High Performance Receiving Antennas for a Small Lot

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Sponsors
High performance receiving antennas for small lots

Basic concepts and practical aspects
• Directivity & gain
• Signal to noise ratio
• RDF antenna comparison for 1.8 MHz
• What a receiver antenna can do for you

New Receiving antennas
• What is a Horizontal Waller Flag
• Detuning TX antenna
• Common mode noise
• Conclusions

Dual loaded loop receiving antenna (resources back up slides)
• Historic evolution
• Beverage EWE FLAG DHDL QDFA
• Rotatable Rx antennas HWF VWF
• Constructions details

- NX4D Doug Waller QTH 1/5 acre city lot subdivision
- 309 countries heard on 160m
- 298 worked 2003 to 2016 40 zones since 2011
- Average of 2 new countries every! Month!
- Average of 24 new countries every! Year!
- 13 years in a row! >> http://nx4d10.wix.com/waller-flag

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RX antennas directivity & gain

- It is all about signal to noise ratio

All we need is 3 dB SNR for CW and 8 dB for SSB

RX antenna has negative power gain and needs a preamplifier

[Graph showing signal and noise levels with 30dB above noise and at noise level]
The gain is the difference between an amplifier input and output intensity.

Adding a 18 db. gain amplifier, the signal and the noise will increase 18db and the signal noise still will be the same.
RX antennas directivity & gain

1840 KHz carrier received with vertical TX antenna

Same signal received with a Big Waller Flag
When the signal is above noise there is little difference on the audio. The receiver AGC will make the strong signal just more comfortable to copy but it should not be used for evaluation of the receiver antenna.

A good receiver antenna will provide copy of weak signals not present or buried in the noise on the transmit antenna.

Increasing the directivity by 1 dB RDF the SNR increases 1.5 to 2 dB.
Understanding directive antenna gain
Understanding directive antenna gain

$\text{SNR} = \frac{\text{Area signal}}{\text{Area Noise}}$

DX SIGNAL AREA

TX ANT NOISE AREA

RX ANT NOISE AREA
RDF calculation using EZNEC

- Directivity gain is the difference between Total Average gain and maximum antenna gain.
- W8JI Receive Directivity Factor > http://www.w8ji.com/receiving.htm
- On EZNEC it is easy to calculate RDF using 3D plot configuration

• RDF = Gain – Average Gain

![Diagram](image-url)

RDF = -18.0 - (-28.47) = 10.47 dB
RDF antenna comparison for 1.8 MHz

- VERTICAL 1/4
- *Inverted V for 160m at 120 Ft high
- 400 Ft BOG
- Dipole 160m at 3 m high
- Dipole 160m at 20 m high
- AS-SAL
- Dipole; Inverted "V" BOG's
- Beverage and HWF
- Waller Flag
- Vertical
- 180
- 120
- 12 dB
- 11 dB
- 10 dB
- 9 dB
- 8 dB
- 7 dB
- 6 dB
- 5 dB

- Magnetic Loop
- EWE K9AY FLAG
- Vertical Flag
- Single Horizontal Flag
- Beverage 500 Ft
- DHDL
- HI-Z 4 sq 200 Ft
- Waller Flag
- Beverage 1000 Ft
- HI-Z 8 sq 330 Ft

3/4/2016
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RDF from well know antennas

- 2 Elements Vertical Array: 8 dB
- 4 Square Vertical Array: 9 dB
- 2 elements Yagi: 10 dB
- Cubic quad 2 elements: 11 dB
- 3 elements Yagi: 12 dB
- 5 elements Yagi: 13 dB
- Horizontal WF single flag: 15 dB

http://www.k7tjr.com/rx1comparison.htm
What RDF really can do for you?

1. Vertical RDF 5 dB > FLAG RDF 7 dB (2) = 3 to 4 dB improvement on (1.5 to 2 dB SNR for 1 dB RDF)
2. DX 1 only copy on the FLAG antenna  HUGE DIFFERENCE
3. DX 2 much improved copy on the FLAG

Transmit antenna noise level (5 dB RDF)
Flag noise level

First Step > FLAG EWE K9AY 7 to 8 dB RDF
Can I improve my RX with a better antenna???

SECOND STEP >> DHDL SAL or single Horizontal Flag 8.5 to 10 dB RDF

1. Vertical RDF 5 dB > FLAG RDF 9 dB (4) = 6 to 8 dB improvement
Can I improve my RX with a better antenna???

SECOND STEP >> DHDL SAL or single Horizontal Flag 8.5 to 10 dB RDF

1. Vertical RDF 5 dB > FLAG RDF 9 dB (4) = 5 to 8 dB improvement
2. DX 3 only copy on the DHDL antenna MONSTER DIFFERENCE
3. DX 3 at noise level on the FLAG
4. Vertical useless for RX FRUSTRATION !!!
Can I improve my RX  EVEN  better antenna???

THIRD STEP >> RX 4 square  Waller Flag  1000Ft beverage  11.5 dB RDF

1. Vertical RDF 5 dB > WF 11.5 dB ( 6.5 ) = 9.7 to 13 dB improvement
THIRD STEP >> RX 4 sq  WF  1000Ft beverage  11.5 dB RDF

1. Vertical RDF 5 dB > WF 11.5 dB (6.5) = 9.7 to 13 dB improvement
Can I improve my RX EVEN better antenna???

THIRD STEP >> RX 4 sq WF 1000Ft beverage 11.5 dB RDF

1. Vertical RDF 5 dB > WF 11.5 dB (6) = 9 to 12 dB improvement
2. DX 3 very comfortable copy on the WF
3. DX 4 below noise level on the FLAG and the DHDL
4. WF copy DX4 UNBELIEVABLE !!!!
Can I improve my RX EVEN better antenna??

THIRD STEP >> Rotating the WF

1. Rotating the antenna we always can aim to maximum gain or 0 dB attenuation
2. Moving the antenna from that point the reduce the SNR
3. Moving half the aperture to -3 dB point the signal goes to noise level and hard to copy
4. Moving the 10 to 20 degree each side can get a noise source at the side null and increase the SN even more
Polarization filter, the HWF, Horizontal Waller Flag

MAN MADE
NOISE
REJECTION
BUT !!! WHAT ABOUT MY LOCAL CITY NOISE!

FORTH STEP >> Polarization filter HWF 11.5 to 12 dB RDF

1. The HWF attenuate vertical polarized signal > -30 dB
2. Removing local ground wave noise the HWF noise floor is 10 dB better
3. DX 4 very comfortable copy on the HWF
4. HWF copy DX4 for long time with much better SNR
5. HWF can hear DX 5
6. HWF can hear what others can’t, and anywhere
7. DIGITAL Modes JT9 or JT65 can experience 18 dB more in SNR (30 dB)
Harold Beverage patents 1938 1941 (80 years ago)

- **US 2138134 A** Phasing antennas
- **US 2247743 A** Broad Band RX Antenna
- **ABSTRACT** > available in

LOADED LOOP = WIRE + TRANSFORMER + RESISTOR
N4IS Horizontal Waller Flag HWF

Boom 40 Ft (12m)
Elements 26 Ft (8m)
N4IS Horizontal Waller Flag HWF

Boom 40 Ft (12m)
Elements 26 Ft (8m)

2006 VWF
2009 HWF
299 DXCC heard
282 DXCC worked
39 zones

30 ATNO
Average per year on 160m
HWF, Horizontal Waller Flag Polarplot 40m
HWF, Horizontal Waller Flag Polarplot 80m / 160m
WHAT is a Horizontal Waller Flag?

- Take off angle does not change with height above ground.
- RDF does not change with size.
- RDF does not change with frequency.
- Not resonant.
- No interaction with other antennas.
- Vertical isolation 27 dB.
HWF Gain change with height above ground

![Graph showing HWF Gain change with height above ground.](image)

### Table: ANT. HEIGHT vs Gain Change

<table>
<thead>
<tr>
<th>ANT. HEIGHT</th>
<th>7 MHz</th>
<th>3.5 MHz</th>
<th>1.8 MHz</th>
</tr>
</thead>
<tbody>
<tr>
<td>30 Ft</td>
<td>1/4</td>
<td>1/8</td>
<td>1/16</td>
</tr>
<tr>
<td>60 Ft</td>
<td>1/2</td>
<td>1/4</td>
<td>1/8</td>
</tr>
<tr>
<td>120 Ft</td>
<td>1</td>
<td>1/2</td>
<td>1/4</td>
</tr>
<tr>
<td>240 Ft</td>
<td>2</td>
<td>1</td>
<td>1/2</td>
</tr>
<tr>
<td>480 FT</td>
<td>4</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>
Horizontal signal intensity changes with height above ground

\[ G_b = \frac{55H}{T_{\text{DEG}}} \]

Figure 1 — Waves arrive directly and via an earth reflection forming a local vertical standing wave pattern.

Figure 2 — The vertically polarized (V-pol) and horizontally polarized (H-pol) field strengths vary differently and depend on whether the reflection is from medium earth ground (solid), fresh water (dashed) or sea water (dotted).

Fig.1— K. Siwiak, KE4PT, “Is There an Optimum Height for an HF Antenna?” Jun 2011, *QST*, pp 33– 35.
Fig.2— K. Siwiak, “Ionospherica – The Last Bounce”, QRP Quarterly, Fall 2013, pp 32-33.
Man-Made Noise in a 500Hz Bandwidth

Man-Made noise
vertical polarized
ground wave

dBm above receiver noise floor
in a 500Hz Bandwidth

160 m  47 dBm  42  30
80 m   35 dBm  30  22
40 m   20 dBm  15  10

RECEIVER NOISE FLOOR

Man-Made Noise in a 500Hz Bandwidth from Rec. ITU-R P.372.7 Radio Noise

residential  rural  quiet rural  typical receiver MDS
Power line noise at home

- **s2**: 3.2 miles, -88 dBm
- **s9**: 1.25 miles, -73 dBm
- **s7**: 1.7 miles, -77 dBm

Noise during the day with no QRN: -90 dBm (500Hz)
Antenna noise temperature in Kelvin

Noise temperatures at medium and high frequencies Fig 11-44 pg. 414 Edward C. Jordan and Keith G. Balmain -RECOMMENDATION ITU-R P.372-7 - Radio noise*

1.8 MHz

Sky wave propagation noise

- Minimum noise during a quiet winter morning can be as low as 1.3 dB
- System Noise Figure of 1.3 dB degrades the signal to noise ratio by 3 dB
- The insertion loss of all passive devices adds directly to Noise Figure
- N4IS RX system has 1.4 dB NF >>
  - IC7800 20 dB NF
  - N4IS .5 dB preamplifier (40 dB gain)
  - Input Filter .2 dB

WF system operates near the receiver noise floor

Shielding, grounding, isolation and common mode noise reduction is critical
Noise layers and low band DX signals

- RX FRONT END NOISE
- PULSE NOISE (DSP NB)
- REFLECTED NOISE
- TX ANTENNA LEAKING NOISE
- COMMON MODE NOISE
- LOCAL NOISE
- THERMAL NOISE
- LOW BAND DX SIGNAL
DETUNING TX antenna is a “MUST DO”!

Detuning a resonant structure is a critical factor to success. Removing the detuning effect of the skirt by a short circuit to ground has a drastic impact on the plot diagram.
DETUNING TX antenna is a “MUST DO”!

Detune TX antennas, nearby structures, elevated radials and low dipoles, that degrade radiation pattern.
INTERACTION BETWEEN ELEMENTS

- Maximum interaction $\frac{1}{2}$ wave
- Minimum interaction $\frac{1}{4}$ wave
TX antenna is not the only resonant element in your station

ALL CABLES, FEED LINES, ROTOR CABLE AND METAL STRUCTURES MUST BE DETUNED TO PREVENT DEGRADED RADIATION PATTERN

120FT = 40 m

Changing the impedance $Z_{\text{in}}$ or $Z_{\text{out}}$ does not detune the feedline cable

Easy way to kill all your RX antennas is; Low dipole and ¼ wave elevated radials

10 m Dipole

Common mode current

re-radiation

Easy way to kill all your RX antennas is; Low dipole and ¼ wave elevated radials
DEGRADED RADIATION PATTERN

ALL SIGNAL MIXING AT PREAMPLIFIER INPUT

OPEN FRAME RELAY – PLASTIC BOX -OPEN SHIELD CONNECTOR

RX SIGNAL FROM WF

TX ANTENNA SIGNAL

COMMON MODE NOISE

PREAMPLIFIER IS PART OF THE RADIO - NOT THE ANTENNA

0 dB
-10 dB
-20 dB
NX4D >> When the WF is beaming 90° or less toward the tower, I get 1.5 to 2.0 S-units of noise reduction. Removing the center coax cable conductor from the tower helps some, but neutralizing the tower is a big noise reduction.

PY2XB >> Antenna Detuning - Relay Boxes: In order to not jeopardize the RX Flag antenna's pattern, it is necessary to avoid interaction with nearby antennas or structures. The relays are operated in such way that, on receiving, the 80m folded dipole and the 160m sloper are not "seen" by the RX Flag antenna.

• https://www.flickr.com/photos/133647736@N07/sets/72157653478604348/
Protecting RX feed lines from common mode noise

- COAXIAL
- ROTOR CABLE
- ELECTRICAL FIELD
- MAGNETIC
- GROUND

GROUND STRAP
RX antennas metal conduit shield
Protecting RX feed lines from common mode noise
Protecting RX feed lines from common mode noise
WF system is a one year long project

Low system Noise Figure < 2 dB
CHOKE is your best friend

Steve Dove  W3EEE  Reducing EMI Noise on Receive Antennas

http://www.hifidelity.com/w3eee/Noiz%20.html
Common mode current runs outside the shield, if you open the shield the noise gets inside!

CHOKE IS YOUR BEST FRIEND

A Ham's Guide to RFI, Ferrites, Baluns, and Audio Interfacing by Jim Brown K9YC


Common-Mode Chokes 1 by Chuck Counselman, W1HIS

http://www.yccc.org/Articles/W1HIS/CommonModeChokesW1HIS2006Apr06.pdf
N4IS  220 V  ac Filter
Crimp On PL-259 Connectors PLEASE  !!!!!!!

http://www.bcdxc.org/pl259_crimp_on_connectors.htm

http://www.eham.net/articles/19257

I am using “N” and SMA connectors only

One BAD connector increase noise 2-4 S units
PY1RO single HWF
THAT IS IT! OR IS THERE MORE TO COME?

FIFTH STEP >> N8PR UNIQUE Polarization Tilt HWF

SIXTH STEP SDR BEAM FORMING WITH 4 LOOPS (70 FT)

14.3 dB RDF  53 degree front lobe
Conclusions

• Noise is up!

• More noise coming: LED lights, VFD-s, Electric Car-Chargers!

• Not everybody has room for Beverages in city lots

• Vertical Waller Flag: Excellent but noisy

• Horizontal Waller Flag: Low noise, practical size

• The RX antenna for the urban Top-bander
1919 March 5, 1919, Roy A. Weagant, Chief Engineer of the Marconi Wireless Telegraph Co. of America, delivered a paper describing in detail his apparatus for the elimination of the great bug-bear of transoceanic wireless communication -- static interference. >>


1938 Harold Beverage invented wide band receiver antenna, loaded loop. The present invention relates to short wave antennas and, more particularly, to antennas for receiving horizontally polarized waves over a wide band of frequencies. An object of the present invention is to enable the reception of horizontally polarized signals over a wide band of frequencies such-as is at present used in television.


1940. Nearly all the newly re-invented compact receive antennas derive from the terminated loop, the earliest reference was in an appallingly mimeographed prewar training manual of W3EEE Dad’s

1973 **COMMUNICATIONS 74 CONFERENCE BRIGHTON** Wednesday, June 5 1974 — Session 5 Equipment Design

**Paper 5.3: Loop Antennas for HF Reception** Contributed by: B.S.Collins, C & S Antennas Ltd.,
JF1DMQ wrote an earlier article about the Flag antenna in November 1995 in a Japanese magazine. His was only 3.3 feet by 16.4 feet long (1 by 5 m). K6SE's 160m optimized versions are 14 by 29 feet (4.3 by 8.8 m).

"Is This EWE for You?" (QST February, 1995, p.31) and "More EWES for You", QST January, 1996, p. 32) both by WA2WVL.

The Pennant was originated by EA3VY and optimized for 160 meters by K6SE, who first wrote about them on the Top Band Reflector in 1998.

The K9AY Terminated Loop—A Compact, Directional Receiving Antenna By Gary Breed, K9AY

W7IUV rotate Flag and preamplifier >> http://w7iuv.com/

QST Magazine, July 2000, page 34 for K6SE's classic article: "Flags, Pennants, and Other Ground-Independent Low-Band Receiving Antennas" ...

NX4D developed the first dual flag vertical array

N4IS developed the BIG flag vertical array >> www.n4is.com

N4IS developed the Horizontal flag array

Dr Dallas Lankford, wrote the Flag Theory and design the Quad Flag Array >> Dallas Files
The Dallas Files are now found here: http://groups.yahoo.com/group/thedallasfiles2

AA7JV George Wallner developed the DHD (TX3A) >> http://tx3a.com/docs/TX3A_DOUBLE_HALF DELTA LOOP.ZIP

DOUBLING the Double Half-Delta Loop Receiving Antenna by Pierluigi "Luis" Mansutti IV3PRK >> http://www.iv3prk.it/user/image/..-rxant_prk_tx3a.pdf
Pre War terminated loop

1940 Pre War terminated loop

THE RADIATION PATTERN OF LOOP ANTENNAS

The current which flows in a loop antenna may be represented by a Fourier series of cosine and sine terms. The zero order term represents a constant current flowing around the hop and gives rise to the familiar figure-of-eight radiation pattern typical of a small loop.

The odd order (sine) terms represent the currents which flow in the same direction in both sides of the loop and therefore do not give rise to any output voltage across a balanced terminating impedance. The azimuth radiation pattern associated with this current mode in a small loop is circular. When the loop is fed with an unbalanced feed both even and odd modes can exist. The total radiation pattern of the loop will be the sum of those due to the separate modes. The zero order mode predominates in a simple loop; in order to obtain a cardioid radiation pattern the amplitude of the zero order mode current must be reduced relative to the first order mode current, and the relative phase of the currents must be adjusted so that the cancellation obtained in the rearwards direction is complete. This result can be achieved by inserting a suitable impedance in series with the loop at a point diametrically opposite the feed point.

The terminated loop exhibits a near cardioid azimuth radiation pattern for vertically polarized incident energy and an input impedance which may easily be matched to 50 ohms.
Flag   EWE   K9AY   Delta Pennant = LOADED LOOP

+ Resistor and Transformer

TWO VERTICALS IN PHASE
Dual Half Dual Loop AA7JV
Vertical Waller Flag

Two Flags phased 180 degree

Resistor

Transformer
Phased Delta Flag Arrays

Dallas Lankford, 2/21/09, rev. 4/23/10

The delta antenna is a variant of the flag antenna. The earliest delta flag antenna I am aware of was designed by K6SE and constructed by ON4UN for use by FO0AAA some time before June 2000. While it was designed for the 160 meter ham band, it probably worked well in the MW band. I became interested in phased delta flag arrays because I wanted to experiment with quad phased flag arrays for splatter reduction in the MW band; see my article “Phased Flag Arrays” in The Dallas Files. My flag array experiments were inspired by the phased rotatable dual flag arrays of NX4D and N4IS, but inexpensive masts are not good for flag construction because of sag problems.
Phased Delta Quad Flag Arrays

The Dallas Files are now found here: http://groups.yahoo.com/group/thedallasfiles2
Phased Delta Flag Arrays

LC Delay Phased Delta Flag Arrays
DL, 3/18/09

- null
- 70' between centers
- 30' base, 15' altitude
- 25T:8T FT-114-75
- 1000
- 100'
- 18 gauge speaker wire
- T = 8 bifilar turns
  #24 enameled copper wire on insulated Amidon FT-50-75

- All resistors, capacitors, and inductors are 1%.
- To RX

Phasing and Feeding

Big Waller Flag

Back

RL2

TR2

4 m

7 m

4 m

Front

RL1

TR1

6 m

RL1 = 820 Ohms
RL2 = 836 Ohms

TR1 = TR2

9:1 BALUN

PL2

TR3

PL1

CHOKE

CHOKE

CHOKE

TR3 1:1 BALUN

PL1 = PL2 100 ohms Balanced Line

50 ohms line
Phasing details of Waller Flag

INVERT WIRES TO GET 180 DEGREE PHASE

9:1 BALUN

900 ohms

TAPE TWO FT505-77
1 turn = 1 pass  2 turns = 2 passes

50 ohms

1:1 BALUN
RG 58

TAPE 2 RG58 TOGETHER
SOLDER SHIELDS EACH END

Belden 2907 Twinax

100 ohms Balanced Coax

ZIP CORD or SPEAKER WIRE

ZIP cord inside the boom
HWF Horizontal Waller Flag pictures PT9ZE N4IS PP5JR
K9UWA's HWF at 150 feet

10M Yagi interlaced on WF boom
6M Beam on HWF Boom. TH-11 below. There is no interaction between the three antennas.
HWF Horizontal Waller Flag pictures  PY2XB

More HWF photos >>>>>>>>