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

Elevation angle in degrees vs. decibels graph with different heights showing gain for Europe and Asia with specific elevation angles.
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 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
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

- NW Moxon @ 140 ft
- NE Quad @ 170 ft
- West Quad @ 170 ft
- SSW Quad @ 170 ft
- SSE Quad @ 140 ft
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

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

600 Ft. Beverage
11.1 dB RDF

1 or 2 Directions

images courtesy 4NEC2 Arie Voors
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

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

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](http://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

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160 and 80 Meter Receiving Antenna Layout at W3LPL

Eight 160M 24 foot umbrella verticals in a 350 ft diameter circle

Eight 80M 24 foot umbrella verticals in a 175 ft diameter circle
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

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

- 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.

- 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.

- 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.
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