# *SEA-PAC Workshop*
# *Antenna Topics*

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# Agenda

- The purpose of an antenna
- Elevation angles
- Baluns and common-mode chokes
- Antennas for the lower HF bands
  - 160m, 80m, 60m, 40m, 30m
- Antennas for the higher HF bands and 6m
  - 20m, 17m, 15m, 12m, 10m and 6m
- Multi-band antennas

# The Purpose of an Antenna

- When someone asks him “what antennas should I put up”, Frank W3LPL always asks “what are your goals?”
- What is your interest?
  - Traffic handling, EmComm, rag chewing, DXing, contesting, etc ?
  - Serious or casual?
  - Local, domestic, international?
- Thus the purpose of an antenna is to put the maximum radiation at the azimuth angle and elevation angle dictated by the ionosphere to meet your goals

# *Elevation Angles*

# Elevation Angles – to JA in June ($R_{12}$ = 85)

Japan to Portland, June 2022, smoothed sunspot number = 85

| Elev | 80m | 40m | 30m | 20m | 17m | 15m | 12m | 10m |
|---|---|---|---|---|---|---|---|---|
| 1 | 8.4 | 6.1 | 4.6 | 7.5 | 5.2 | 3.0 | 0.0 | 0.0 |
| 2 | 6.4 | 6.2 | 4.6 | 8.3 | 6.2 | 8.9 | 0.0 | 0.0 |
| 3 | 7.5 | 6.2 | 3.9 | 4.5 | 8.3 | 26.6 | 0.0 | 0.0 |
| 4 | 8.1 | 7.2 | 6.0 | 5.1 | 10.2 | 31.2 | 0.0 | 0.0 |
| 5 | 4.4 | 5.2 | 5.0 | 6.0 | 10.5 | 20.3 | 0.0 | 0.0 |
| 6 | 5.9 | 3.9 | 5.2 | 3.6 | 11.1 | 8.4 | 0.0 | 0.0 |
| 7 | 2.0 | 3.0 | 4.2 | 2.9 | 12.9 | 1.7 | 0.0 | 0.0 |
| 8 | 2.0 | 1.7 | 2.1 | 2.5 | 18.9 | 0.0 | 0.0 | 0.0 |
| 9 | 0.0 | 2.2 | 2.9 | 4.4 | 5.4 | 0.0 | 0.0 | 0.0 |
| 10 | 0.9 | 4.0 | 3.5 | 5.5 | 5.9 | 0.0 | 0.0 | 0.0 |
| 11 | 4.0 | 7.1 | 4.6 | 5.6 | 4.1 | 0.0 | 0.0 | 0.0 |
| 12 | 4.0 | 4.3 | 3.5 | 5.4 | 1.2 | 0.0 | 0.0 | 0.0 |
| 13 | 5.3 | 3.8 | 4.5 | 5.3 | 0.0 | 0.0 | 0.0 | 0.0 |
| 14 | 2.4 | 4.3 | 4.1 | 4.5 | 0.0 | 0.0 | 0.0 | 0.0 |
| 15 | 3.7 | 6.6 | 5.6 | 6.7 | 0.0 | 0.0 | 0.0 | 0.0 |
| 16 | 3.1 | 5.0 | 4.7 | 2.8 | 0.0 | 0.0 | 0.0 | 0.0 |
| 17 | 3.5 | 3.8 | 4.2 | 2.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 18 | 2.0 | 2.1 | 2.6 | 11.8 | 0.0 | 0.0 | 0.0 | 0.0 |
| 19 | 3.5 | 4.3 | 1.5 | 1.6 | 0.0 | 0.0 | 0.0 | 0.0 |
| 20 | 1.5 | 2.7 | 2.9 | 3.9 | 0.0 | 0.0 | 0.0 | 0.0 |
| 21 | 3.1 | 2.5 | 1.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 22 | 2.0 | 1.9 | 1.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 23 | 3.1 | 1.9 | 2.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 24 | 1.8 | 1.7 | 2.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 25 | 2.9 | 0.9 | 4.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 26 | 2.2 | 0.9 | 4.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 27 | 0.0 | 0.4 | 1.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 28 | 0.0 | 0.1 | 1.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 29 | 1.8 | 0.1 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 30 | 1.3 | 0.0 | 1.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 31 | 2.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 32 | 0.9 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 33 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 34 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 35 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |

- 10m
  - Nothing
- 12m
  - nothing
- 15m
  - Elevation angles from 1-7°
  - Ideal antenna height = 165 feet
    - This centers the peak of the lobe at 4°
    - At 1°, down about 1 S-unit
    - At 7°, down about 1 S-unit

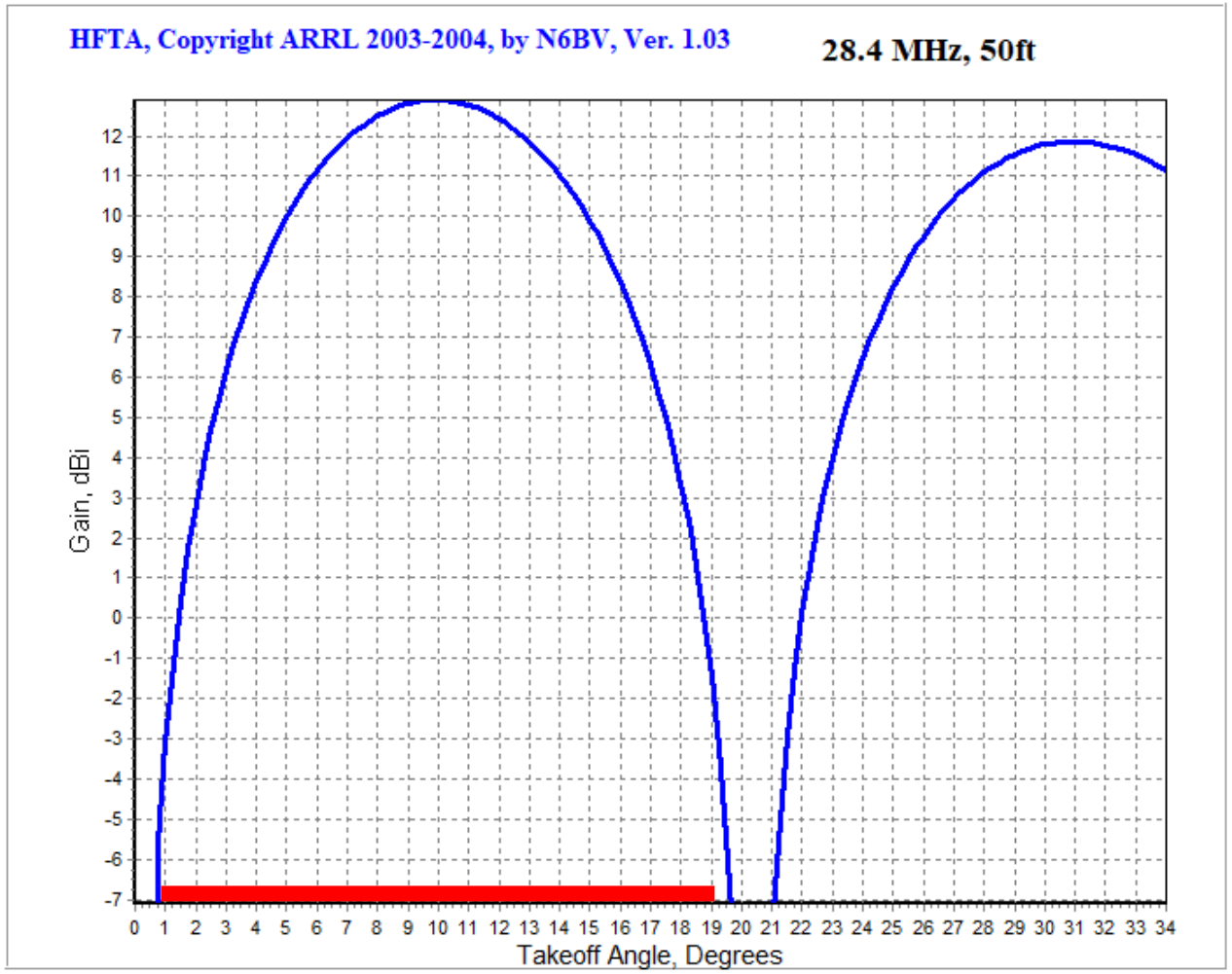
# Elevation Angles – to JA in Nov ($R_{12}$ = 125)

Japan to Portland, Nov 2022, smoothed sunspot number = 125

| Elev | 80m | 40m | 30m | 20m | 17m | 15m | 12m | 10m |
|---|---|---|---|---|---|---|---|---|
| 1 | 5.7 | 3.6 | 4.1 | 4.9 | 1.8 | 1.0 | 2.3 | 1.1 |
| 2 | 2.5 | 2.0 | 3.0 | 7.3 | 4.8 | 4.8 | 3.5 | 4.1 |
| 3 | 2.8 | 3.8 | 4.2 | 9.0 | 6.8 | 7.8 | 6.0 | 7.7 |
| 4 | 3.5 | 4.7 | 4.3 | 9.3 | 9.9 | 10.3 | 8.2 | 7.5 |
| 5 | 6.0 | 6.9 | 6.2 | 10.9 | 8.1 | 7.8 | 6.4 | 10.7 |
| 6 | 7.8 | 6.3 | 5.6 | 4.6 | 4.7 | 6.3 | 6.4 | 6.3 |
| 7 | 5.8 | 5.9 | 7.4 | 5.3 | 5.6 | 5.1 | 4.8 | 5.4 |
| 8 | 2.9 | 4.7 | 7.0 | 7.3 | 5.9 | 6.8 | 4.7 | 7.0 |
| 9 | 3.2 | 6.1 | 6.7 | 6.0 | 8.4 | 7.5 | 7.1 | 6.6 |
| 10 | 5.0 | 6.6 | 5.6 | 6.7 | 7.3 | 6.4 | 7.4 | 4.8 |
| 11 | 5.5 | 4.8 | 5.3 | 7.2 | 7.0 | 4.4 | 5.3 | 6.1 |
| 12 | 6.2 | 6.5 | 5.9 | 4.7 | 8.0 | 4.0 | 4.8 | 6.1 |
| 13 | 6.3 | 6.7 | 5.8 | 5.0 | 5.4 | 6.6 | 5.5 | 5.7 |
| 14 | 5.7 | 5.8 | 8.2 | 4.7 | 3.7 | 6.0 | 2.4 | 3.2 |
| 15 | 6.4 | 6.2 | 4.7 | 2.1 | 2.5 | 2.7 | 3.1 | 1.1 |
| 16 | 5.5 | 5.7 | 2.5 | 1.0 | 1.7 | 1.5 | 3.2 | 8.8 |
| 17 | 4.1 | 5.2 | 2.3 | 0.5 | 1.2 | 1.4 | 1.6 | 1.4 |
| 18 | 1.0 | 4.3 | 3.5 | 0.1 | 2.1 | 2.4 | 4.2 | 4.5 |
| 19 | 2.7 | 2.3 | 1.2 | 0.1 | 1.9 | 1.5 | 0.6 | 1.8 |
| 20 | 1.9 | 1.2 | 1.2 | 1.3 | 1.2 | 1.3 | 6.8 | 0.0 |
| 21 | 1.4 | 0.5 | 1.0 | 0.6 | 0.2 | 0.9 | 2.1 | 0.0 |
| 22 | 1.2 | 0.0 | 3.7 | 1.2 | 0.1 | 0.9 | 1.9 | 0.0 |
| 23 | 0.8 | 0.0 | 0.5 | 0.0 | 0.0 | 0.1 | 0.2 | 0.0 |
| 24 | 0.8 | 0.0 | 0.1 | 0.0 | 1.3 | 1.0 | 1.4 | 0.0 |
| 25 | 0.9 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 26 | 0.8 | 0.0 | 0.0 | 0.0 | 0.1 | 0.5 | 0.0 | 0.0 |
| 27 | 1.6 | 0.0 | 0.0 | 0.0 | 0.2 | 0.5 | 0.0 | 0.0 |
| 28 | 0.6 | 0.0 | 0.0 | 0.1 | 0.0 | 0.3 | 0.0 | 0.0 |
| 29 | 0.9 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 30 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 31 | 0.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 32 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 33 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 34 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 35 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |

- 10m
  - Elevation angles from 1-19º
  - Ideal antenna height = 50 feet
    - This centers the peak of the lobe at 10º
    - What about min and max angles?
      - Low percentage of the time, but . . . .
- 12m
  - Elevation angles from 1-24º
  - Ideal antenna height = 45 feet
    - This centers the peak of the lobe at 12.5º
- 15m
  - Elevation angles from 1-28º
  - Ideal antenna height = 45 feet
    - This centers the peak of the lobe at 14.5º

# 10m to JA in Nov ($R_{12}$ = 125)




- Angles from 1-19°
- 50 feet centers the peak of the lobe at 10°
- At 1°, down 2 S-units
- At 19°, down 2 ½ S-units
- What can you do?

*Stack two antennas:*
*high antenna to cover low angles*
*low antenna to cover high angles*

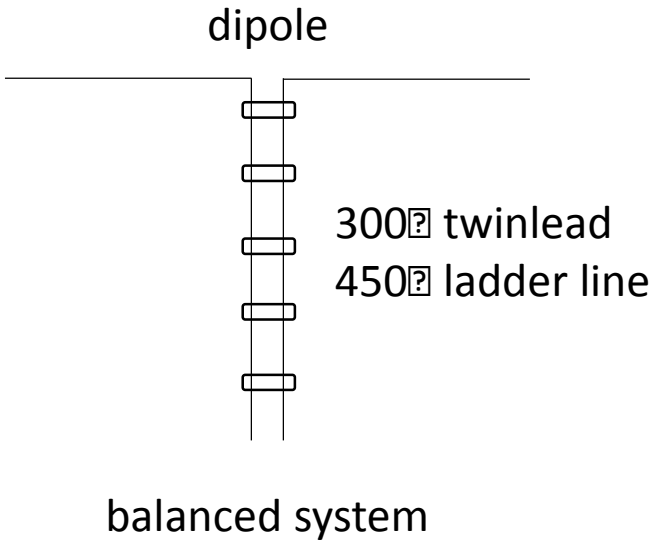
# Elevation Angles – Lessons Learned

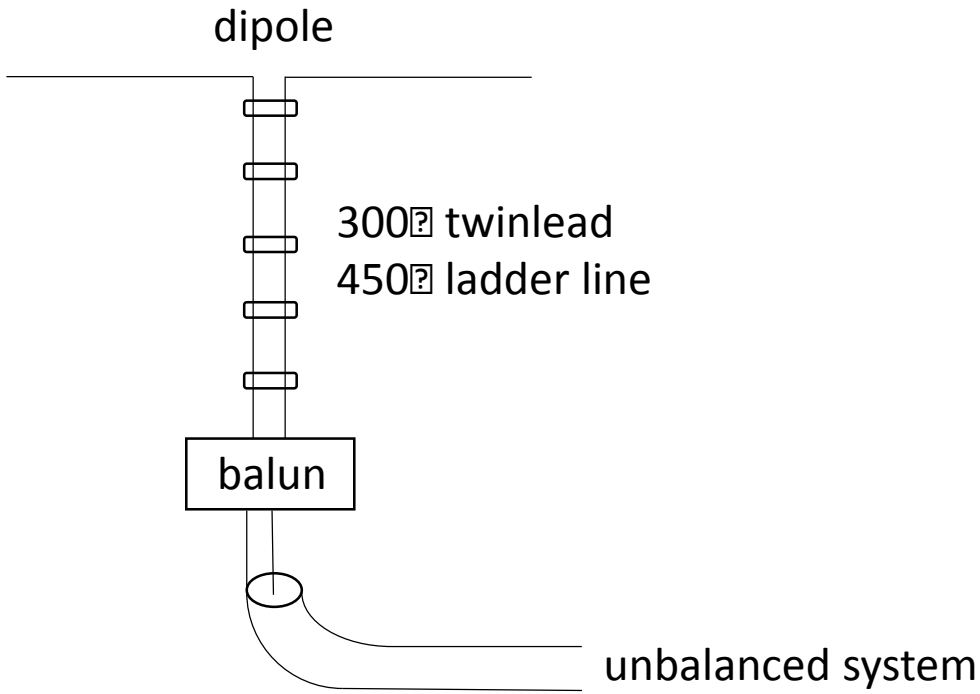
- More sunspots offer higher elevation angles
  - More ionization to refract higher angles
- Fall/winter months offer higher elevation angles
  - More ionization due to change in atmospheric composition during these months
- Put your station on a nice hill to cover the really low elevation angles
  - Be careful – it's easy to put something up too high on a hill
- If you truly want to be competitive, pay attention to all of these issues – use HFTA by N6BV

# *Baluns and Common-Mode Chokes*

# Baluns

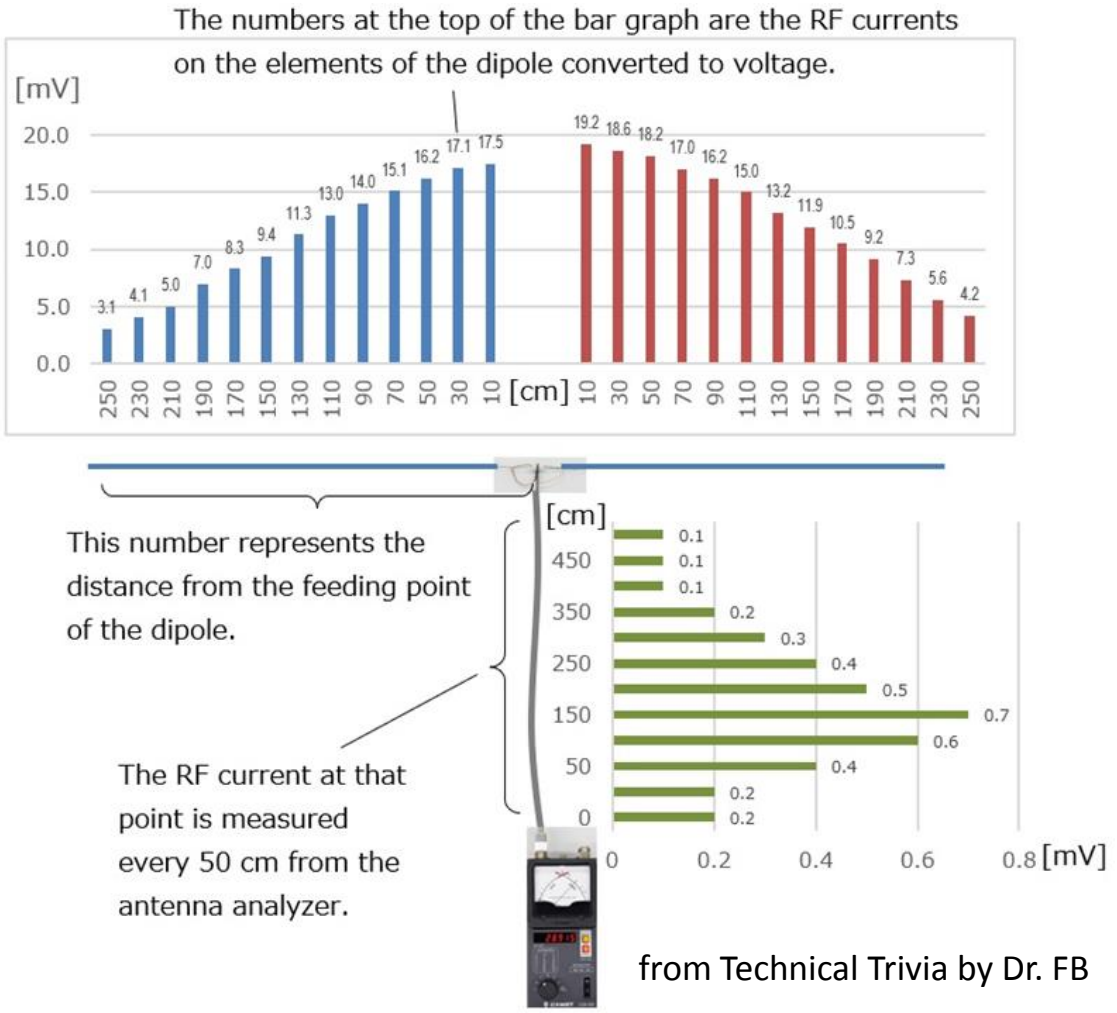
- What is a balun?
  - It's a device that converts a balanced antenna (like a half-wave center-fed dipole) to an unbalanced feed line (like 50Ω coaxial cable)
- Assures that the current on each side of the dipole is the same



# Balun vs No Balun

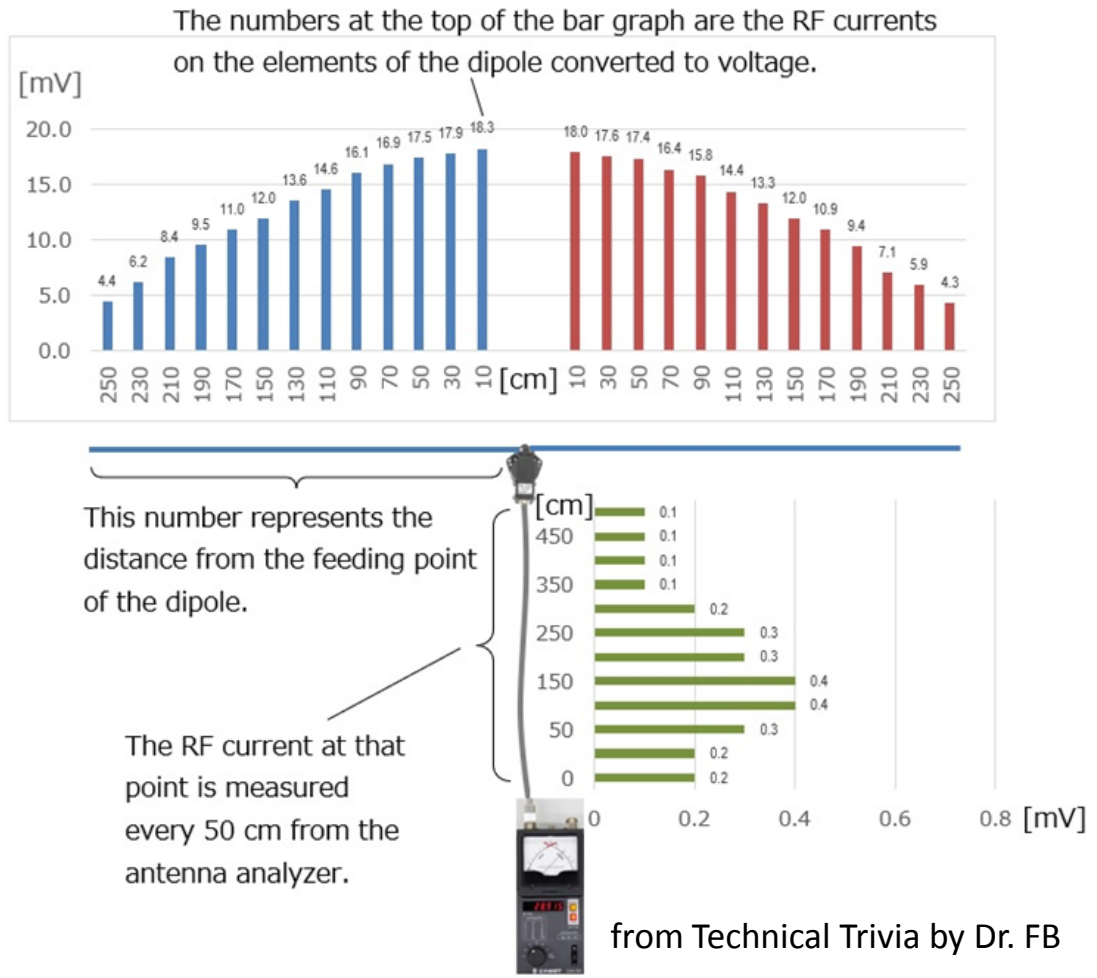
- Image on right is for a 10m dipole **without a balun**
- Note the magnitude of the voltages (converted from measured currents) on each side of the dipole – not equal
- Note the magnitude of the voltage (0.7 mV max) on the feedline




from Technical Trivia by Dr. FB

# Balun vs No Balun

- Image on right is for the 10m dipole **with a balun**
- Note that the magnitude of the voltages on each side of the dipole are very similar now
- Note the reduced magnitude of the voltage (0.4 mV max) on the feedline
- May still need a common-mode choke

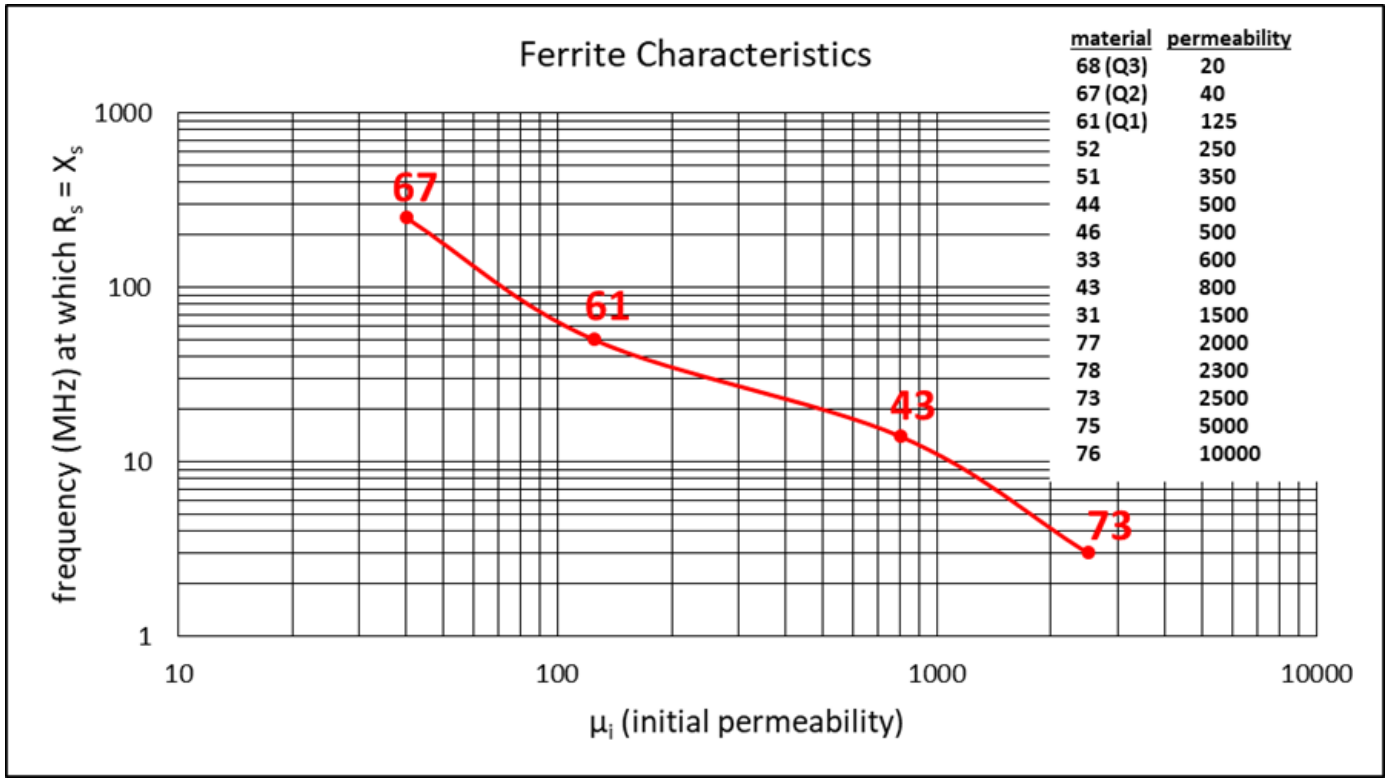



from Technical Trivia by Dr. FB

# Common-Mode Choke

- What is a common-mode choke?
  - It's a device that keeps current off the outside of the braid on a coax cable
- Because the skin depth is smaller than the thickness of the braid, there can be current on the inside of the braid and current on the outside of the braid
  - We don't want current on the outside of the braid
- One of the simplest common-mode chokes is a number of ferrite beads slipped on the coax
- See the ARRL Antenna Book 24th Edition for baluns and common-mode chokes
  - Mostly in Chapter 24
  - In another Workshop today, AC7NP and KF7DPV discuss baluns
  - Visit K9YC website at http://www.audiosystemsgroup.com/RFI-Ham.pdf

# Name That Ferrite

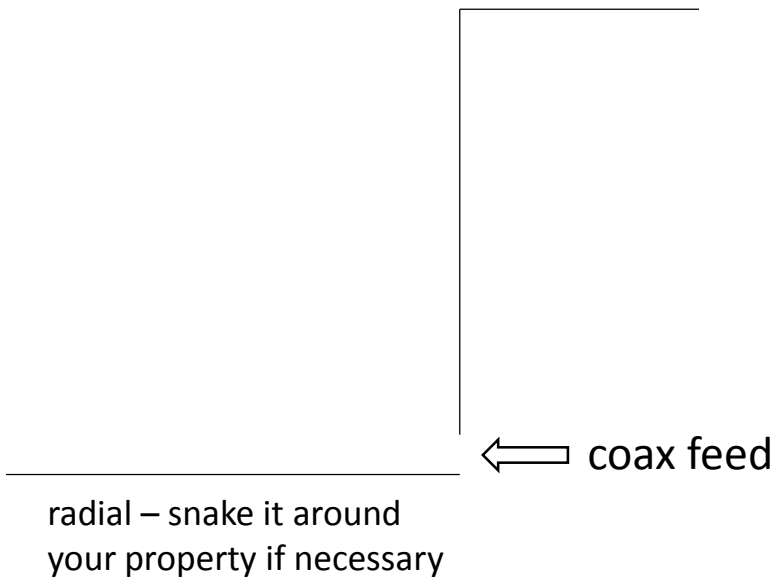



One turn through the ferrite core

- I used my MFJ-259B to measure the frequency at which Rs = Xs
- Powdered iron cores have lower permeability, so generally frequency would be much higher

# *Antennas for the Lower HF Bands*

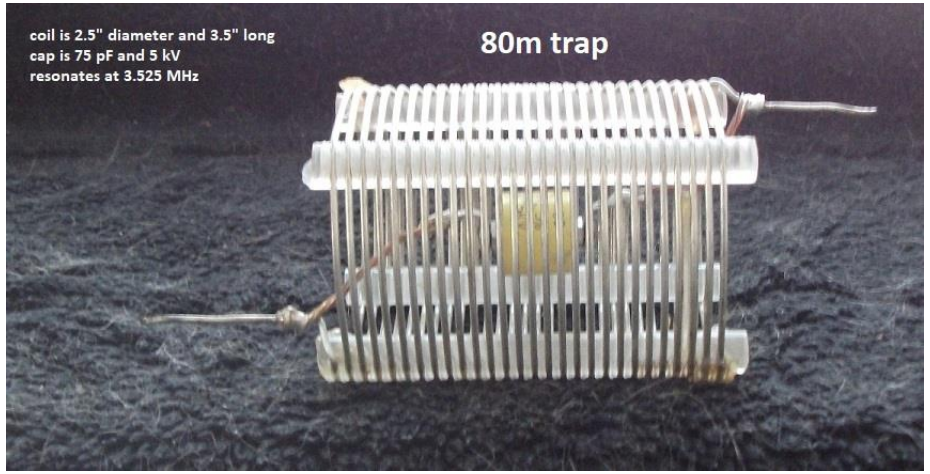
# Simple 160m Inverted-L

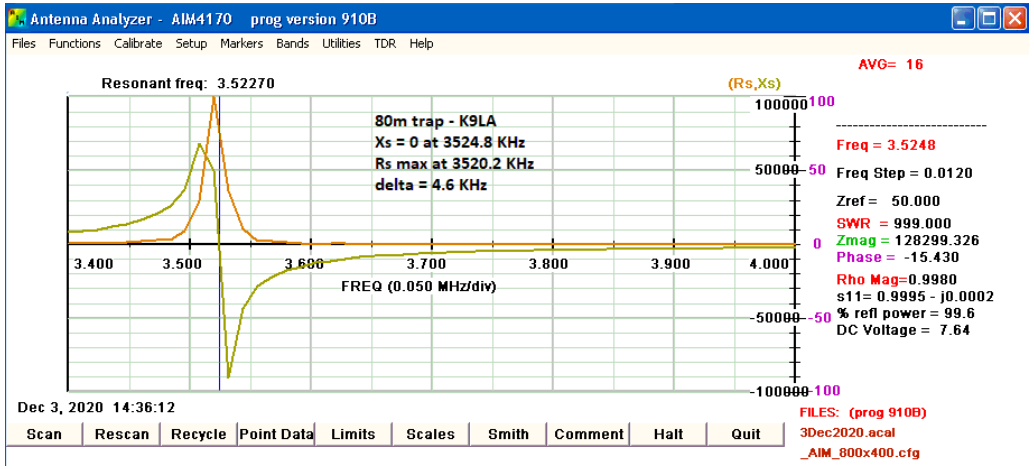



- Total radiator length 1/4λ
  - About 135 feet
- Up 40 feet, over (or slanted down) 95 feet
- A single 135 foot radial
- SWR should be close to 50
  - It's 50 because there aren't enough radials to reduce ground loss
- It will be great for domestic work and some DX work

# Put the 160m Inverted-L on 80m, Too

- Add an 80m trap at the top of the vertical wire and add a 70 foot radial
  - Might need a small base loading inductor for 80m if the vertical portion is less than about 65 feet
- Homebrew trap using B&W air-wound coil stock (27.2 uH) and a high-voltage door knob capacitor (75 pF, 5kV)
- Coil Q ≈ 200



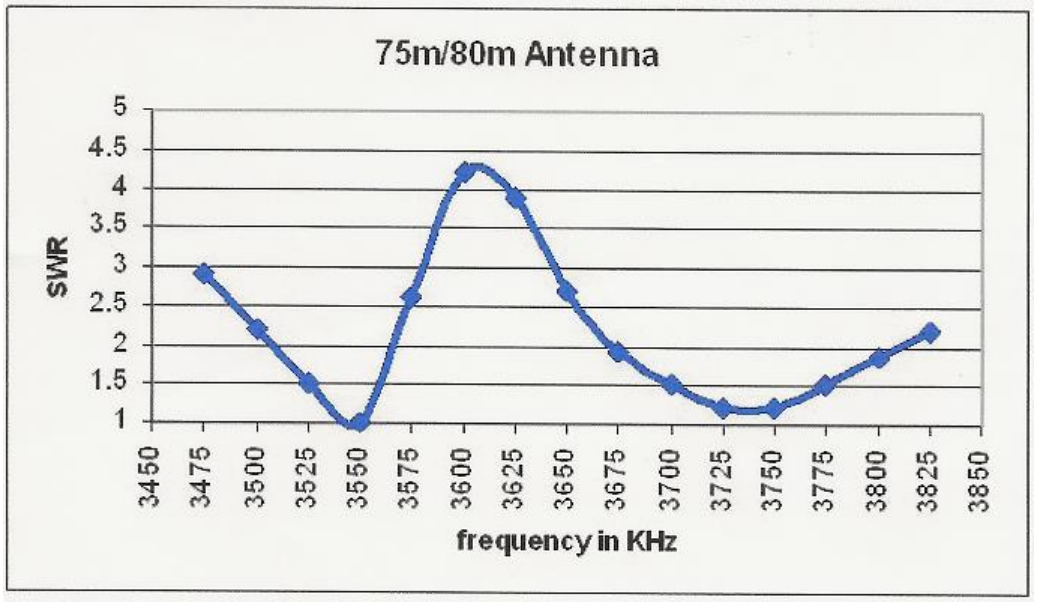
# Other Simple Lower-Band Antennas

- Half-wave Dipole
  - If desire low angle radiation, height is important
- Inverted-vee
  - Only one support needed
- Quarter-wave vertical
  - Need good ground system – buried or elevated
- Keep in mind that a horizontal antenna picks up less noise than a vertical antenna and is less dependent on ground than a vertical antenna

| Band | 1/2λ | 1/4λ |
|---|---|---|
| 160m | 270ft | 135ft |
| 80m | 140ft | 70ft |
| 75m | 128ft | 64ft |
| 60m | 93ft | 46ft |
| 40m | 68ft | 34ft |
| 30m | 49ft | 24ft |

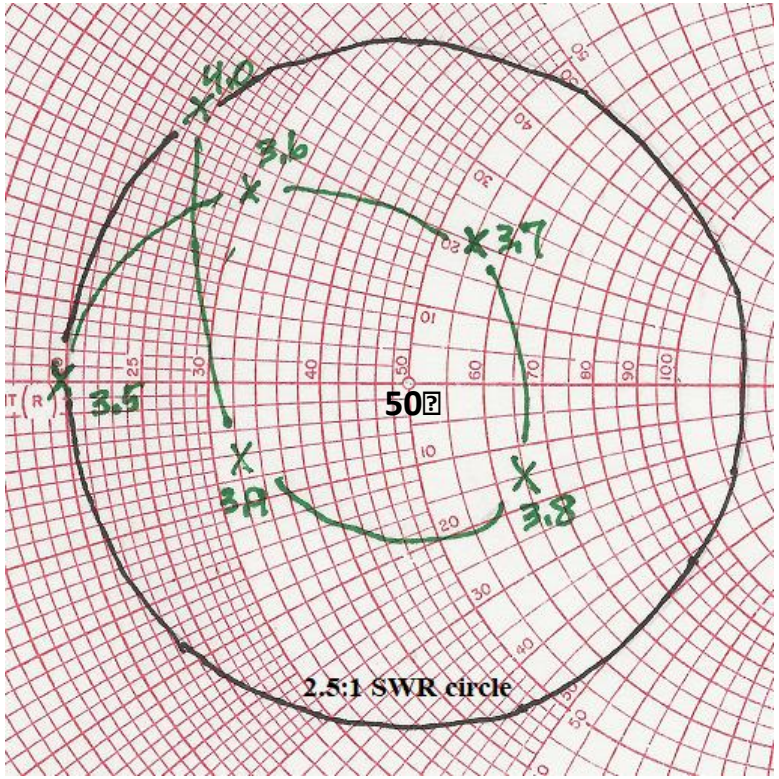
# What If You Want 80m and 75m?

- Use an 80m trap
- Cut inner section for 3.750 MHz (or higher if so desired)
- Add trap and add length to resonate at 3.550 MHz
- YMMV depending on height and ground characteristics



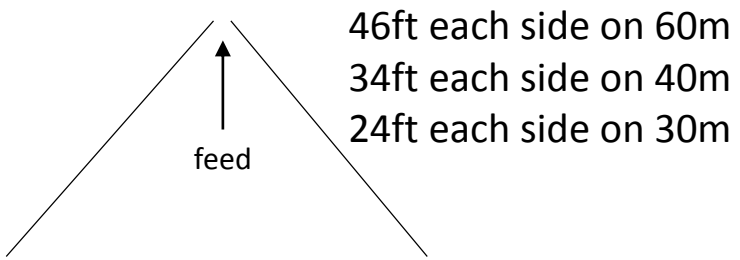
# What If You Want 80m and 75m?

- Use dipole cut for 3.750 MHz
- Add 1λ (electrical length at 3.750 MHz) of 50Ω coax
- Then add 1/4λ of 75Ω coax
- End up with SWR ≤ 2.5:1 from 3.5-4.0 MHz
- YMMV depending on height and ground characteristics

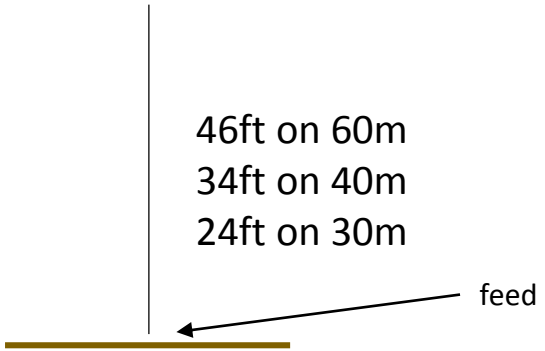


# 60m, 40m, 30m

- A good old inverted-vee (or dipole) at a reasonable height



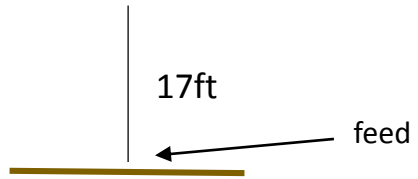

- Vertical with good ground system

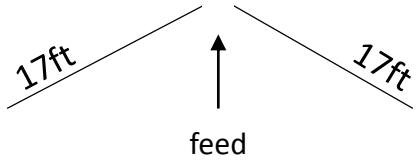


# *Antennas for the Higher HF Bands*

# 20m Antenna

- If you can only put up one antenna, try to make it a 20m antenna
- 20m is good throughout a solar cycle
  - From solar min to solar max and back to solar min
- Vertical is simple
- Dipole/inverted-vee is simple
- 2-element Yagi might be feasible



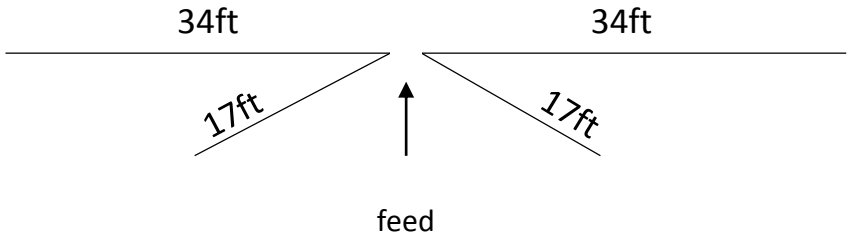



# 20m Antenna – Quad vs Yagi

- Age-old question – which is better?
- I had a 2-element Yagi and a 2-element Quad oriented for minimal interaction to the northeast
  - Short path to Europe and long path to VK/ZL
- I could not tell the difference on short distance or long distance QSOs
- Quad, being 3-dimensional, was tougher to put up

# 40m Dipole/20m Inverted-Vee

- 40m and 20m are good all-around bands for use throughout a solar cycle
- Easy way to operate on these bands is to use a 40m dipole with a 20m inverted-vee attached at 40m feed point
- A 40m dipole was my Novice antenna in late 1961 (at about 15 feet)
- When I received my General, I added the 20m inverted-vee

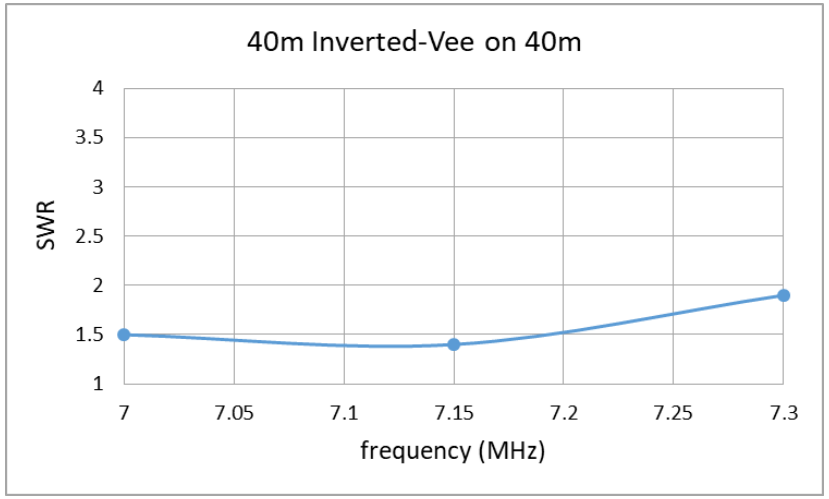


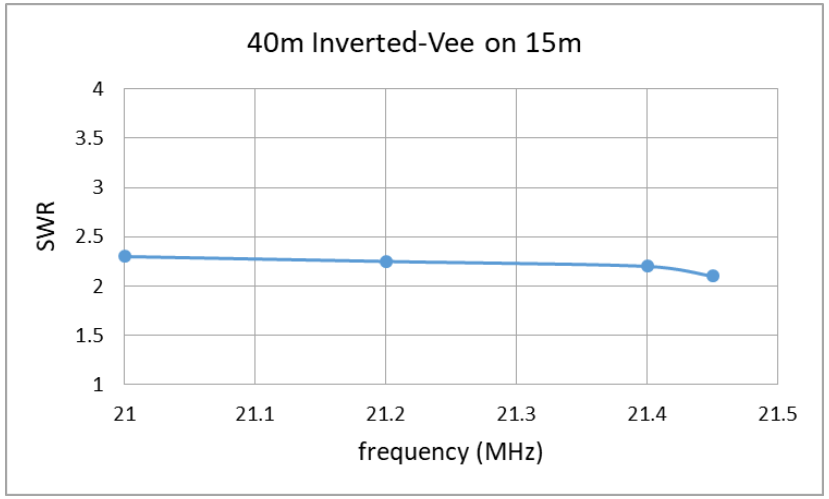

*It's also works on*

*15m – see next slide*

# Antennas for 15m

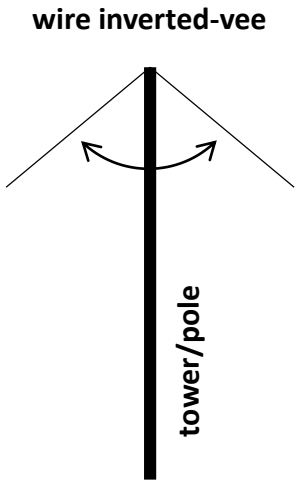
- Use your 40m dipole/inverted-vee
  - Works as a 3/2-wavelength antenna
    - A bit of gain in some directions
  - Lowest SWR on 15m will likely be above 21.450 MHz
    - Probably need to use a tuner – either your rig's internal tuner or an external tuner
- Vertical with four elevated radials
  - I have a Hustler 4BTV – gives decent results
- 15m dipole/inverted-vee
  - Overall length about 22 feet (11 ft each side)
  - Put it up at 20 feet
- 2-element Yagi
  - 6 foot boom, 22 foot elements, need rotator

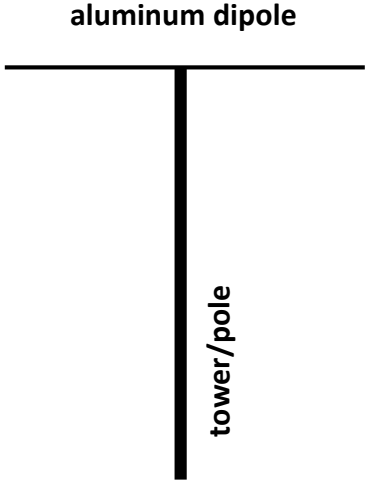


# Antennas for 12m

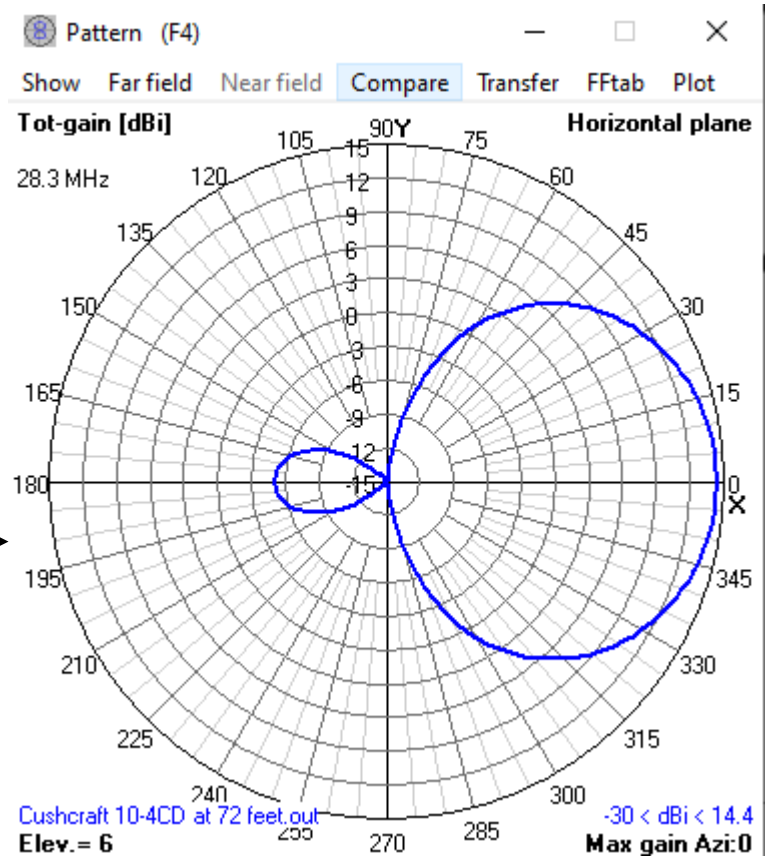
- Inverted-vee
  - Each side about 9.25 feet
  - Keep angle > 90 degrees
- Dipole made with aluminum tubing
  - About 18.5 feet from tip-to-tip
- 2-element Yagi
  - A bit smaller than a 15m Yagi
- 3-element Yagi
  - More gain
  - Better F/B ratio



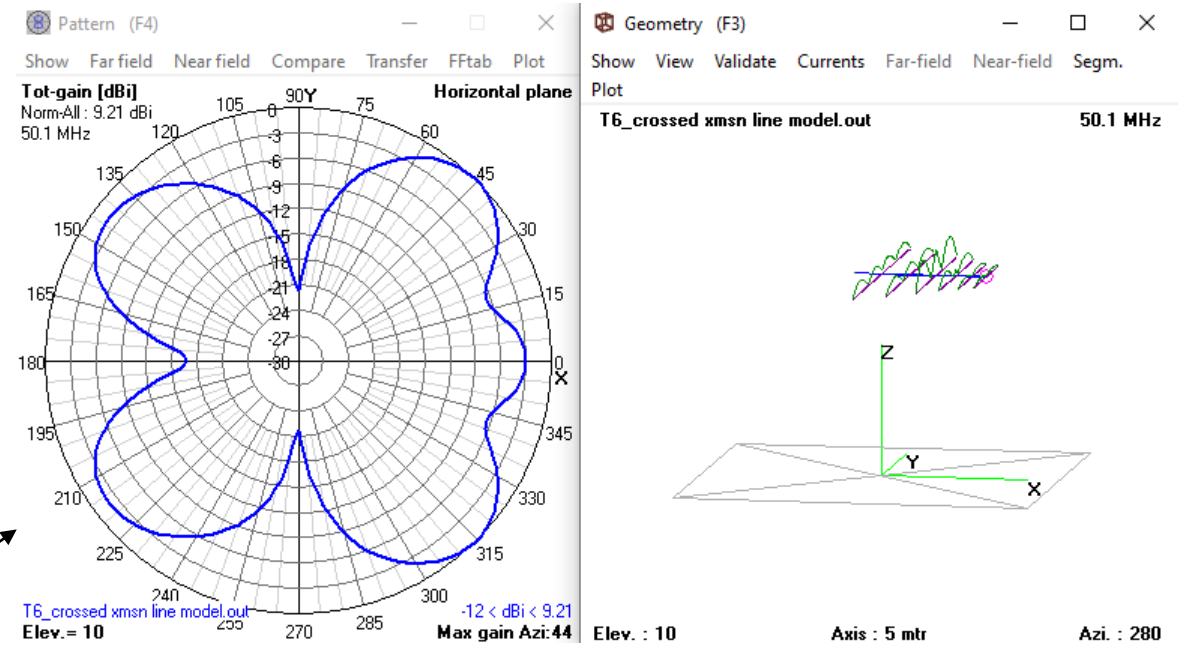
# Antennas for 10m

- Dipole (made of aluminum) is relatively small
  - About 16.5 feet tip-to-tip
  - It will give great results at 15-20 feet high
- Multi-element Yagis are quite reasonable
  - I have a 4-element Cushcraft 10m Yagi
    - 16 foot boom, elements about 17 feet tip-to-tip
    - Used it to work many stations with my homebrew QRP (250 milliwatts) 10m DSB transceiver during the big Cycle 22



# Antennas for 6m

- 3-element Yagi
  - 6 foot boom
  - 9.5 foot elements
  - Couple pounds
- Use an HF antenna
  - I've used my 40m inverted-vee
    - My OMNI VII internal tuner handles the SWR okay
  - Similarly, I've used my Tennadyne T6 LPDA
    - It's 14-30 MHz
    - SWR is 1.8:1 at the shack

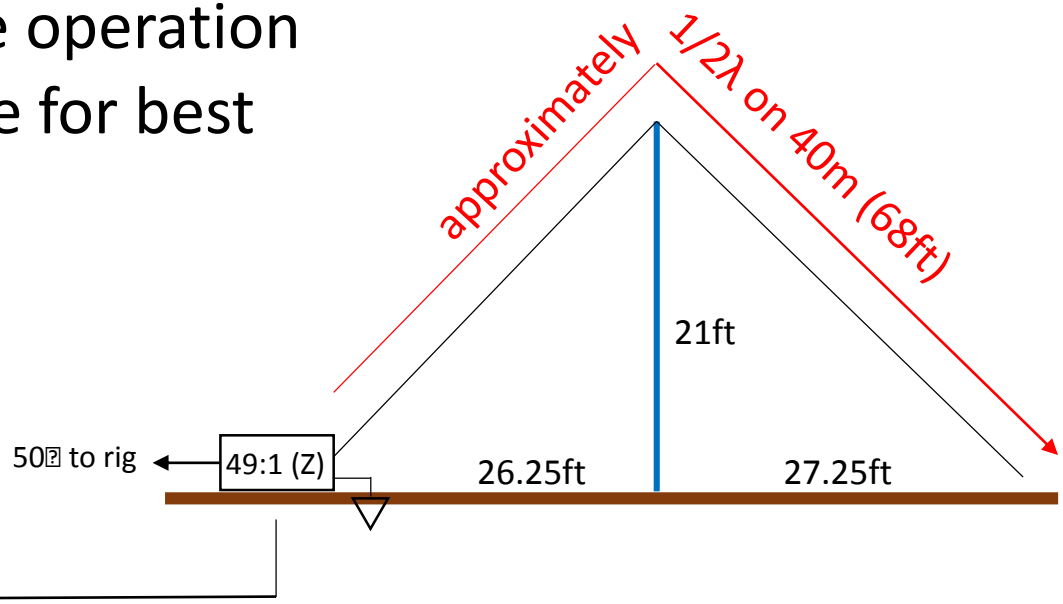


# *Multi-Band Antennas*

*YMMV*

# End-Fed Half-Wave - Design

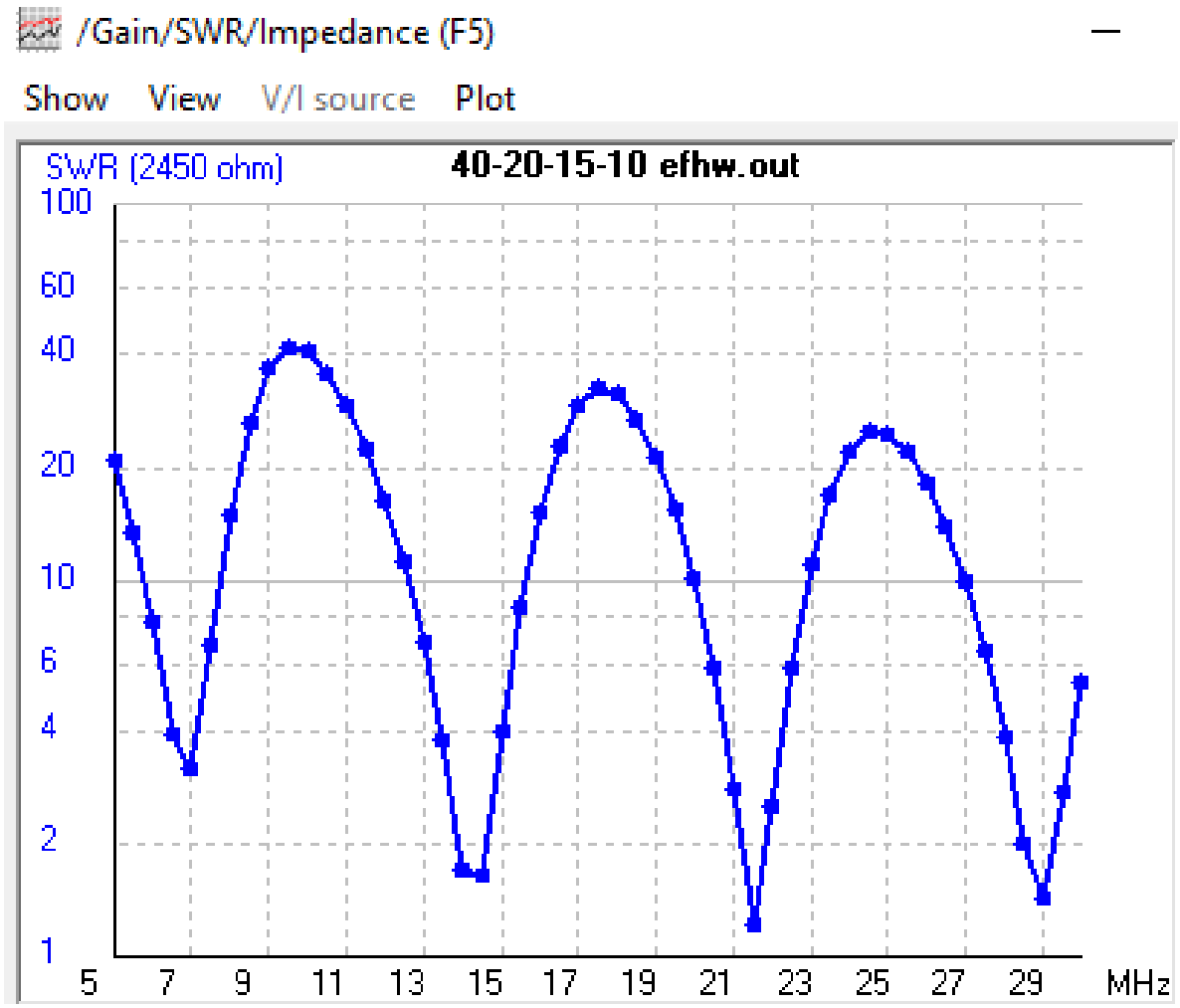
- Popular antennas nowadays
- Figure shows 40m/20m/15m/10m implementation
- Nice antenna for a portable operation
- Likely need to tweak on-site for best SWR




https://km1ndy.com/diy-491-unun-impedence-transformer-for-end-fed-half-wave-efhw-antenna/

*In another Workshop today, AC7NP and KF7DPV discuss baluns*

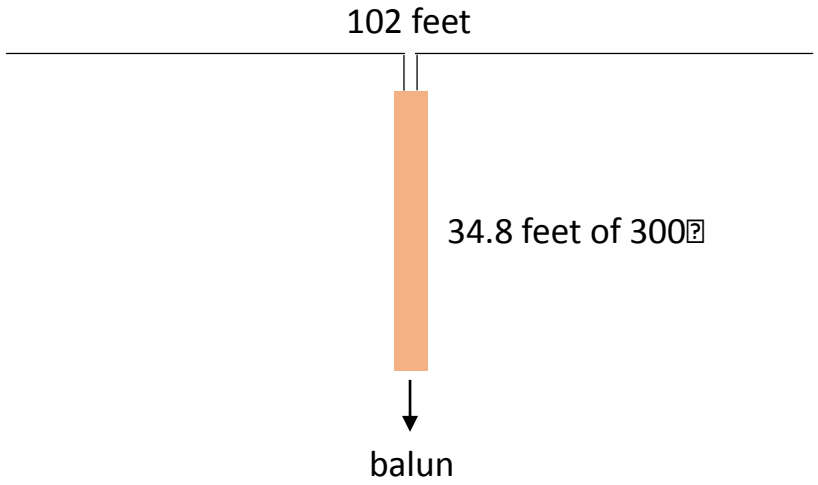
# End-Fed Half-Wave - SWR



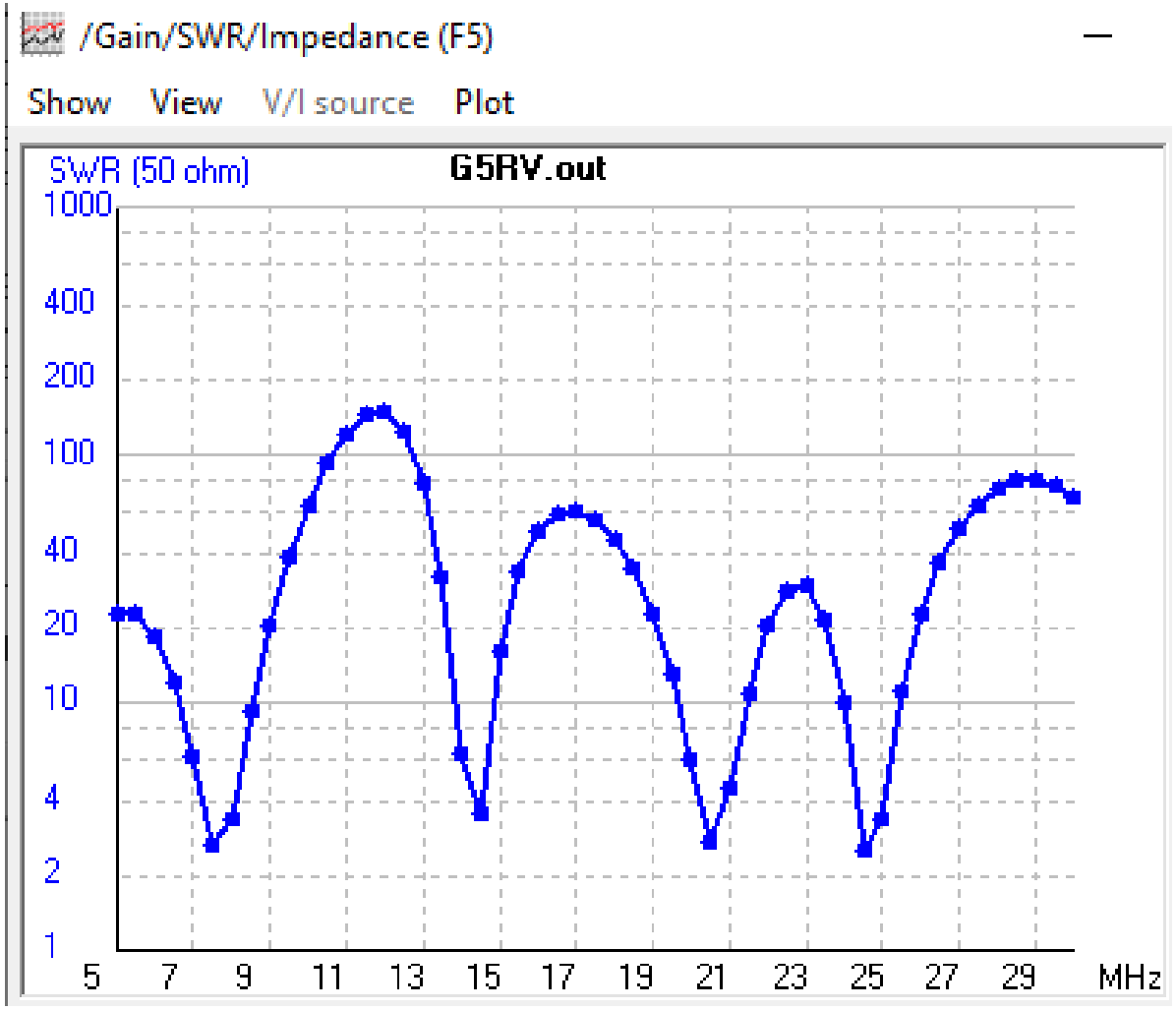

Low SWR on 40m, 20m, 15m, 10m

# G5RV Antenna - Design

- G5RV optimized this antenna for 20m
- G5RV said you'd probably need a tuner for other bands
- Not too bad on the other bands – see next slide



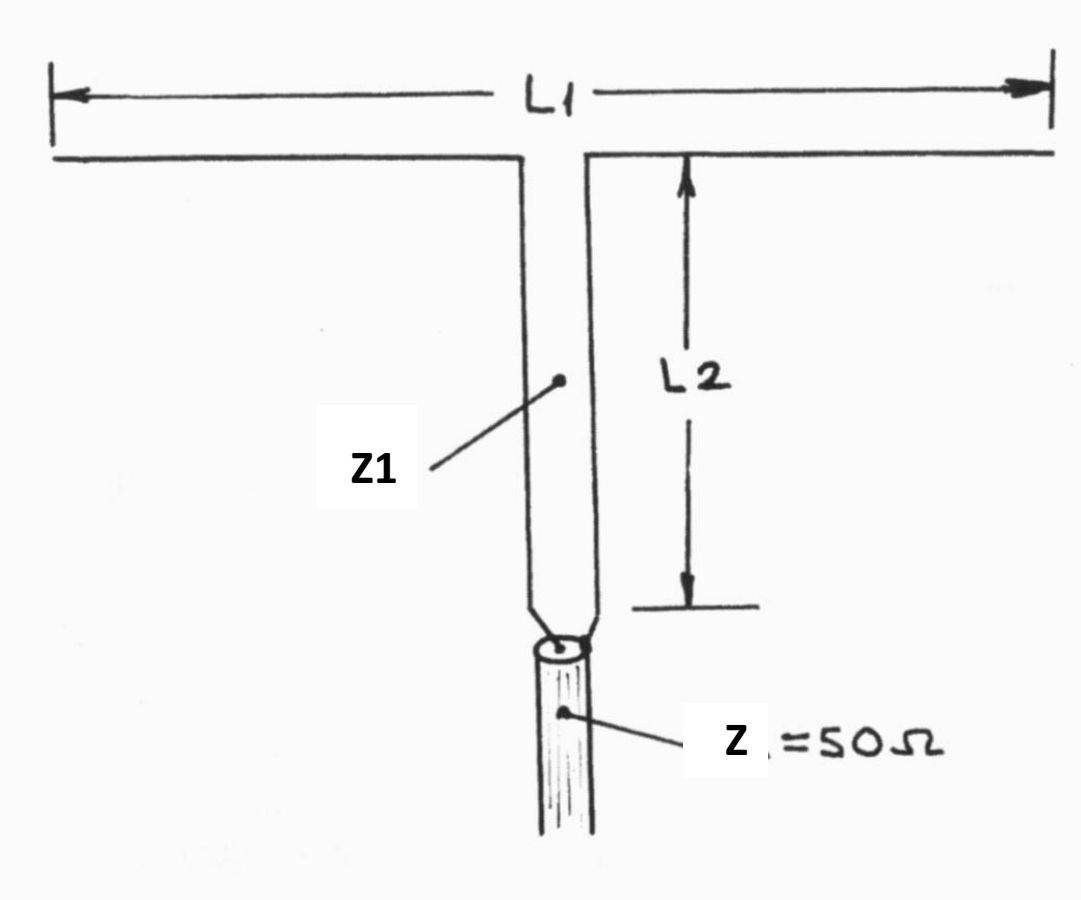
# G5RV Antenna – SWR



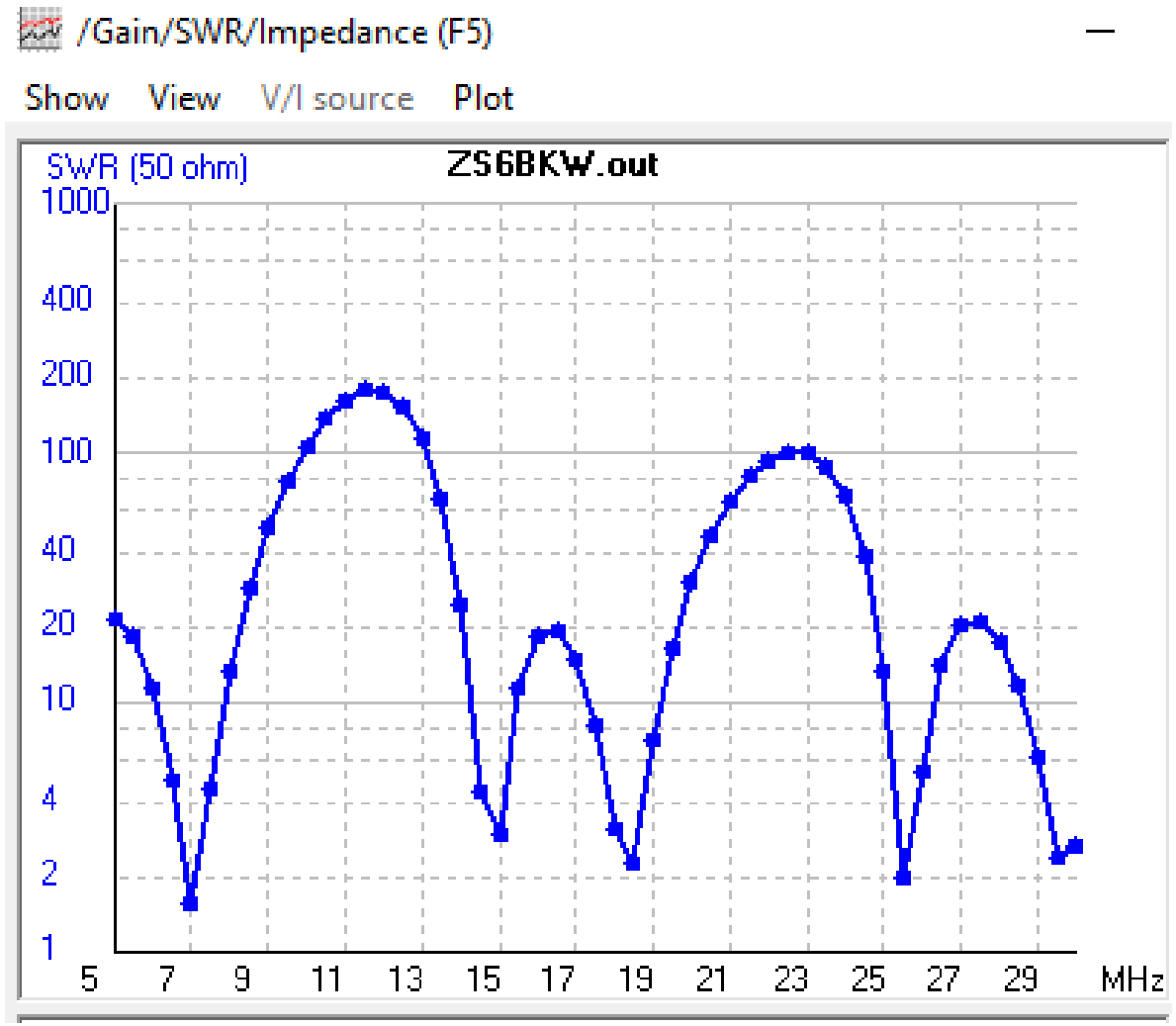

Low SWR on 40m, 20m, 15m, 12m

# ZS6BKW (now GØGSF) Antenna - Design

- Computer optimization of the G5RV antenna
- Covers 40m, 20m, 17m, 12m and 10m
- At 45 feet
- L1 = 93.4 feet
- Z1 = 300Ω
- L2 = 42.0 feet



# ZS6BKW (now GØGSF) Antenna - SWR




Low SWR on
40m, 20m,
17m, 12m, 10m

# The Digital Modes

- The digital modes can decode a signal farther down in the noise

## Weak-Signal S/N Limits

| Mode | (B = 2500 Hz) |
|---|---|
| SSB | ~+10 dB |
| MSK144 | - 8 |
| CW, “ear-and-brain” | -15 |
| FT8 | -21 |
| JT4 | -23 |
| JT65 | -25 |
| JT9 | -27 |
| QRA64 | -27 |
| WSPR | -31 |

- FT8 has taken over

from Club Log, May 23 to May 30

Most active modes

This chart illustrates which modes are being used most heavily during the period of this report.

| Mode | % Use | QSOs | Graph |
|---|---|---|---|
| FT8 | 55.05 | 575,759 | |
| CW | 31.57 | 330,213 | |
| FT4 | 6.43 | 67,216 | |
| SSB | 6.33 | 66,251 | |
| FM | 0.19 | 2,000 | |
| MFSK | 0.13 | 1,369 | |
| DIGITALVOICE | 0.08 | 786 | |
| RTTY | 0.06 | 584 | |
| PSK | 0.04 | 405 | |
| DYNAMIC | 0.03 | 274 | |
| DSTAR | 0.01 | 115 | |
| MSK144 | 0.01 | 72 | |
| AM | 0.01 | 59 | |
| All other | 0.07 | 714 | |

# Summary

- Lots of antennas out there
  - Use the Amateur Radio spirit and try some of them
  - Cycle 25 is in its ascent – take advantage of the simpler antennas on the higher HF bands
- Elevation angles are important
  - Need to cover a wide range of angles – even for Field Day!
  - How far you go in covering all the angles depends on your goals, your acreage and your finances
- Take advantage of the digital modes
  - Especially as Cycle 25 rises from solar minimum