CTU Presents

How to Maximize the Performance of Low Band Receiving Antennas

Joel Harrison W5ZN

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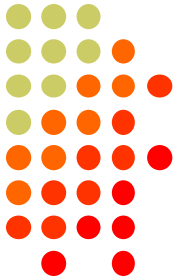
Objectives

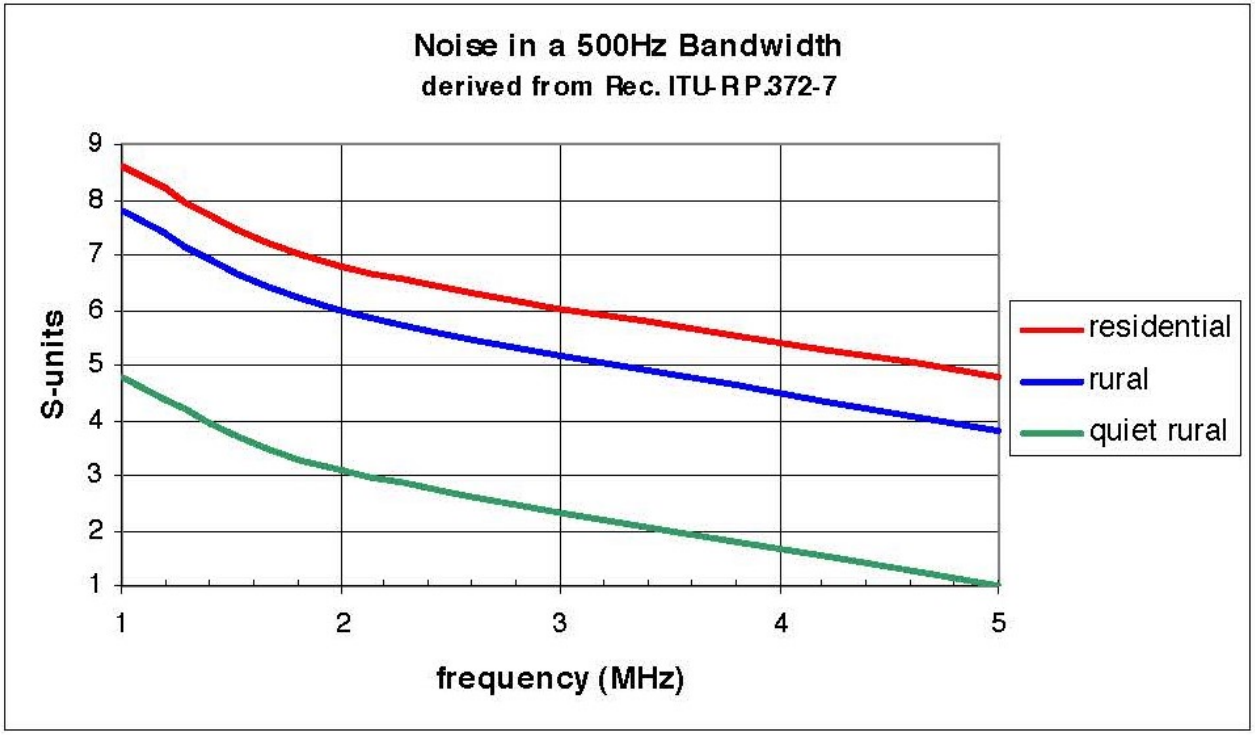
- Understand why we use receive antennas and why maximum performance is mandatory
  - You can't work 'em if you can't hear 'em
    - Or decode them with FT8 !!!
- What you should expect from a receive antenna based on station location
  - Propagation is a major factor
- Understand how different receive antennas vary in design and performance
- Understand Best Construction Practices

Why Do We Use Receive Antennas?



- Reduce receive noise (Improve SNR)
- Improve the forward pattern in the desired direction
  - Provide directivity away from noise sources
- Gain antennas for TX aren't necessarily good RX antennas as they provide gain for noise as well as the desired signal

Why Do We Use Receive Antennas?



Prepared by K9LA

W5ZN is in a "rural" area. Without receive antennas 160-meter noise is between S6 to S8 (-91 to -79 dBm) in line with ITU data

With receive antennas it is S1 (-120 dBm)

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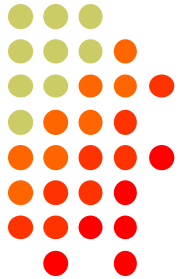
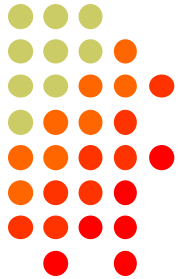
What Should You Expect from a Receive Antenna?



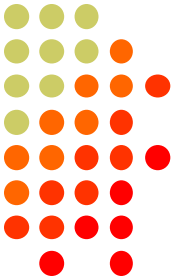
- Evaluation of any antenna system requires you to have a realistic understanding of what to expect!
- Some radio amateurs erroneously assume after installing an RX antenna you will automatically begin to miraculously hear stations that never existed at your location before
- The most important factor to hear stations on the low bands is propagation characteristics.

What Should You Expect from a Receive Antenna?



- Low band receive antennas cannot be properly evaluated without taking into consideration geographical and propagation differences
- Comparing one antenna from a location 1000 miles away on the east coast to the same antenna located in rural Arkansas will not give an accurate comparison
  - the exact same antenna may perform differently in those two locations for a variety of reasons

What Should You Expect from a Receive Antenna?

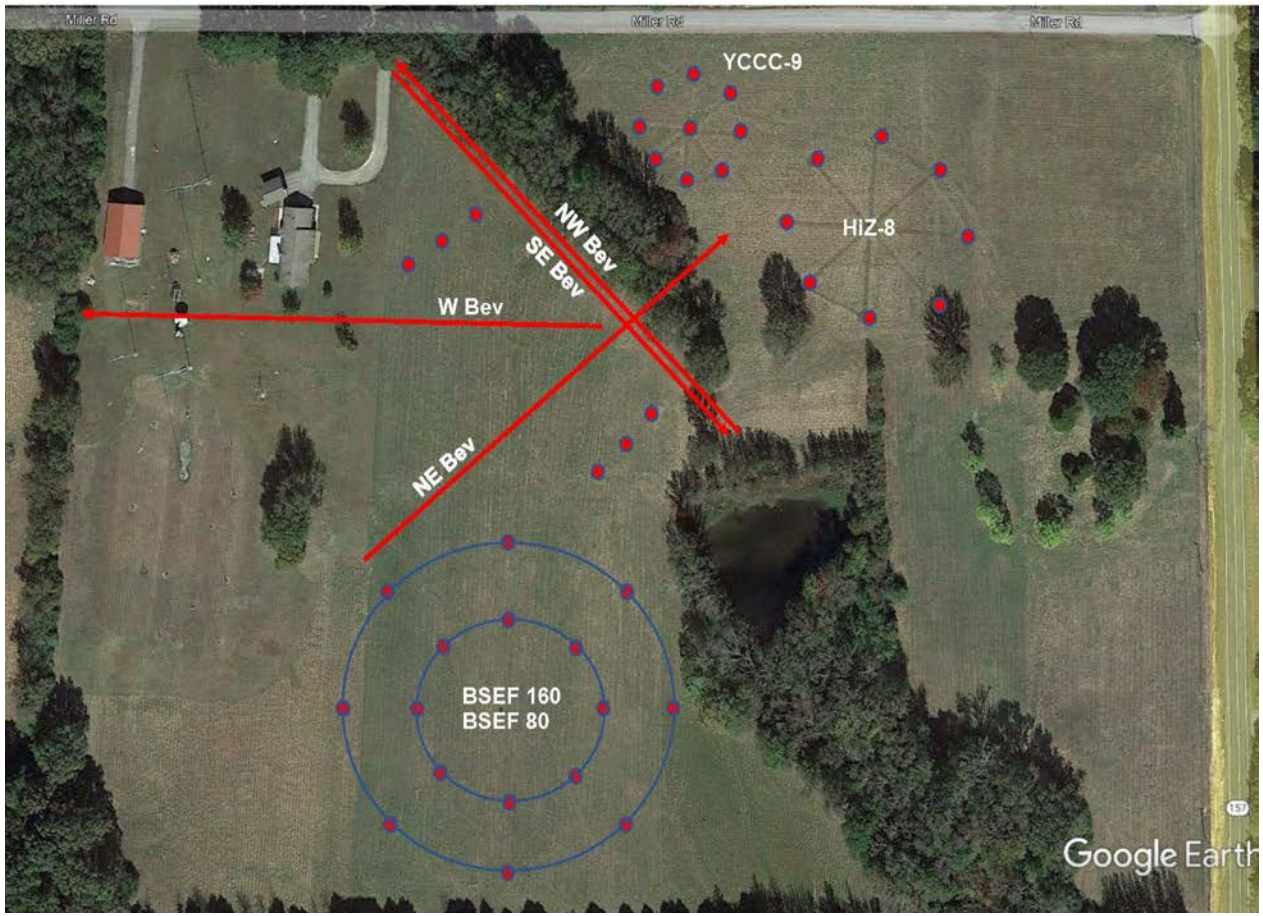


- W5ZN uses three stations for propagation comparison
  - W0FLS in Iowa 425 miles north at 344° azimuth
  - W5UN in Texas 200 miles SW at 235° azimuth
  - K5RK in Texas 450 miles S/SW at 205° azimuth
- The propagation difference of what we each can and cannot hear at any one time is significant!

What Should You Expect from a Receive Antenna?

- Even closer, K5UR is 25 miles SW, WD5R is 20 miles north, & K5EJ 20 miles NE.
  - We compare notes frequently and the differences between signal-to-noise ratios for all of us that close is sometimes eye opening.
- 160-meter propagation is beyond the scope of this presentation. Please read the excellent work by K9LA & W3LPL.

Receive Antennas and Testing Range at W5ZN



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Location Location Location

- Where you place a receive antenna is important
- Structures or other antennas will affect the pattern and thus the performance
  - Avoid nearby metal objects or buildings
  - Resonant TX antennas
    - May need to detune the TX antenna during receive
  - Sometimes this is unavoidable, just understand there will be an effect and take steps to minimize the impact

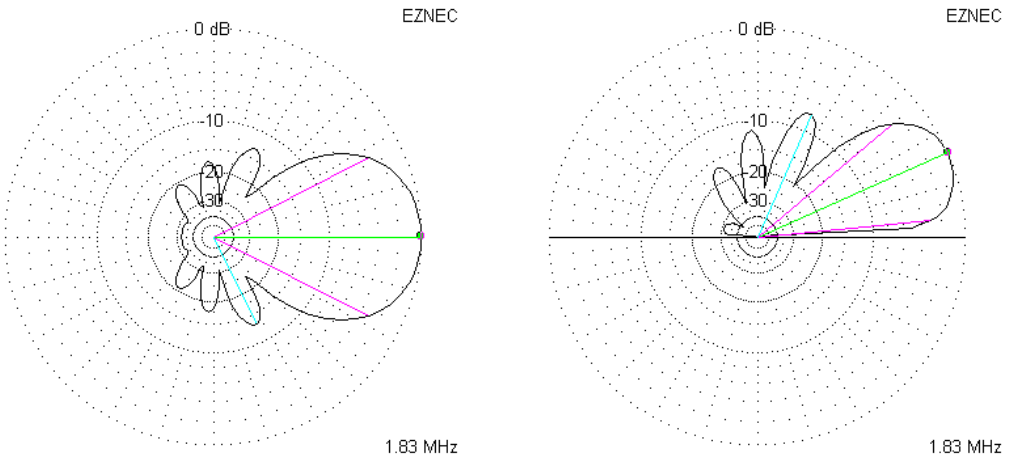
Receive Antenna Standard

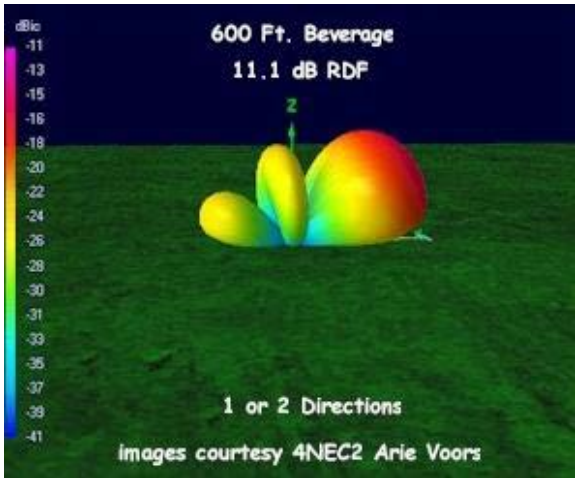
- Beverage was introduced in 1921
- The Beverage Antenna Handbook
  - Old “go to” reference - No longer in publication
- Low Band DX’ing
  - New “go to” source for Beverage details
- The Benchmark Beverage - Greg Ordy, W8WWV:

“For me, the Beverage represents a yardstick which can be used to compare the performance of other receive antennas”.

Receive Antenna Standard
The Benchmark Beverage

You can evaluate the expected performance of an RX antenna by comparing modeling data of your desired antenna to the Benchmark Beverage





Azimuth, Elevation, & 3-D Patterns for a ~580 ft Beverage

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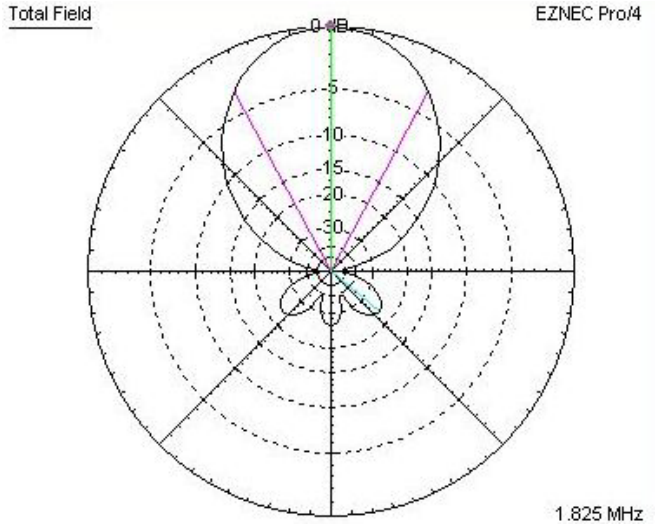
Comparing Modeling Results to What You Will Actually Hear

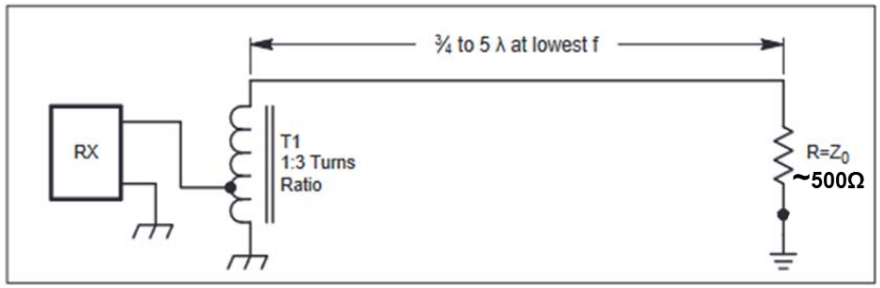
A forward signal level of S9 is -73 dBm. If the rear lobe produces a 30 dB reduction from the forward lobe, the -103 dBm result will be equivalent to S4. Even an almost unrealistic 40 dB rear lobe would provide a signal just slightly above S2

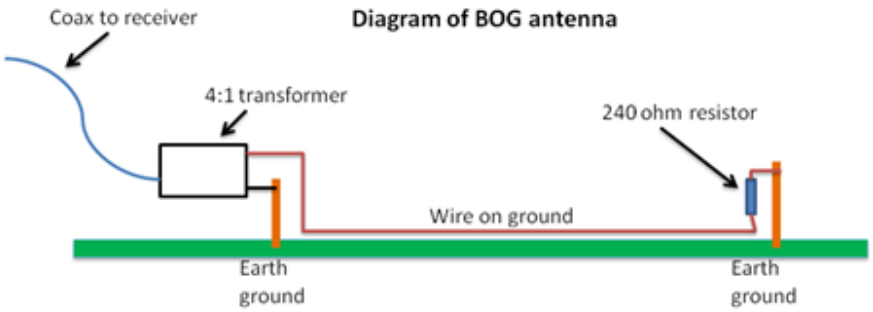


S-Meter	dBM	V	dBuV
S9 + 10 dB	-63 dBm	0.16 mV	44 dBµV
S9	-73 dBm	50 µV	34 dBµV
S8	-79 dBm	25 µV	28 dBµV
S7	-85 dBm	12.6 µV	22 dBµV
S6	-91 dBm	6.3 µV	16 dBµV
S5	-97 dBm	3.2 µV	10 dBµV
S4	-103 dBm	1.6 µV	4 dBµV
S3	-109 dBm	800 nV	-2 dBµV
S2	-115 dBm	400 nV	-8 dBµV
S1	-121 dBm	200 nV	-14 dBµ

Construction Best Practices
Beverages

- Many different versions and lengths
  - 2-direction, phased, Beverage on Ground (BOG), etc.





Construction Best Practices
Beverages

Beverage Supports are ½” PVC Cut to 7 ft

PVC support is 3/8”x18” Rebar about 9 inches in ground. Slide PVC over rebar

Cut a slit in a ½” T coupling to place Beverage wire in on top of PVC support

Easy installation & take down (if needed). Four 580 ft Beverages can be easily installed in one day by one person

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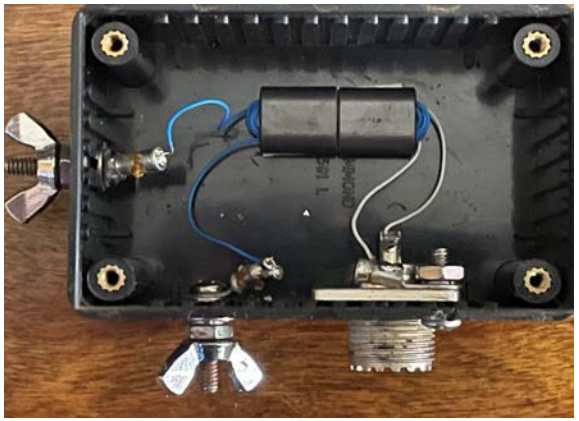
Construction Best Practices
Beverage

Termination End – Two 1000 Ω 2 Watt Carbon Resistors in parallel = 500 Ω

Neon bulb across resistors for lightning protection

Plastic enclosures are Hammond 1591LSBK Available from Mouser

Feed point End – Matching transformer #73 Binocular core (only one required)



Binocular Cores are Fair-Rite 2873000202 available from Mouser.

Wire is #28 wire wrap wire available from DigiKey W28-6H-ND (select your favorite color!!)

Winding details – ON4UN's "Low Band Dx'ing", fifth edition, Table 7-28, page 7-69

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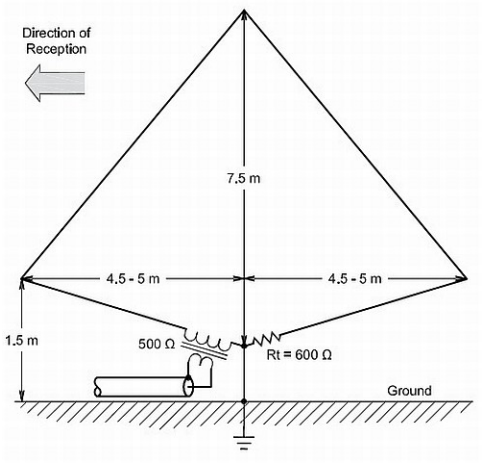
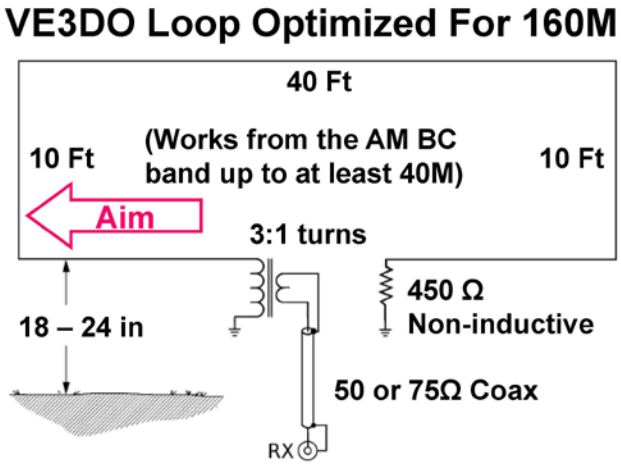
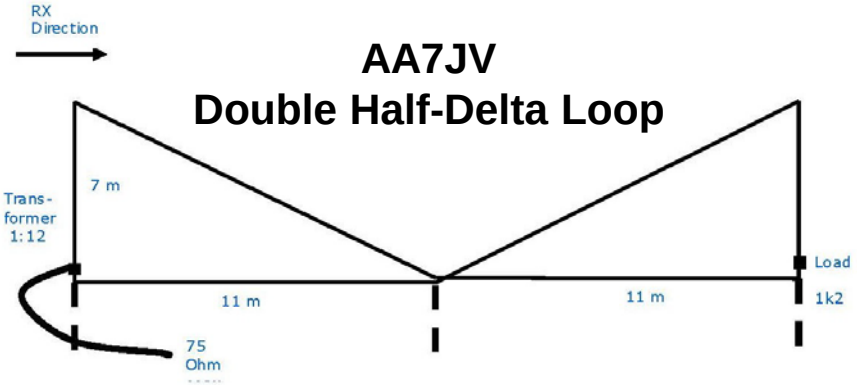
Construction Best Practices
Loops

Loop antennas come in all shapes and sizes



K9AY Loop





The Double Half-Delta Loop.

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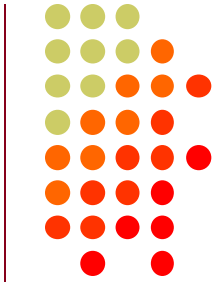
Construction Best Practices Loops

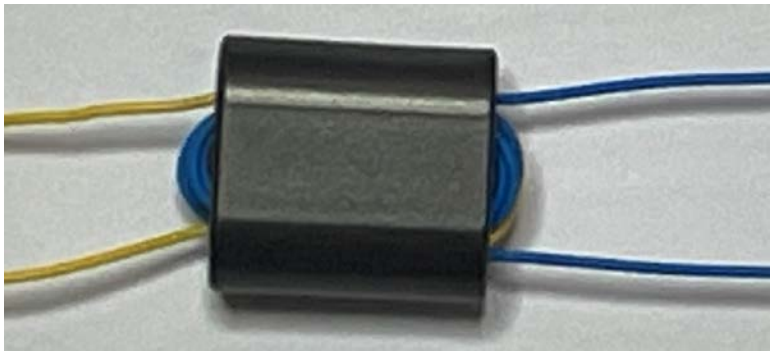


- Construction best practices are the same for all
- Pay attention to dimensions
  - This isn't UHF or microwave construction, but be reasonably precise
- Matching the feedline impedance to the impedance of the antenna feed point is important

Construction Best Practices
Impedance Matching

- Matching the feedline impedance to the impedance of the antenna for Beverages and loops is important
  - Most Beverages & loops have a feed point impedance of around 500Ω, but depends on the design
  - Matching transformers are simple and very easy to build, just wrap the required turns through the core

28 gauge “wire wrap” wire



#73 binocular core. Use different color wire for the primary and secondary

75Ω primary=3 turns secondary=8 turns
50Ω primary=3 turns secondary=10 turns

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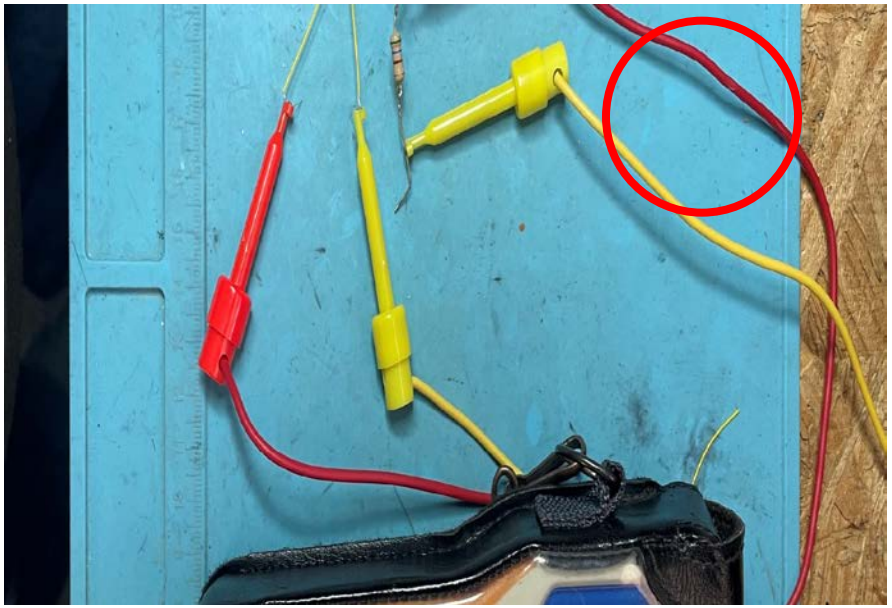
Transformer Testing

- Simply connect a resistor equal to the value of the antenna impedance (~500Ω) to the secondary and an antenna analyzer to the primary

The impedance should be 75 Ω (or 50 Ω) and a relatively flat SWR curve over the intended frequency range



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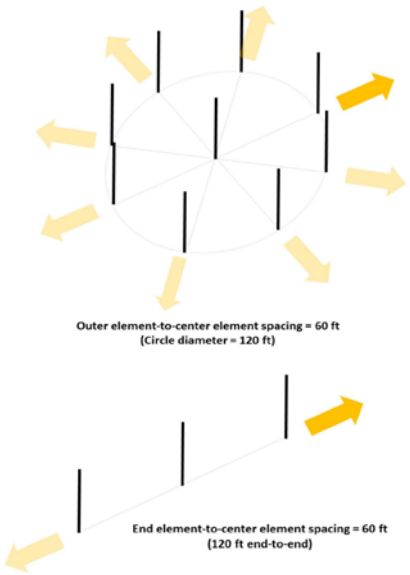
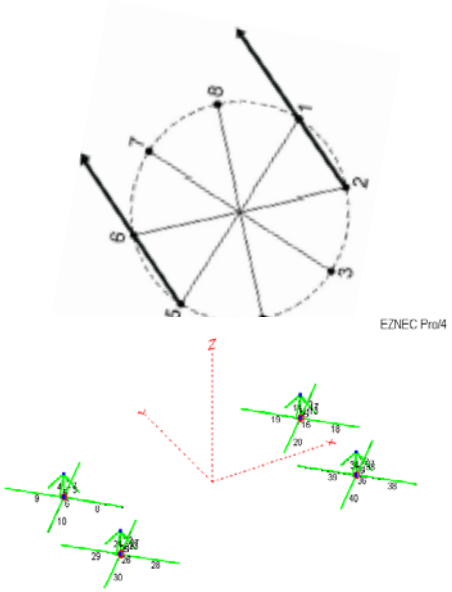
Construction Best Practices
Vertical Arrays

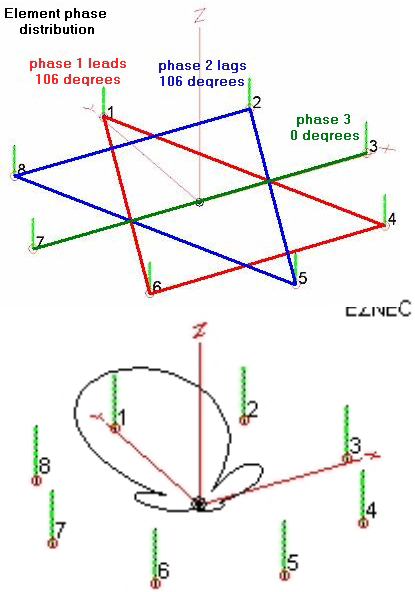
Even though there are different array designs the individual vertical element is common to all



YCCC-9



BSEF-8



HiZ-8

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Construction Best Practices
Vertical Arrays

- To obtain optimum results from a vertical array it is mandatory that your focus be to assemble each vertical element the same, using the same element material and same size/diameter
- Use an anti-seize compound on aluminum tube joints. I prefer Jet-Lube SS-30

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Construction Best Practices Vertical Arrays

- Waterproof the joint. Water can cause long-term issue in tubing joints
- Tightly wrap the joint with Scotch 2228 rubber tape. Stretch it tight beginning on the
- Cover this with Scotch Super 33+ or Super 88 tape. Stretch it tight but don’t wrinkle the turn. Overlap each turn by ½ of the tape width

Construction Practices
Vertical Arrays

Waterproof vertical element joints

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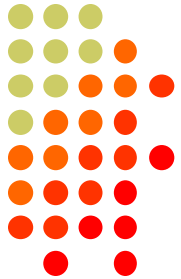
Feedline

- Feedline loss on 160 and 80 meters is low but cannot be dismissed
- For lengths less that 200 ft, RG-59 (75Ω) or RG-58 (50Ω) is acceptable
- For longer runs RG-11 (75Ω) or RG-8 (50Ω) is recommended
- Flooded cable is recommended. It is excellent in preventing moisture ingress
- Double shield is good, quad shield is excellent

Preamps

- One of the most frequent questions I'm ask about receive antennas is "Do I need a preamp"?
  - To which I always respond "I don't know, do you?"
  - Meant to encourage self-learning about preamps"
- Gain is NOT a factor for receive antennas
  - Some RX antennas have very low gain and will require a preamp
    - Loops and possibly some Beverages

Document Your Antenna's Performance



- It is mandatory that you document an antenna's performance to compare to future conditions
  - Noise floor
    - in each direction if a multi-directional array
  - Front to back & front to side, etc
- Documenting this data will allow you to assess future revisions to the design or construction, and determine if a failure has occurred
- Do *NOT* simply "assume" an improvement or failure has occurred – verify it!

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Station Improvements to Maximize Performance

Noise is the Grim Reaper of Weak Signal Reception

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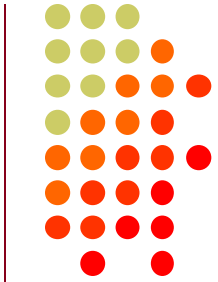
Station Improvements to Maximize Performance



- What can I do if I have installed a receive antenna that's working great, but I still have a high noise floor?
- Several years ago, the only noise threat to your station was line noise
  - Amateur radio was viewed as the noise & interference threat to consumer electronics (TV's & telephones)
- Today, consumer electronics generate significant noise and interference to amateur radio reception

Station Improvements to Maximize Performance - Noise

#1 Offender
Wall Warts

#2 Offender
Internet Modems

Others include switching power supplies, plasma TV's, medical devices, LED lights, dimmer controls

The list is endless and they are everywhere!

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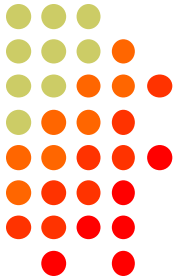
Station Improvements
Maximize Performance - Noise



- Cleaning up your station is Rule #1.
- Here are some guidelines:
  - Unplug all unused wall warts, better yet, don't use them but that's a tall order
  - If you must use a switching power supply, be very selective on what you purchase/use
  - Use high quality cables and connectors to interconnect all of your equipment.

Station Improvements to Maximize Performance - Noise

- If you are using a 12 Vdc wall wart, cut the cable off and connect it to a clean 12 Vdc power supply. Throw the wart in the trash
- Can’t live without it? Here’s how to neuter a wall wart – Toroids!!!!

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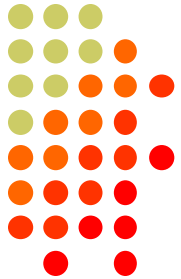
Station Improvements to Maximize Performance-Toroids



- Extremely effective – but MUST use the right ones
  - Do NOT buy something out of a tray at a hamfest or order one that simply advertises “Excellent RFI suppression”
- Use a #31 mix toroid

  Mouser # 623-2631803802

  Fair-Rite Part No:2631803802
  - If it’s a DC voltage or control cable – WRAP IT!

Station Improvements to Maximize Performance-Toroids

http://www.k9yc.com/RFI-Ham.pdf

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Station Improvements to Maximize Performance-Toroids

- Even if the internet inside your home is all wireless, it can still create noise issues
  - Any power or other cable connected to these devices is an antenna!
  - For CAT5 or 6, wrap several turns of the cable in a #31 toroid. Also use the DX Engineering DXE-ISO-Plus in-line filters

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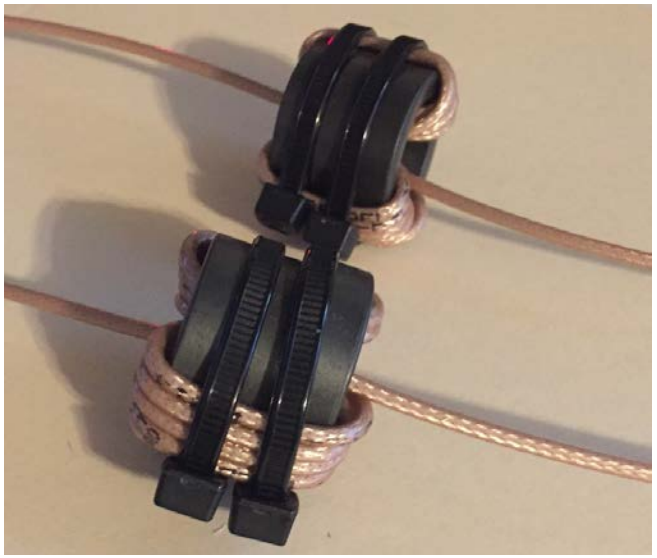
Station Improvements to Maximize Performance-Toroids

To eliminate common mode noise on the on the shield of the feedline (note this is Teflon cable)



See ON4UN's "Low Band DXing" Fifth Edition for specific details

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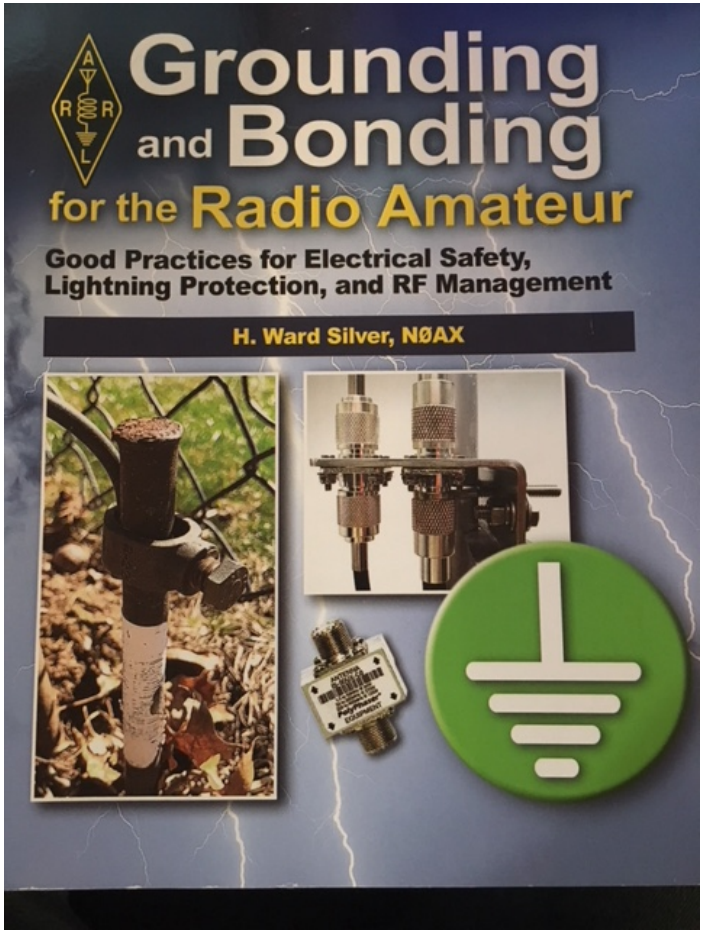
Station Improvements to Maximize Performance



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Station Improvements to Maximize Performance

- RF bonding & ground planes
  - An “RF ground” using a piece of wire is a myth!
  - Connect ALL equipment to a ground or ground plane. Ensures equipment will all be at the same potential and eliminate stray voltage and currents

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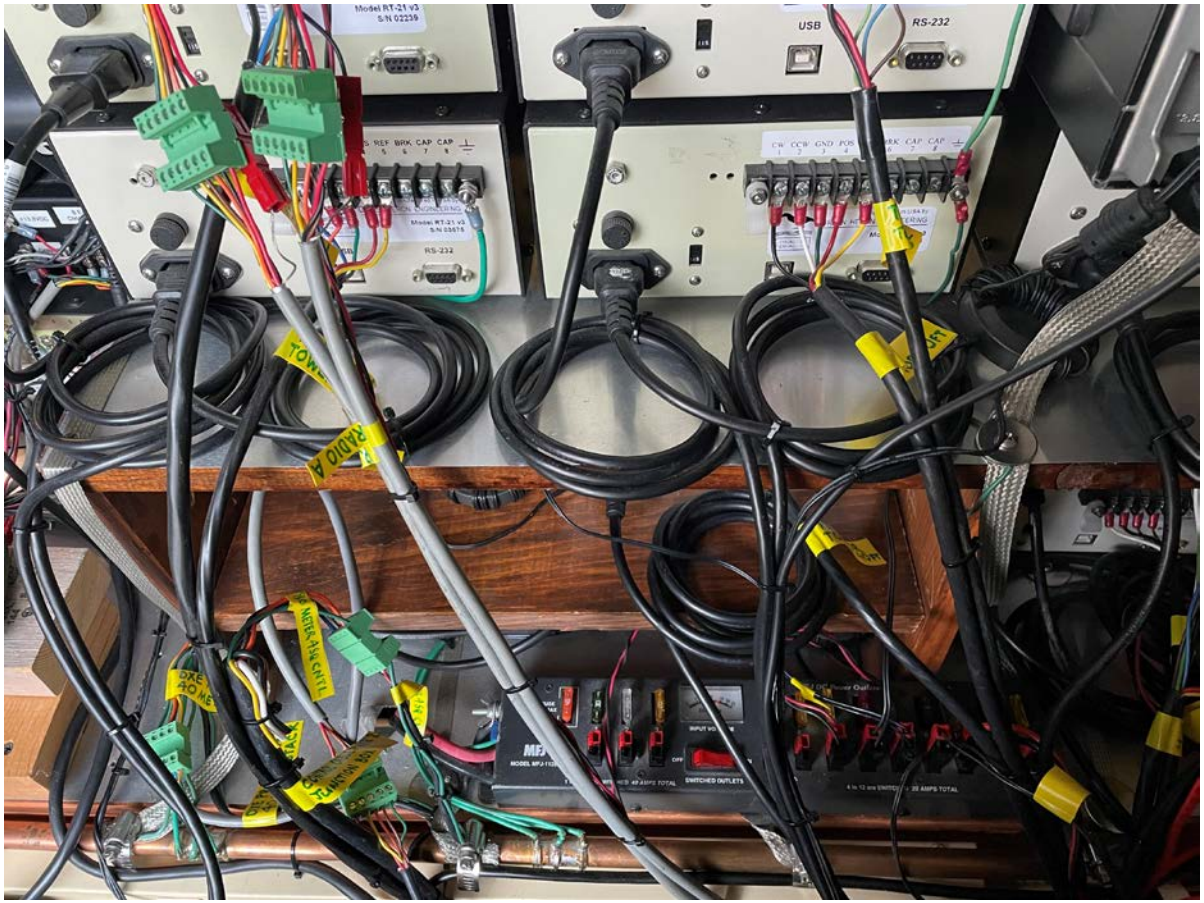
Station Improvements to Maximize Performance



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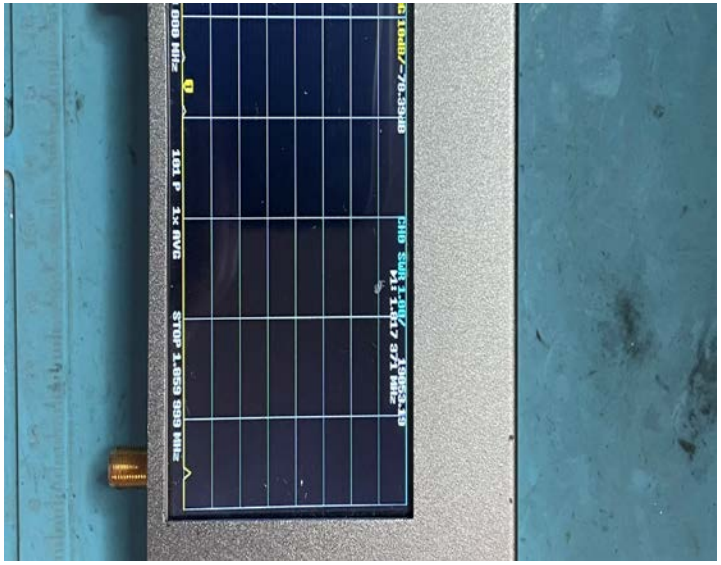
Test Equipment to Maximize Performance

The most valuable instruments you need other than a VOM

Signal Source
Elecraft XG3

Antenna Analyzer



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Summary

- Propagation is the major factor on whether you will hear DX stations after installing an RX antenna but you will notice noise reduction
- Pay attention to construction details. Do NOT think “oh this doesn’t matter”. IT DOES!
- Document your noise floor and general F/B and F/S readings immediately after installation
- Make sure your station is “clean” of noise sources

Final Thoughts

- Determine the receive antenna that fits your location and available space
- Evaluate the modeling & simulation result against the Benchmark Beverage to determine if the selected antenna meets your needs
- Build it, test it, document the results
- “GET IN THERE AND WORK ‘EM !!!!”

Thank You

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