Some Thoughts On HOA Antennas

San Juan County Amateur Radio Society

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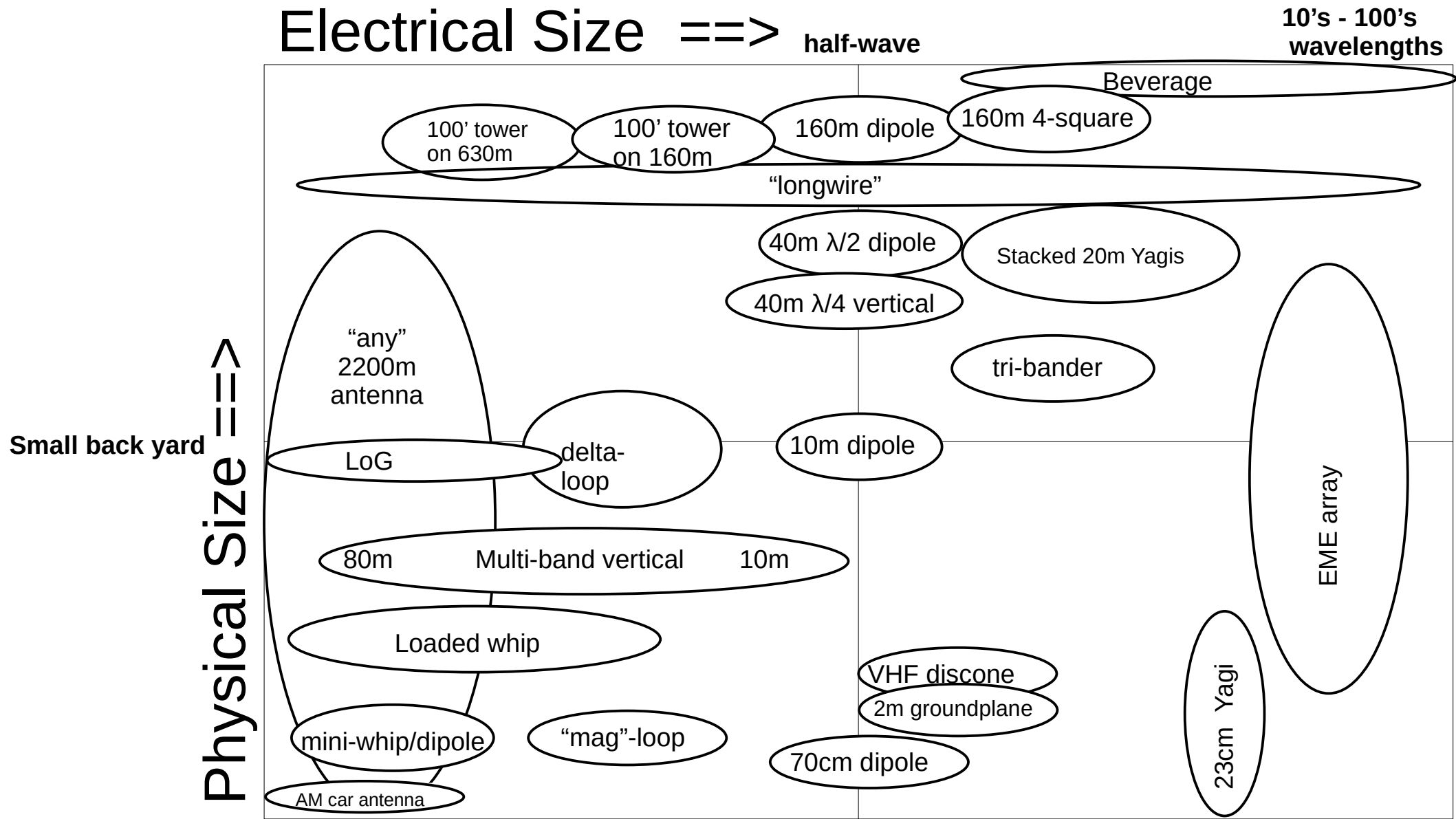
Some Thoughts On HOA Antennas

- Considering physical rather than legal HOA solutions

- Electrically small antennas have ~same gain as a half wave dipole.
  - Some antenna theory
- Receive vs. Transmit antennas – different goals, use both
  - SNR vs. power transfer efficiency; receive-only broadband ‘probes’ vs. narrowband tuned/matched transmit(&receive) antennas
- Some antennas that can work well in an HOA constrained environment
- No ‘Silver Bullet'. Each situation is unique and a great deal of effort may be necessary but major improvement IS almost certainly possible!


Electrical Size ==>
half-wave
10's - 100's wavelengths
Physical Size ==>
Small back yard
Beverage
160m 4-square
100' tower on 630m
100' tower on 160m
160m dipole
"longwire"
40m λ/2 dipole
Stacked 20m Yagis
40m λ/4 vertical
"any" 2200m antenna
tri-bander
LoG
delta-loop
10m dipole
EME array
80m
Multi-band vertical
10m
Loaded whip
VHF discone
2m groundplane
23cm Yagi
mini-whip/dipole
"mag"-loop
70cm dipole
AM car antenna

(alarming?) Antenna Theory

- For matched half-wave and smaller, **antenna size doesn't matter!**

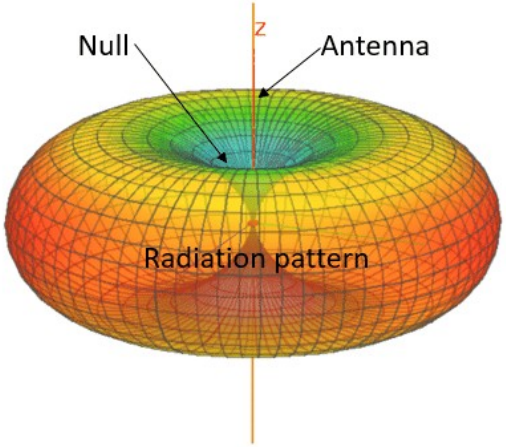
  ERP and Signal to Noise Ratio(SNR) < .5 dB different (one tenth of an S-unit)

  e.g. at LF-HF a 1 inch antenna and a half-wave dipole have ~same pattern,capture area,aperture and the same SNR.

  See http://wsprdaemon.org/ewExternalFiles/N6GN_Notes_on_Improving_Station_Noise_Performance03.pdf

Physics:

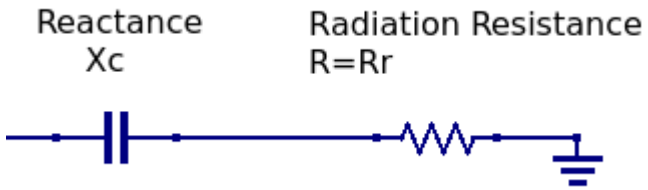
Conservation of Energy
Lorentz Reciprocity Theorem



Transmit or Receive, λ/2 and smaller, antennas have almost exactly the same aperture, pattern & gain

(alarming?) Antenna Theory

The difficulty in making electrically small antennas work well is in **matching** and coupling to the *radiation resistance,* R_r, which is related to electrical size/height, (not the R measured at the feed point)

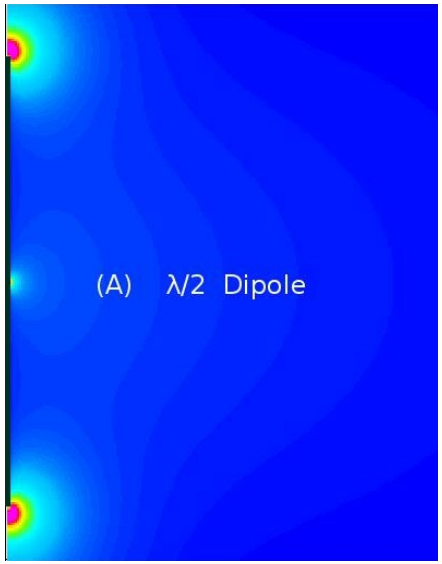


R_r varies as the square of length and gets extremely small for short antennas at the same time reactance gets very high. This high Q situation can quickly become impossible to match.

Antenna elements don't actually radiate! Antennas are **INVISIBLE** !

- The antenna is a region of space where radiation is converted to/from moving charge, the part we see and call an 'antenna' is actually a matching network.

http://www.sonic.net/~n6gn/Elmore3.pdf, & QEX Magazine Jul/Aug 2012



Receive vs. Transmit Antenna Goals

- A receive antenna system needs to achieve a low noise floor *compared to* propagated noise levels within its $\boldsymbol{R_r}$

  Feed Line common mode currents, imperfect baluns and near-field QRN can easily dominate to raise the noise floor and reduce SNR.

  Coaxial line without adequate balance DOES NOT ACT AS A SHIELD to common mode noise ! Commercial wideband ferrite baluns are often not sufficient to prevent noise floor degradation.

- A transmit antenna system needs to efficiently match the transmitter to the $\boldsymbol{R_r}$ in order to generate Effective Radiated Power (ERP)

  Losses can easily dominate and reduce ERP. Most of the transmitter power can go into heating earth, foliage & matching networks (antenna tuners etc.).

Receive Goal: ITU-R P.372-8 propagated noise

Noise Level, F_a, compared to thermal Noise, KTB

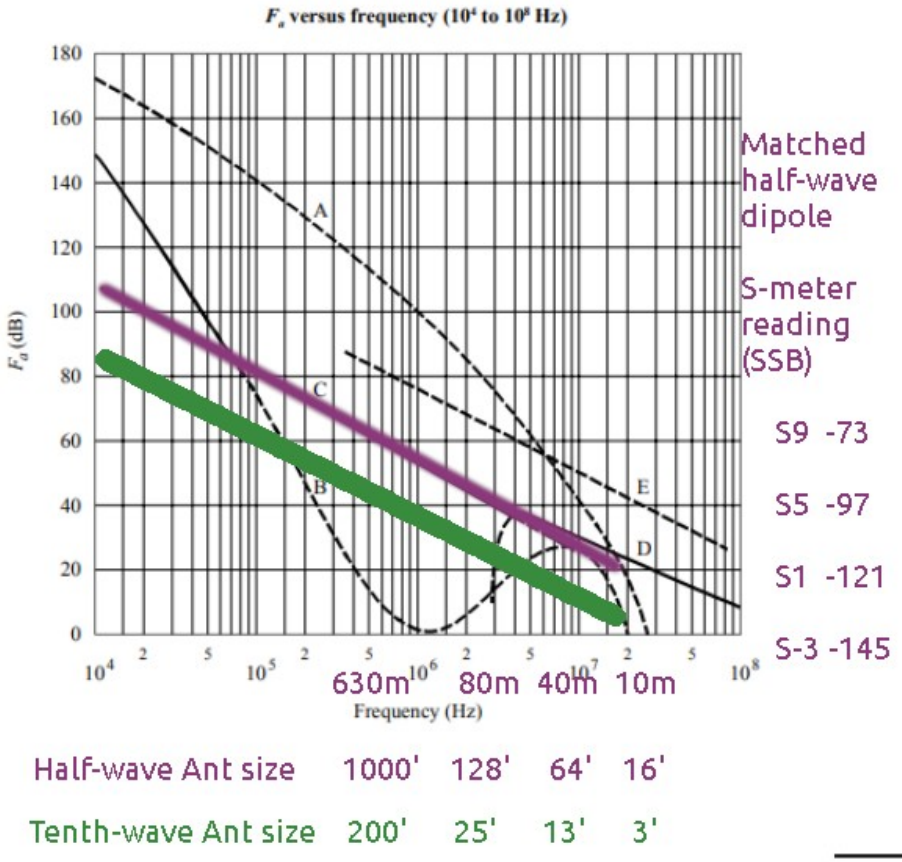
For a Small Antenna, $R_r = 20\ (\pi\ L/\lambda)^2$

Example:

for antenna length, L= .1 λ,

(20% of a half-wave dipole)

R_r = only 2 ohms and without Transformation the available signal at the 50 ohm receiver is -15 dB, 2 ½ S-units LOWER . The unwanted system noise must be this much lower to achieve equal performance.



Noise power in an antenna *when matched* to its R_r

Measured in a 2.5 kHz SSB bandwidth.

Transmit Goal – maximize ERP

Transmit Antennas

- low matching/tuner & ground/foliage absorption/loss.
  - Here bigger *is* easier to match and so better.
  - larger antennas have lower fields in their vicinity, lower environmental losses
  - usually H polarization not desirable due to higher ground loss and high take-off angle.
  - Height may help somewhat, to reduce absorption, improve take-off angle and to a degree, increase SNR

HOA Antennas That Can Perform Well

- Receive Antennas

  Use symmetry to reduce image plane (ground/radial) losses and to limit common mode noise ingress. Vertical dipoles better than whips.

  Use ‘probe antennas’ along with very high impedance preamplifiers (not 50 ohm!) to achieve ***broad bandwidth*** and high SNR. Loop with a low impedance preamp can achieve similar results.

  You probably already use one of these.

Small or Invisible Antennas

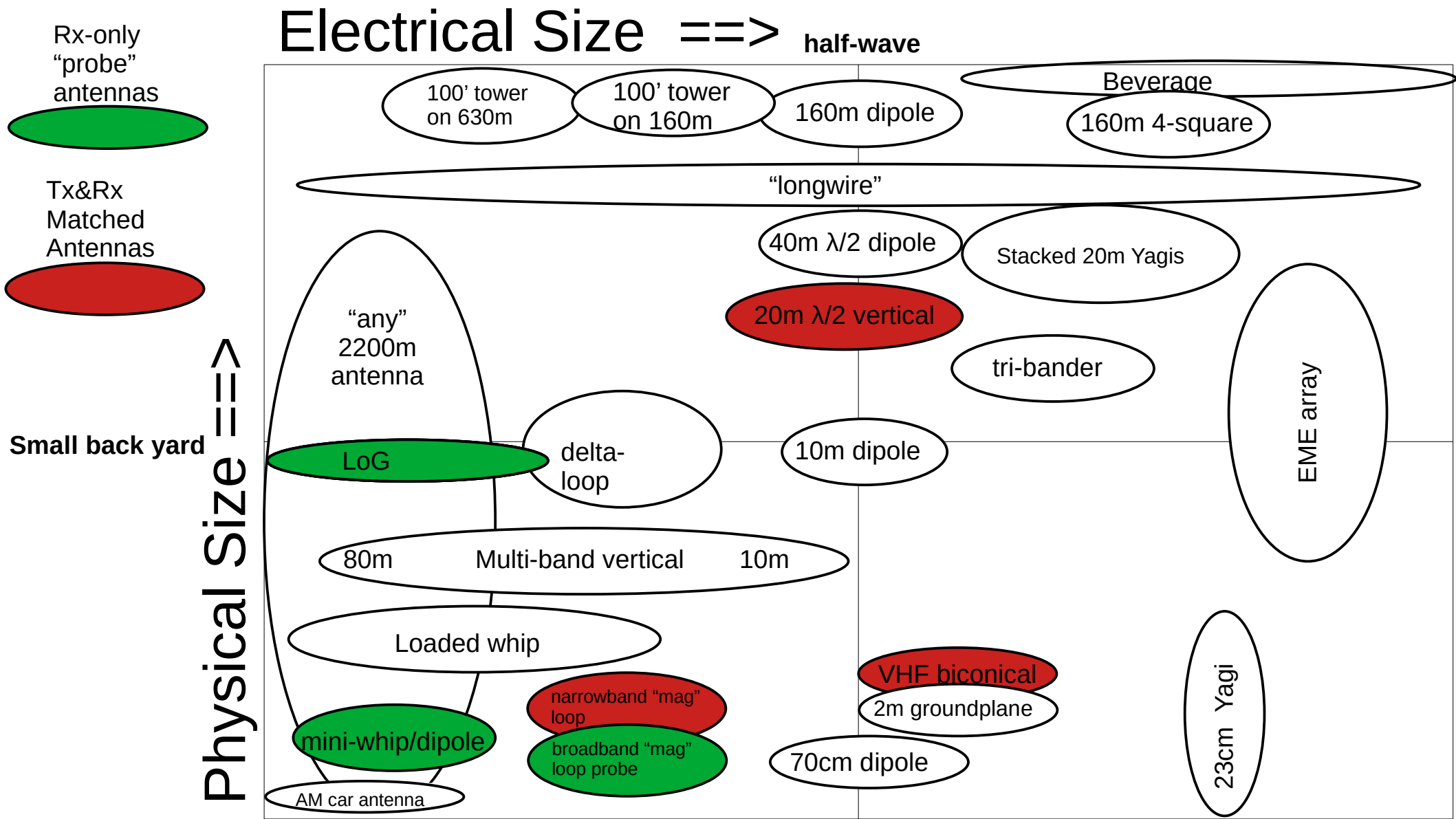
- Broadband coupling for receive & narrowband matching for transmit matching methods are key

  - On transmit, ground losses (earth, foliage & radial systems) may dominate when compared to radiation resistance. High Q and large fields.

    example: 630m/474kHz radiation resistance of a 60’ vertical < .1 ohms, compared to typical 20 - 30 ohm ground/matching resistance which is in series with it at the feed point.

    Efficiency may be -25 dB. 100W transmitter power ==> 300 milliwatt ERP.

  - On receive, small R_r means lower signal voltage, common mode and near-field QRN, can easily dominate and reduce SNR. Antenna symmetry, excellent balance and low noise preamp necessary if all voltage developed across R_r is to be transferred to the receiver and SNR maintained. One must carefully manage unwanted near-field QRN as well as symmetry/balance and common mode noise current. **Watch out, your ‘antenna’ may actually be your feed line !**


Rx-only "probe" antennas
Tx&Rx Matched Antennas
Small back yard
Electrical Size ==>
half-wave
Physical Size ==>
100' tower on 630m
100' tower on 160m
160m dipole
Beverage
160m 4-square
"longwire"
40m λ/2 dipole
Stacked 20m Yagis
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Multi-band vertical
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Loaded whip
VHF biconical
2m groundplane
narrowband "mag" loop
mini-whip/dipole
broadband "mag" loop probe
70cm dipole
23cm Yagi
AM car antenna

Antenna placement for low near-field QRN

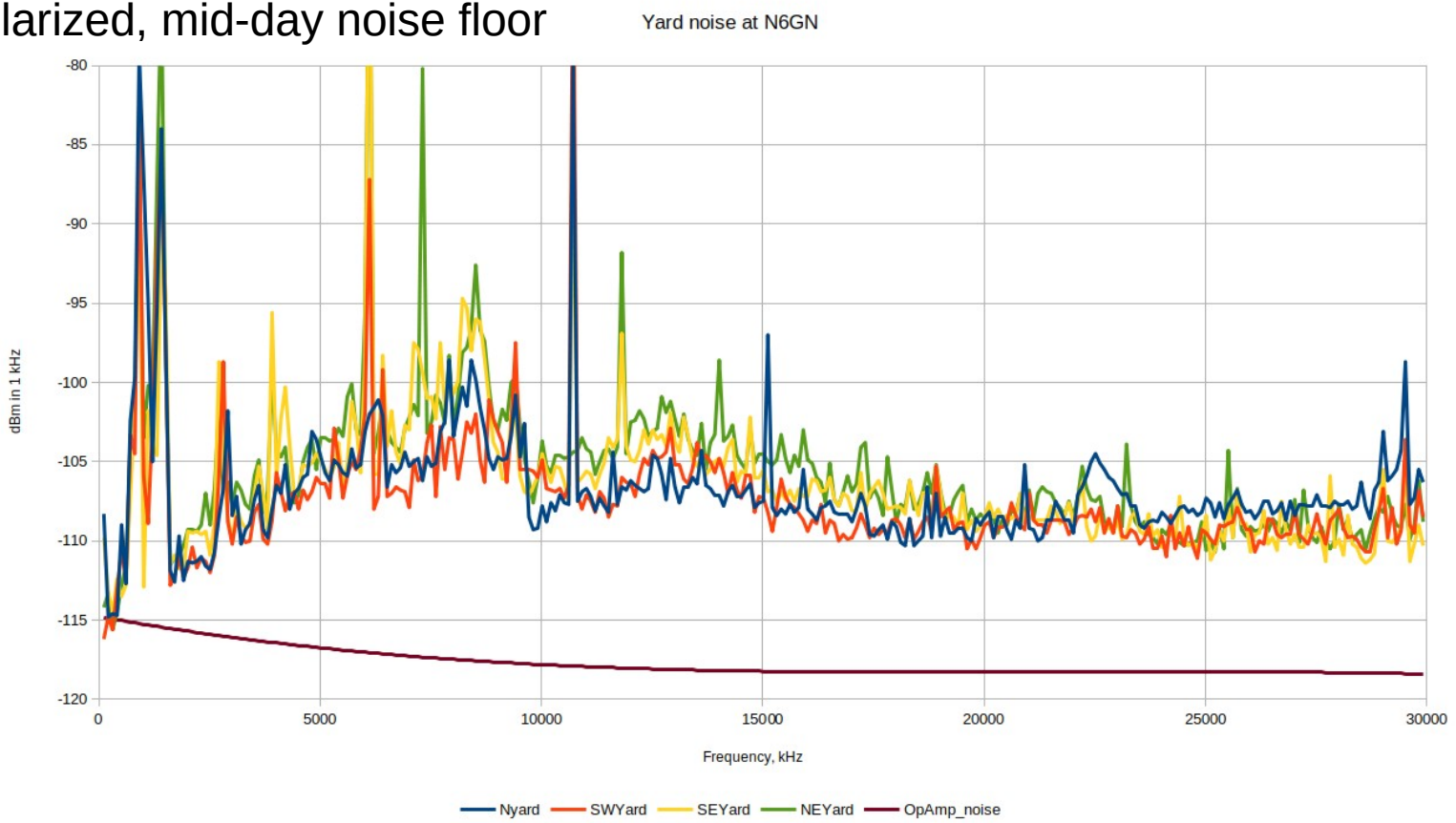
- A small ‘probe’ antenna for 10 kHz - 30 MHz, can be first used to ‘map’ a QTH to find lowest *near-field* noise location and then placed for permanent operation.

- Use “Magnetic” loop (LZ1AQ https://active-antenna.eu/amplifier-kit/) or N6GN dipole ‘probe’ antennas (shown)

  Near-field noise drops very rapidly with distance. (This saves the day!)

Near-field QRN variation in backyard

Vertically Polarized, mid-day noise floor

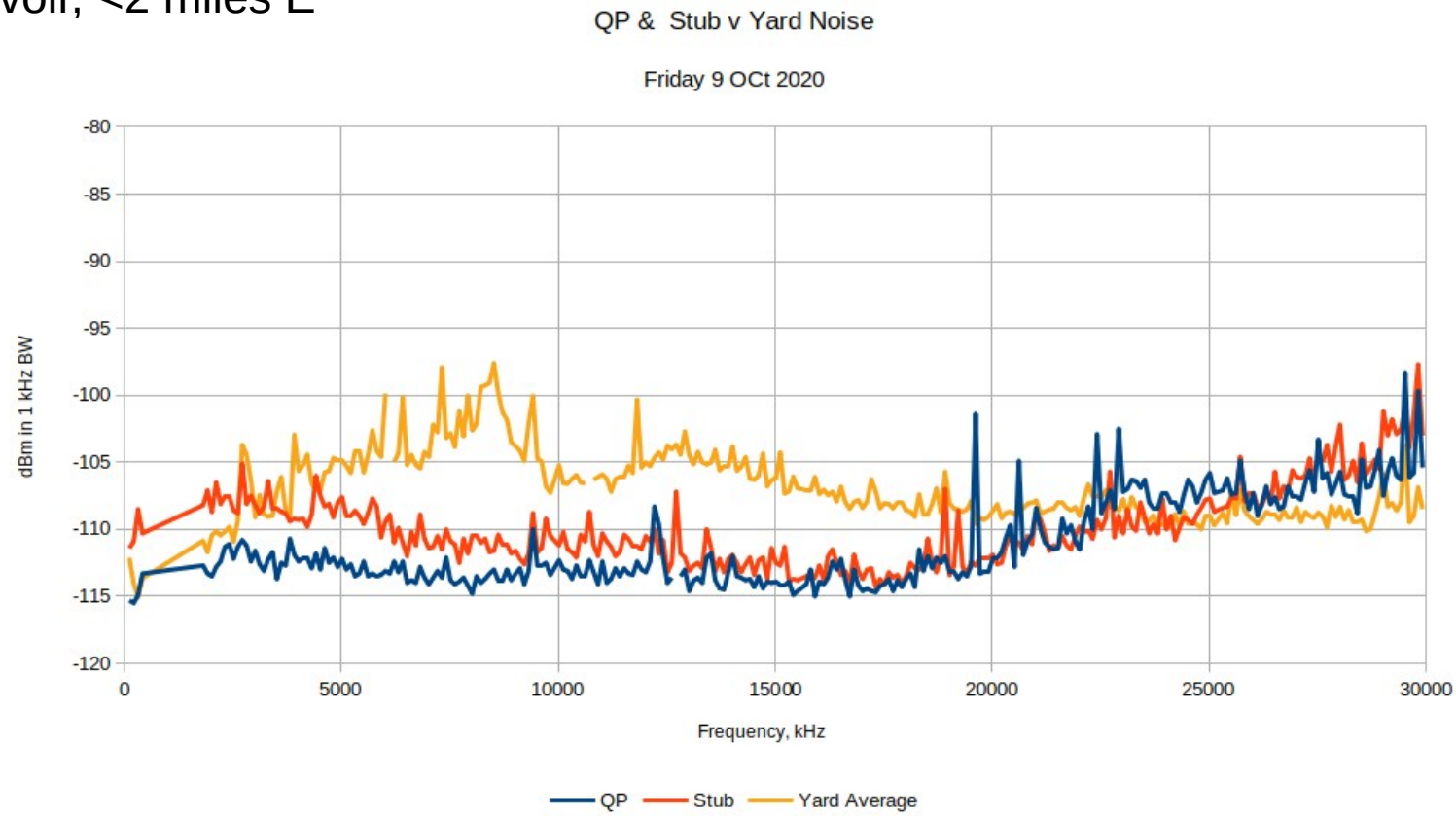


Mid-day Local Noise Comparisons

QP – Fossil Creek Reservoir, <2 miles E

Stub – 3000’ SE

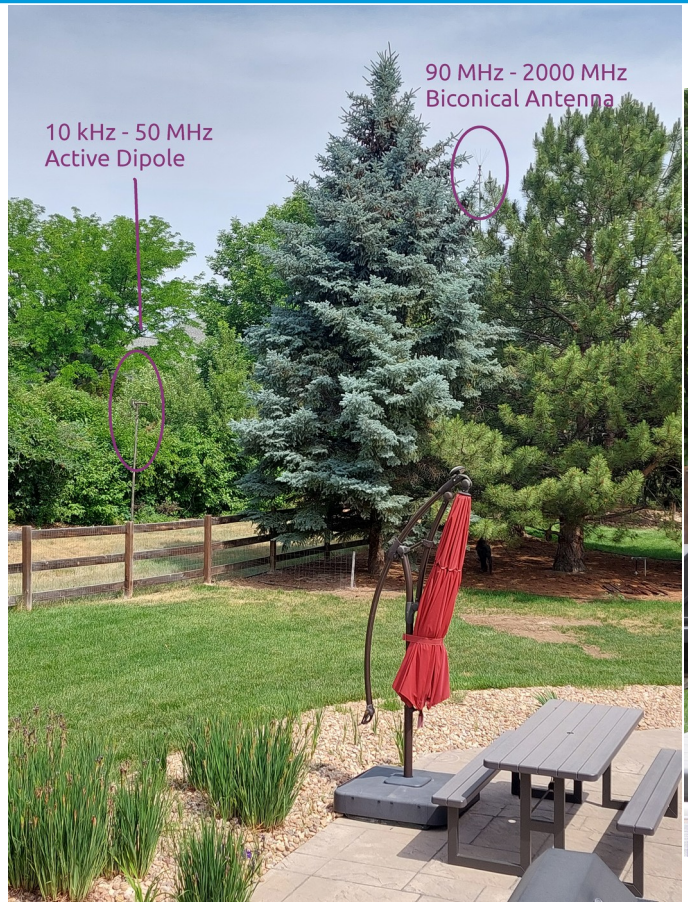
Yard – N6GN QTH

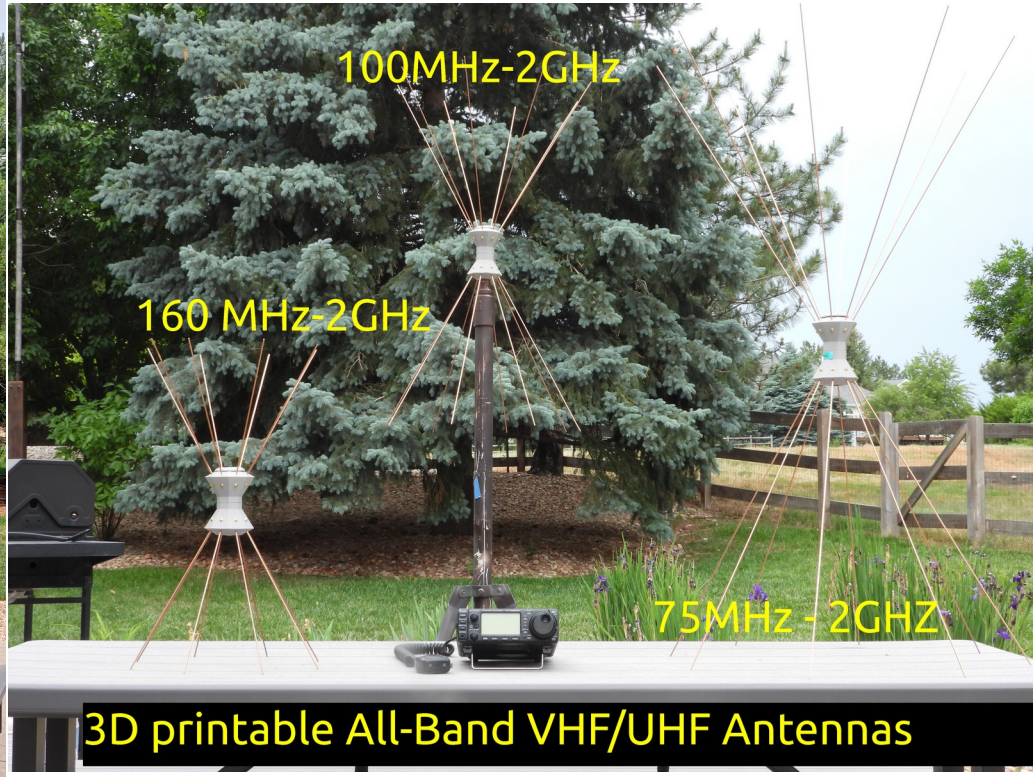


Practical HOA **VHF/UHF** Antenna examples

Matched, for both Receive & Transmit:

100 MHz – 2000 MHz (3D printed) biconical Antennas half wave, not electrically small.





Example HOA HF ‘Invisible’ Antenna

Matched: Receive & Transmit for HF:

Antenna does not need to be resonant!
Does need to be well matched.
(The fallacy of SWR).

Usable over MW-HF. Half-wave (or smaller) dipole on an insulated mast supporting a “weather station”, fed with balanced line and balanced tuner on HF, monopole at LF-HF.

Hybrid Receive Antenna Example

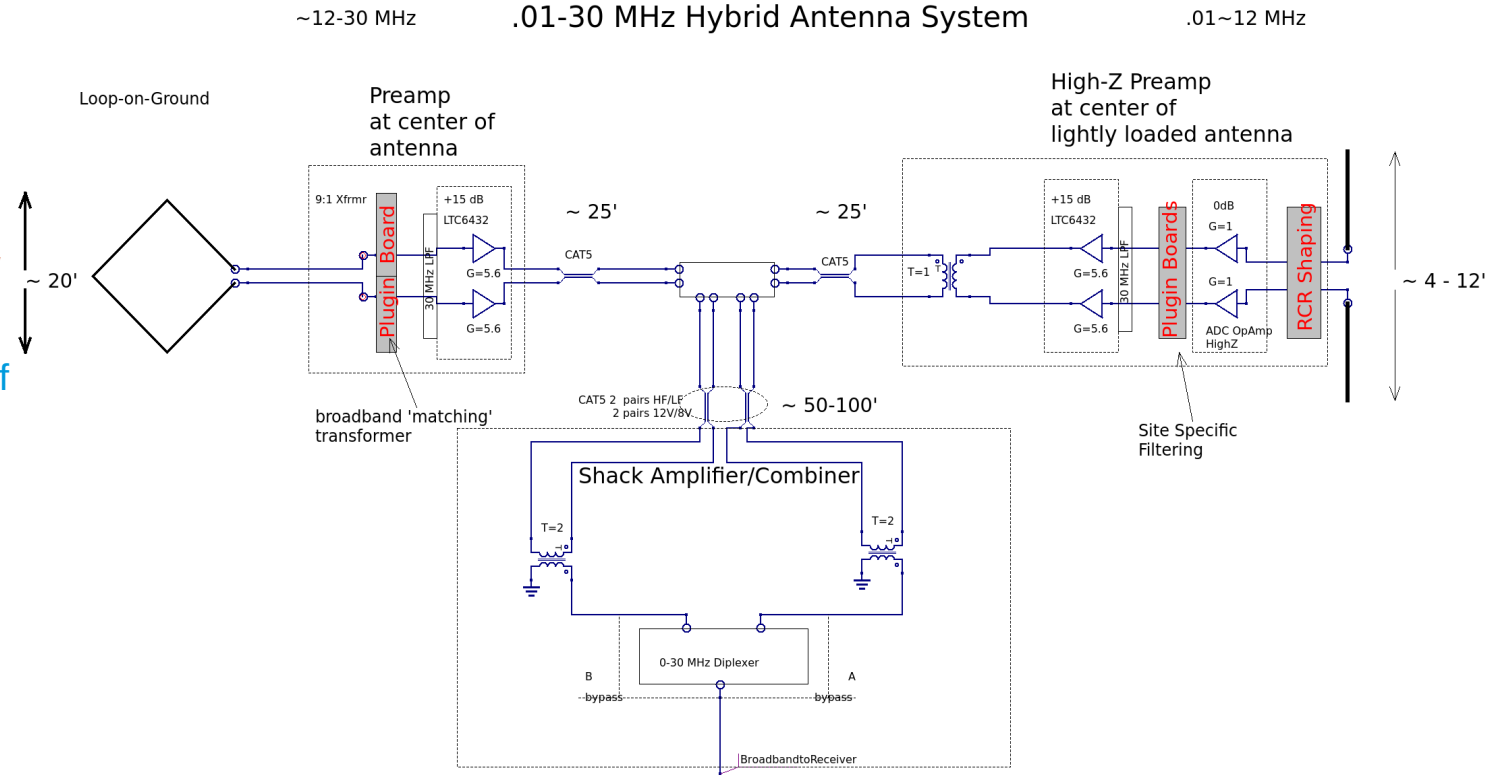
Loop_on_Ground + Active Dipole

- N6GN Active Dipole
- LoG http://www.kk5jy.net/LoG/
- This combination at N6GN/K is near the top of North American WSPR rankings.

  Should pass almost any HOA requirements!

  Try it out at

  http://n6gn.no-ip.org:8075



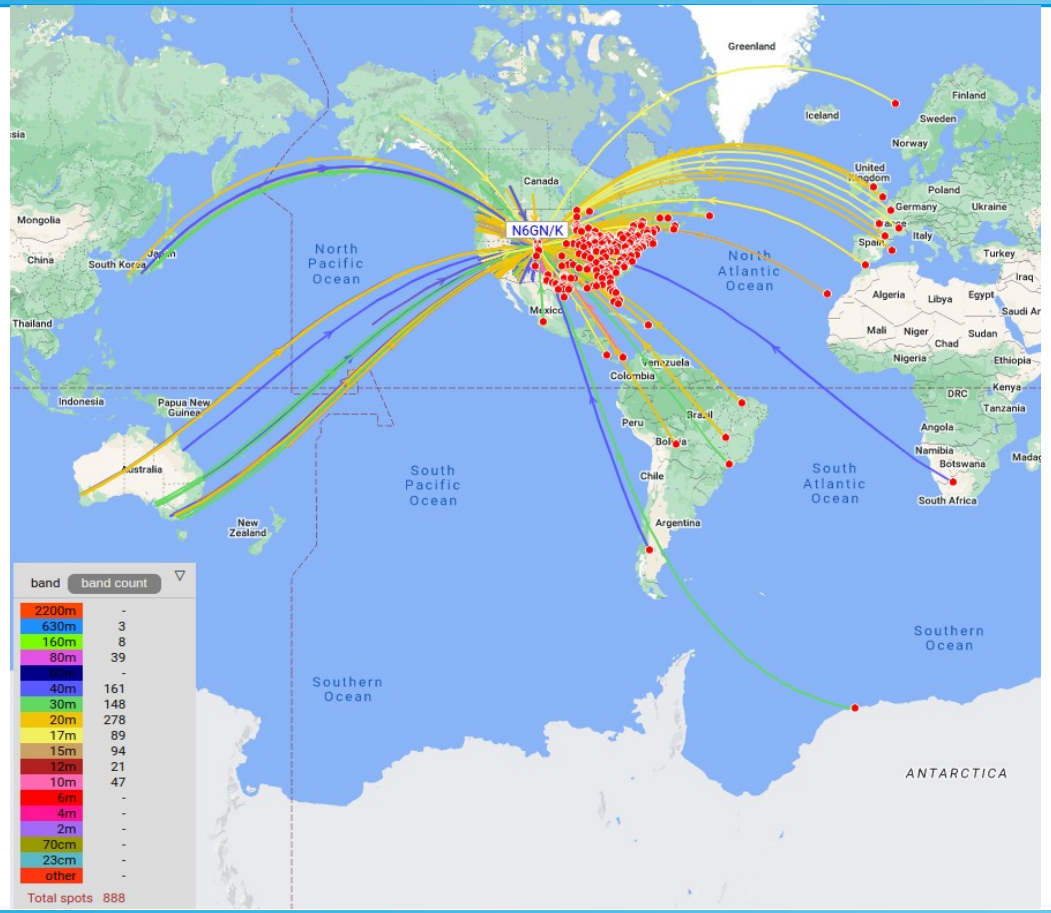
N6GN/K WSPR spots

Typically receives all 7 continents in 24 hours, all bands from 2200m -10m

http://wspr.rocks/
https://www.pskreporter.info/pskmap.html

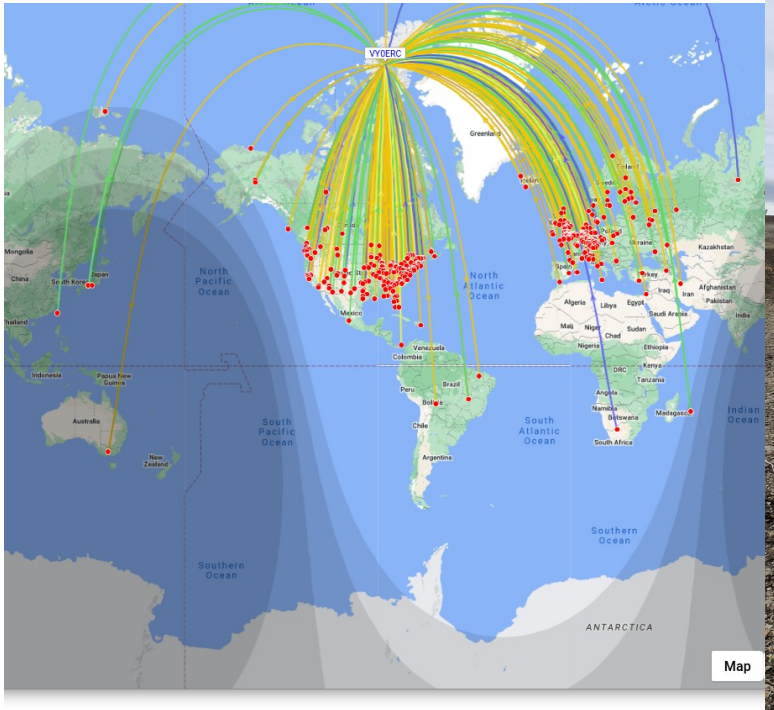
This performance is due to managing the receive system noise floor. Done with HOA-friendly snow/ice tolerant antennas.

A quiet location but only 1 ½ S-units better than what can be done in residential Fort Collins.



VYOERC at 80 degrees North

24H WSPR spots from Ellesmere Island with hybrid antenna system



Polar Environmental Atmospheric Research Laboratory
https://www.pearl-candac.ca

Summary

- Work on receive first, reduce receive system noise floor
  - Remove common mode noise ingress mechanisms
  - Consider a ‘probe’ antenna and broad band analysis
  - Map your environment (location and polarization)
  - Play ‘whack-a-mole’ with QRN sources *only* as a last resort
- For transmitting, worry about coupling to the radiation resistance – not the SWR Bridge !

It takes effort but an ‘HOA-acceptable’ antenna system CAN work well!