# Easy to Build Low Band Receiving Antennas for Small and Large Lots

- Small antennas
- High performance antennas
- Quantitative performance evaluation

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• CTU •
CONTEST UNIVERSITY

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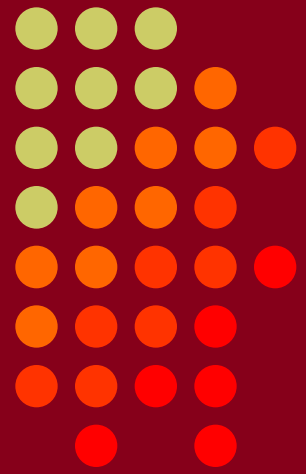


# Why Receiving Antennas?

- Much better performance than most transmitting antennas
  - much lower cost
  - greatly reduced footprint
  - greatly reduced height  (7 to 25 feet)
  - good directivity on as little as 650 to 2500 square feet
  - excellent directivity on less than an ¼ acre
  - superb directivity on less than 3/4 acre
  - greatly reduced mutual coupling between individual verticals
  - greatly reduced need for high efficiency matching and radial systems
- High performance arrays perform equivalent to a 5 element Yagi!
- Combining two antennas with a variable phase controller
  - steerable nulls
  - optimizes the front-to-back ratio of phased arrays of Beverages and verticals
- Diversity reception with dual phase locked receivers

**All receiving antennas dimensions are for 160 meters - simply scale them to 80 meters**

# Receiving Directivity Factor (RDF)

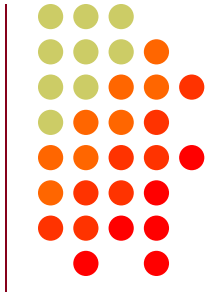
- A proven measure of receiving antenna performance
  - compares forward gain at the desired azimuth and elevation angle to average gain over the entire hemisphere
  - assumes noise is equally distributed over the entire hemisphere, an invalid assumption for suburban and especially urban locations where noise is more intensely concentrated on the horizon
  - assumes that the noise is the far field of the antenna -- more than 1000 feet away -- where the antenna pattern is fully formed and the noise sources look more like a point sources

https://www.w8ji.com/receiving

Re-radiation from antennas, towers and power lines within about 1000 feet can degrade your actual RDF **especially high RDF arrays**

# Small Receiving Antennas

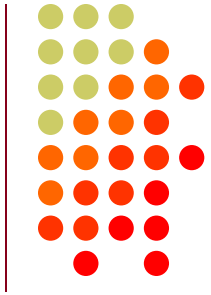
## 4-9 dB RDF



- 4 dB: 8 foot diameter “magnetic” loop
- 5 dB: Single vertical antenna (short vertical or ¼ wavelength vertical)
- 6 dB: 225 foot Beverage on Ground (BOG)
- 6 dB: 250-400 foot Beverage
- 7 dB: Unidirectional terminated loop
  - flag, pennant, EWE, VE3DO
- 8 dB: Pair of 250-400 foot staggered Beverages
- 8 dB: Close spaced arrays of two small terminated loops
  - K9AY Array
  - Shared Apex Loop Array
- 9 dB: Two phased short verticals with 60-80 foot spacing
- 9 dB: Triangle array of phased short verticals with 60-80 foot spacing

Small antennas are the best RFI reduction antennas when your RFI sources are within about 1000 feet of the antenna

# High Performance Receiving Antennas
## 10-14 dB RDF



- 10 dB: 500-600 foot Beverage
- 11 dB: Two or three close spaced 500-600 foot Beverages, staggered 65 feet
- **12 dB: 4 square array of short Hi-Z or passive verticals (80 x 80 feet)**
- **12 dB: 3 element YCCC tri-band array of short verticals (84 x 84 feet)**
- **12 dB: 5-square YCCC tri-band array of short verticals (84 x 84 feet)**
- **12 dB: 9-Circle YCCC tri-band array of short verticals (120 foot diameter)**
- 12 dB: Horizontal Waller Flag: 2 phased horizontal loops at least 100 feet high
- 13 dB: BSEF array of four short verticals switchable in two directions (1/2 acre)
- 13 dB: Hi-Z 8-circle array of short pre-amplified verticals (200 foot diameter)
- 13 dB: 8-circle BSEF array of short passive verticals (350 foot diameter+radials)
- 14 dB: Four broadside/end-fire 800 foot Beverages (800 feet x 330 feet)

Large receiving antennas are much less effective when your RFI sources are within a few thousand feet of your antenna

# Small Loop Antennas

## 4-7 dB RDF  120-165º Beamwidth

- 8 foot diameter “magnetic” loop  4 dB RDF
  - 150 degree bi-directional beamwidth
  - a specialized antenna for steering a very deep null
- Unidirectional terminated loops  6-7 dB RDF
  - flag
  - pennant
  - EWE
  - K9AY
  - VE3DO
- Mechanically rotatable unidirectional terminated small loops
  - e.g., rotatable flag

Small antennas are the best RFI reduction antenna when RFI sources are within 1000 feet of your antenna

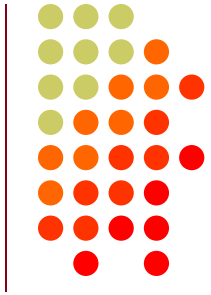
# Arrays of Small Loops
## 8-11 dB RDF  80-120º Beamwidth

- Electrically steerable compact arrays of two small loops
  - Two switchable K9AY loops  8-9 dB RDF
  - Shared Apex Loop Array  8-9 dB RDF
- 350 foot broadside spaced pair of small loops  9-10 dB RDF
  - pennant
  - EWE
  - K9AY
  - VE3DO
- Mechanically steerable array of two small loops  10-11 dB RDF
  - Vertical Waller Flag

Small antennas are the best noise reduction antenna when noise sources are within 1000 feet of the antenna

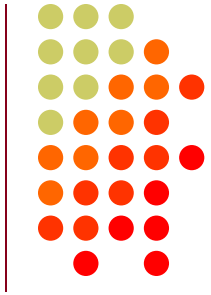
# BOGs and Arrays of BOGs

## 6-8 dB RDF 60-90º Beamwidth



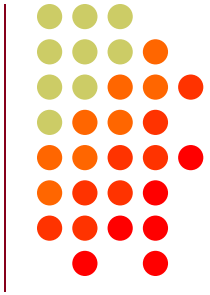
- BOG 6 dB RDF 90º beamwidth
  - a 225 foot wire laid just above the surface of the ground
- Close spaced staggered BOGs 7 dB RDF 90º beamwidth
  - two or three close spaced staggered BOGs
  - significantly improves front-to-back ratio especially if a variable phase controller is used
- Two wide spaced BOGs 8 dB RDF 60º beamwidth
  - 350 foot broadside spacing

# Beverages and Arrays of Beverages



- 250-400 foot Beverage 6 dB RDF 90-120º beamwidth
  - 250-400 feet long, approximately 7 feet high
  - single wire or two wire bi-directional
- 500-900 foot Beverage 8-10 dB RDF 50-70º beamwidth
  - single wire or two wire bi-directional
  - bi-directional Beverage
- Close spaced Beverage arrays 11 dB RDF 50-70º beamwidth
  - two or three close 65 foot spaced end-fire (staggered) Beverages
  - significantly improved front-to-back ratio especially if a variable phase controller is used
- Wide spaced Beverage arrays 12-14 dB RDF 45-60º beamwidth
  - two Beverages with 350 foot broadside spacing
  - four Beverages with 65 foot end fire spacing and 350 foot broadside spacing

# Arrays of Short Verticals
## 9-14 dB RDF  50-135º Beamwidth



- Active high impedance 20 foot verticals
  - requires a high input impedance amplifier at the base of each vertical

- Passive low impedance 25 foot verticals
  - **simple to troubleshoot and repair.  Low parts count.  Very reliable**
  - requires eight 70 foot or sixteen 35 foot radials at the base of each vertical
    - stabilizes feed point impedance in all weather and decouples the coax shield
  - four 25 foot umbrella wires
    - reduces the required height to 25 feet
    - increases the array bandwidth

# Small Diameter Loop Antenna

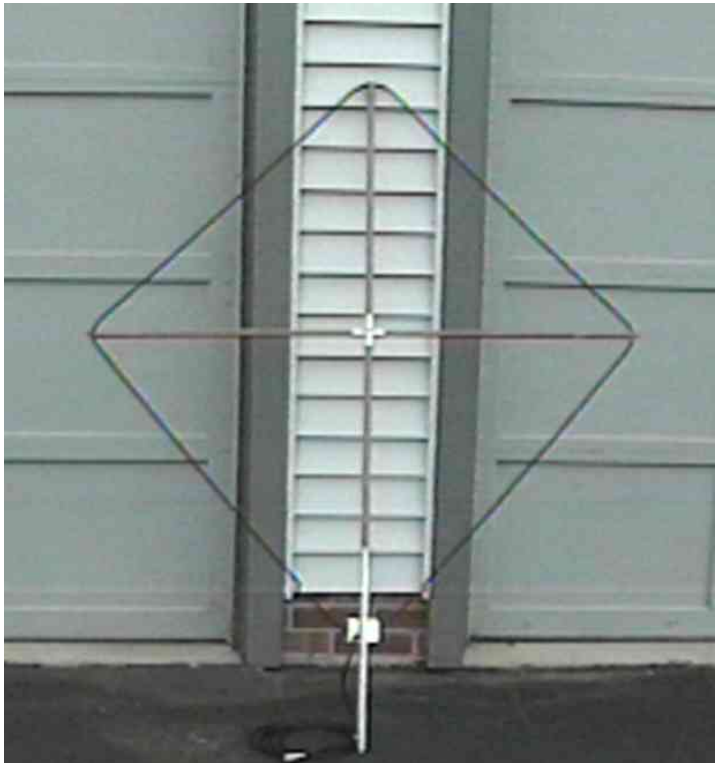
## Eight Foot Diameter "Magnetic" Loop

- Excellent for nulling a single nearby RFI source
  - but a poor low angle DX receiving antenna
  - RFI must be vertically polarized and received at a low angle via ground wave
- Excellent for very accurately locating RFI sources
- Bi-directional figure-8 pattern  150 degree 3 dB beamwidth
  - But its omni-directional for skywave propagated signals
- Very deep nulls (only 2 degrees wide) off both sides of the loop
  - mechanically rotate the loop until the single local RFI source is nulled
  - no useful nulls for skywave propagated signals
- Small loop antennas produce very low signal levels
  - requires a high gain, low noise preamplifier
- Decouple stray pickup from all attached cables
  - install chokes on the coaxial feed line shield and the DC power cable
  - bury cables about 12 inches deep for optimum null depth
- Avoid re-radiated signals from nearby antennas and power lines
  - locate the antenna as far as possible from other antennas and power lines

# Small Diameter Loop Antenna

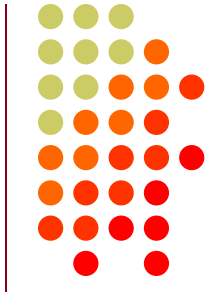
## 4 dB RDF

inexpensive and very easy to build and use
8 foot diameter
Very deep, 2 degree beam width nulls for local RFI suppression
bidirectional 150 degree 3 dB beam width



www.seed-solutions.com/gregordy/Amateur%20Radio/Experimentation/160loop.htm

# Electrically Steerable Loop Arrays

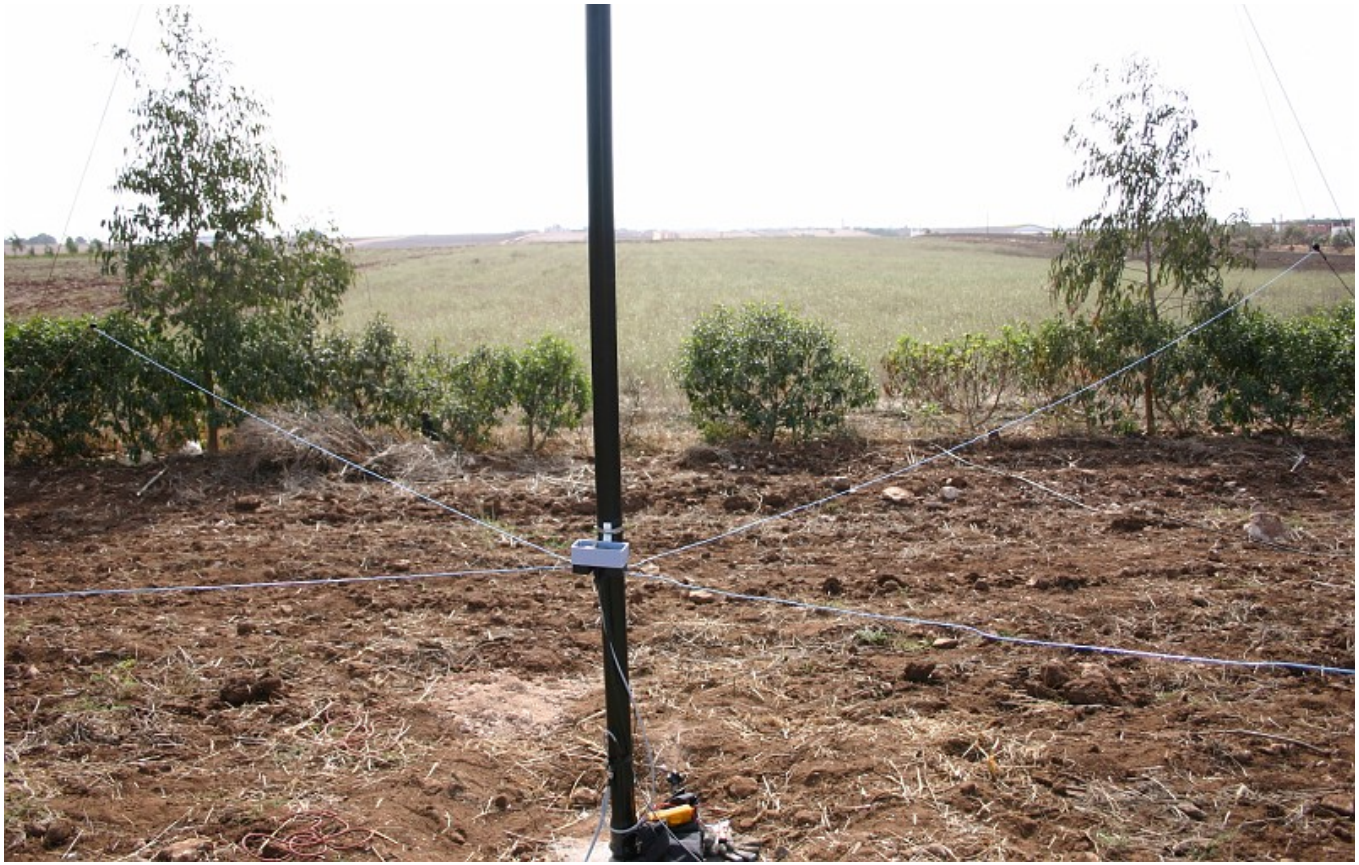


- Two K9AY loops
  - switchable in four directions
  - footprint is only 25x25 feet and 25 feet tall
  - 120 degree 3 dB beam width
  - 7 dB RDF
- Shared Apex Loop Array
  - switchable in eight directions
  - footprint is only 50x50 feet and 25 feet tall
  - 75 degree 3 dB beam width
  - 8 dB RDF
- Loops produce very low signal levels
  - a high gain, low noise figure preamplifier must be used
  - requires very careful attention to eliminating all unwanted signal coupling
    - decouple the coaxial feed line shield, control cable and DC power cable
    - bury cables about 12 inches deep for best unwanted signal rejection
- Avoid re-radiated signals from nearby antennas, towers and power lines
  - locate the antenna as far as possible from antennas, towers and power lines

# Two K9AY Loops

## 7 dB RDF in only 625 square feet

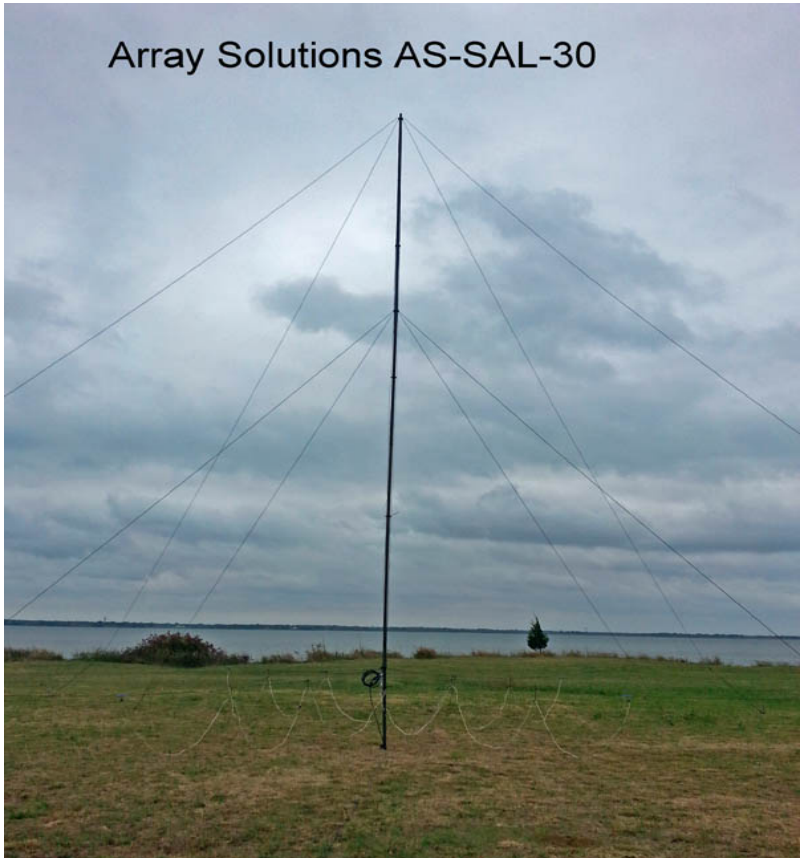
very small 25x25 foot square x 25 feet high footprint
switchable in four directions
120 degree 3 dB beam width



# Shared Apex Loop Array

## 8 dB RDF in only 2500 square feet

50x50 foot square x 25 feet high footprint
switchable in eight directions
75 degree 3 dB beamwidth




www.arraysolutions.com/antennas/as-sal-30

# 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 |

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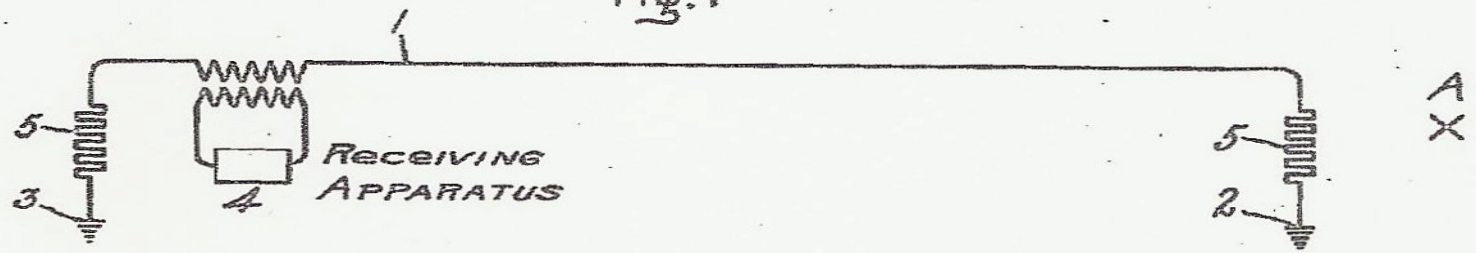
H. H. BEVERAGE.
RADIORECEIVING SYSTEM.
APPLICATION FILED APR. 10, 1920.

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

# Beverage on (or near) Ground

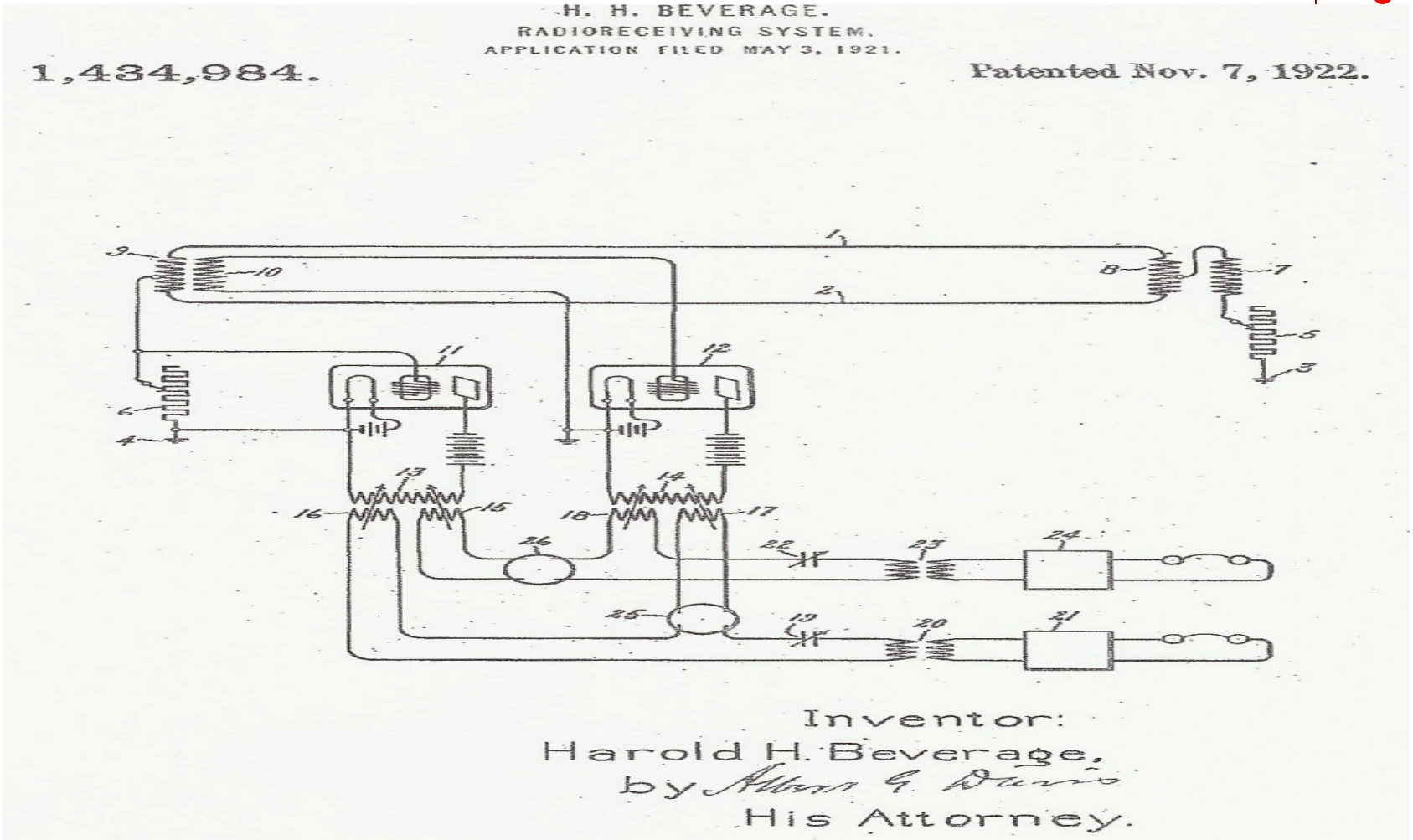
## 6-8 dB RDF with only 200 feet of length

a good choice when stealth is important
only 200-250 feet long for 160 meters
longer lengths degrade performance
70 - 100 degree 3 dB beam width

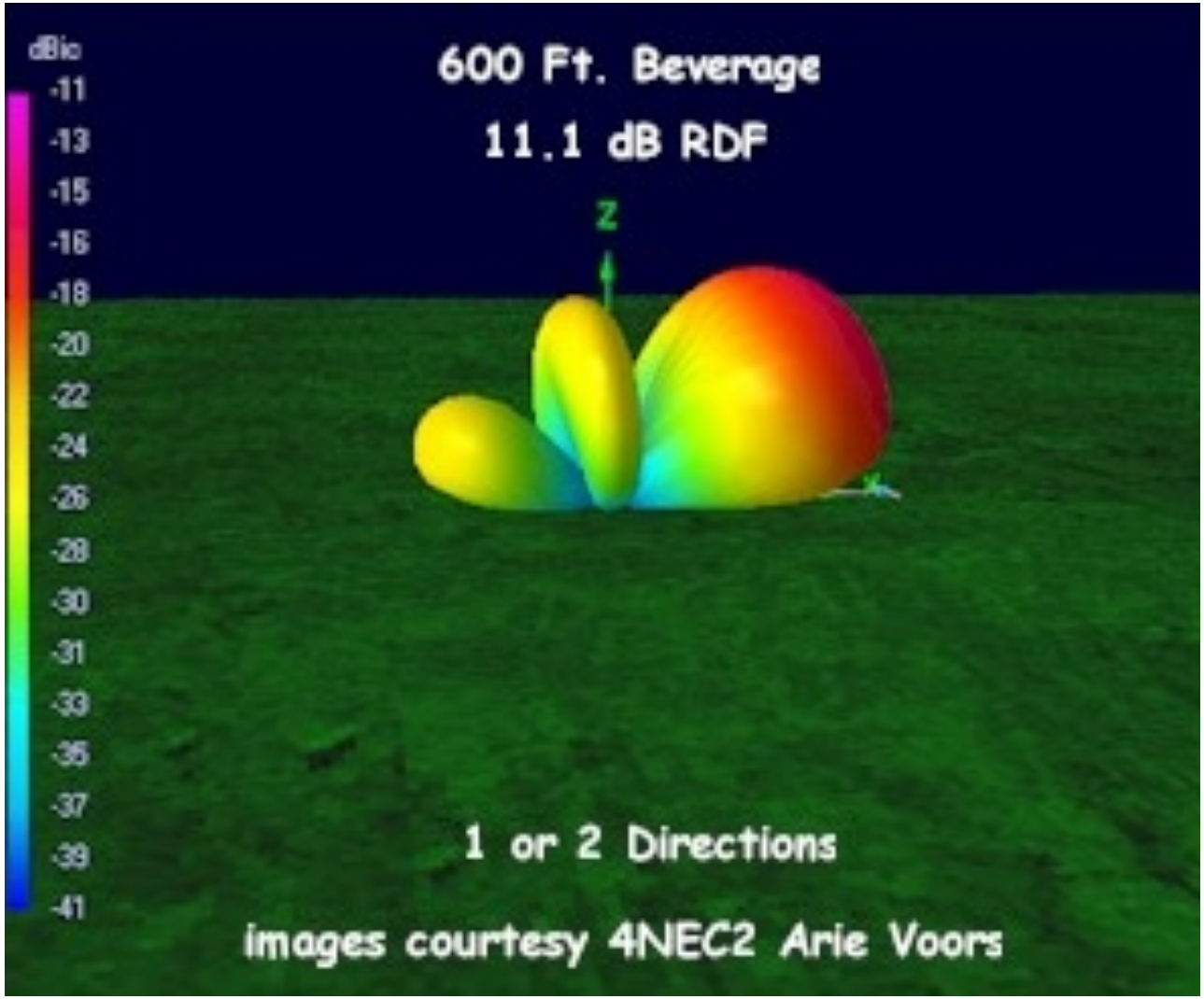
https://vimeo.com/199235390

# Two Wire Bidirectional Beverage

Switchable in two directions with one feed line
deep steerable rear null if both feed lines feed a variable phase combiner



# Radiation Pattern of a 600 Foot Beverage



# Close Spaced Staggered Beverage Arrays

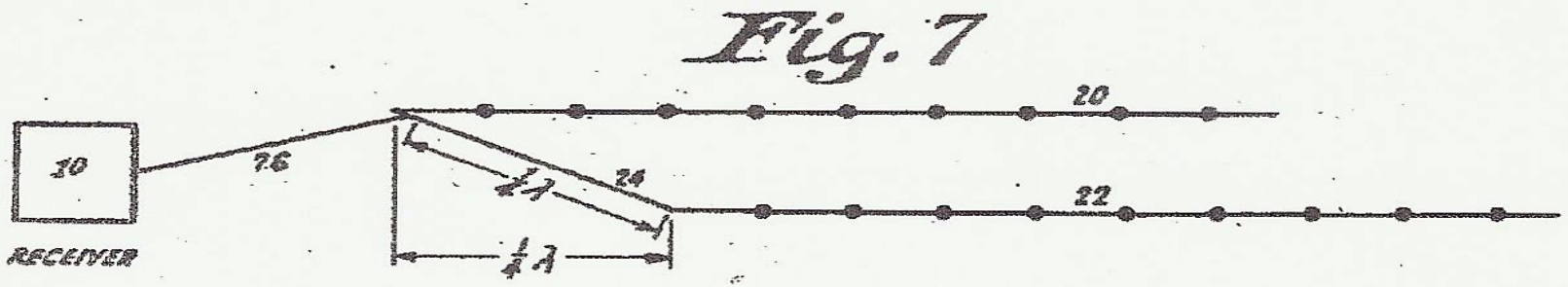
## 11 dB RDF on one acre

two or three close spaced, 500-600 foot staggered Beverages
two or three close spaced 200-225 foot BOGs – 7 dB RDF
enhanced front-to-back ratio compared to a single Beverage or BOG
the deep rear null can be steered by a variable phase controller

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

ANTENNA

Filed Nov. 8, 1927 2 Sheets-Sheet 2



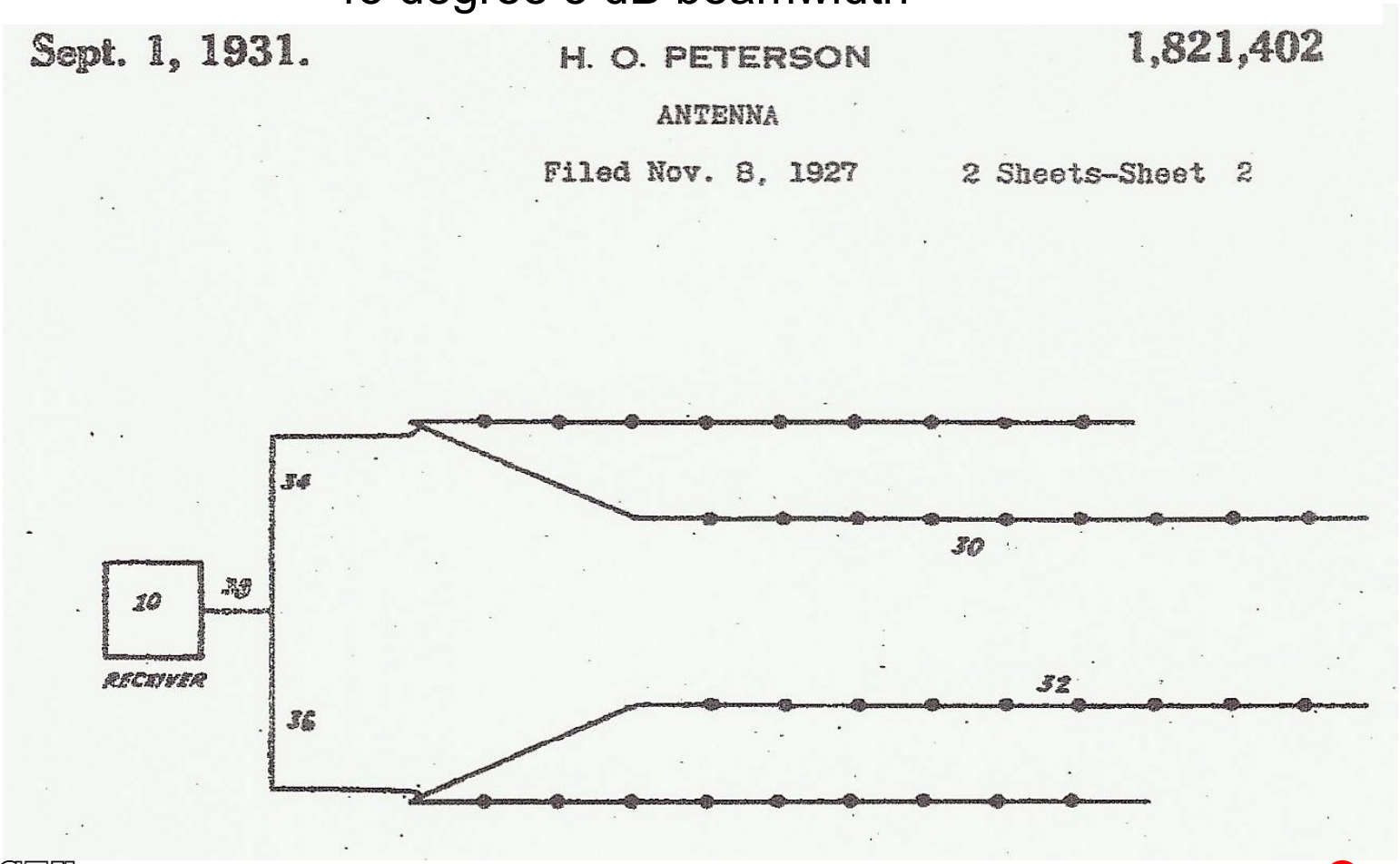

http://ncjweb.com/features/sepoct11feat.pdf

# Broadside Pair of Staggered Beverages

## 14 dB RDF on 8 Acres

800-900 foot Beverages, 330 foot broad side spacing

45 degree 3 dB beamwidth

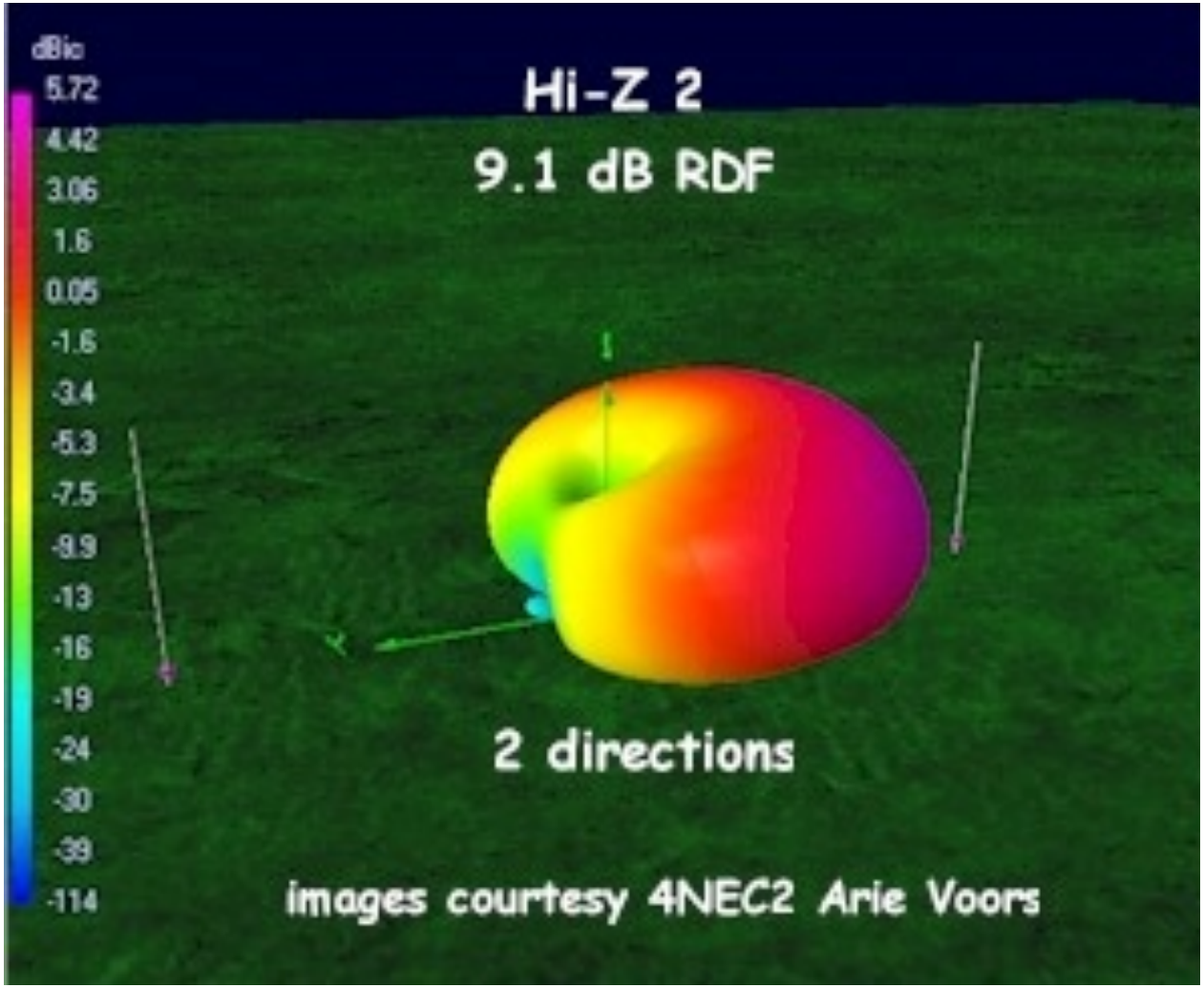


# Phased High Impedance Verticals

## Two or More 20 Foot Verticals

- No radials
- No umbrella wires
- Dual band operation with compromise 65 foot element spacing
- 80 foot element spacing for improved 160 meter performance
  - closer spacing is possible by using a variable phase combiner
- High input impedance amplifier at the feed point of each vertical
  - stray capacitance to nearby trees and other objects, at the feed point of each vertical and at the input to each amplifier must be as low as possible
- Switchable in multiple directions
- Verticals must not be installed within ten feet of nearby objects
  - Avoid nearby trees or any conductive or partially conductive structure
- Avoid re-radiated signals from nearby antennas and power lines
  - locate the antenna as far as possible from antennas, towers and power lines

# Radiation Pattern of a Two Element Array of 20 Foot Verticals

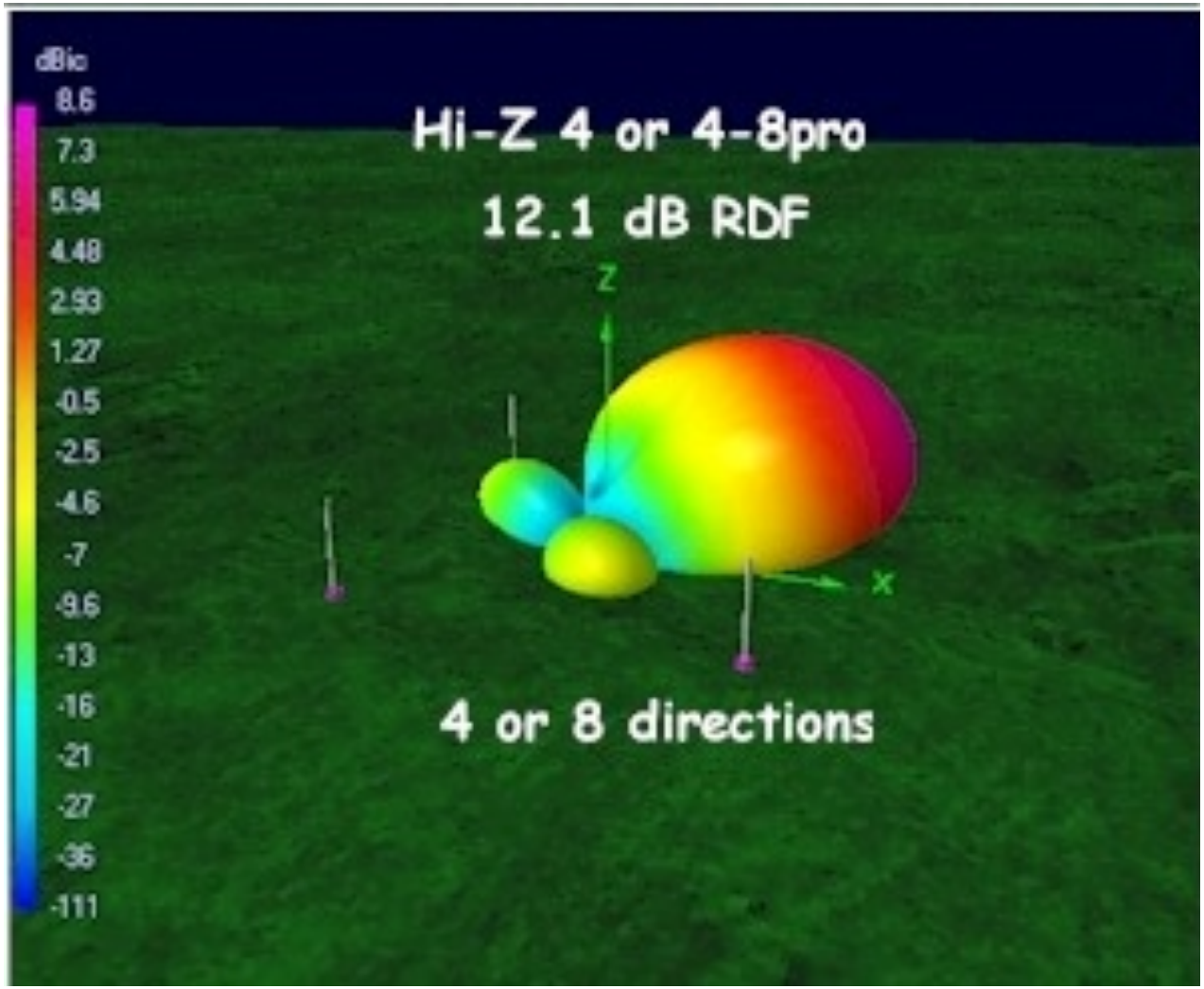


# Electrically Steerable 4-Square Vertical Array

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

# Radiation Pattern of a 4-Square Array of 20 Foot Verticals

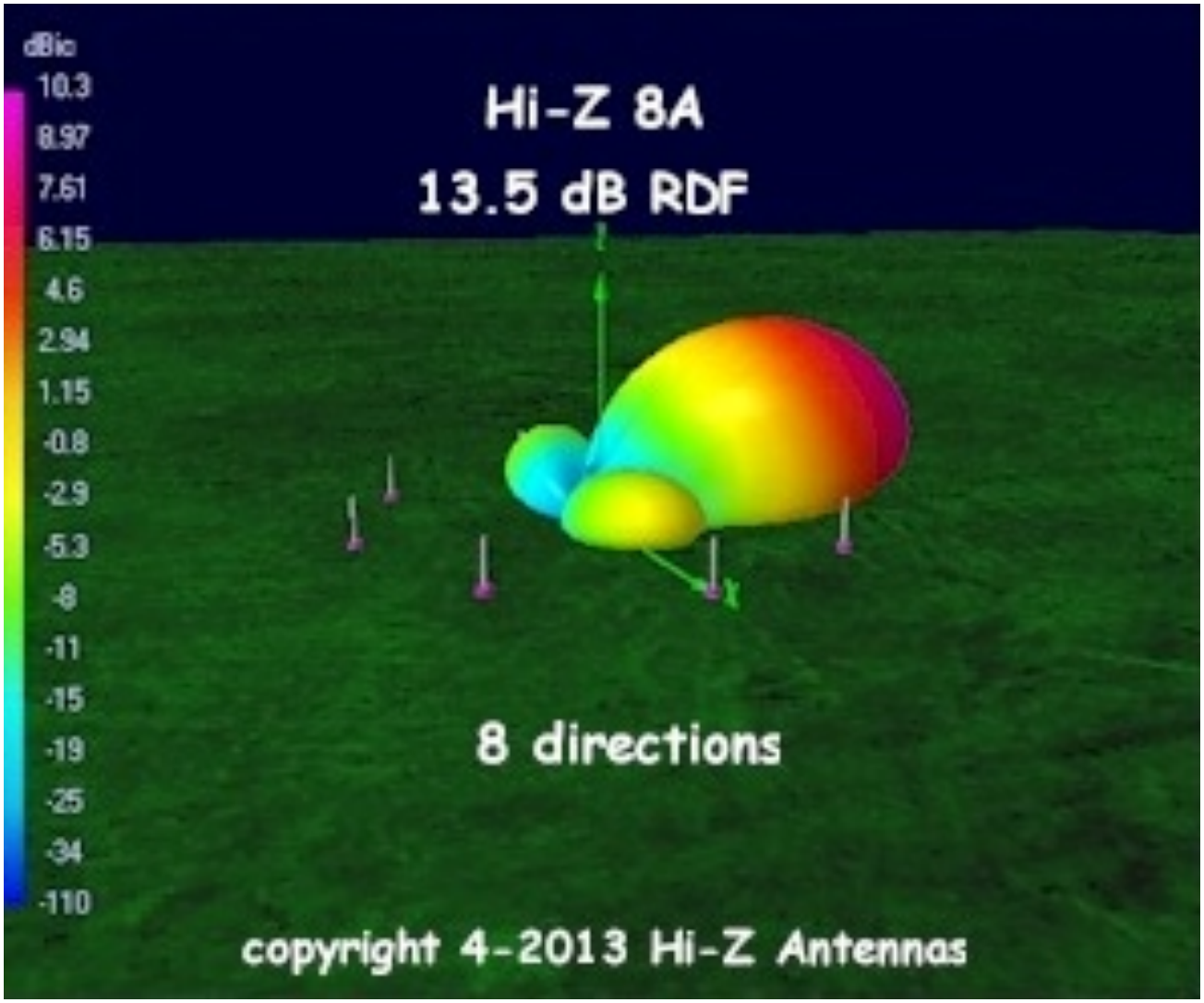


# Electrically Steerable 8-Circle Vertical Array

eight high impedance 20 foot verticals
no radials and no umbrella wires
requires a high input impedance amplifier at the base of each vertical
200 foot diameter array with 106 degree phasing
switchable in eight directions
50 degree 3 dB beam width, the performance of a 5 element Yagi

**13.5 dB RDF on ¾ acre**

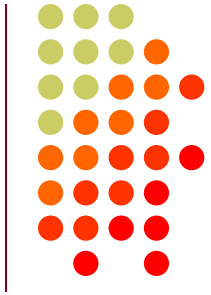
# Radiation Pattern of a 200 Foot Diameter 8-Circle Array




Eight phased verticals with 106 degree phasing

# Phased Low Impedance Verticals

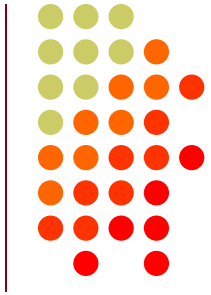
## Two or More 25 Foot Umbrella Verticals



- 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
  - its difficult to achieve stable, repeatable performance with smaller spacing
- Amplifiers not needed at the base of each vertical – higher reliability
- 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-radiated signals from nearby towers, antennas and power lines
  - locate the antenna as far as possible from other antennas and power lines

# YCCC Triband Receiving Arrays

## Nine High Impedance Short Verticals



- 3 element, 5 element and 9 element configurations
  - switchable in 180, 90 and 45 degree steps
  - All have identical 80 degree 3 dB beamwidths, slightly wider on 80 and 40M
- 120 foot diameter array
- No radials
- High impedance amplifier at the feed point of each 20 foot vertical
- A common mode choke must be attached to each feedline where it connects to the controller
- Must be kept clear of nearby trees and metallic structures
- Avoid re-radiation from nearby towers, antennas and power lines
  - locate the antenna as far as possible from other antennas and power lines



static.dxengineering.com/global/images/instructions/dxe-yccc-3inline.pdf

# Electrically Steerable 4-Square Vertical Array

four low impedance 25 foot umbrella verticals
four 25 foot umbrella wires attached 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
easy and inexpensive to build
100 degree 3 dB beamwidth
**12 dB RDF on ¼ acre**

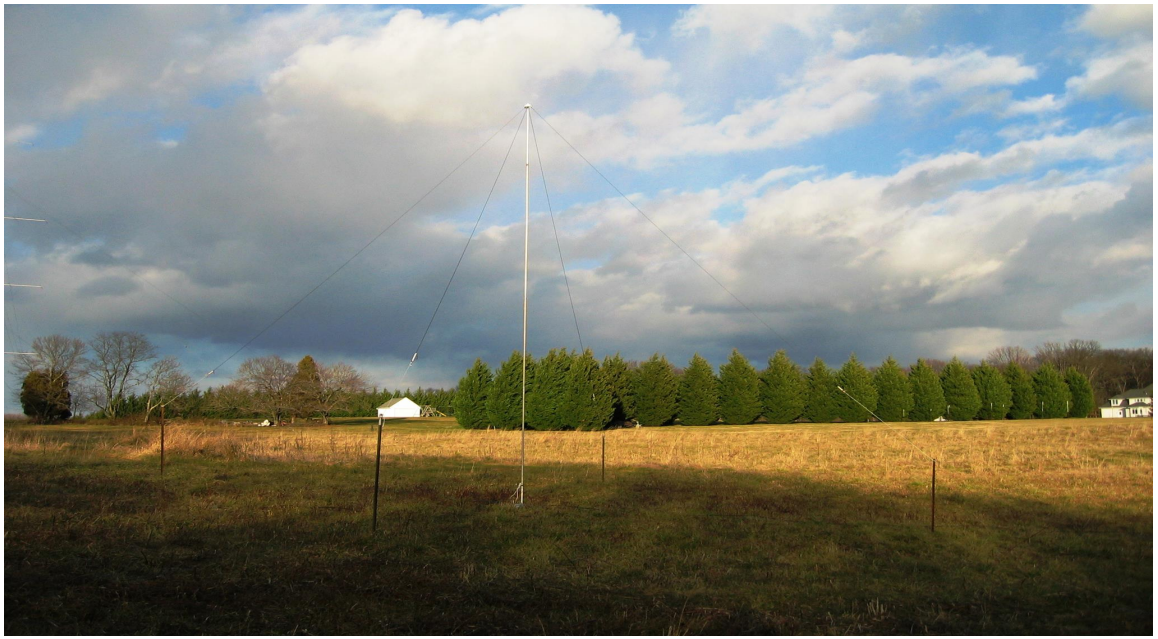


www.iv3prk.it/user/image/site2-rxant.prk_4-square_1.pdf

# 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 1/4 wavelength spacing plus space for radials
or only 200 foot diameter with a 106 degree Hi-Z phasing controller
switchable in eight directions
Very easy and inexpensive to build
50 degree 3 dB beam width, the performance of a 5 element Yagi

**13.5 dB RDF on one acre**



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

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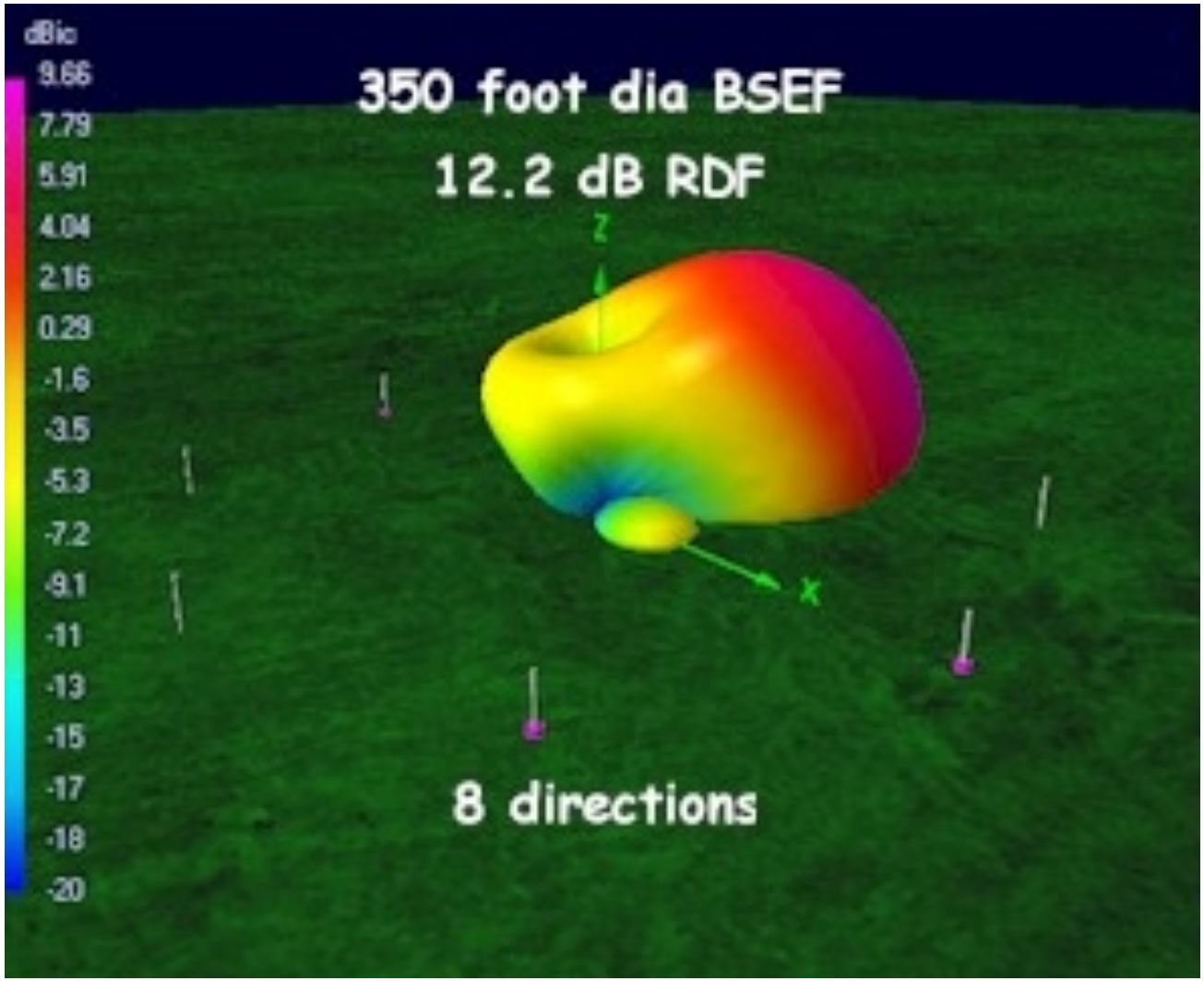
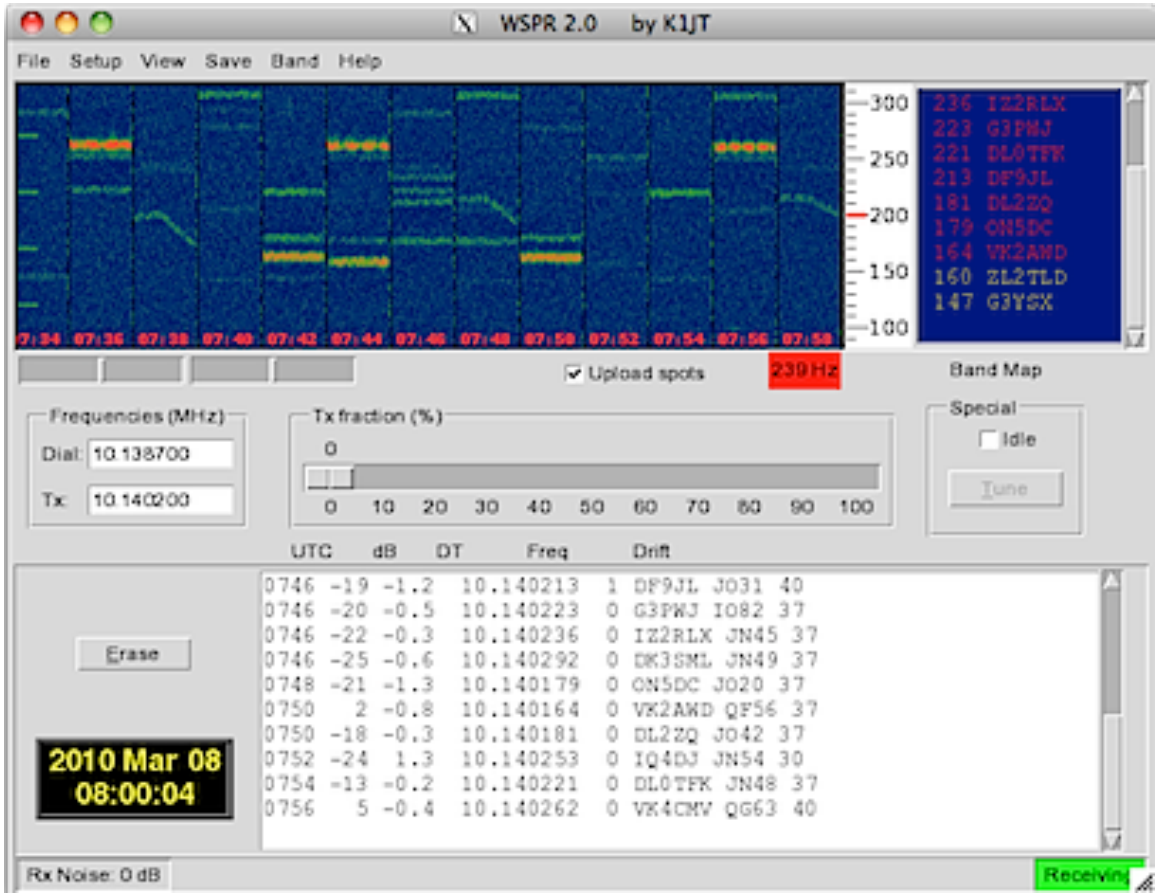
# Radiation Pattern of a 350 Foot Diameter 8-Circle Array




Four phased elements with 115 degree phasing

# Quantitative Performance Evaluation
## K1JT's WSPR

Use WSPR to compare the performance of two antennas

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http://physics.princeton.edu/pulsar/K1JT/WSPR_2.0_User.pdf

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# Receive Antenna Variable Phasing Controller

## DX Engineering NCC-2

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

# Phase Synchronous Diversity Reception

two widely spaced antennas (500 to1000+ feet) feeding
two identical high performance phase locked receivers


Elecraft K3s transceiver with KRX3 sub-receiver