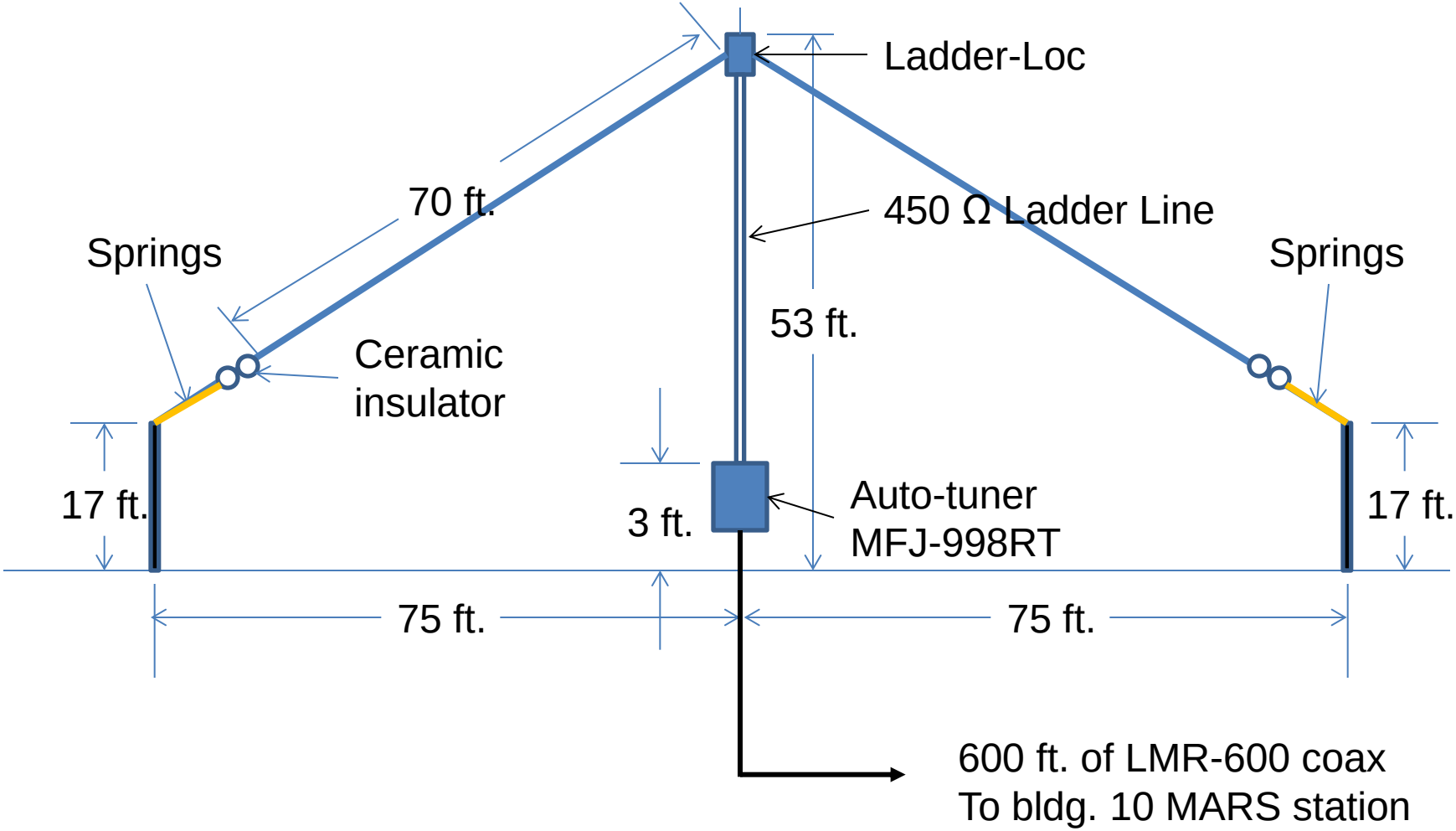
- Portable
- Fixed Inverted-V
- Fan Dipoles
- Stealth
  - Long-Wire
  - L-Shaped long wire
  - Fence

PORTABLE AUTO-TUNED ANTENNA



SG-230 $500.
RF power - 200 watts max.
Tune 8 ft. wire 3.5 to 30 MHz
Waterproof

CCG Antenna
Bldg. 10 Camp Mabry

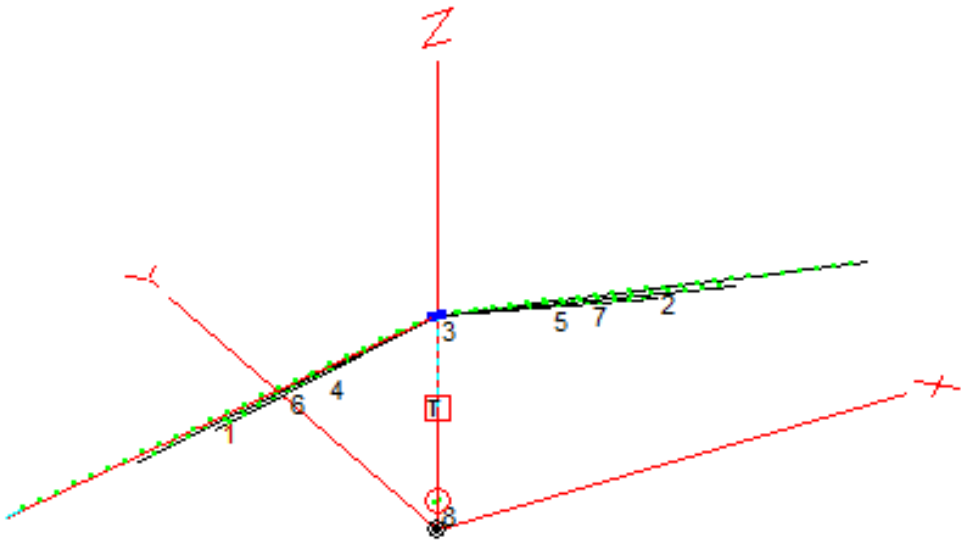


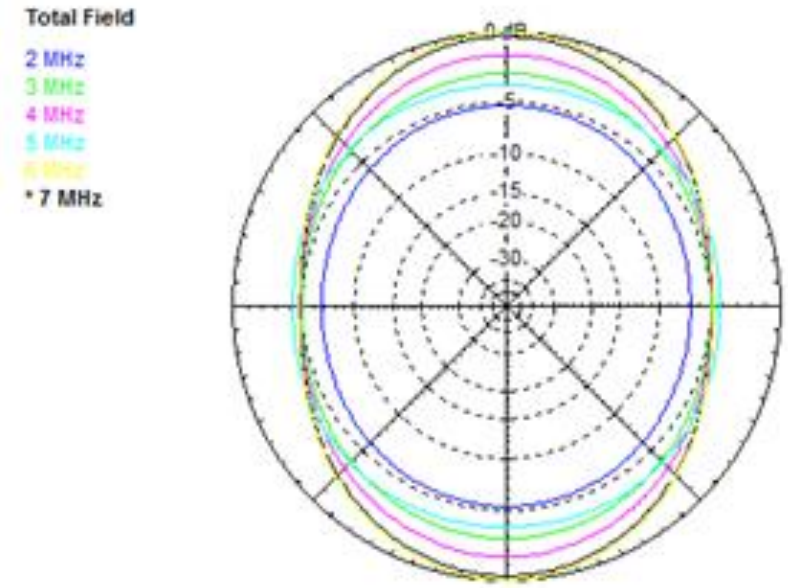
Fan Dipole

Apex Height – 38 ft.
Legs 1, 2 – 76.5 ft.
Legs 4, 5 – 53.5 ft.
Legs 6, 7 – 39.5ft.
Note that leg 3 is EZNEC Modeling artifact

End heights:
Leg 1 – 24.3 ft.
Leg 2 – 25.2 ft.
Leg 4 – 29 ft.
Leg 5 – 29.7 ft.
Leg 6 – 28 ft.
Leg 7 – 28.7 ft.

Transmission Line:
Length – 32 ft.
Type – 450 ohm ladder line





STEALTH ANTENNAS

- LONG-WIRE
- L-SHAPED LONG WIRE
- FENCE

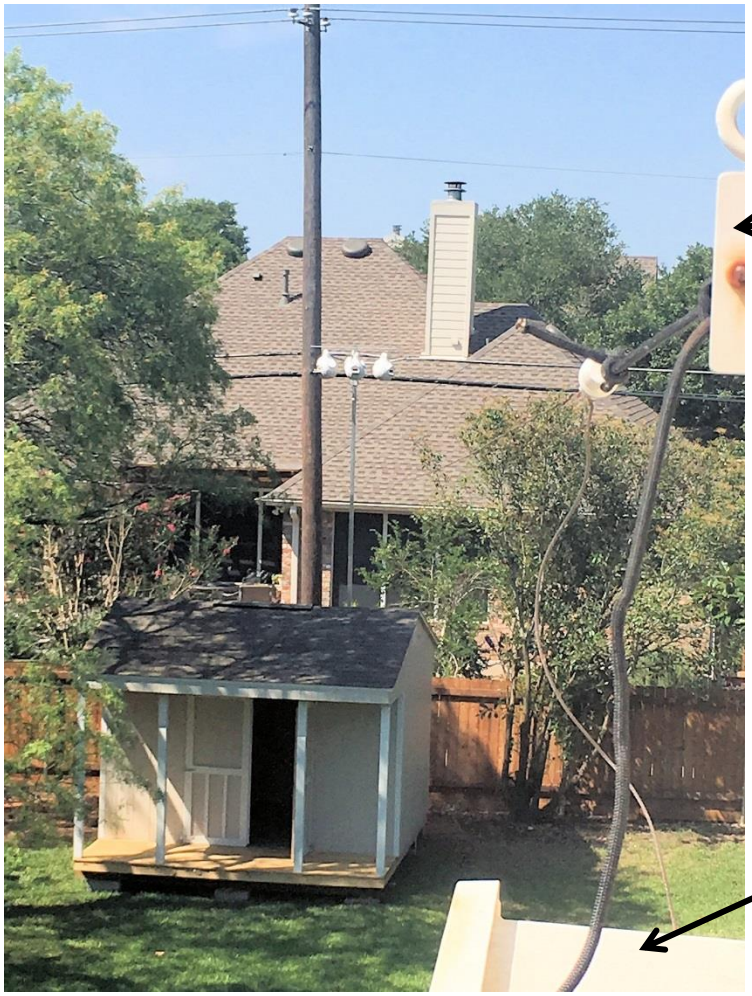
LONG-WIRE ANTENNAS

- Dominate radiator is one long wire with a much shorter "counterpoise" wire going to ground.
- Ideally this antenna should be driven by an auto-tuner at the junction between the long-wire radiator and the counterpoise wire or at the base of an L-shaped antenna.
- If small wire is used, and the auto-tuner hidden, this design can be reasonably stealthy. A bare, Cu #14 AWG wire is effectively invisible to a casual observer beyond about 20 ft.
- The terminating end of the wire can be a bird house (endangered species??).
- Insulators can be heavy mono-filament fishing line.

Long-Wire at Residence

Bird House

View From Behind Auto-Tuner



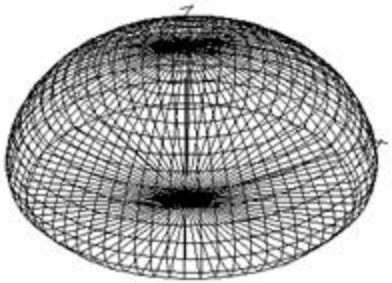
Chimney Bracket with insulator

Total Distance – 106 ft.
Wire Height – 21 ft. horizontal

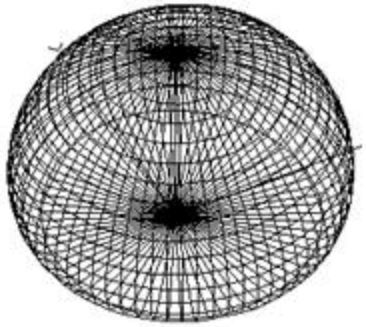
Auto-Tuner

AUTOTUNER ON CHIMMNEY

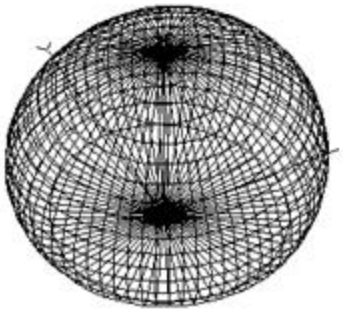
Long-Wire Patterns



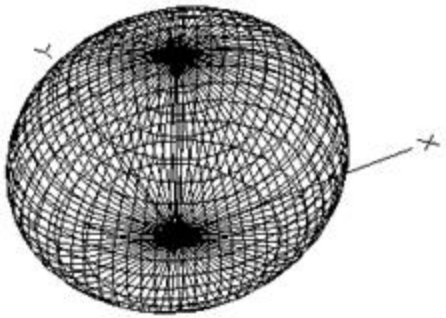
2.2 MHz



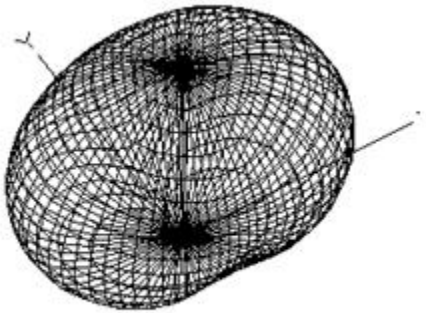
3.2 MHz



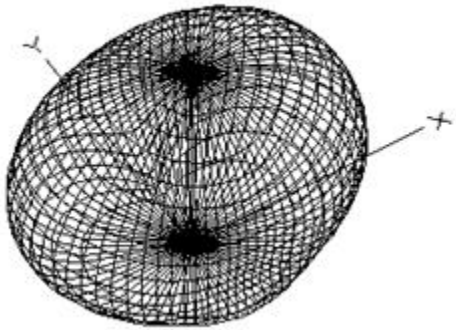
4 MHz



5.2 MHz



6.8 MHz



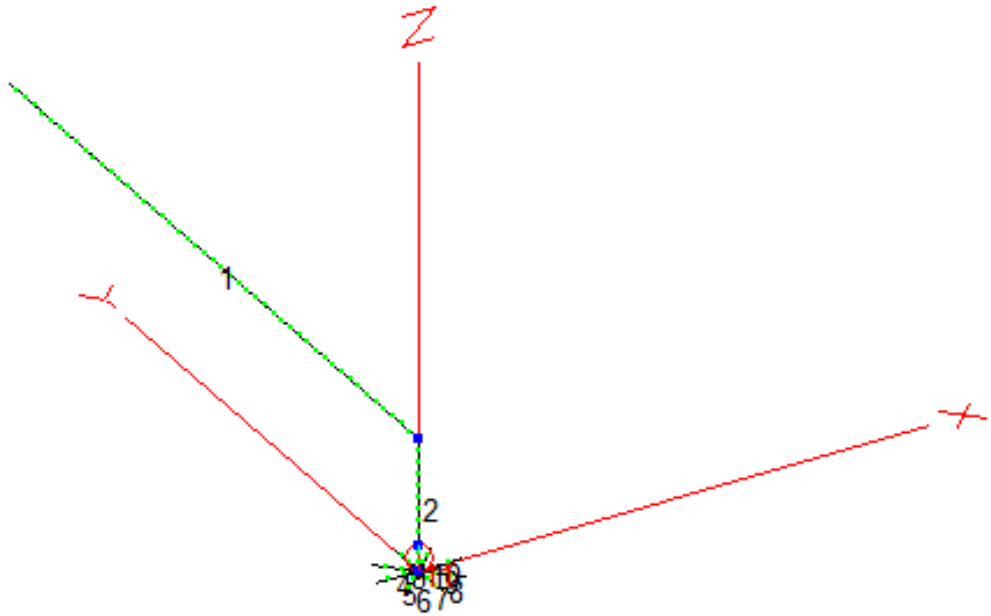
7.5 MHz

L- Shaped Long-Wire

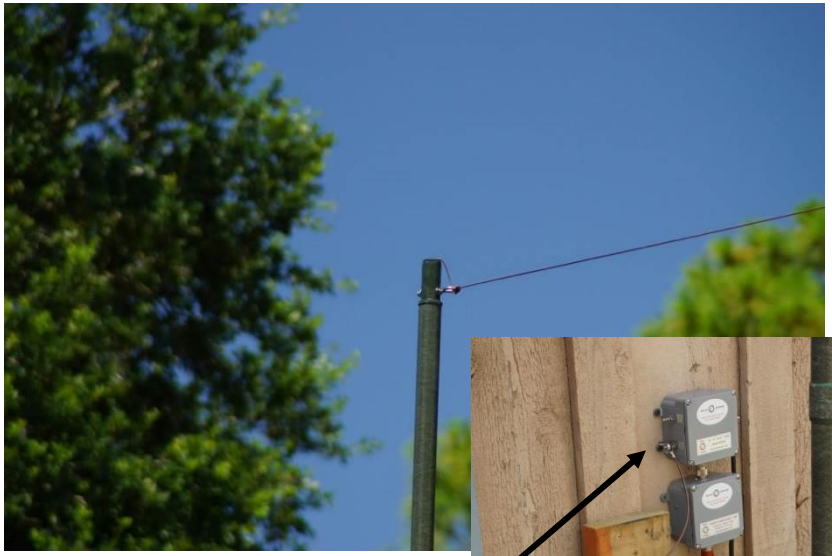
Wire I – 71.5 ft.
Wire 2 – 21 ft.
Mast - fiberglass
Wire 2 End height – 18 ft.

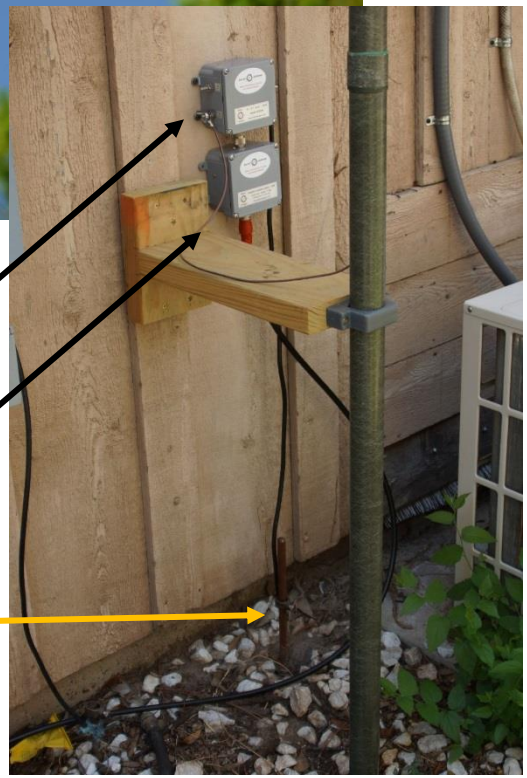
Wire type - #14 AWG Cu.
Balun 4:1 (Balun Designs)
Lead-in cable – 23.5 ft. of LMR-400 + 7 ft. of RG8-X
To LDG-200AT located at rig.

EZNEC Pro/2



L-shaped Long-wire

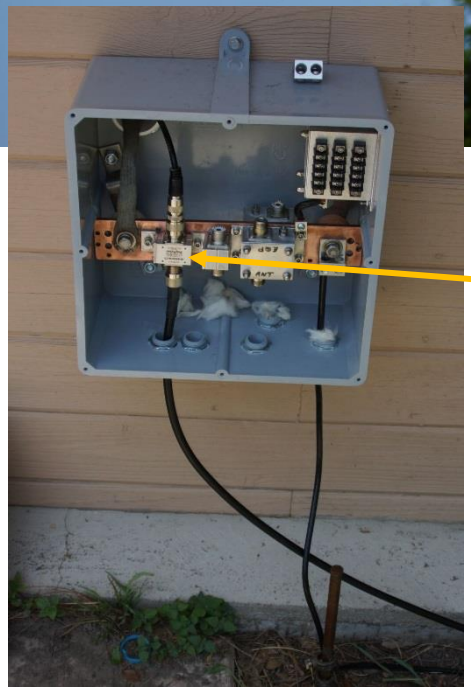




Unun Balun

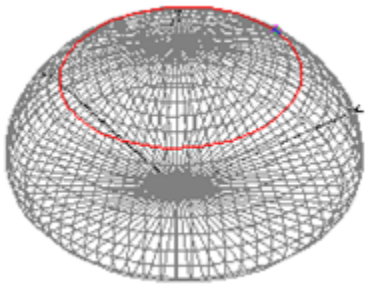
Choke Balun

Gnd. Rod

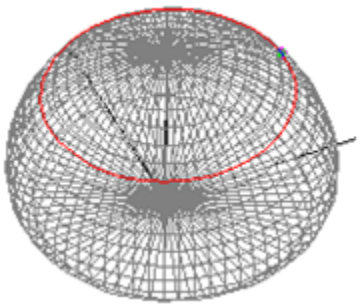


Lightning Arrestor

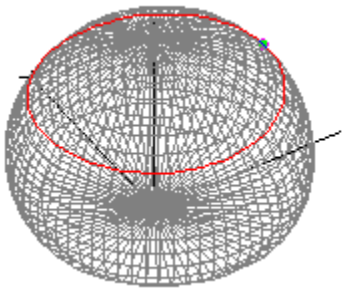
L-Shaped Antenna Patterns



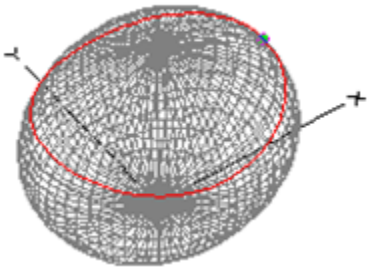
2.2 MHz



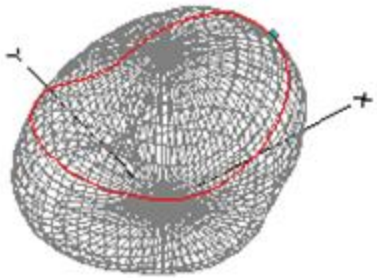
3.2 MHz



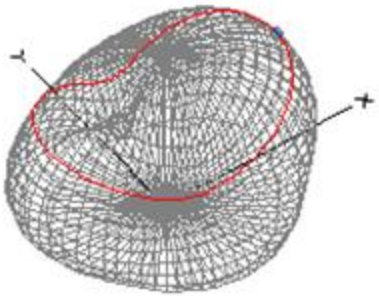
4 MHz



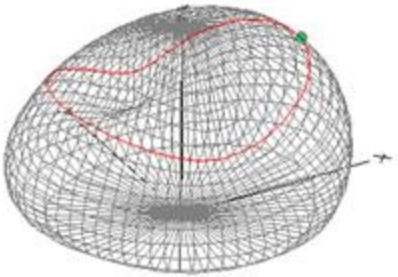
5.2 MHz



6.8 MHz



7.5 MHz



9.3 MHz

Gutter & Eave Antennas

- Avoid these solutions if possible.
- Should be dipole not long-wire
- Total length should be greater than 100 ft.
- Can be OCF (off center feed)
- As high as possible
- Unknown effects of house components (AC wiring, air conditioning ducts, etc.).
- Potential human RF Exposure issues.
- Will probably trigger burglar alarm.
- The two following examples are “works-in-progress”. Contact me in near future for actual results.
- Models assume antennas are located on level ground supported by dielectric masts.

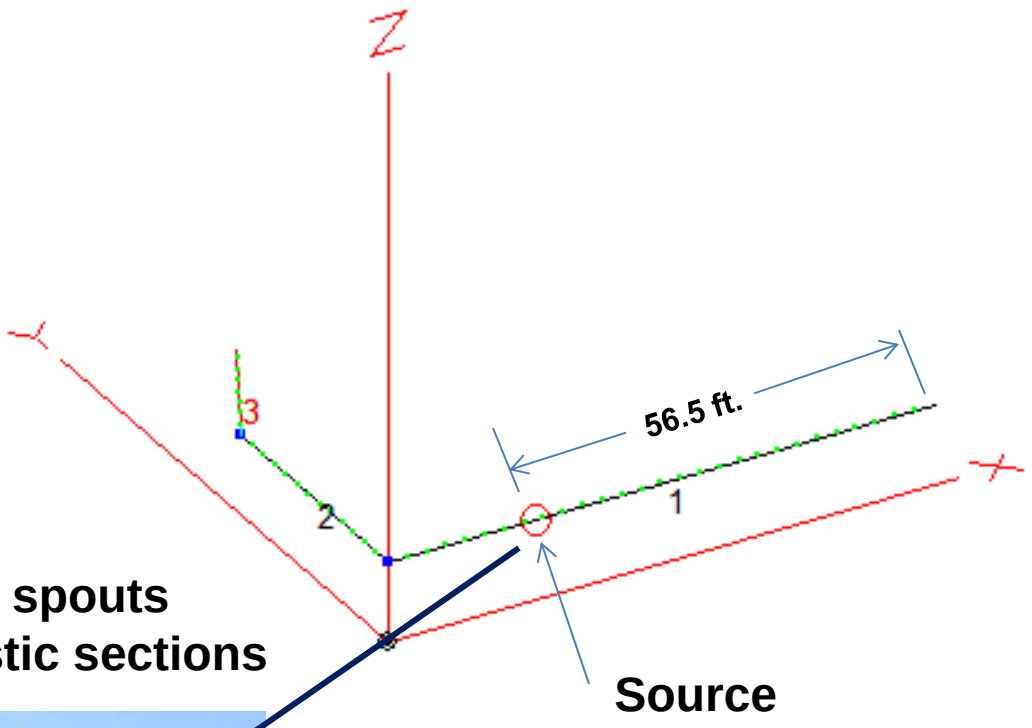
Gutter EZNEC Pro Geometry

Wire 1:
- **Length – 75.25 ft.**
- **Height – 11 ft.**

Wire 2:
- **Length – 35 ft.**
- **Height – 11 ft.**

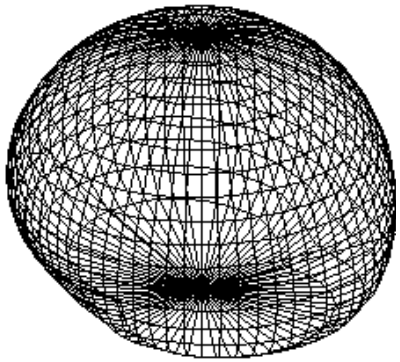
Wire 3:
- **Length – 21 ft.**
- **Height – 11 ft.**

All conductors are aluminum
Gutters riveted together. Down spouts and source connection are plastic sections

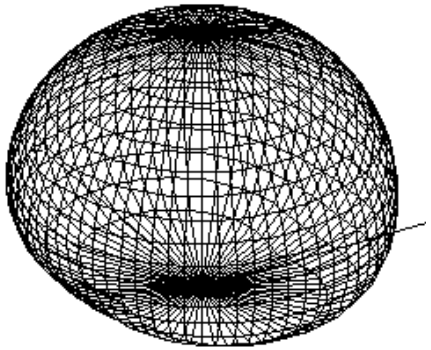


Gutter Antenna Patterns

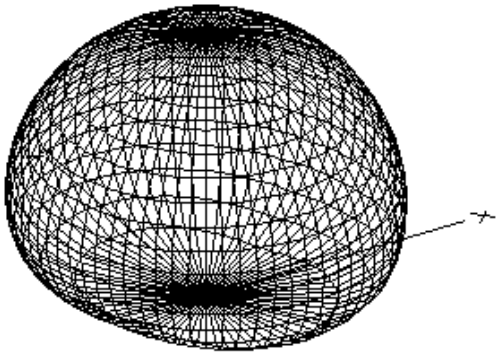
EZNEC Pro/2



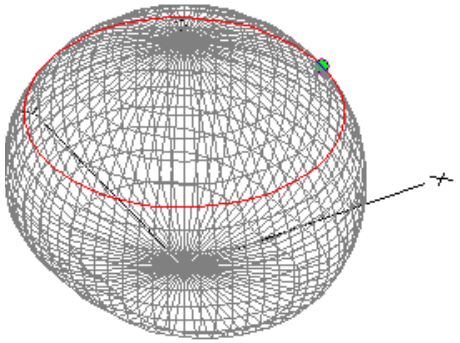
2.2 MHz



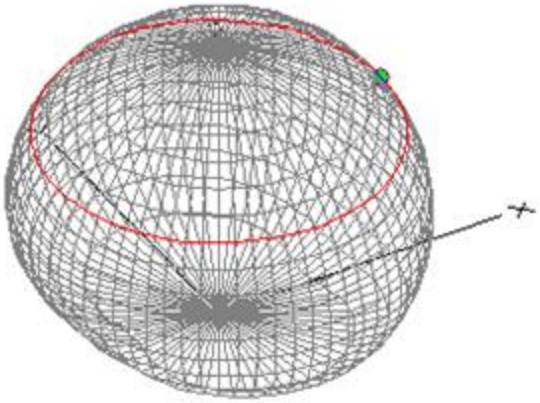
4.02 MHz



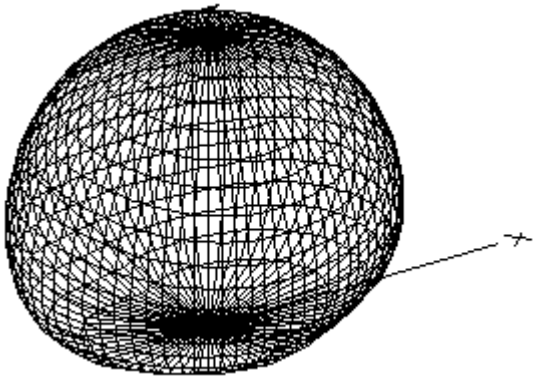
5.2 MHz



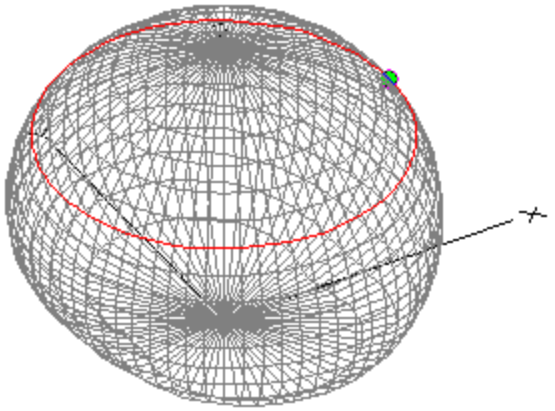
6.8 MHz



7.5 MHz



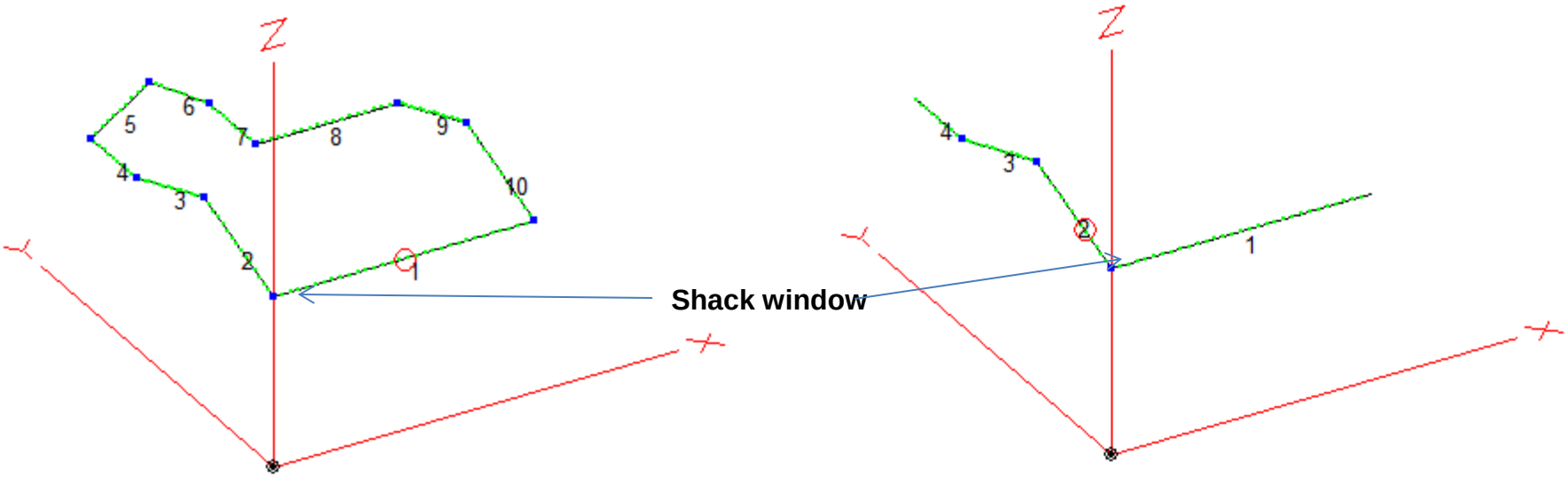
8.06 MHz



9.3 MHz

Eave Antenna Options

- Two potential antenna designs were considered as shown below:
- The position of the source (red circle) was varied to maximize antenna gain and potential for successful tuning solutions.

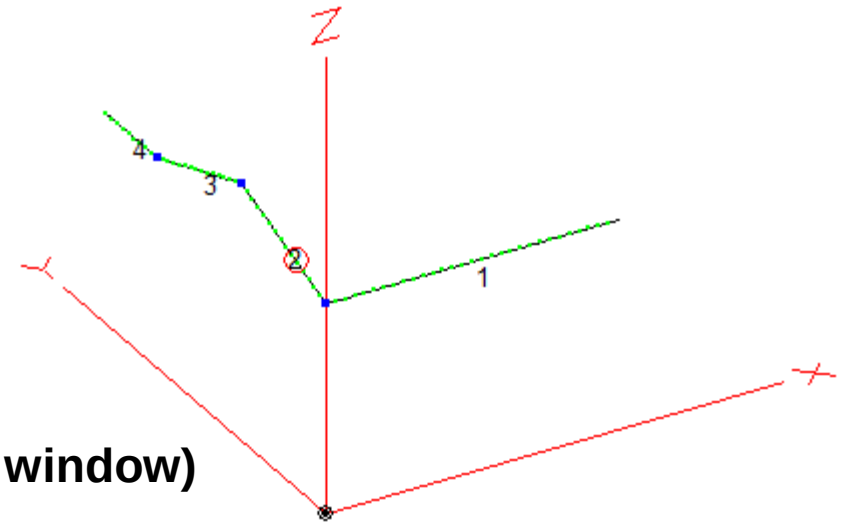


Horizontal Loop

Dipole

Antenna Dimensions

Wire Lengths:
Wire 1 – 30 ft.
Wire 2 – 15.8 ft.
Wire 3 – 15.8 ft.
Wire 4 – 10 ft.

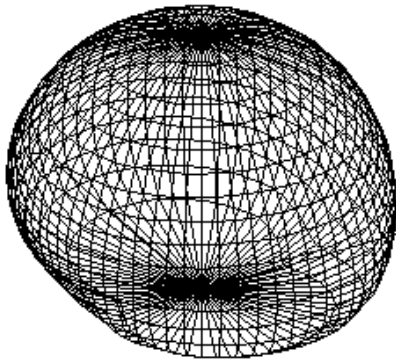


Height:
Wire 1, 4 - 21.5 ft.
Wire 2, 3 apex – 26.5 ft. (I assumed 5 ft. window)

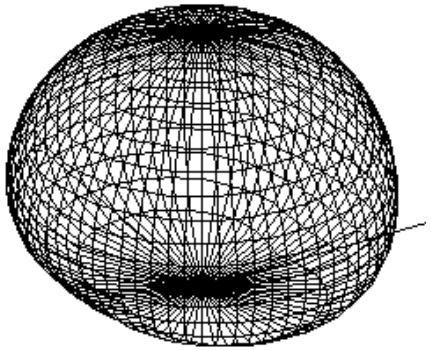
Driven point – 5.8 ft. from corner
Wire:
#14 AWG insulated, stranded, Cu wire stapled to eave.

Tuner – AT-140 at driven point.

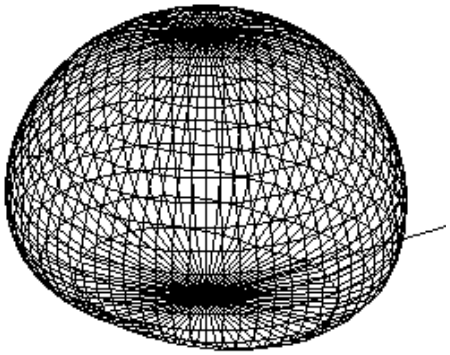
Eave Antenna Patterns



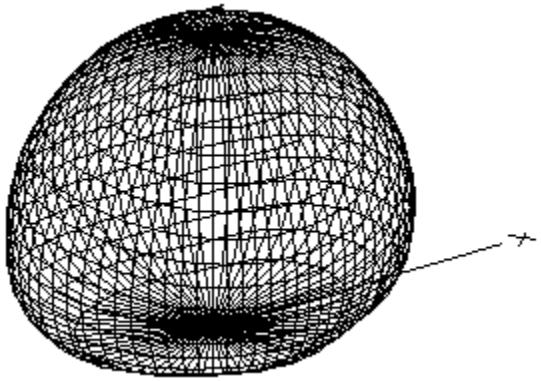
2.2 MHz



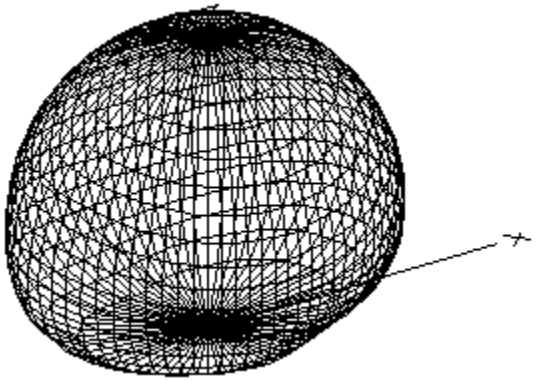
4.02 MHz



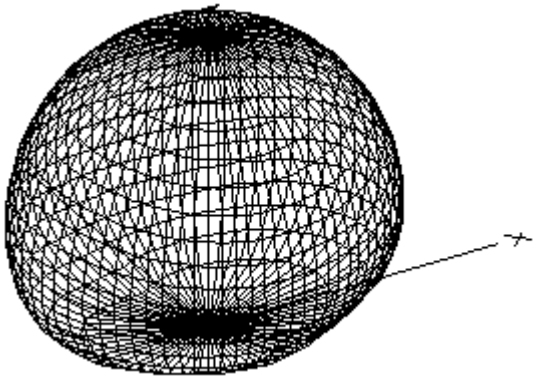
5.2 MHz



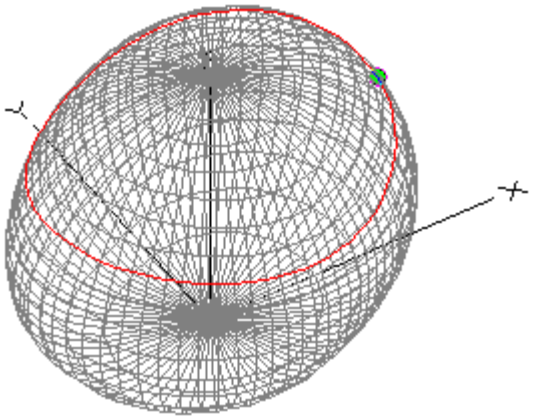
6.8 MHz



7.5 MHz



8.06 MHz



9.3 MHz

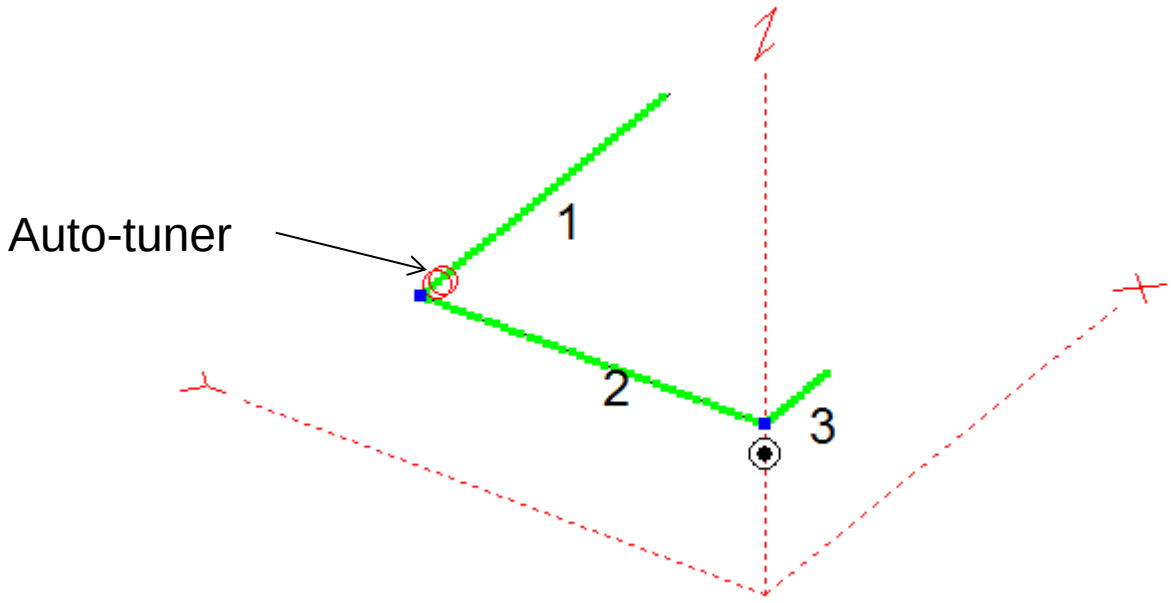
FENCE ANTENNAS

- Avoid this solution if possible.
- Potential human RF Exposure issues since neighbor is in an uncontrolled space.
- For any success, antenna efficiencies must be maximized by using an **auto-tuner at the driven point of the antenna.**
- Modeling must be done to maximize pattern efficiency.
- A 25% offset drive has shown to improve directivity patterns across MARS frequencies.
- Radiating efficiency goes down with frequency since the wavelength height goes down with frequency.
- When this antenna is compared with a 140 ft. inverted-V at 35 ft., the difference in gain versus frequency is as follows:
  - 2.2 MHz: -11.7 dB less
  - 3.2 MHz: -11.1dB less
  - 4.0 MHz: -10.5 dB less
  - 5.2 MHz: - 9.9 dB less
  - 6.8 MHz: -7.3 dB less
  - 7.5 MHz: -6.4 dB less

Fence Antenna

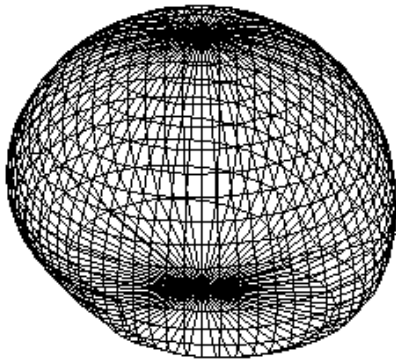
- Wire 1 – 67 ft. with source 93% from far end
- Wire 2 – 62.5 ft.
- Wire 3 – 18 ft.
- Height – 5.3 ft.

- Fence type - wood

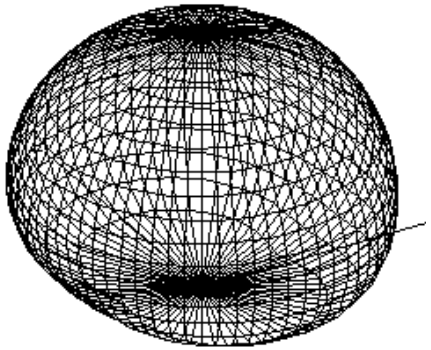


Fence Antenna Pictures

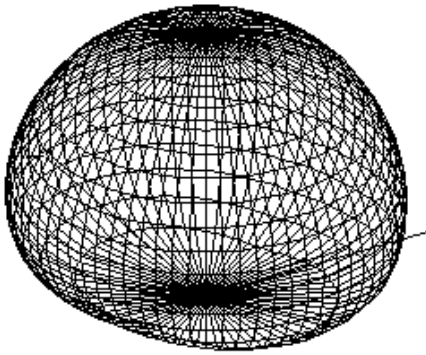
Fence Antenna Patterns



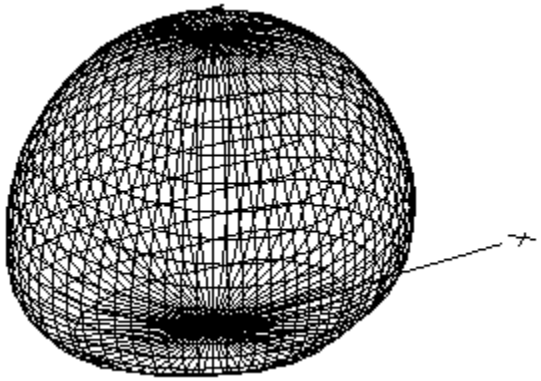
2.2 MHz



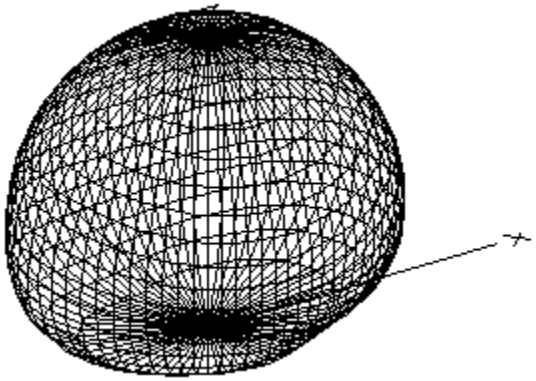
4.02 MHz



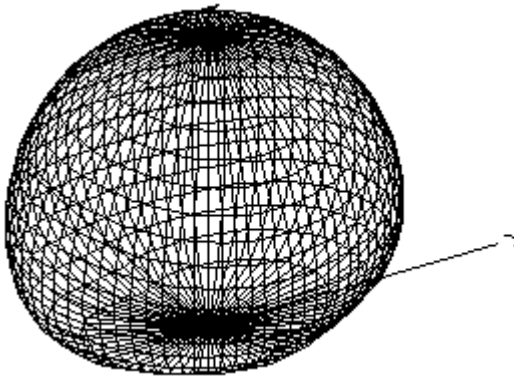
5.2 MHz



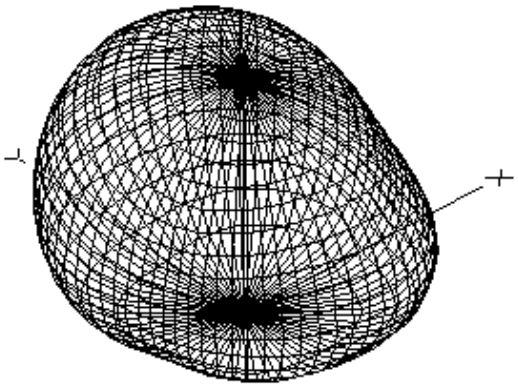
6.8 MHz



7.5 MHz



8.06 MHz



9.3 MHz

ANTENNA MODELING

Antenna Modeling does not design your antenna, it only allows you to evaluate your design.

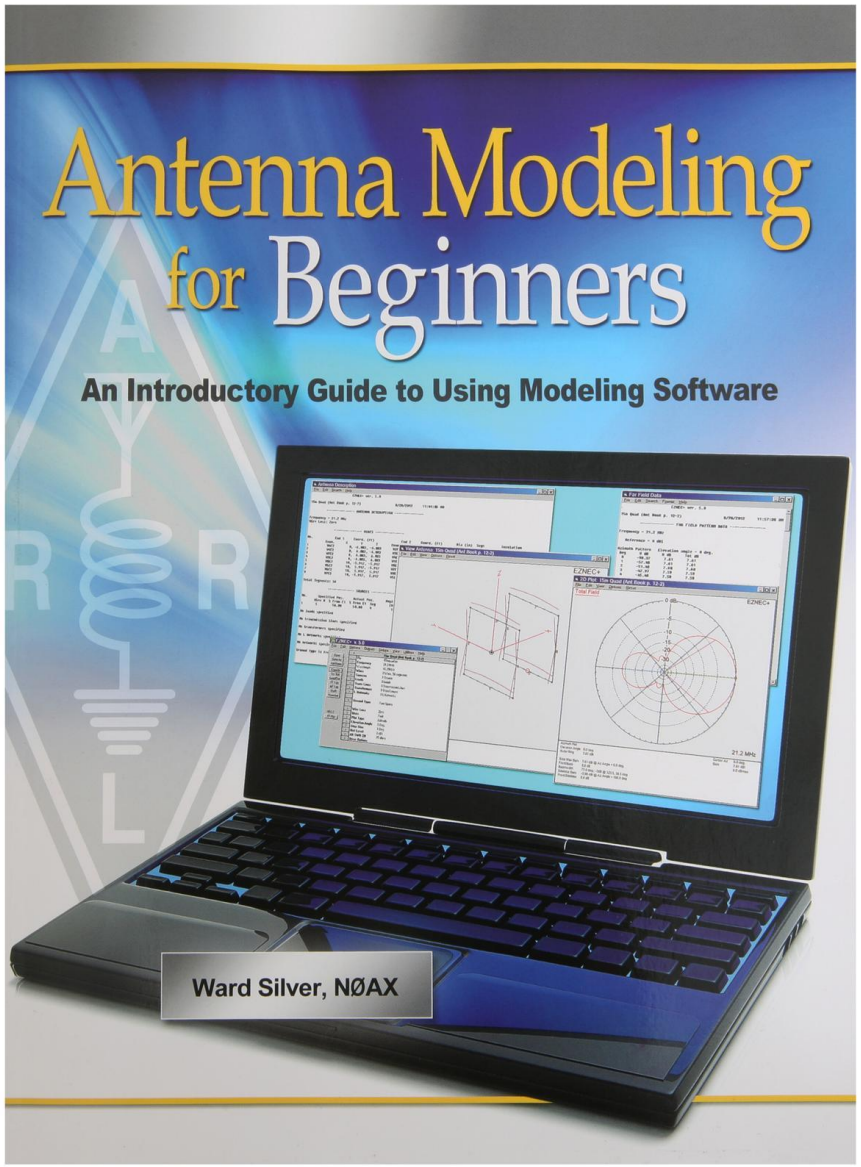
ARRL - Antenna Modeling for Beginners 3961 by N0AX

Arrl Antenna Modeling Course

by L. B. Cebik

(Both books have been discontinued but might be available as used books.)

Note: The ARRL Antenna Book includes a free copy of EZNEC



ANTENNA MODELING

On line course:
http://www.arrl.org/files/file/Antenna%20Modeling%20for%20Beginners%20Supplemental%20Files/EZNEC%20Modeling%20Tutorial%20by%20W8WWV.pdf

How to Start Modeling Antennas using EZNEC

Greg Ordy, W8WWV
CTU, Contest University
Dayton, May 19, 2011
Version 1.01

This modeling tutorial is the companion document to a slide presentation given at a Contest University session on May 19th, 2011.

Table of Contents

Appendix
Antenna Construction Parts

Auto Tuners

LDG-AT 600Pro - 10.07 uH, 1270 pF (Not recommended)
MFJ-998 - 24.25 uH, 3922 pF (1500 watts)
MFJ-929 - 24.87 uH, 3961 pF
MFJ-939 - 24 uH, 3900 pF
MFJ-926 - 24.866 uH, 3961 pF lower power but high SWR tolerance
SG-230 - 63.75 uH, 7095 pF implements both L/C, C/L and Pi (200 watts)
SG-235 - 31.82 uH, 6696 pF (600 watts)
MFJ-994 - 24.85 uH, 3907 pF 600W, but lower SWR Tolerance
MFJ-998RT - Components same as MFJ-998
ICOM AH-4 - Only works with ICOM radios

I have underlined Tunes I own and would recommend

Note: MFJ remote tuners are not even close to water proof. Must place in Water resistant housing.

Antenna Poles

- Source: http://tmastco.com/main/page_products_mast_sections.html
- Description:
- Military surplus aluminum mast tubes. Each tube is 48 inches long by 1.785 inch outside diameter (inside diameter 1.57 inch), wall - 0.11 inch, and weigh 2.7 lbs each. The last 3.25 inches is a smaller diameter (1.55 inch OD, 1.33 inch ID) that then fits into the next mast section. This 1.55 inch diameter piece is 6 inches long and is used as an inner sleeve that forms a strong joint.
- Prices vary (from $9.50 to $12.00 each) due to the condition of the tube sections and the erratic availability of these through surplus outlets.
- Note that these poles have no external protruding joints, so a PVC pipe “car” can be hoisted up and down the complete mast if only top guying is used.

Pivoting Base Assembly

- Insulated Pivoting Base Assembly (IPBA1)
- This heavy-duty base assembly (used in our Vertical Antenna Kit) is made from two pieces of composite material (high density polyethylene and wood flour) fastened with long lasting stainless steel hardware and includes a heavy duty zinc-plated steel U-shaped pivot piece. Overall length is 11 inches and width is 5.5 inches. A short length (7-inches) of aluminum mast section is included for easy connection to your mast sections. A 3/8-inch diameter zinc-plated steel hinge pin is included to fit the pivot piece. In addition, 4 galvanized 12-inch long ground stakes are included for use when setting the base assembly directly on the ground. The larger section of composite material has 6 drilled holes that will accept the ground stakes, or you can use 3/8 inch bolts (not included) to attach to other surfaces (fence posts, tree trunks, concrete pads, deck floors, etc.). Depending on your total height and top load (antenna, mount, pulley, etc.), you can then easily walk up the mast. The Base Assemby will work with either the standard or ribbed-sided aluminum sections. The pivot piece does not lock into a vertical position; therefore, guying is required to maintain the mast in a vertical position.
- Price is $45.00 each, plus packaging & shipping

Vertical Mast Kit

- Pricing & Ordering of Basic Kit:

VAK1 is $165.00 (plus packaging/shipping to your address).

- Note external coupling joints do not permit sliding “car”

Fiberglass Telescoping Mast

Site: https://mgs4u.com/fiberglass-push-up-masts/?v=7516fd43adaa#masts

25 feet Heavy Duty Fiberglass Push-Up Mast MK-4-HD
$159.95

Maximum Usable Length (Height): 25 feet
Length when sleeved: 5 feet and 6 inches
Minimum overlap of tubes: 4.25 inches
Length of Tubes: 46.5 inches
Outer Diameter of Bottom Section: 2.5 inch
Outer Diameter of Top Section: 1 inch
Total Number of Sections: 7
Weight (when assembled): 12 pounds

Note: I used J-B Weld Epoxy to glue quick clamps onto each section

Balun

Balun – See: https://www.balundesigns.com/model-4113-4-1-current-balun-1-5-54-mhz-3kw/

Note - best if ladder line connections on side of case i.e. 4113s model


Model 4113t

Model 4113 - 4:1 Current Balun 1.5 - 54 MHz 3kW

$71.95

SKU: 4113

Shipping: Calculated at Checkout

Select Model: Required

- 4113t - Studs on top
- 4113tw - Studs on top w/ wingnuts
- 4113s - Studs on sides
- 4113e - Eyebolts on sides only
- 4113et - Eyebolts on sides and top

Quantity: 1

Ladder Line Components

In-Stock

WA1FFL LADDER-LOC

WA1FFL Ladder Line Locking Center Insulator

HRO Discount Price: $15.95*

In-Stock

JSC 450 OHM-#1318

450 Ohm Ladder Line - #18 AWG Solid Conductors - Per Foot

HRO Discount Price: $0.70*

Insulators and Wire

MFJ MFJ-16C01

SKU: ZMF-16C01

Add to Cart

PayPal CREDIT

The safer, easier way to pay

$1.75

Add to Wish List

Ready to Ship!

Check Store Stock

Home / Electrical / Wire / Building Wires

Internet #202564770 Model # 112-3401A Store SKU #197931

Cerrowire >

25 ft. 14-Gauge Single Conductor Black Stranded THHN Wire

★★★★★ (0) Write the First Review Questions & Answers (2)

- THHN cable is designed for indoor use
- Gas and Oil resistant
- THHN conductors are primarily used in conduit and cable trays

Covers 25 ft. (22¢ /ft.)

$5.61

Save up to $100 on your qualifying purchase.
Apply for a Home Depot Consumer Card

How to Get It

Home Depo – should be able to buy by the foot. I buy the 500 ft. roll

Summary

- Highest efficiency NVIS antennas must be clear of any structures and have an average height of 0.15 ʎ and a total length of ½ ʎ at lowest frequency.
- Azimuthal asymmetry can be reduced by using an inverted-V shape rather than horizontal.
- Minimize transmission line losses:
  - Minimize the use of coaxial cable between antenna and tuner.
  - Use ladder-line (450 ohm) to connect antenna to tuner or balun.
  - Place tuner as close as possible to antenna
- Model your proposed antenna
- Build your own antenna
- There are no “magic” antennas only dummy loads!

Questions?

Lewis Thompson

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