Field Expedient Antennas

24 NOV 2021

Objective

Utilize equipment and supplies that can be found locally to construct a Field Expedient antenna when a purpose built HF antenna is not available.

Radio Hardware Available

1. The design of a wide-bandwidth Field Expedient antenna will depend on the availability of an antenna tuner (manual or automatic). Note that a typical amateur transceiver auto-tuner does not have sufficient matching range (SWR <3:1). A few notable exceptions follow. Both are 20 watt maximum output radios.
2. If no tuner is available, then a single frequency, resonant antenna must be constructed.

AN/PRC-150(C)

SOFTWARE-DEFINED RADIO INNOVATION

The AN/PRC-150(C) is the most advanced and integrated HF radio in the world. The radio features Automatic Link Establishment (ALE), data rates up to 9600 bps with advanced error-free protocols, MELP digital voice, Citadel encryption, digital ECCM, and a built-in Internet Protocol (IP) interface. Covering the 1.6 to 60 MHz spectrum in 10 Hz steps, it goes beyond the standard HF band, making it a highly versatile HF-SSB/VHF FM transceiver. The built-in multi-waveform modem and 600/2400 bps vocoders provide high data throughput and secure digital voice over the most challenging HF channels.

- ENCRYPTION
- ENHANCED FREQUENCY HOPPING (ECCM)
- HIGH-SPEED MODEM WAVEFORMS
- MELP AND LPC-10, 600/2400 BPS DIGITAL VOICE
- MIL-STD-188-141B, APPENDIX A AUTOMATIC LINK ESTABLISHMENT (ALE)
- STANAG 4538 THIRD GENERATION HF LINK AUTOMATION
- TACTICAL INTERNET

Xiegu G90

Types of Resonant Antennas

With a few exceptions; there are two basic types of antennas of which most other common antennas are derived.

- Hertz (dipole)
- Marconi (vertical) - Not good for NVIS propagation.

Dipole Antennas

The dipole was one of the earliest type of antenna; it was invented by German physicist Heinrich Hertz around 1886 in his pioneering investigations of radio waves.

The Dipole is an electrically “balanced” antenna.

Dipole Antennas

- It is not a requirement for a dipole to be horizontally oriented, but at lower HF frequencies, they usually are for practical reasons.
- The horizontal orientation means the energy transmitted from the antenna is horizontally polarized. This usually results in additional power gain from the ground reflected signal.
- For the following discussion about dipole antennas, unless otherwise described, assume a horizontal antenna.

Dipole Antennas

b. Transportable equipment will often be used on relatively short paths, for which the half-wave horizontal dipole is well suited. The effectiveness of the horizontal dipole is dependent upon its being erected at the proper height. Figure 5–3 provides guidance on the optimum height. Because it may not be possible to achieve the optimum height under field conditions, the figure also gives the height at which a 3-dB penalty is incurred.

Dipole Antenna Height

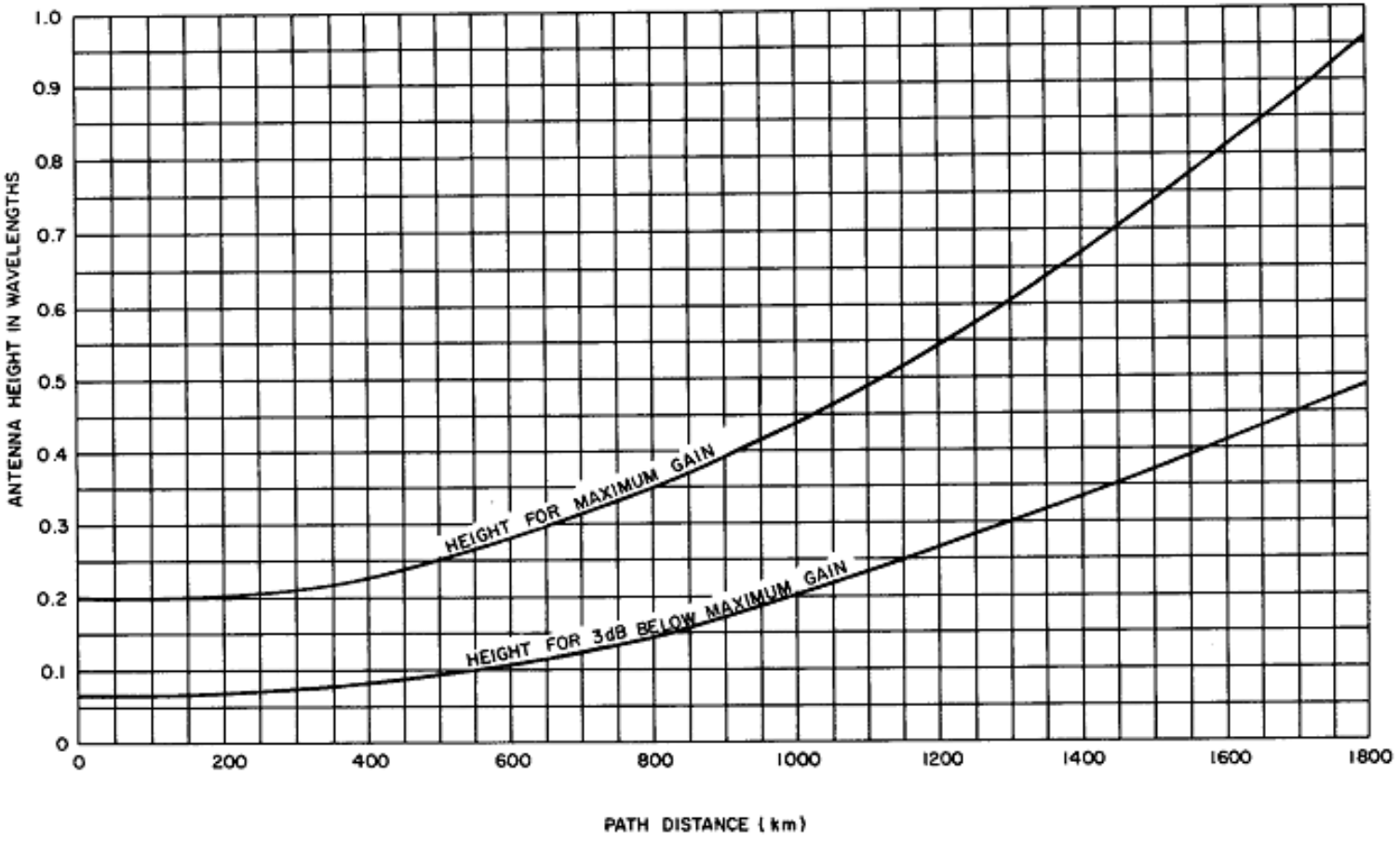
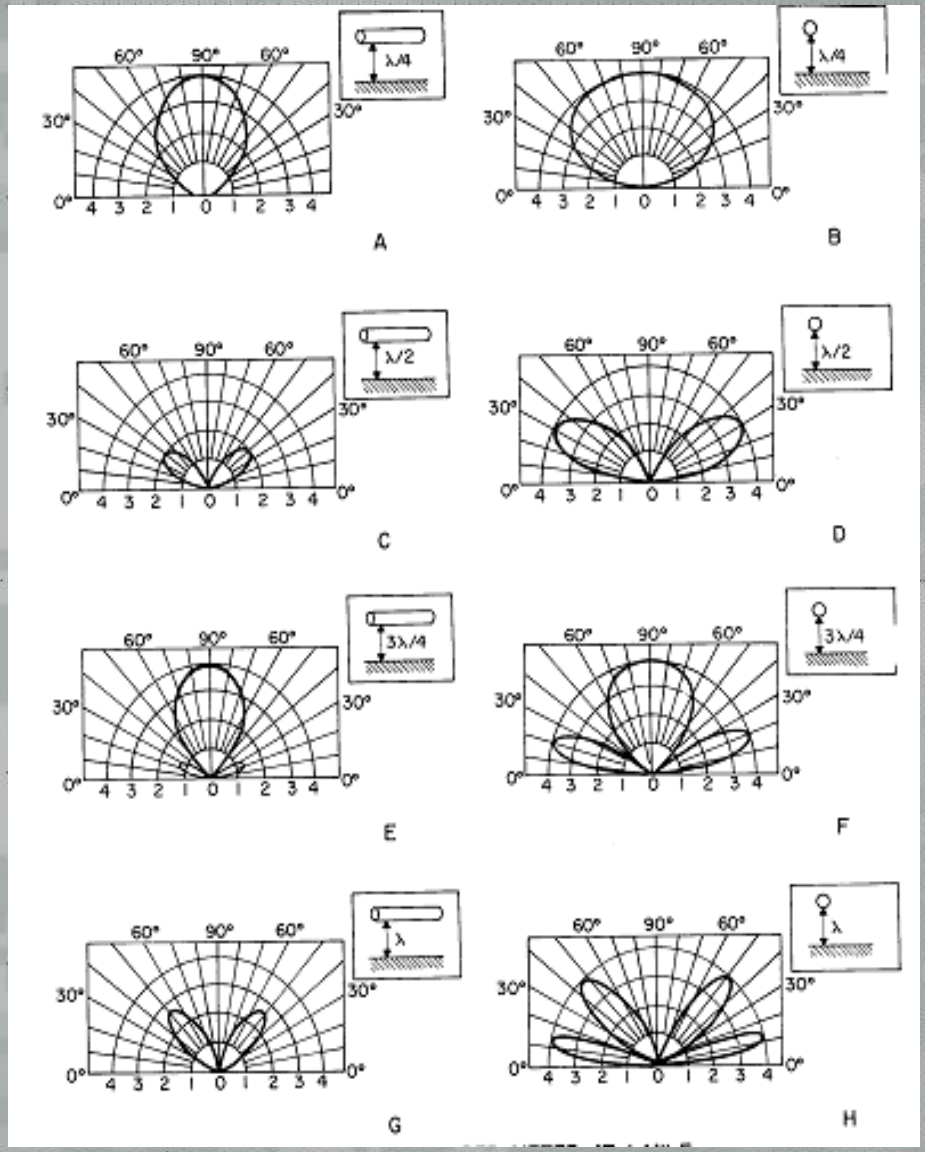


Figure 5–3. Approximate height of half-wave dipole for best F2 layer propagation.

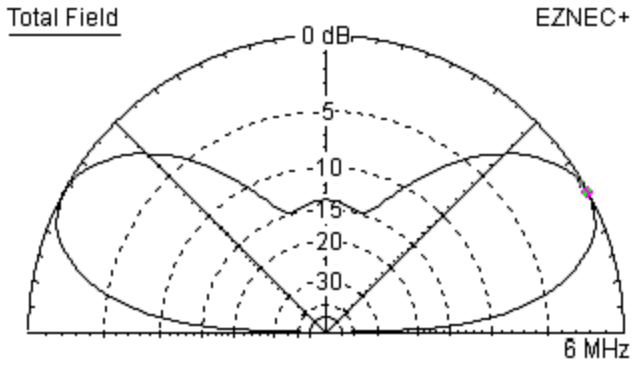
Dipole Antenna Take-Off and Arrival Angles at various Heights

EZNec



Dipole Take-Off and Arrival Angle at ½ Wavelength above Ground

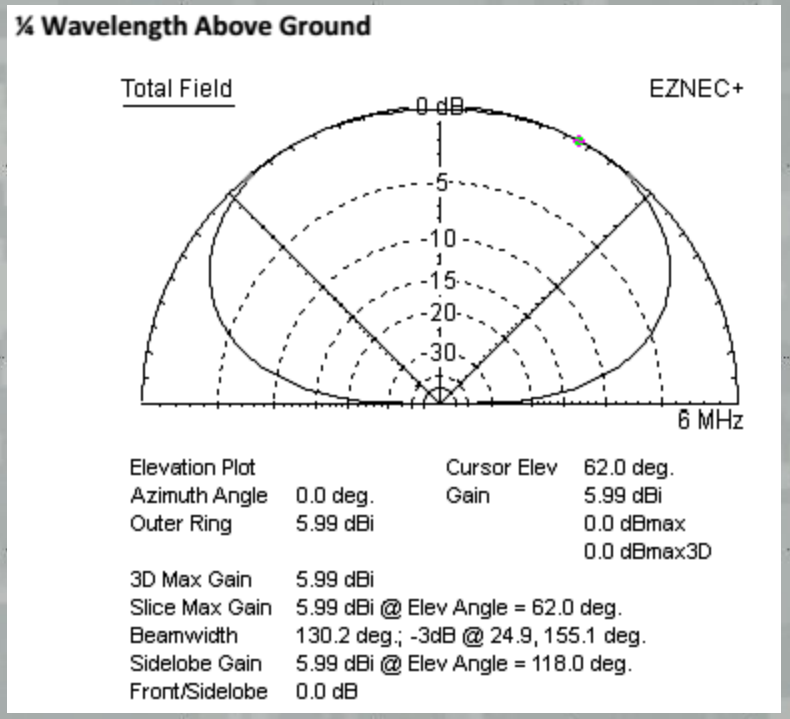
½ Wavelength Above Ground



Elevation Plot		Cursor Elev	28.0 deg.
Azimuth Angle	0.0 deg.	Gain	7.63 dBi
Outer Ring	7.63 dBi		0.0 dBmax
			0.0 dBmax3D

3D Max Gain	7.63 dBi
Slice Max Gain	7.63 dBi @ Elev Angle = 28.0 deg.
Beamwidth	32.4 deg.; -3dB @ 13.3, 45.7 deg.
Sidelobe Gain	7.63 dBi @ Elev Angle = 152.0 deg.
Front/Sidelobe	0.0 dB

Dipole Take-Off and Arrival Angle at 1/4 Wavelength above Ground (NVIS)



Half Wave Resonant Dipole (Can be an Inverted-V)

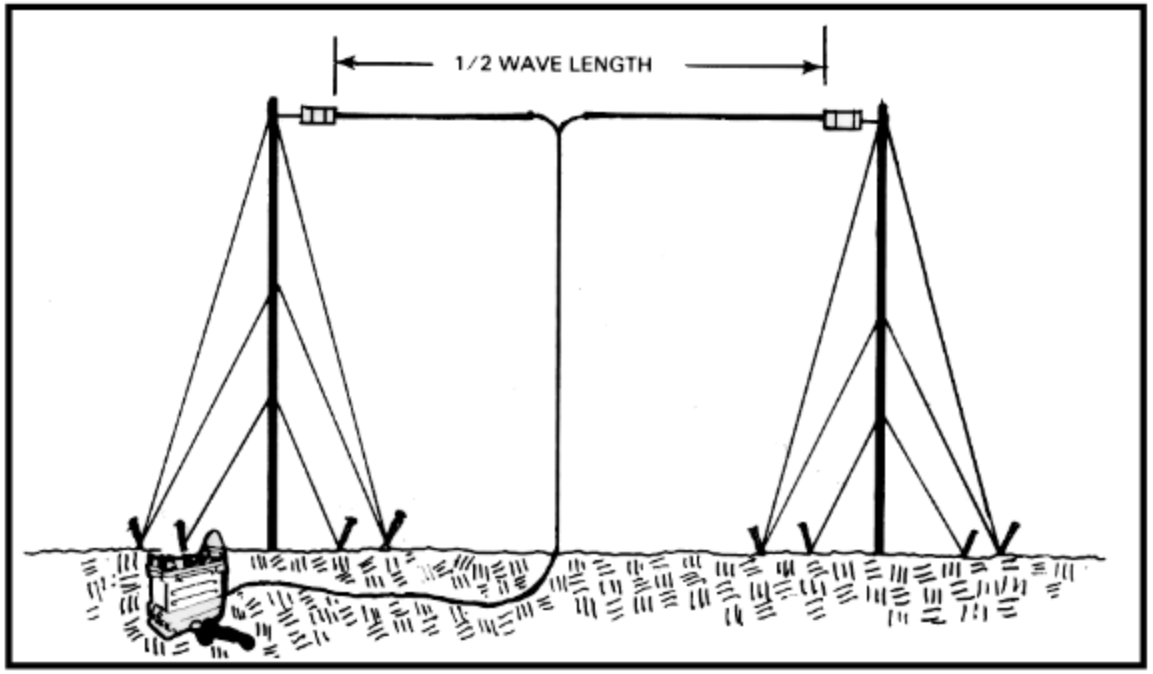


Figure 3-12. Center-fed Hertz antenna with two upright supports.

Half Wave Resonant Dipole

- Operates on one frequency, in a very narrow bandwidth.
- Total Length - 468/f MHz (See Table 1)
- Simple to build, but requires careful tuning.
- Can use coaxial cable and requires no tuner.
- Use 1:1 balun to balance load from coax cable.

TABLE 1 – ½ Wavelength to Frequency

Frequency (kHz)		1/2 Wavelength (Feet)	
2,194.00	2,495.00	224.3	197.2
2,505.00	2,850.00	196.5	172.7
3,155.00	3,400.00	156.0	144.7
4,000.00	4,063.00	123.0	121.1
4,438.00	4,650.00	110.9	105.8
4,750.00	4,995.00	103.6	98.5
5,005.00	5,450.00	98.3	90.3
5,730.00	5,950.00	85.9	82.7
6,765.00	7,000.00	72.7	70.3
7,300.00	8,195.00	67.4	60.1
9,040.00	9,500.00	54.4	51.8
9,900.00	9,995.00	49.7	49.2
10,150.00	11,175.00	48.5	44.0
11,400.00	11,650.00	43.2	42.2
12,050.00	12,230.00	40.8	40.2
13,410.00	13,600.00	36.7	36.2
13,800.00	14,000.00	35.7	35.2
14,350.00	14,990.00	34.3	32.8
15,600.00	16,360.00	31.5	30.1
17,410.00	17,550.00	28.3	28.0
18,030.00	18,068.00	27.3	27.2
18,168.00	18,780.00	27.1	26.2
18,900.00	19,660.00	26.0	25.0
19,800.00	19,990.00	24.9	24.6
20,010.00	21,000.00	24.6	23.4
21,855.00	23,200.00	22.5	21.2
23,350.00	24,890.00	21.1	19.8
25,330.00	25,550.00	19.4	19.3
26,480.00	28,000.00	18.6	17.6
29,800.00	30,000.00	16.5	16.4

Resonant Dipole Tuning Procedure

- Install dipole of length Lm (from Table 1) and find lowest SWR frequency (Fm).
- Adjust length to move resonance frequency Fr to required frequency as follows:

$$Lr = Fm/Fr \times Lm$$

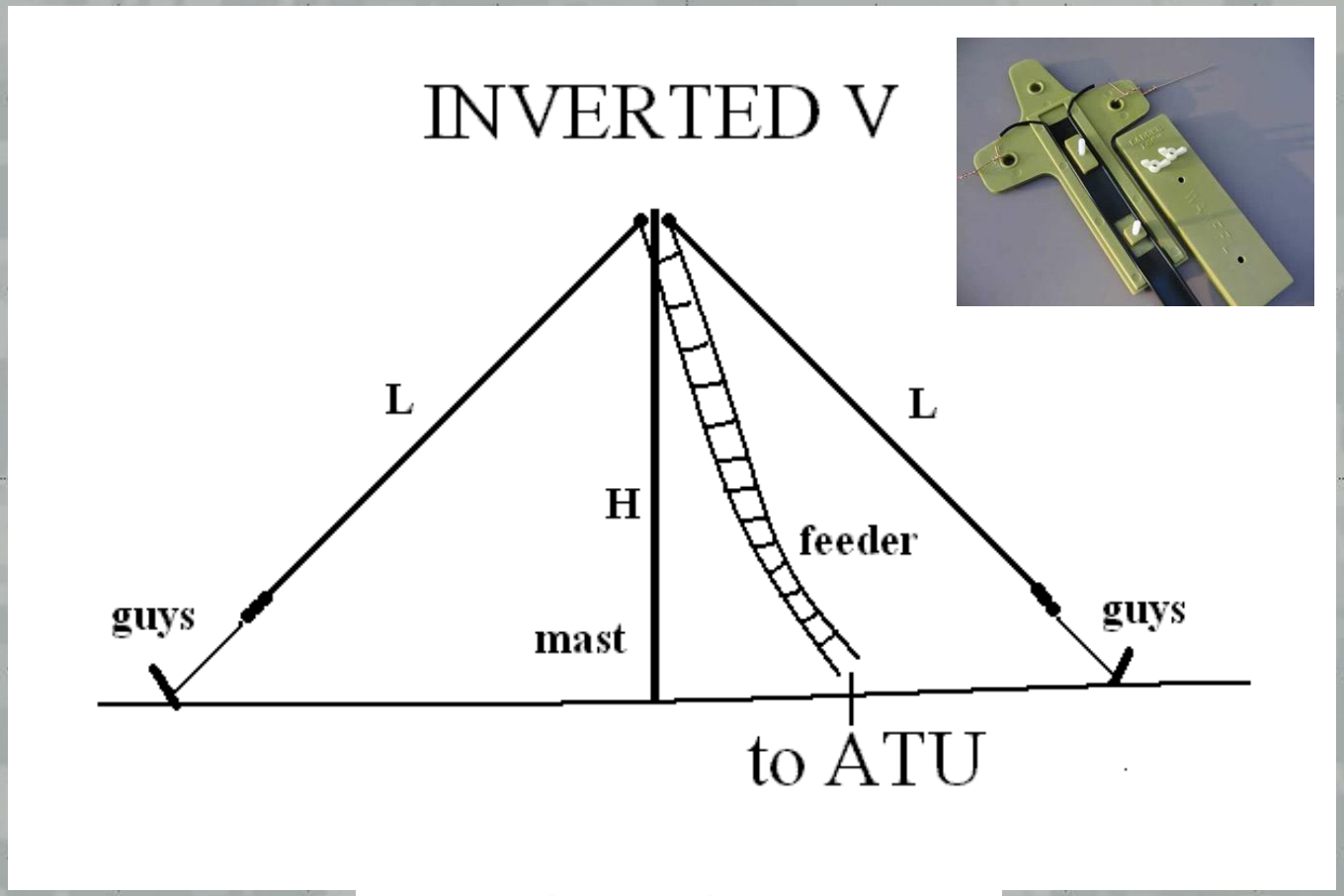
For example: Required resonant frequency (Lr) = 5.202 MHz
Initial cut (Lm) = 95 ft.
Measured resonance (Fm) = 5.4 MHz

Therefore, increase length by 5.4/5.202 x 95 = 98.6 ft.,
i.e., increase each half of dipole by 1.8 ft.

Non-Resonant Antennas

- It is assumed that the user has a wide-range antenna tuner available to couple to wide bandwidth Field Expedient antennas.
- Coaxial transmission line length should be minimized to reduce dielectric loses.
- The use of open wire transmission line is recommended.
- Recommended Balun:
  - Wide-band dipole with ladder line – 4:1
  - Single-ended Long wire – 9:1

Non-Resonant Doublet



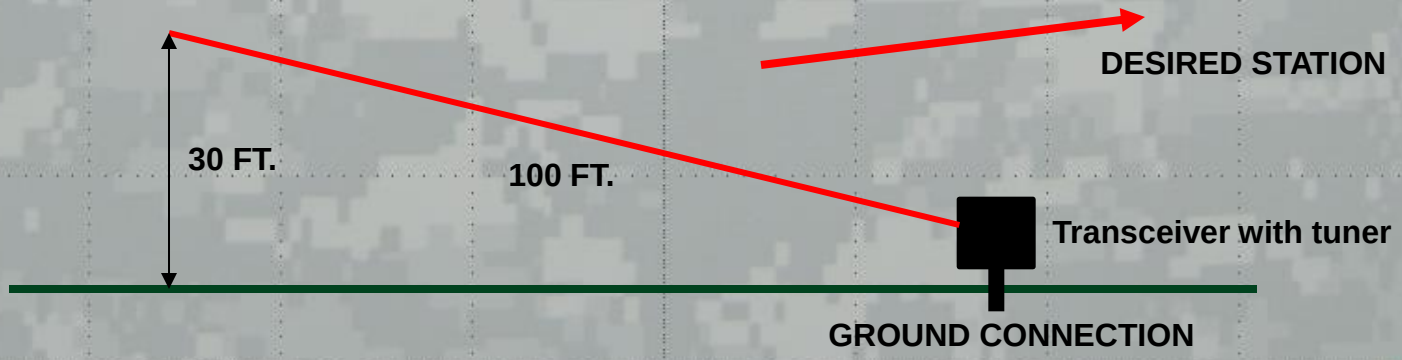
L = 65 ft. – 75 ft.
H = 30 – 50 ft.
Angle = As large as possible

Long Wire Antennas

- The Long Wire is a simple, easy to construct antenna that can be used to improve the efficiency of transmitting and receiving radio system over the short whip antennas used for mobile or portable operation.
- The Long Wire improves efficiency by utilizing a long horizontal wire, at a greater distance above the ground that is practical for a vehicle or man-portable whip.

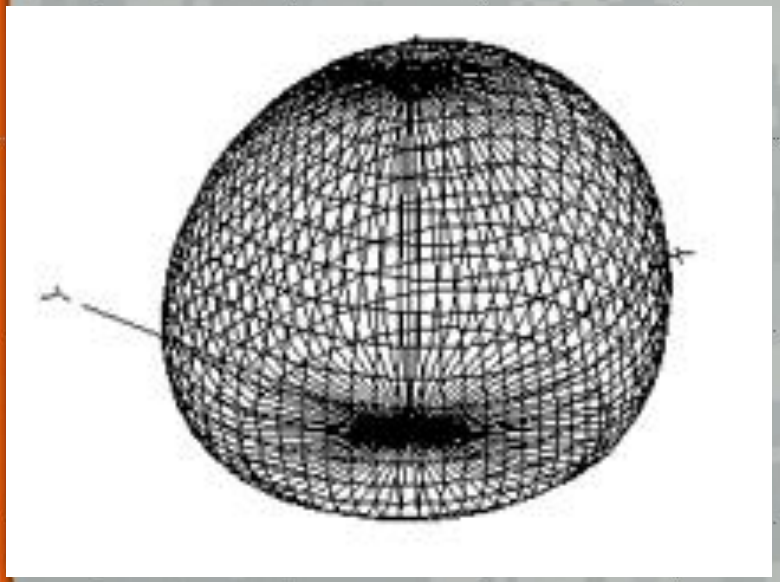
Long Wire

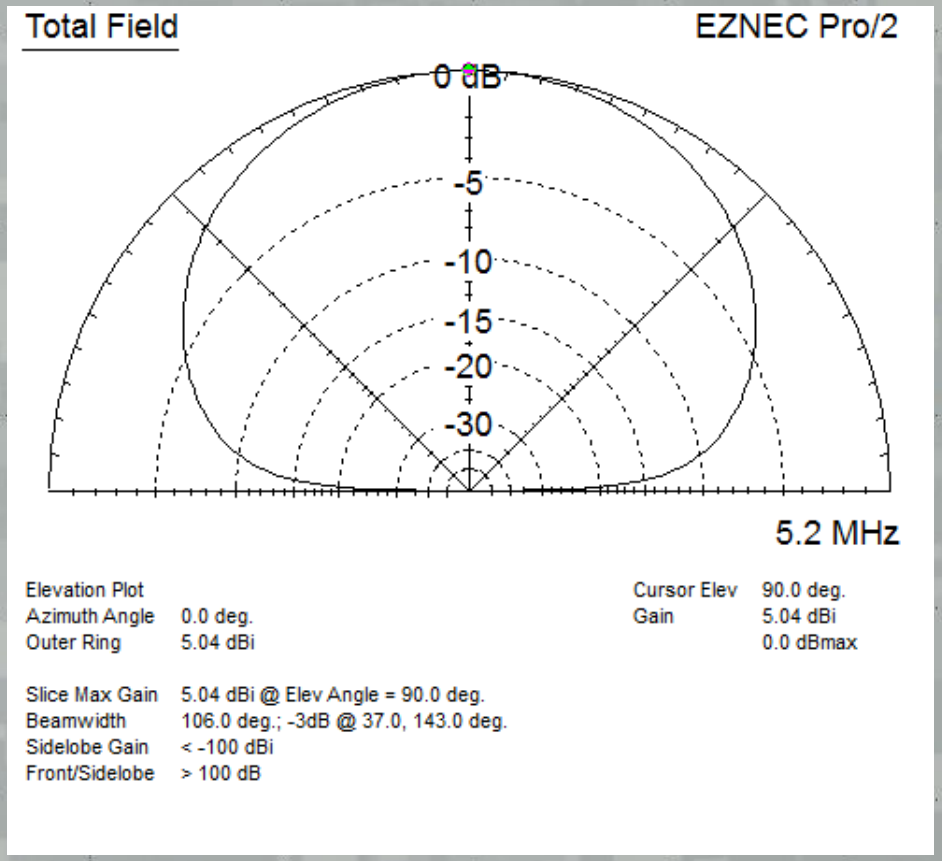
- The Long Wire improves NVIS (+/- 300 miles) capability over whip antennas.
- On frequencies greater than 10 MHz, the long wire is directional, and should be pointed towards the station in which communications is desired.
- Point wire down-slop towards desired station.
- Coupler must be engaged and show low SWR.



Long Wire Example -NVIS

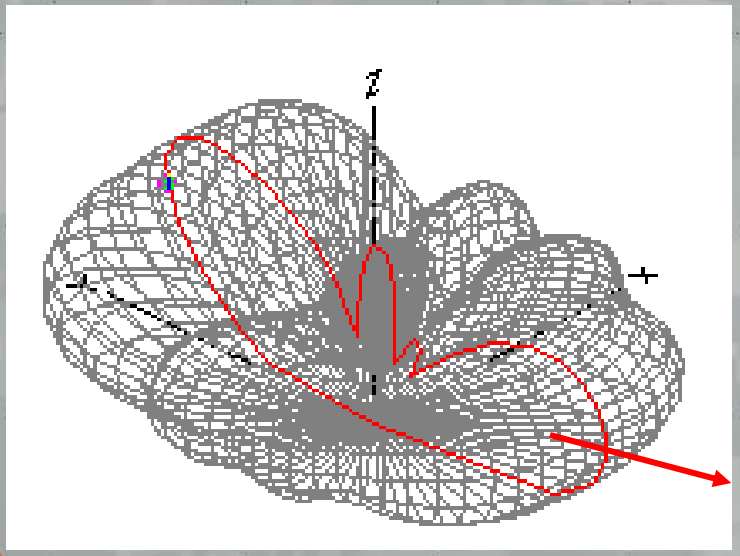
5.2 MHz
100 ft. wire

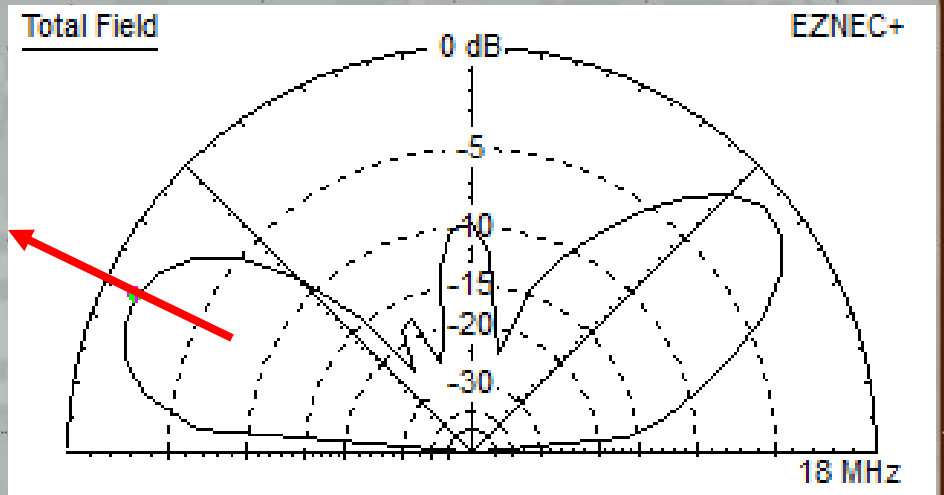




Long Wire Example – Long Range

18 MHz
100 ft. wire





Elevation Plot		Cursor Elev	155.0 deg.
Azimuth Angle	90.0 deg.	Gain	2.76 dBi
Outer Ring	4.34 dBi		-0.54 dBmax
			-1.57 dBmax3D

3D Max Gain	4.34 dBi
Slice Max Gain	3.3 dBi @ Elev Angle = 40.0 deg.
Beamwidth	26.8 deg.; -3dB @ 24.8, 51.6 deg.
Sidelobe Gain	2.76 dBi @ Elev Angle = 155.0 deg.
Front/Sidelobe	0.54 dB

Supplies

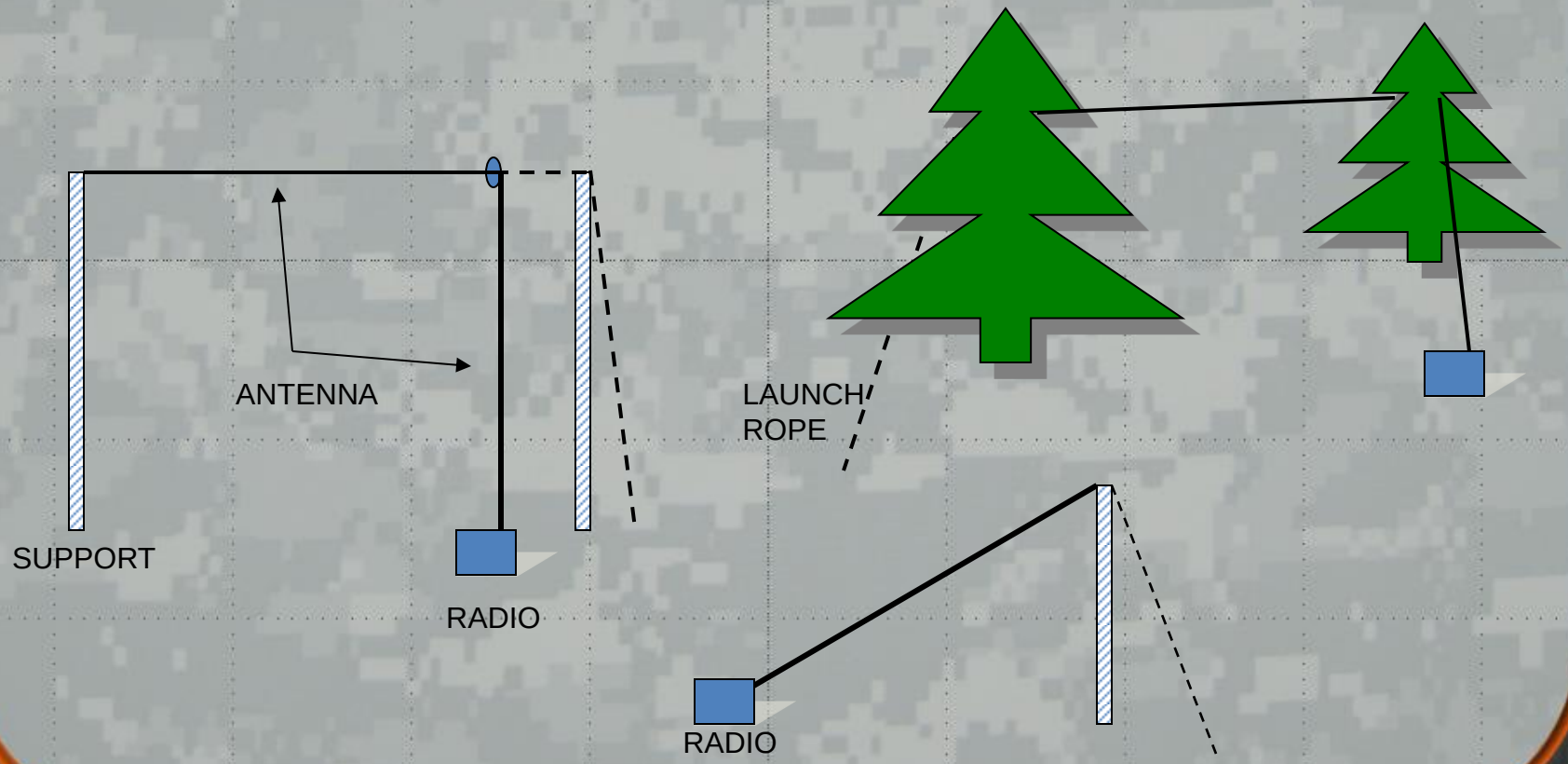
- Antenna Wire :
  14-18 gauge, stranded, insulated or un-insulated 75- 150’
- Insulators:
  Ceramic/plastic – non conductive. Can be improvised with plastic water bottles, dry rope, etc.
- Clamps & pulleys:
  Hose Clamps, screw type, approx 2” diameter, small pulley
- Rope:
  Synthetic line (parachute line), etc. =/> 150 feet
  Counterweight on end of rope to facilitate throwing to support Pulleys, carabineers, etc.
- Support:
  Examples; flagpole, push up pole, structures, tree, etc.
- Baluns: 1:1 Balun Designs 1110w (Resonant dipoles)
  4:1 Balun Designs 4110 sw (wide-band dipole)
- 9:1 Balun Designs 9130sw (Long-wire)

Throw Rope

SUPPORT ROPE WITH WEIGHT

- Use rope with weight on one end, throw, toss, cast rope to highest available point;
- Pull rope to move antenna to desired height

Long-Wire Set Up Options



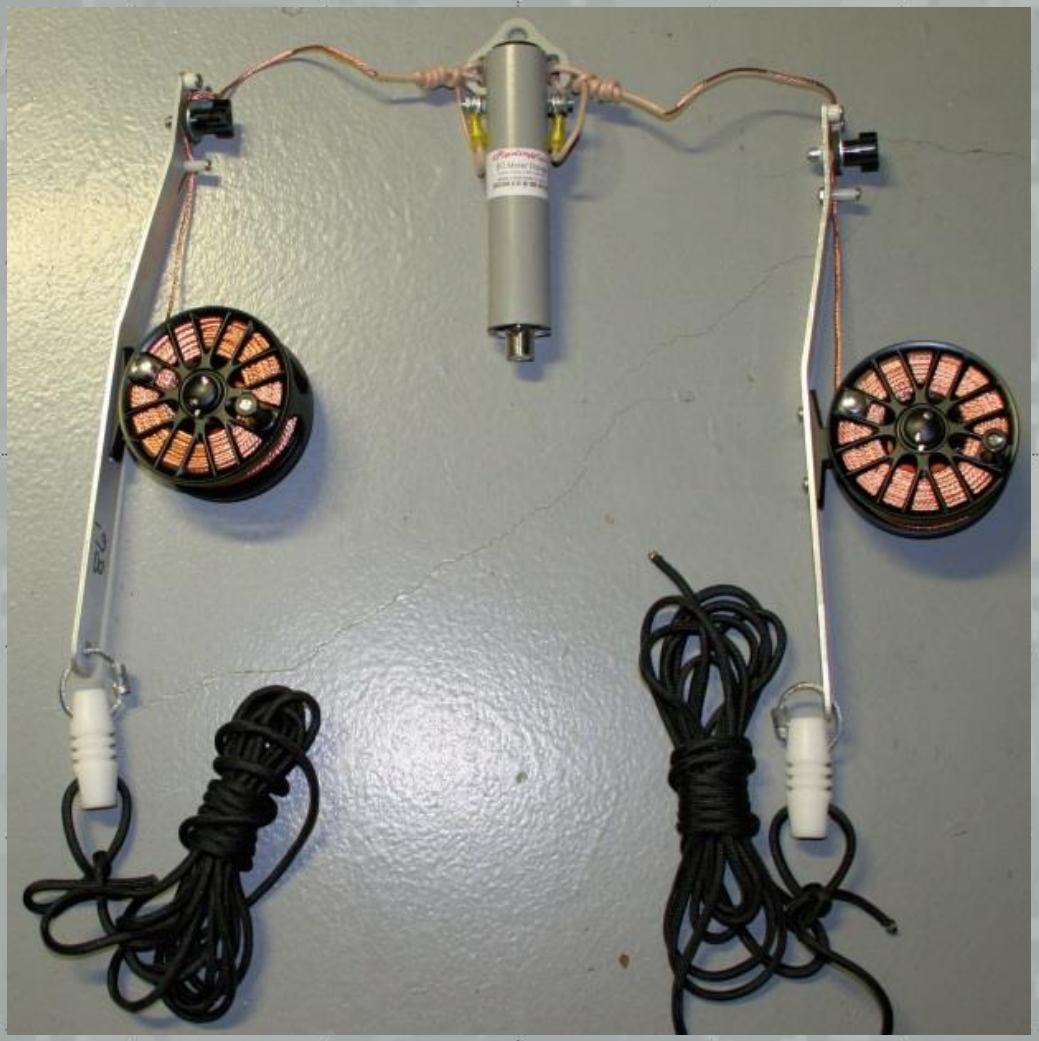
Long-Wire Disadvantages

- Requires transceiver or antenna tuner to be located at the end of the long-wire.
- Any radio with a built-in tuner is exposed to weather.
- If an external auto-tuner is used, it must be weather proof.
- In the case of the military PRC-150, with its built-in tuner, this exposes the soldier to enemy fire.

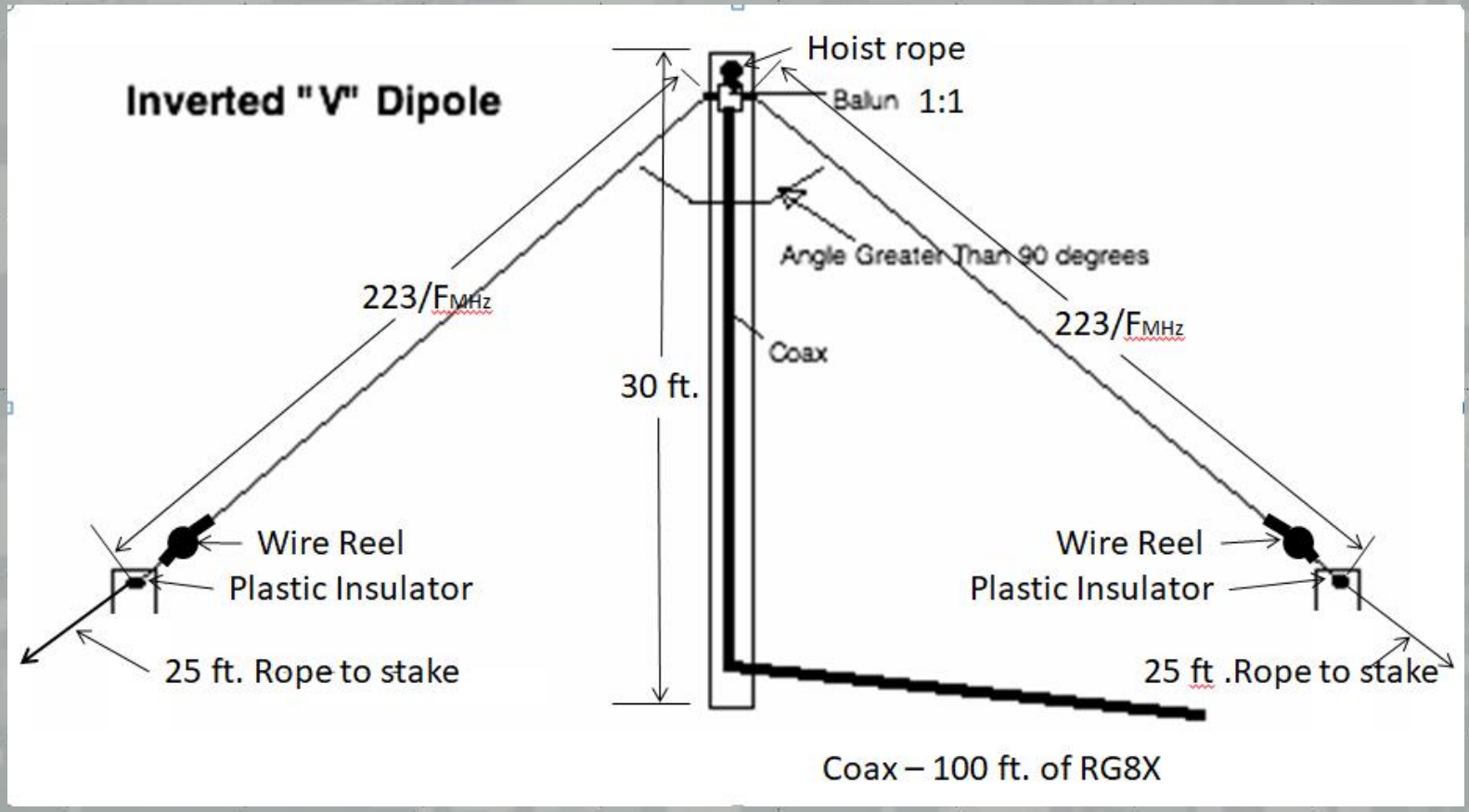
Emergency Antenna Kits

- The MARS/Amateur operator might want to build an emergency antenna kit(s) that could quickly be deployed when needed.
- Two kits are shown in the following pages:
  - The first is a single frequency adjustable dipole that uses coaxial cable.
  - The second is a wide-bandwidth dipole that uses rugged ladder line but requires a tuner.

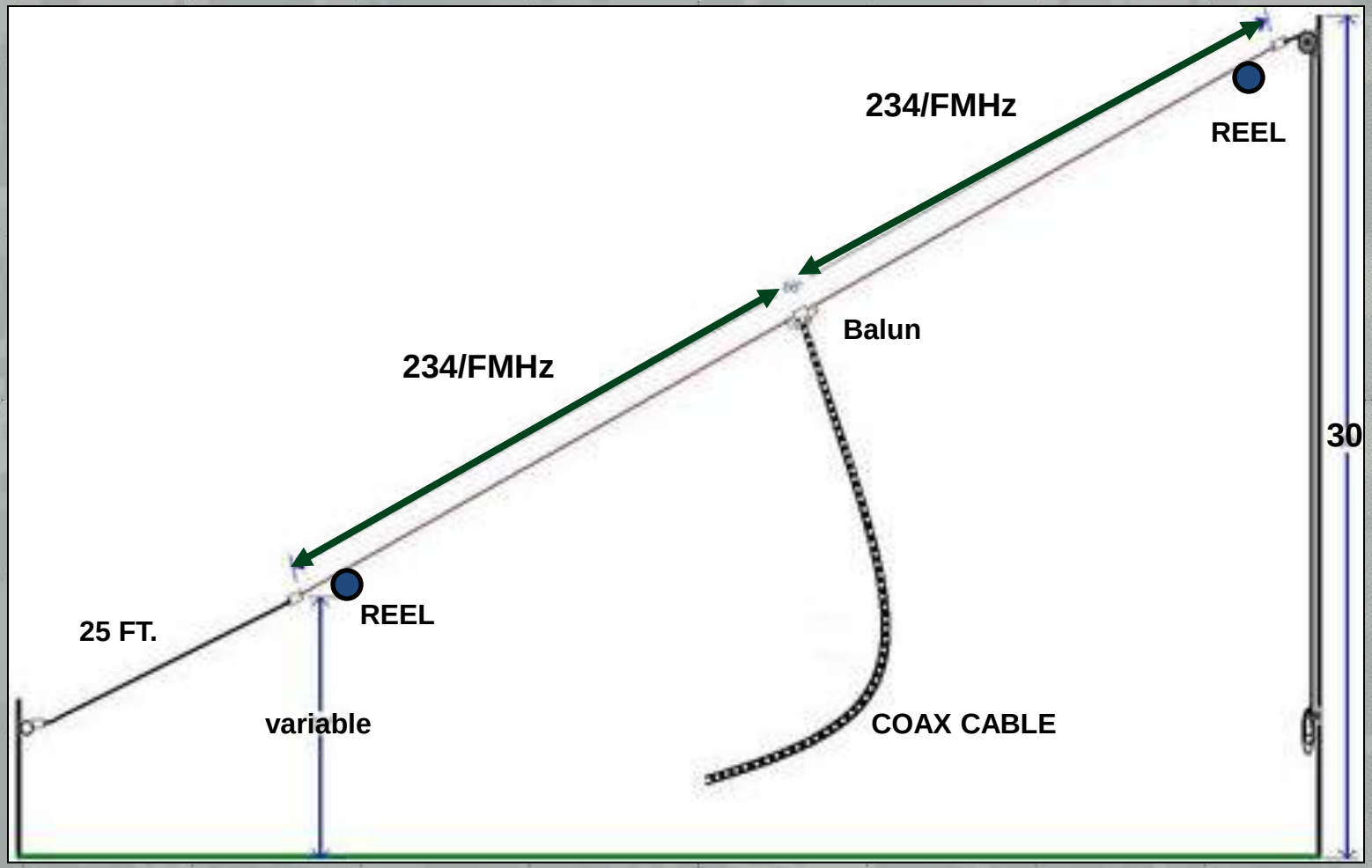
Adjustable (resonant) Dipole



NVIS Deployment



Long-Range Deployment



Additional Kit Parts

LENGTH OF EACH LEG OF DIPOLE

1 MHz		0.5 MHz		0.2 MHz		0.1 MHz		0.05 MHz	
Freq Mc	Dist Ft	Freq Mc	Dist Ft	Freq Mc	Dist Ft	Freq Mc	Dist Ft	Freq Mc	Dist Ft
20.0	11.7	11.0	21.3	7.0	33.5	4.0	58.6	3.00	78.0
19.0	12.3	10.5	22.3	6.8	34.5	3.9	60.0	2.95	79.4
18.0	13.0	10.0	23.5	6.6	35.5	3.8	61.6	2.90	80.7
17.0	13.8	9.5	24.7	6.4	36.6	3.7	63.3	2.85	82.1
16.0	14.7	9.0	26.0	6.2	37.8	3.6	65.0	2.80	83.6
15.0	15.7	8.5	27.6	6.0	39.0	3.5	66.9	2.75	85.1
14.0	16.8	8.0	29.3	5.8	40.4	3.4	68.9		
13.0	18.0	7.5	31.3	5.6	41.8	3.3	70.0		
12.0	19.6	7.0	33.5	5.4	43.4	3.2	73.2		
11.0	21.3			5.2	45.0	3.1	75.5		
				5.0	46.0	3.0	78.0		
				4.8	48.8				
				4.6	50.9				
				4.4	53.2				
				4.2	55.8				
				4.0	58.6				

NOTE: Measure from Balun to reel insulator, i.e. include reel in total length. See antenna diagram.

Specifications

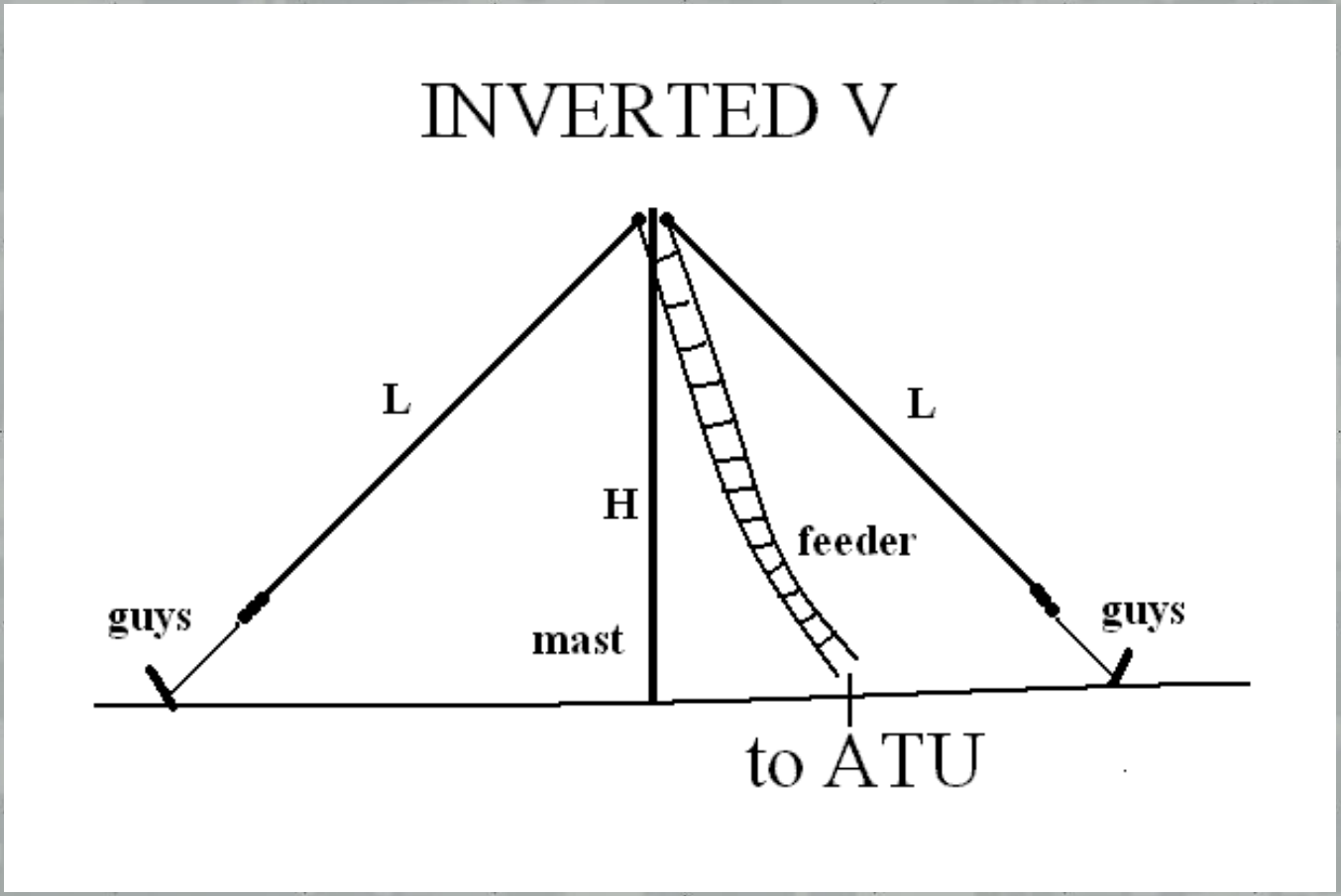
1. Frequency adjustment range – 2.75 – 30 MHz
2. Balun - 1:1 current
3. Wire - #14 AWG copper “Flex-Weave”, breaking strength – 110 lbs.
   Working load – 30 to 60 lbs.
4. Measured SWR – no greater than 1.2:1 at end of 100 ft. of RG 8X coaxial cable.
5. Coaxial Cable lose – 0.8 dB/100 ft. at 10 MHz

Component List

- The complete kit includes the following:
- Adjustable dipole antenna
- 100 ft. tape measure
- Length versus frequency table
- Coaxial cable – 100 ft. of RG8X
- Fabric carrying bag
- Total weight – 11 lbs.
- Carrying bag dimensions – 16” x 10” x 9”
- I can provide construction details.

Wide Band Dipole (WBD-40)

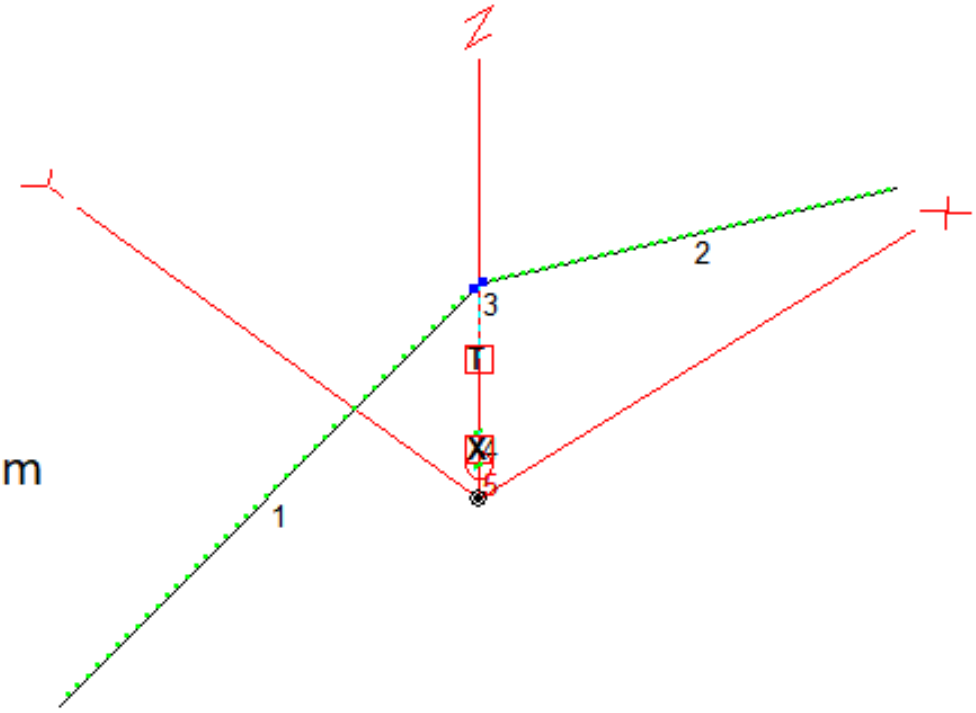
Non-Resonant Doublet



Non-Resonant Doublet

Leg lengths – 67 ft.
Apex height – 32 ft.
End heights – 7.7 ft.
Wire - #14 AWG Cu.

Transmission Line (T) – 300 ohm
Ladder line length – 40 ft.
Balun (X) – 4:1



Materials List for WBD Antenna – page 1

https://www.dxengineering.com/search/department/antennas

$23.99
(Includes end insulators.)

DX Engineering EZ-BUILD® UWA Center-T and End Insulator Kits DXE-UWA-KIT

★★★★½ (7) Review This Product

Antenna Wire Components, Center and End Insulators, 4-Gauge Maximum Wire, Kit

Availability: In Stock

Estimated Ship Date: Today

In-Store Pick Up Available in Ohio Details

$49.99
(Enough for two dipoles)

DX Engineering 300-ohm Ladder Line DXE-LL300-1C

★★★★★ (3) Review This Product

Ladder Line, 300 ohms, Window Style Open Wire, 18 AWG Stranded CCS, 2500 W, 0.88 VF, 100 ft. Length, Each

Estimated Ship Date: 11/20/2020
(if ordered today)

- Fast Shipping
- Tech Advice
- Low Prices
- Easy Returns

Materials List for WBD Antenna – page 2

https://www.dxengineering.com/search/department/antennas

$26.99

DX Engineering Premium Antenna Wire DXE-ANTW-150

★★★★½ (18) Review This Product

Antenna Wire, Premium, 14 AWG Stranded Copper, UV Resistant Black PVC Insulation, 150 ft. Length, Each

Availability: In Stock

Estimated Ship Date: Today

In-Store Pick Up Available in Ohio Details

$12.29
(Enough for both ends and hoisting halyard)

Synthetic Textile Industries Antenna Support Rope DBR-94-100

★★★★★ (2) Review This Product

Rope, Antenna Support, Polyester, Break Strength 260 lbs., 0.094 in. Diameter, 100 ft. Length, Each

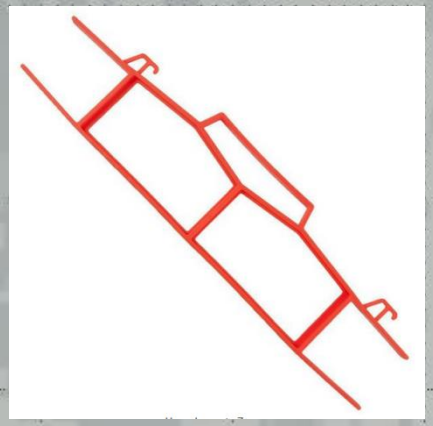
Availability: In Stock

Estimated Ship Date: Today

In-Store Pick Up Available in Ohio Details

Materials List for WBD Antenna – page 3

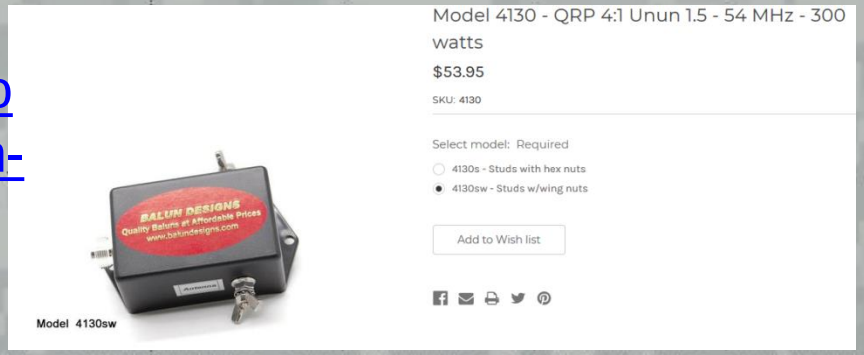
$1.97



$32.95

Husky 15 in Tool Bag
Brand: HUSKY

https://www.balundesigns.com/model-4130-qrp-4-1-unun-1-5-54-mhz-300-watts/



Total Cost - $187.05 + tax and shipping

Specifications

1. Frequency range – 2 – 30 MHz (dependent on tuner performance)
2. Balun - 4:1 unun
3. Wire - #14 AWG Cu insulated
4. 300 ohm ladder line loss - 0.48 dB/100 ft. at 10 MHz

Conclusions

- A Field Expedient antenna will allow the MARS/Amateur operator to communicate when his existing antenna is not available.
- The frequency agility of a Field Expedient antenna is greatly enhanced with a wide-range antenna tuner.
- The dimensions (length and height) control the antenna's performance.
- Examples of two "jump" kit emergency antennas have been provided. Both of these antennas have been tested by Army National Guards Teams.

Questions?

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