A Five Element Parasitic Rotatable Vertical Yagi for 160 meters

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The Need for a New TX Array

10 years perfecting RX arrays at W5ZN

260 DXCC countries confirmed but became stagnate

- The countries needed are much more difficult to work

Needed extra TX gain and directivity to advance my DX standings from Arkansas

The Search for the Right Array at W5Z

Spent well over two years fretting over what to do

Revisited the section on vertical arrays with parasitic elements in "Low Band DX'ing"

- Chapter 13, Section 3.9, page 13-39 Fifth Edition

Studied the design for about 2 weeks

- Literally became obsessed with this design

K3LR's version is described

Traveled to K3LR to see his installation

Further discussion with K3LR at Six Meter BBQ in Austin in Sept 2017

Became convinced this was the perfect array for the W5ZN station

Why a Vertical Yagi Array with Parasitic Elements Over a 4 Square?

The array can be built around an existing single TX vertical

Do not need full size elements

Existing land area around the single TX vertical can be utilized

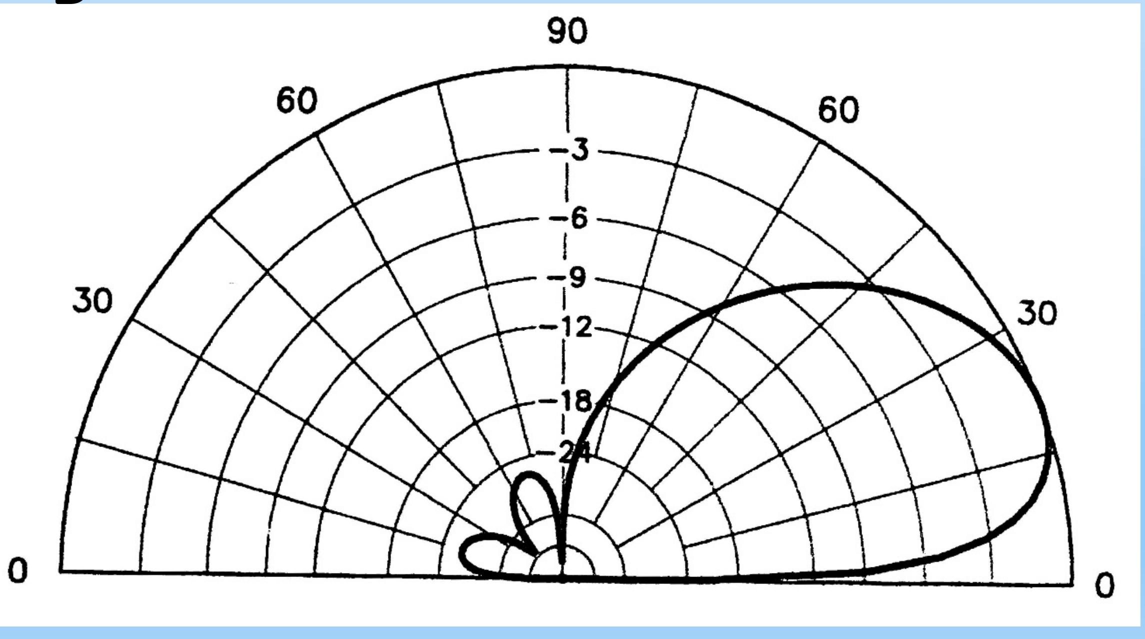
Same basic gain and F/B is realized in 4 rotatable direction

Very simple feed system. No phasing or complicated schemes. The existing matching network on my single vertical is all that is required

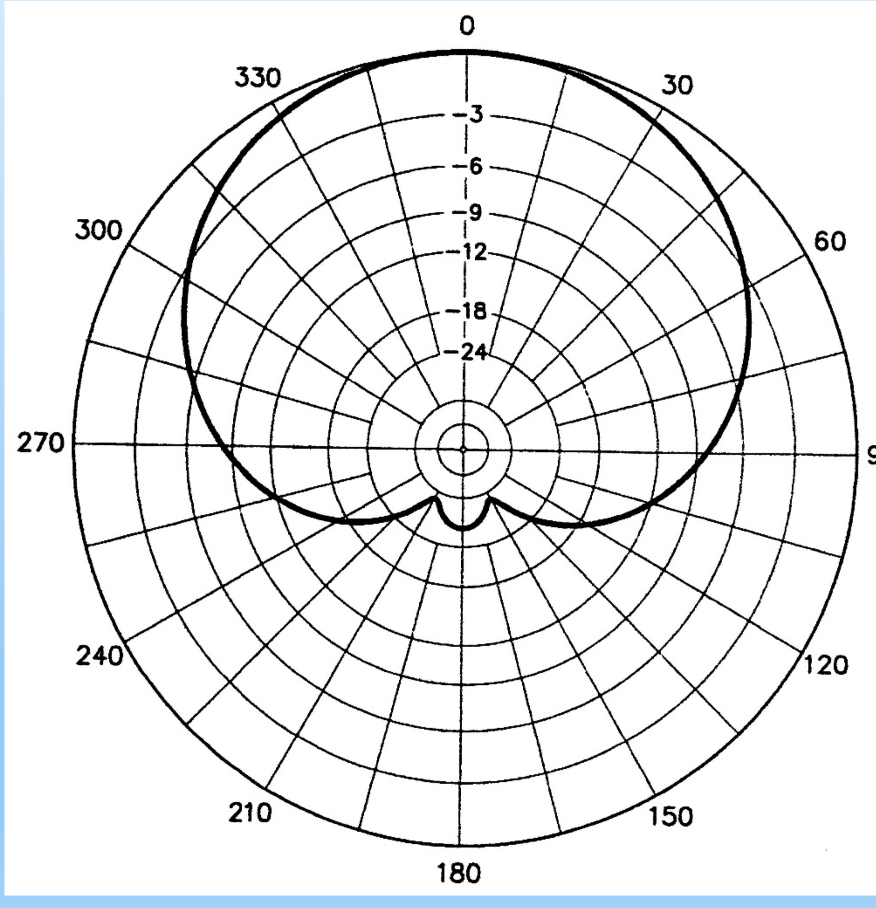
Slightly smaller element footprint than 4 Square

Why a Vertical Yagi Array with Parasitic Elements Over a 4 Square?

Equivalent Forward Gain and F/B



25 dB F/B 5 dB Forward Gain



Horizontal Patter at 20 degrees elevation

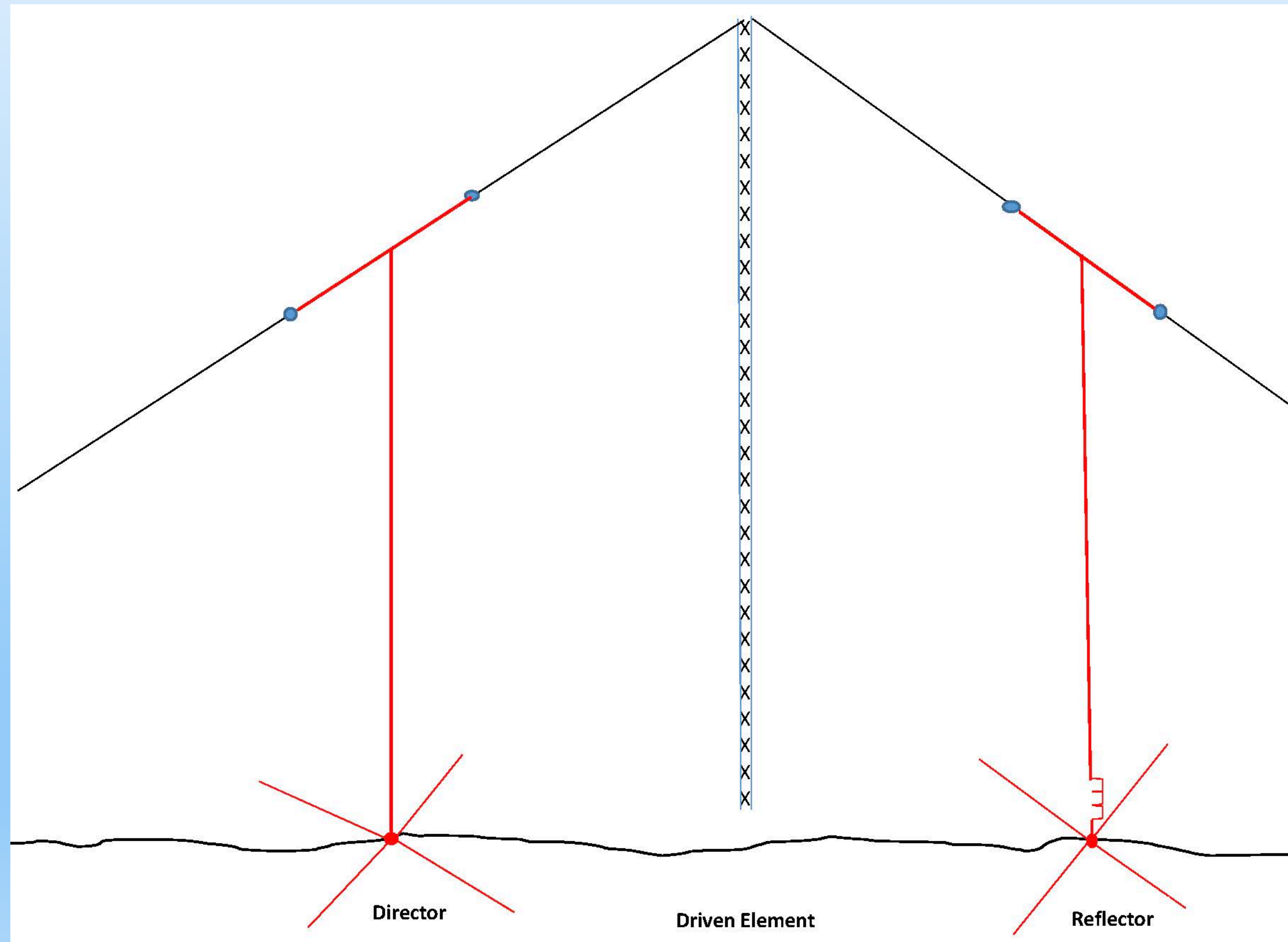
The Vertical Yagi Array with Parasitic Elements

- Popularized by Bill Hohnstein, K0HA
- Comprised of 3 or more vertical elements with one active driven element and the rest parasitic
- Currently in use at AA1K, VE3EJ, K3LR, NR5M & K9CT
  - AA1K has a 2nd Director to Europe on his array for a tad more gain

The Top Loaded Vertical Element

Top loaded vertical parasitic elements are extremely effective

Elements can be easily suspended with catenary ropes from the existing TX vertical



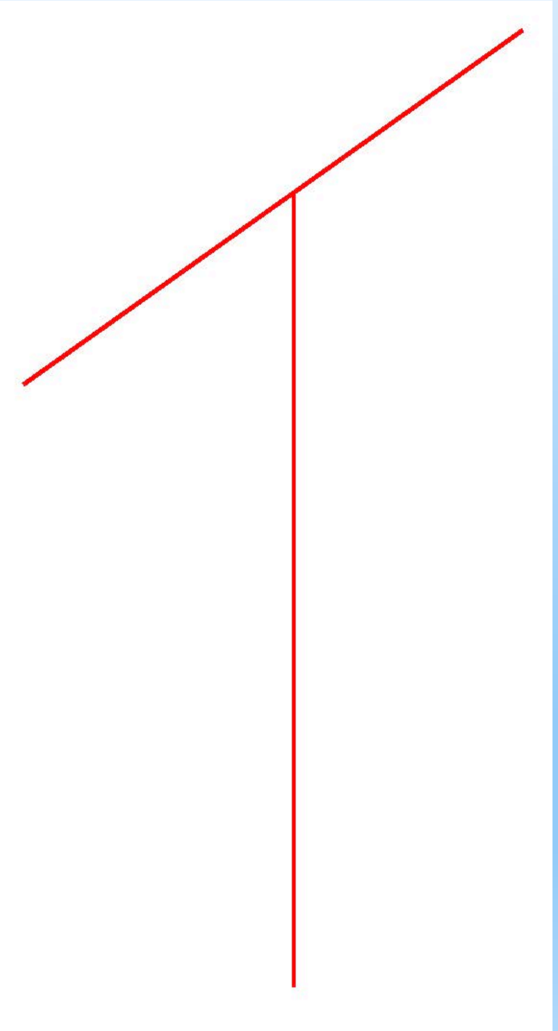
The Top Loaded Vertical Element

Resonant with a shorter vertical length

No Far Field horizontal component as the top load wire is symmetrical to vertical wire.

Sloping top loading wire is ~65 ft.

Vertical wire is ~75 ft.



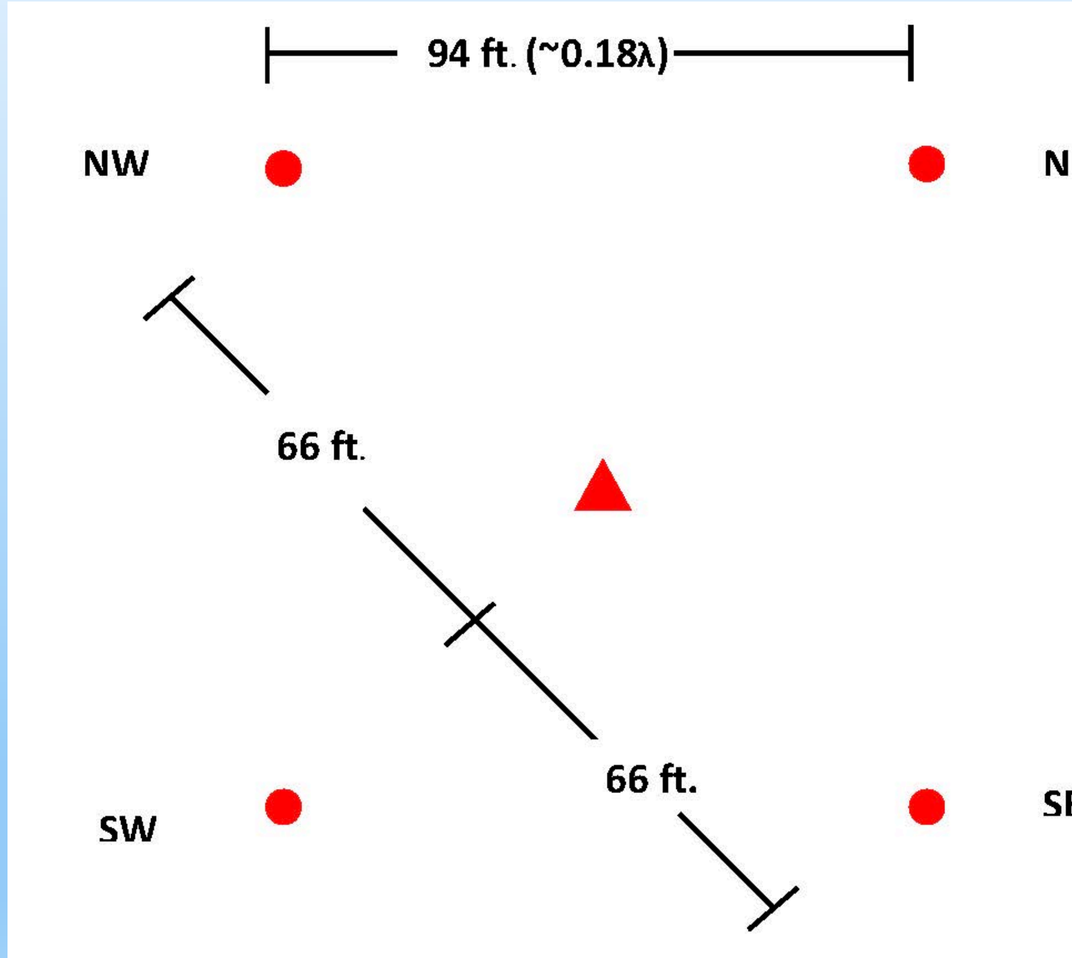
Constructing the Array

Construction effort organized in to 5 Phases

1. Physical Layout
2. Radial System
3. Element Construction & Erection
4. Tuning
5. Parasitic Array Switching

Physical Layout

- Very simple Process – 30 mins or less
- Elements spaced 66 ft. from Driven Element
- 4 parasitic elements spaced 90 degrees around a driven element

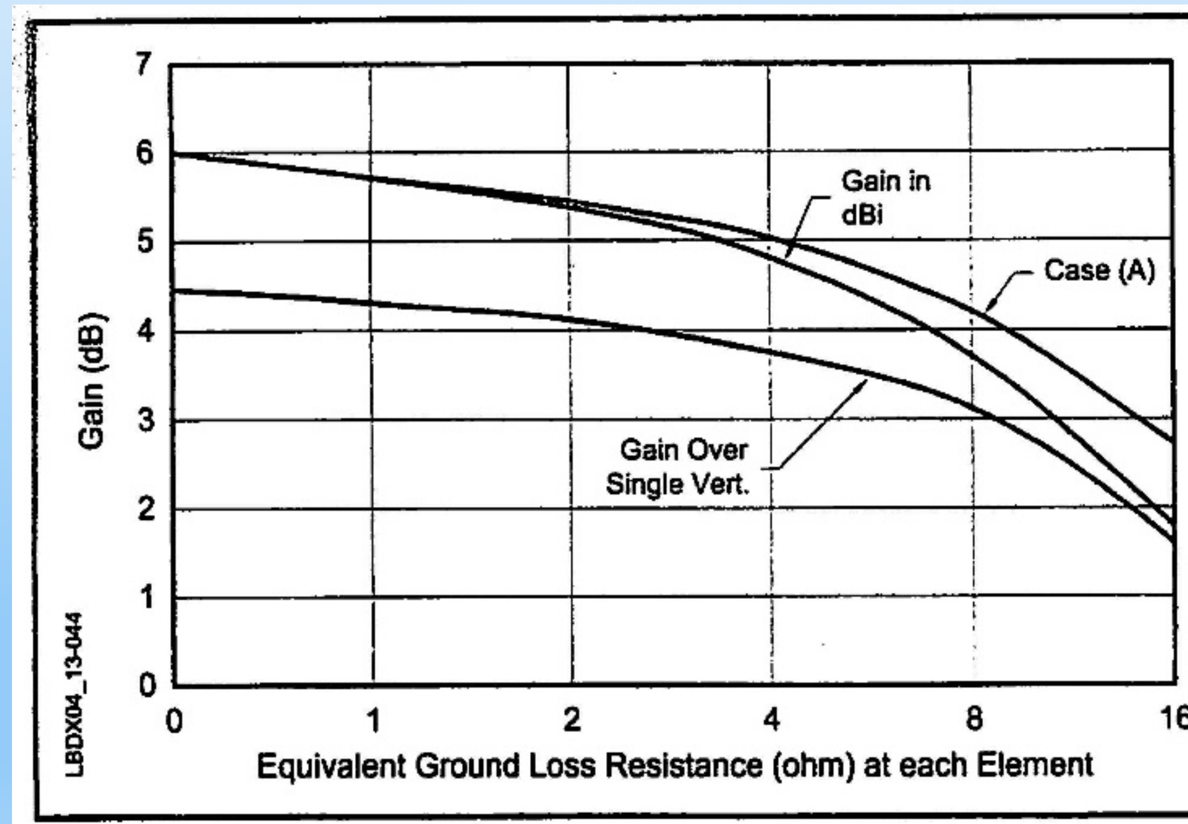


Radial System

- The most complicated and time consuming part of the project
  - It is MOST important!!!!
- Parasitic arrays have a greater impact from a poor ground system
- Elevated radials simply won't work
  - ON4UN's modeling shows significant pattern distortion
- With a phased array (e.g. 4 Square) current distribution is forced into each element
- Proper current distribution and thus gain in a parasitic element is impacted by ground resistance so an effective radial system is mandatory

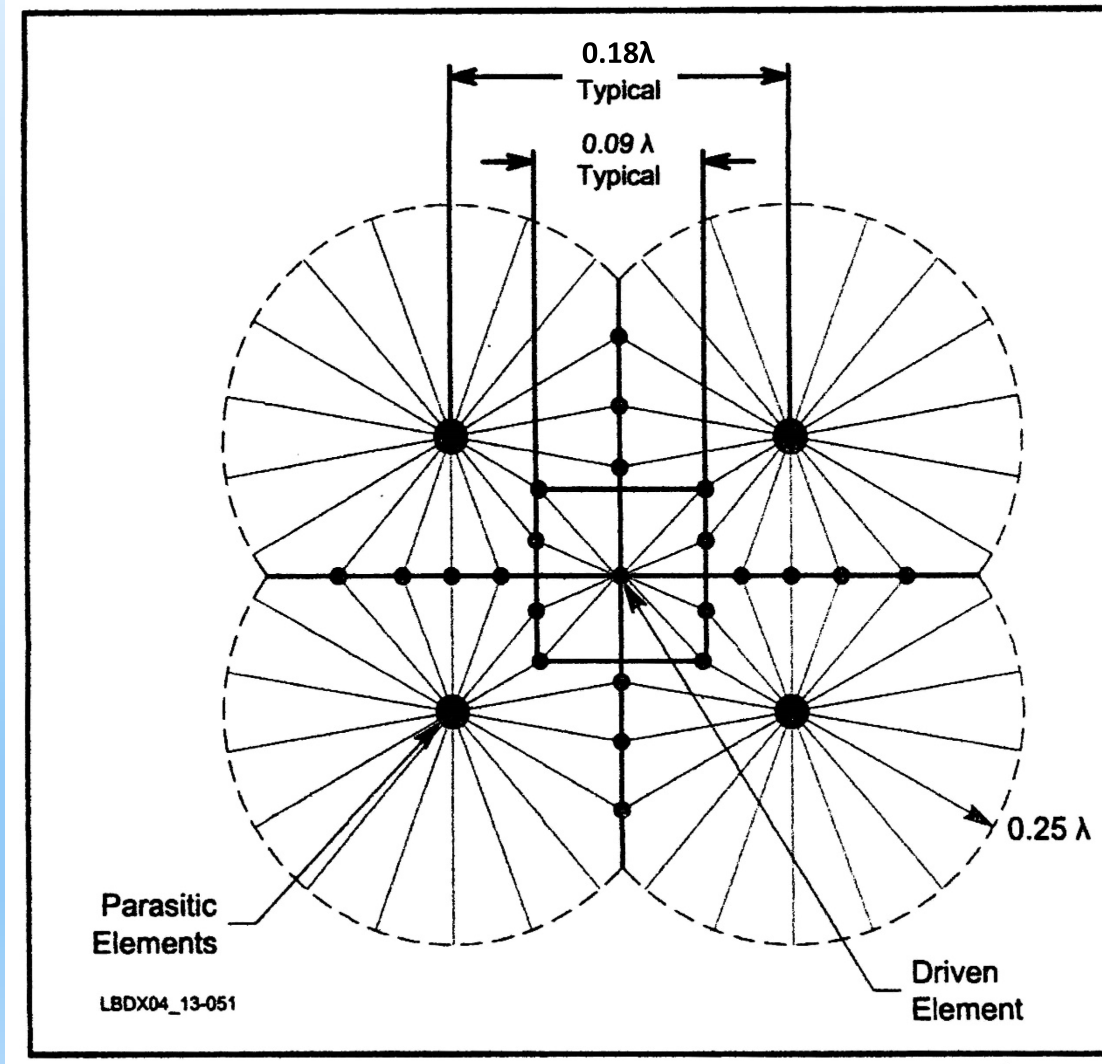
Radial System

- Gain of 3 element array as a function of ground loss resistance
- Case A is for a driven element with a fixed 1Ω loss resistance but with varying ground loss resistance at the parasitic elements



Radial System

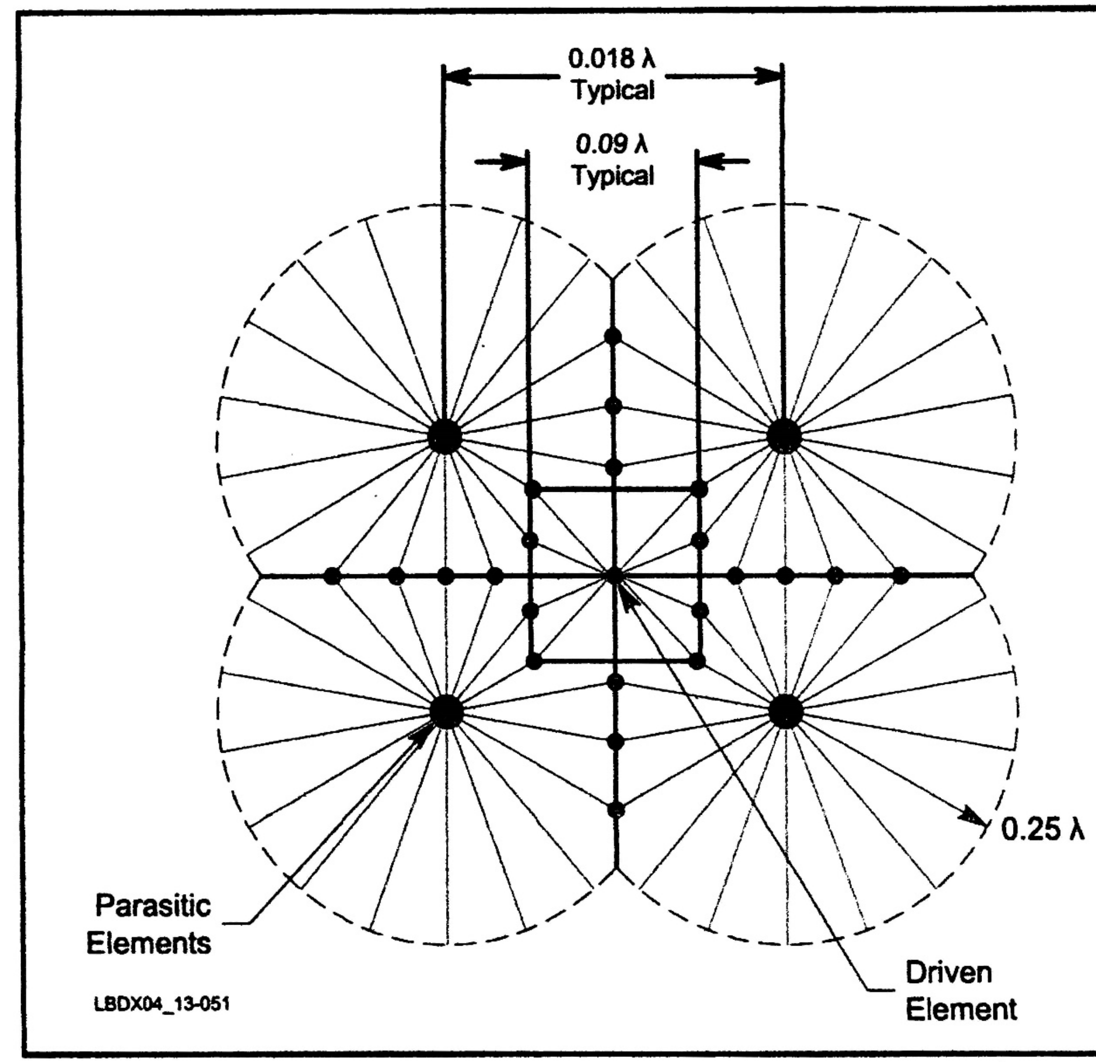
- 120 radials used under each element
- Radials are tied together at intersecting points
- 13.7 miles (22KM) of wire used in radial system



Radial System

W5ZN construction procedure

1. Install 120 radials from driven element to 48 ft. perimeter wire
2. Install radials from each element that intersect 48 ft. diameter perimeter wire
3. Install all radials from each element that intersect the cross buss wire
4. Install all remaining 1/4λ length radials to complete a total of 120 at each element



Radial System

48 ft. diameter perimeter wire (#4 solid copper) around driven element

120 radials from the driven element tied to this perimeter wire

Radial System

Perimeter wire laid in a 48 ft. diameter circle around driven element

Radial System

Radial wires from the driven element are soldered to the perimeter wire

Radial System

Radial wires from each element that intersect the perimeter circle are soldered to the perimeter wire.

All connections are then coated with liquid tape

Radial System

Some of the radial wires from an element.

I do NOT bury radial wires!

Mow grass very short (don’t scalp) and lay radials on the ground. Secure with radial staples

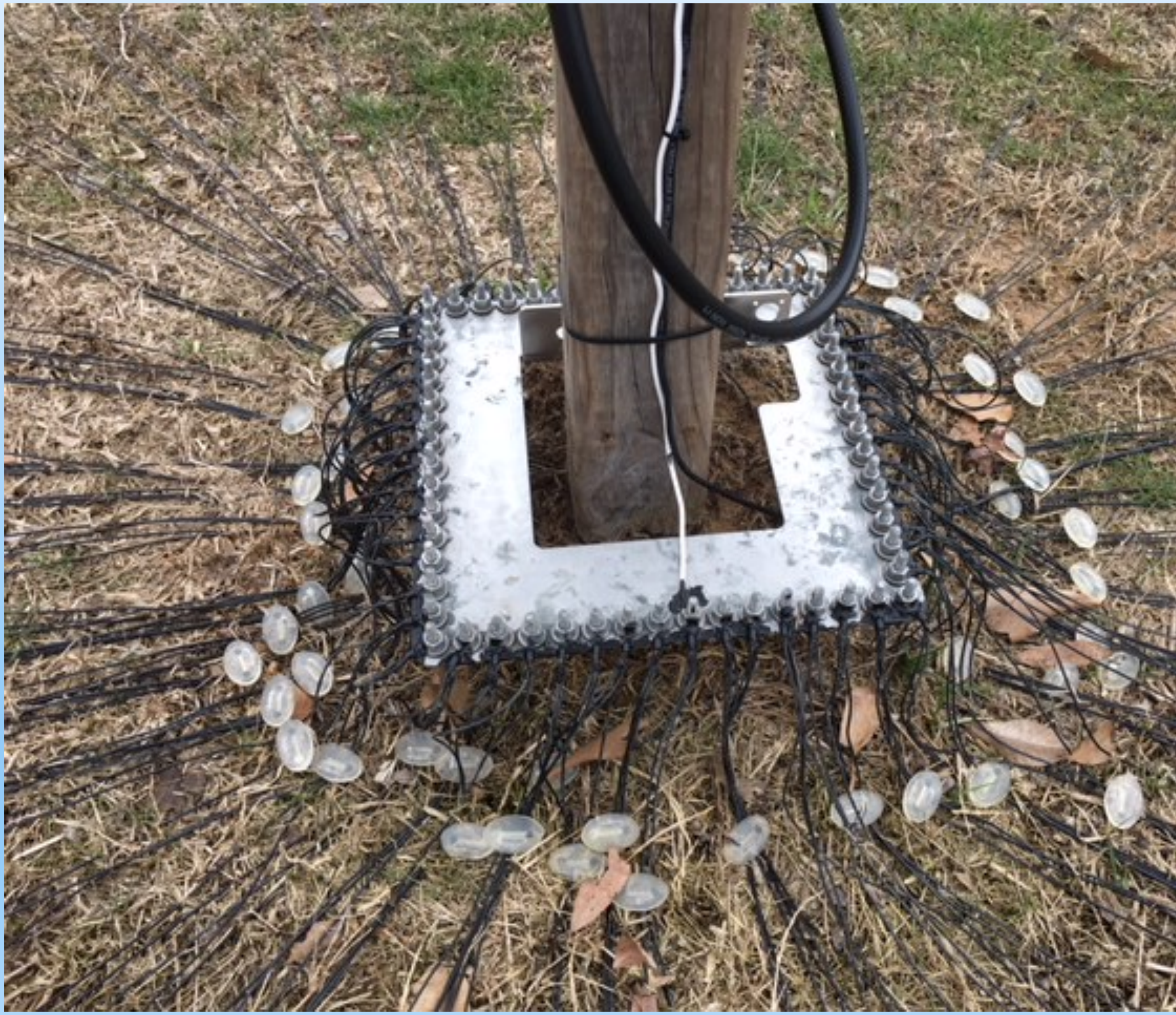
New grass growth in spring will cover the wires.

Radial System

- You can use any sound method for attaching radials wires at the elements. I prefer the DX Engineering Radial Plates
- I crimp & solder the radial wires to ring terminal lugs then coat the joint with liquid tape.
- I use Penetrox to maintain a good connection over time and prevent galvanic corrosion with different metals of the plate and terminals

Radial System

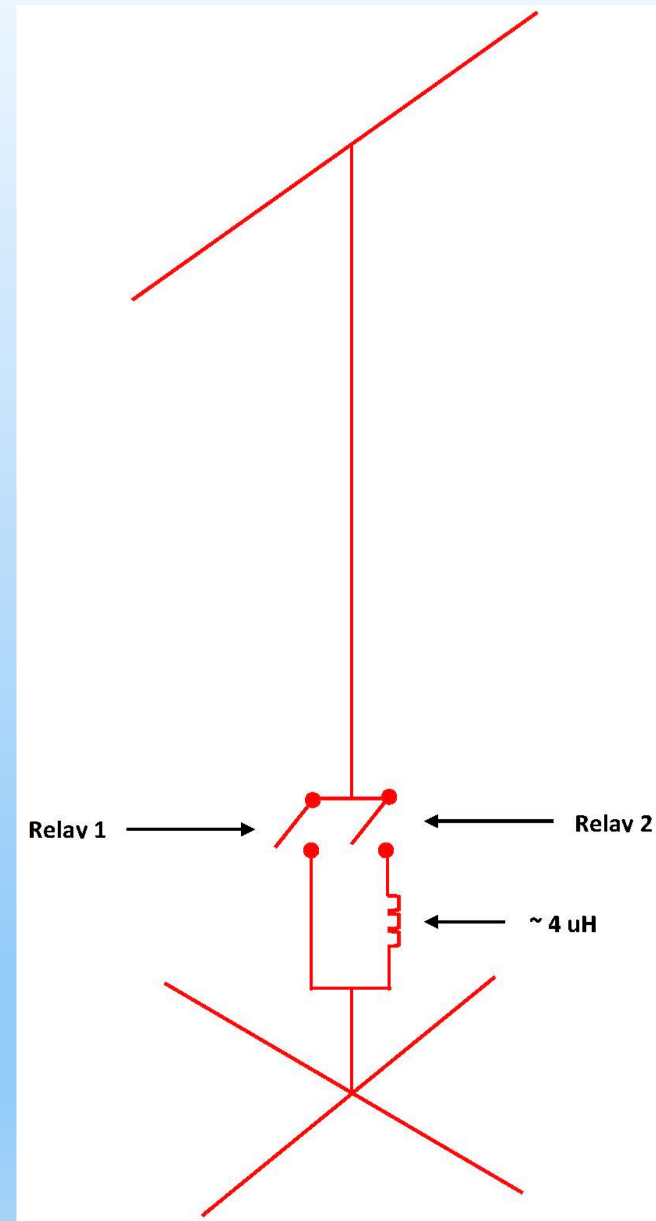
- Completed radial system under one element
- I use biodegradable staples to hold radials in place prior to new grass growth
- Total radial system area < 2 acres
- Total construction time for radial field - 4 weeks



Element Construction

Each element will need to function as a director and a reflector for different directions

To accomplish this, the element is switched directly to the radial system as a director, or through a 4 uH inductor to function as a reflector



Element Construction & Erection

Vertical & top load exact lengths are achieved by trial & error

Build one element, erect it and then tune to the target frequency. The remaining elements should be the same.

Use a rope and pulley on the first element unless you enjoy climbing 135 ft multiple times!!!!

Distance from driven element to first insulator on the top loading segment will be approx. 45 ft.

Distance from driven element to end tie point will be approx. 265 ft.

Element Construction

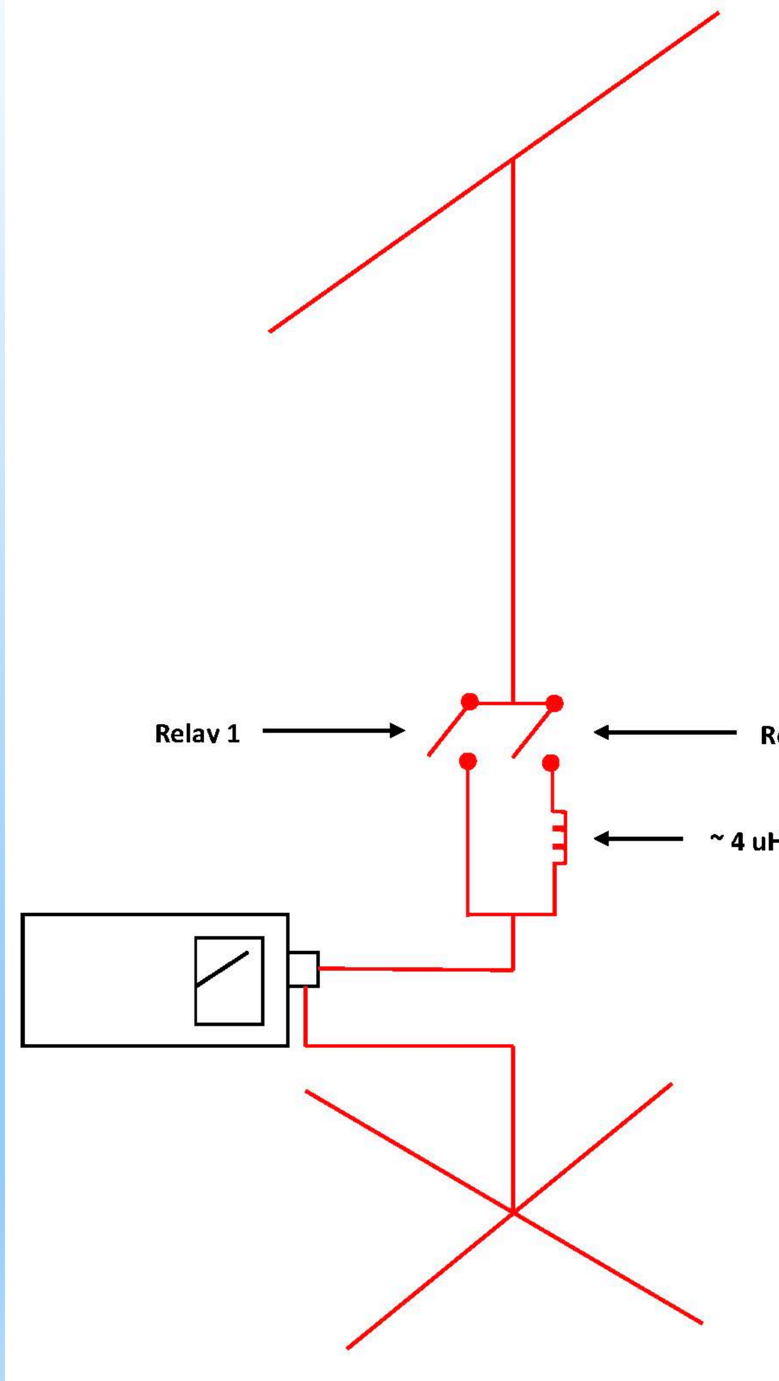
	ON4UN Model	K3LR System	W5ZN Initial	W5ZN Final
Top Load	64.7 ft.	58.3 ft.	58.3 ft.	65 ft.
Vertical	75.5 ft.	64.2 ft.	64.2 ft.	75 ft.
Director	1935 KHz	1904 KHz	2070 KHz	1904 KHz
Reflector	1778 KHz	1800 KHz	1950 KHz	1800 KHz

Tuning - Each Element

Connect an antenna analyzer between the vertical element and the radial system

Switch in the vertical wire directly to the radials and adjust the length to the desired director frequency

Switch in the vertical wire and inductor to the radials and adjust the turns spacing on the inductor for the desired reflector frequency



Tuning – As an Array

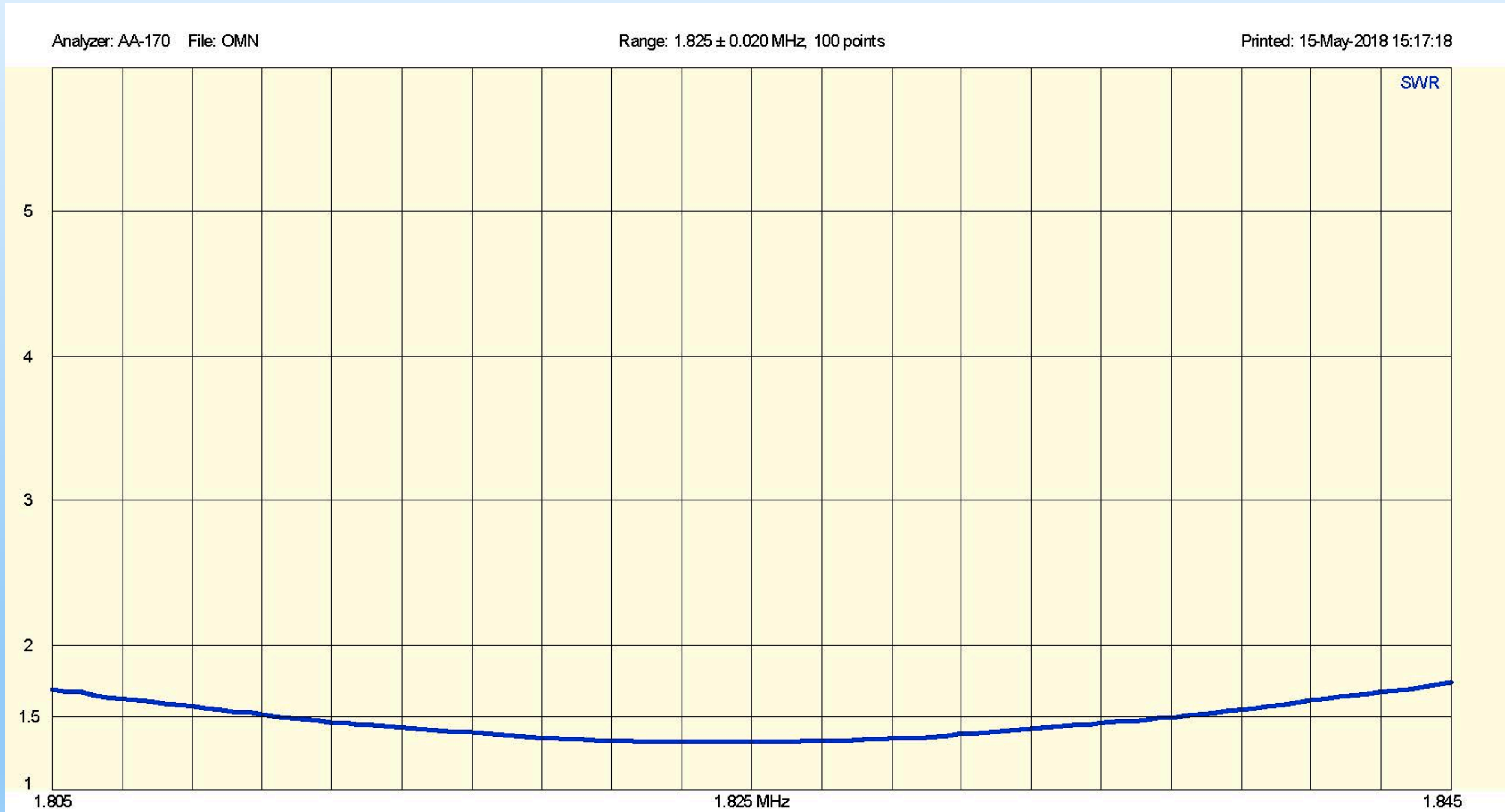
The system has an “Omni” mode when all four parasitic elements are floating however there is a difference in feed point impedance characteristics when the array is active.

- The Omni modes primary purpose is RX signal comparison

Make final SWR tuning adjustments with the “array” active

Should realize a very low 1.1:1 SWR with a 1.5:1 bandwidth of approximately 40 KHz

Tuning – As an Array



40 KHz Bandwidth

Final Adjustment Produced a 1.1:1 SWR at 1.825 MHz

Tuning – Fine Tweaking

Drive out approximately 1 to 2 miles in each of the four directions with a low level signal source

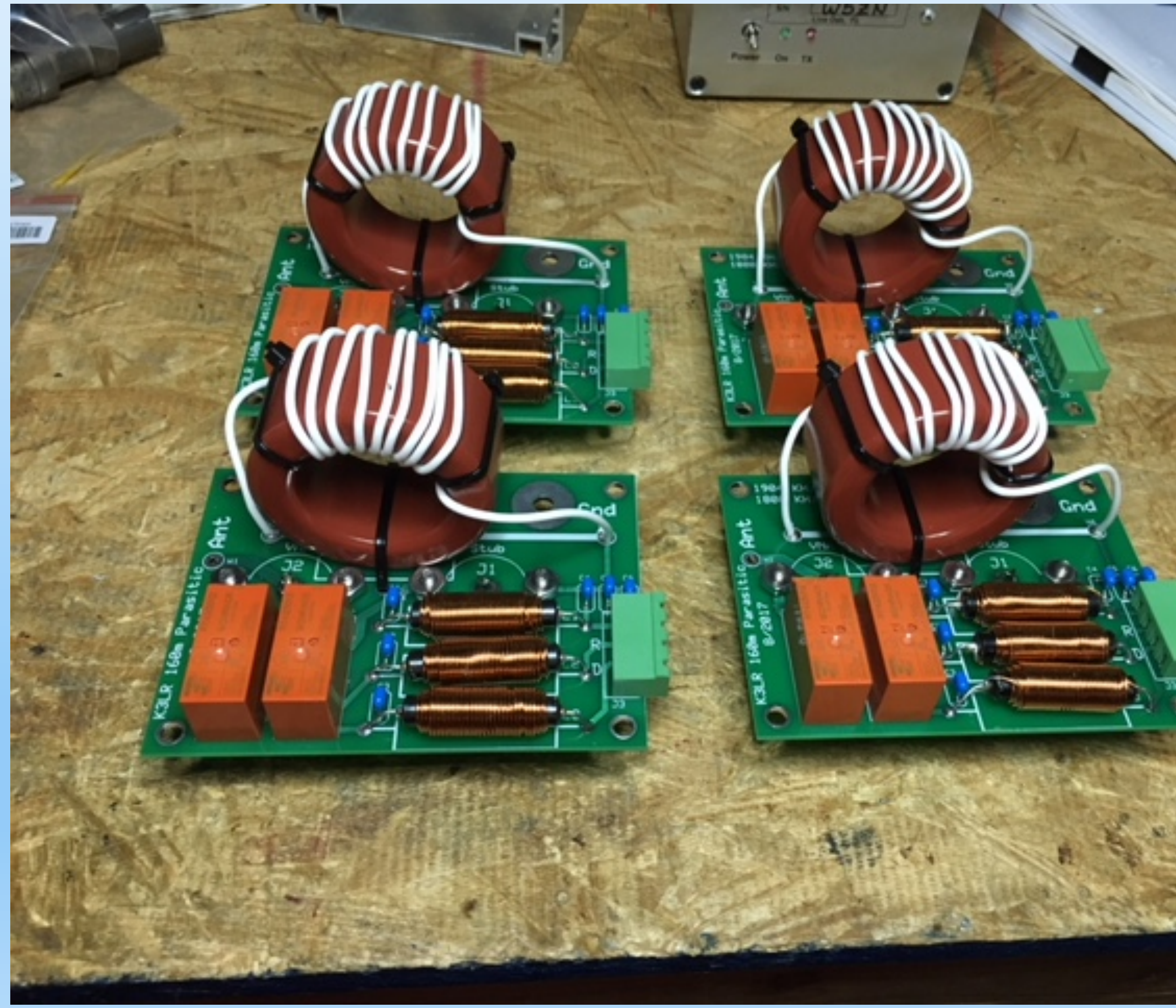
Adjust for maximum F/B – Procedure:

1. Drive to the opposite direction, e.g. SW for the NE direction
2. Select the NE Direction for the array
3. Transmit from the distant low level signal source
4. Adjust the turns spacing on the reflector element inductor for lowest signal (max F/B)

Array Switching

Greg Ordy, W8WWV designed a circuit board for K3LR

Once assembled it contains two relays and inductor



Array Switching

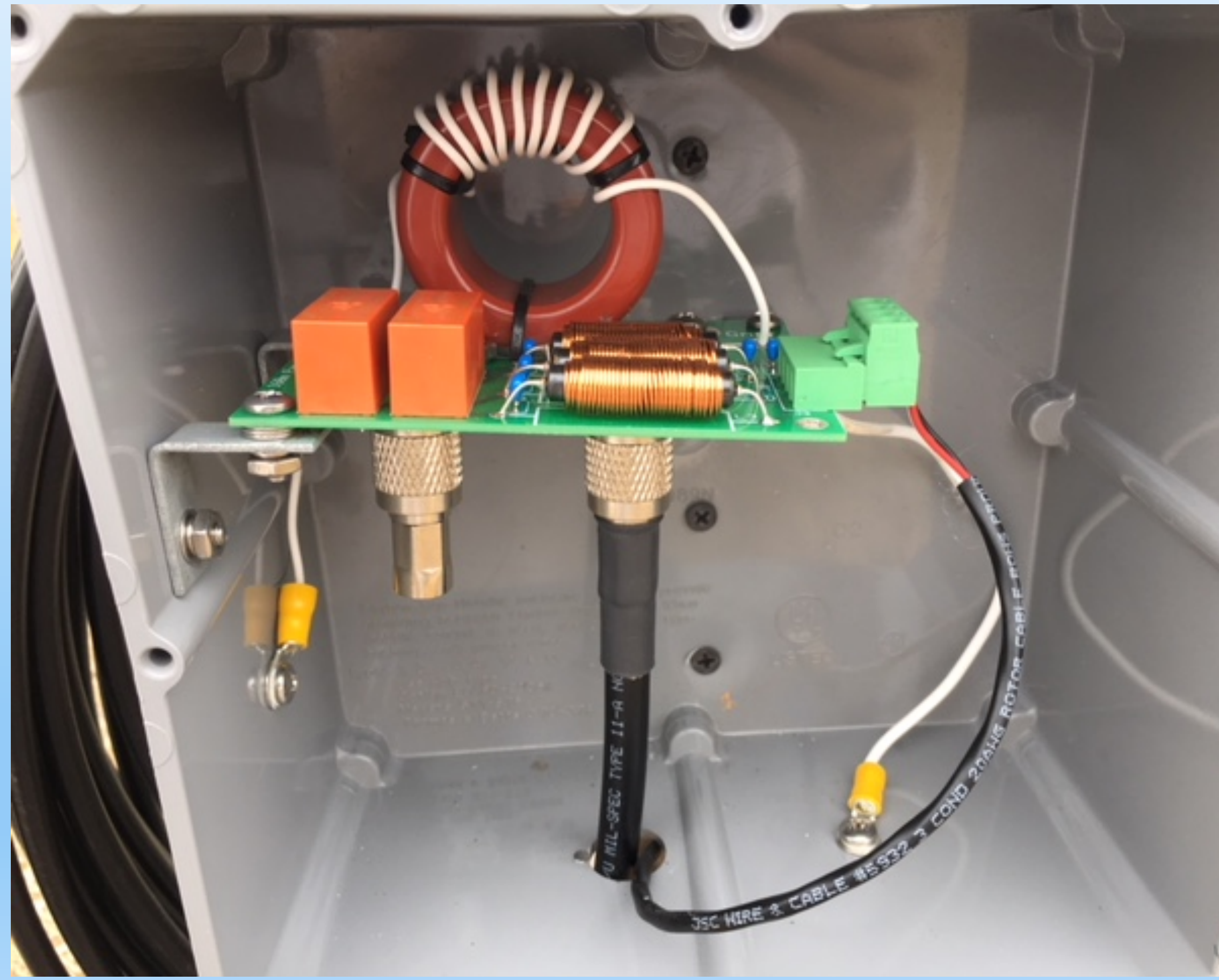
A 5 position switchbox is used to switch array direction

For one direction, relay 1 is energized on the forward director element and relay 2 on the rear reflector element

Unused elements are not connected from their radials and "float"

Array Switching

- Switch board installed at one element
- Plastic box housing used at each parasitic element



Array Switching

What the Heck is That Roll of Cable?

160 meter 1/4λ shorted stub

The 160 array is close to W5ZN's 80 meter 4 Square array

Invisible on 160 meters

- Stub is invisible on 160 meters, appears as an "open"

On 80 meters this is 1/2λ and appears as a "short" at the feed point

Eliminates/minimizes interaction between the two arrays

What the Heck is That Roll of Cable?

The Southeast 160 meter element is only 60 ft. from the northeast 80 meter 4 Square element

On-the-Air Results

- Realize 5 dB forward gain
- F/B ~25 dB
- RBN indicates significant improvement over single vertical
- Significant improvement in pileups!
- 9MØW Spratly 160 meter operator Jeff, K1ZM:
  - "Your signal was better than MOST! About RST 339 which may not sound LOUD - but compared to all the others at RST 219, you were LOUD (HI HI)"

Acknowledgements

Tim Duffy, K3LR

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