Basic Practical Antennas

Welcome to Ham Radio University 2026!

Ham Radio University

2026

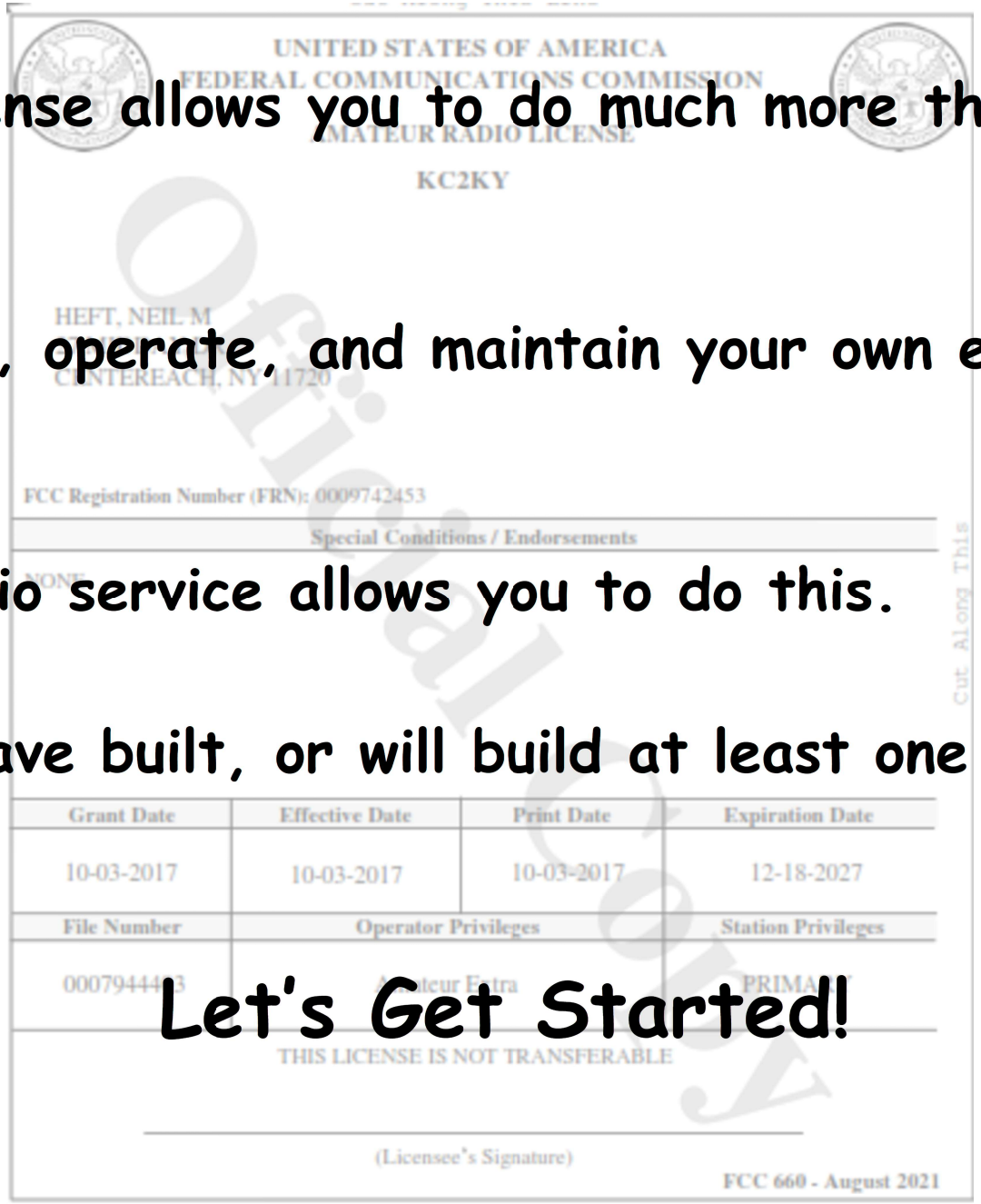
Our 27th Year!

Dedicated to the Memory of

Phil Lewis, N2MUN

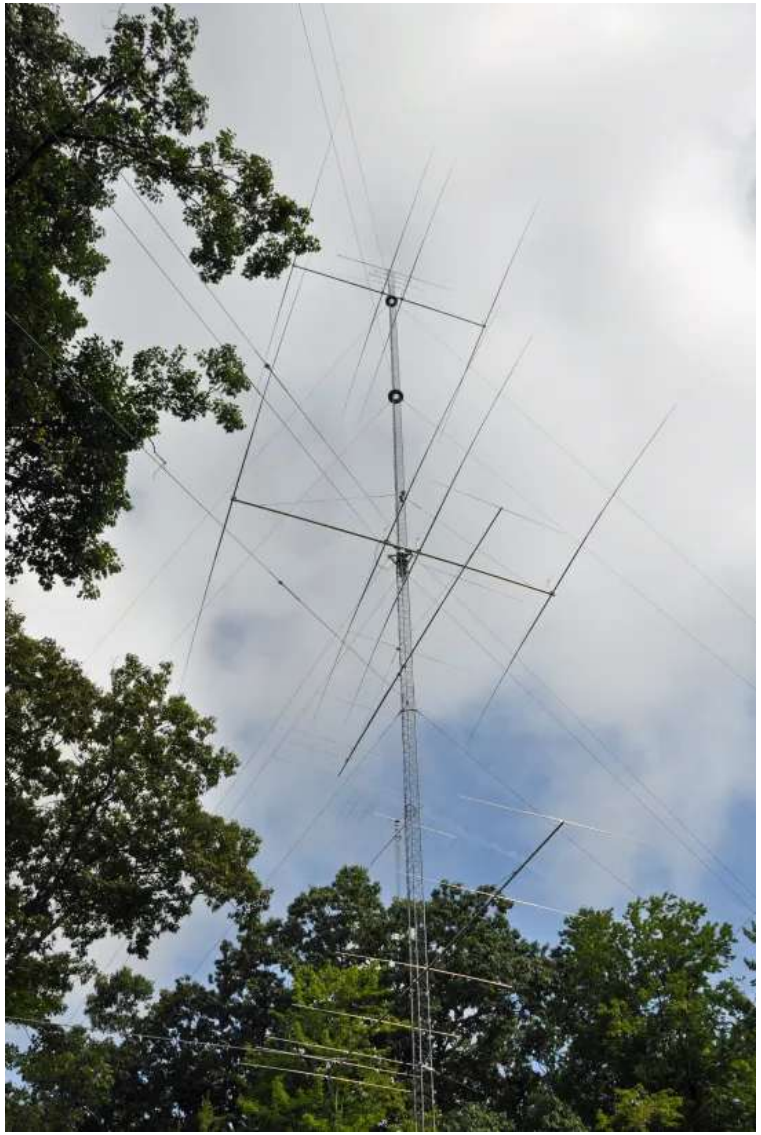
Founder of Ham Radio University

- Your ham license allows you to do much more than just operate a radio.
- You can build, operate, and maintain your own equipment (on ham bands).
- No other radio service allows you to do this.
- Most hams have built, or will build at least one antenna. You can, too.

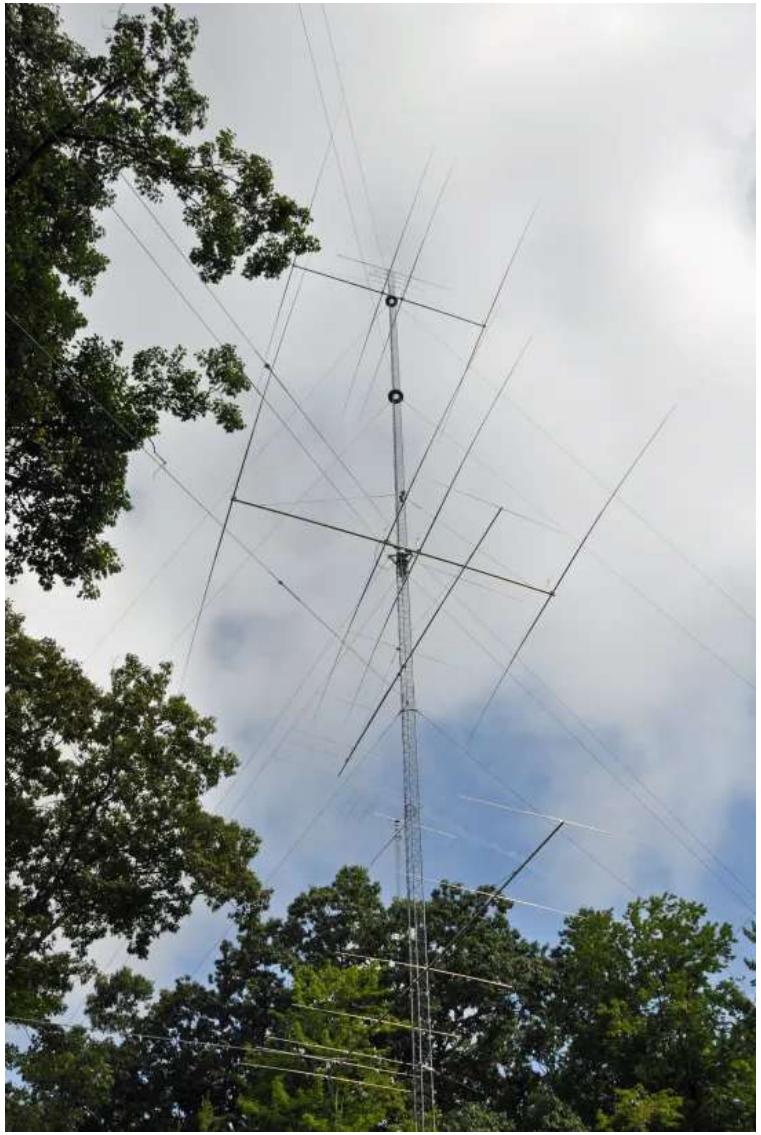

UNITED STATES OF AMERICA
FEDERAL COMMUNICATIONS COMMISSION
AMATEUR RADIO LICENSE
KC2KY
HEFT, NEIL M
CENTEREACH, NY 11720
FCC Registration Number (FRN): 0009742453
Special Conditions / Endorsements
NONE
Grant Date | Effective Date | Print Date | Expiration Date
10-03-2017 | 10-03-2017 | 10-03-2017 | 12-18-2027
File Number | Operator Privileges | Station Privileges
0007944483 | Amateur Extra | PRIMARY
THIS LICENSE IS NOT TRANSFERABLE
(Licensee's Signature)
FCC 660 - August 2021
Official Copy
Cut Along This

Let's Get Started!

Three Things These Two Antenna Installations Have in Common

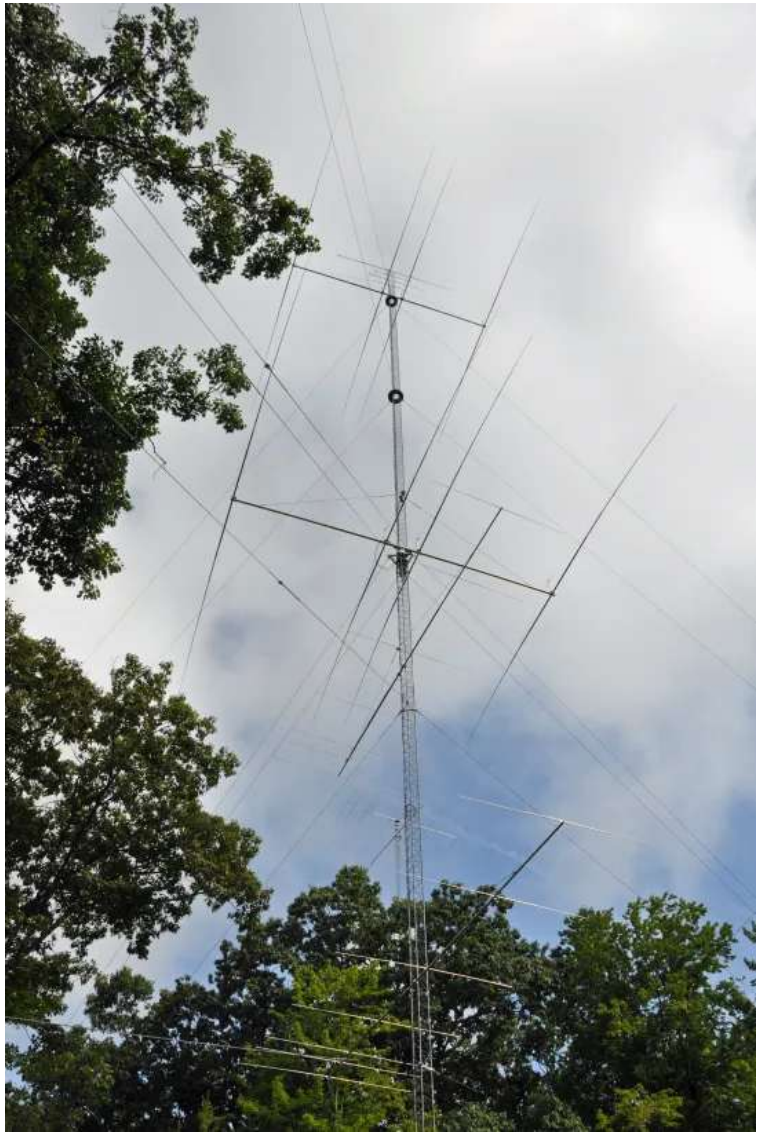


Three Things These Two Antenna Installations Have in Common



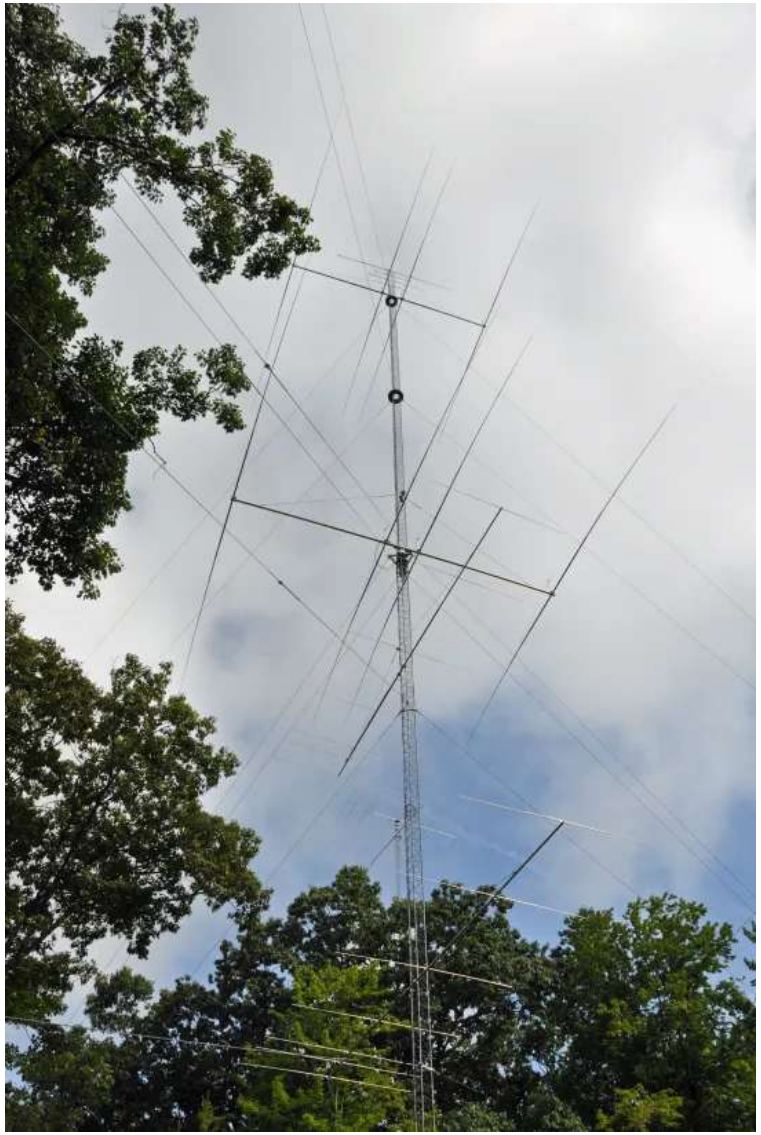
1. They Are both Compromise Antennas

Three Things These Two Antenna Installations Have in Common



1. They Are both Compromise Antennas
2. They Were Both Designed with Specific Constraints in Mind

Three Things These Two Antenna Installations Have in Common

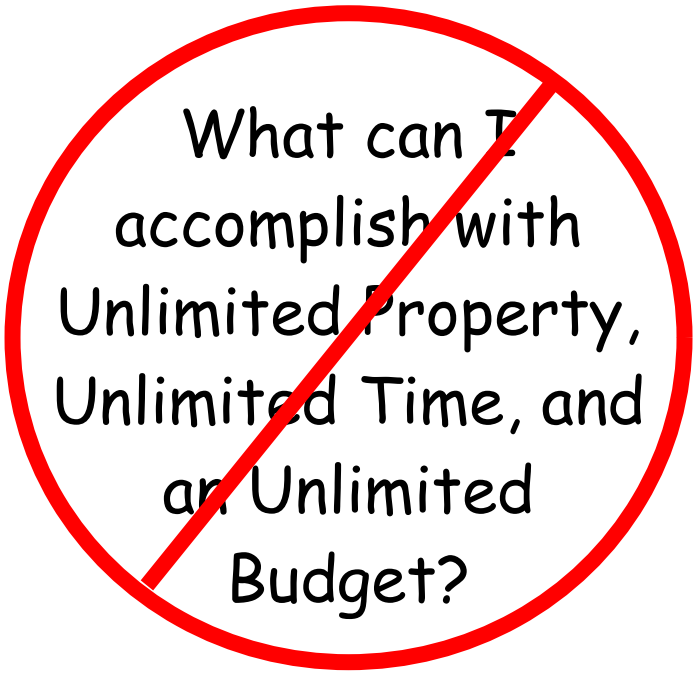


1. They Are both Compromise Antennas
2. They Were Both Designed with Specific Constraints in Mind
3. They Can Both Get You on HF

Basic Practical Antennas

What can I
accomplish with
Unlimited Property,
Unlimited Time, and
an Unlimited
Budget?

Basic Practical Antennas

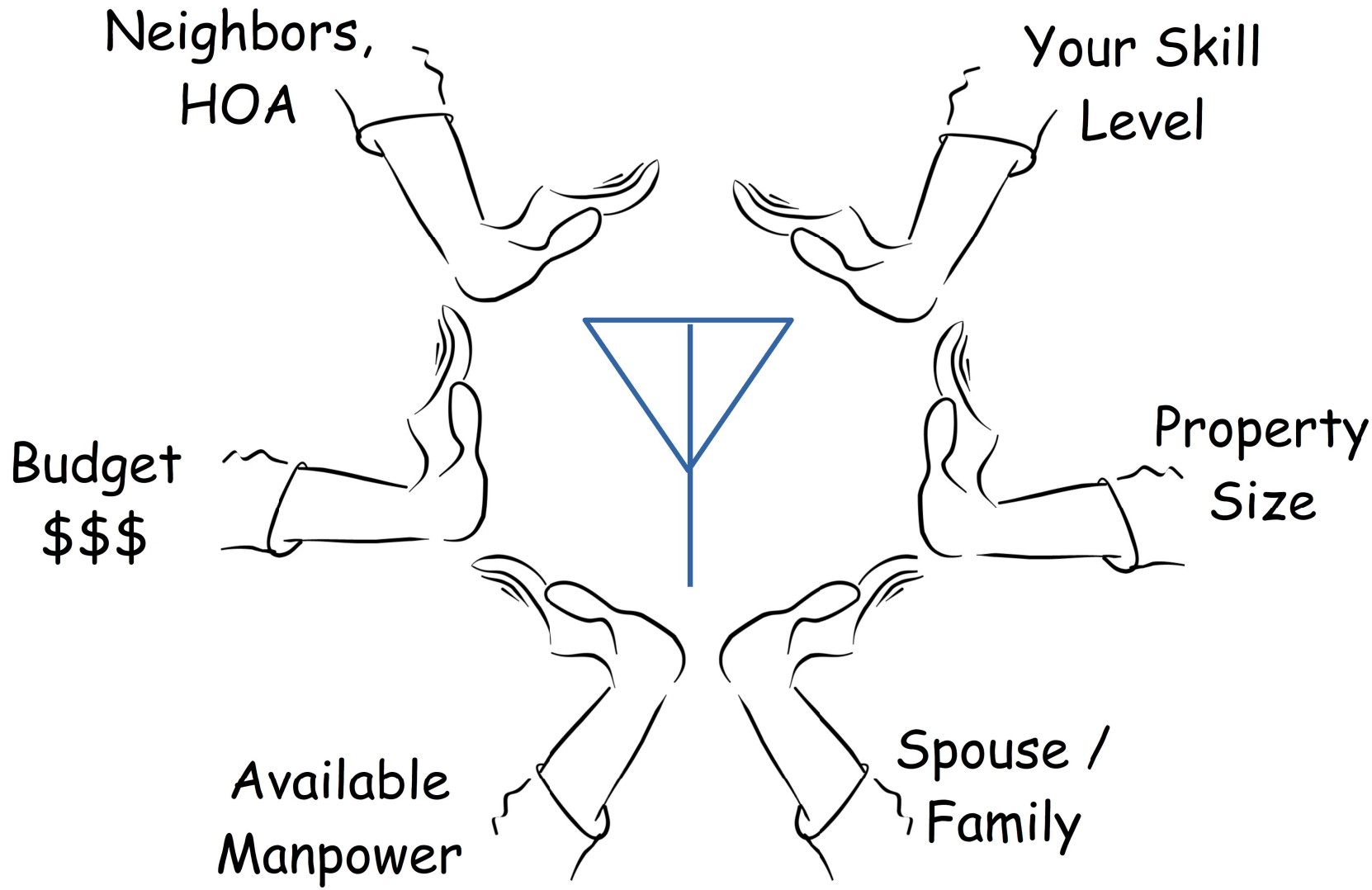


What can I accomplish with

What I've Got?

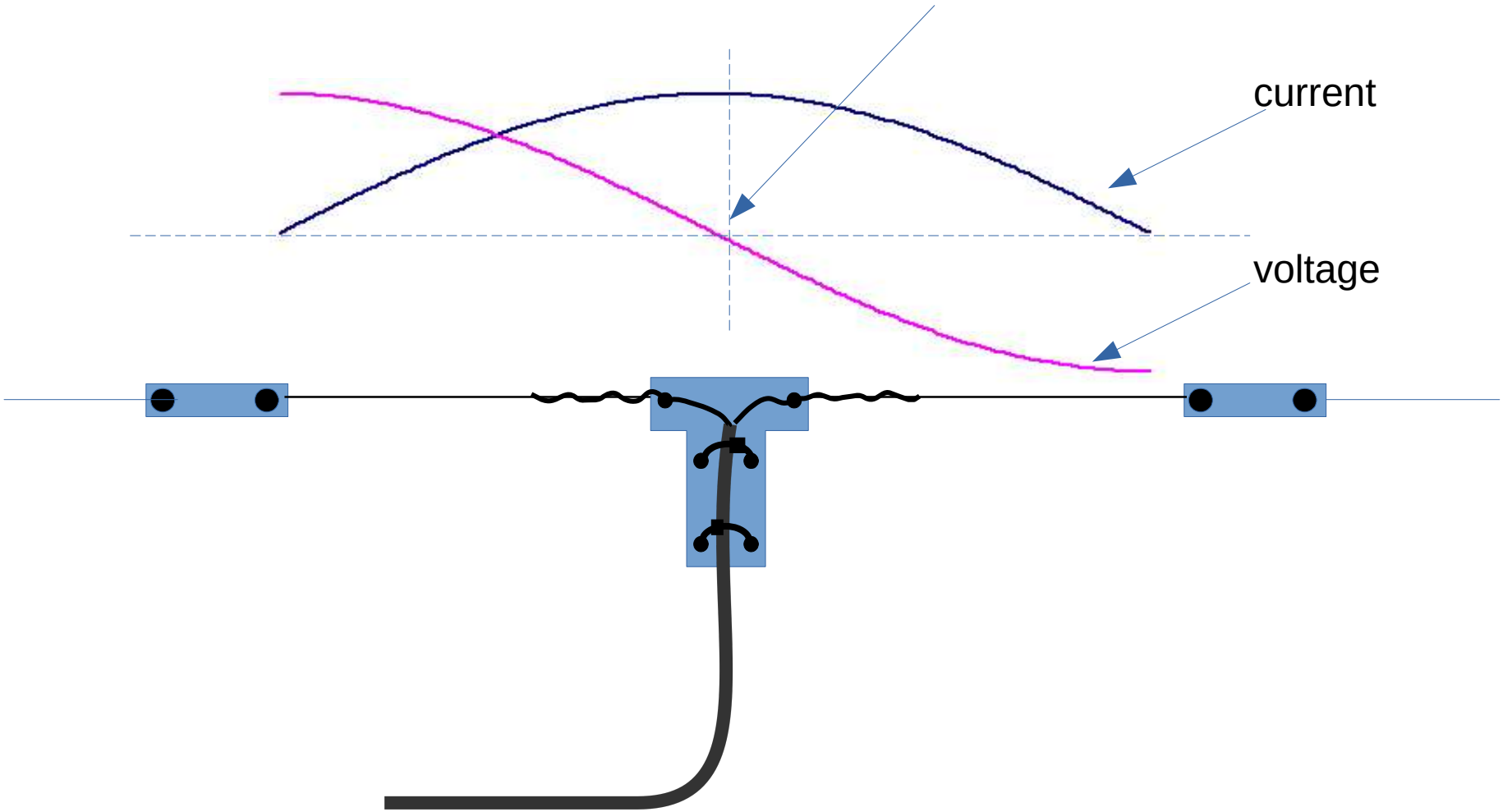
Every Antenna is a Compromise Antenna !

We All Have to Work Within **Constraints**

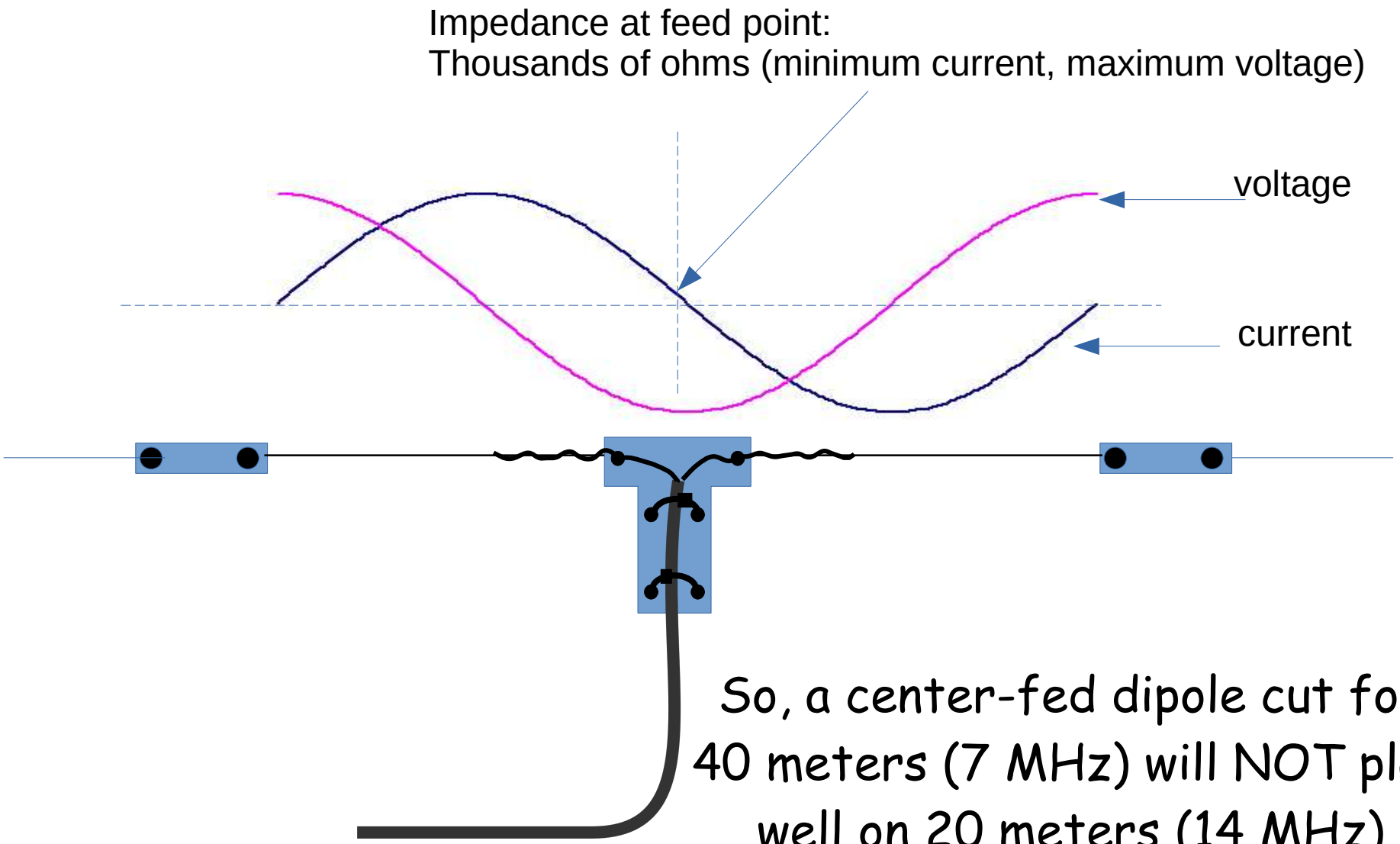


Single-Band, Half-Wave, Center-Fed Dipole

Impedance at feed point:
About 70 ohms in free space, but closer to 50 ohms if the antenna is closer to the ground



Single-Band, Half-Wave, Center-Fed Dipole
Not good for double the half-wave frequency

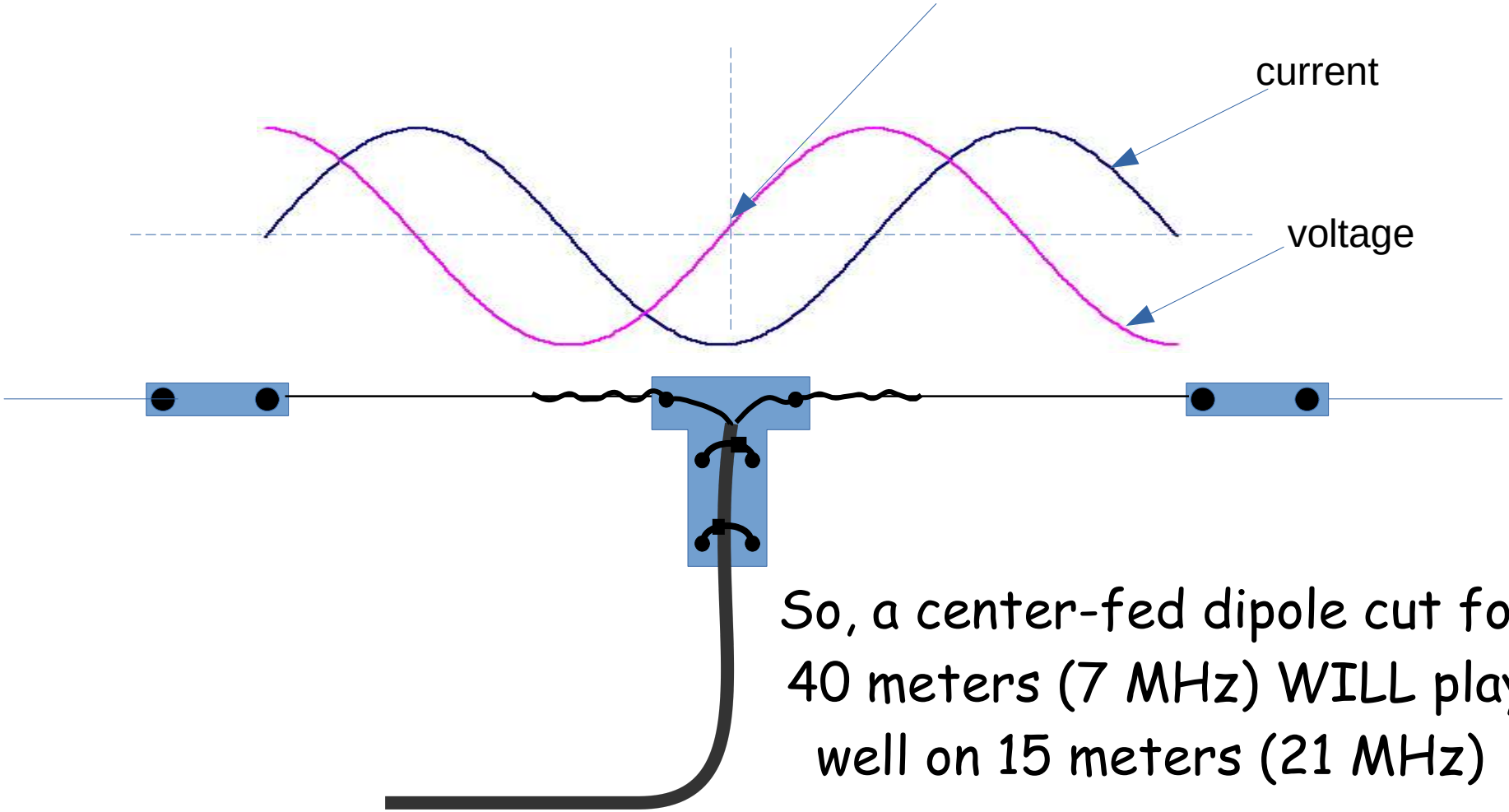


So, a center-fed dipole cut for 40 meters (7 MHz) will NOT play well on 20 meters (14 MHz)

Single-Band, Half-Wave, Center-Fed Dipole

How about triple the half-wave frequency?

Impedance at feed point:
Back to maximum current, minimum voltage!
About 70 ohms in free space, but closer to 50 ohms if the antenna is closer to the ground

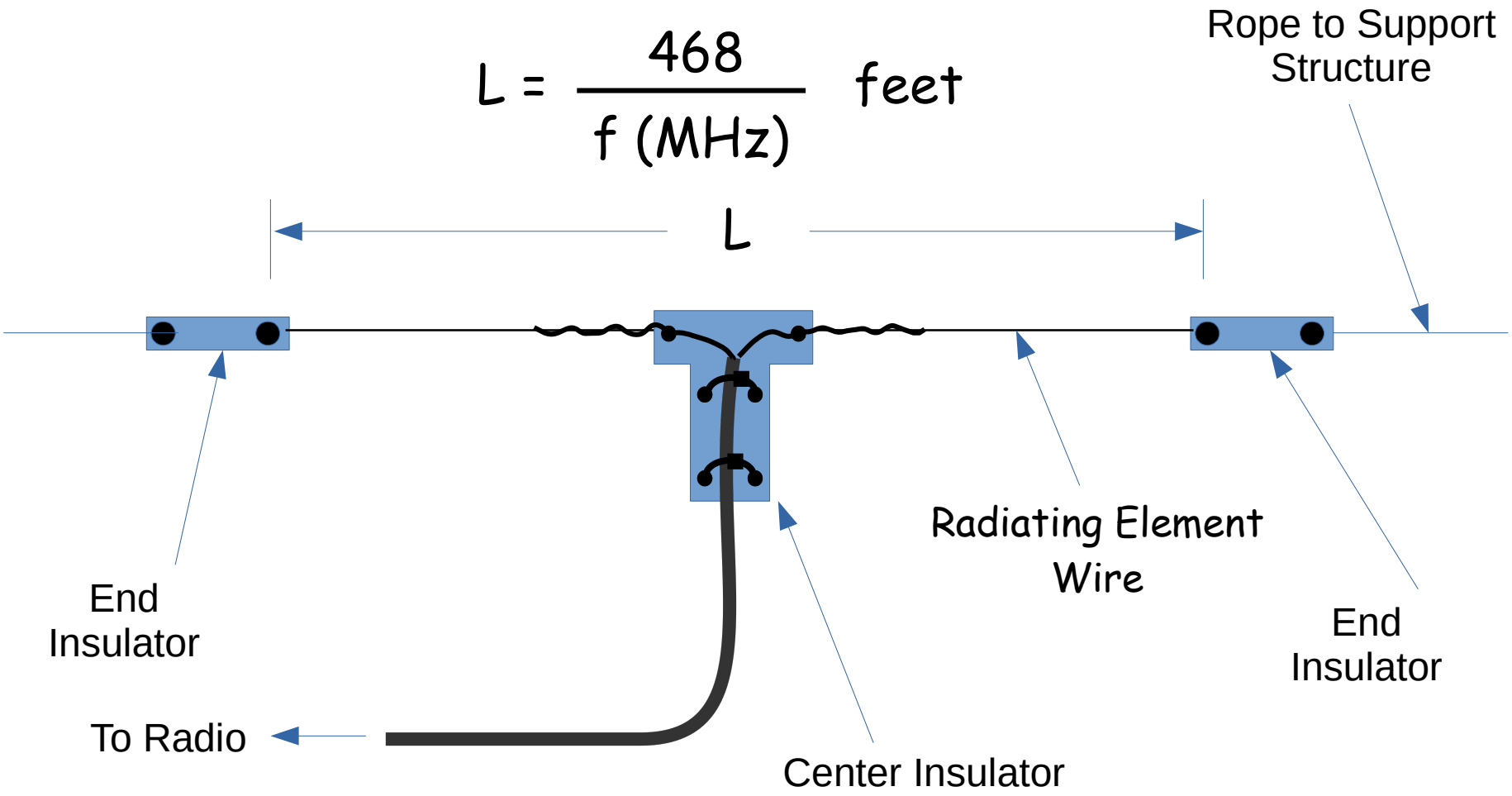


So, a center-fed dipole cut for 40 meters (7 MHz) WILL play well on 15 meters (21 MHz)

Odd Harmonics GOOD, Even Harmonics BAD

Single-Band, Half-Wave, Center-Fed Dipole

$$L = \frac{468}{f\ (MHz)}\ \text{feet}$$



Let's Pick a Band!

1/2 Wave Dipole Lengths (Starting Point)		
Band	Frequency	Length (feet)
80 CW / Digital	3.575	130.91
75 Phone	3.900	120.00
40 CW/Digital	7.075	66.15
40 Phone	7.240	64.64
30 (CW Only)	10.125	46.22
20 CW / Digital	14.075	33.25
20 Phone	14.250	32.84
17 CW / Digital / Phone	18.100	25.86
15 CW/Digital	21.075	22.21
15 Phone	21.300	21.97
12 CW / Digital / Phone	24.940	18.77
10 CW / Digital	28.075	16.67
10 Phone (SSB)	28.300	16.54
10 FM	28.600	16.36
6 meter Calling freq	50.120	9.34

80 is primarily a night time band. With some creativity most of us can shoe-horn a half-wave (130 ft) dipole onto an average ¼ acre lot.

40 is good for local (500-800 miles) during the day, but goes long for DX at night. A full size dipole (65 feet) can usually fit in a ¼ acre property.

20 is your meat and potatoes daytime DX band, starts to close at night except at the very top of the sunspot cycle. A full size dipole (33 feet) is relatively easy to get onto a ¼ acre property.

15 thru 10 – Primarily daytime bands. Fewer band openings than 20 meters, but their openings are much more intense.

You've seen this formula for a half wave antenna...

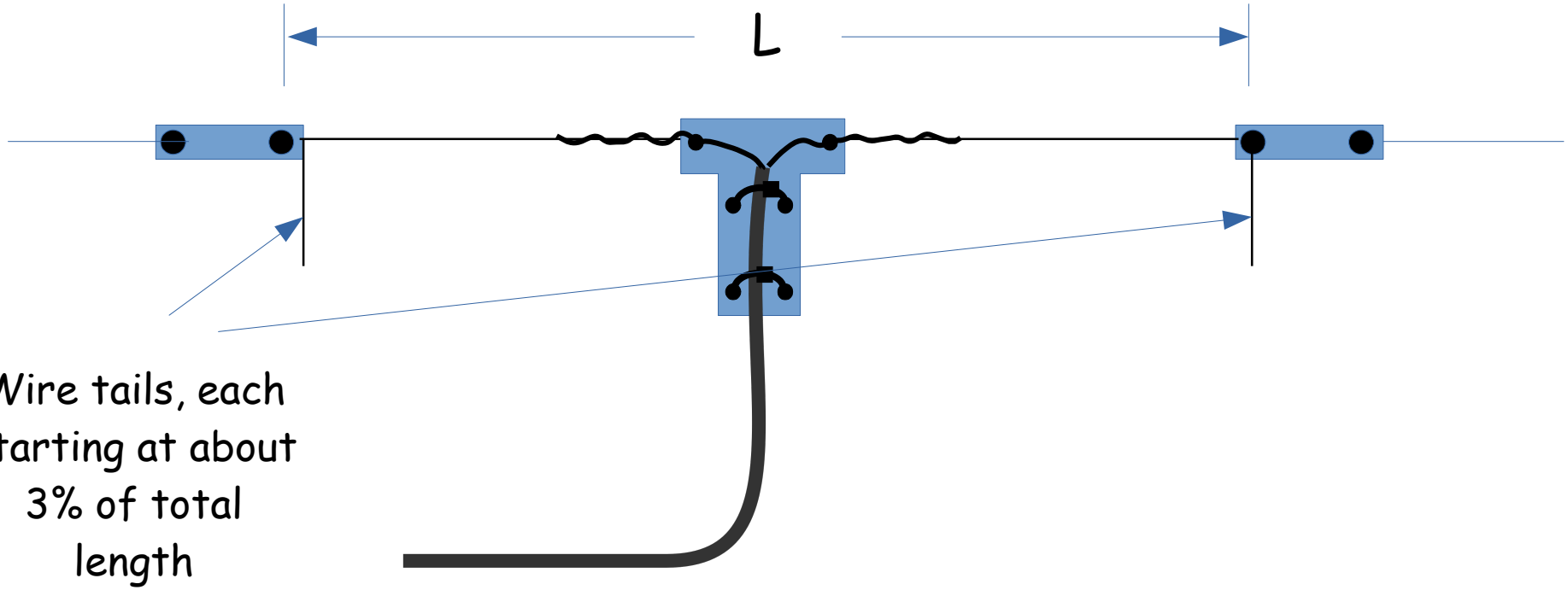
$$L = \frac{468}{f\ (MHz)} \quad \text{feet}$$

So where do we get the 468??

- Radio Waves travel at the speed of light, about 300,000,000 meters/second
- This translates to 984,000,000 feet/second
- One wavelength of an RF wave is 984,000,000/f (cycles/sec) or 984/f(MHz)
- So $\frac{1}{2}$ wave, in feet, is 492/f(MHz)
- For various reasons – end effects, velocity factor of the wire, interaction with ground (physicists debate on the exact reason), antennas typically need to be about 5% shorter than 492/f.
- 492*.95 = 467.4 or approximately 468.
- This is a rule of thumb; it may (probably ***will***) be different at your specific location!

Here's what I like to do...

$$L = \frac{468}{f\ (MHz)} \text{ feet} - 5\%$$



Initially, shoot for TOO LONG with the tails and TOO SHORT without the tails.

We'll trim the tails down based on actual antenna behavior.

Tuning the Dipole

1. Find the actual frequency where your SWR is MINIMUM

2. If the actual frequency is LOWER than where you plan to operate, the antenna is TOO LONG; trim the tails by this amount:

$$\left(1 - \left(\frac{\text{Actual Freq}}{\text{Desired Freq}}\right)\right) \times \text{Original Length} \times 12 \text{ inches}$$

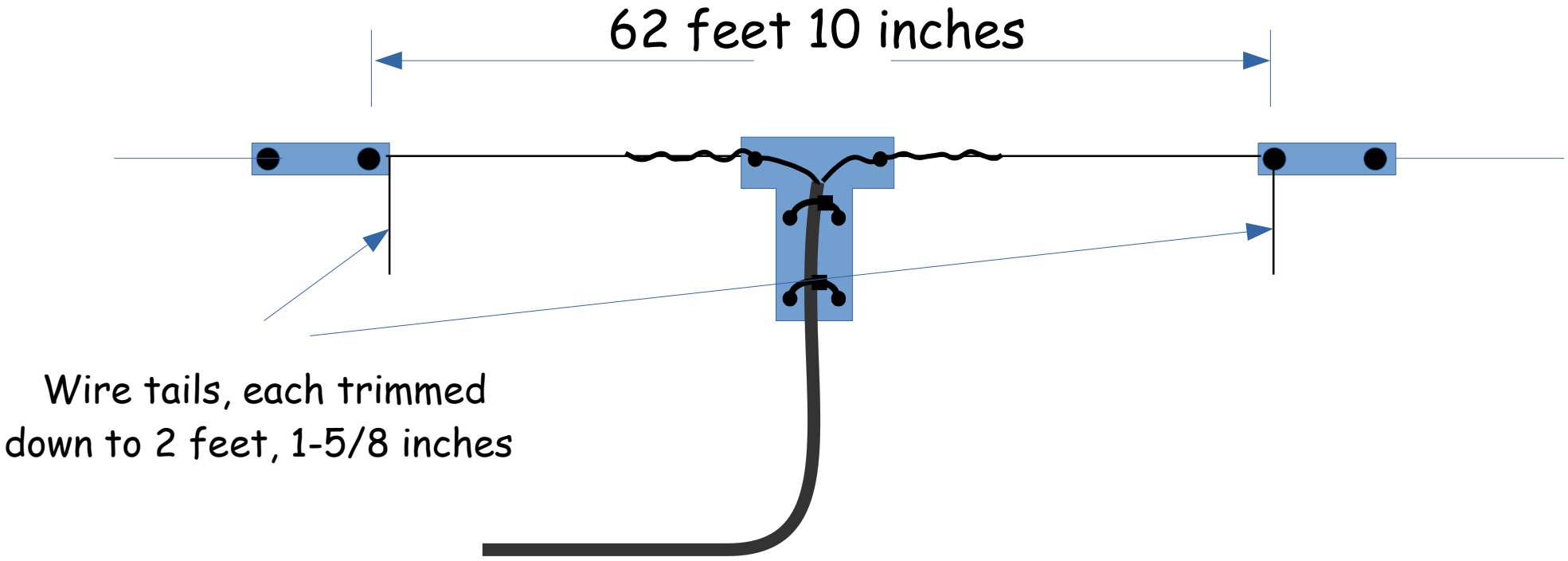
3. If the actual frequency is HIGHER than where you plan to operate, the antenna is TOO SHORT; lengthen the tails by this amount:

$$\left(1 - \left(\frac{\text{Desired Freq}}{\text{Actual Freq}}\right)\right) \times \text{Original Length} \times 12 \text{ inches}$$

40 Meter Dipole Example

- We want to build a dipole for 40 meters
- FT-8 is a popular mode and 40 meter FT-8 activity is at 7.074 MHz
- Our starting point is 468 / 7.074 = 66.16 feet, or about 66 ft 2 inches.
- That's 33 ft 1 inch per side.
- Let's make the main sides about 95% of that, or 31 feet 5 inches
- The tails are just about 2 feet. I'd rather start too long than too short because it's easier to cut the tails than lengthen them so let's go to 2 ft 6 inches. Original length of each side is 33 feet 11 inches or 33.92 feet.
- Haul the antenna up and measure the SWR above and below 7.074 MHz. If you have an antenna analyzer you can make measurements below 7 MHz. Look for the frequency with the lowest SWR.
- Suppose the best frequency is 6.998 MHz. As planned, the antenna is too long and it's time to trim the tails down.
- (1-6.998/7.074) * 33.92 * 12 = 4.37 inches (about 4-3/8 inches)
- So trimming the tails by 4-3/8 inches from each tail should get us to 7.074 MHz.
- You'll do OK in the CW band and most of the phone band with this antenna.

So here's what we ended up with . . .



This antenna is optimized for the 40 meter FT-8 sub-band but should be OK for all of CW band and most of SSB on 40 meters.

Some Insulator Options for Wire Antennas

Inexpensive Store Bought Insulators

Dog Bone Insulator

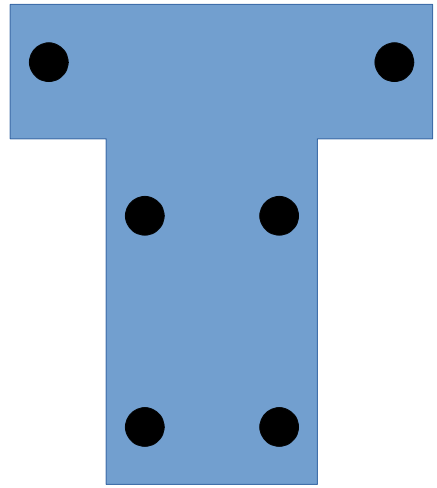
Egg Insulator

Homebrew Insulators are Easy…

Just be sure to use non-porous materials!

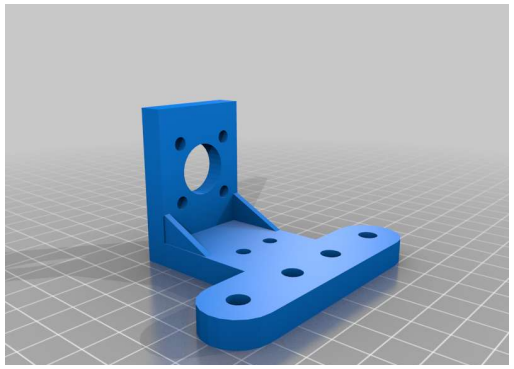
Homebrew Lexan Insulator

Drill a couple of holes in a piece of PVC pipe!



Quick Center Insulator Idea
Top two holes drilled for wire
Bottom four holes are for tie-wraps to secure feed line

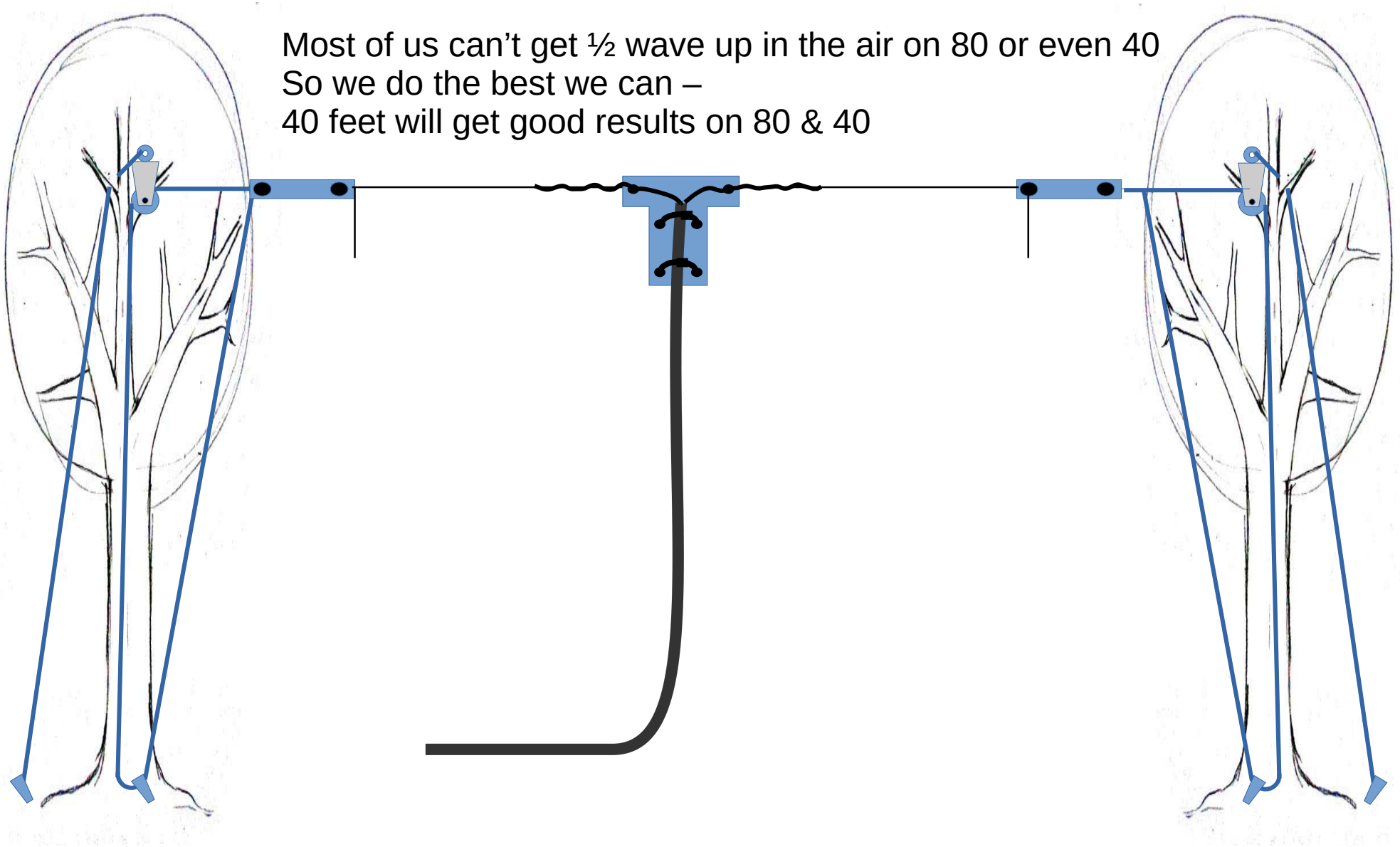
3-D Printable Insulator Options for Wire Antennas



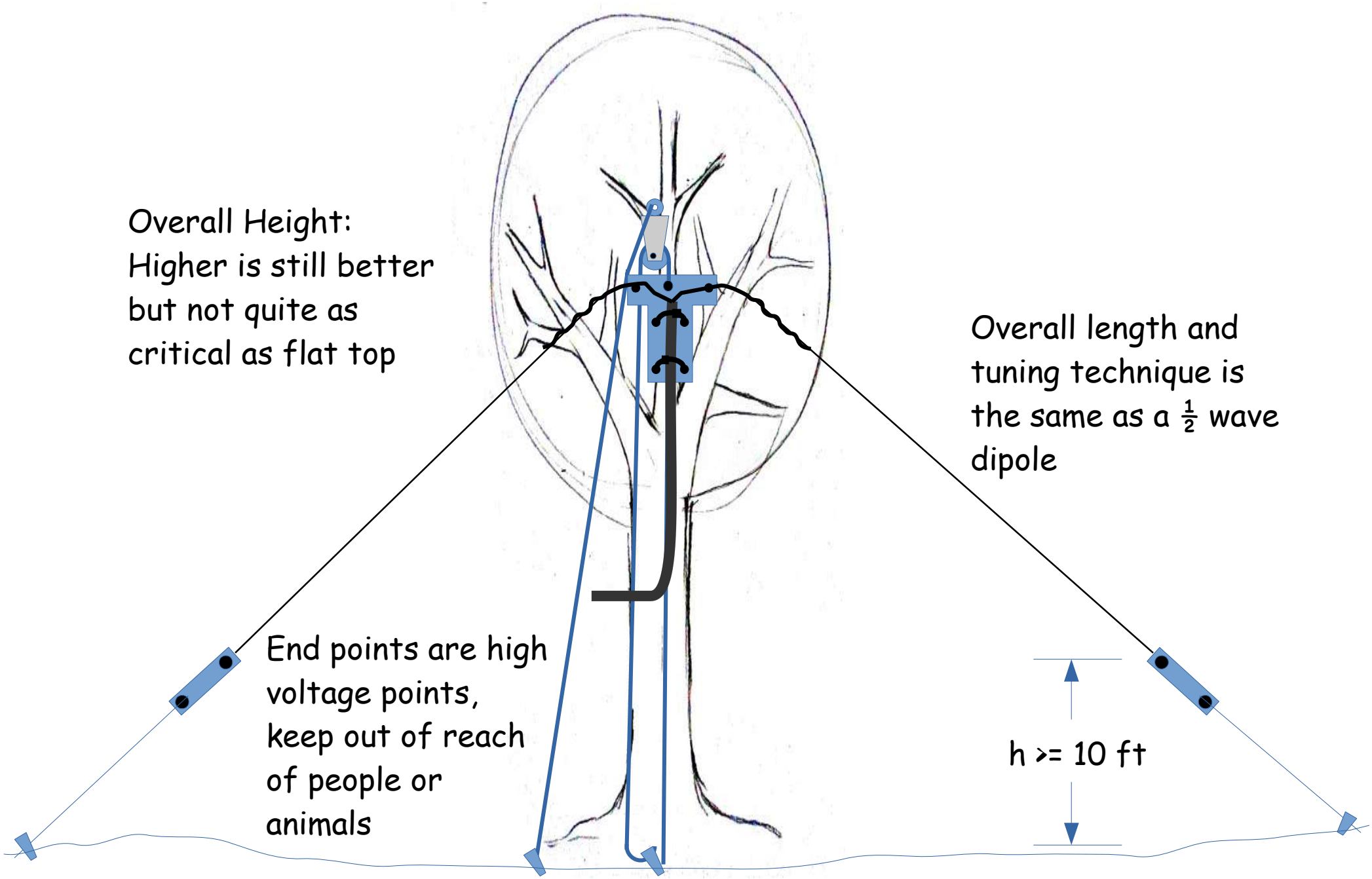
Flat Top – If you have two support structures (Trees in this case)

Height Above Ground
Ideally, minimum ½ wave above the ground
80m: 130 ft, 40m: 66 ft, 20m: 33 ft

Most of us can't get ½ wave up in the air on 80 or even 40
So we do the best we can –
40 feet will get good results on 80 & 40

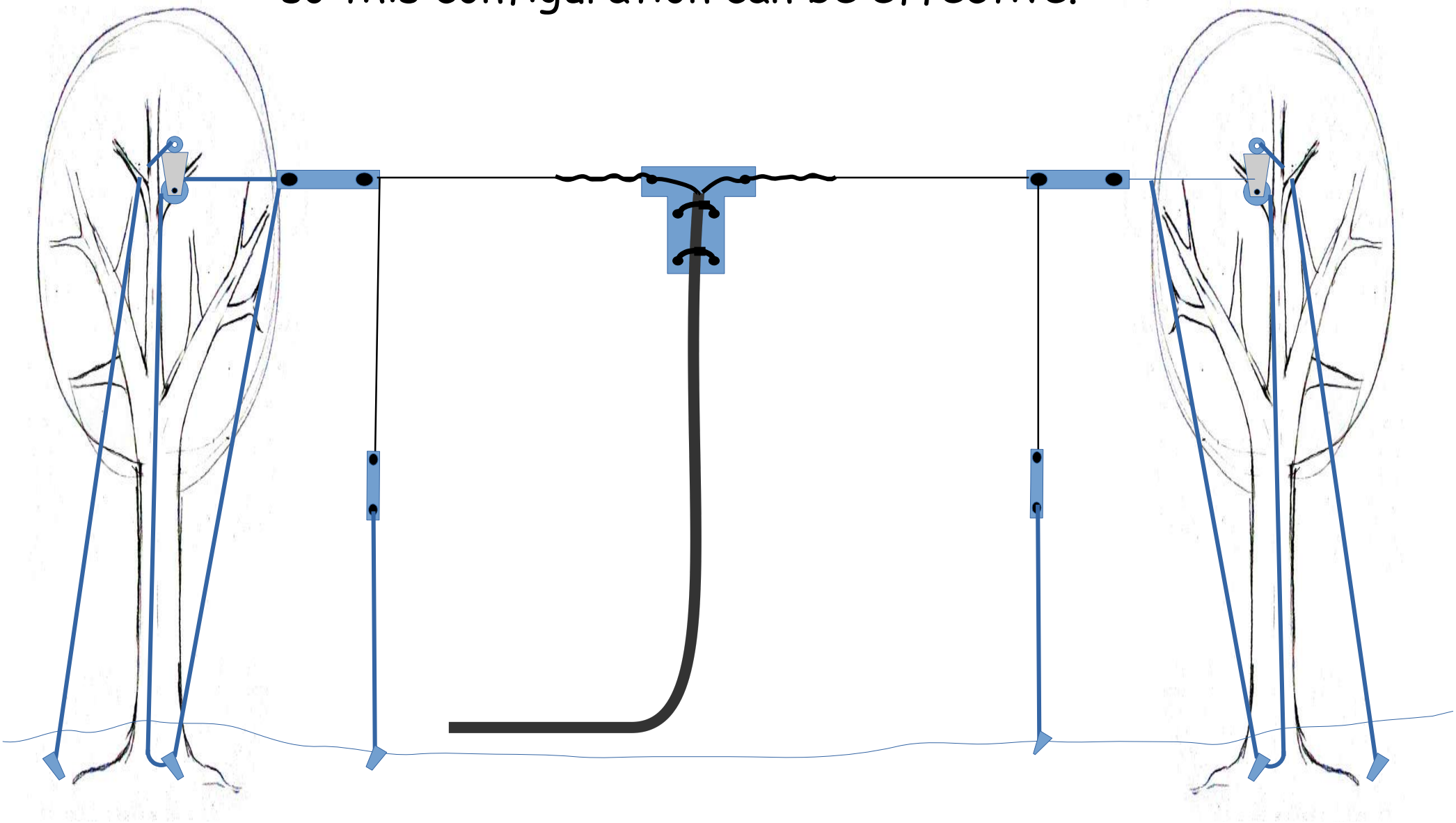


Only one support available? Consider an Inverted VEE



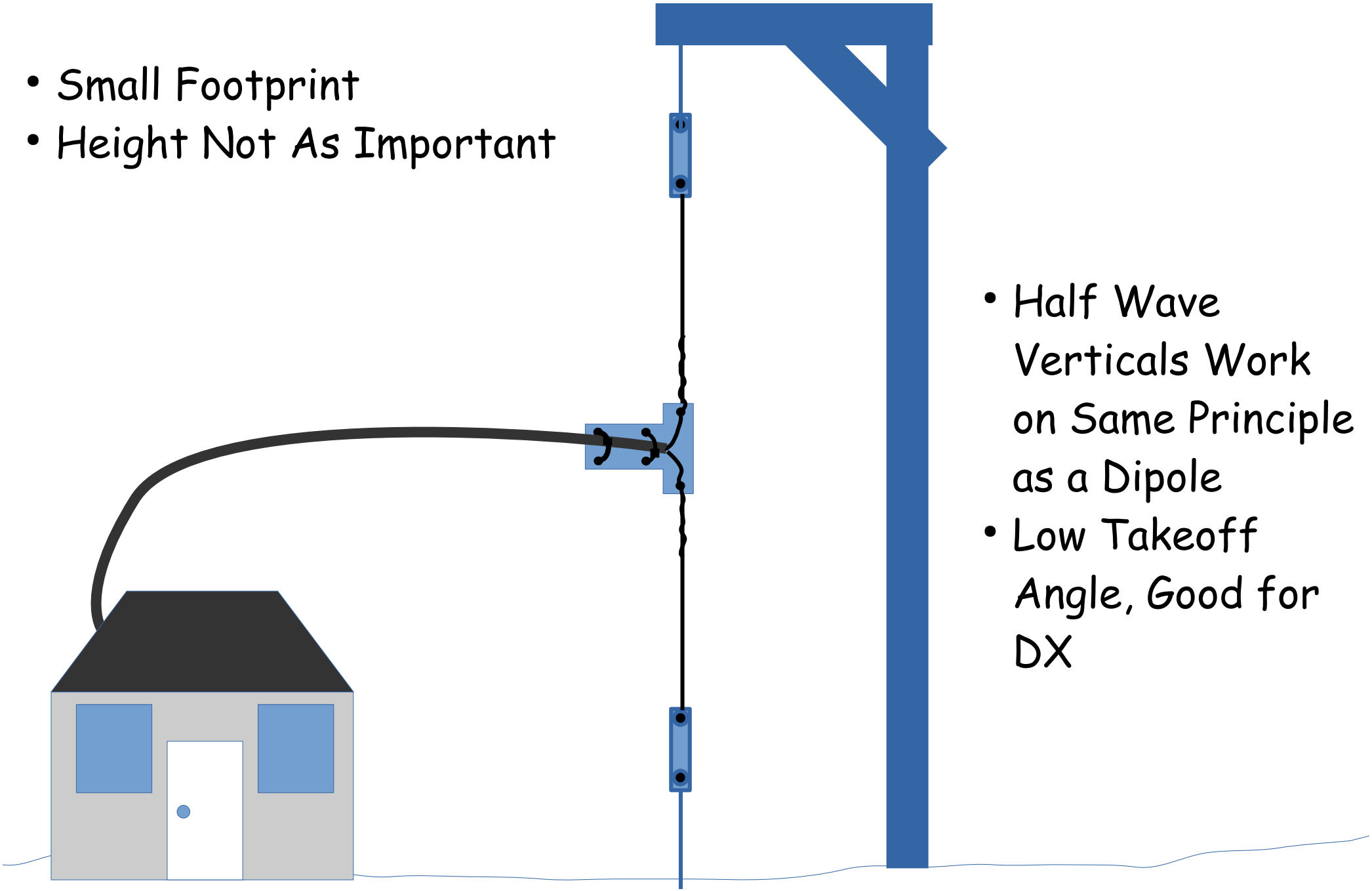
Got 2 trees but not far enough apart for a ½ wave antenna?

You can bend your dipole into an Inverted U.
The middle 60% of the antenna does most of the work,
so this configuration can be effective.



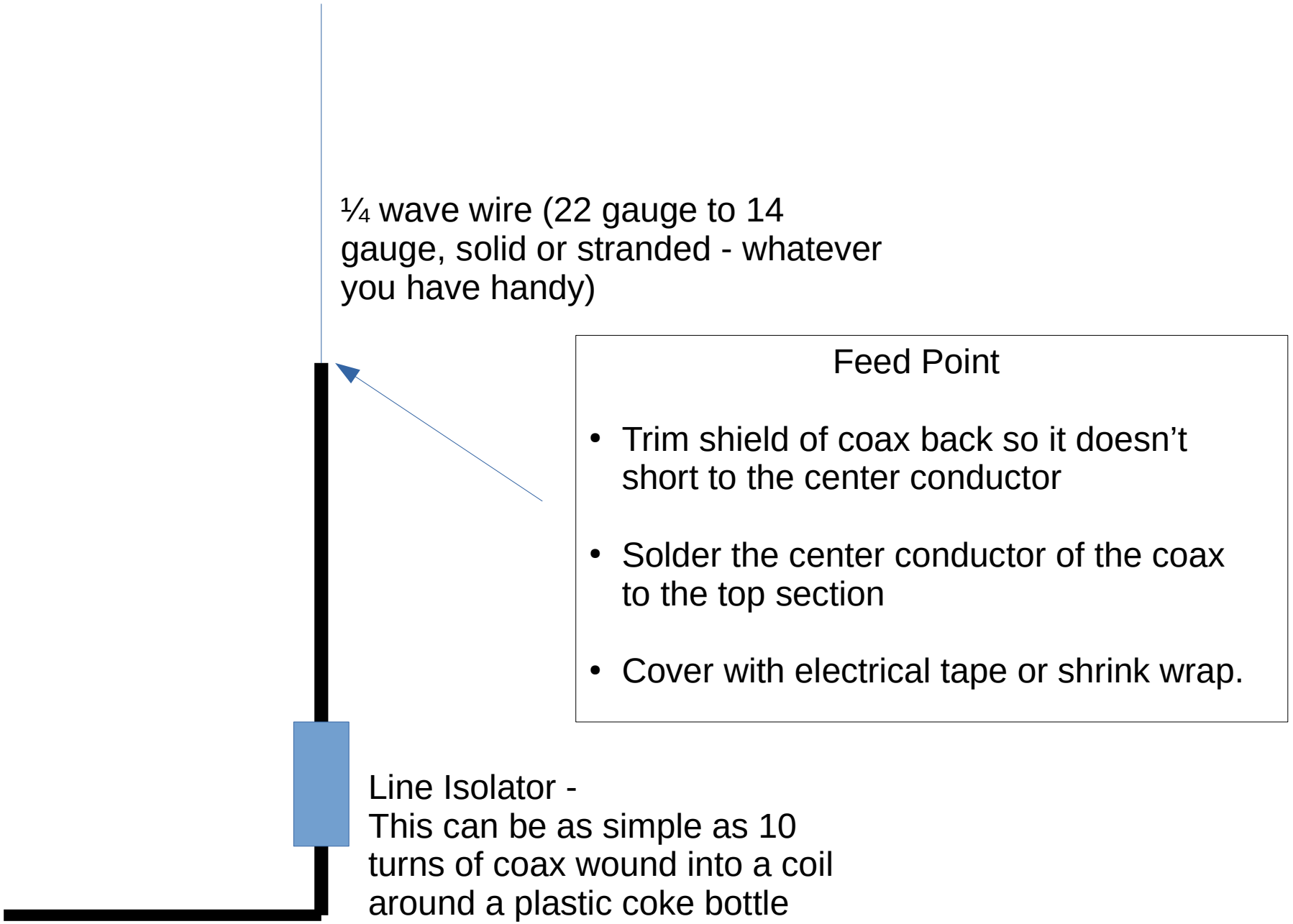
Vertical Antennas

- Small Footprint
- Height Not As Important



- Half Wave Verticals Work on Same Principle as a Dipole
- Low Takeoff Angle, Good for DX

Here's a More Practical Approach to Homebrewing a Half Wave Vertical



1/2 Wave Coaxial Vertical Lengths (Starting Point)			
Frequency	Lower Element	Upper Element	Total Height
3.750	58' 9"	62' 3"	121' 0"
7.150	30' 6"	32' 6"	63' 0'
10.125	21' 5"	22' 1"	43' 6"
14.175	15' 2"	16' 4"	31' 6"
18.118	11' 10"	12' 10"	24' 8"
21.225	10' 1"	11' 0"	21' 1"
24.950	8' 7"	9' 4"	17' 11'
28.300	7' 6"	8' 3"	15' 9"

Coax Verticals are Great Portable Antennas for 14 Mhz and Up. Hang it From a Tree or a Fiberglass Push-Up Pole and You're On HF!

Not so practical on 40 and 80 meters – If you have a 63' or 121'vertical support you will do better with an inverted Vee.

Portable Verticals are Gaining Popularity

Wolf River SOTA Special

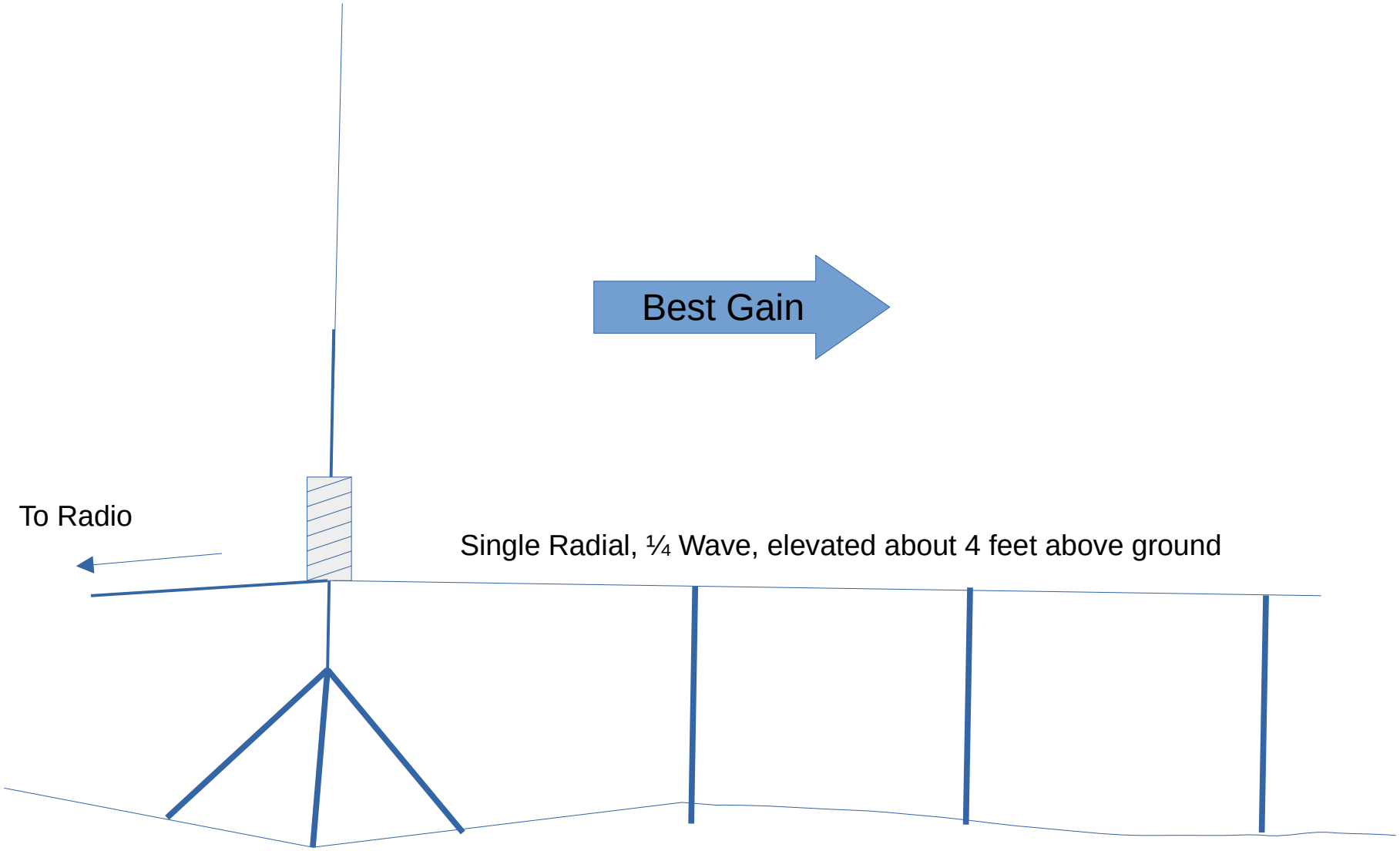
Available Ready-Made at Reasonable Cost

Compact Storage

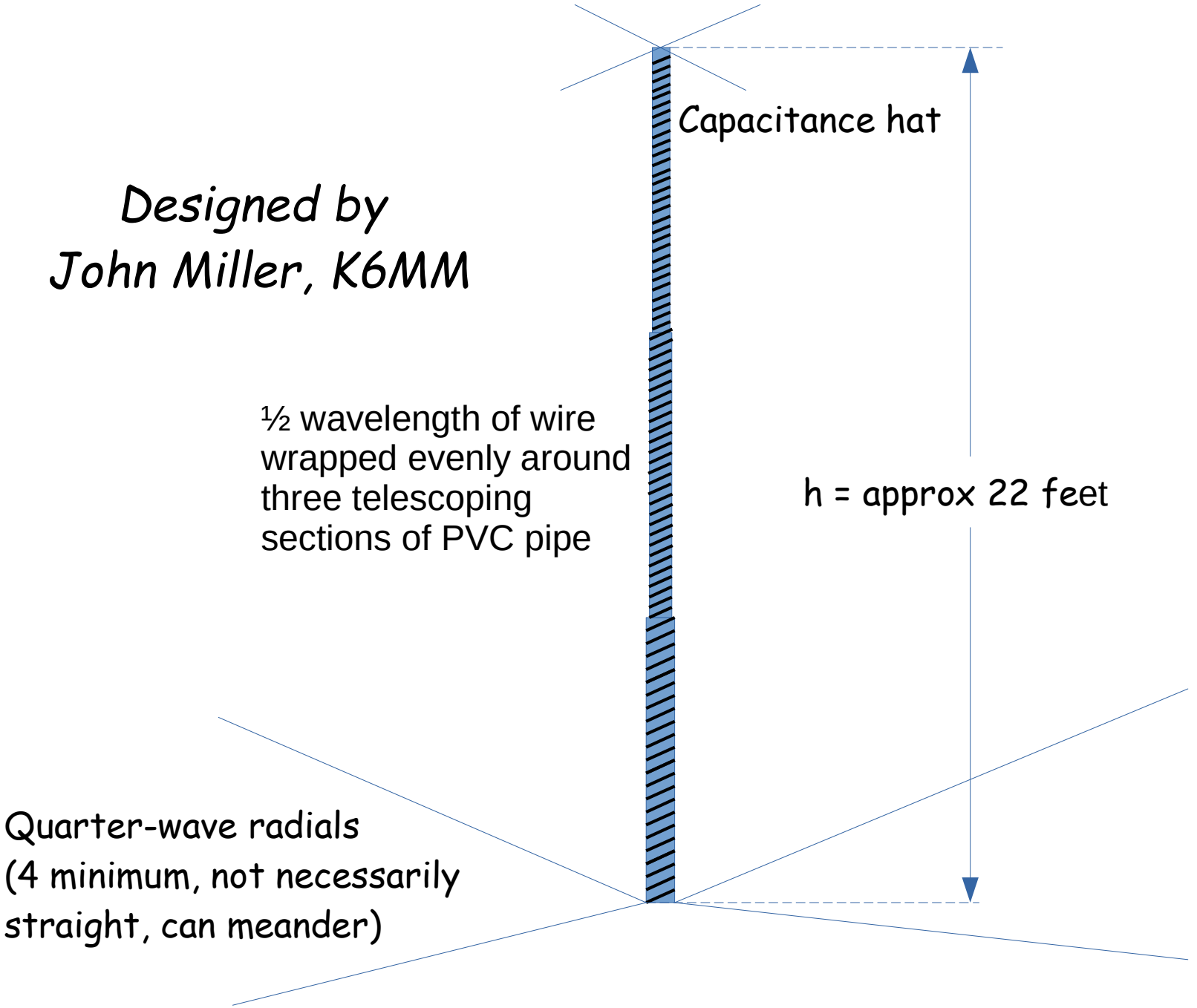
Easy Setup and Teardown (Set up in about 5 minutes)

Most brands work well from 20M to 10M – Some will play on 40 and 30 as well. You probably won't be on 80 or 160 during the day.

GOOZEEZOO Portable Vertical Kit


Best Gain
To Radio
Single Radial, ¼ Wave, elevated about 4 feet above ground

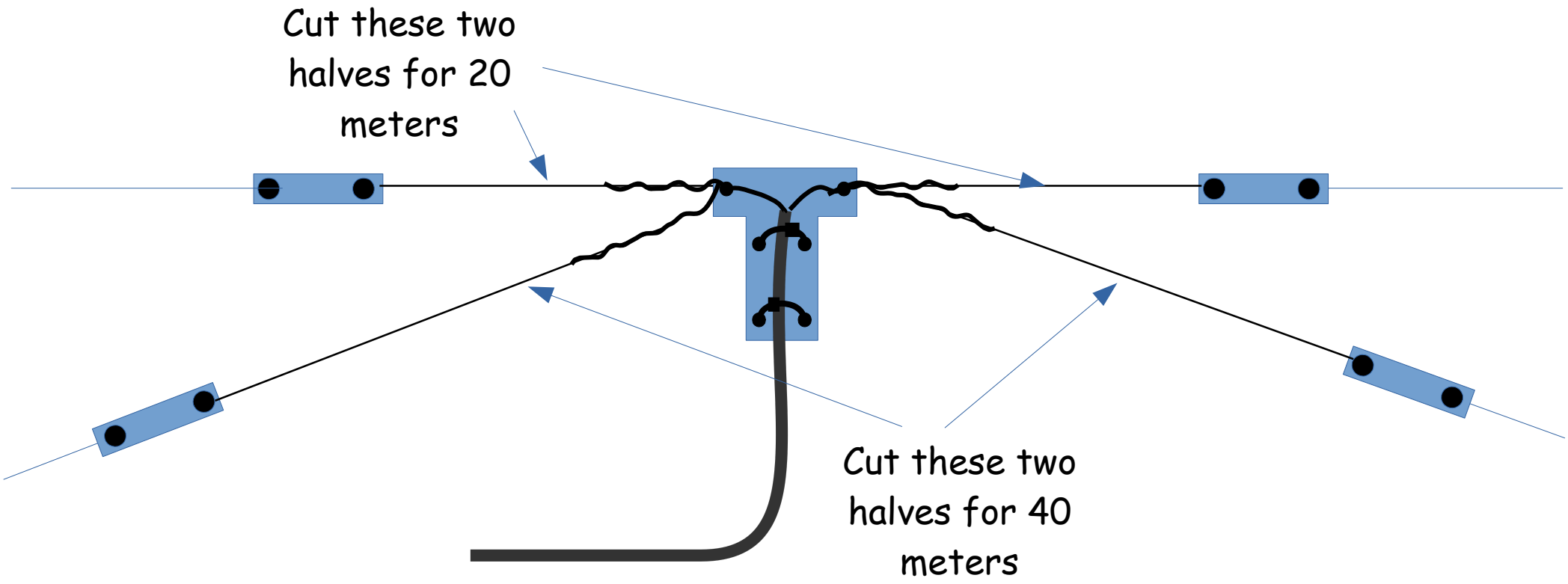
Helically-Wound Vertical: You can get on 160 meters!



Construction details at http://www.smeter.net/antennas/short-helical.php

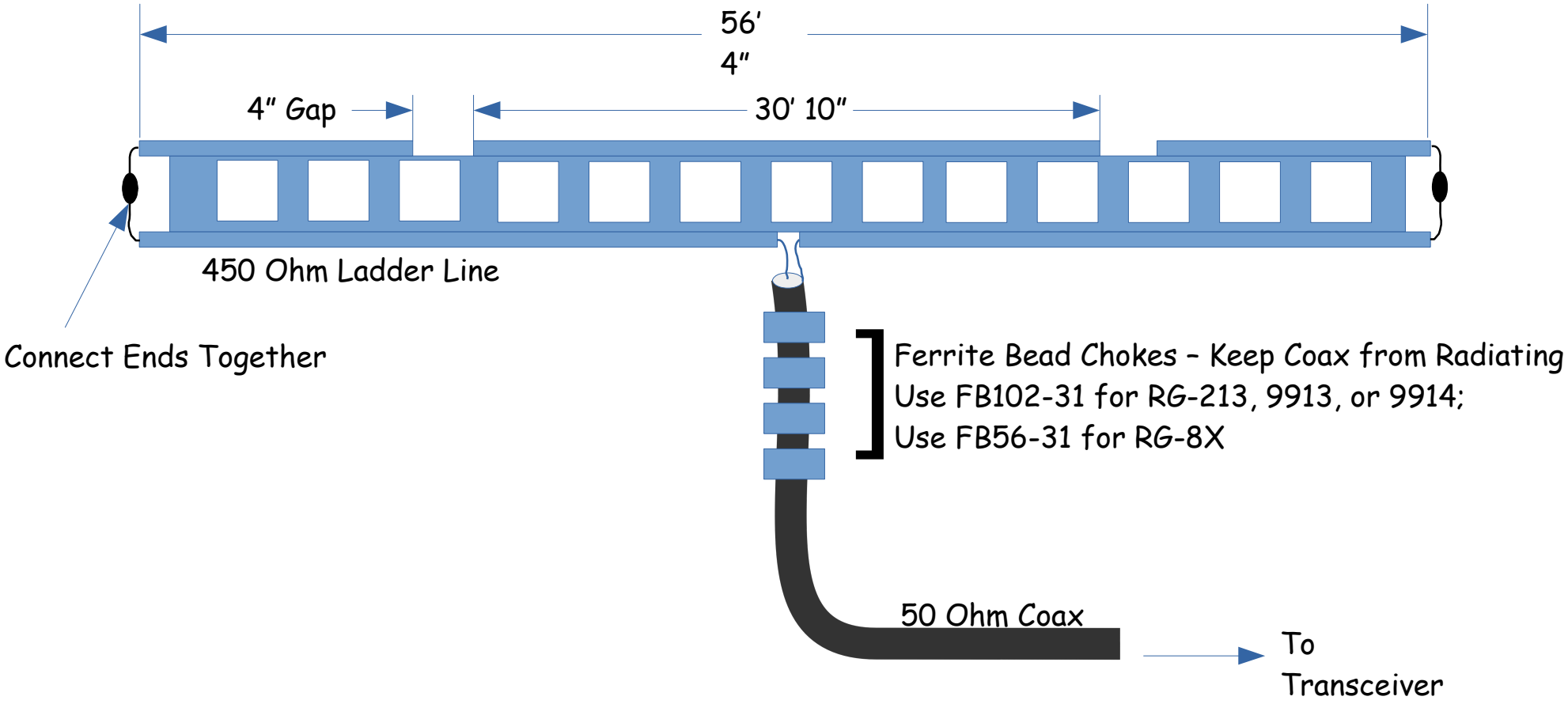
Multi-Band Antennas

A Multi-Band Fan Dipole for 40, 20, and 15 meters



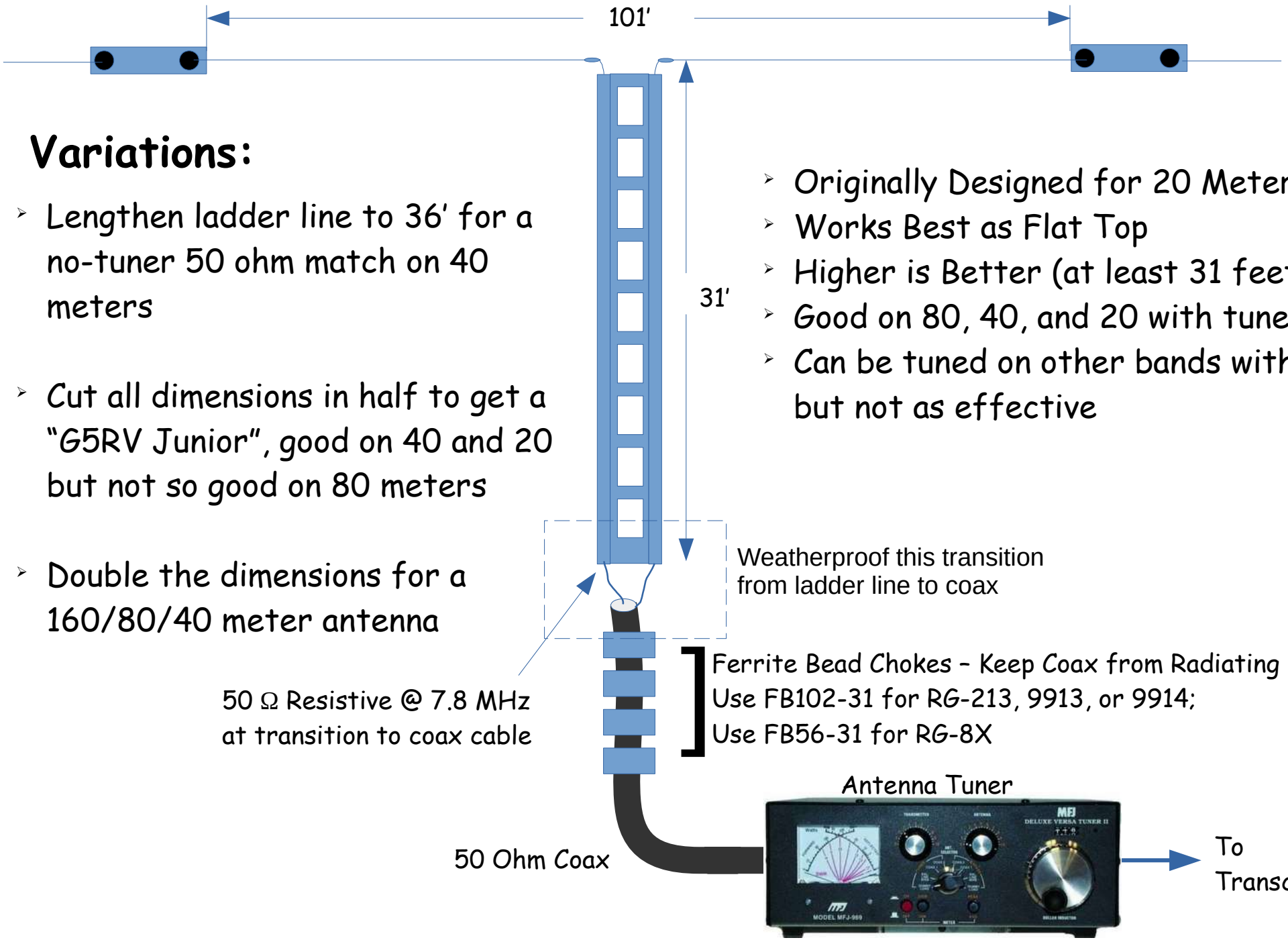
- On 20 meters, the 40 meter dipole is high impedance at the center so the practically all of the power goes into the 20 meter dipole.
- Similarly, on 40 meters, the 20 meter dipole is a higher impedance than the 40 meter section, so the power goes to the 40 meter dipole.
- As an added bonus, the 40 meter side will do OK on 15 as well! (odd harmonic)

W1ZR Dual Band Folded Skeleton Sleeve Dipole



- Adjust the 40 meter section first, then the 20 meter section.
- Interaction between 40 meter element and 20 meter element is minimal if at all.
- As an added bonus, the 40 meter section will do OK on 15 as well! (odd harmonic)

G5RV Multi-Band Dipole

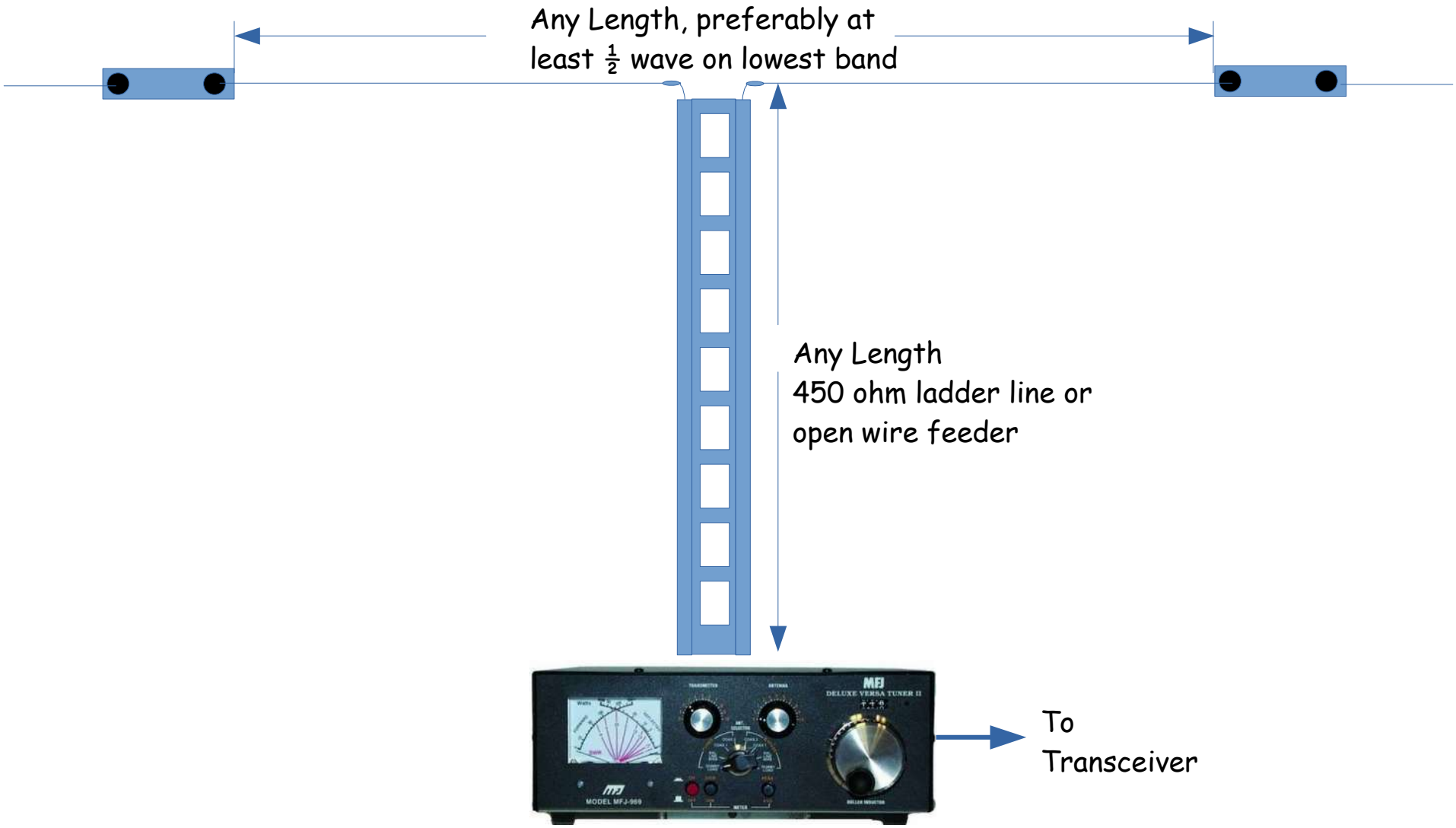


Variations:

- Lengthen ladder line to 36' for a no-tuner 50 ohm match on 40 meters
- Cut all dimensions in half to get a "G5RV Junior", good on 40 and 20 but not so good on 80 meters
- Double the dimensions for a 160/80/40 meter antenna

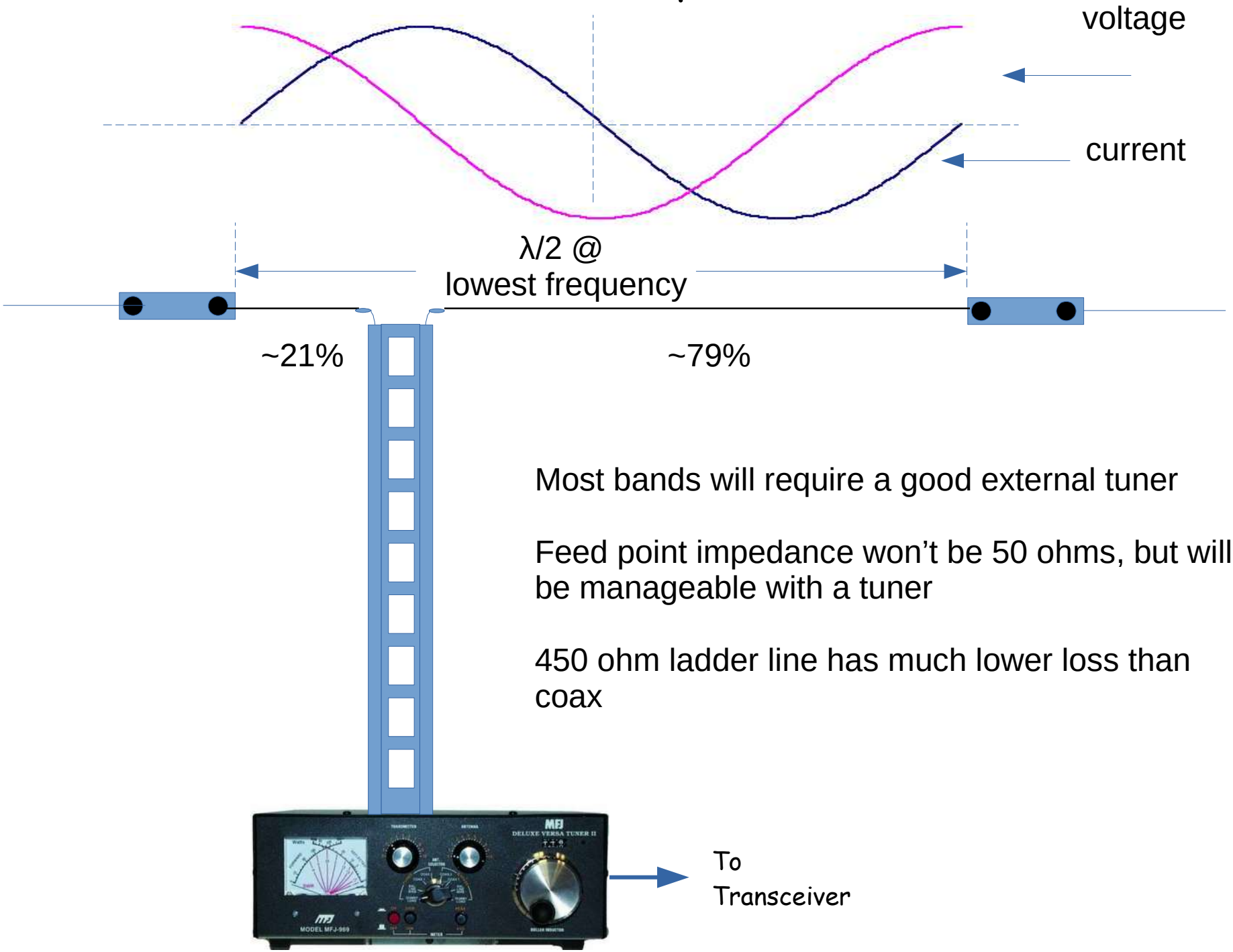
- Originally Designed for 20 Meters
- Works Best as Flat Top
- Higher is Better (at least 31 feet)
- Good on 80, 40, and 20 with tuner
- Can be tuned on other bands with tuner, but not as effective

Random Length Doublet ("Zepp")



Balanced Wire Antenna Tuner
(Most commercially made tuners can handle this)

Off-Center Fed Dipole (OCFD)

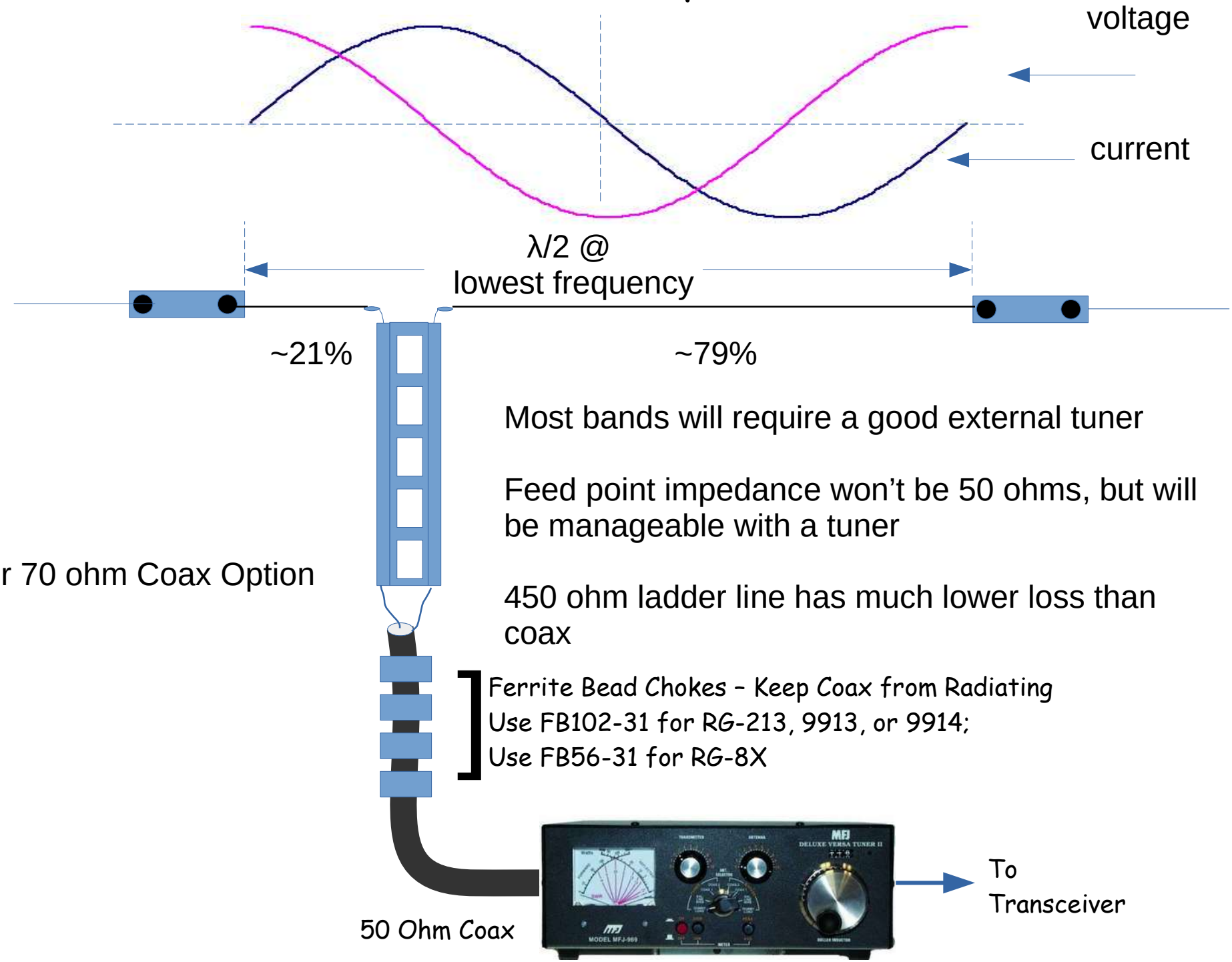


Most bands will require a good external tuner

Feed point impedance won't be 50 ohms, but will be manageable with a tuner

450 ohm ladder line has much lower loss than coax

Off-Center Fed Dipole (OCFD)



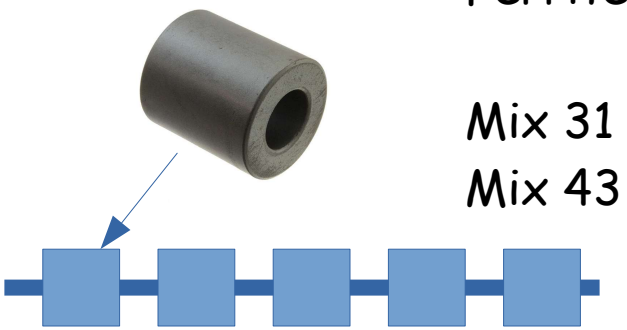
Keeping RF In the Coax Cable and Off of the Shield

~ 10 turns of coax wound around an old coffee can

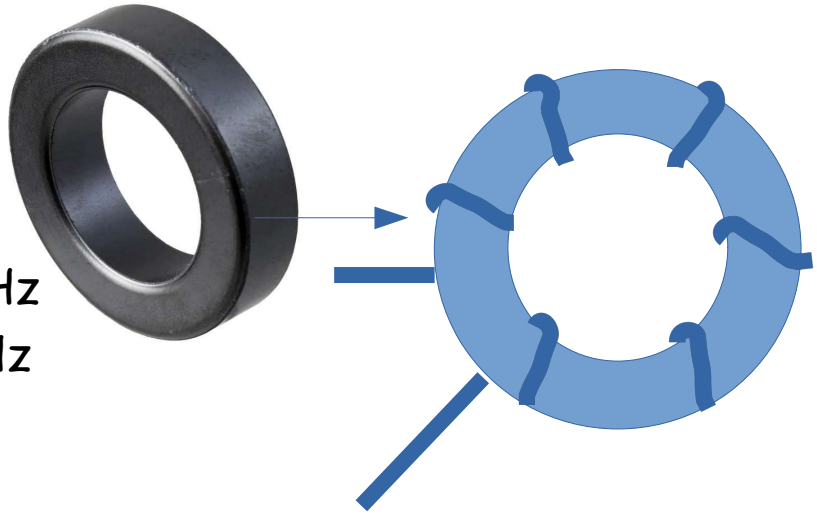
Store Bought "Line Isolator"
These retail for about $60.00

Ferrite Compositions:

Mix 31 good down to 1 MHz
Mix 43 good above 10 MHz



Mix 31 Ferrite Beads
Slipped Over the Coax



5 or 6 turns Through a
Mix 31 Ferrite Core

Antenna Getter Uppers

EZ-Hang
(Check local laws!)

Light Fishing Rod and Golf Ball

33 ft telescoping
fiberglass mast

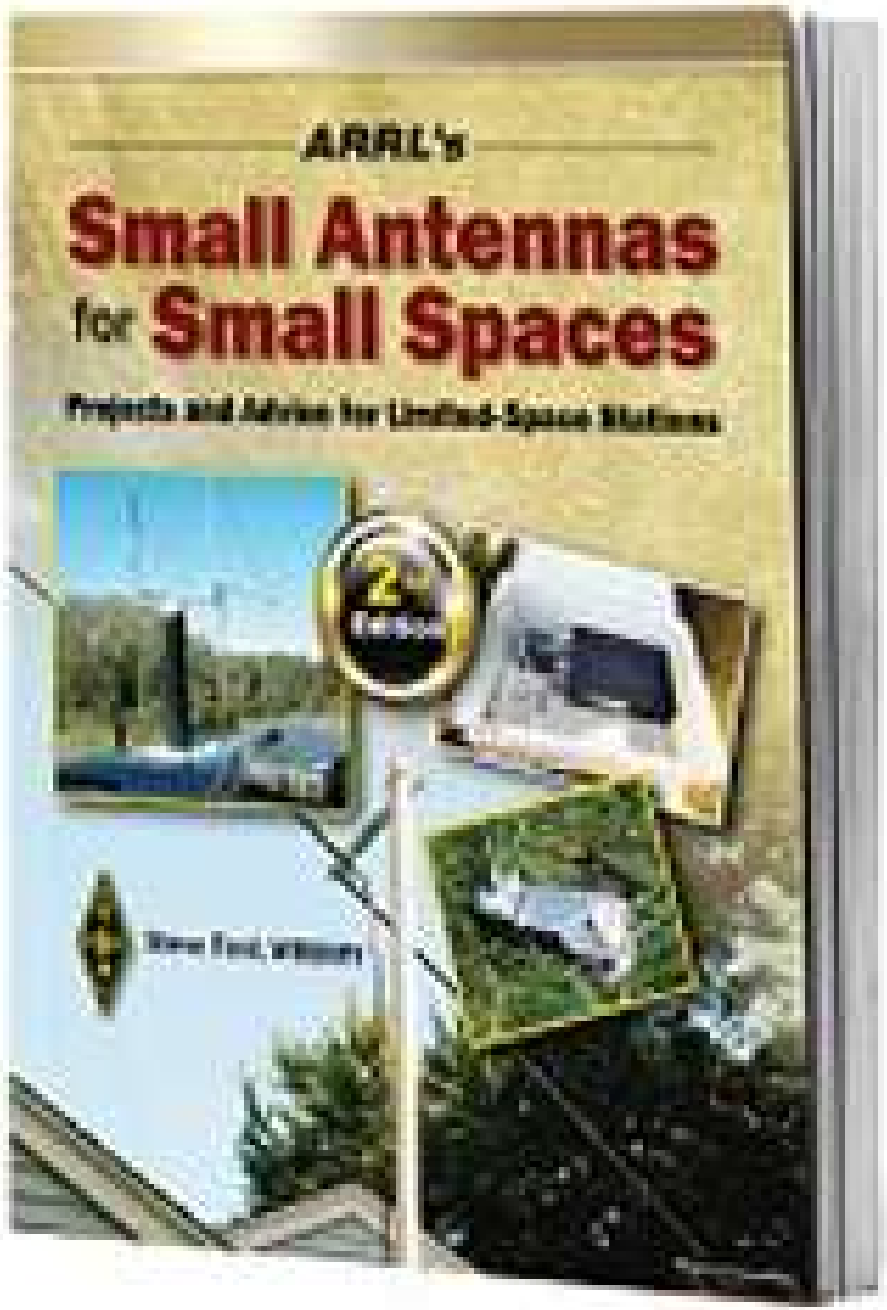
Magic Rock and String

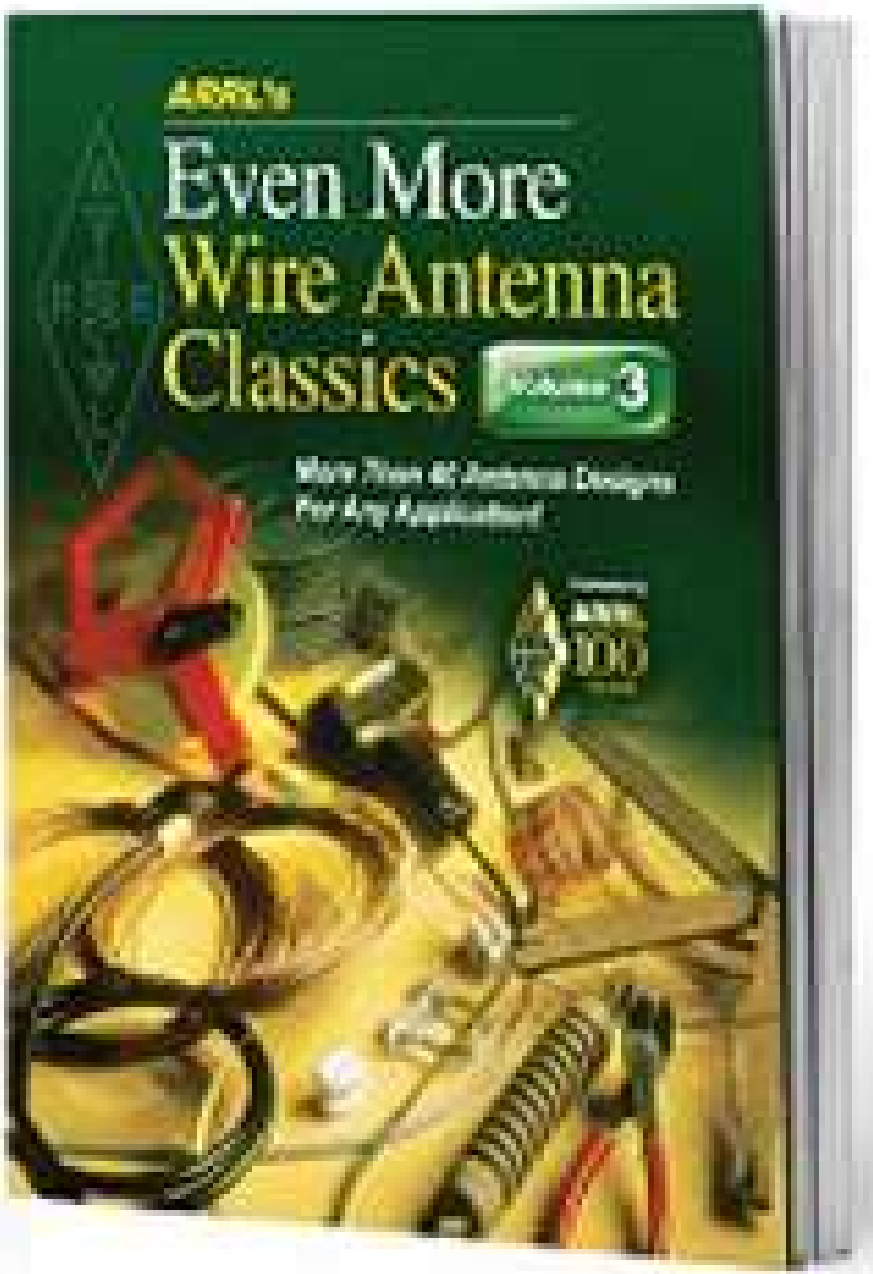
Pneumatic
Launcher

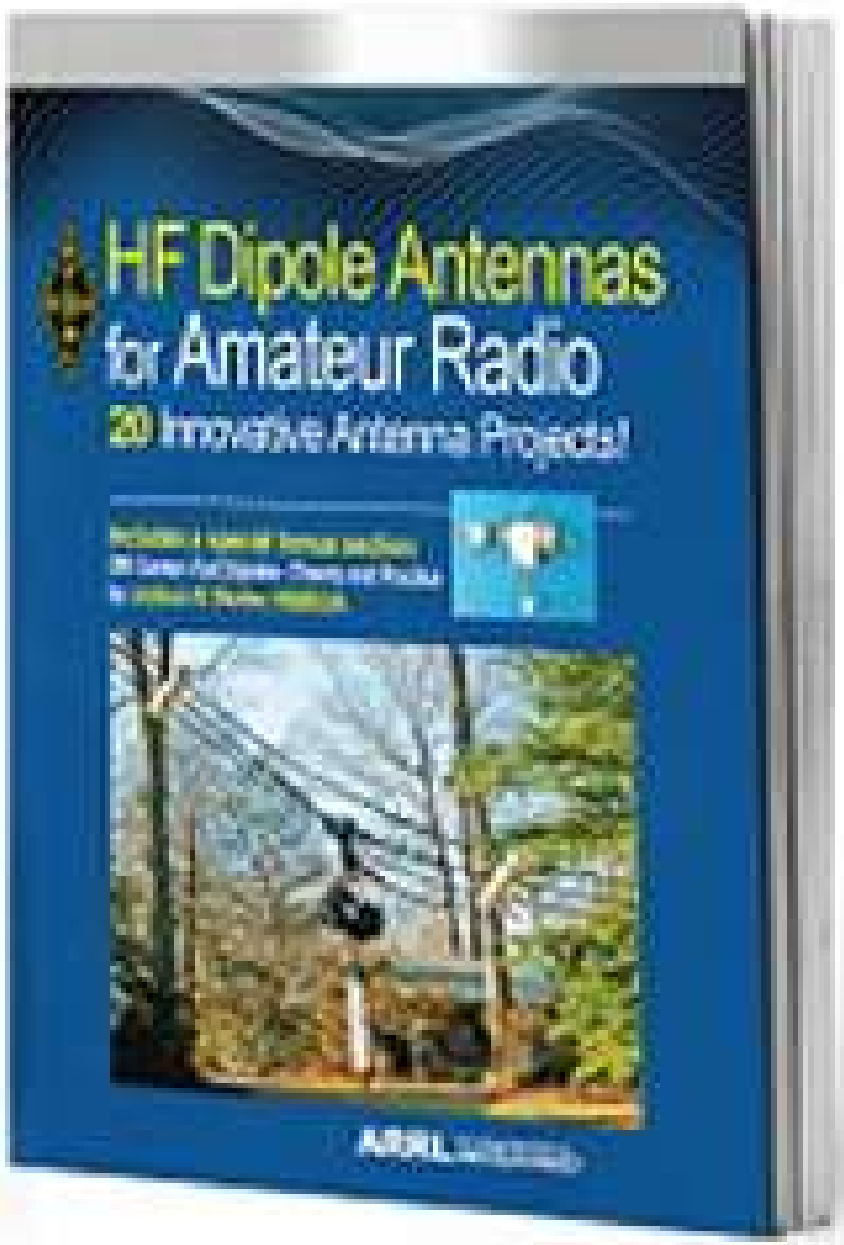
Recommended Reading . . .

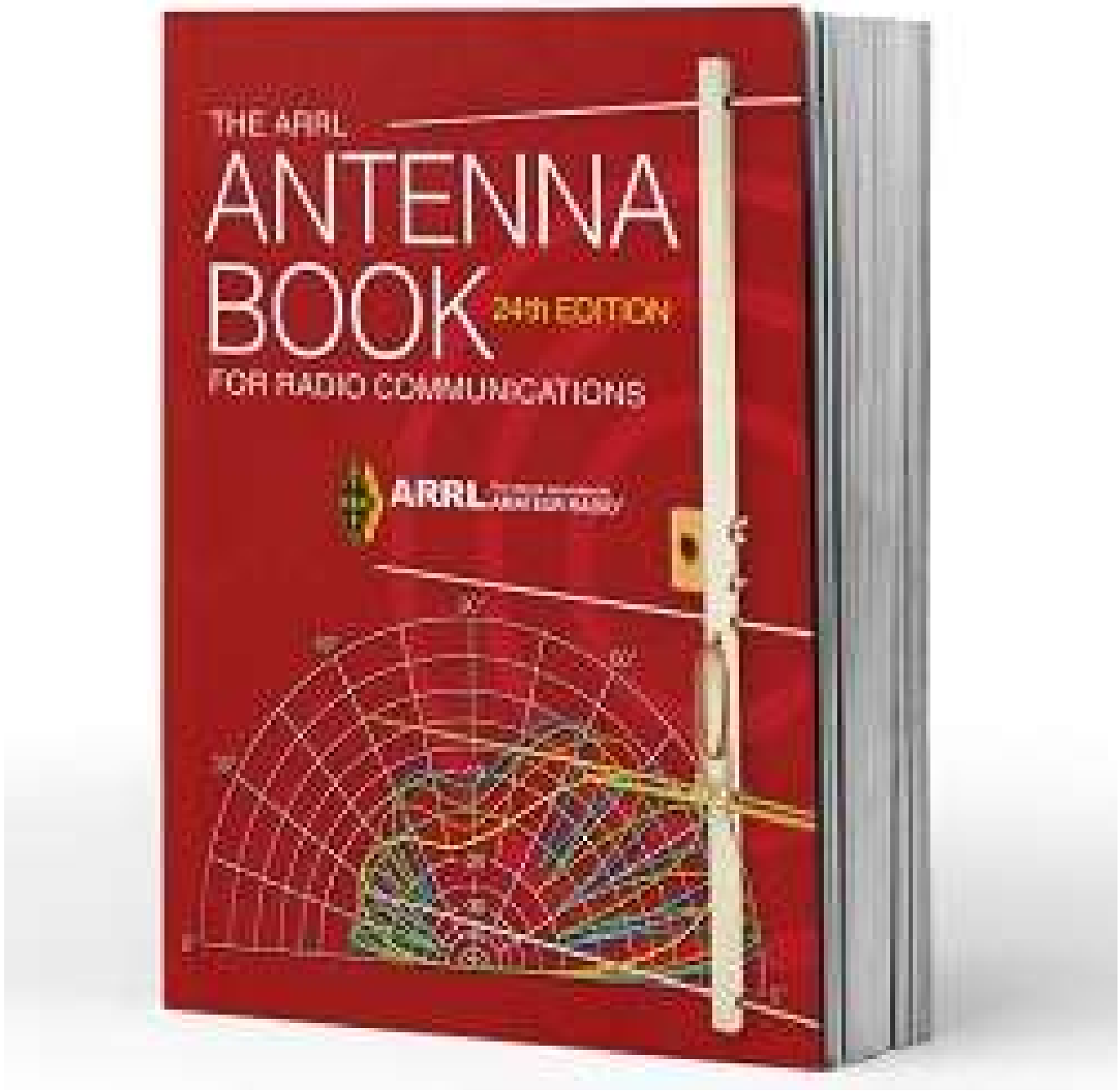
A Comparative Look at Multiband Antennas
http://www.hamclass.net/ranv/pres/HC16MultAnt.pdf
Joel R. Hallas, W1ZR

https://www.hamuniverse.com/k6mm160metervertical.html
The "No-Excuses" 160 Meter Vertical
(As published in the June 2009 issue of QST)
John Miller, K6MM


ARRL's
Small Antennas
for Small Spaces


ARRL's
Even More
Wire Antenna
Classics
VOLUME 3


HF Dipole Antennas
for Amateur Radio
20 Innovative Antenna Projects!
ARRL


THE ARRL
ANTENNA
BOOK
24th EDITION
FOR RADIO COMMUNICATIONS
ARRL

Thanks for Listening, 73, and See You On the Air!

Neil, KC2KY
kc2ky@arrl.net

These Slides are Available at http://www.rcarc.org/Presentations.htm