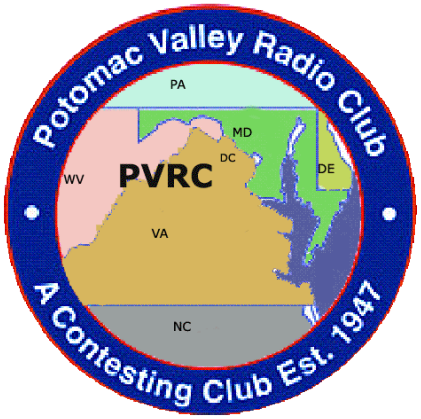
Low Band Antennas at W3LPL

Lessons Learned from More than Fifty Years of Continuous Improvement



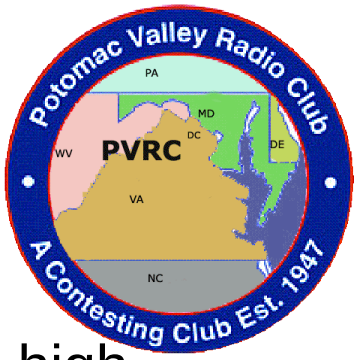
High Performance

Transmitting and Receiving Antennas

for 160, 80 and 40 meter

DXing and Contesting

High Performance 40 Meter Transmitting Antennas



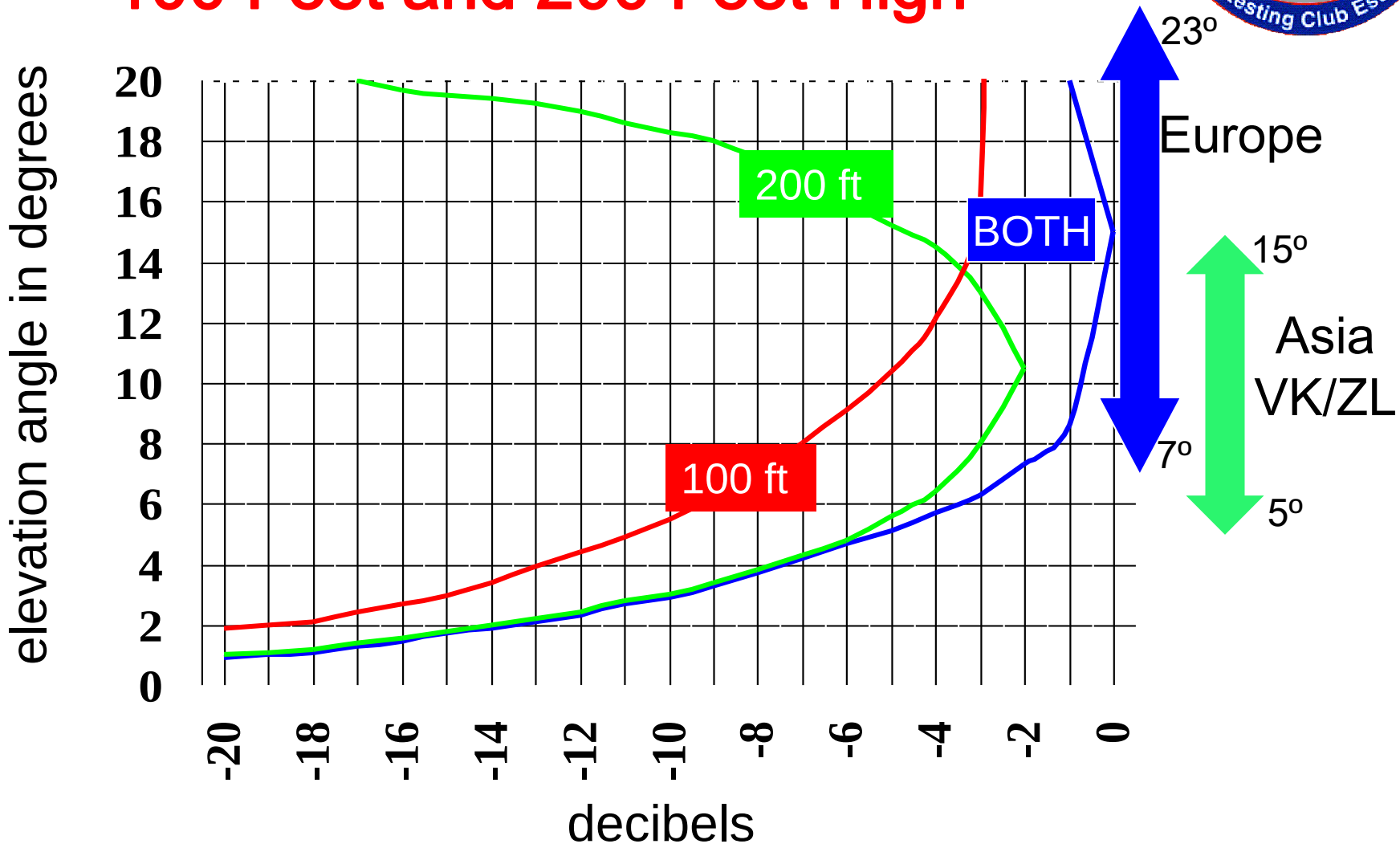
- High horizontally polarized dipole at least 70-100 feet high
  - easily provides 6 dB of ground gain – for free!
- 4-Square array of phased 33 foot verticals with 30-60 radials
  - good performance if high horizontal Yagis and quads aren't feasible
  - at least 50-70 feet away from all nearby towers and antennas
- "Shorty 40" 2 element Yagi or Moxon Rectangle 70-100 feet high
- 3 element Yagi or 4 element OWA Yagi 100-140 feet high
- Stacked 2 element "shorty 40" Yagis or Moxon Rectangles
  - lower Yagi 70-75 feet high upper Yagi 140-150 feet high
- Stacked 3 element Yagis or 4 element OWA Yagis
  - lower Yagi 100-120 feet high upper Yagi 190-200 feet high

High horizontally polarized antennas *almost always* provide better 40 meter DX performance than *any* vertically polarized antenna

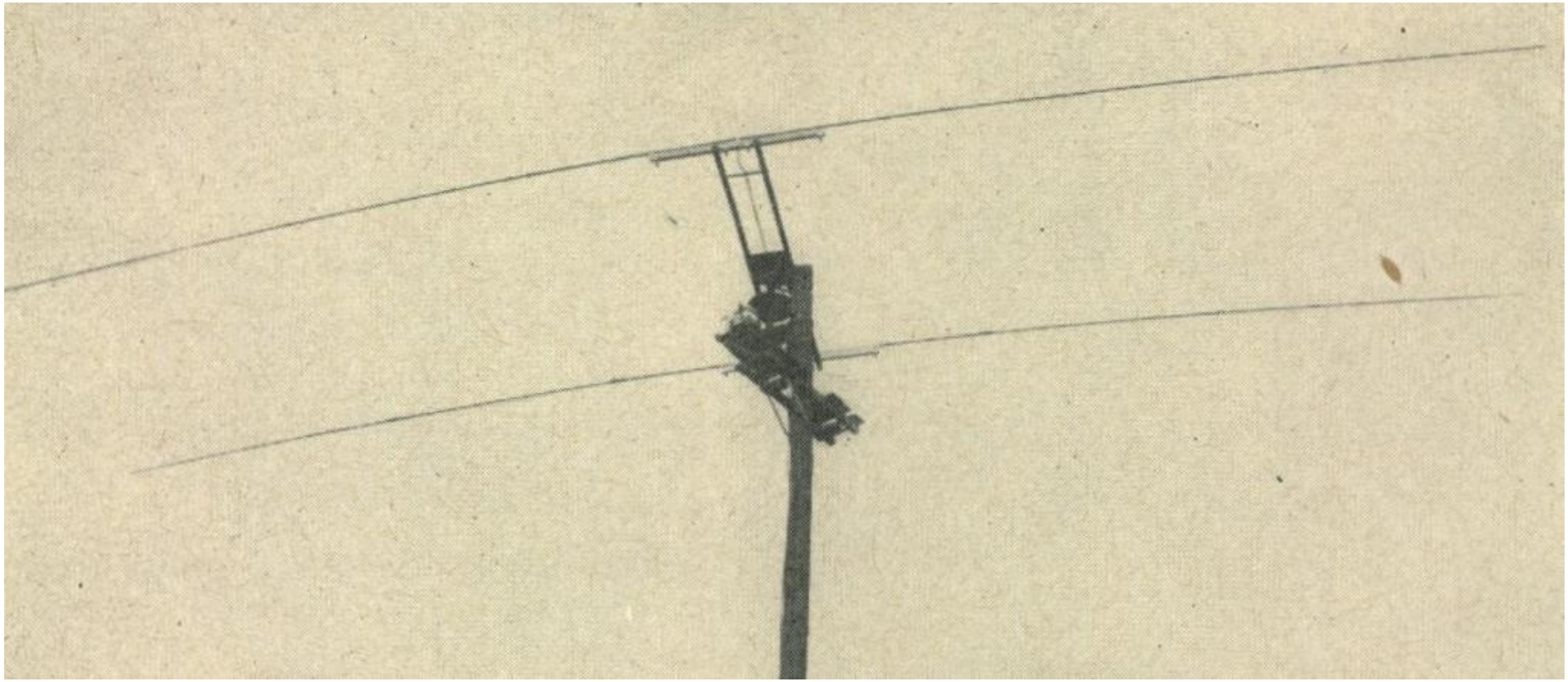
Stacked 3 Element 40 Meter Yagis

48 Foot Booms

100 Feet and 200 Feet High

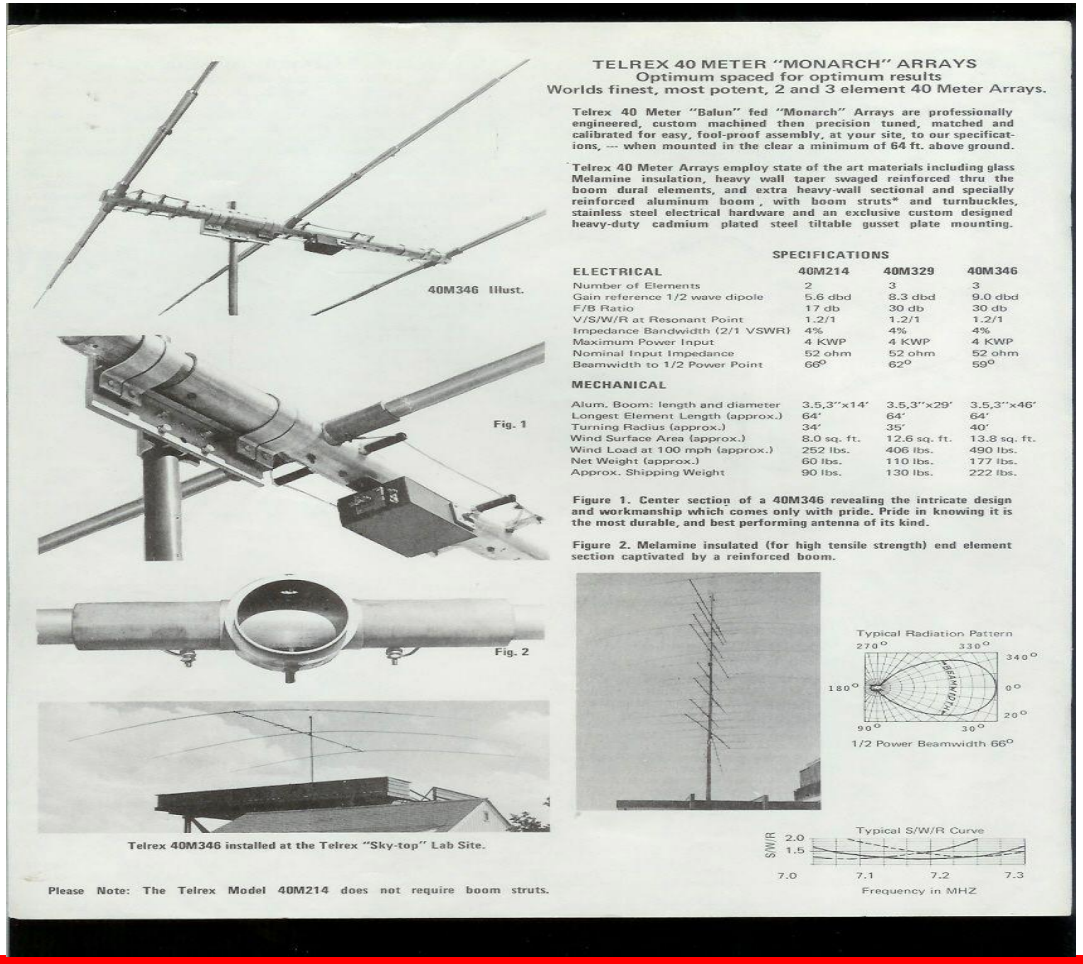


First Known 40 Meter Rotatable Yagi
2 Element Full Size Yagi at 60 Feet
Constructed by W9LM in 1950



Shortly after testing his new 40 meter Yagi,
W9LM removed all of his 40 meter phased verticals

The First (near) Full Size 3 Element 40 Meter Yagi in 1955



TELREX 40 METER "MONARCH" ARRAYS
Optimum spaced for optimum results
Worlds finest, most potent, 2 and 3 element 40 Meter Arrays.

Telrex 40 Meter "Balun" fed "Monarch" Arrays are professionally engineered, custom machined then precision tuned, matched and calibrated for easy, fool-proof assembly, at your site, to our specifications, -- when mounted in the clear a minimum of 64 ft. above ground.

Telrex 40 Meter Arrays employ state of the art materials including glass Melamine insulation, heavy wall taper swaged reinforced thru the boom dural elements, and extra heavy-wall sectional and specially reinforced aluminum boom, with boom struts* and turnbuckles, stainless steel electrical hardware and an exclusive custom designed heavy-duty cadmium plated steel tiltable gusset plate mounting.

40M346 Illust.

Fig. 1

Fig. 2

Telrex 40M346 installed at the Telrex "Sky-top" Lab Site.

Please Note: The Telrex Model 40M214 does not require boom struts.

SPECIFICATIONS

ELECTRICAL	40M214	40M329	40M346
Number of Elements	2	3	3
Gain reference 1/2 wave dipole	5.6 dbd	8.3 dbd	9.0 dbd
F/B Ratio	17 db	30 db	30 db
V/S/W/R at Resonant Point	1.2/1	1.2/1	1.2/1
Impedance Bandwidth (2/1 VSWR)	4%	4%	4%
Maximum Power Input	4 KWP	4 KWP	4 KWP
Nominal Input Impedance	52 ohm	52 ohm	52 ohm
Beamwidth to 1/2 Power Point	66°	62°	59°
MECHANICAL			
Alum. Boom: length and diameter	3.5,3"x14'	3.5,3"x29'	3.5,3"x46'
Longest Element Length (approx.)	64'	64'	64'
Turning Radius (approx.)	34'	35'	40'
Wind Surface Area (approx.)	8.0 sq. ft.	12.6 sq. ft.	13.8 sq. ft.
Wind Load at 100 mph (approx.)	252 lbs.	406 lbs.	490 lbs.
Net Weight (approx.)	60 lbs.	110 lbs.	177 lbs.
Approx. Shipping Weight	90 lbs.	130 lbs.	222 lbs.

Figure 1. Center section of a 40M346 revealing the intricate design and workmanship which comes only with pride. Pride in knowing it is the most durable, and best performing antenna of its kind.

Figure 2. Melamine insulated (for high tensile strength) end element section captivated by a reinforced boom.

Typical Radiation Pattern

1/2 Power Beamwidth 66°

Typical S/W/R Curve

Frequency in MHZ

Telrex 3 element Yagis transformed 40 meter DXing in the 1950s

W0MLY W1FZ K2DGT K2GL K2LWR WA2SFP(W2PV) W8FGX W8VSK W9EWC

W3KRQ's Homebrew Full Size 3 Element 40 Meter Yagi in 1959

Contesters and DXers built many excellent 3 element Yagis
W3GRF W3KRQ W3MSK (W3AU) W8JIN and others

Cushcraft XM-240
2 Element 40 Meter Yagi

One of the most popular “Shorty Forty” Yagis

www.cushcraftamateur.com/Product.php?productid=XM-240

40 Meter Moxon Rectangle

VSWR less than 1.4:1 from 7.0-7.3 MHz
22 foot boom and 48 foot elements

Stacked Moxons on a 140 foot tower are fully competitive with a more expensive full size 3 element Yagi

www.k3lr.com/engineering/moxon

Stacked 40 Meter 4 element OWA Yagis at K9CT

k9ct.us/contest-antennas/40-m

The Array Solutions Stack Match

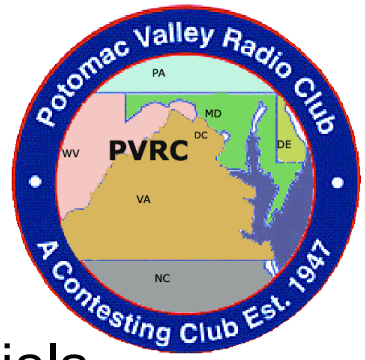
www.arraysolutions.com/Products/stackmatch.htm

A Stackmatch significantly improves the capabilities of any stacked Yagi array

The Comtek
4-Square Controller

www.dxengineering.com/search/brand/comtek

High Performance 80 Meter Transmitting Antennas



- 65 foot vertical with 30-60 shallow buried 65 foot radials
  - good performance if a high dipole isn't feasible
- High horizontally polarized dipole at least 70-100 feet high
  - easily provides 6 dB of ground gain – for free!
- Horizontally polarized 2 or 3 element Yagi, 2 element quad or Moxon Rectangle
  - at least 140 feet high
- 4-Square array of phased 65 foot verticals
  - excellent performance as an alternative to horizontal quads or Yagis
  - at least 30-60 shallow buried 65 foot radials under each vertical
  - at least 70-140 feet away from all nearby towers and antennas

High horizontally polarized antennas *almost always* provide better 80 meter DX performance than *simple* vertically polarized antennas

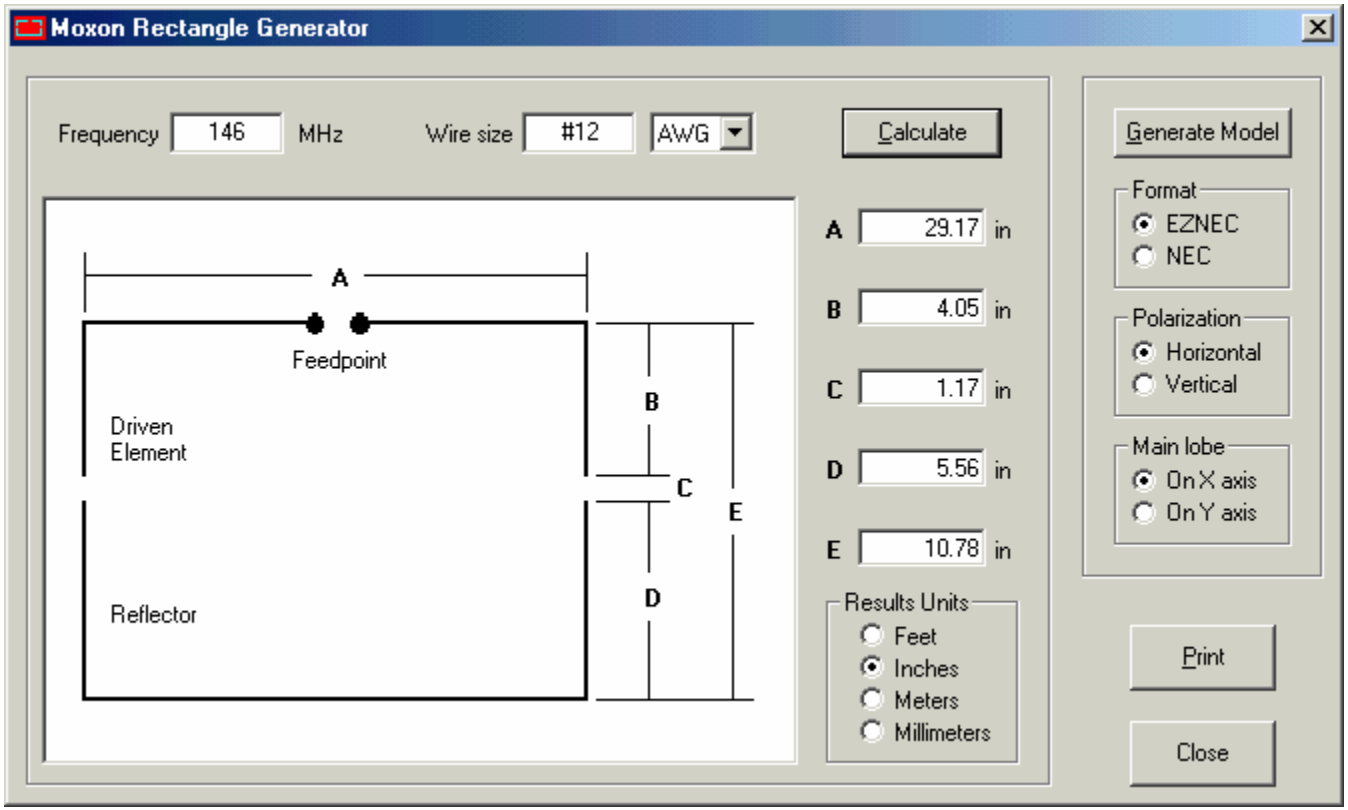
K3ZO Installed this 3 Element 80 Meter Yagi at 140 Feet in 1984

K3ZO's very successful horizontally polarized 3 element Yagi changed my thinking about 80 meter antennas for DX

80 Meter Wire Moxon Rectangle at 140 feet at W3LPL

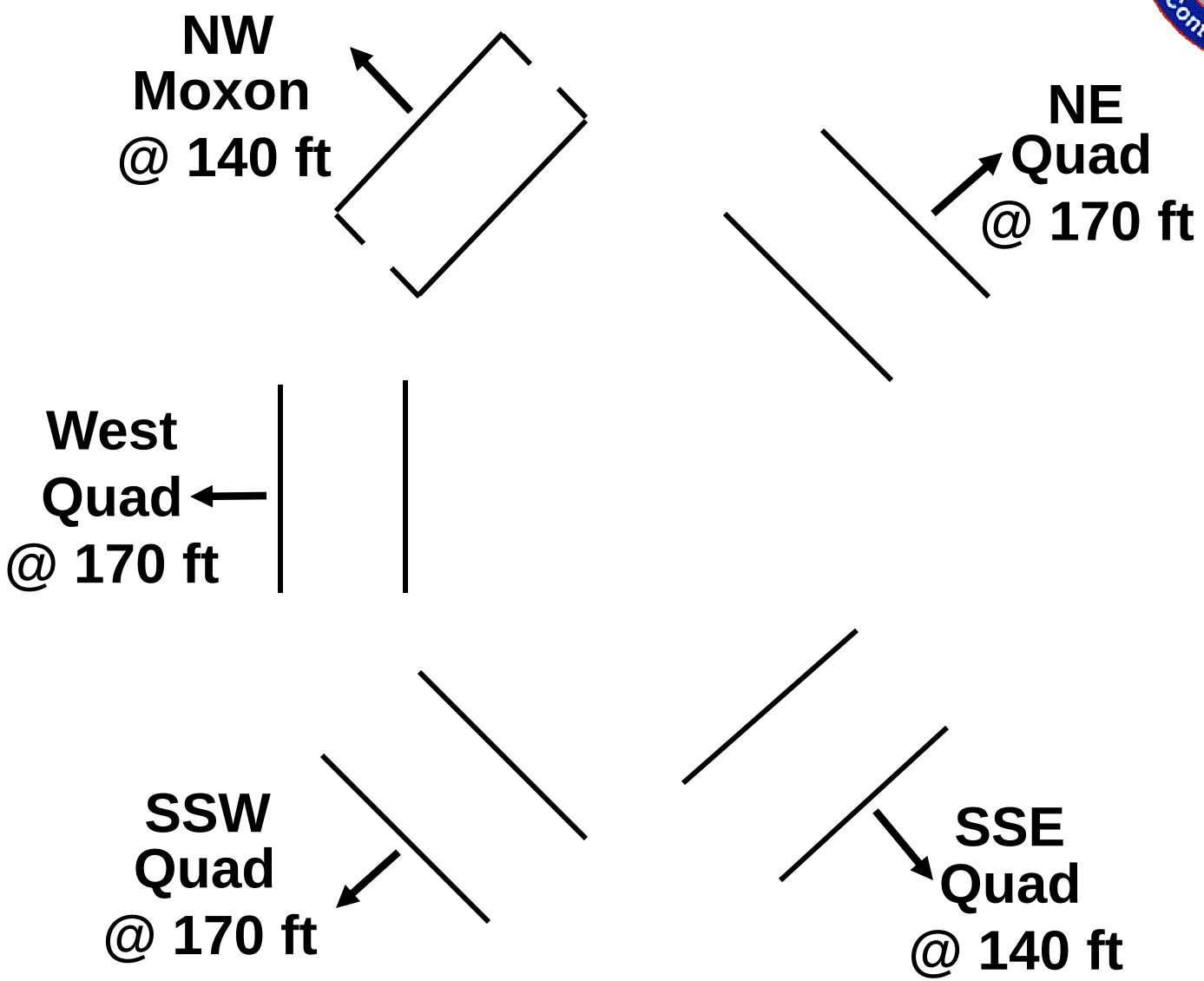
Broad VSWR bandwidth from 3.5-3.8 MHz

102 feet x 37 feet

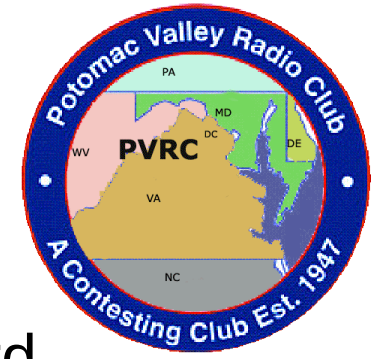


www.moxonantennaproject.com

80 Meter Transmitting Antenna Layout at W3LPL



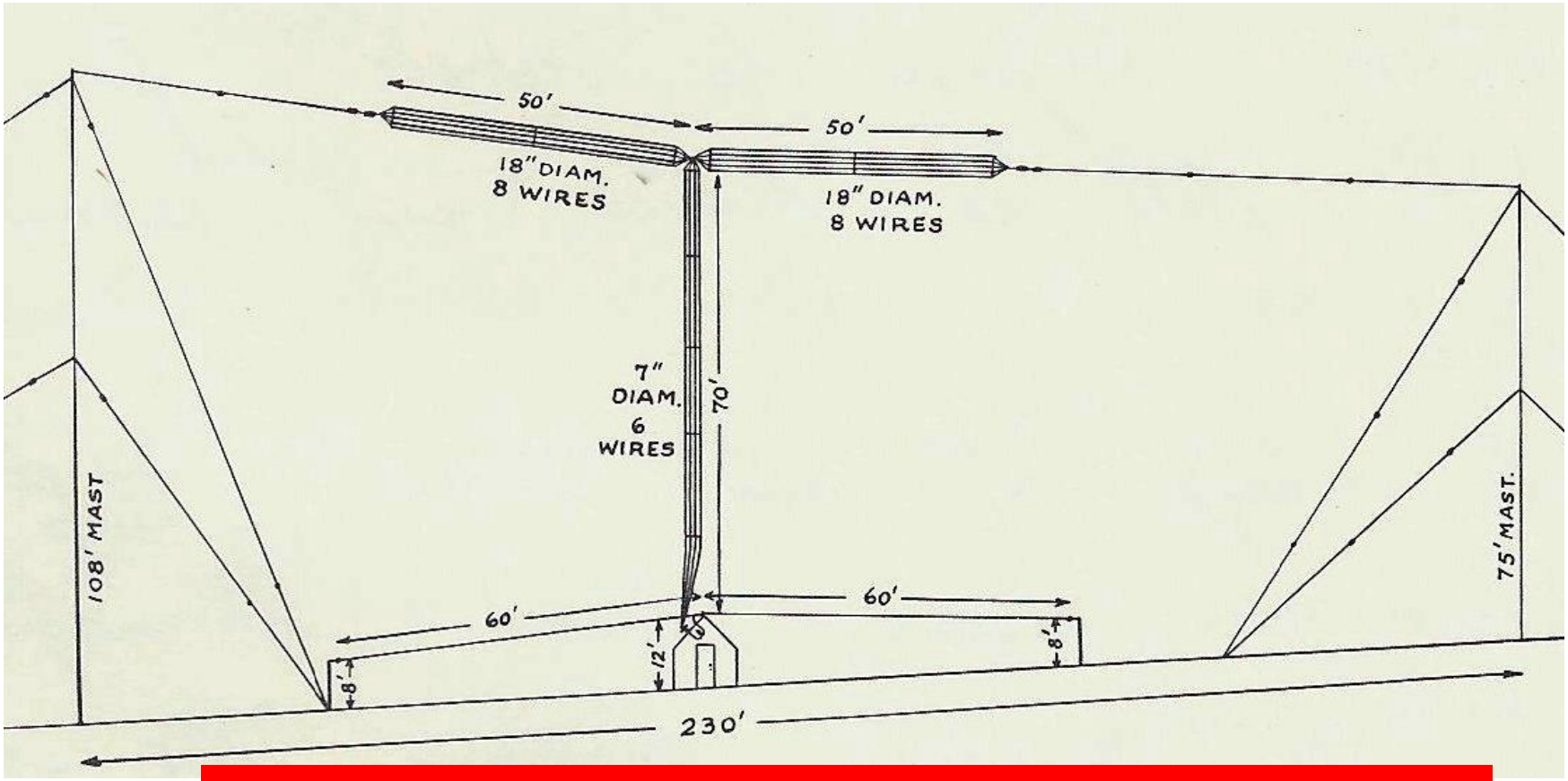
High Performance 160 Meter Transmitting Antennas



- The 125 foot vertical: the 160 meter gold standard
  - at least 30-60 shallow buried 120 foot radials
- 4-square arrays of phased 125 foot verticals
  - very high performance for both transmitting and receiving
  - at least 30-60 shallow buried 120 foot radials for each vertical
- Tall towers and antennas will significantly degrade the performance of nearby vertical antennas
  - at least 125-250 feet away from all nearby towers and antennas
    - significant antenna pattern degradation
    - increased ground losses
  - tower detuning is possible but it's a complex task

Horizontally polarized transmitting antennas are *almost always* a poor choice for 160 meter DX

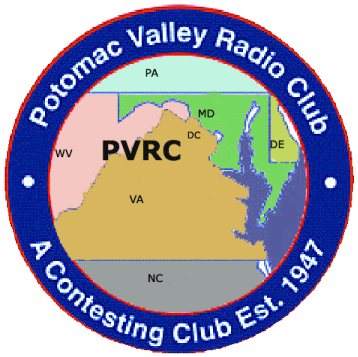
Cage T-Vertical Used by 1 BCG in the Successful 1921 Trans-Atlantic Tests



By far the strongest North American signal heard in Europe during the Trans-Atlantic Tests

High Performance
Low Band Receiving Antennas

Beverages and Phased Arrays of Short Verticals



- Much better directivity than most transmitting antennas
  - much lower cost
  - instant azimuth selection
  - greatly reduced footprint and greatly reduced height (7 to 25 feet)
  - superb QRM, QRN and RFI suppression on as little as 3/4 acre
  - in-band receiving capabilities for multi-op and SO2R stations
  - greatly reduced mutual coupling between individual verticals
  - greatly reduced need for high efficiency matching and radial systems

- Beverages
- Arrays of Beverages

- Arrays of short passive verticals
- Arrays of short active verticals

All receiving antenna dimensions in this presentation are for 160 meters - simply scale them to 80 or 40 meters

Single Wire Beverage

The simplest and most reliable high performance receiving antenna

250 - 400 feet long	4 - 6 dB RDF	100 degree beam width
500 - 700 feet long	10 -11 dB RDF	70 degree beam width
800 - 900 feet long	12 dB RDF	60 degree beam width

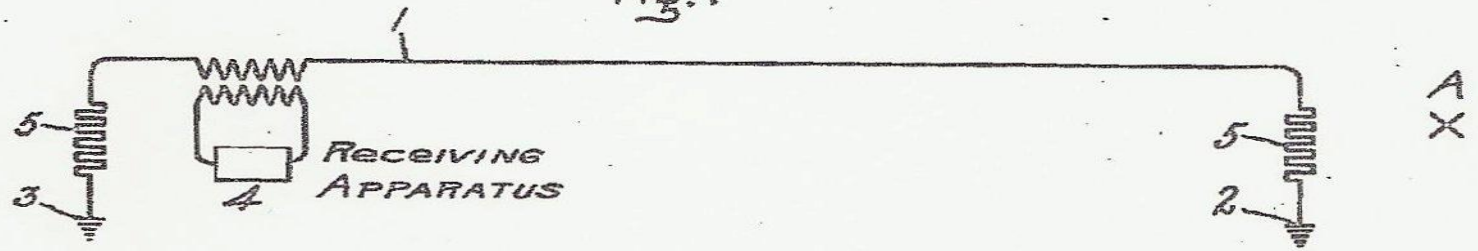
H. H. BEVERAGE.

RADIORECEIVING SYSTEM.

APPLICATION FILED APR. 10, 1920.

1,381,089. Patented June 7, 1921.

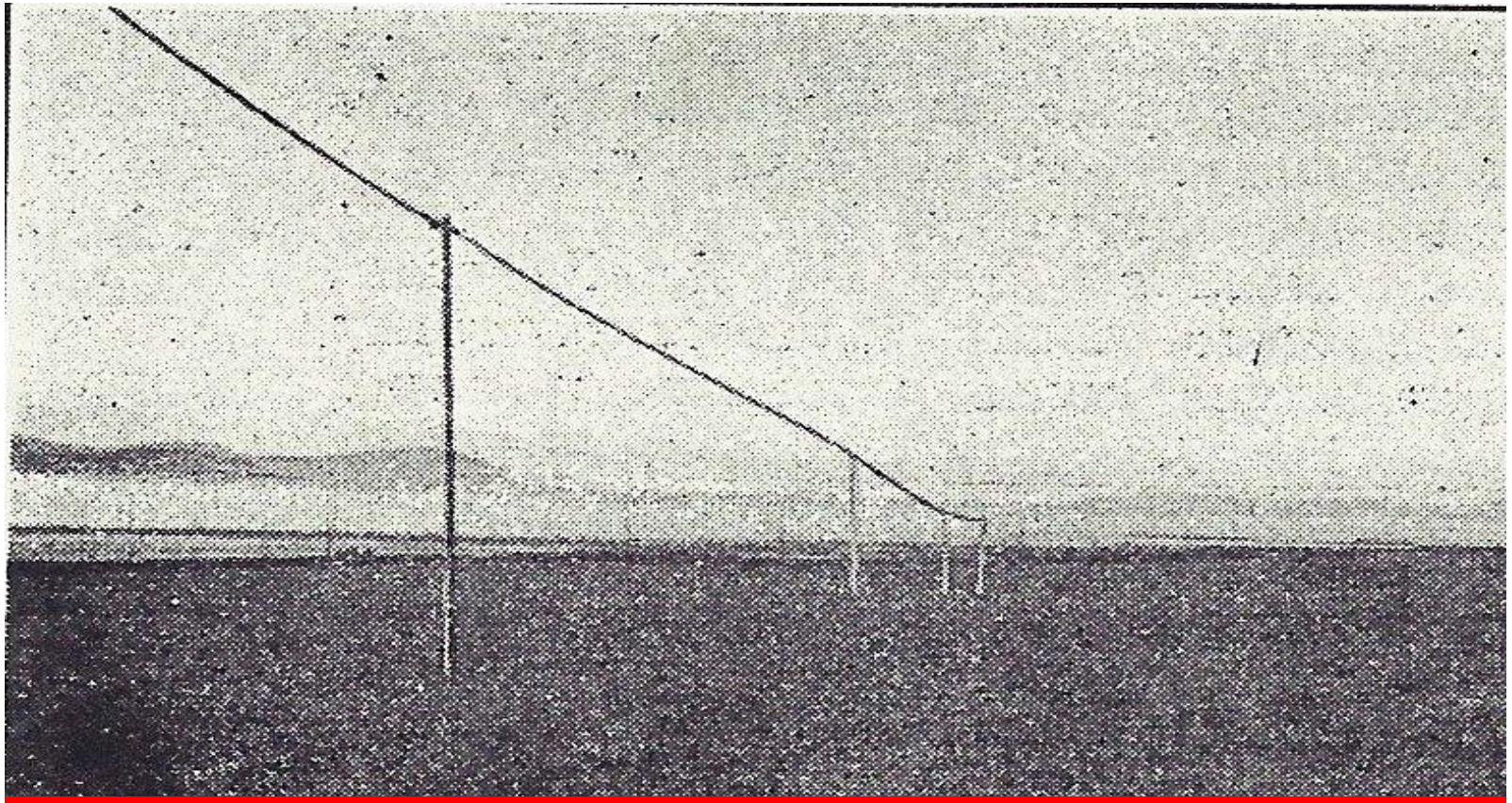
Fig. 1



Inventor:
Harold H. Beverage,
by Albert G. Davis
His Attorney.

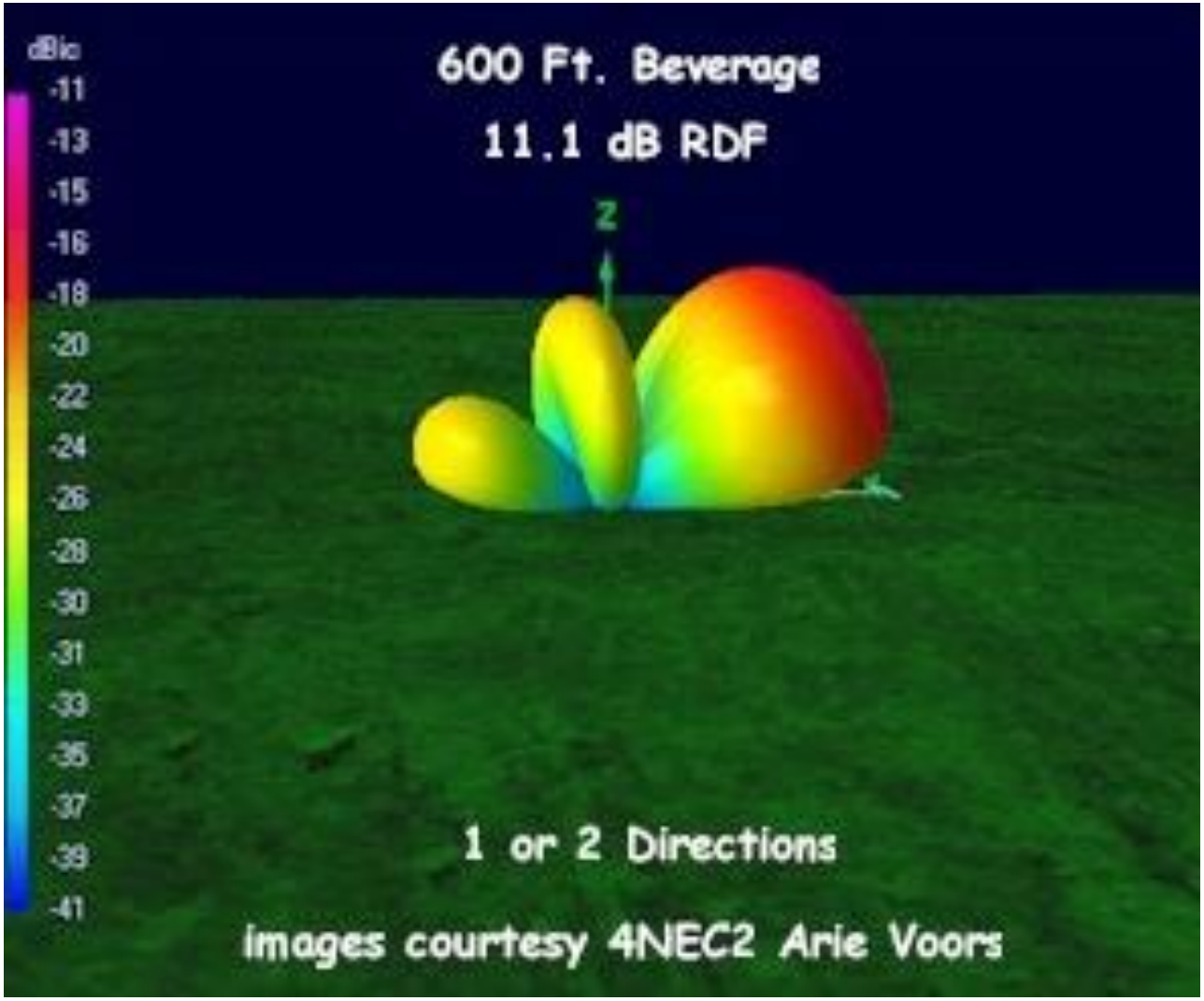
http://www.w8ji.com/beverages.htm

1300 Foot Beverage Installed by 2ZE Paul Godley at Androssen, Scotland during the Successful 1921 Trans-Atlantic Tests



Beverages were all but forgotten by hams for 45 years until K1PBW re-introduced them to 160 meter DXers in 1967

160 Meter Radiation Pattern of a Simple 600 Foot Beverage

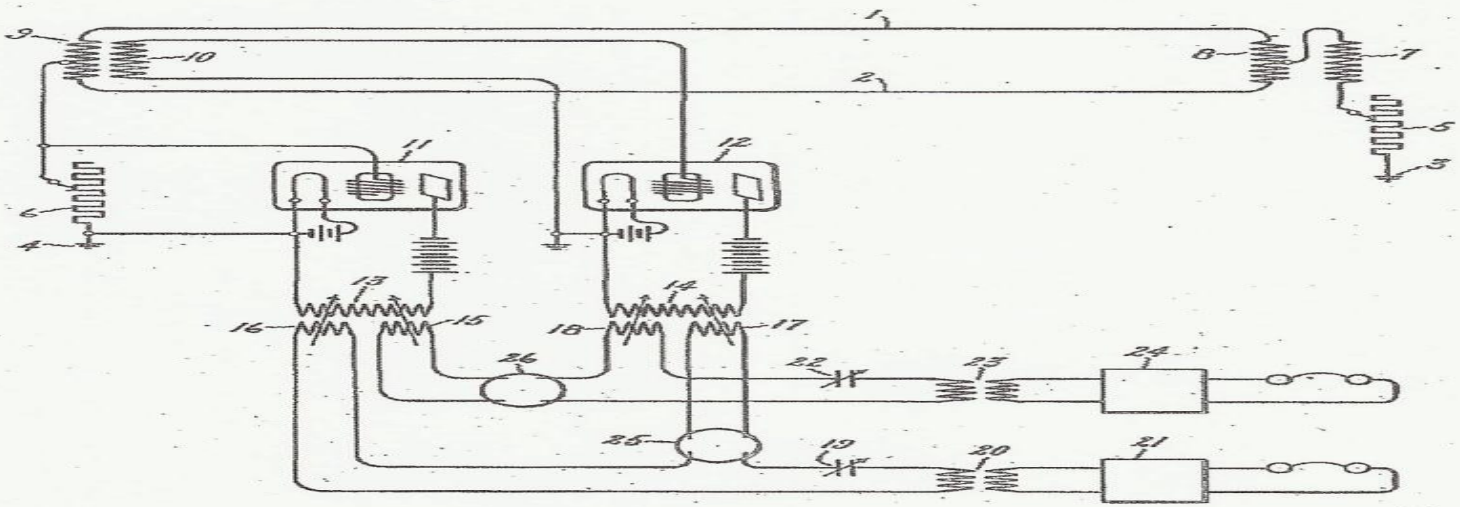


Two Wire Bidirectional Beverage

Switchable in two directions with one feed line
A deep rear null can be steered if both feed lines
feed a variable phase combiner

H. H. BEVERAGE.
RADIORECEIVING SYSTEM.
APPLICATION FILED MAY 3, 1921.

1,434,984. Patented Nov. 7, 1922.



Inventor:
Harold H. Beverage,
by Albert G. Davis
His Attorney.

www.w0btu.com/Beverage_antennas.html

Close Spaced Staggered Beverage Arrays

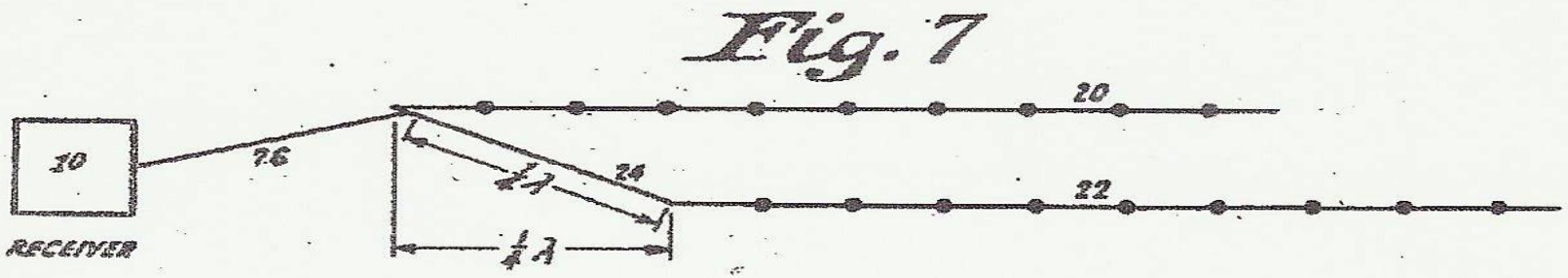
Two or three close spaced, staggered 500-600 foot Beverages
Enhanced front-to-back ratio compared to a single Beverage
A deep rear null can be steered if both feed lines
feed a variable phase combiner

11 dB RDF on one acre

Sept. 1, 1931. H. O. PETERSON 1,821,402

ANTENNA

Filed Nov. 8, 1927 2 Sheets-Sheet 2



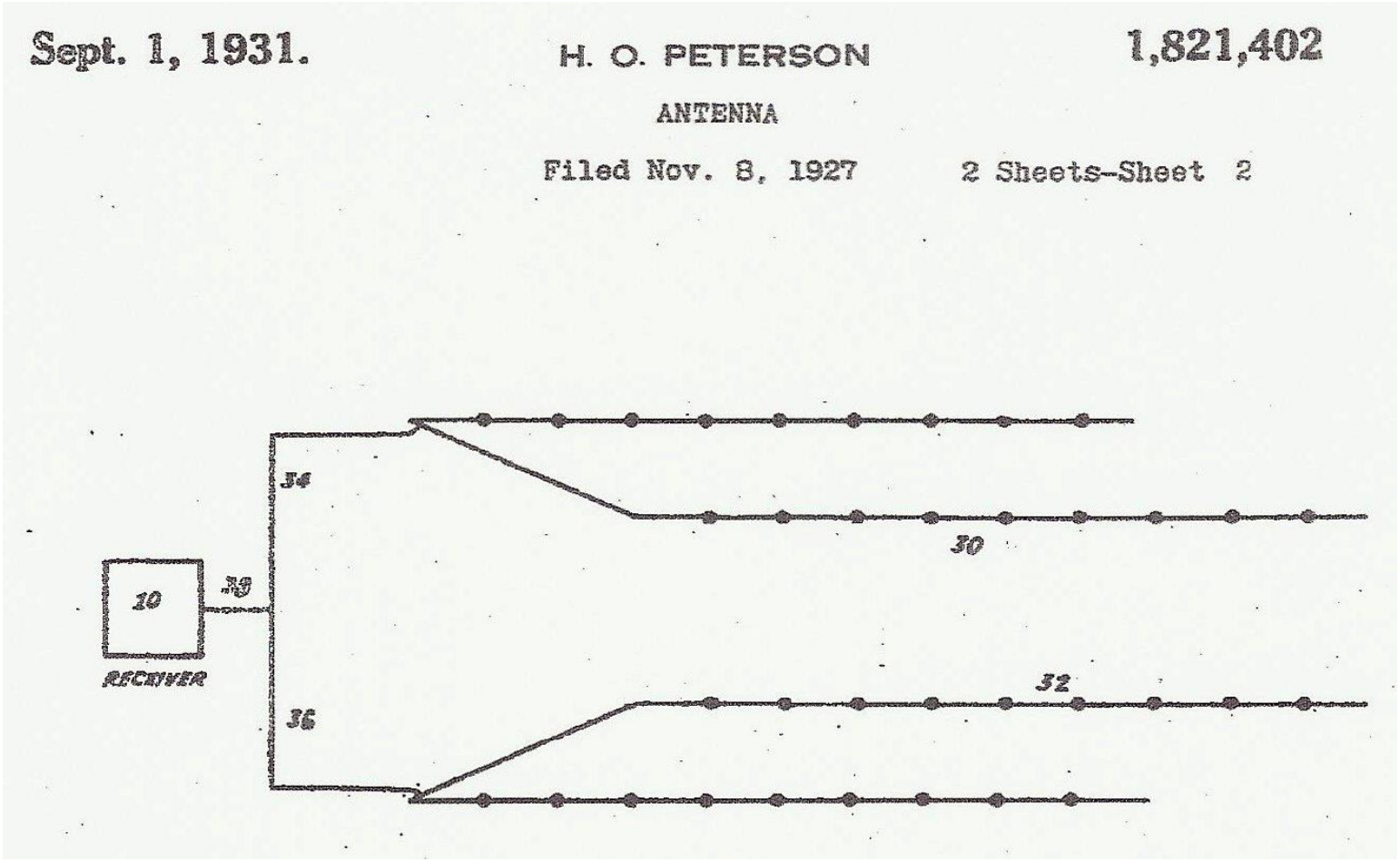
http://ncjweb.com/features/sepoct11feat.pdf

Broadside Pair of Staggered Beverages

Four 800-900 foot Beverages, 330 foot broad side spacing

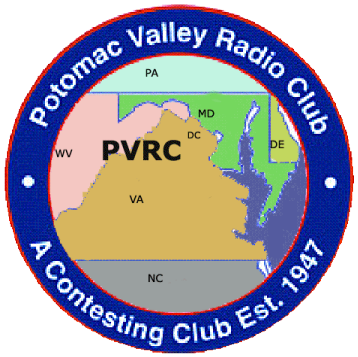
45 degree 3 dB beamwidth

14 dB RDF on 8 acres



Phased Low Impedance Verticals

25 Foot Passive Umbrella Verticals



- Short radials are required at the base of each vertical
  - eight 70 foot radials, sixteen 35 foot radials or chicken wire
  - randomly laid on the ground or shallow buried, symmetry is not important
- Four 25 foot umbrella wires attached to the top of each vertical
  - reduces antenna height and improves array bandwidth
  - if necessary, use 35 foot verticals with no umbrella wires
- As little a 65 foot element spacing in a 4-square array
  - its difficult to achieve stable, repeatable performance with smaller spacing
- No amplifiers – much higher reliability than active arrays
- Switchable in multiple directions
- Very easy and low cost to homebrew your own antenna
  - large diameter arrays are very tolerant of moderate amplitude and phase errors
- Low impedance verticals are tolerant of nearby trees and buildings
- Avoid re-radiation from nearby towers, antennas and power lines
  - locate the antenna as far as possible from other antennas and power lines

Excellent Performance with Very High Reliability

Electrically Steerable 4-Square Vertical Array

Four High Impedance 20 Foot Verticals

no radials and no umbrella wires

80x80 foot square x 20 foot high footprint

high input impedance amplifier at the base of each vertical

switchable in four directions

100 degree 3 dB beam width

12 dB RDF on less than ¼ acre

www.dxengineering.com/parts/hiz-4-lv2-80

Electrically Steerable 4-Square Vertical Array

Four Low Impedance 25 foot Umbrella Verticals

four 25 foot umbrella wires attach to the top of each vertical

eight 70 foot or sixteen 35 foot radials per vertical

65x65 foot square footprint plus additional space for radials

switchable in four directions

inexpensive and very easy to build

100 degree 3 dB beamwidth

12 dB RDF on ¼ acre

www.iv3prk.it/user/image/site2-rxant.prk_4-square_1.pdf

Electrically Steerable 8-Circle Vertical Array

Eight Low Impedance 25 Foot Umbrella Verticals

four 25 foot umbrella wires per vertical
eight 70 foot or sixteen 35 foot radials per vertical
350 foot diameter with plus space for radials
or only 200 foot diameter with a 106 degree Hi-Z phasing controller
switchable in eight directions
inexpensive and very easy to build
50 degree 3 dB beam width, the performance of a 5 element Yagi

13.5 dB RDF on one acre

construction details: http://www.w5zn.org

Electrically Steerable 8-Circle Vertical Array

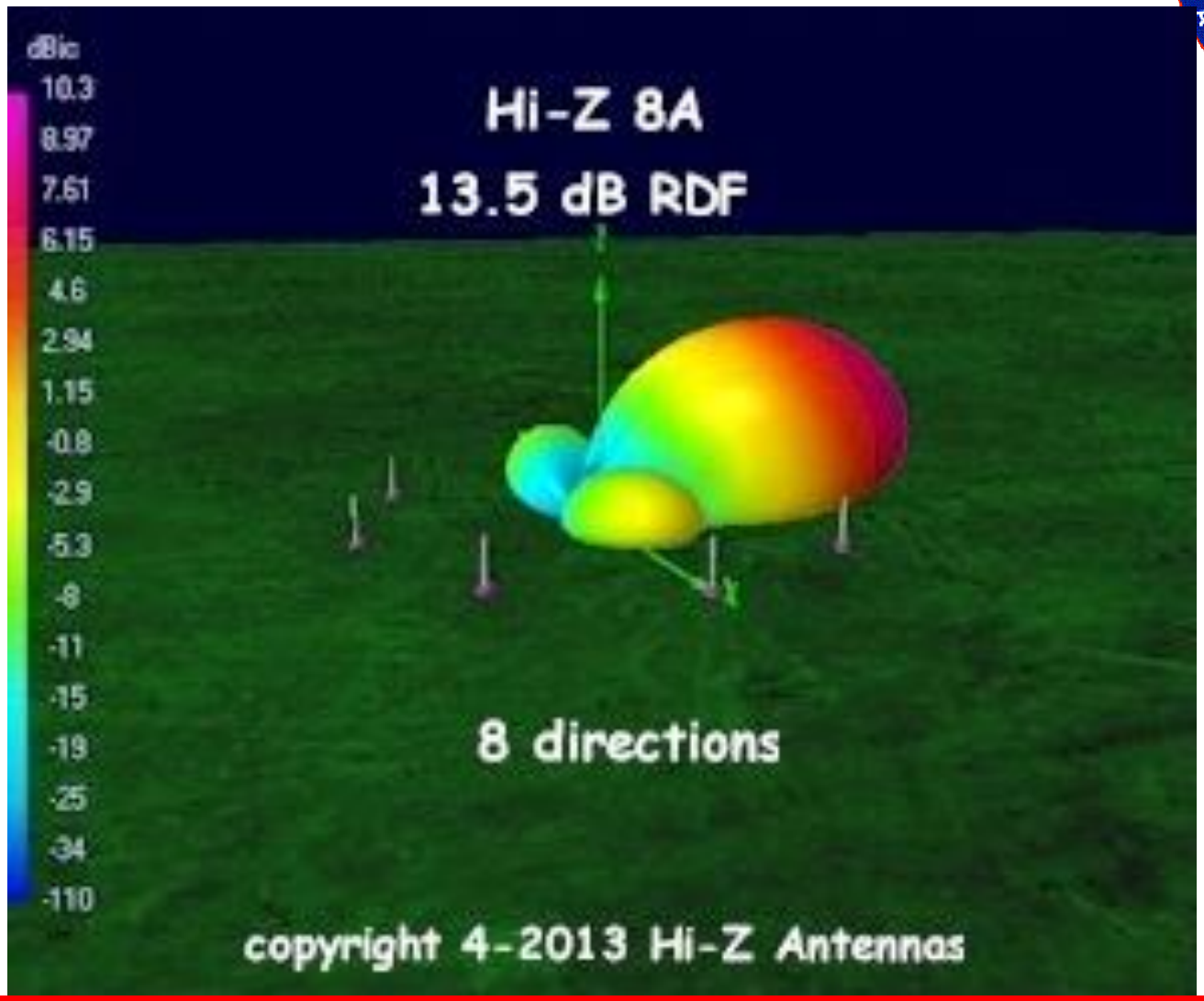
Eight High Impedance 20 Foot Verticals

200 foot diameter
no radials and no umbrella wires
high input impedance amplifier at the base of each vertical
106 degree phasing with a Hi-Z phasing controller
switchable in eight directions
50 degree 3 dB beam width, the performance of a 5 element Yagi

13.5 dB RDF on 3/4 acre

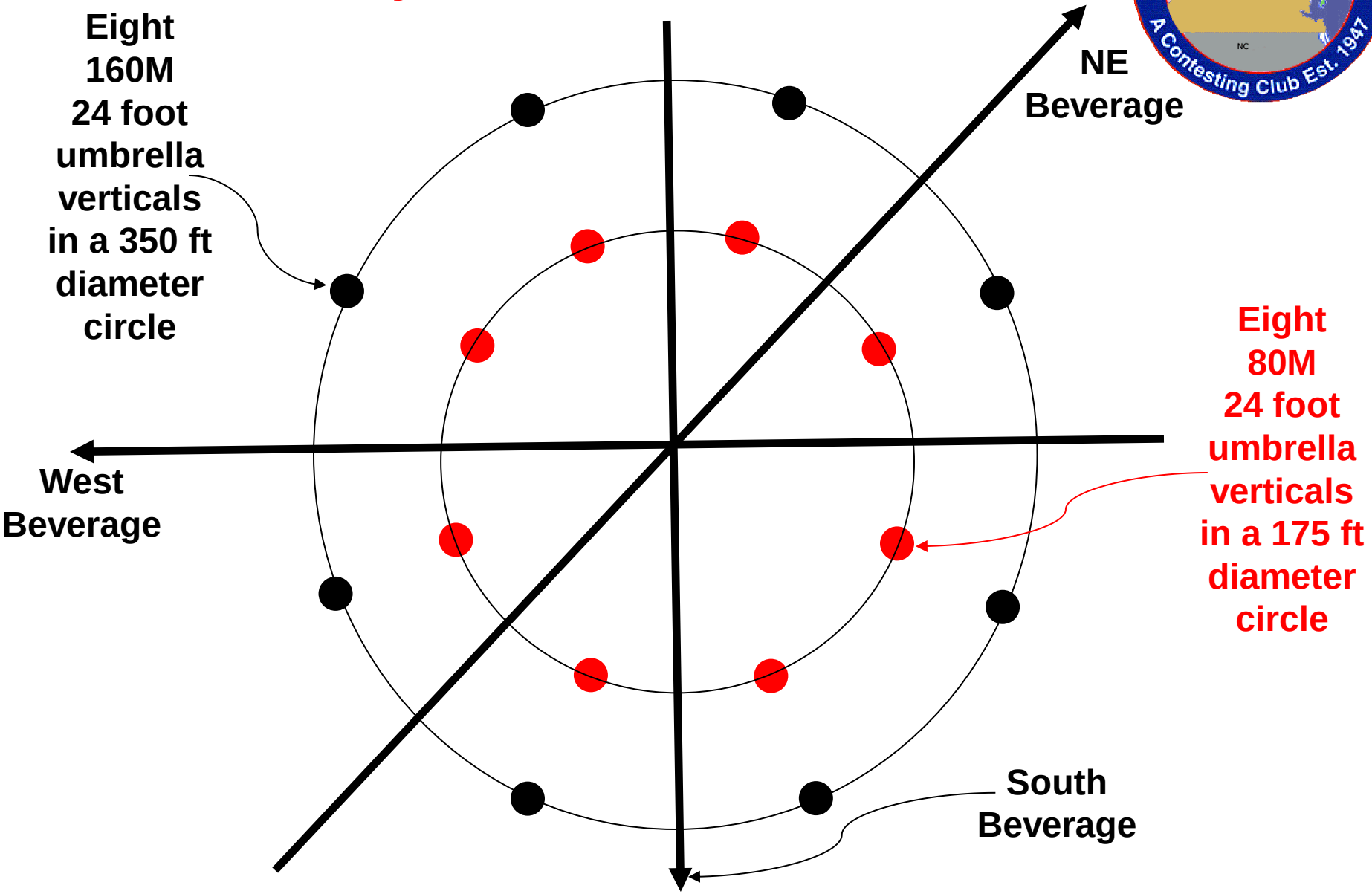
www.hizantennas.com/8_element_arrays.htm

160 Meter Radiation Pattern of a 200 Foot Diameter 8-Circle Array



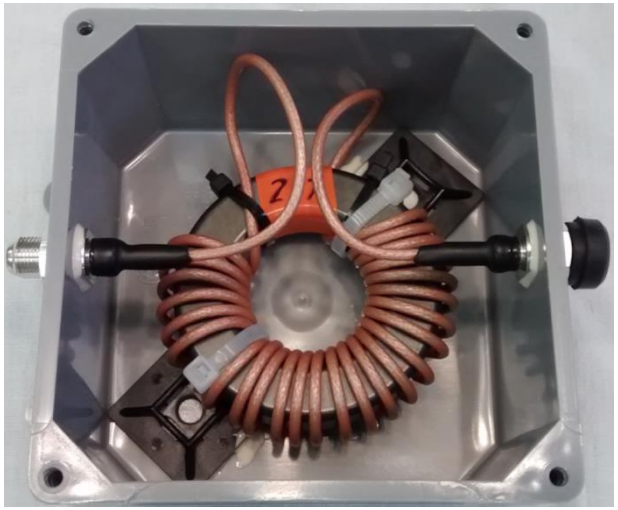
Eight active or passive phased short verticals with 106 degree phasing

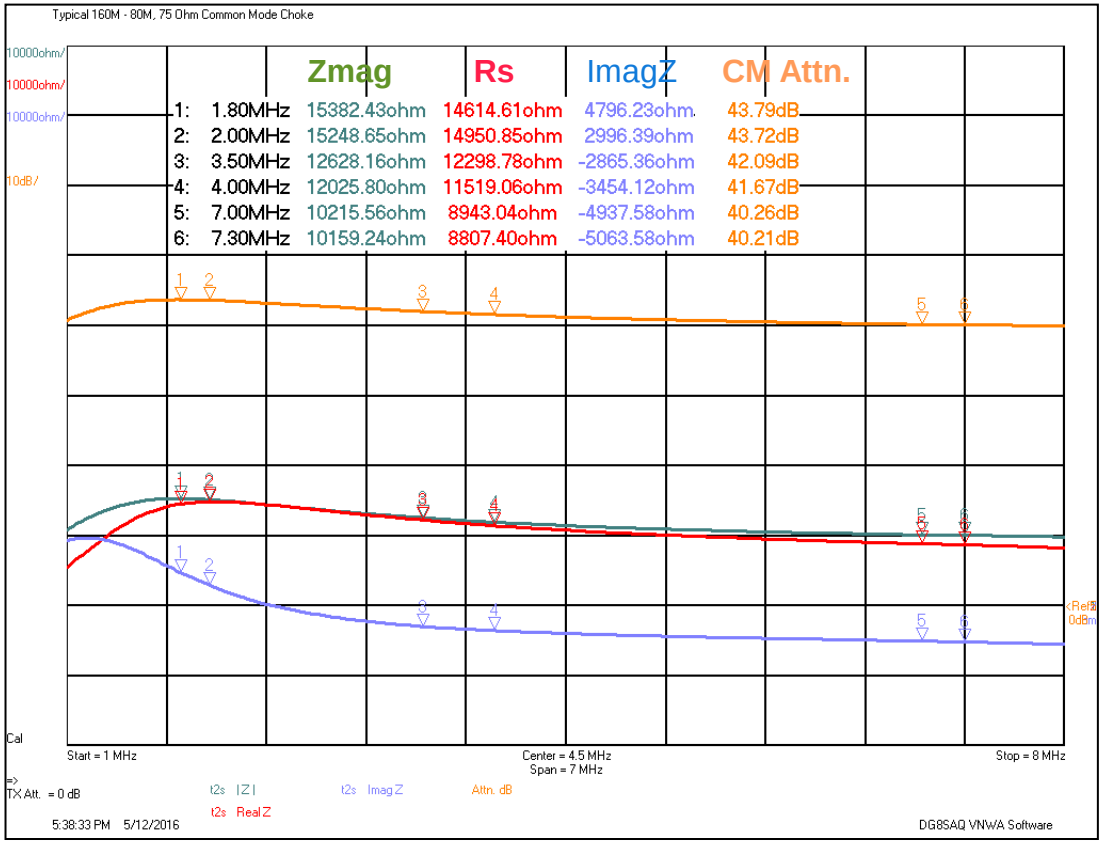
160 and 80 Meter Receiving Antenna Layout at W3LPL



Solve Common Mode Noise Issues with Common Mode Chokes

For Beverages, Active 8-Cir/4-SQ Arrays, Other RX-Antennas





N3RR Solutions, Typical 75 Ohm Common Mode Choke

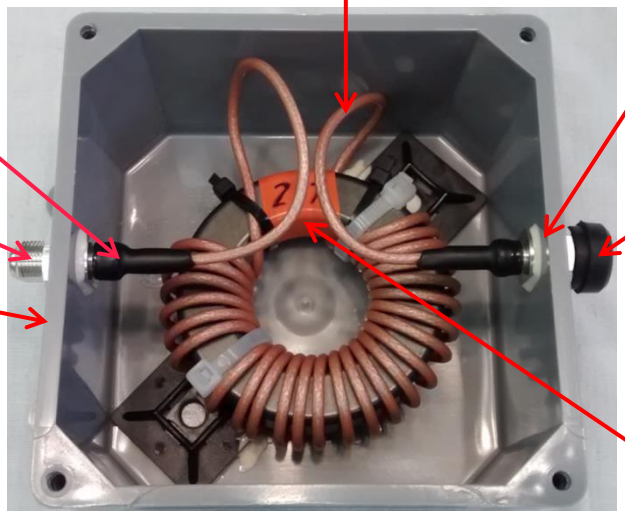
Common Mode Chokes

N3RR Solutions Typical 75 Ohm Common Mode Choke

RG-179 cables, coax cut from same reel, then for phased array applications cable-sets are selected for min. variance in phase delay & electrical length.

Coax center conductor continuously shielded input to output, coax shield crimped then heat-shrunk to Amphenol 222114-10 connector.

Marine-Rated, PVC box, Carlon E989NNJ has sealed top w/SS hardware.



Urethane epoxy sealant on F-Connector interface to PVC box.

Weather seals (WS-250) on both external F-connector interfaces to RG-6 cable.

Ferrite Cores electrically tested with VNWA during incoming inspection, serialized & characterized in proprietary database for optimizing choke designs going forward.

Electrical spec:
Greater than 10K Ohm Zmag & Rs on 160M & 80M as measured on DG8SAQ VNWA 3E Software.

Receive Antenna Variable Phasing Controller

DX Engineering NCC-1

Combines the inputs from two antennas

- creates a directional pattern with deep steerable nulls
- optimizes the performance of phased Beverages and phased verticals
- very well engineered and exceptionally easy to use

www.dxengineering.com/parts/dxe-ncc-1

Phase Synchronous Diversity Reception

Two 500-1000 feet spaced antennas feeding
two identical high performance phase locked receivers

Elecraft K3 transceiver with KRX3 sub-receiver