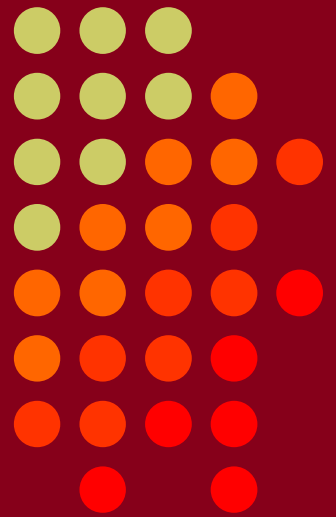
CTU Presents

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

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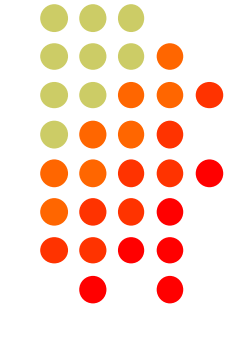
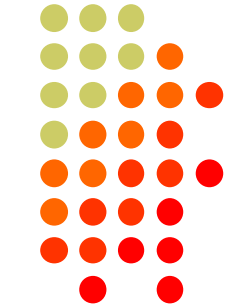
Why Do We Use Receive Antennas?



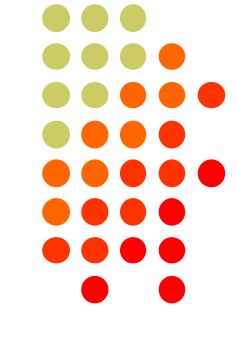
- Reduce receive noise (Improve SNR)
- Improve the forward pattern in the desired direction
  - Provide directivity away from noise sources
- Gain antennas for TX aren't necessarily good RX antennas as they provide gain for noise as well as the desired signal

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

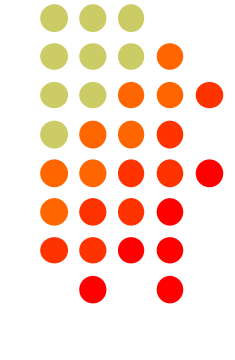


- Low band receive antennas cannot be properly evaluated without taking into consideration geographical and propagation differences.
- Comparing one antenna from a location 1000 miles away on the east coast to the same antenna located in rural Arkansas will not give an accurate comparison.
  - the exact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

Comparing Receive Antennas

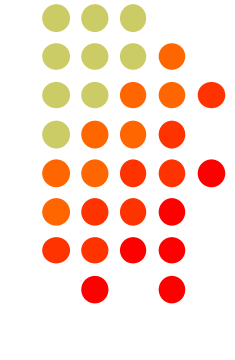
- W5ZN uses three stations for propagation comparison
  - W0FLS in Iowa 425 miles north at 344° azimuth
  - W5UN in Texas 200 miles SW at 235° azimuth
  - K5RK in Texas 450 miles S/SW at 205° azimuth
- The propagation difference of what we each can and cannot hear at any one time is significant!

Comparing Receive Antennas



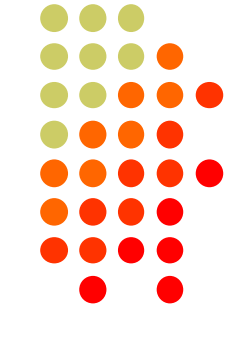
- Even close to home, K5UR is 25 miles SW and WD5R is 20 miles north.
  - We compare notes frequently and the differences between signal-to-noise ratios for all of us that close is sometimes eye opening.
- 160 meter propagation is beyond the scope of this presentation. Please read the excellent work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

Comparing Receive Antennas



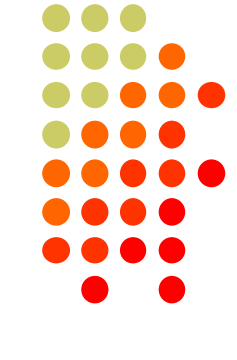
- My objective was to have all vertical arrays and Beverages erected at my location in order to achieve an as near perfect “A-B” test possible and not rely on comparative readings from another station some distance away.

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

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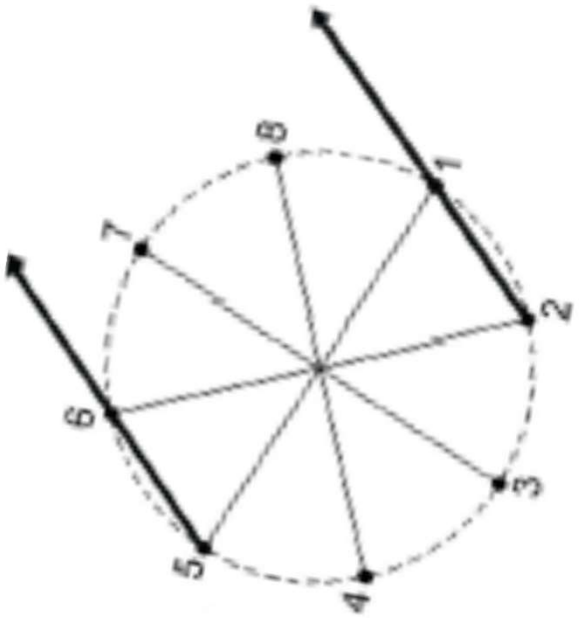
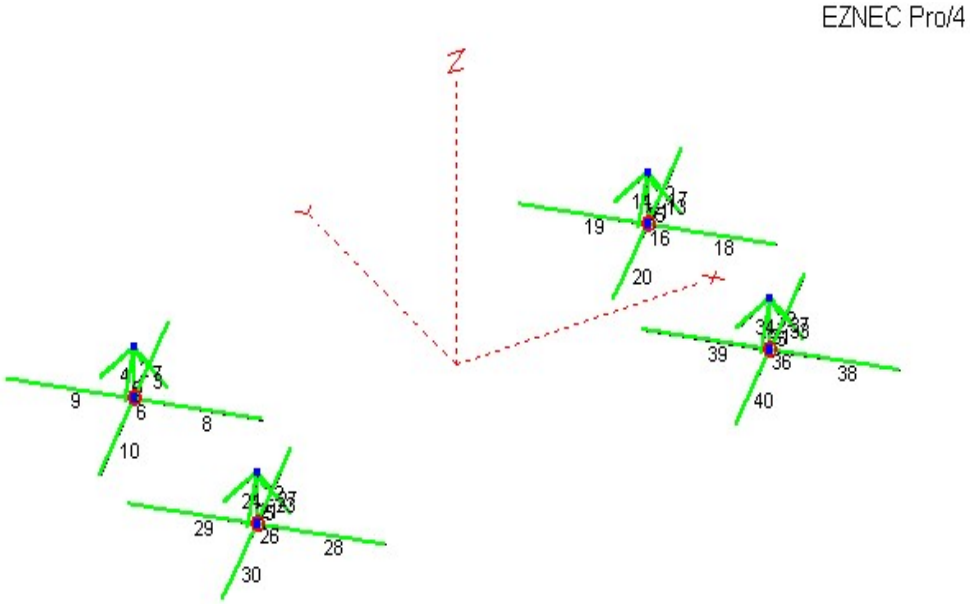
Broad Side End Fire (BSEF) 8 Vertical Array

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





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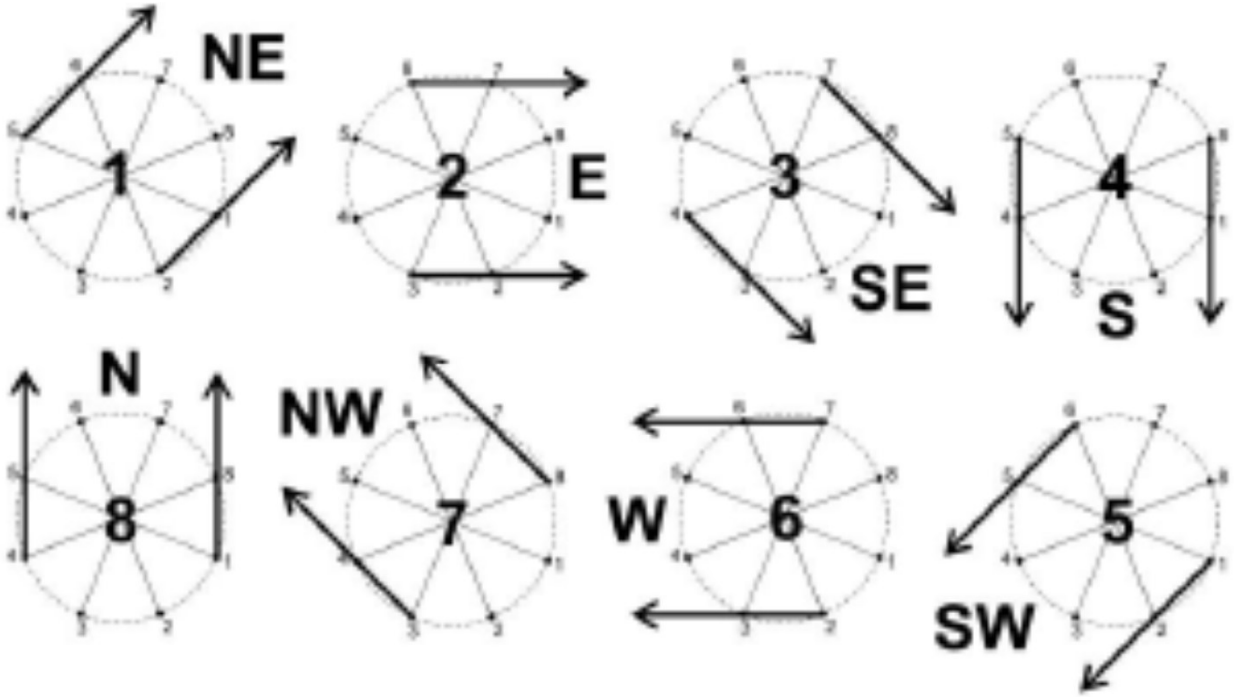
Broad Side End Fire (BSEF) 8 Vertical Array

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



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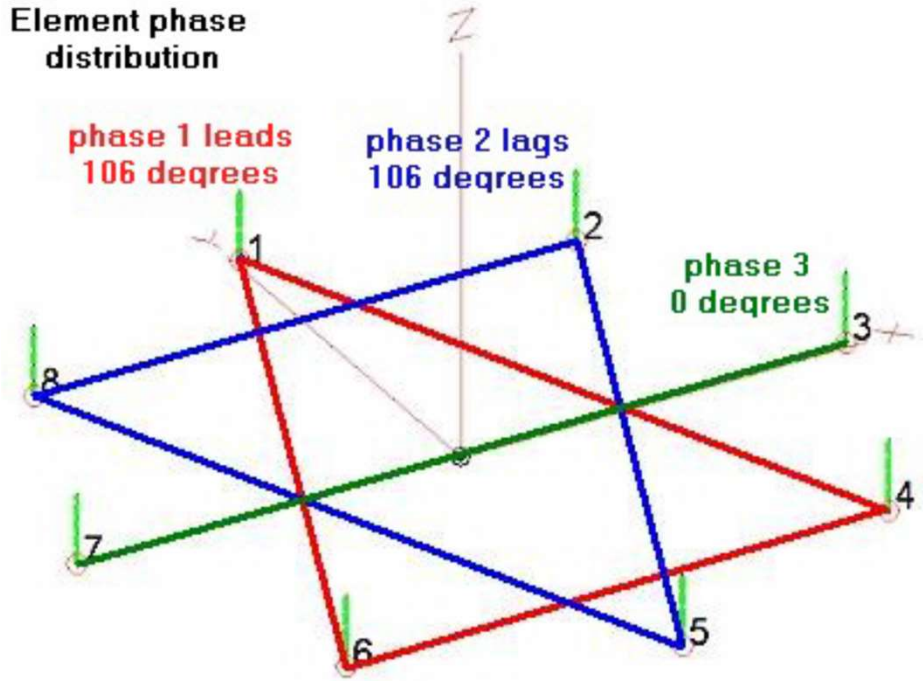
HiZ-8A

- 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.



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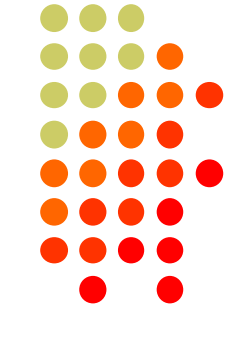
Other Hi-Z Arrays



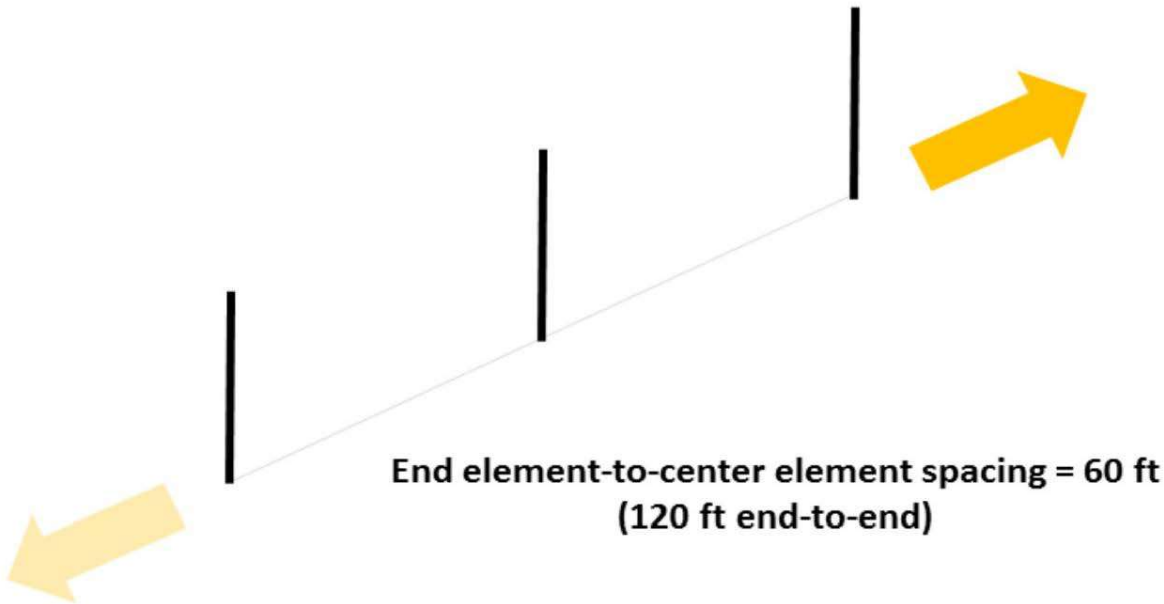
- Not yet evaluated the other Hi-Z arrays
  - HIZ-PC-8PRO
    - 8 vertical array
    - 85’ or 113’ diameter circle
    - Claimed 12.1 dB RDF, 30 dB F/B
  - HIZ-PC-4A
    - 4 square vertical array
    - 60’ or 80’ per side element spacing
    - Claimed 12.1 dB RDF, 30 dB F/B

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



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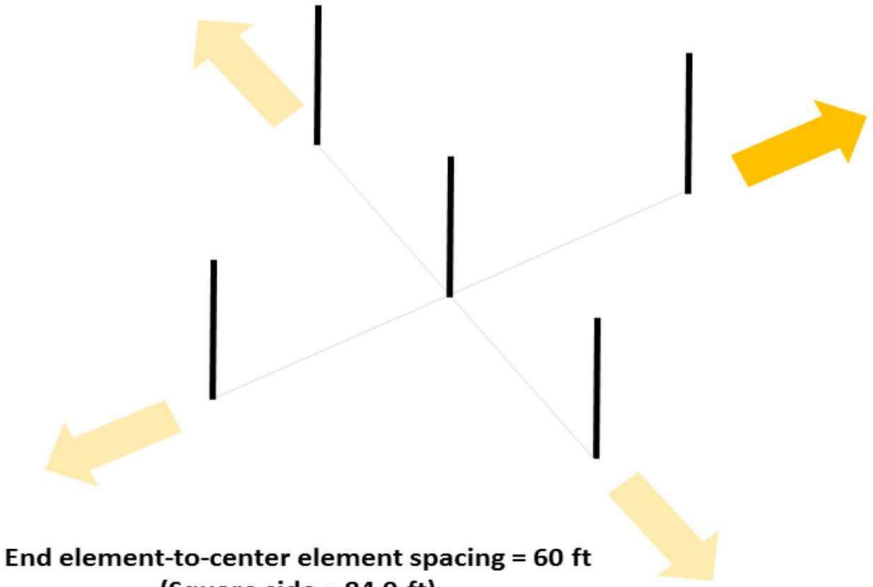
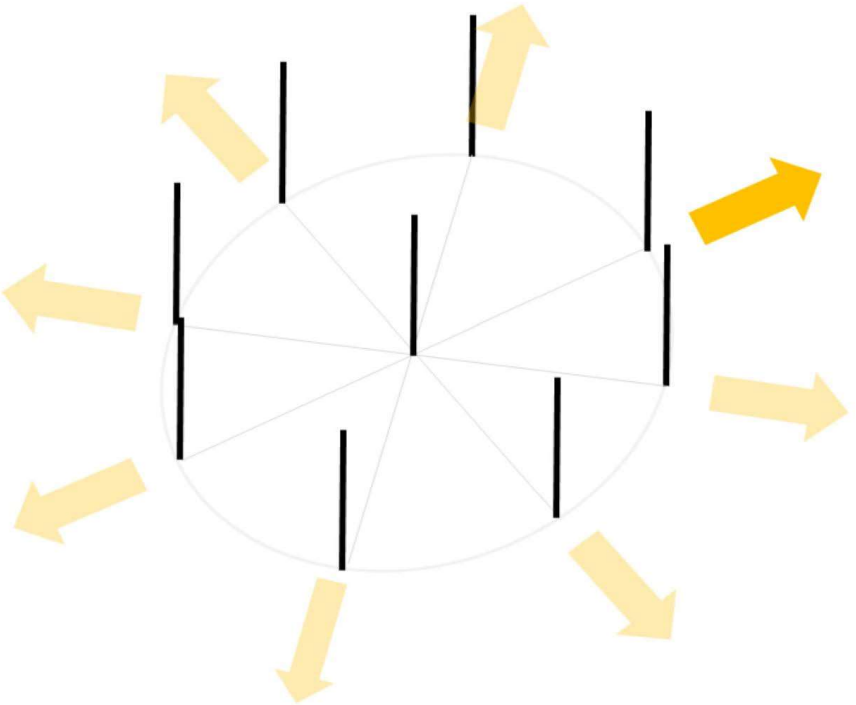
YCCC-9

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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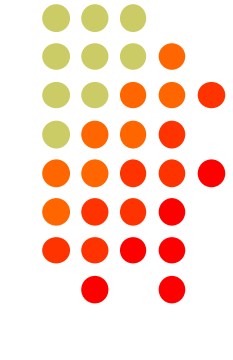
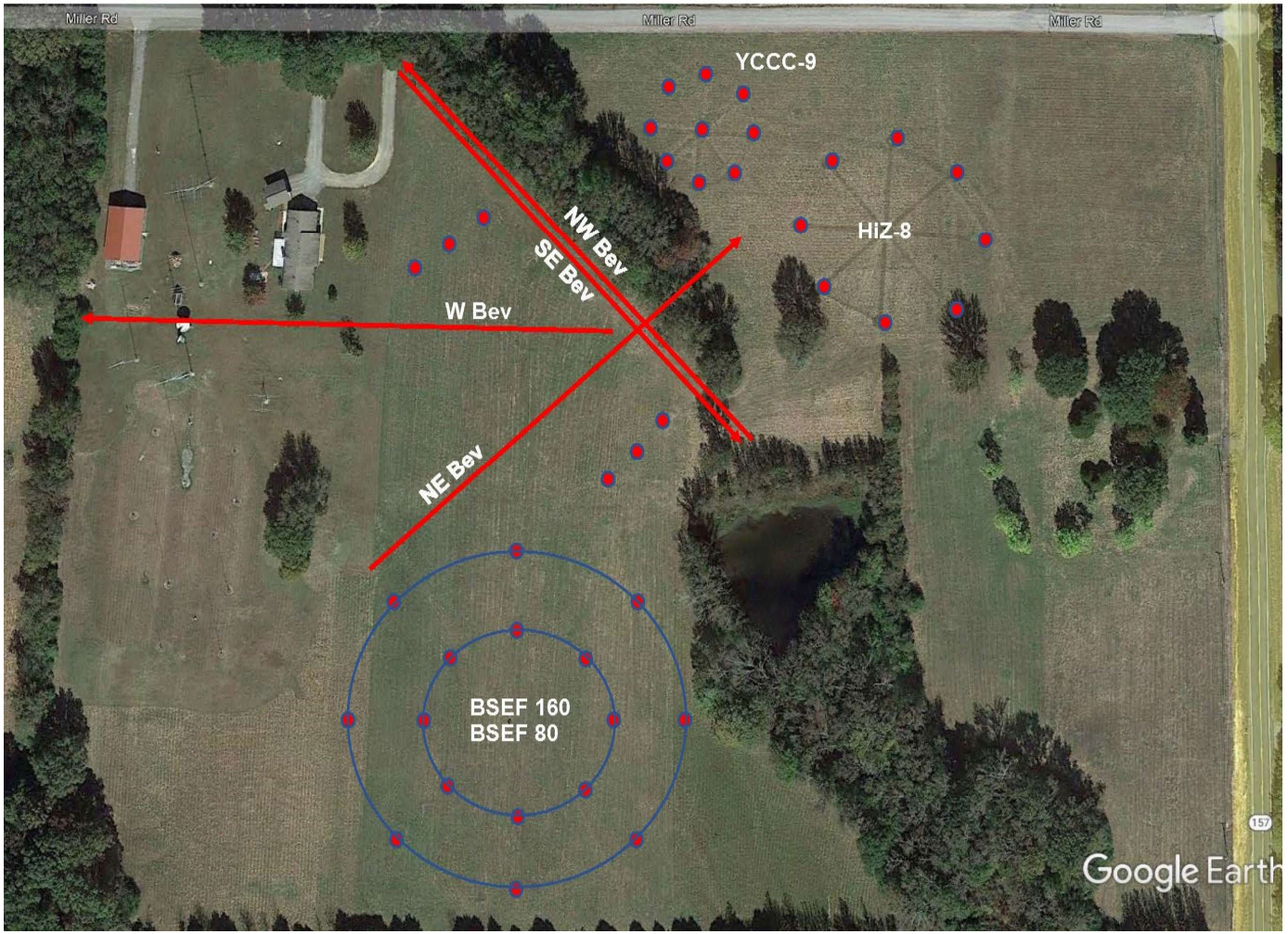
Vertical Array Pro –vs- Con



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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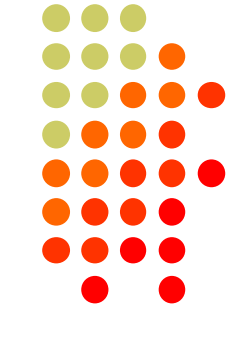
Data Recorded for Each Antenna



- 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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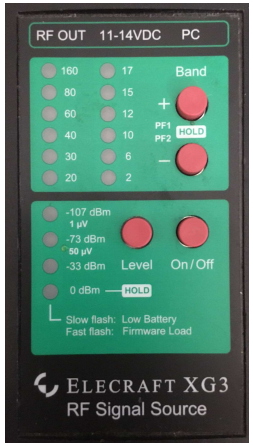
Equipment Used for Measurements

- 2 – LP-Pan SDR Receiver

- Elecraft XG3 Signal Generator



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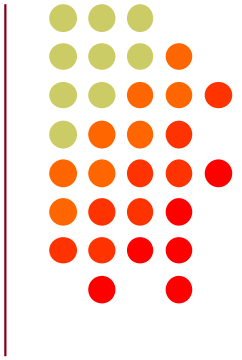
Calibration Procedure



- 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

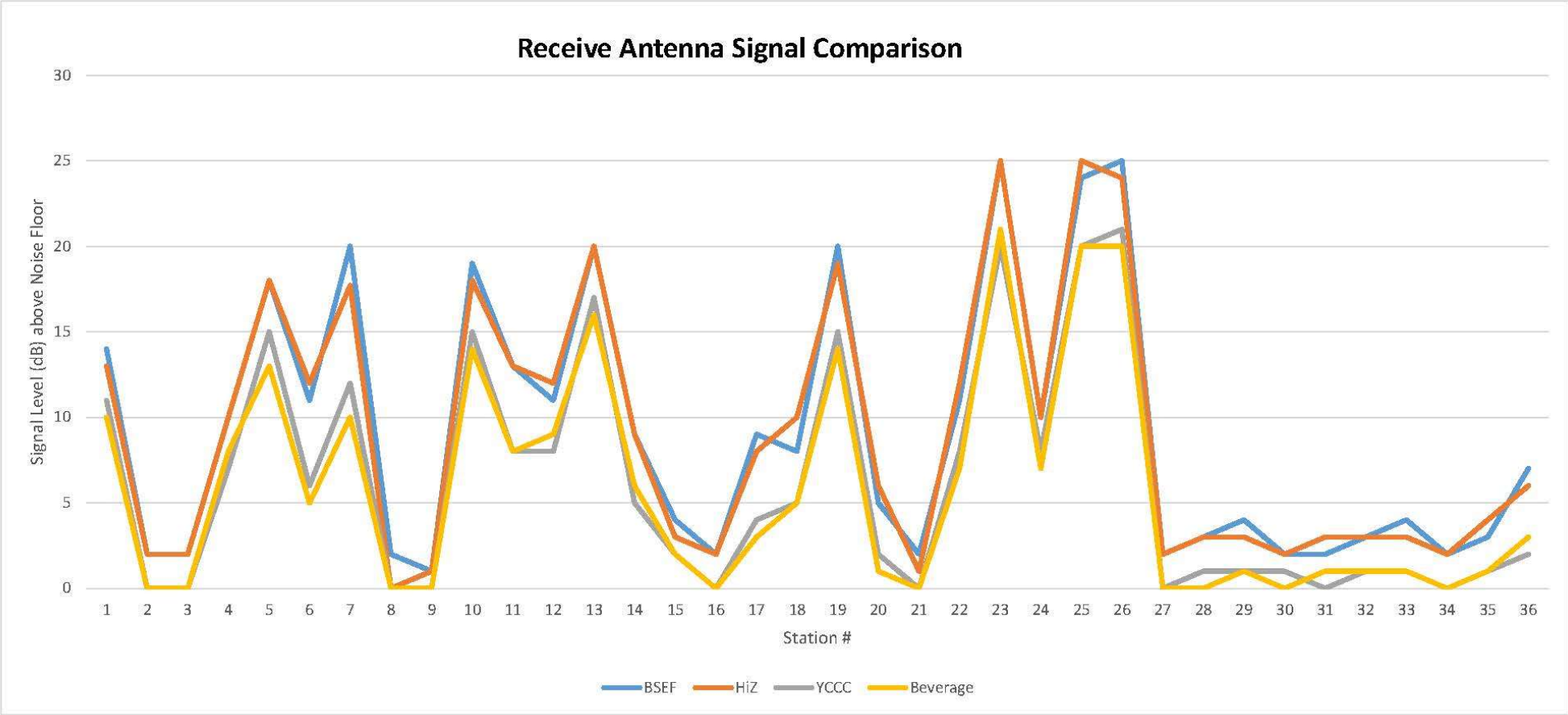
RX Antenna Signal Comparison

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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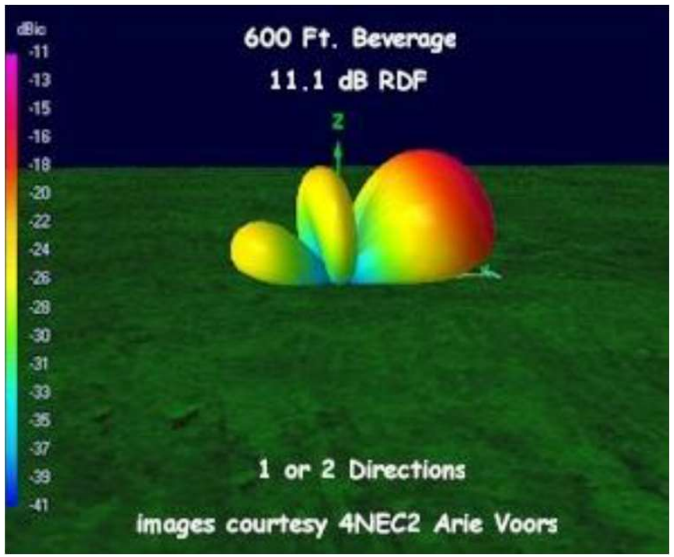
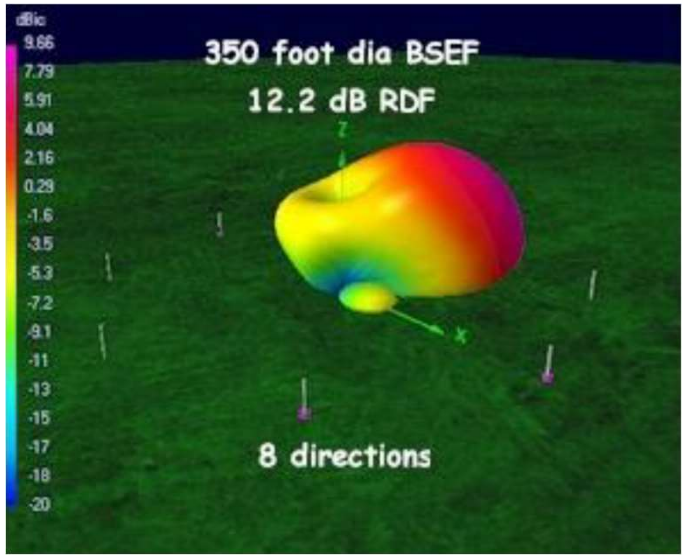
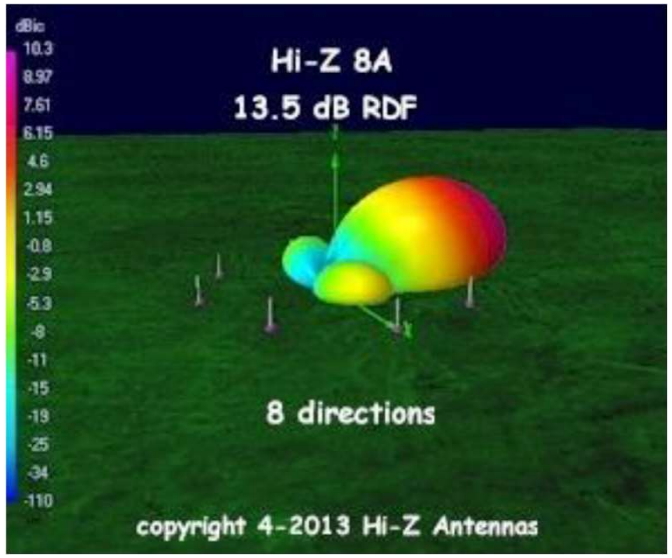
Model –vs- Actual Field Measurements



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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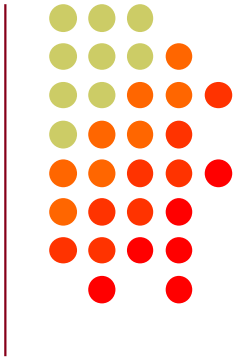
Summary

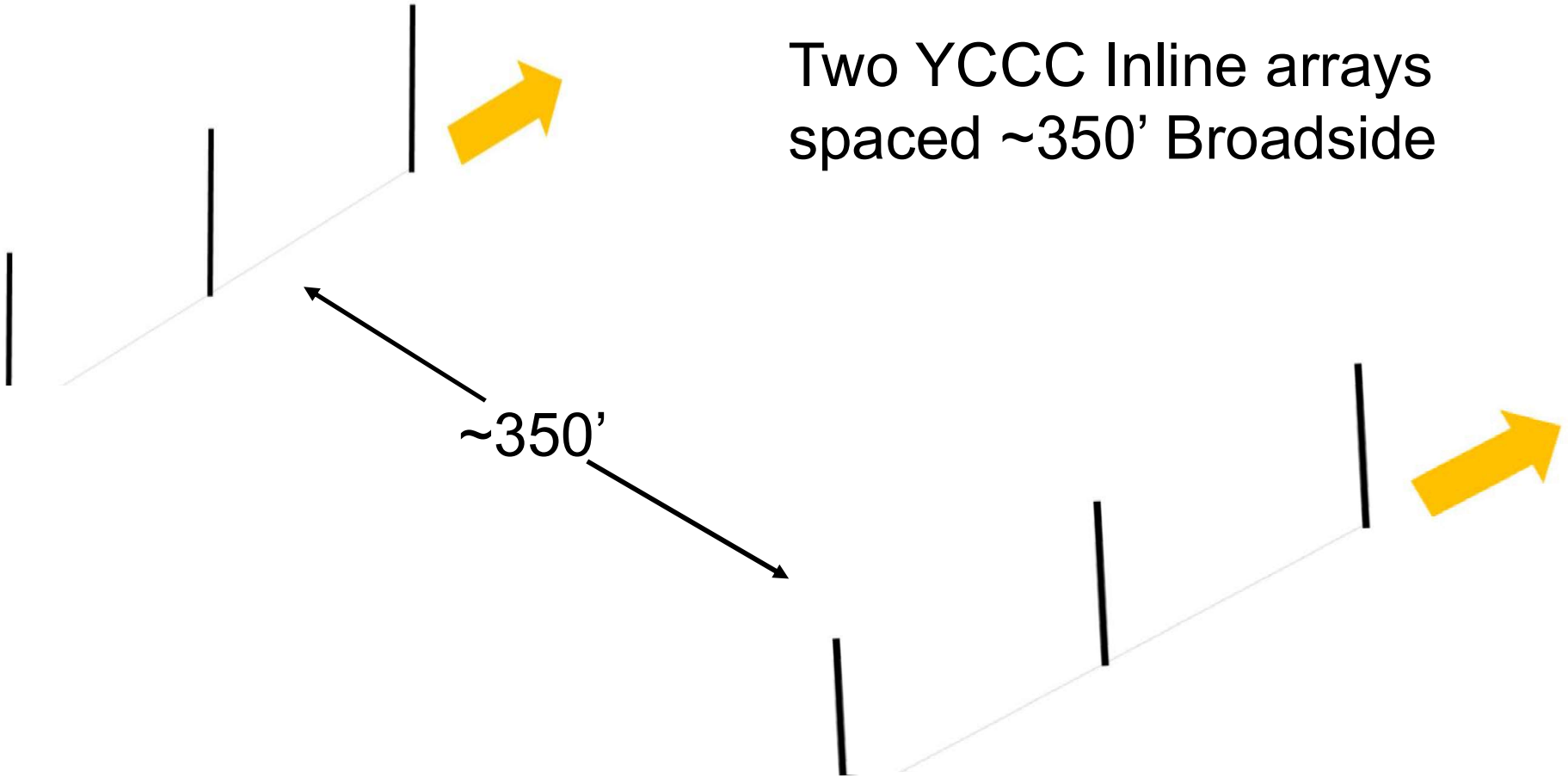
- Field measurements validate the model results for the arrays evaluated
- All are outstanding RX antennas and performance, depending on the array, is equal to or greater than a 540 ft Beverage
- Vertical arrays cover less space for 8 direction coverage than eight 540 ft Beverages

Summary (Cont)



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

Additional Array Currently Under Evaluation



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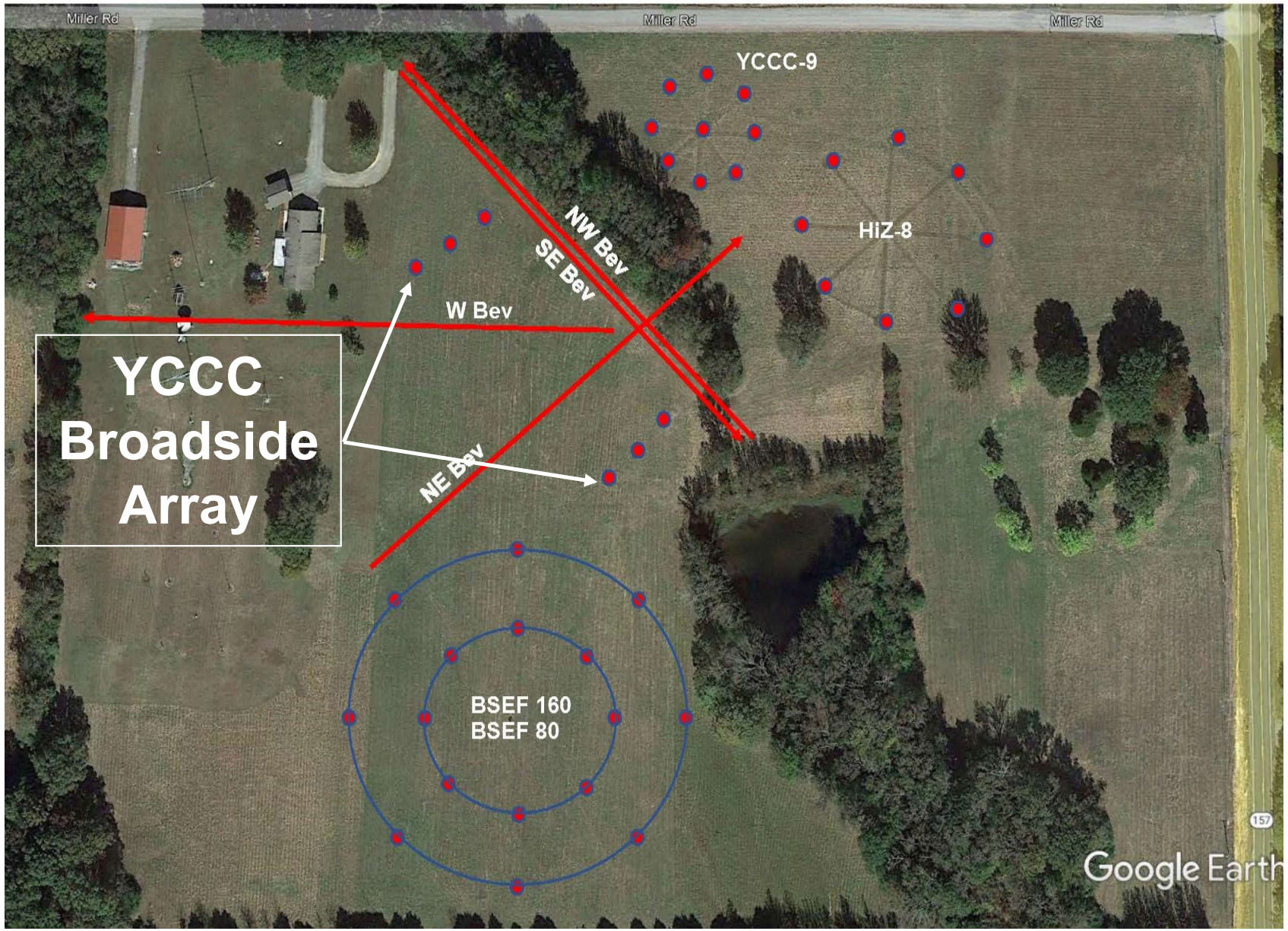

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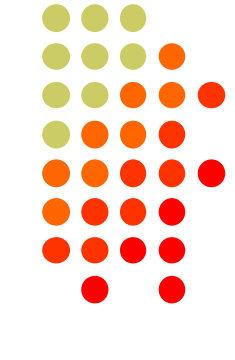
K3LR "Rules of Sameness"



- 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

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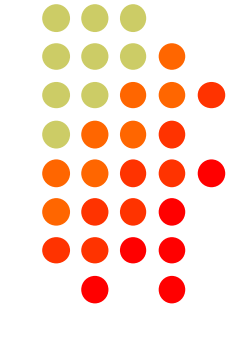
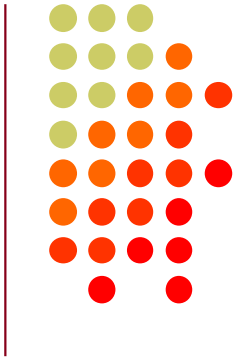
K3LR "Rules of Sameness"



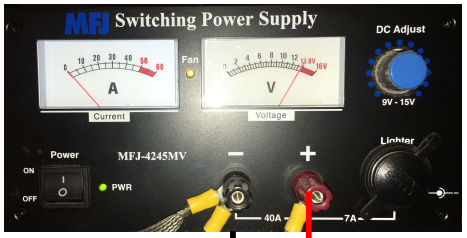
- Signal cable to each vertical in the array must be the same
  - Do not use different types of RG6
  - W5ZN will not use RG-6 from different spools in an array
- Waterproof all connections and electronic components. Moisture is your *enemy!*
  - It will create noise in the system

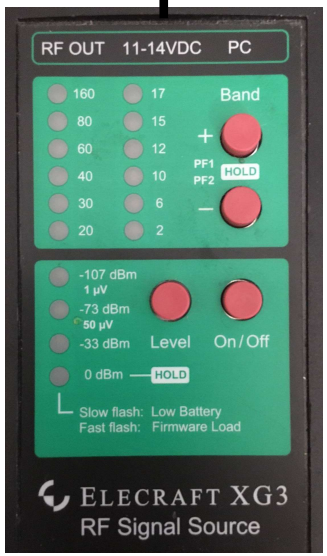
K3LR “Rules of Sameness”



- 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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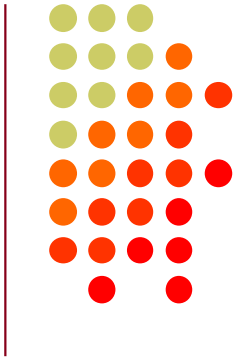
Testing HiZ and YCCC Amplifiers – Simple Method



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)

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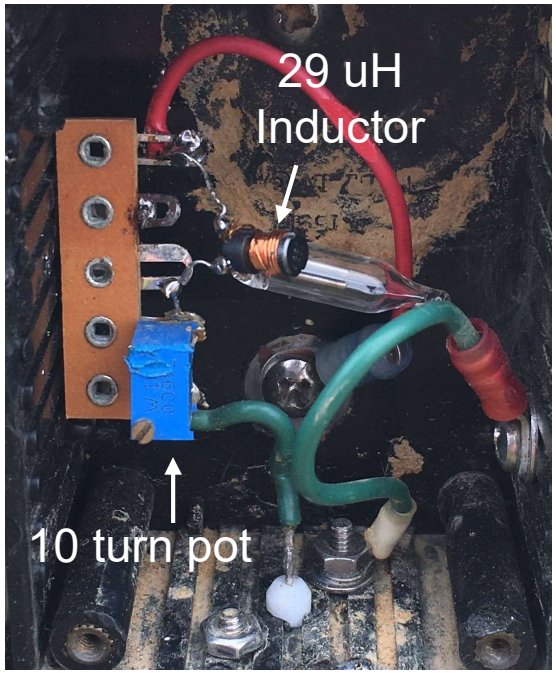
Testing BSEF Low Impedance Matching Network

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



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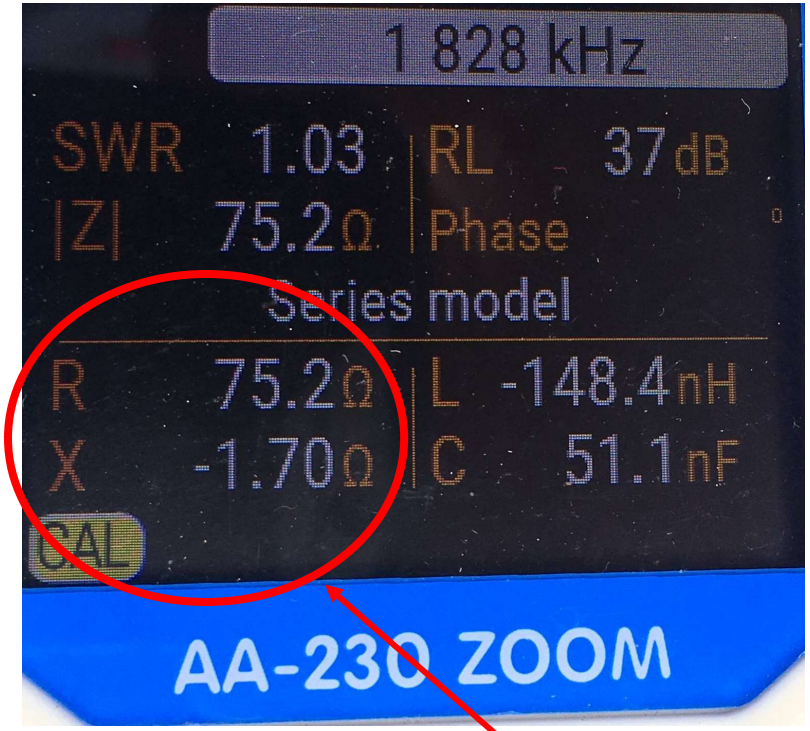
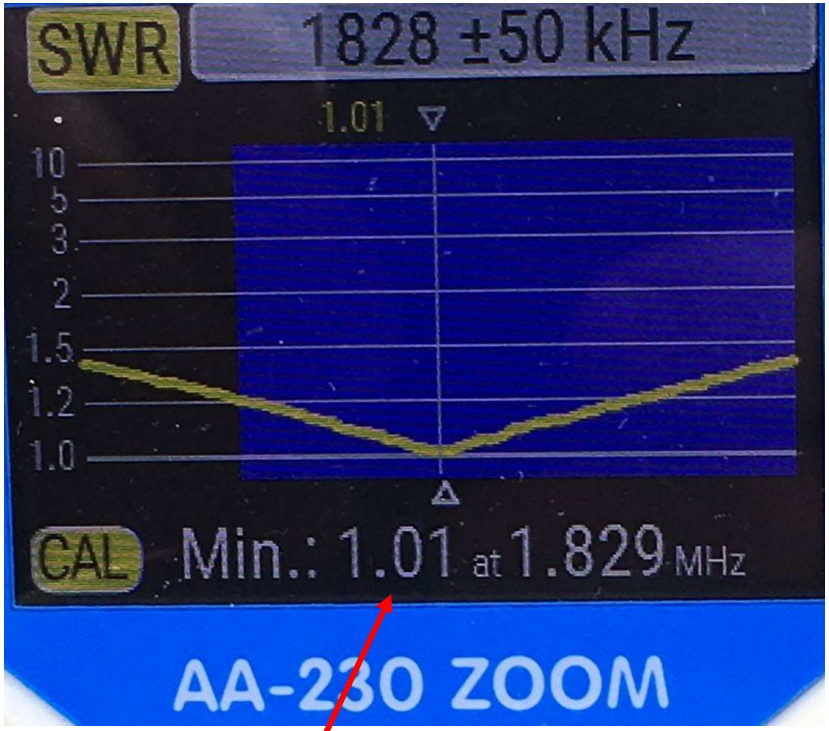
Testing BSEF Low Impedance Matching Network

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
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