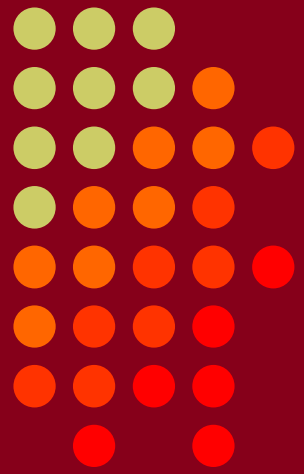
# CTU Presents

# Field Measurements and Comparison of Low Band Receive Arrays



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# Objectives

- What you should expect from a receive antenna based on station location
- Understand why we use receive antennas
- Understand the difference between vertical arrays
- Review of field measurements
- Vertical array comparison

# 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

# Comparing Receive Antennas

- 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.

# Comparing Receive Antennas

- 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

# Comparing Receive Antennas

- 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!

# Comparing Receive Antennas

- Even close to home, K5UR is 25 miles SW and WD5R is 20 miles north.
  - 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 Carl Luetzelschwab, K9LA.

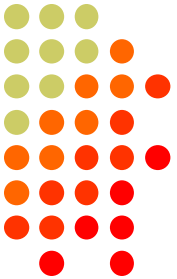
# Comparing Receive Antennas

- My objective was to have all vertical arrays and Beverages erected at my location in order to achieve an as near perfect “A-B” test possible and not rely on comparative readings from another station some distance away.

# Differences in Vertical Arrays

- The BSEF-8, HiZ-8A, and YCCC-9 vertical arrays are not identical and the differences, often confused by radio amateurs, should be understood.
  - There are also several versions of HiZ receive arrays
- High impedance -vs- low impedance
- Active -vs- passive

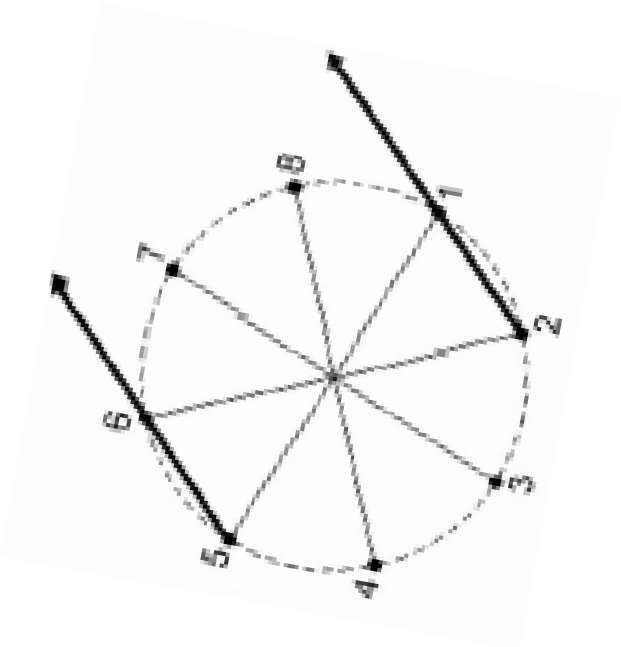
# Broad Side End Fire (BSEF) 8 Vertical Array

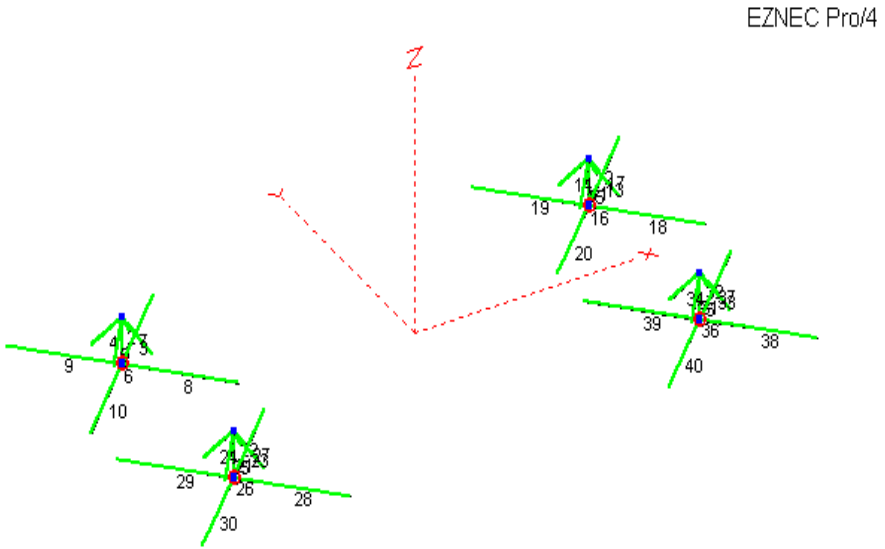


- Uses 25’ “umbrella” verticals
- Typically low impedance
  - 75 Ohm impedance
  - Vertical element natural resonance ~3.9 MHz
  - Requires short radials to stabilize the low feedpoint impedance
  - Does not require amplifiers at elements
- Requires a large area ~350’ diameter

# Broad Side End Fire (BSEF) 8 Vertical Array

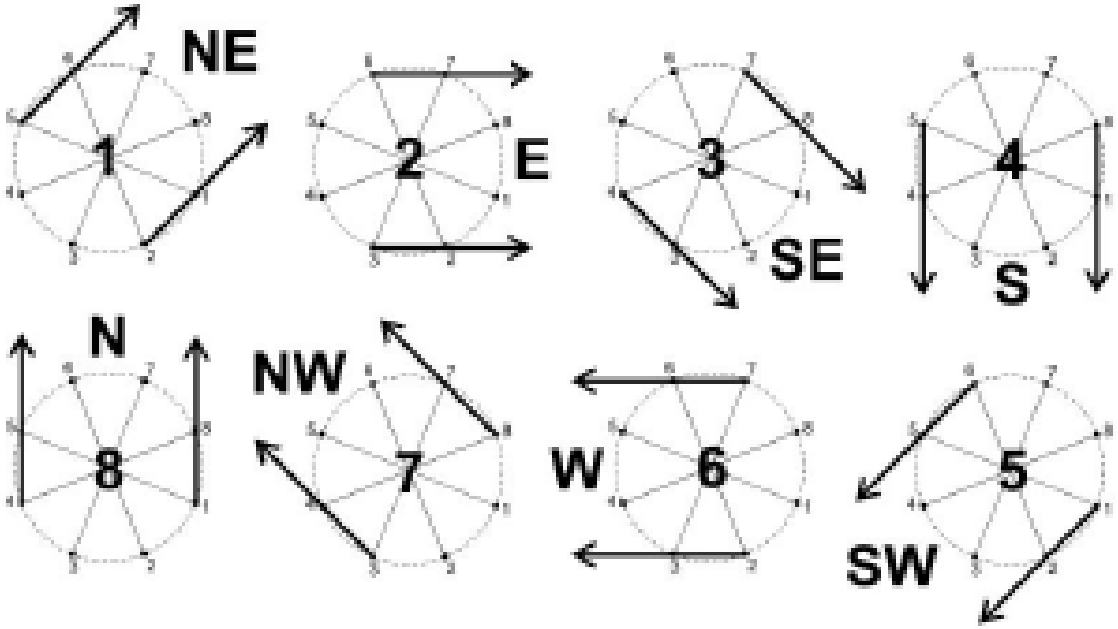
- Even though it contains 8 verticals, only 4 are used for any one direction



# Broad Side End Fire (BSEF) 8 Vertical Array

- Passive array but can be configured as active high impedance system

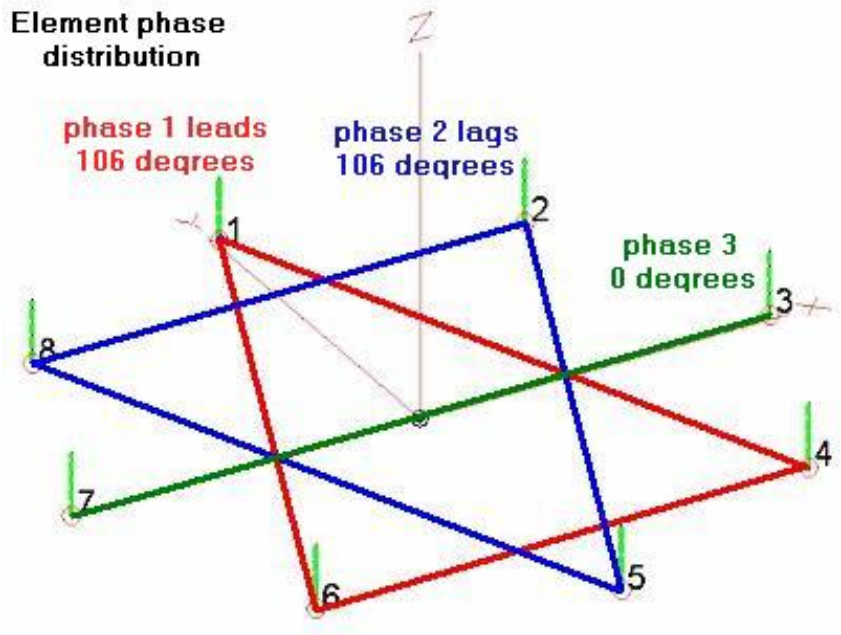


# HiZ-8A

- Uses 18’ to 25’ vertical elements
  - No top hat wires or radials required
  - Uses high impedance amplifier at each element
  - Feedpoint impedance ~3KΩ
- 160 meter version requires 200 ft diameter
- 80 meter version requires 100 ft diameter

# HiZ-8A

- Uses all 8 verticals with active high impedance amplifiers phased together for any one direction.



# Other Hi-Z Arrays

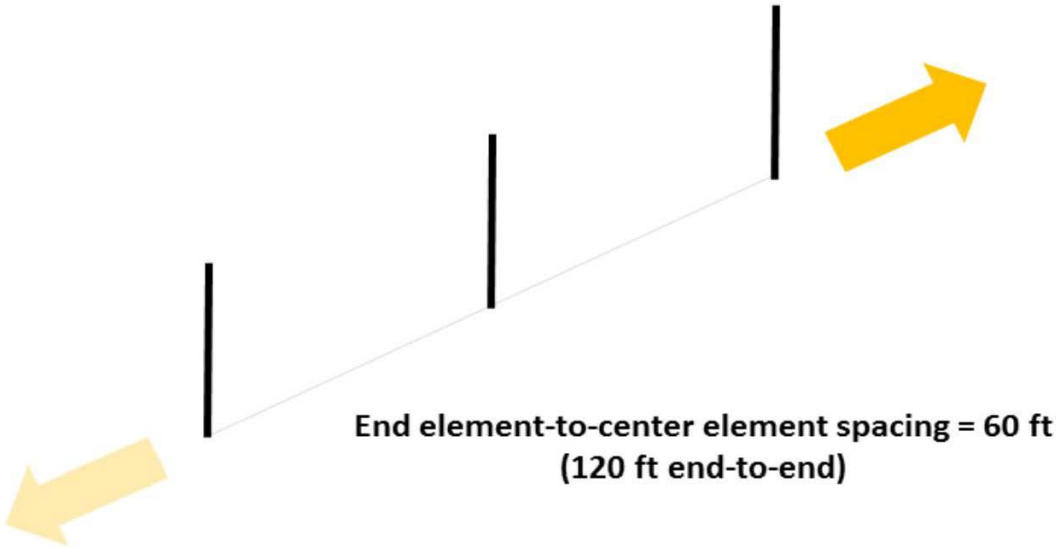
- Not yet evaluated the other Hi-Z arrays
  - HIZ-PC-8PRO
    - 8 vertical array
    - 85’ or 113’ diameter circle
    - Claimed 12.1 dB RDF, 30 dB F/B
  - HIZ-PC-4A
    - 4 square vertical array
    - 60’ or 80’ per side element spacing
    - Claimed 12.1 dB RDF, 30 dB F/B

# YCCC-9

- Designed by John Kaufman, W1FV
- Uses 15’ to 25’ vertical elements
  - No top hat wires or radials required
  - Uses high impedance amplifier at each element
  - Feedpoint impedance ~3KΩ
  - Requires a preamp on output of combiner
- Requires 120’ diameter for 8 directions
  - Covers 160-80-40 meters

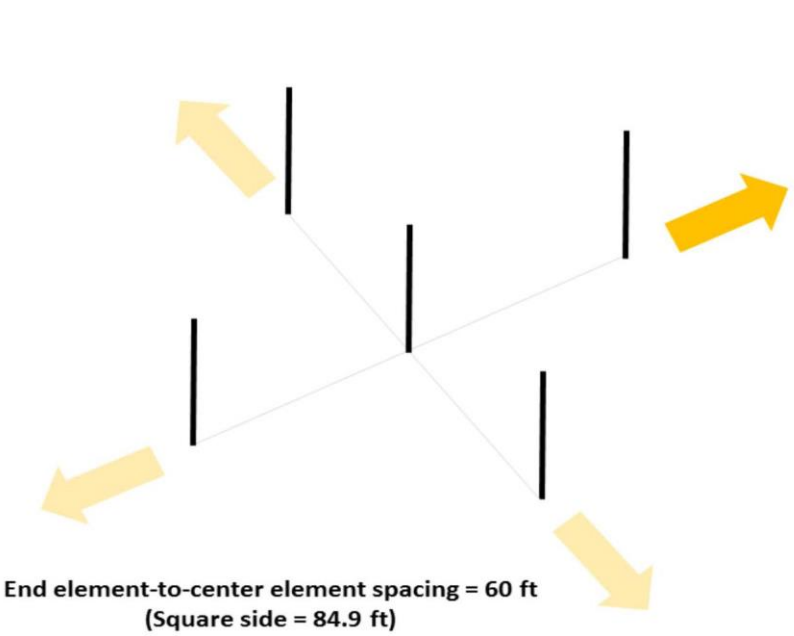
# YCCC-9

Uses 3 inline verticals with active high impedance amplifiers

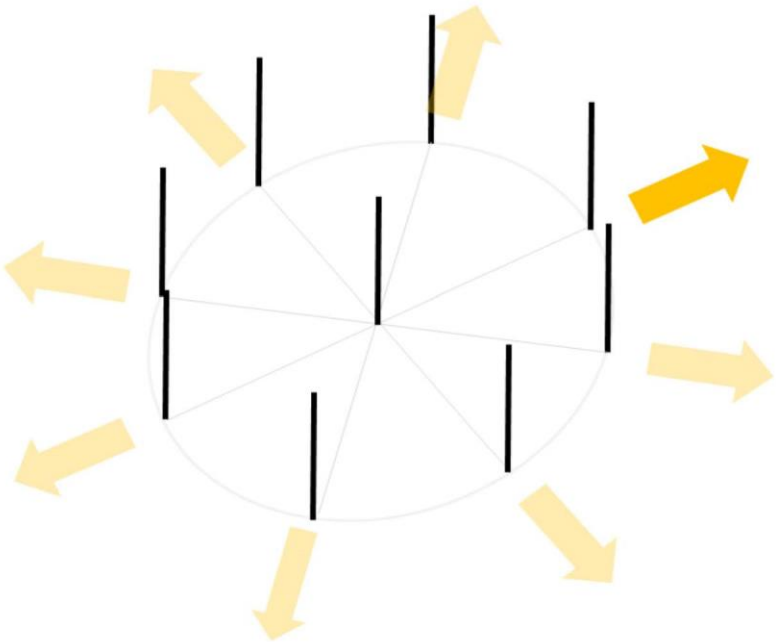


# YCCC-9

Can be configured with up to 9 verticals for eight direction coverage



End element-to-center element spacing = 60 ft
(Square side = 84.9 ft)



Outer element-to-center element spacing = 60 ft
(Circle diameter = 120 ft)

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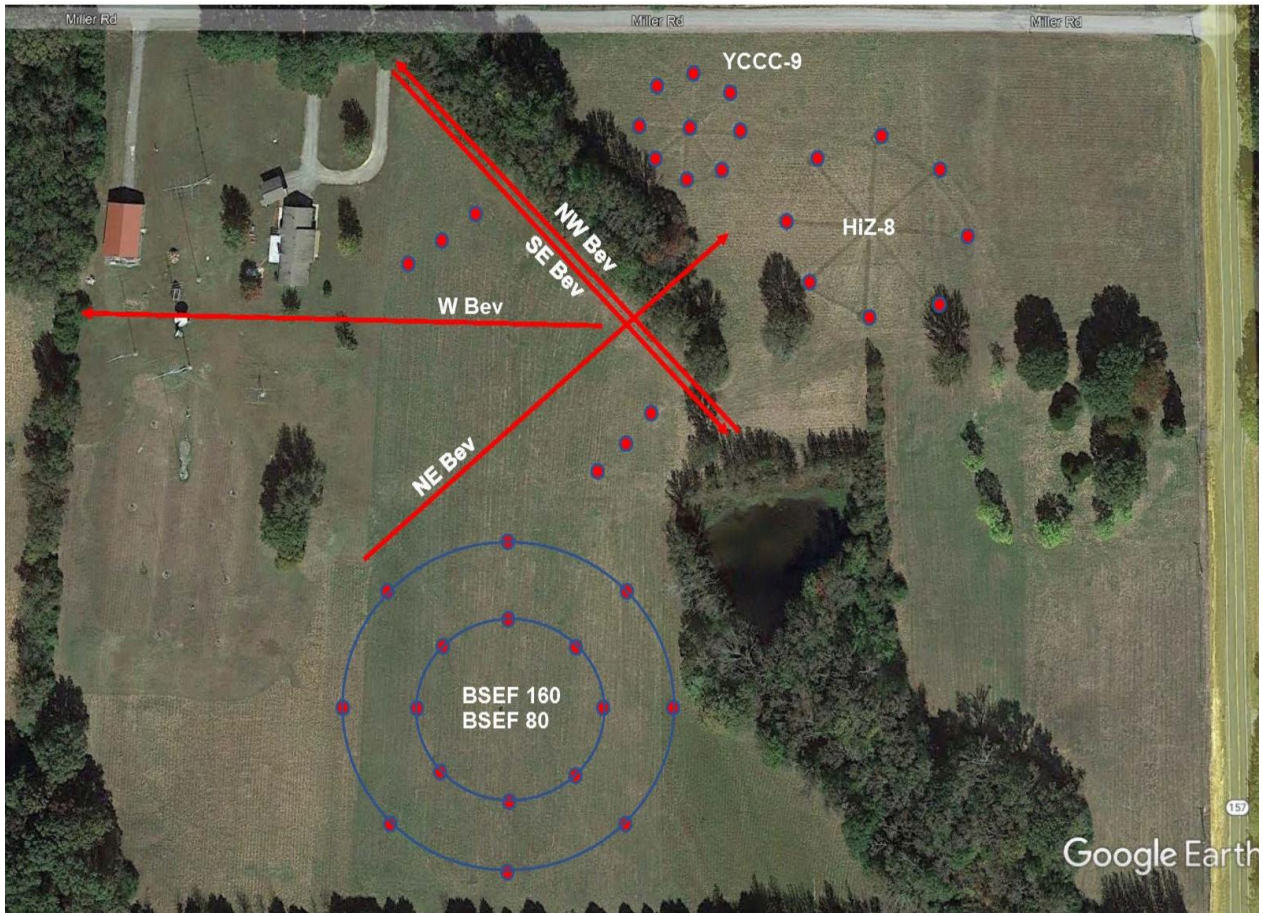
# Vertical Array Pro –vs- Con

| BSEF-8 | | HiZ-8A | | YCCC-9 | |
|---|---|---|---|---|---|
| **Pro** | **Con** | **Pro** | **Con** | **Pro** | **Con** |
| No expensive Electronics | Requires short radials to stabilize feedpoint impedance | No element tuning required | Requires 12 Vdc at phasing unit and at all ele amplifiers | No element tuning required No radials required | Requires 12 Vdc at phasing unit and at all amplifiers |
| Ele & switch unit verify with simple antenna analyzer | Requires a large land area (~350’ dia.) | No radials required | Requires expensive electronics | Requires smaller area than BSEF, HiZ or Beverage | Requires active electronic components |
| Only need to 4 ele for 2 direction | Elements require “top hat” wires | Requires smaller area than BSEF or Beverage | Components not repairable at home | Only need to 3 elements for 2 direction | |
| | Requires additional posts for top hat wire support | Exceptional RDF and F/B pattern | Must utilize all 8 elements for any one direction | Performance equal to 540’ Beverage | |

# RX Antennas at W5ZN

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# Data Recorded for Each Antenna

- Noise floor in each of eight directions
- Peak received signal above noise floor
- Peak received signal compared to the seven other azimuth directions
  - Front to side, front to back, etc

# Equipment Used for Measurements

2 – Elecraft K3 Transceivers & NaP3 Panadapter Software


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# Equipment Used for Measurements

- 2 – LP-Pan SDR Receiver


- Elecraft XG3 Signal Generator


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# Calibration Procedure

- Measure cable loss from array to station
  - At W5ZN the BSEF & HiZ are 800 ft from station, YCCC-9 is 500 ft.
- Inject -73 dBm (S9) and -107 dBm S3) signal into K3
  - Verify accurate signal readings appear on NaP3 Panadapter

# Recording Procedure

- Record peak, F/B, and F/S received signal readings
  - Relative to the noise floor
- Understand amplitude variations due to spatial separation between antennas

# RX Antenna Signal Comparison

| Station | HiZ-8 Signal above noise (dB) | BSEF Signal above noise (dB) | YCCC-9 Signal above noise (dB) | Beverage Signal above noise (dB) |
|---|---|---|---|---|
| F2DX | 14 | 14 | 11 | 10 |
| FT4TA | 3 | 2 | 0 | 0 |
| E51NOU | 2 | 2 | 0 | 0 |
| W1AW/KH8 | 11 | 10 | 8 | 8 |
| F2DX | 18 | 19 | 15 | 15 |
| VK3XQ | 12 | 11 | 7 | 6 |
| 5W0UU | 18 | 20 | 11 | 10 |
| 9K2HN | 0 | 2 | 0 | 0 |
| V63DX | 2 | 1 | 0 | 0 |
| KH6ZM | 18 | 19 | 16 | 15 |
| W1AW/KH6 | 14 | 13 | 10 | 8 |
| JE1BMJ | 12 | 11 | 9 | 8 |
| W1AW/KH6 | 20 | 20 | 17 | 17 |

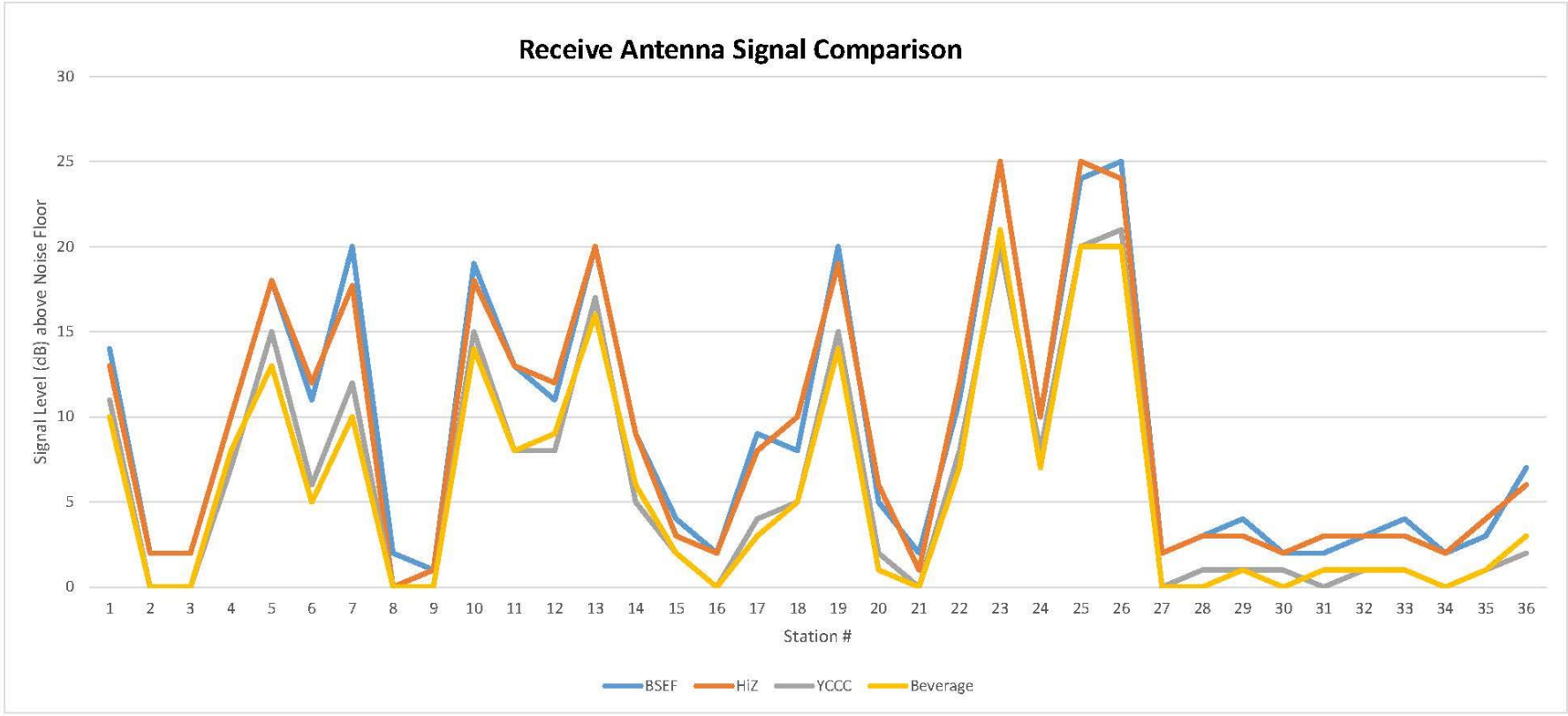
# RX Antenna Signal Comparison

| Station | HiZ-8 Signal above noise (dB) | BSEF Signal above noise (dB) | YCCC-9 Signal above noise (dB) | Beverage Signal above noise (dB) |
|---|---|---|---|---|
| JD1BMH | 6 | 5 | 2 | 1 |
| SP5GPM | 1 | 2 | 0 | 0 |
| DU7ET | 12 | 11 | 8 | 8 |
| HL5IVL | 25 | 25 | 23 | 22 |
| JD1BMH | 11 | 10 | 8 | 7 |
| K5P | 24 | 25 | 23 | 23 |
| VP8STI | 2 | 2 | 0 | 0 |
| VP8SGI | 3 | 3 | 2 | 0 |
| RA0FF | 3 | 4 | 2 | 2 |

# RX Antenna Signal Comparison

| Station | | | |
|---|---|---|---|
| 3C0W | A35T | HL5IVL | VP8STI |
| 3DA0IJ | BD4WN | JD1BMJ | VQ9LA |
| 3X5A | DU7ET | JT1CO | XU7ACY |
| 5V7D | E44CC | OD5NJ | Z81X |
| 5W0UU | E51NOU | RA0FF | ZD8W |
| 9K2HN | EY8MM | V63DX | ZD9T |
| 9M0W | FT4JA | VK3XQ | ZL9HR |
| 9X0CW | FW5RE | VP8SGI | ZM1A |

# RX Antenna Signal Comparison

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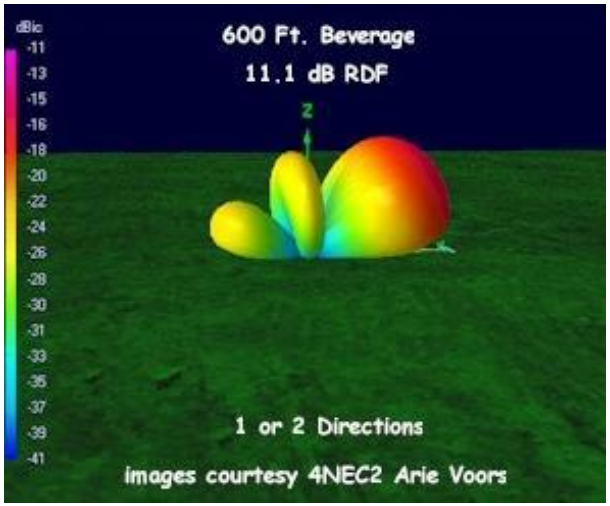
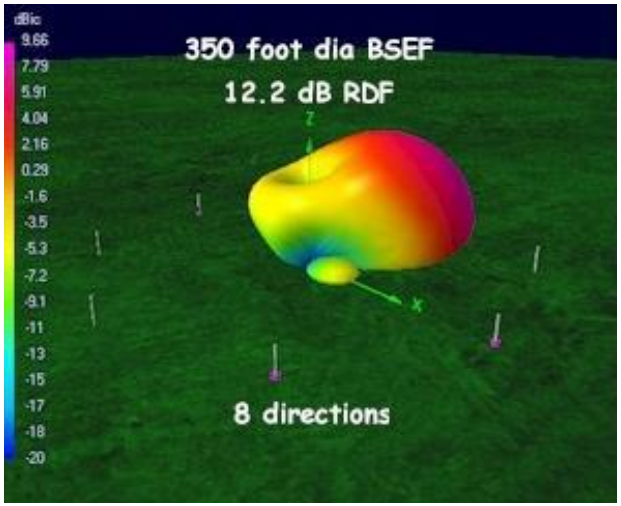
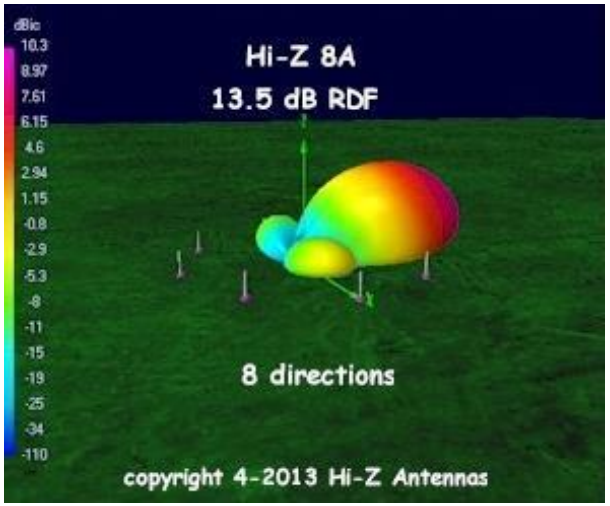
# Model –vs- Actual Field Measurements




F/B = 20 dB
RDF ~10 dB*
3 dB BW = 75°




F/B = 21 dB
RDF confirmed*
3 dB BW = 50°




F/B = >30 dB
RDF confirmed*
3 dB BW = 50°

**YCCC-9**
F/B = 24 dB
RDF confirmed
3 dB BW = 80°

***Based on comparative analysis**

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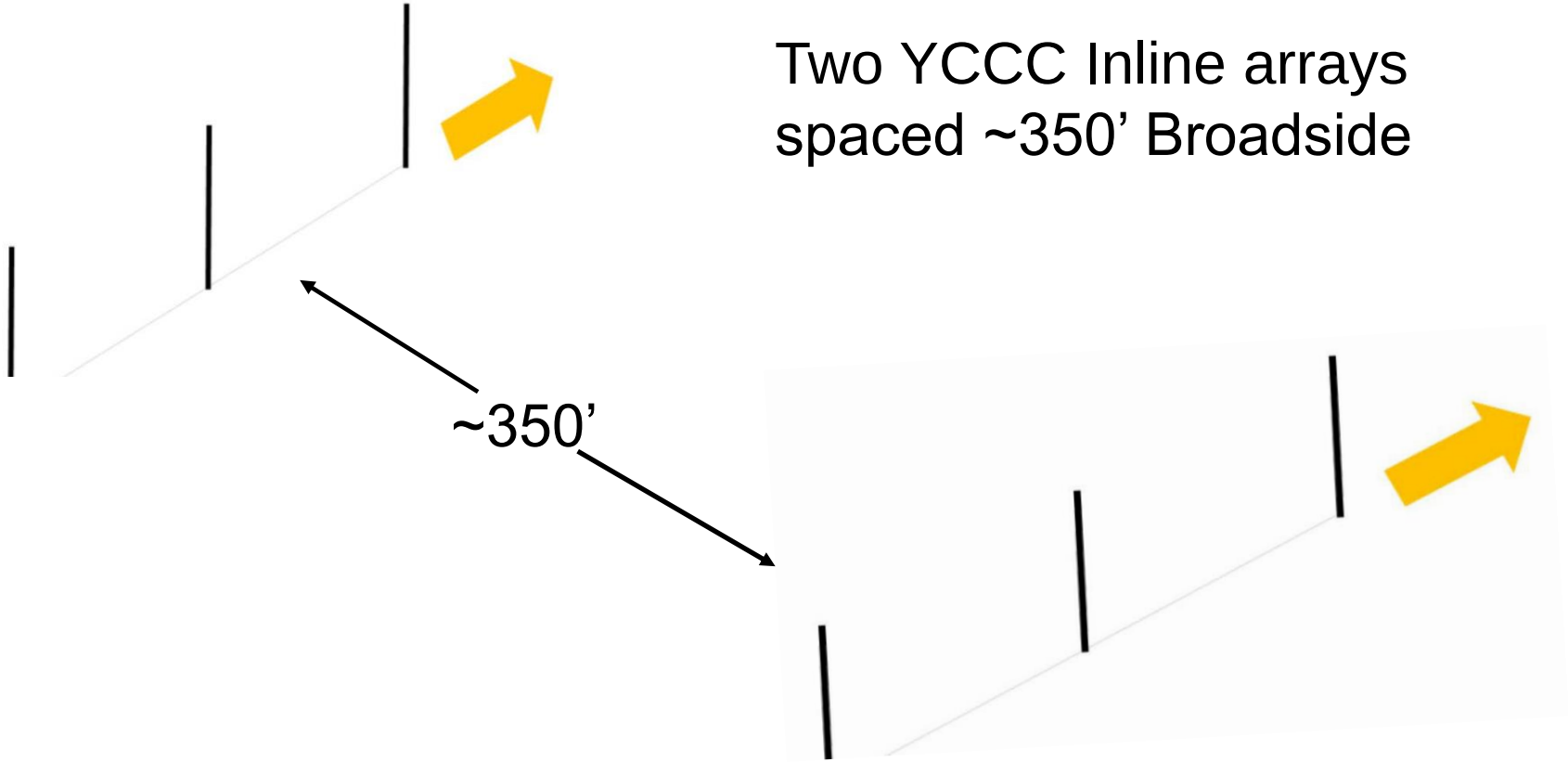
# Summary

- Field measurements validate the model results for the arrays evaluated
- All are outstanding RX antennas and performance, depending on the array, is equal to or greater than a 540 ft Beverage
- Vertical arrays cover less space for 8 direction coverage than eight 540 ft Beverages

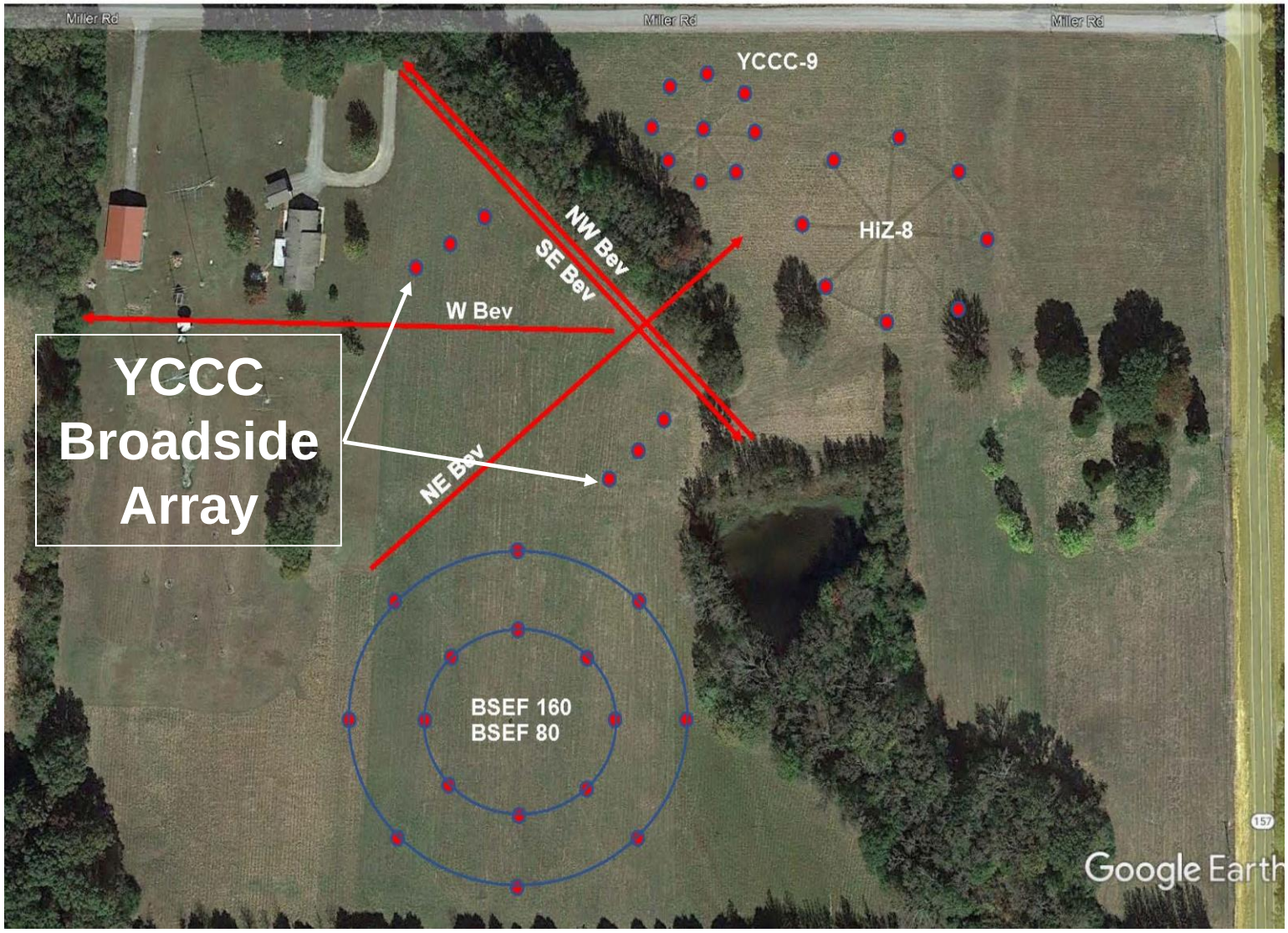
# Summary (Cont)

- Utilizing two of these arrays in a diversity receive configuration produces phenomenal results

# Additional Array Currently Under Evaluation




Two YCCC Inline arrays spaced ~350’ Broadside

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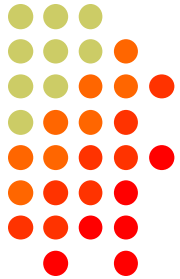
# K3LR "Rules of Sameness"

- To obtain optimum results from any RX array it is *mandatory* that your focus be to assemble each vertical element the same
  - Same element material, same size/diameter
- Amplifiers or matching networks must be connected all in the same manner
- For low impedance verticals, tune each vertical to the same frequency +/- 2 KHz

# K3LR "Rules of Sameness"



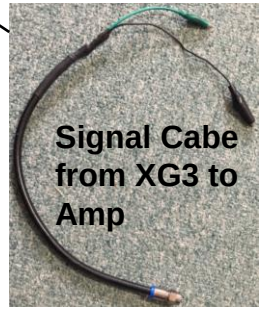
- Signal cable to each vertical in the array must be the same
  - Do  not use different types of RG6
  - W5ZN will not use RG-6 from different spools in an array
- Waterproof all connections and electronic components. Moisture is your *enemy!*
  - It will create noise in the system

# K3LR “Rules of Sameness”

- If possible avoid using signal cables to provide 12Vdc to amplifiers
- Once your array is in operation, measure and record the noise floor and F/B readings in each direction that the array is designed for.
- Any future change in these readings is a sign of possible component change or failure

# Testing HiZ and YCCC Amplifiers – Simple Method



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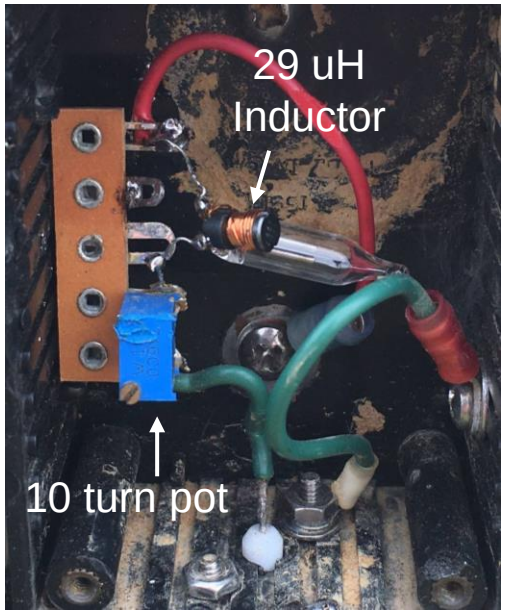
# Testing HiZ and YCCC Amplifiers – Simple Method

1. Insert a -107 dBm signal from XG3
2. Measure signal on panadapter or S meter
   - Obviously should see a signal increase above -107 dBm.
   - ~ 10 dB or so
3. Ensure all amplifiers used in the array have the same gain (“sameness)

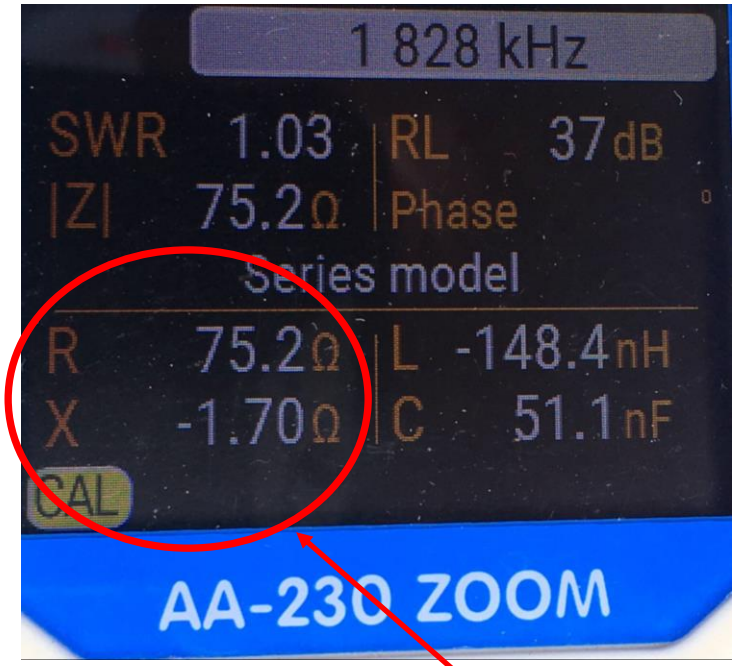
# Testing BSEF Low Impedance Matching Network

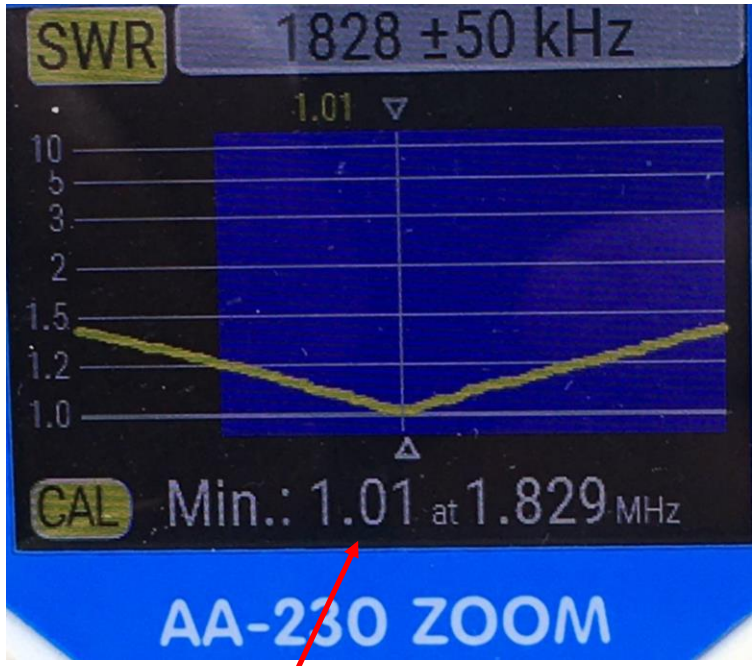
1. Calibrate antenna analyzer & test cable with open, short, and 75Ω load
2. Tune each vertical to lowest SWR at desired frequency, e.g. 1828 KHz.
3. Adjust variable resistor for 75 Ω impedance



# Testing BSEF Low Impedance Matching Network

This is your target result




You want a 75Ω match and no reactance

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# Final Thoughts

- Determine the array that fits your need
- Build it
- Test it
- “GET IN THERE AND WORK ‘EM !!!!”

# Thank You

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# References


- HiZ Antennas https://hizantennas.com/
- “Design, Construction, and Evaluation of the 8 Vertical Circle Array for Low Band Receiving” 2nd Edition by Joel Harrison, W5ZN, Bob McGwier, N4HY, and Frank Donovan, W3LPL - http://w5zn.org
- “A Compact Dual-Band, 9 Circle Receiving Array” by John Kaufmann, W1FV Parts 1 NCJ Sept/Oct 2011, Part 2 NCJ Nov/Dec 2011. See also Steve Babcock, VE6EZ, https://www.youtube.com/results?search_query=ve6wz
- “W8WWV - The Benchmark Beverage” Greg Ordy, W8WWV, http://seed-solutions.com/gregordy/Amateur Radio/Experimentation/Beverage.htm