Low-Band Receive Antennas

How to hear that great DX that you're missing on 40, 80 and 160!

Al Penney
VO1NO / VE3

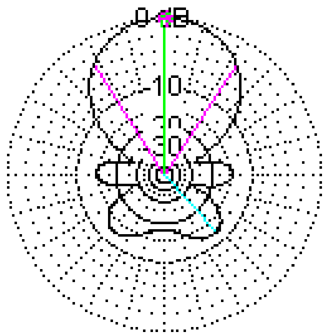
Tonight's Topics…

- Introduction
- Receiving Basics
- RX Loops
- Elongated Terminated Loops
  - EWE Antenna
  - Flag Antenna
  - Pennant Antenna
  - K9AY Loop
- Beverages

Why do we need separate TX and RX antennas?

- Because, they have different requirements:
  - TX antennas need to deliver strongest possible signal into target area compared to other antennas.
  - Efficiency and gain are most important factors.
  - RX antennas need to have best Signal to Noise Ratio (SNR) – gain and efficiency are not necessary.

Diagrams from ON4UN's
Low Band DXing



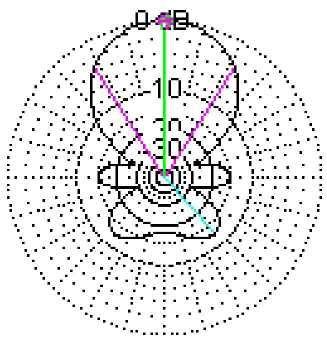
EZNEC

1.83 MHz

Antenna A

Azimuth Plot		Cursor Az	90.0 deg.
Elevation Angle	20.0 deg.	Gain	-11.24 dBi
Outer Ring	-11.24dBi		0.0 dBmax

Slice Max Gain	-11.24 dBi @ Az Angle = 90.0 deg.
Front/Back	18.11
Beamwidth	65.7 deg.; -3dB @ 56.8, 122.5 deg.
Sidelobe Gain	-23.33 dBi @ Az Angle = 312.0 deg.
Front/Sidelobe	12.09 dB



EZNEC

1.83 MHz

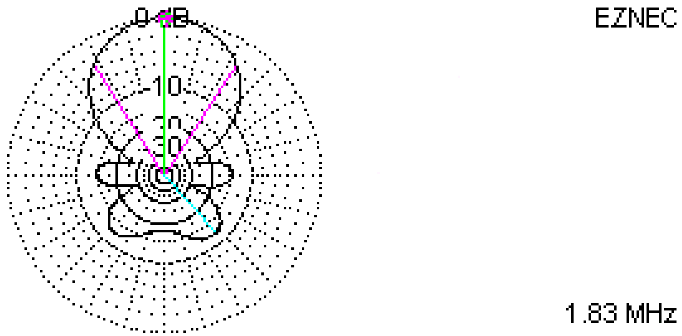
Antenna B
(+3dB gain vs Antenna A)

Azimuth Plot		Cursor Az	90.0 deg.
Elevation Angle	20.0 deg.	Gain	-8.2 dBi
Outer Ring	-8.2dBi		0.0 dBmax

Slice Max Gain	-8.2 dBi @ Az Angle = 90.0 deg.
Front/Back	18.11
Beamwidth	63.8 deg.; -3dB @ 58.1, 121.9 deg.
Sidelobe Gain	-20.76 dBi @ Az Angle = 312.0 deg.
Front/Sidelobe	12.56 dB

Is Antenna B a better TX Antenna than Antenna A?

Diagrams from ON4UN's
<u>Low Band DXing</u>



Single 720-foot Beverage.

Azimuth Plot		Cursor Az	90.0 deg.
Elevation Angle	20.0 deg.	Gain	-11.24 dBi
Outer Ring	-11.24dBi		0.0 dBmax

Slice Max Gain	-11.24 dBi @ Az Angle = 90.0 deg.
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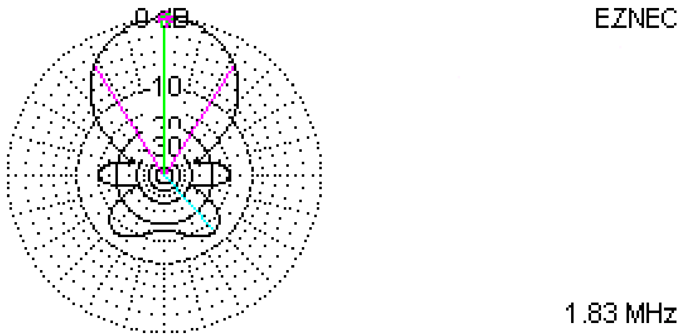


Two 720-foot Beverages. Spaced 70 feet apart.

Azimuth Plot		Cursor Az	90.0 deg.
Elevation Angle	20.0 deg.	Gain	-8.2 dBi
Outer Ring	-8.2dBi		0.0 dBmax

Slice Max Gain	-8.2 dBi @ Az Angle = 90.0 deg.
Front/Back	18.11
Beamwidth	63.8 deg.; -3dB @ 58.1, 121.9 deg.
Sidelobe Gain	-20.76 dBi @ Az Angle = 312.0 deg.
Front/Sidelobe	12.56 dB

- Gain single Beverage: -11.2 dBi
- Gain two Beverages (70-ft sp): -8.2 dBi

- So, a pair of Beverages (with 70-ft spacing) has 3 dB gain over a single Beverage.
- But, has anything actually been gained in terms of Signal/Noise ratio?

NO – nothing has been gained!

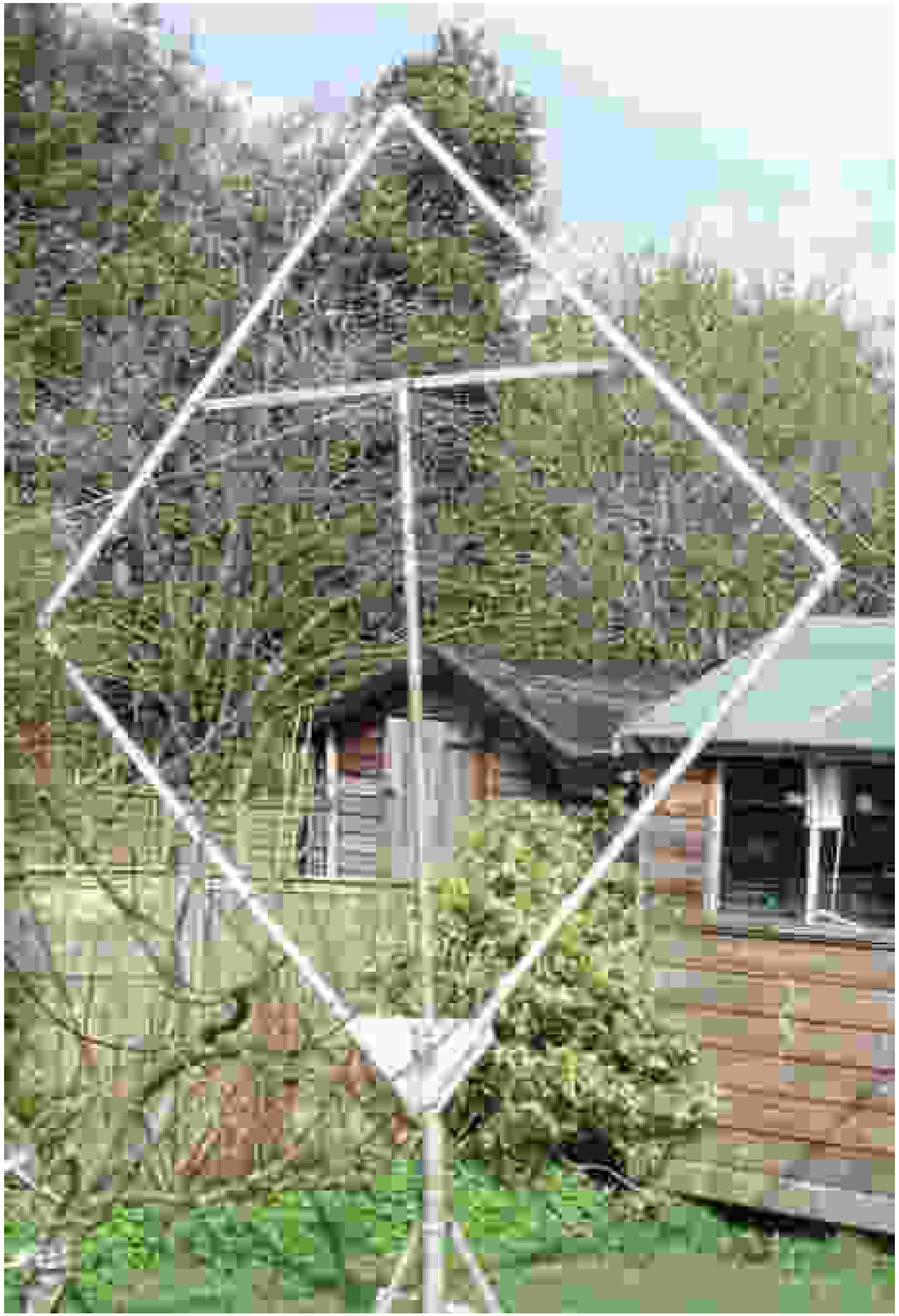
- The pattern is still practically identical
  - Front/Back is the same
  - Front/Side is within 0.47dB
- Unwanted noise is external to the antenna. Because the directivity of the two antenna systems is the same, the Signal/Noise ratio is exactly the same for both.
- We must use Directivity when comparing RX Antennas, not gain.

How much Negative Gain can we tolerate with RX antennas?

- Modern receivers are very sensitive.
- If you can easily hear an increase in background noise when switching from a dummy load to an RX antenna under quietest conditions, then gain is sufficient.
- Minus10 to minus 20 dBi Gain is generally fine for most occasions.

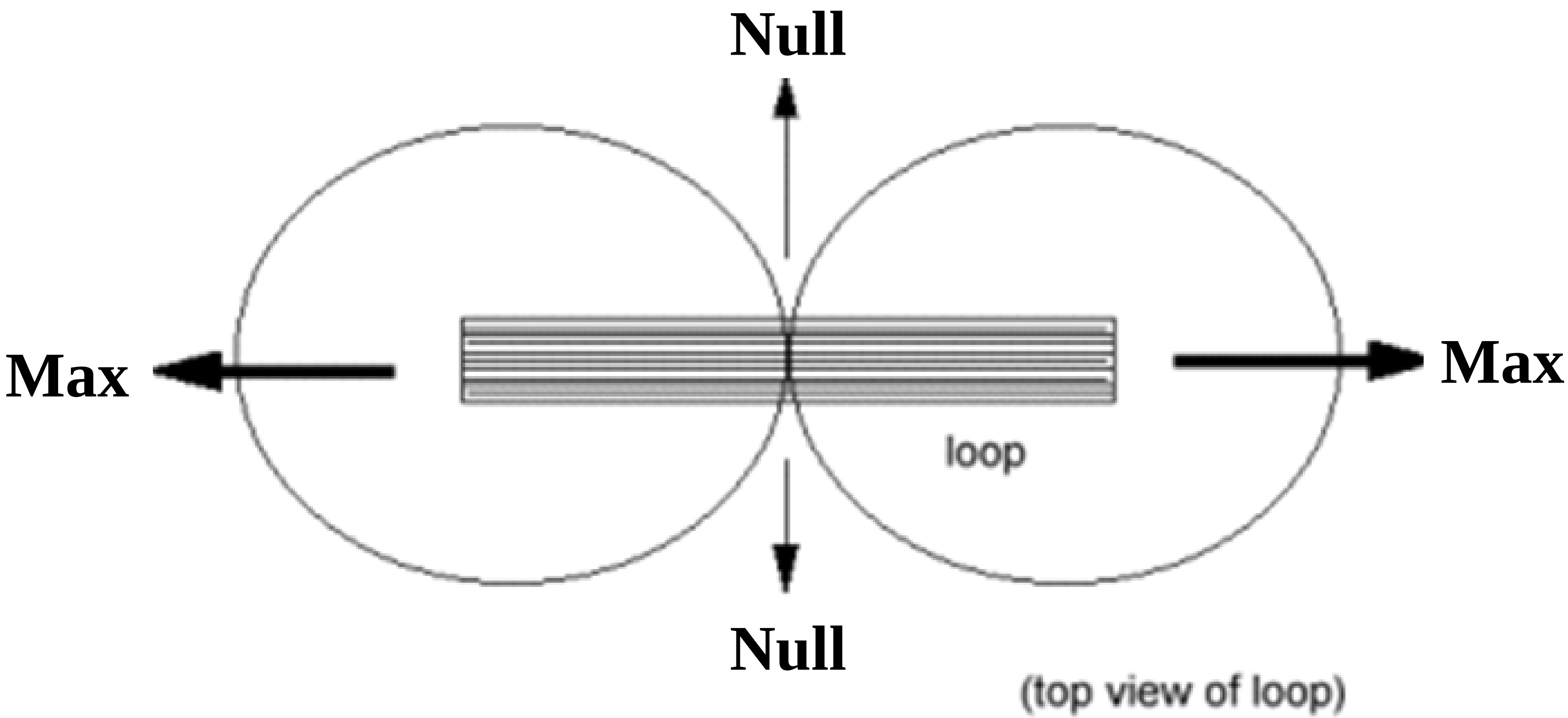
Noise

- The sum of all unidentified signals (thunderstorms, man-made, cosmic etc.).
- Requires its own presentation!
- RX antennas reduce noise through:
  - Directivity
  - Null placement
  - Noise canceling devices
  - Height



Receive Loop Antennas

Diagram from Joseph Carr's
Practical Antenna Handbook



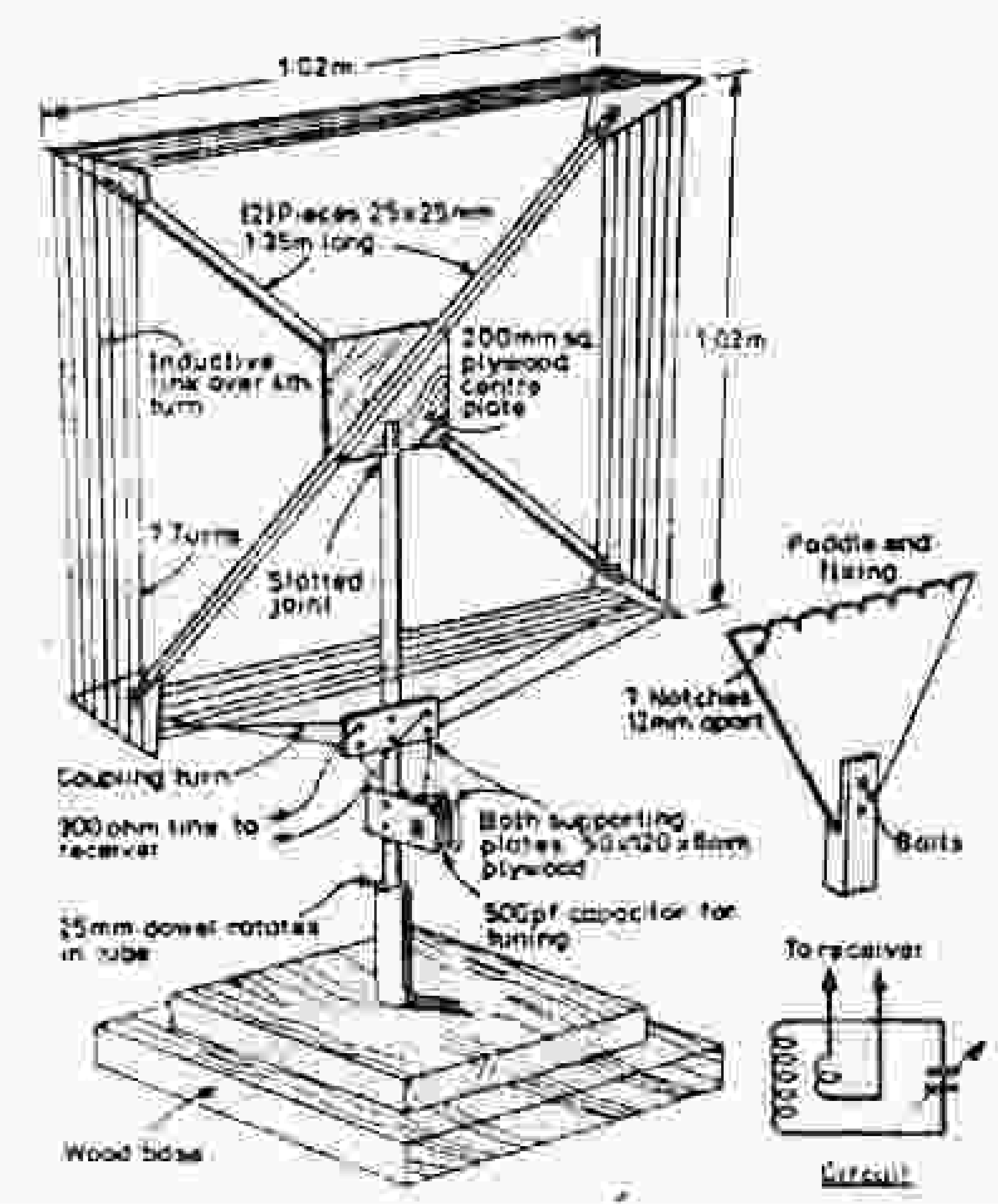
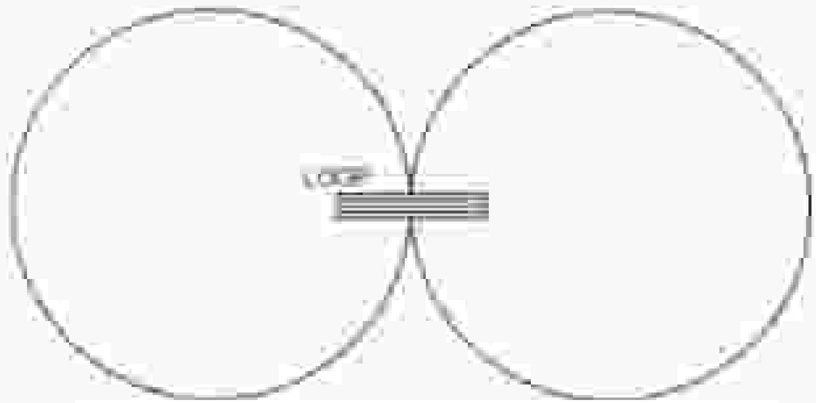
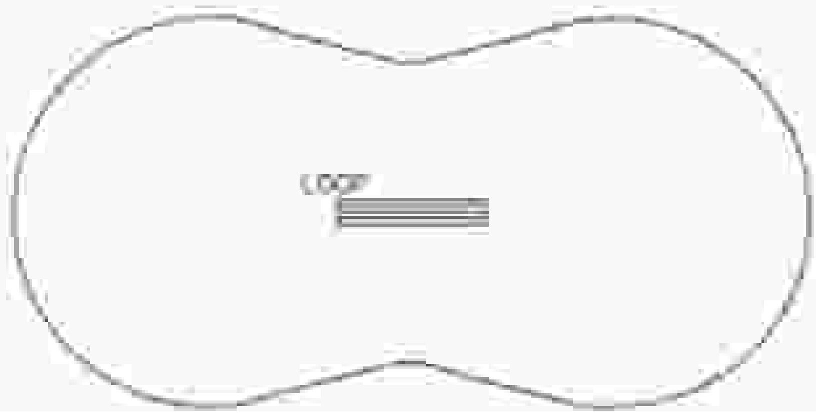

1.02m
(2) Pieces 25x25mm
1.35m long
200mm sq.
plywood
centre
plate
1.02m
Inductive
link over 4th
turn
7 Turns
Slotted
joint
Paddle and
fixing
7 Notches
12mm apart
Coupling turn
300 ohm line to
receiver
Both supporting
plates 50x120x6mm
plywood
Bolts
500pf capacitor for
tuning
25mm dowel rotates
in tube
To receiver
Wood base
Circuit

Diagram from Joseph Carr's
Practical Antenna Handbook

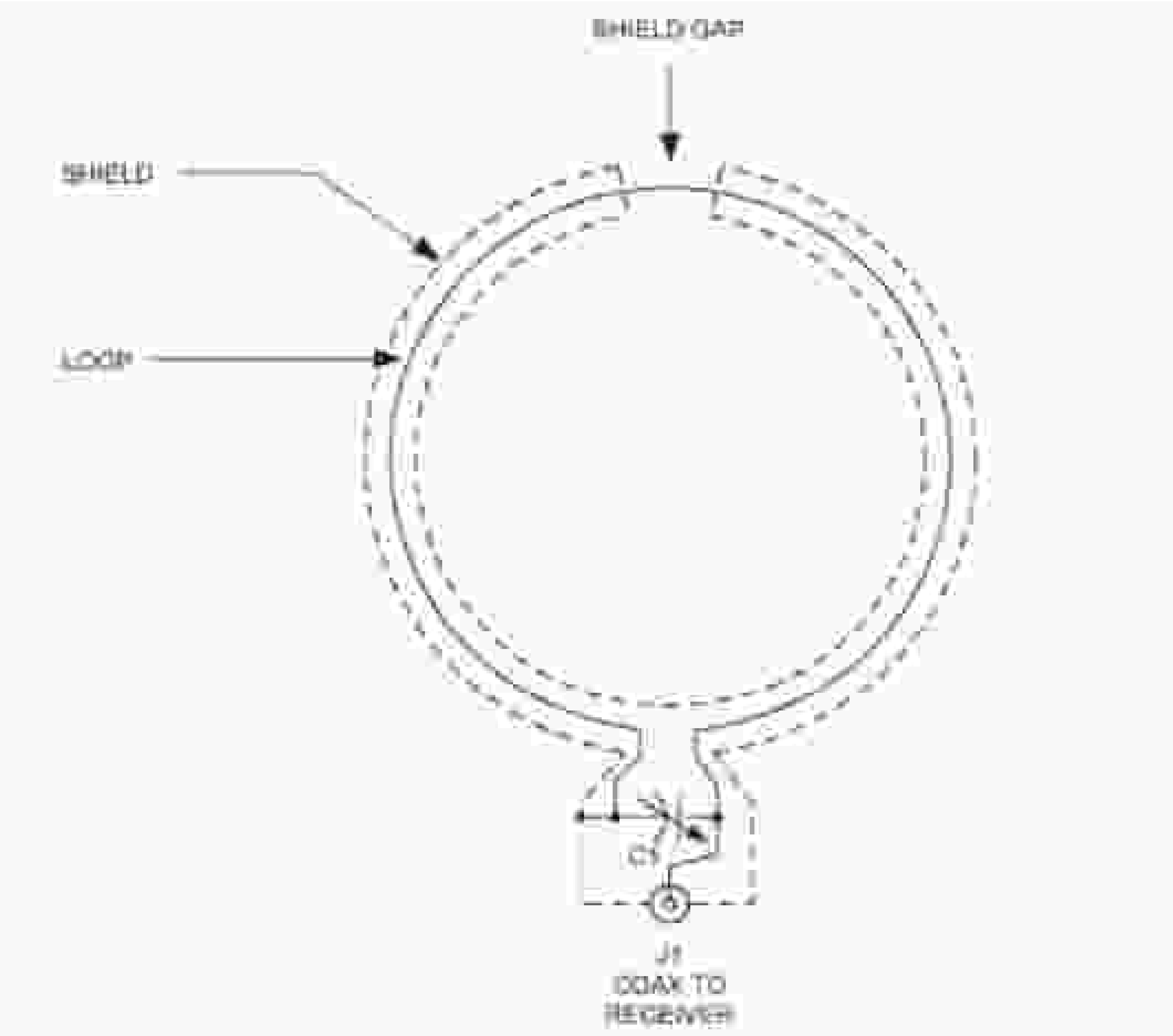


Normal loop in free space



Nulls "filled in" by nearby metal objects

Diagram from Joseph Carr's
<u>Practical Antenna Handbook</u>



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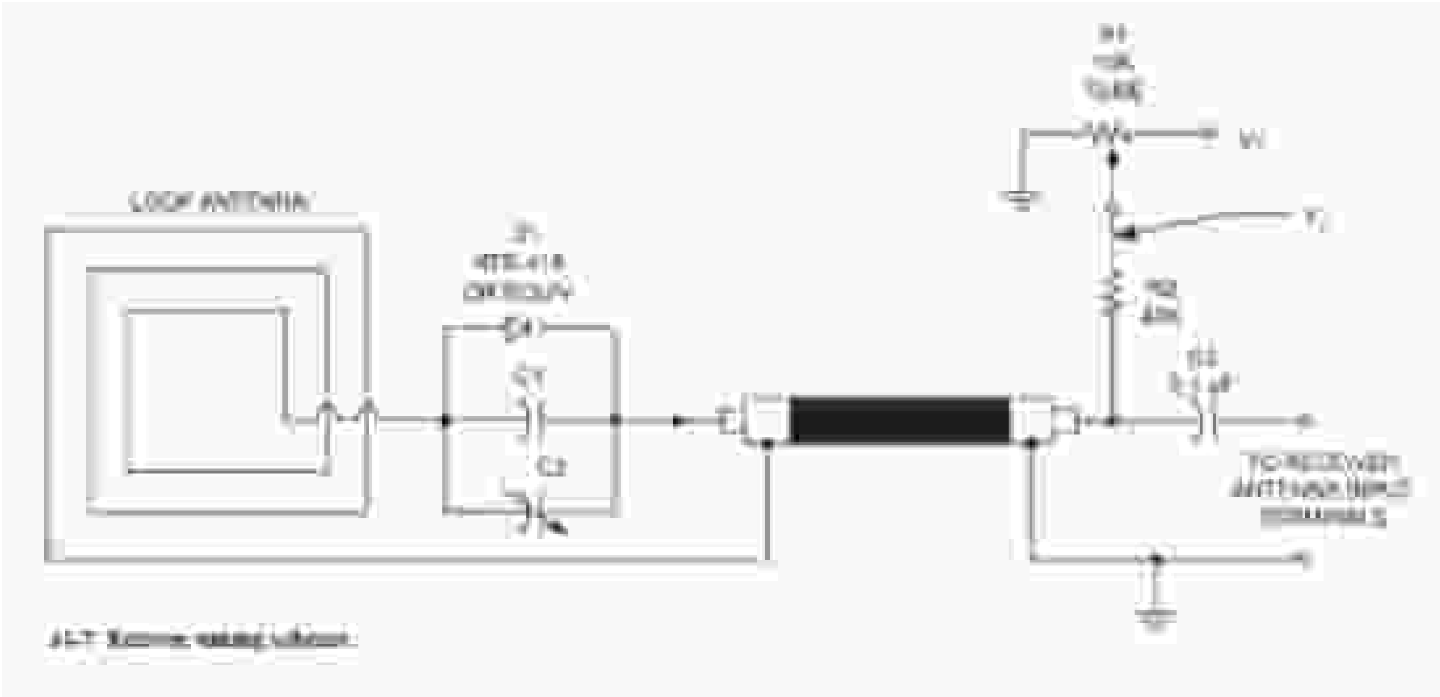

Diagram from Joseph Carr's
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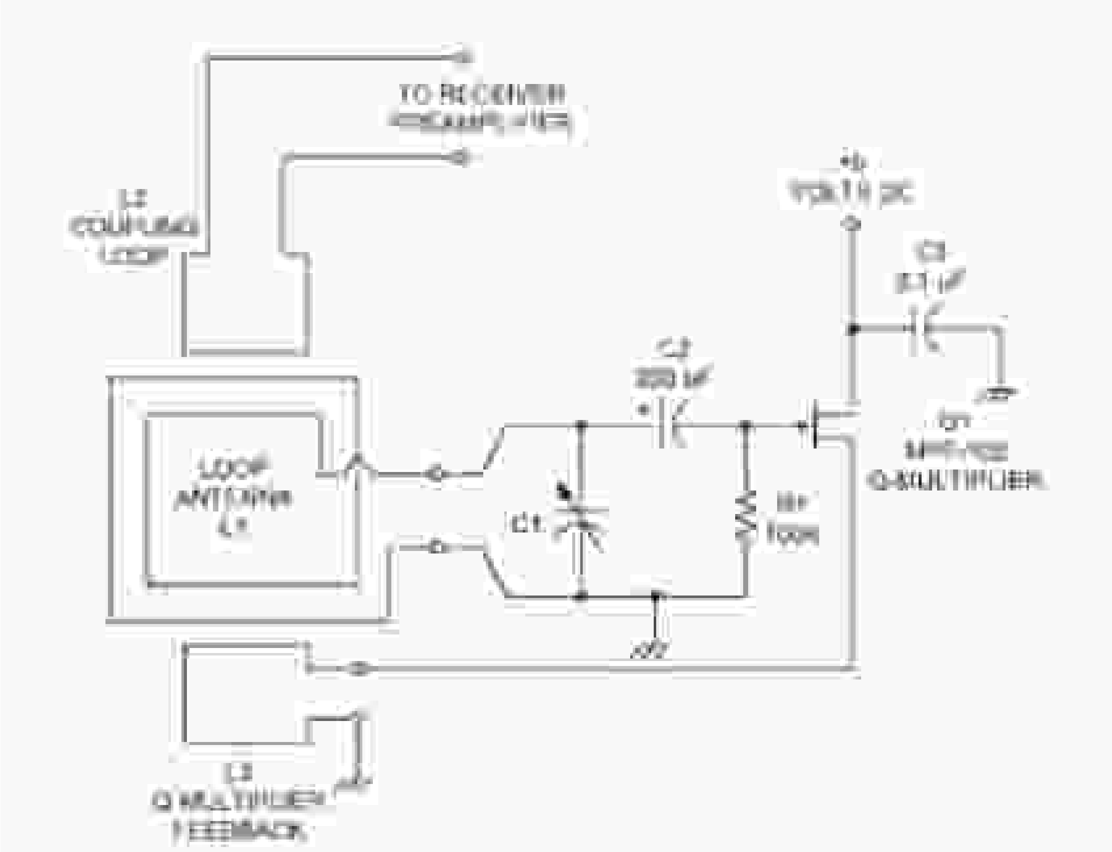


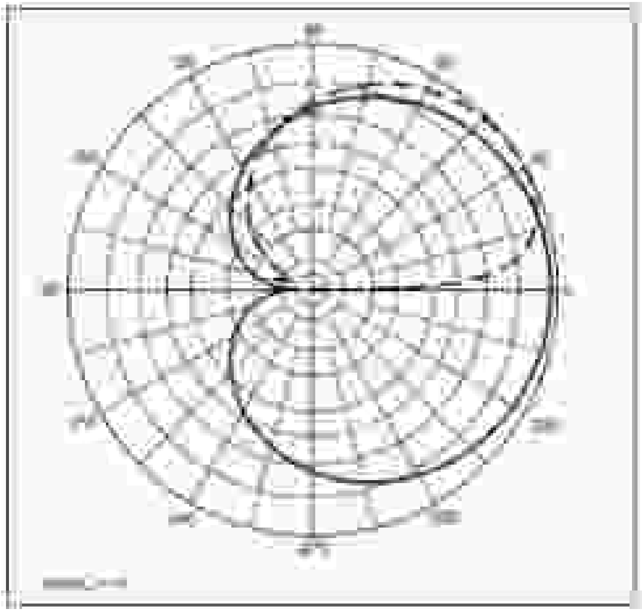
Receive Loops Summary

- Pros
  - Small, lightweight
  - Easy to build
  - Sharp null in 2 directions
- Cons
  - Poor sensitivity
  - Broad RX pattern
  - Often next to noise source in shack

Receive loops can be a useful tool in some situations, but are probably better suited for SWL and BCB/LF Beacon DX’ing.

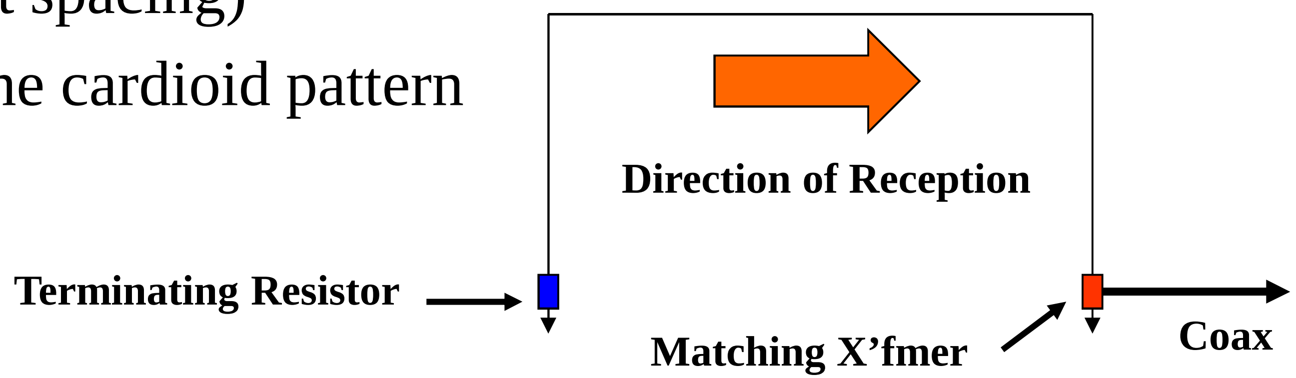
Elongated Terminated Loops

- Include Ewe, Flag, Pennant and K9AY
- Terminated loop produces a cardioid pattern
- Depth and angle of null depend on loop shape



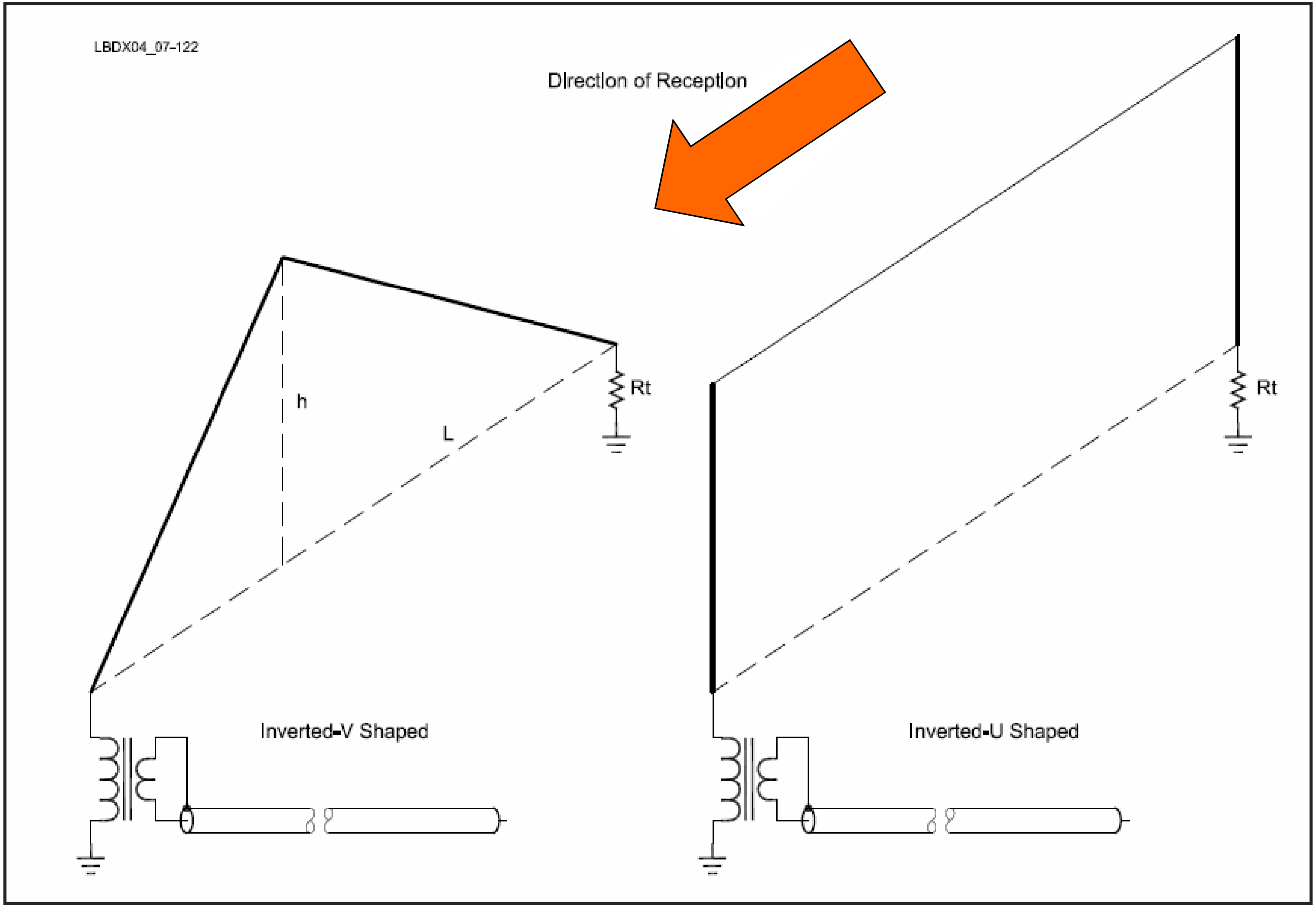
Theory of Operation

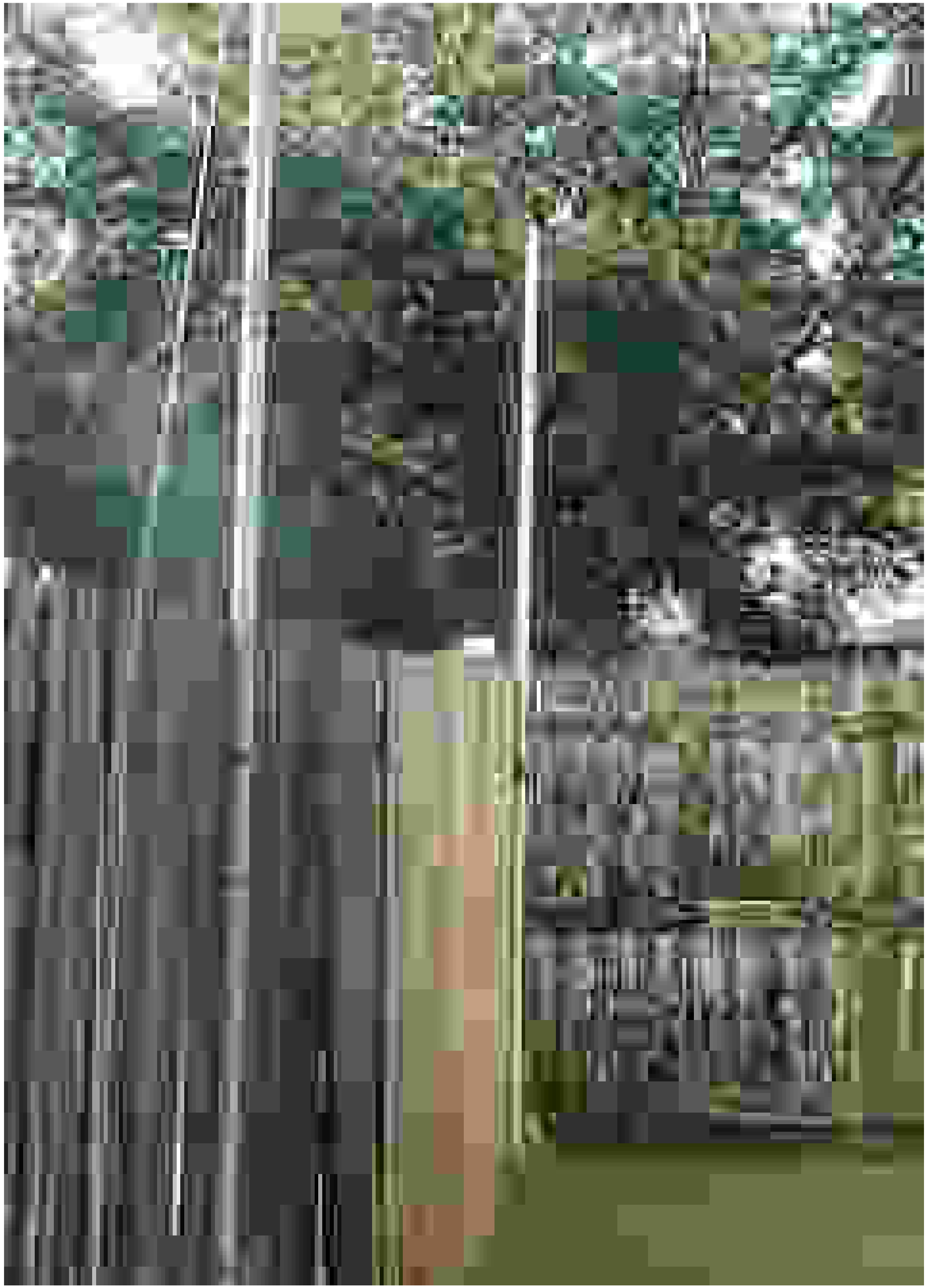
- Despite the shape, actually a pair of verticals
- Feedline on top and bottom gives crossfire phasing towards feedpoint when elements closer than ¼ Lambda
- Terminating resistor is equal to feedpoint impedance, and ensures equal current throughout
- Thus, vertical elements have phase difference of 180 deg plus electrical length of connecting wires (slightly more than element spacing)
- This gives the cardioid pattern



Ewe Antenna

Diagram from ON4UN's
Low Band DXing

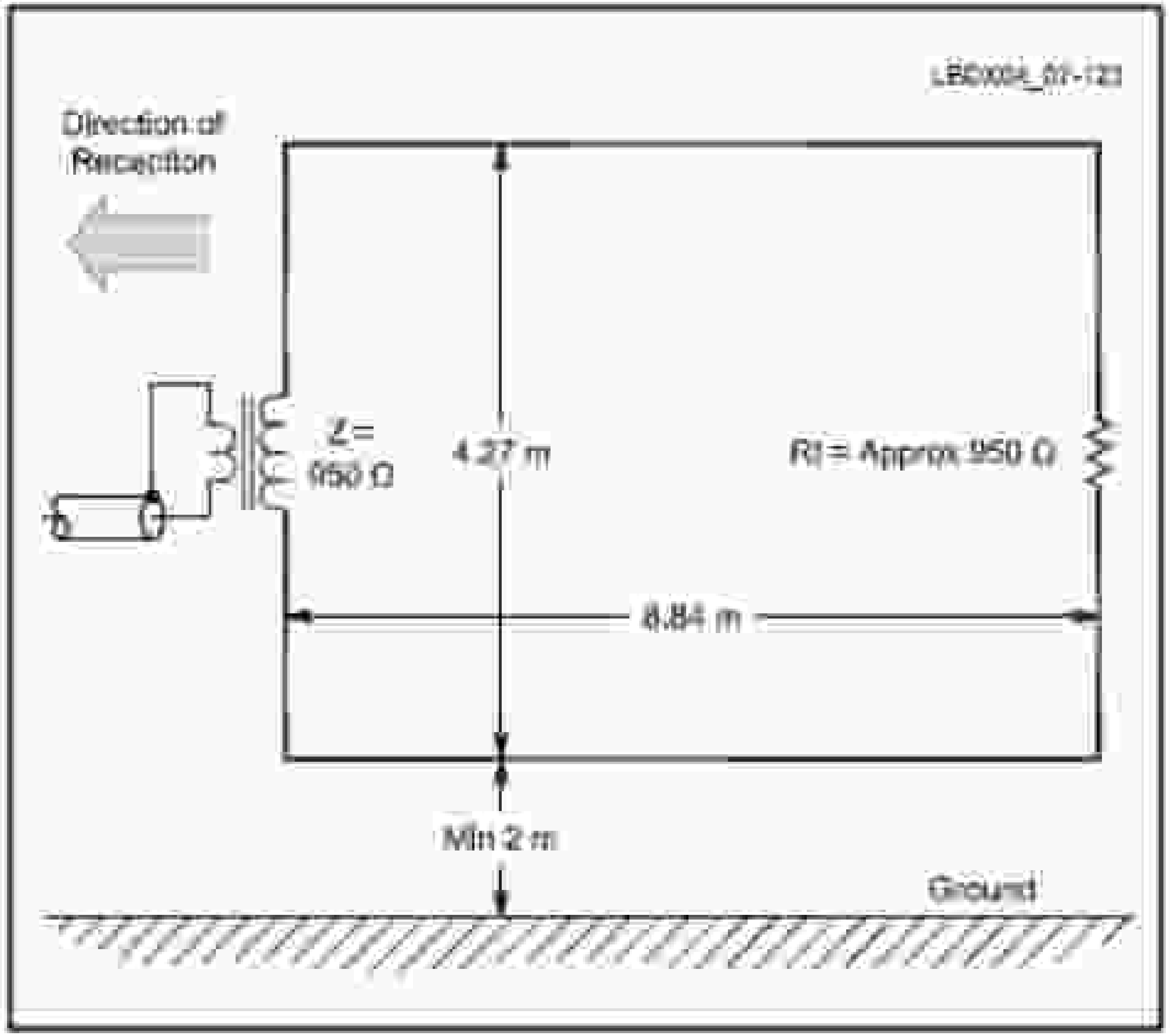




Ewe Antenna at KC4HW

Diagram from ON4UN's
Low Band DXing

Flag Antenna



www.qsl.net/w7iuv/

Diagram from ON4UN's
Low Band DXing

Pennant Antenna

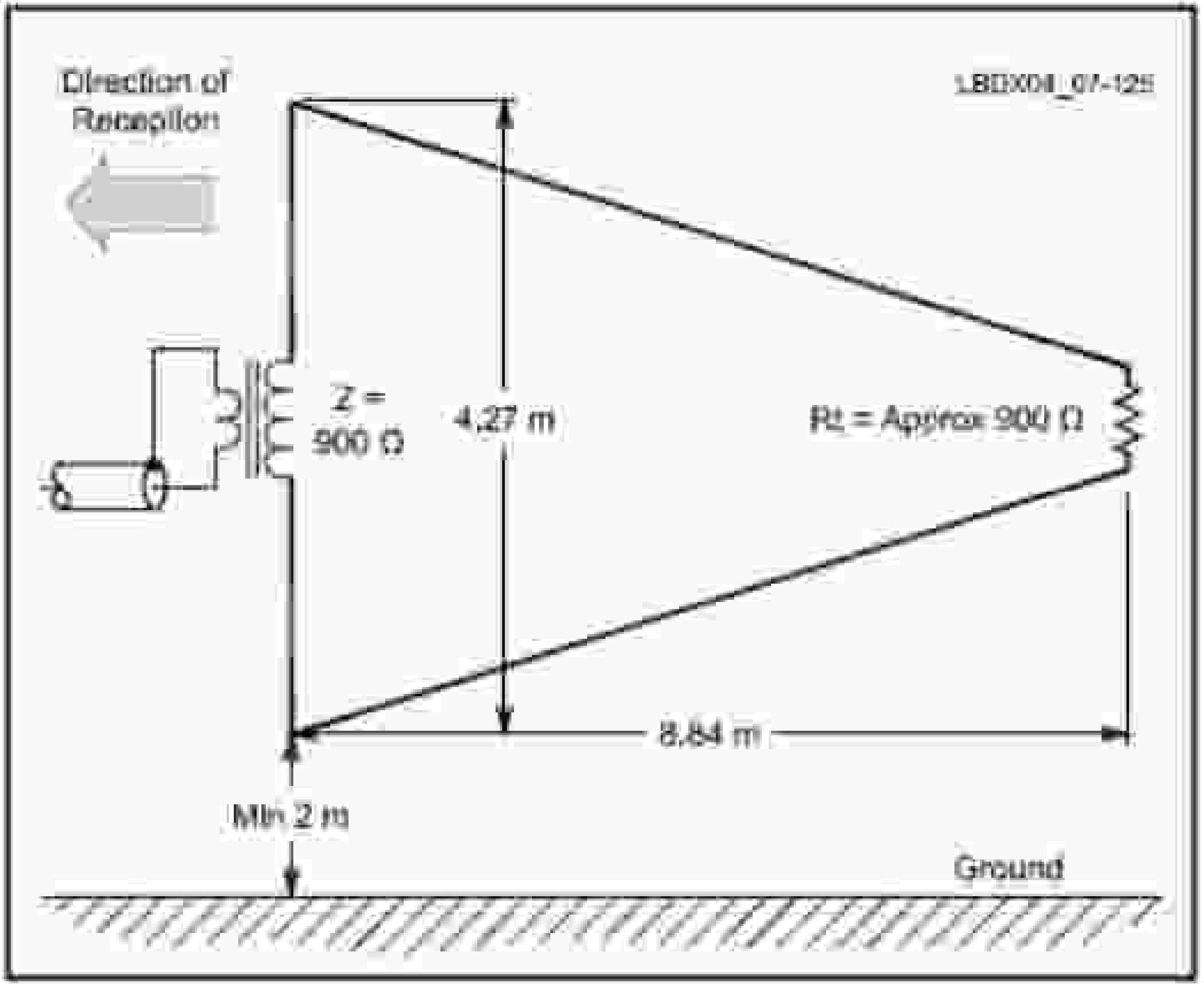


Diagram from ON4UN's
Low Band DXing

Delta Ewe Antenna

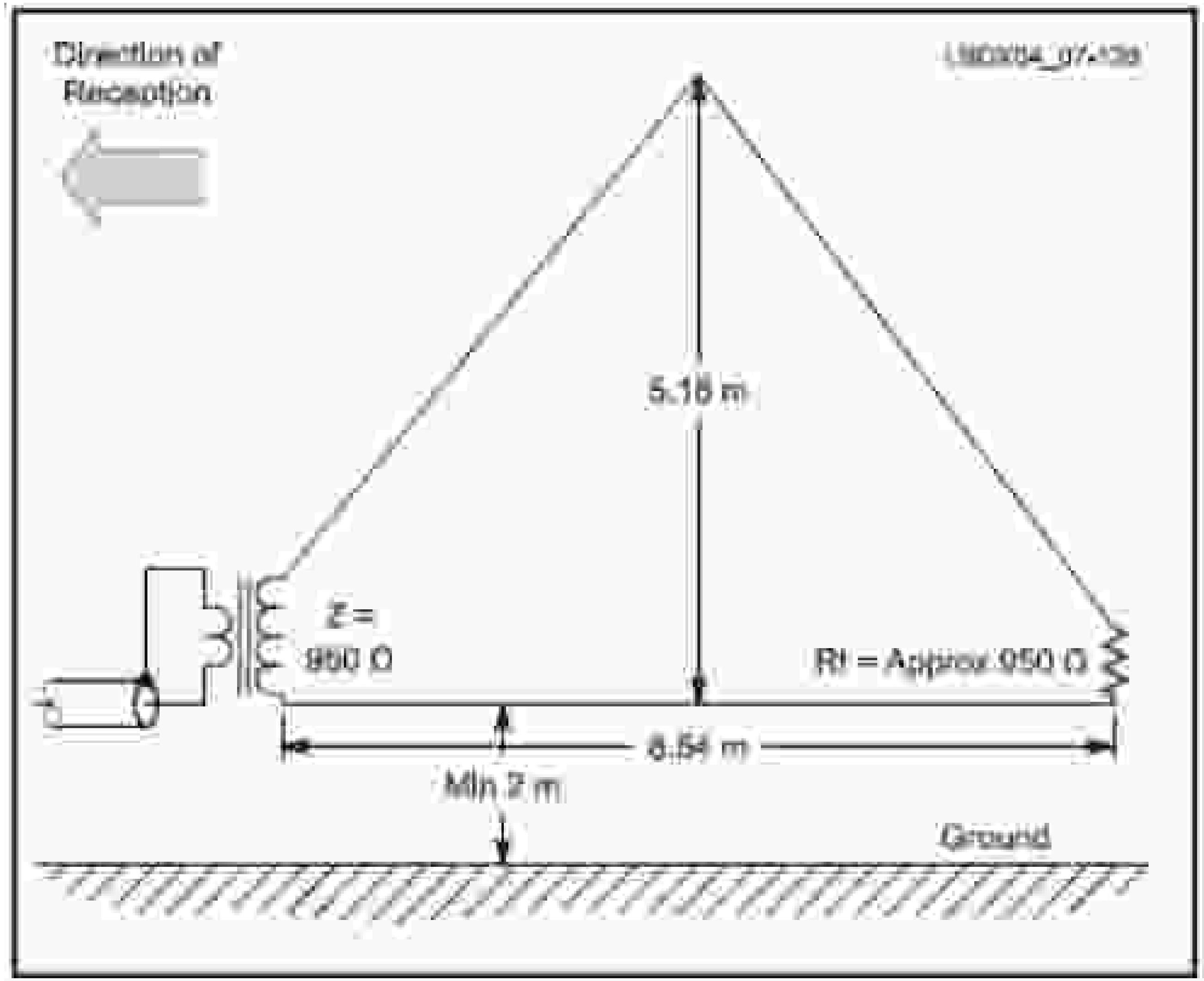
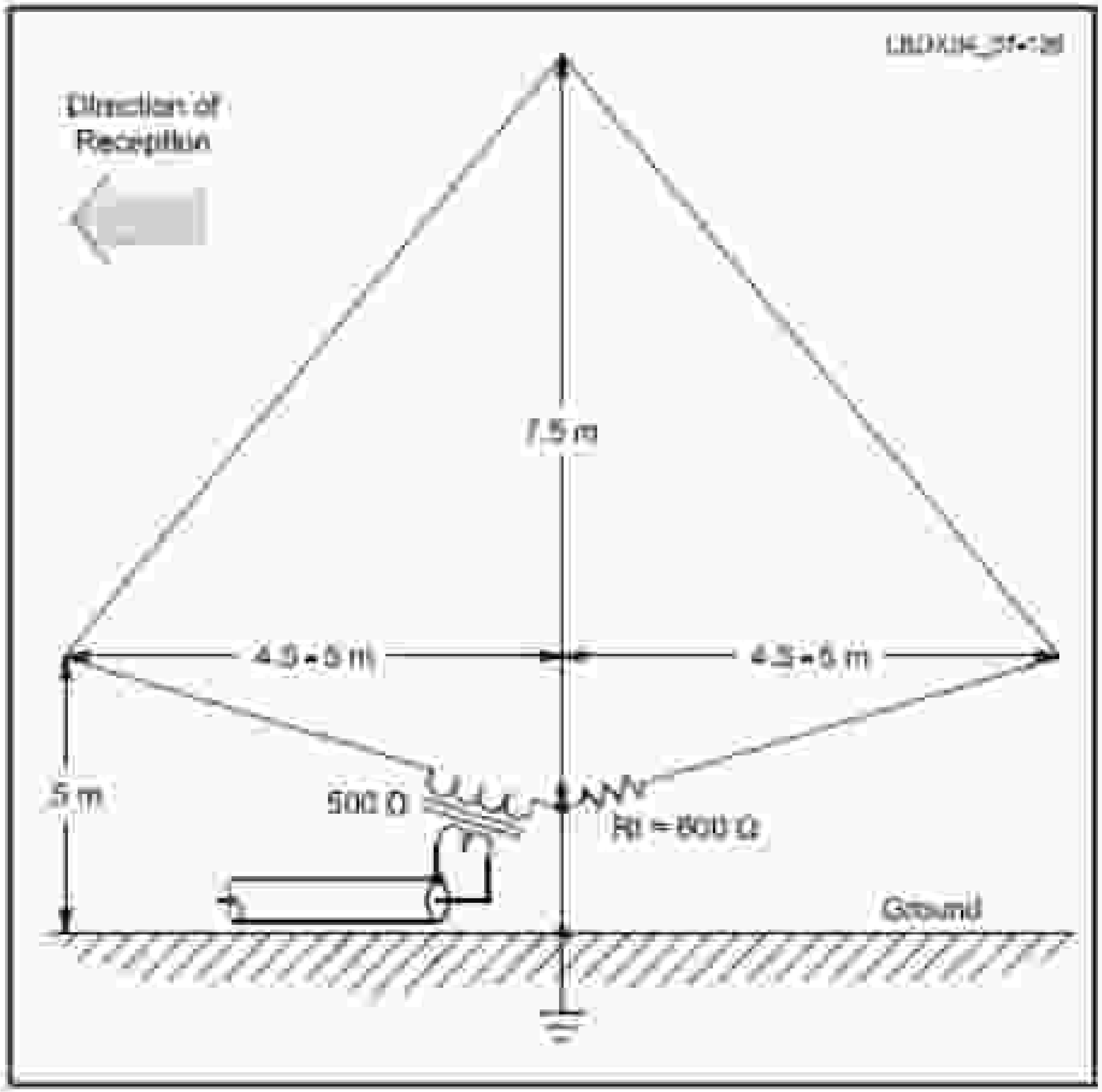
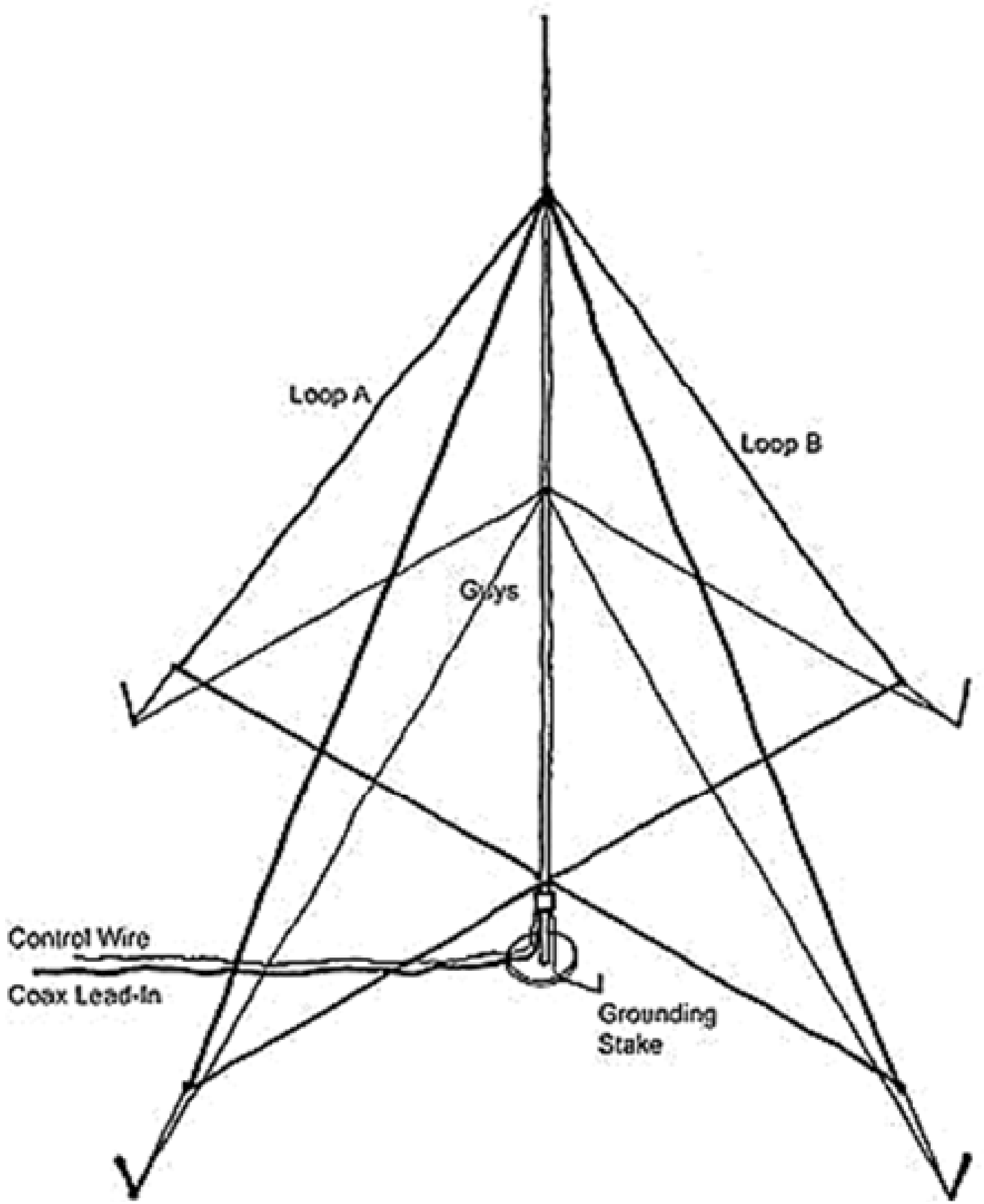


Diagram from ON4UN's
Low Band DXing

K9AY Antenna




Loop A
Loop B
Guys
Control Wire
Coax Lead-In
Grounding
Stake

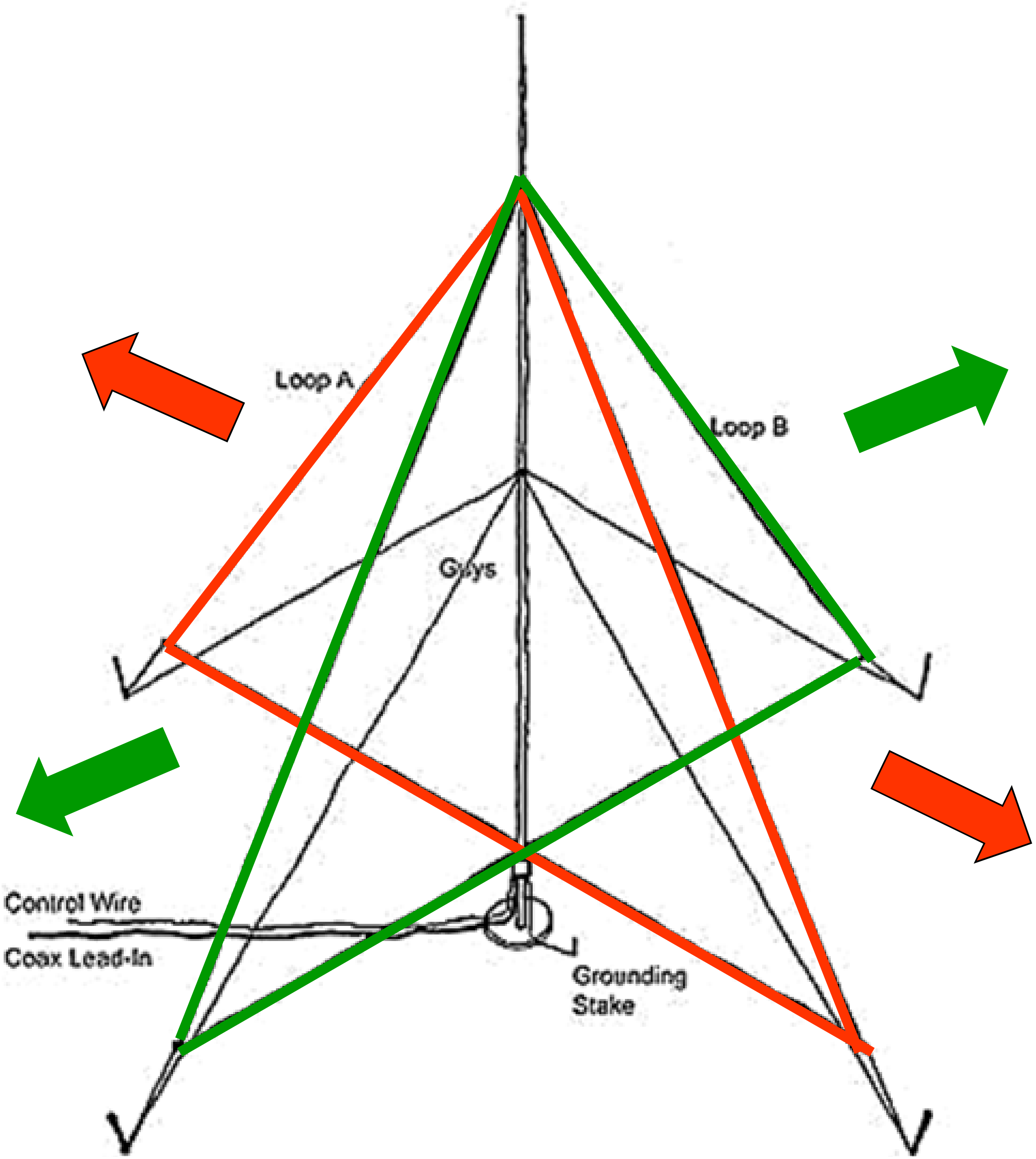

Loop A
Loop B
Guys
Control Wire
Coax Lead-In
Grounding
Stake

Diagram from ON4UN's
Low Band DXing

K9AY Switchbox

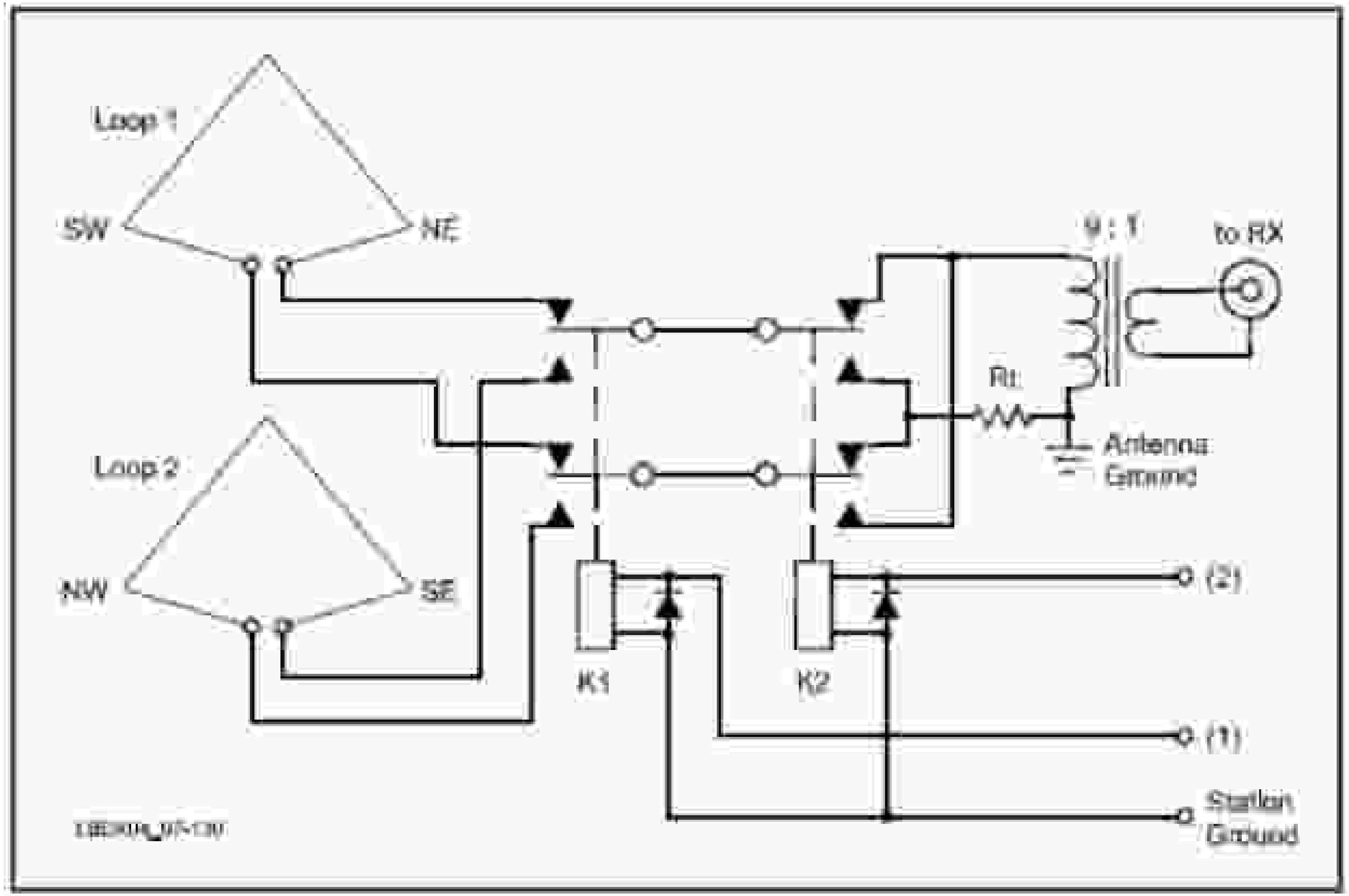


Diagram from ON4UN's
Low Band DXing

K9AY Control Box

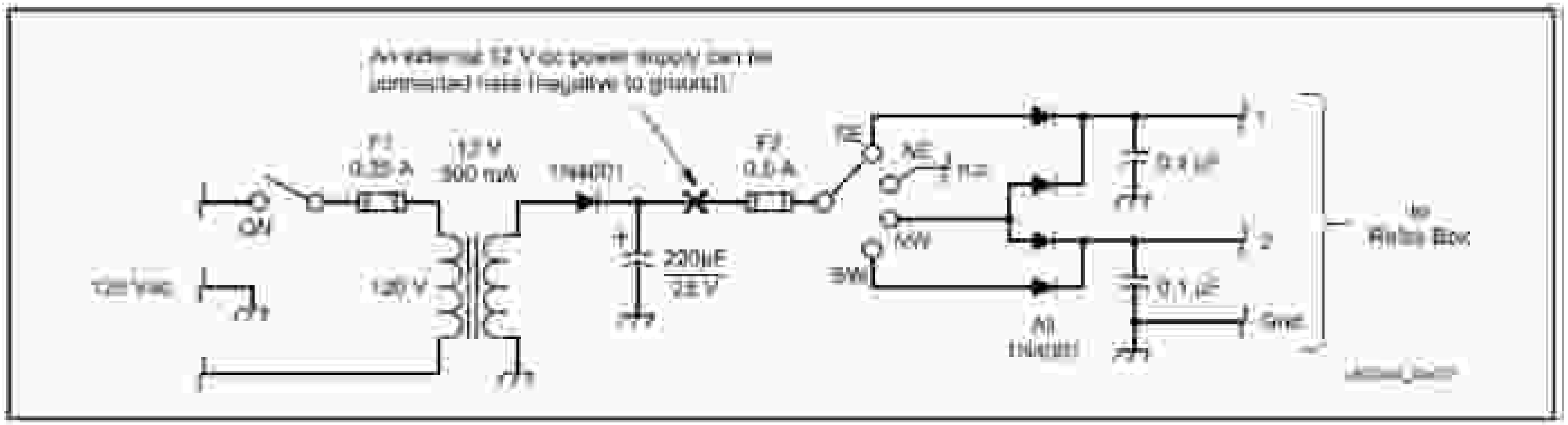


Diagram from ON4UN's
Low Band DXing

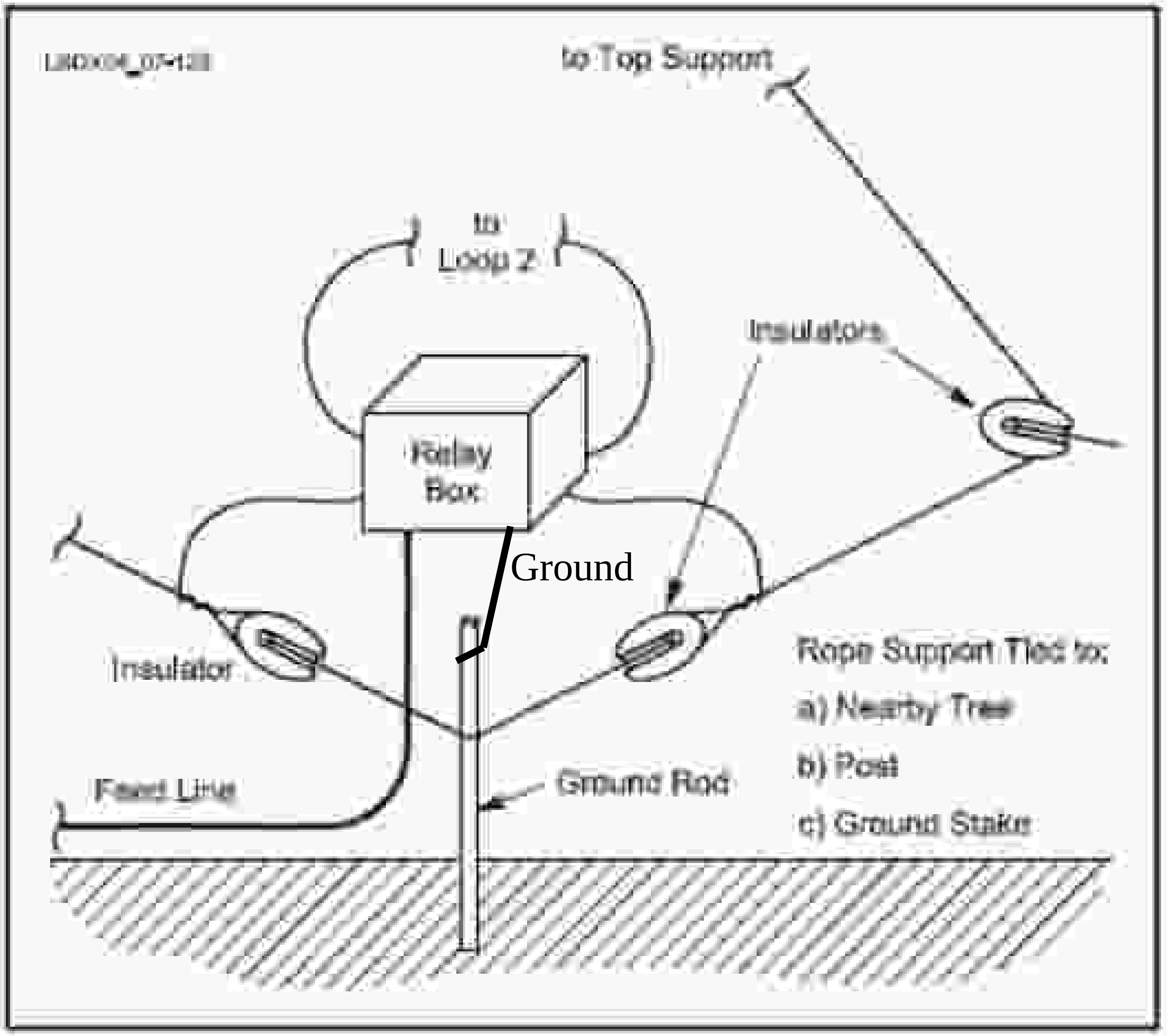
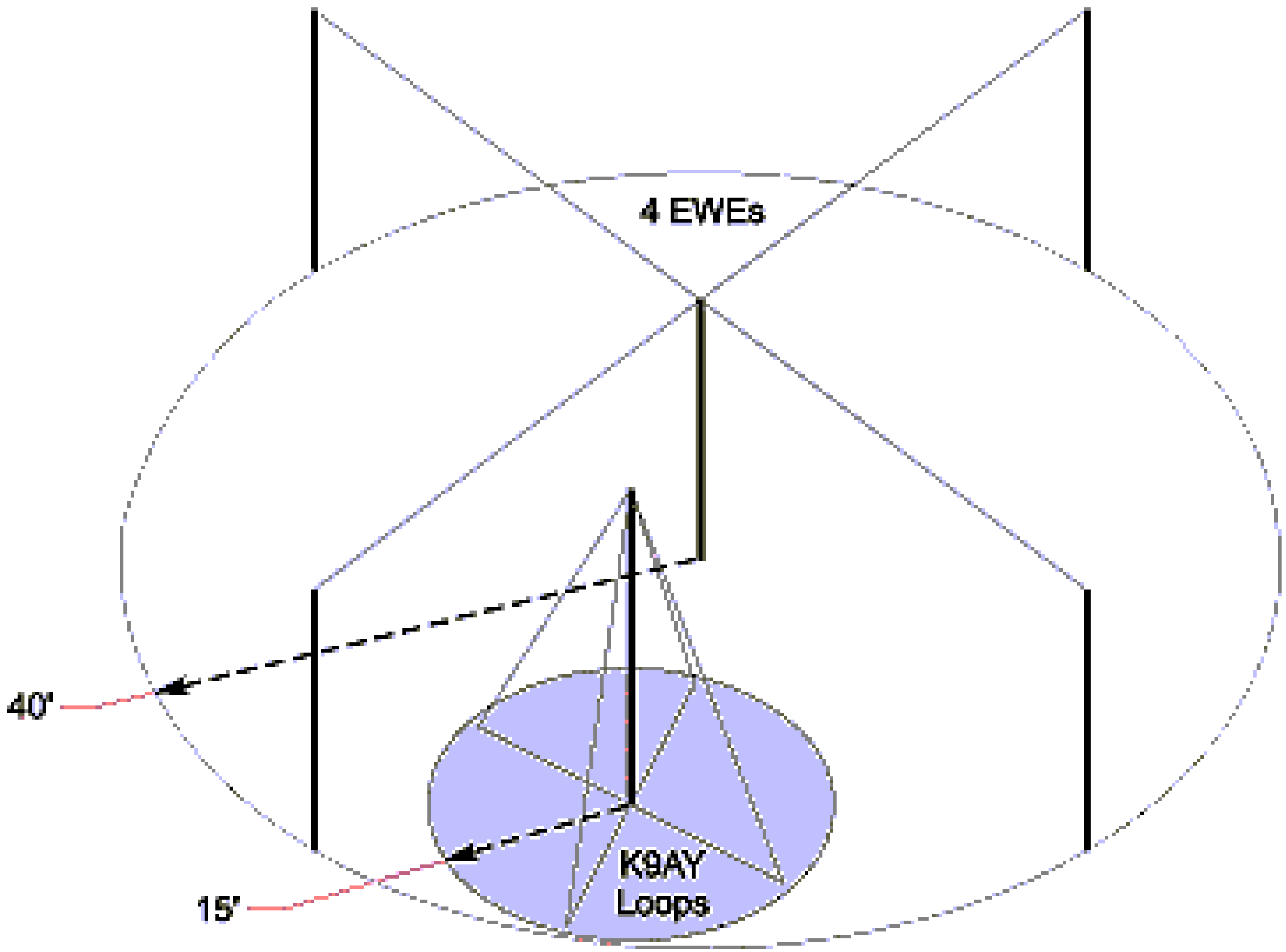


Photo from ON4UN's
Low Band DXing

Diagram from ON4UN's
Low Band DXing



Feeding Elongated Loops

- Impedances range from 500 Ohms in K9AY, to 950 Ohms in Deltas and Flags.
- Important characteristics:
  - Lowest possible capacitive coupling between primary and secondary windings.
  - Low loss, as signals are weak
  - Good SWR if you want to phase loops into an array of loops

I use binocular cores made from #73 material. Separate windings ensure low coupling, and good balance. Other designs are possible.

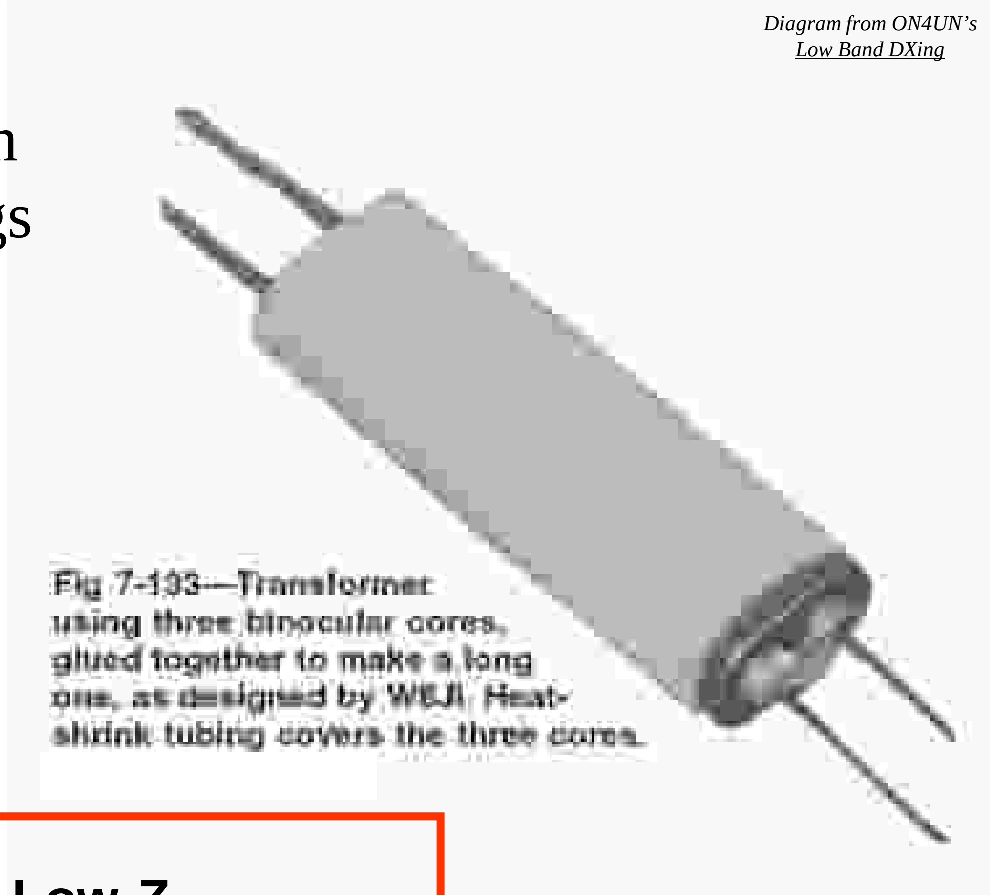


Diagram from ON4UN's *Low Band DXing*

Fig 7-133—Transformer using three binocular cores, glued together to make a long one, as designed by W8JI. Heat-shrink tubing covers the three cores.

Transformation	**Low-Z**	**High-Z**
500 Ω to 75 Ω	2 passes (1 turn)	5 passes
500 Ω to 50 Ω	2 passes (1 turn)	6 passes
950 Ω to 75 Ω	2 passes (1 turn)	7 passes

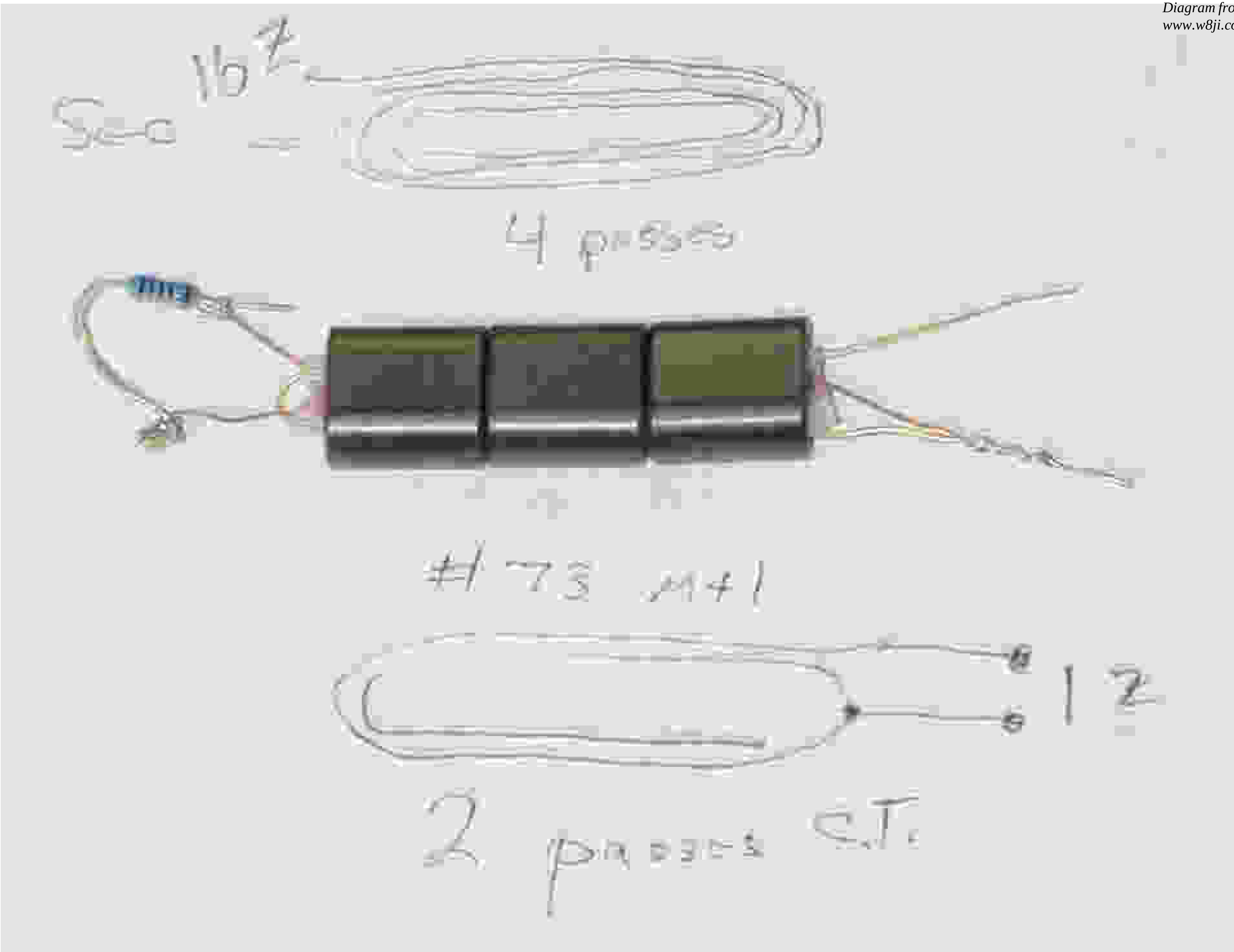


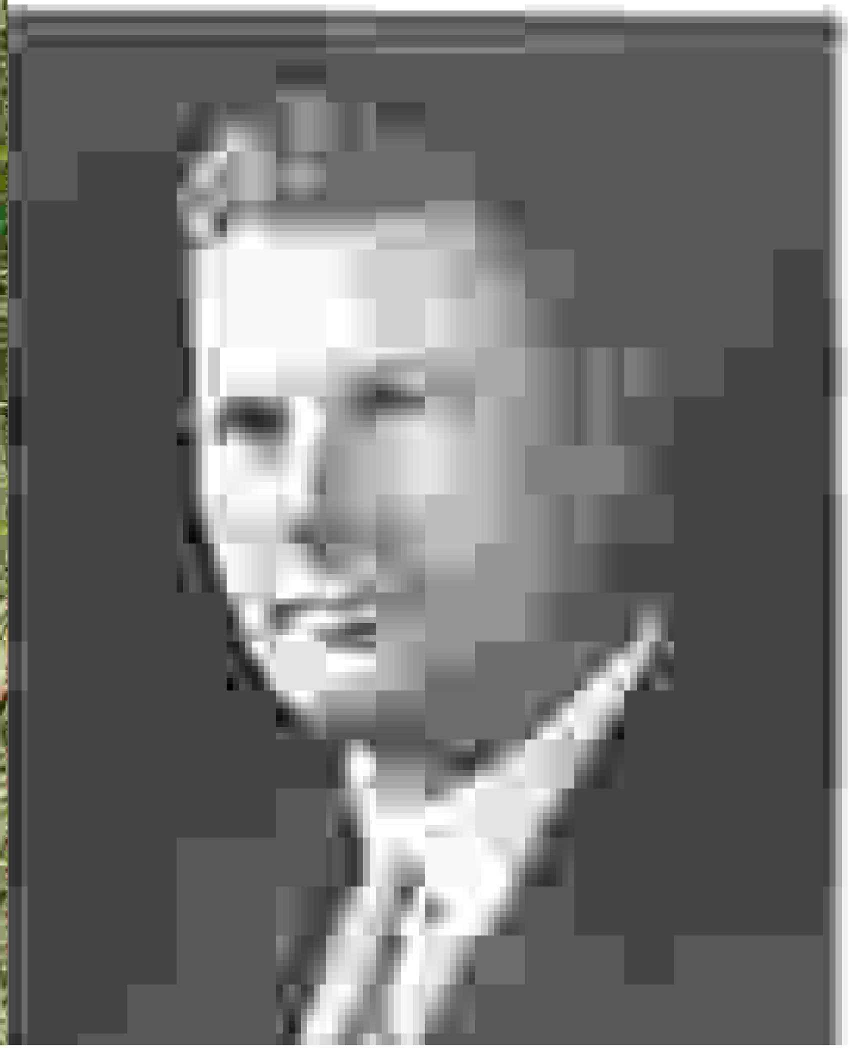
Diagram from www.w8ji.com

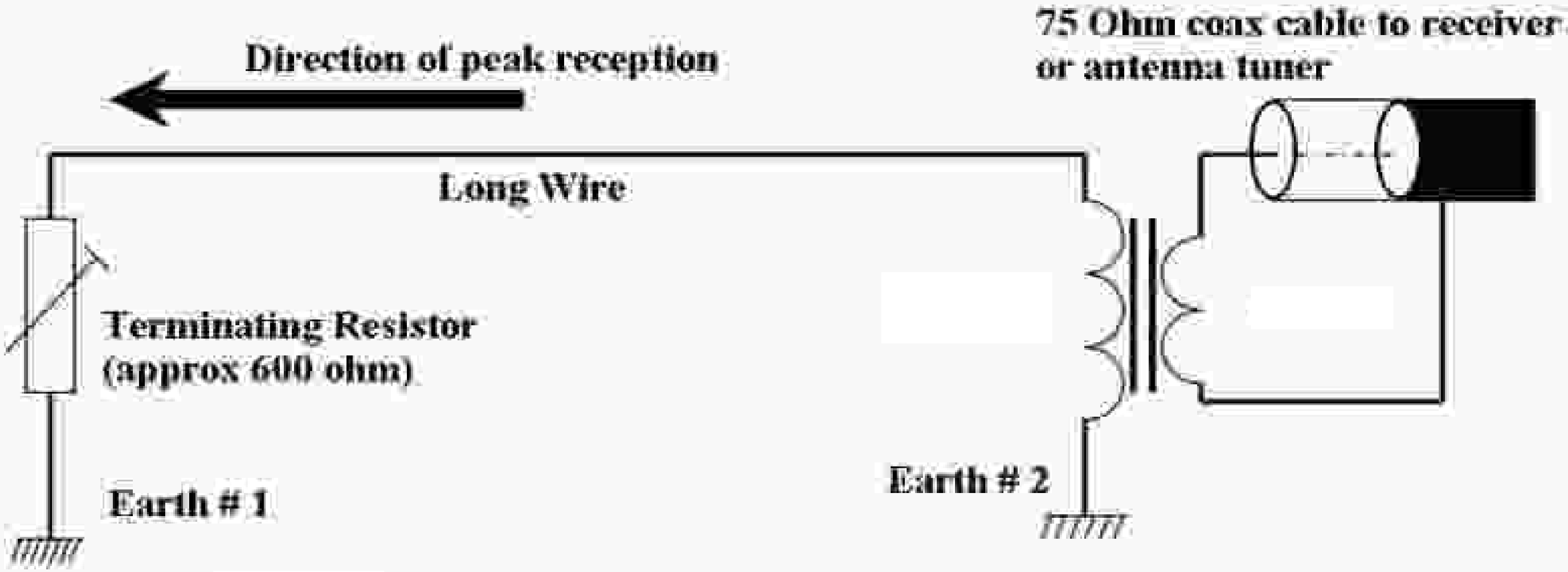
Elongated Loop Summary

- Pros
  - Small footprint
  - Simplicity
  - Can be phased to improve performance
  - Much better than listening to a vertical!
- Cons
  - Insensitive, may require a preamp
  - Directivity not as good as a Beverage
  - Feedline prone to noise pickup

Although not as good as Beverage antennas, Elongated Loops offer good performance for people who don’t have much room.

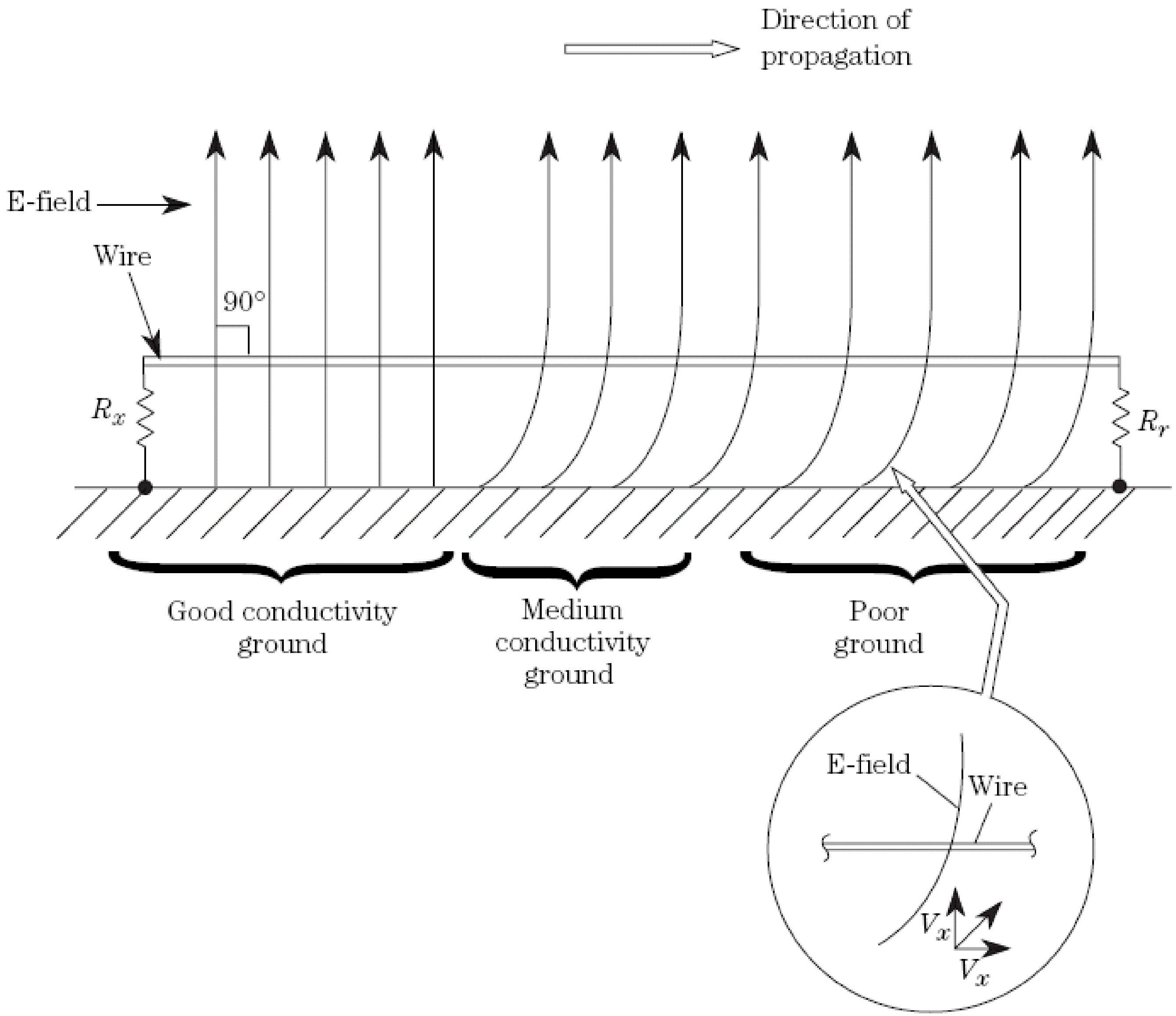
The Beverage Antenna!





A basic uni-directional Beverage antenna

Diagram from Joseph Carr's
Practical Antenna Handbook



Influence of Length

- Following slide shows EZNEC results for a Beverage with following characteristics:
  - 2 meters high
  - Over good ground
  - 600 Ohm termination
  - 0.55 to 4.4 wavelength
  - 160 M band

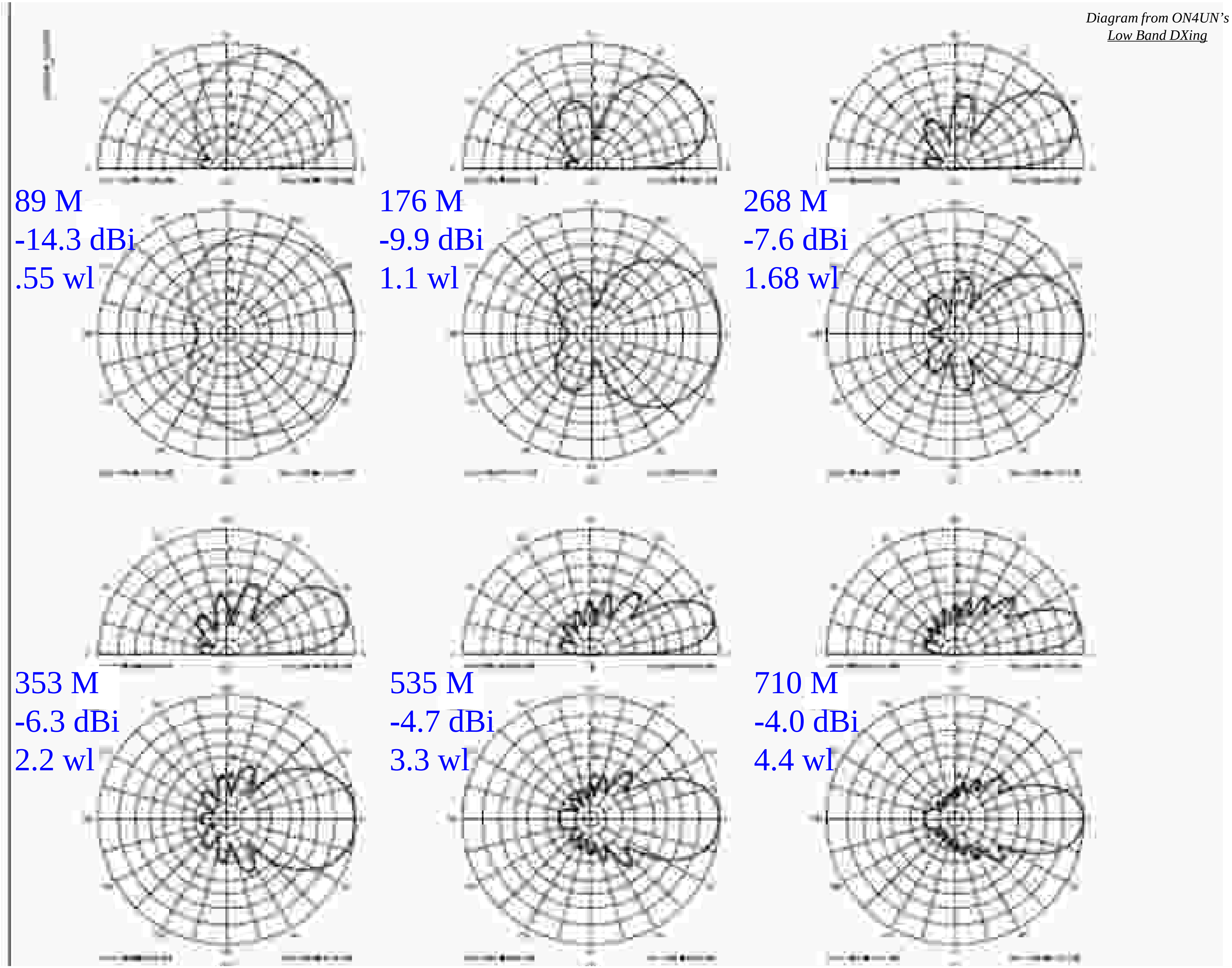


Diagram from ON4UN's
Low Band DXing
89 M
-14.3 dBi
.55 wl
176 M
-9.9 dBi
1.1 wl
268 M
-7.6 dBi
1.68 wl
353 M
-6.3 dBi
2.2 wl
535 M
-4.7 dBi
3.3 wl
710 M
-4.0 dBi
4.4 wl

$$\mathrm{MEL} = \frac{\lambda}{4\left(\frac{100}{K} - 1\right)}$$

where

MEL is the maximum effective length, in meters
λ is the wavelength, in meters
K is the velocity factor, expressed as a percent

How High?

- Not as critical as many think
- General rule:
  - Higher Beverages produce higher output
  - Higher Beverages have larger side-lobes
  - Higher Beverages have a higher elevation angle
  - Higher Beverages have a wider 3-dB forward lobe
- Laying on ground to 6 meters high is acceptable
- 1.5 x Antler Height is good idea!
- 2.5 meters is a good compromise

Ground Quality

- The better the ground, the lower the output
- Ground quality has little impact on radiation angle
- The poorer the ground, the less pronounced the nulls between the different lobes
- Directivity remains almost constant
- Beverage does not work well over salt water

Diagram from ON4UN's
Low Band DXing

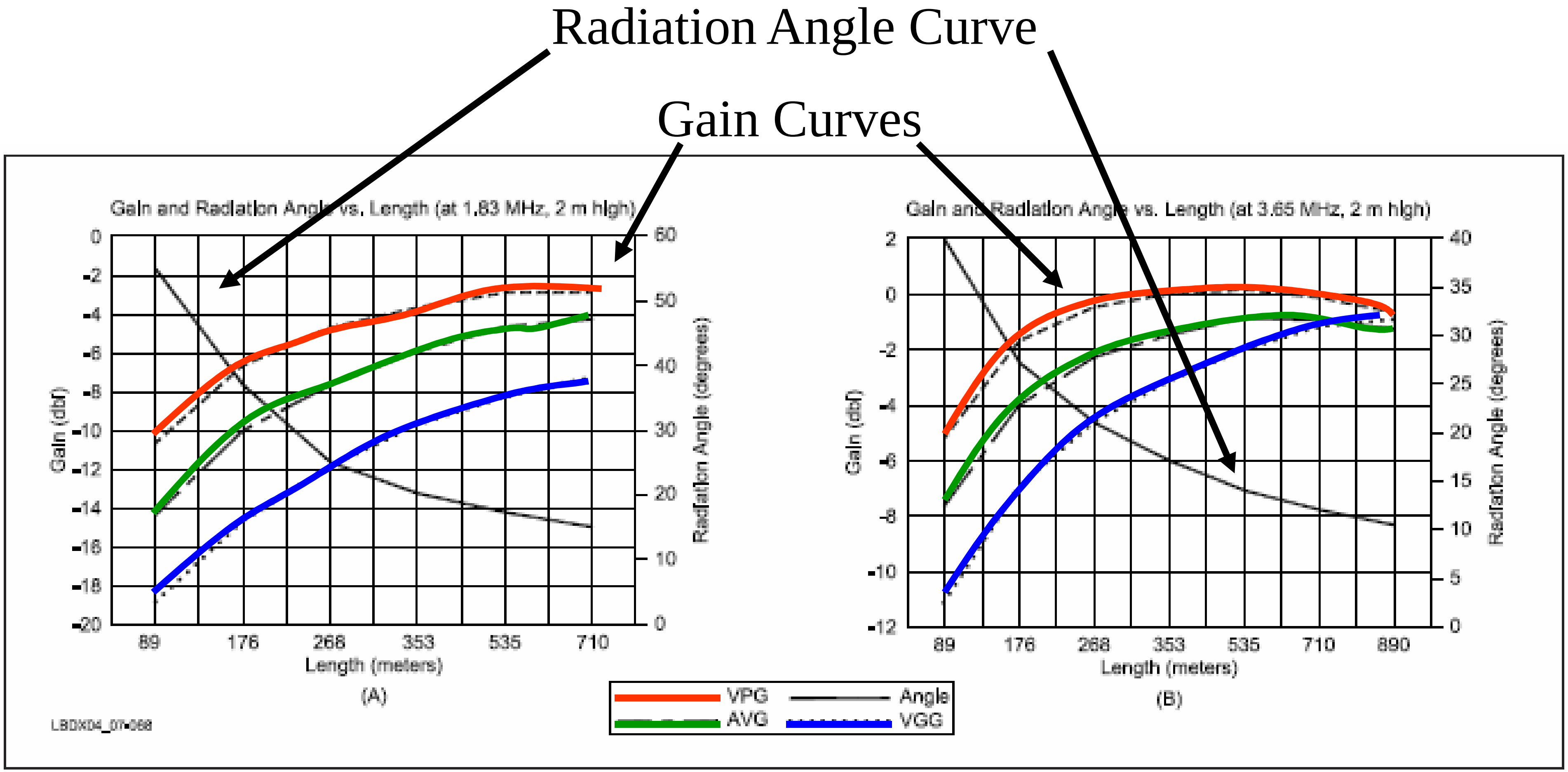


Fig 7-68—Gain and elevation angle for a 2-meter high Beverage antenna for 160 and 80 meters, as a function of the antenna length. Three curves are shows: over Very Poor Ground (VPG), over Average Ground (AVG), and over Very Good Ground (VGG). The radiation angle is computed for Average Ground. This angle only changes marginally between Very Poor and Very Good ground.

Gain and Radiation Angle

Wire

- Inefficient antenna anyway, so size not critical as long as it is physically strong enough
- Insulated, not insulated – doesn’t matter
- Pre-stretch soft-drawn copper wire
- Copper-clad and aluminum wire also okay

Theoretical Surge Impedance

$$Z = 138 \log \frac{4h}{d}$$

Where:

h = height of wire

d = wire diameter (in same units)

Termination Resistor

- Should be non-inductive
- Antenna will pick up TX power and lightning surges, so use 2 watt resistor
- Metal Film and Carbon Film cannot handle surges
- Use Carbon Composition
- Use a Spark Gap

Photo from ON4UN's
Low Band DXing

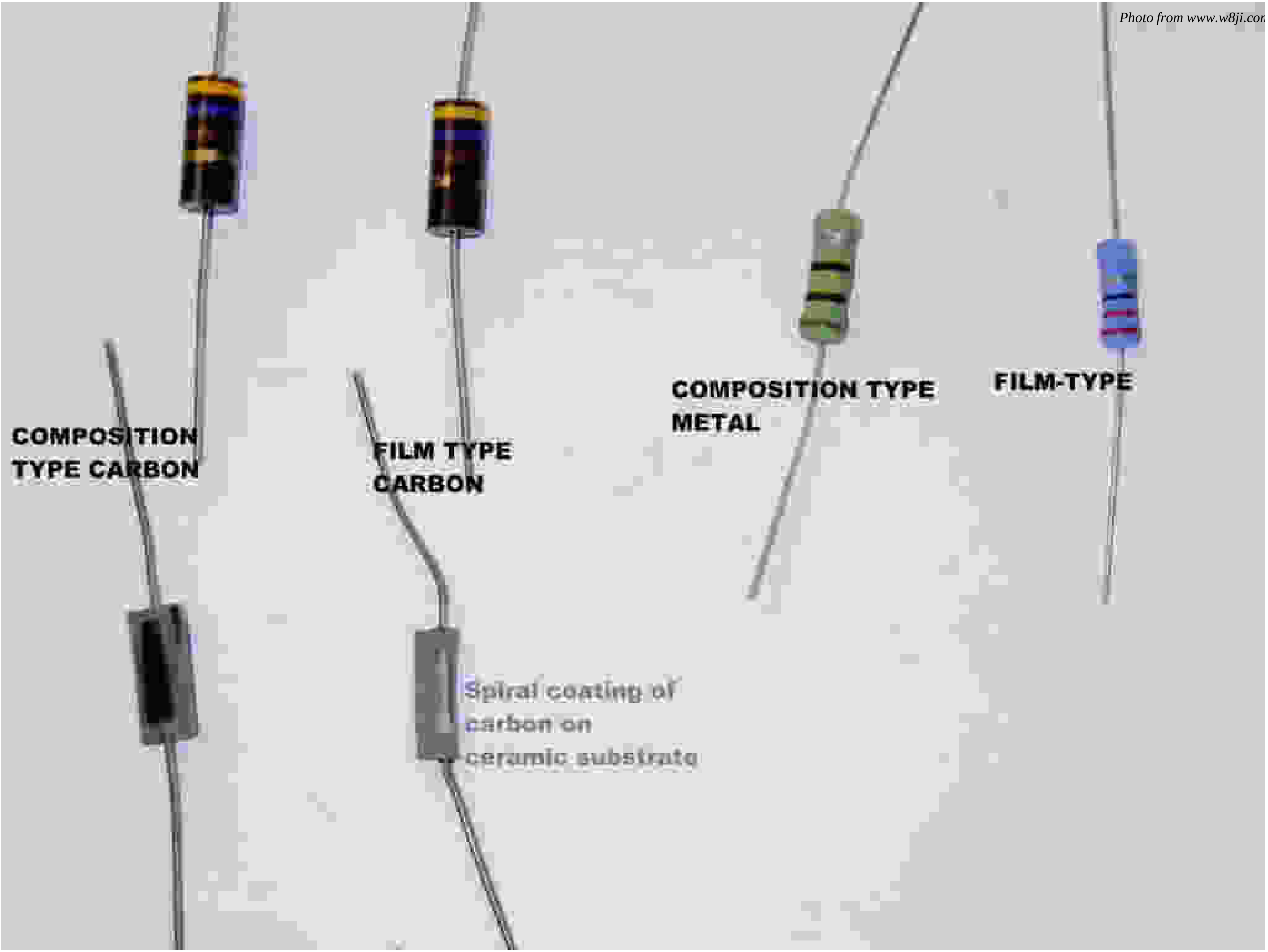
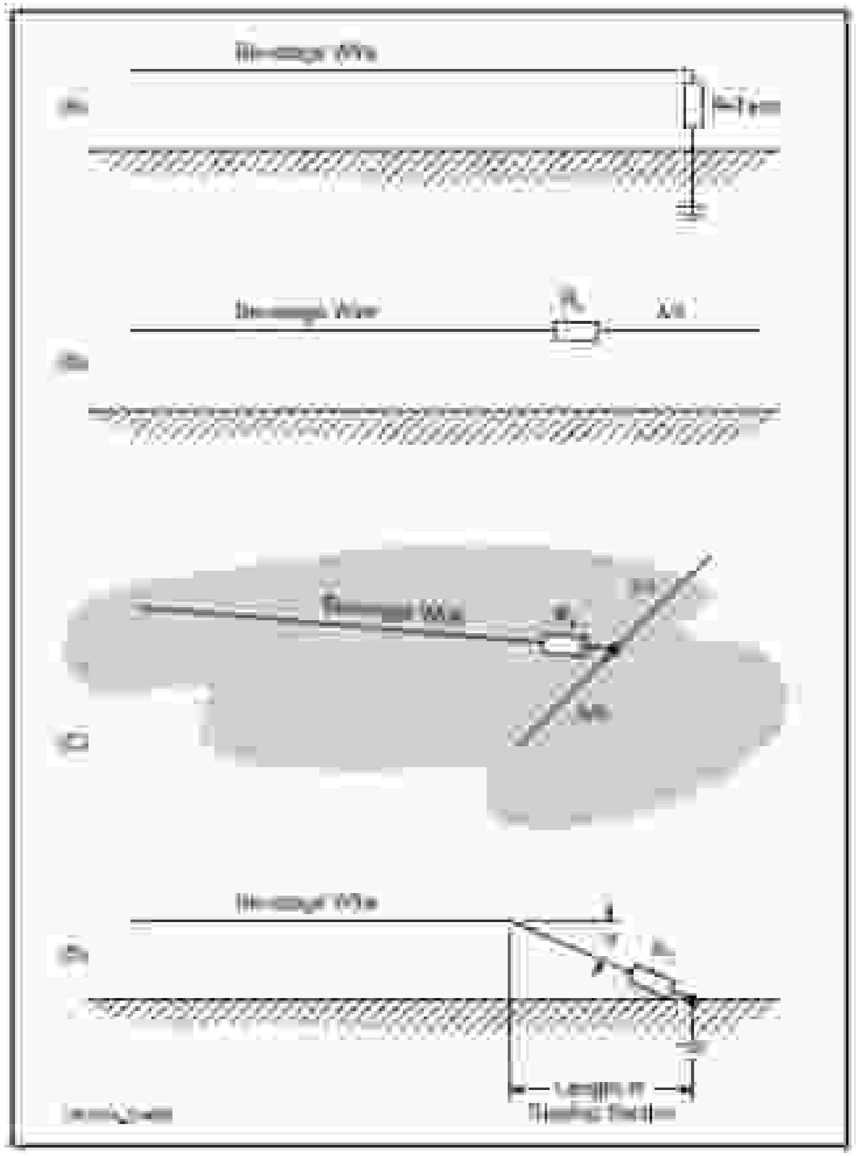


Photo from www.w8ji.com
COMPOSITION TYPE CARBON
FILM TYPE CARBON
COMPOSITION TYPE METAL
FILM-TYPE
Spiral coating of carbon on ceramic substrate

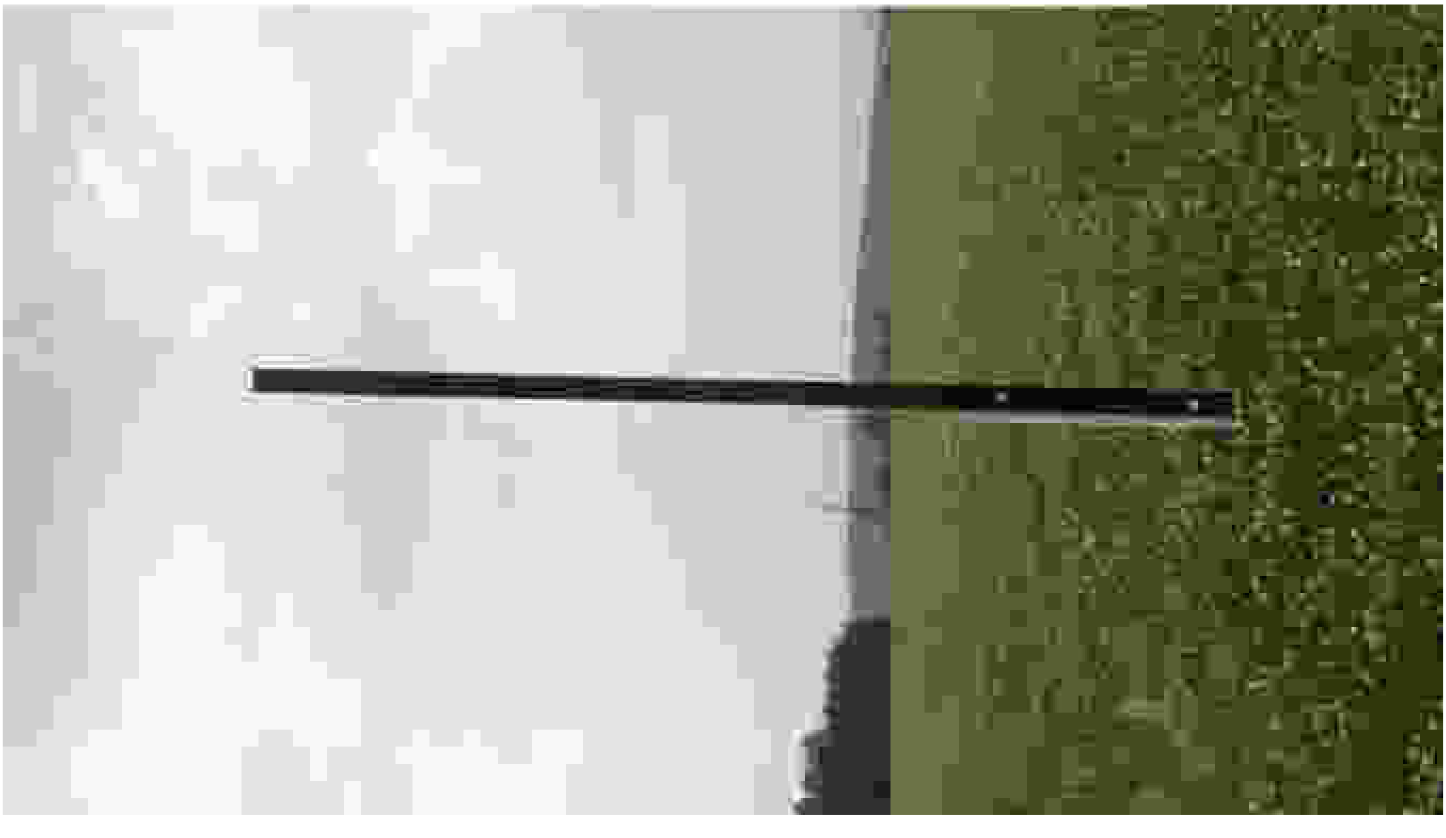
Diagram from ON4UN's

Low Band DXing



Supports

- Metal, non-metallic – doesn’t matter as long as antenna is insulated
- Poles, fence posts, trees, sheds, misbehaving children – whatever is available
- Do not wrap wire around an insulator
- Try to keep it straight and level, but minor variations are okay



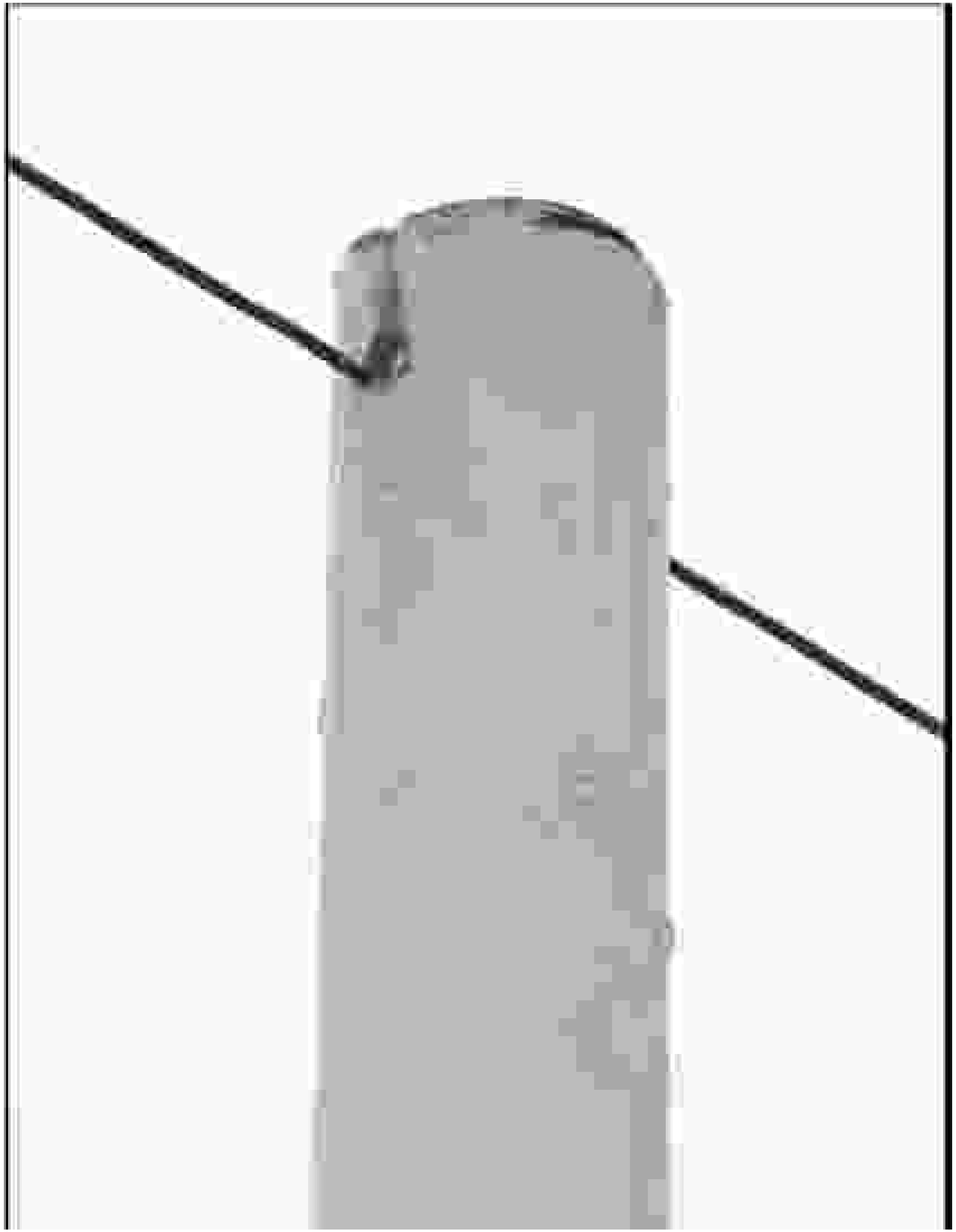


Photo from ON4UN's
Low Band DXing

Photo from www.w8ji.com

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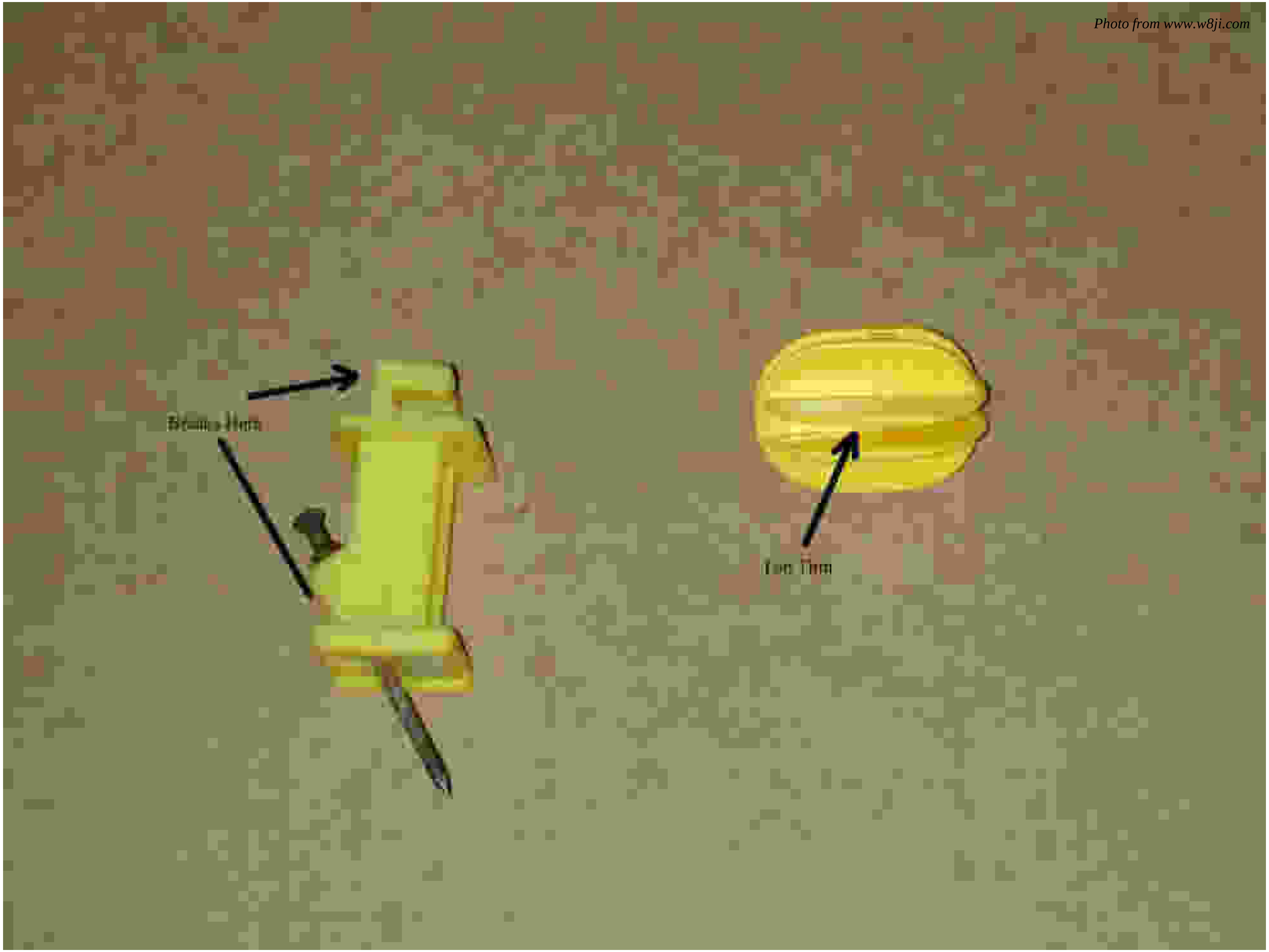
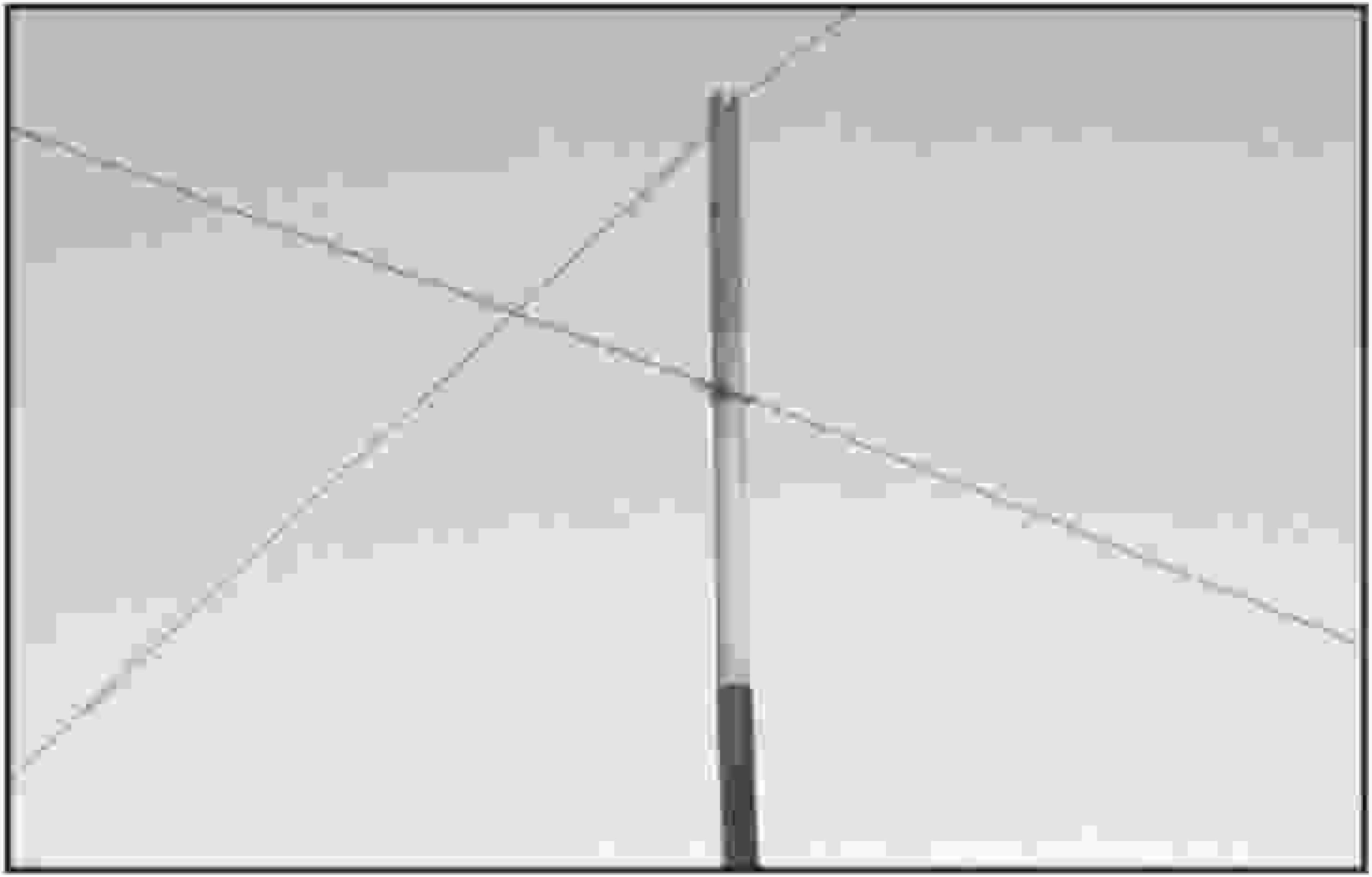


Photo from www.w8ji.com

Parallel and Crossing Beverages

- Separate parallel Beverages by distance equal to their height above ground
- Separate by at least 10 cm when crossing
- Do not run close to parallel conductors (fences, telephone poles etc.)

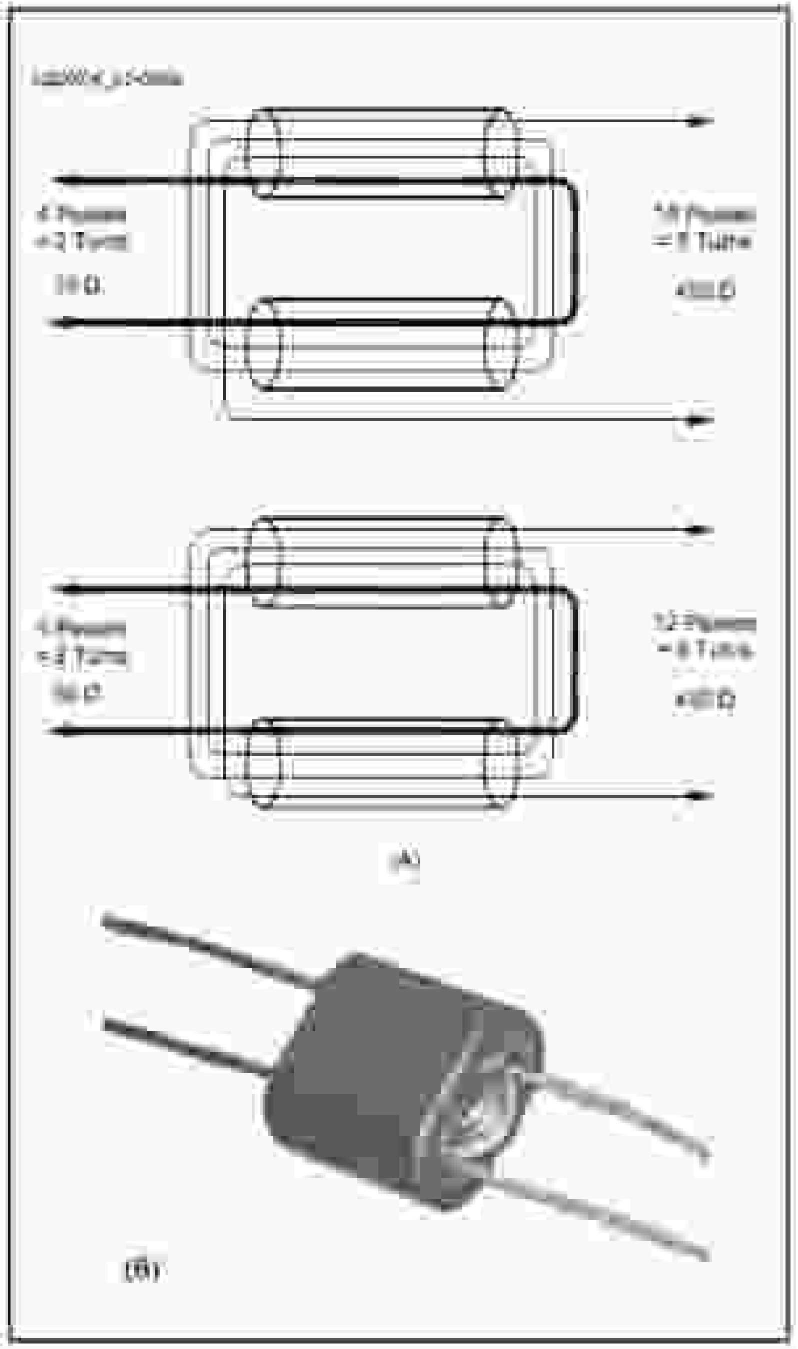
Photo from ON4UN's
Low Band DXing



Matching the Beverage Antenna

- Several different core material/turns combinations available
- Separate primary/secondary windings advisable
- I prefer Type 73 Binocular Cores as recommended by W8JI

Diagram from ON4UN's
Low Band DXing



Winding Binocular Cores

Pri Passes	Sec Passes	Pri Z Ohm	Sec Z Ohm
4	10	75	450
6	16	75	533
4	12	50	450
6	20	50	550

Note: Using Fair-Rite 2873000202 Binocular Cores (1 turn = 2 passes)

Coax

- Can use 50 or 75 Ohm cable
- I prefer 75 Ohm cable
  - Works very well (ensure it is good quality cable)
  - Cheap!
  - Easy to attach connectors in the field
  - Easily identifiable as part of RX system – will not accidentally transmit into it
  - Did I mention that it is cheap?

Grounds

- One 8-foot ground rod *may* suffice
- Will probably need two or more to stabilize the ground system
- Can supplement it with a number of short radials to form capacitance hat to earth
- On coax end of antenna, do not ground the coax braid
- Ensure the coax braid ground is no closer than 5 meters to the ground attached to the transformer

Diagram from ON4UN's
<u>Low Band DXing</u>

Multiple Beverages from one Hub

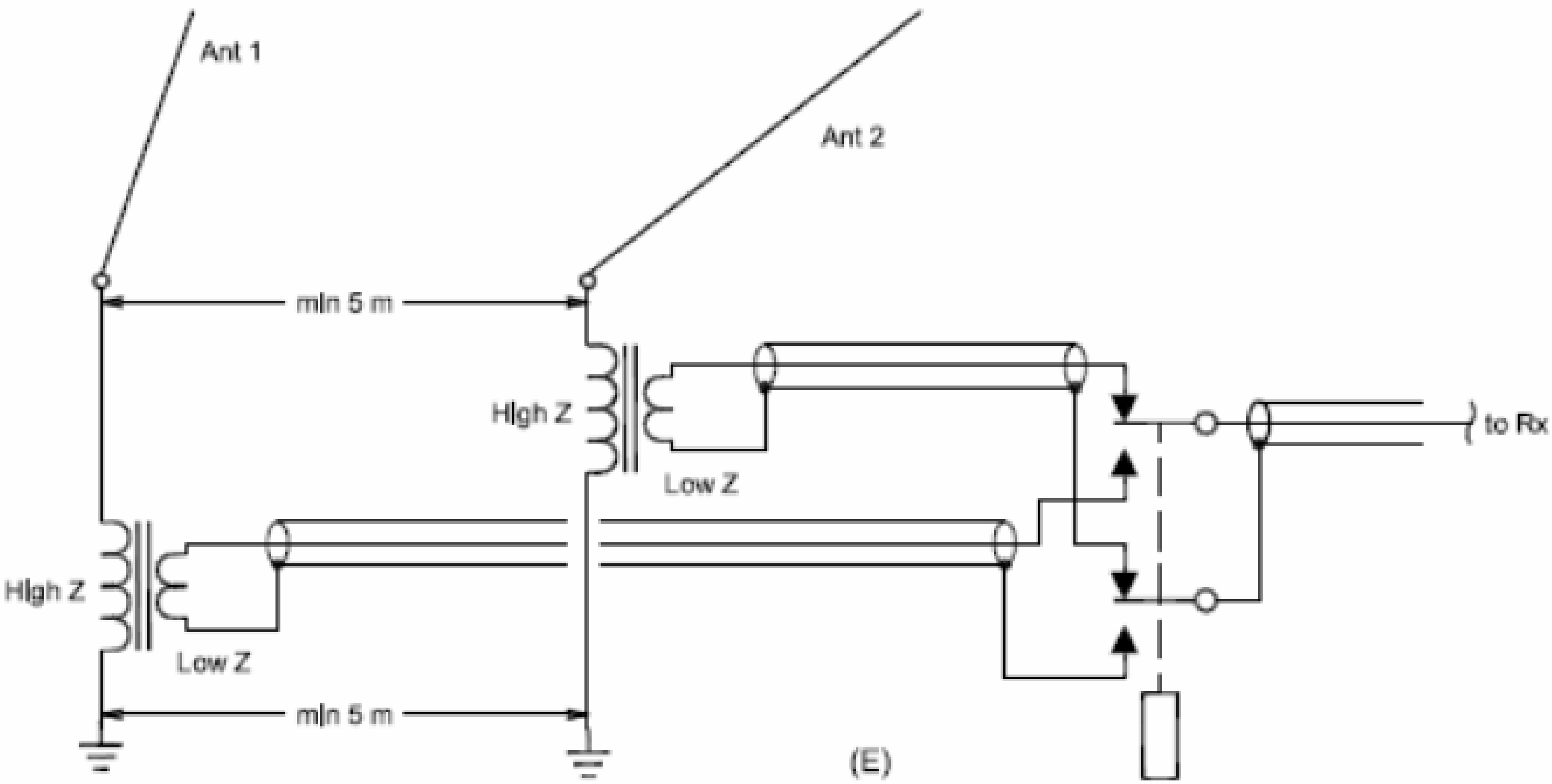
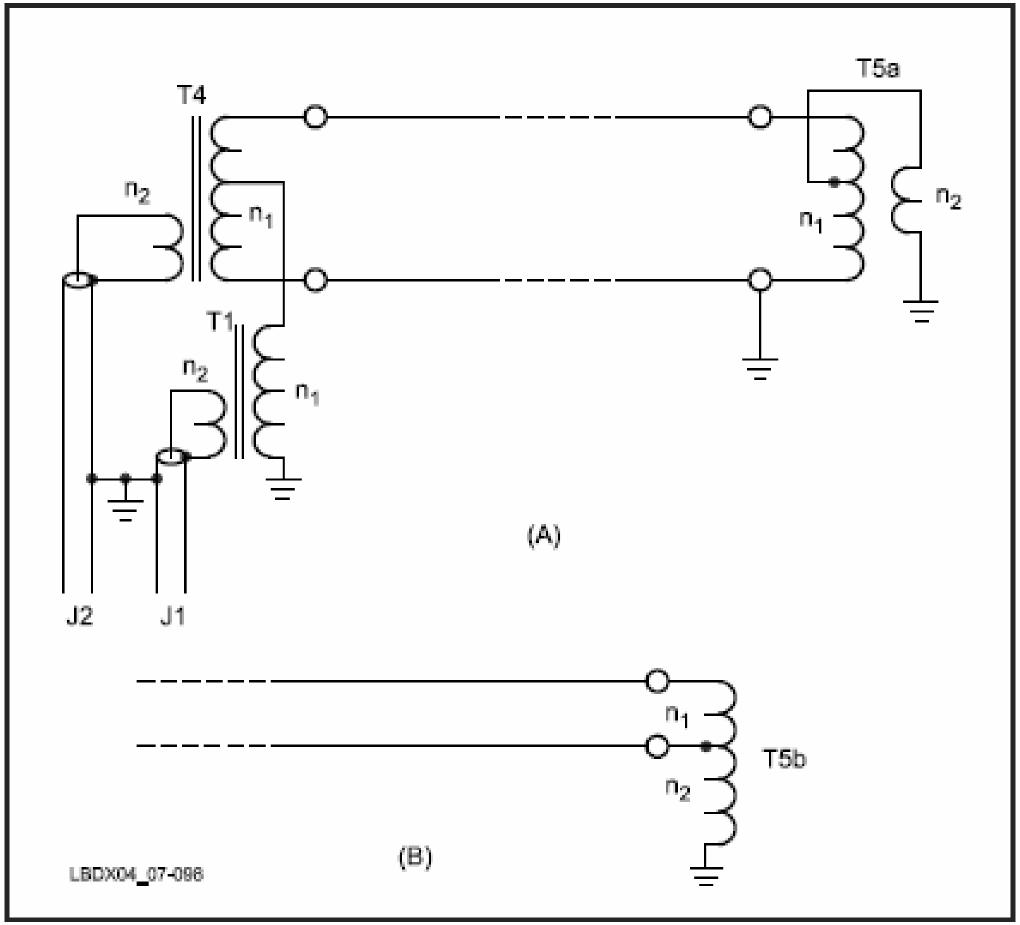


Diagram from ON4UN's
Low Band DXing

Two Directions from one Beverage



Another Method…

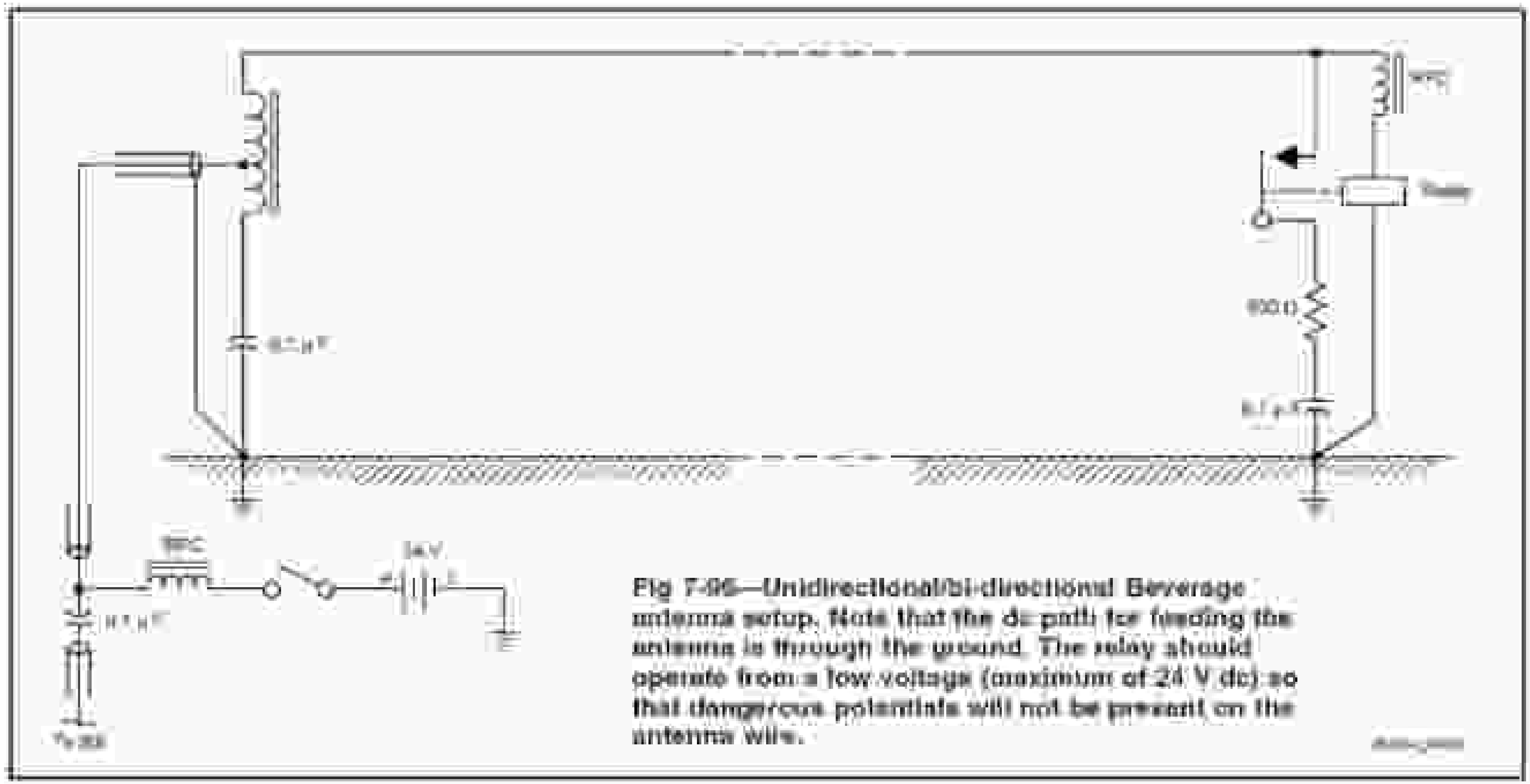


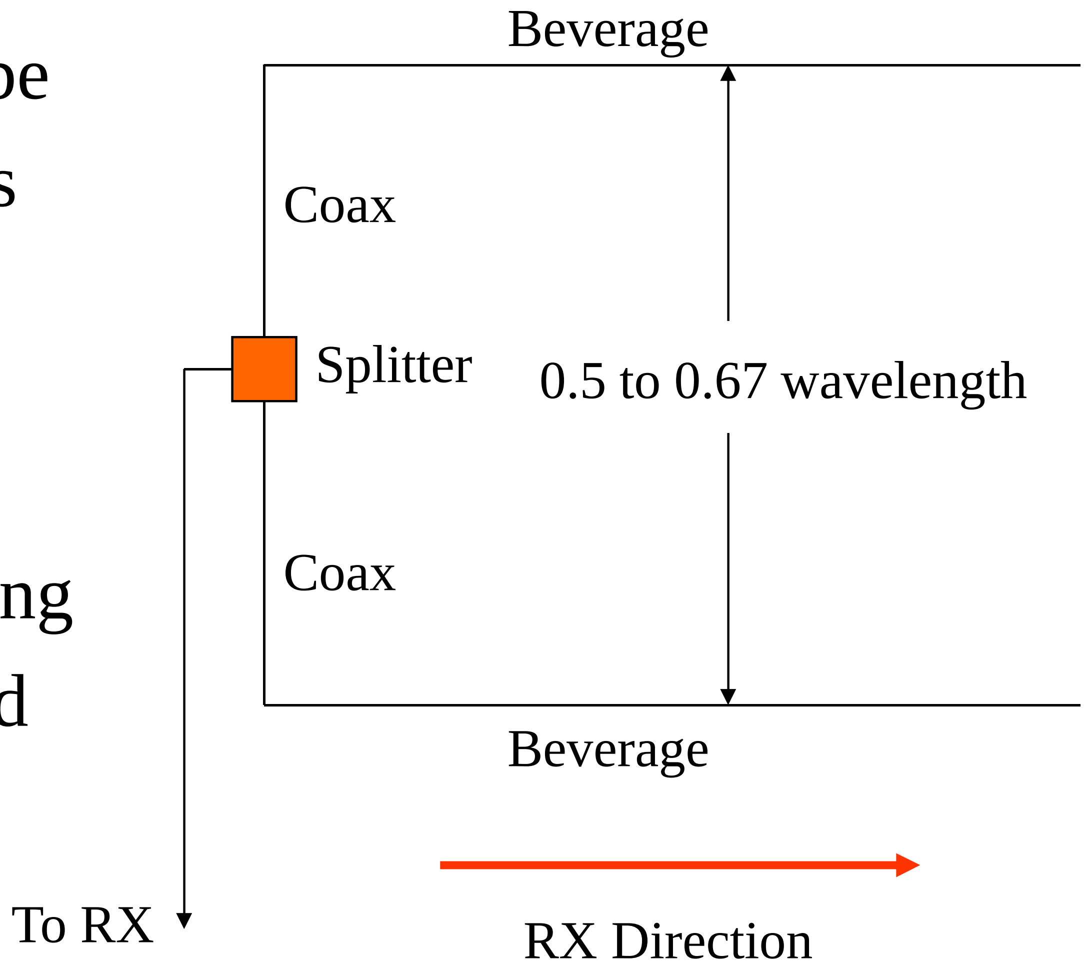
Fig 7-95—Unidirectional/bi-directional Beverage antenna setup. Note that the dc path for feeding the antenna is through the ground. The relay should operate from a low voltage (maximum of 24 V dc) so that dangerous potentials will not be present on the antenna wire.

Phasing Beverage Antennas

- To improve directivity without using long antennas, can phase individual Beverages
- Two methods:
  - Broadside
  - End-Fire (or Staggered)
- Each has its own advantages

Broadside Phasing

- Narrows frontal lobe
- Front/Back remains the same
- Fed in phase
- Multiband
- Require wide spacing
- 0.5 wl spacing good
- 0.67 wl excellent!



End-Fire Phasing

- Greatly improves Front/Back directivity
- Front lobe remains much the same
- Spacing 5 meters
- Stagger NMT 0.5 wl
- 20 m for 40 – 160m ant
- 30 m if only 80 – 160m

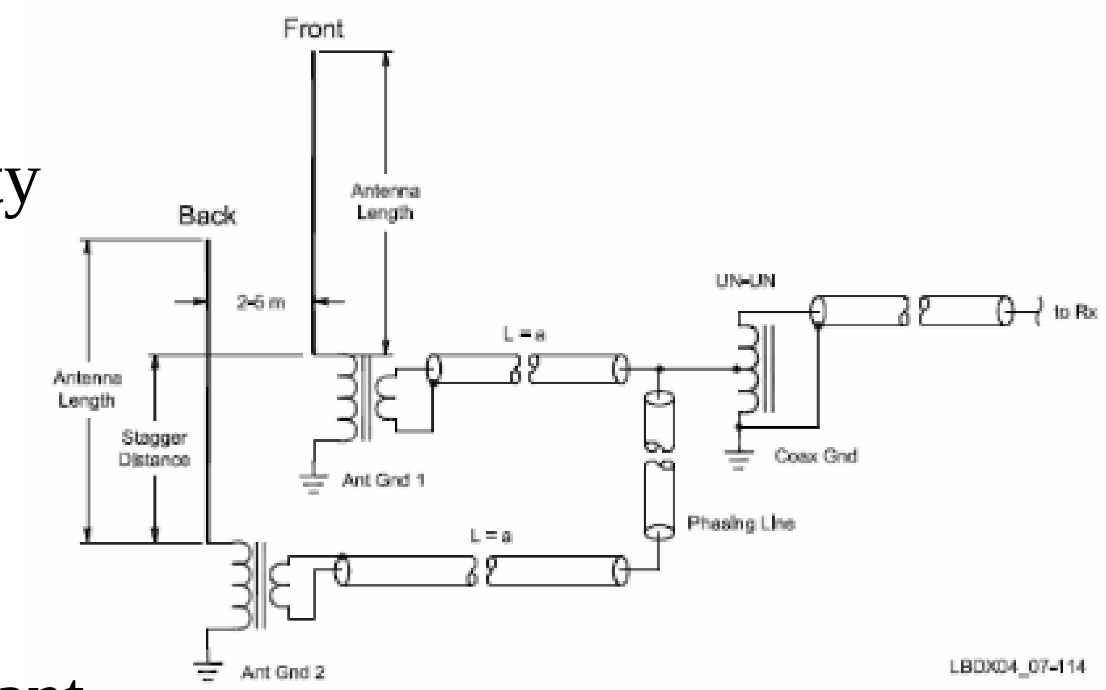


Photo from ON4UN's
Low Band DXing

- Broadside Phasing
- End-Fire Phasing

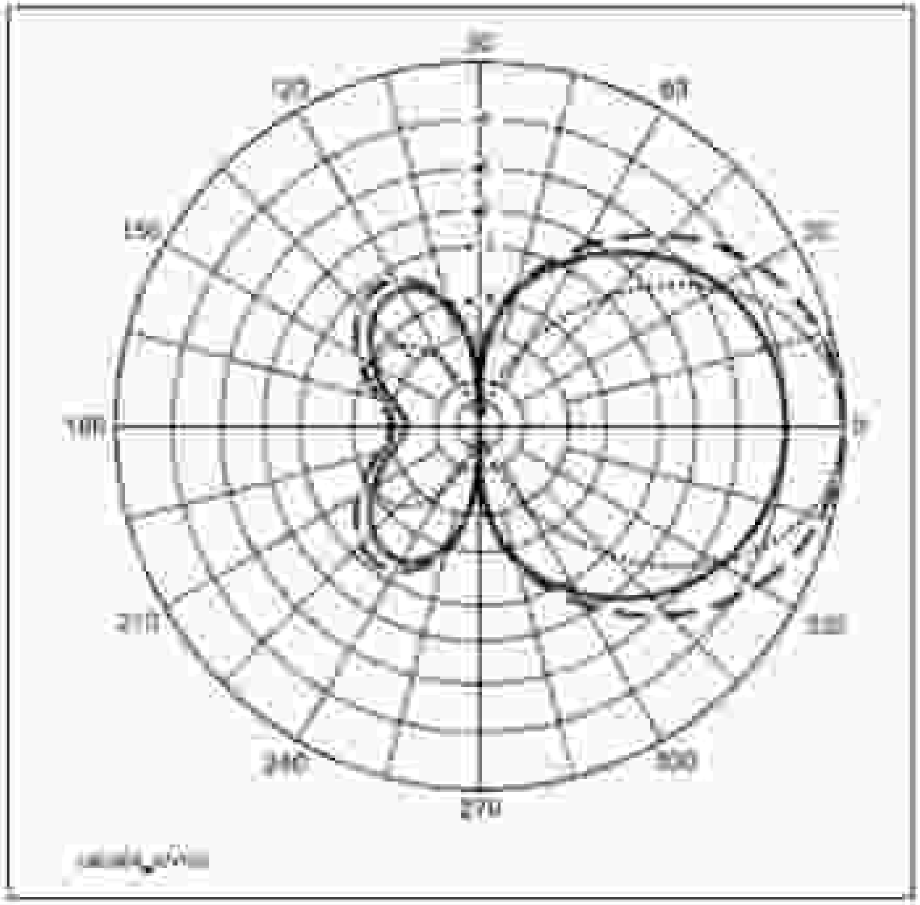


Fig 7-103—A single 160-meter long Beverage (solid line); two such Beverages in phase, side-by-side, spacing 40 meters (dashed line) and 90-meter spacing (slightly over λ/2, dotted line). Actual gain is irrelevant for receiving.

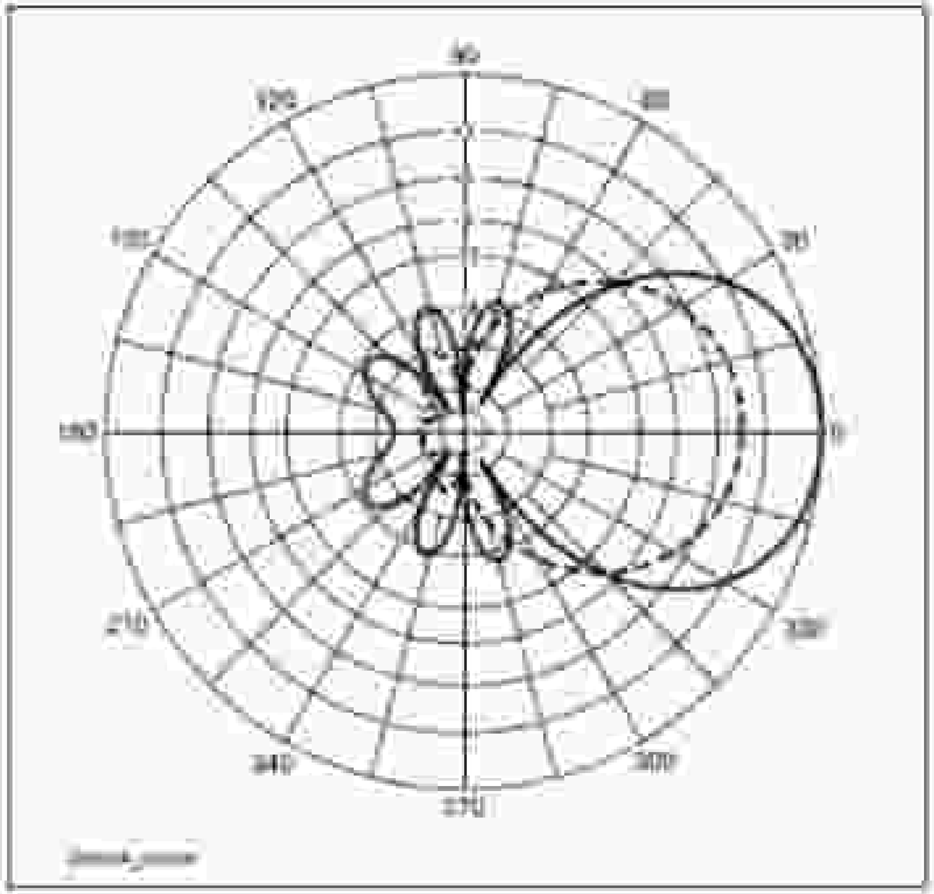
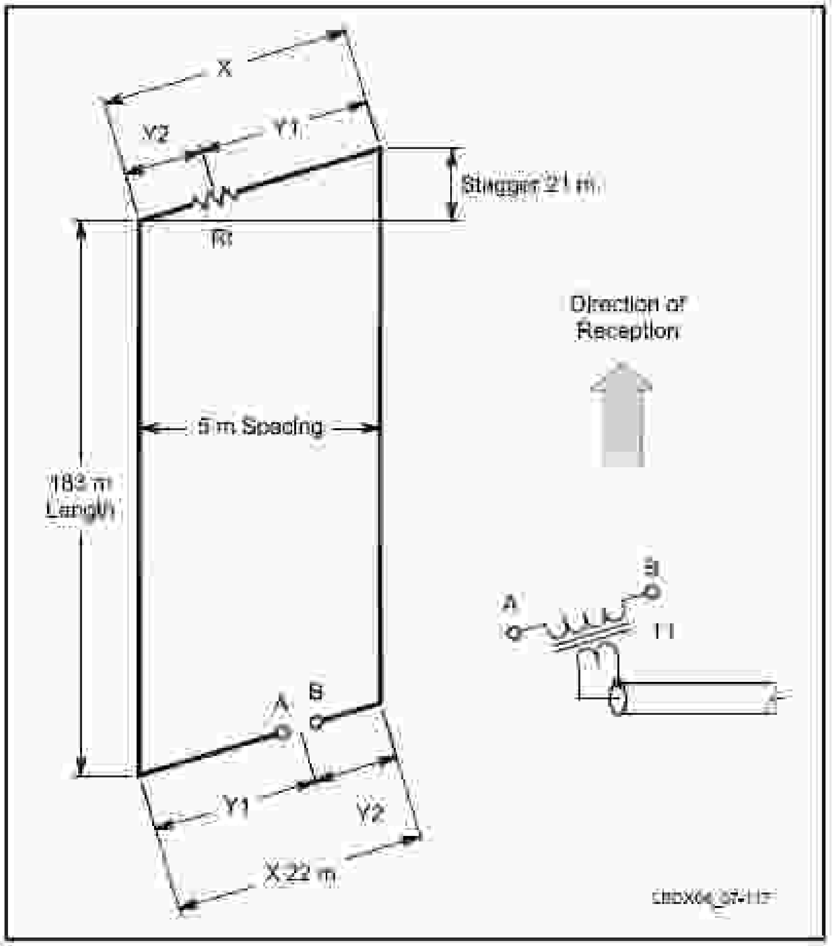


Fig 7-108—Azimuth pattern on 1.83 MHz for a single 320-meter Beverage (solid line); azimuth pattern for end-fire pair of 160-meter long Beverages, half the length (dashed line).

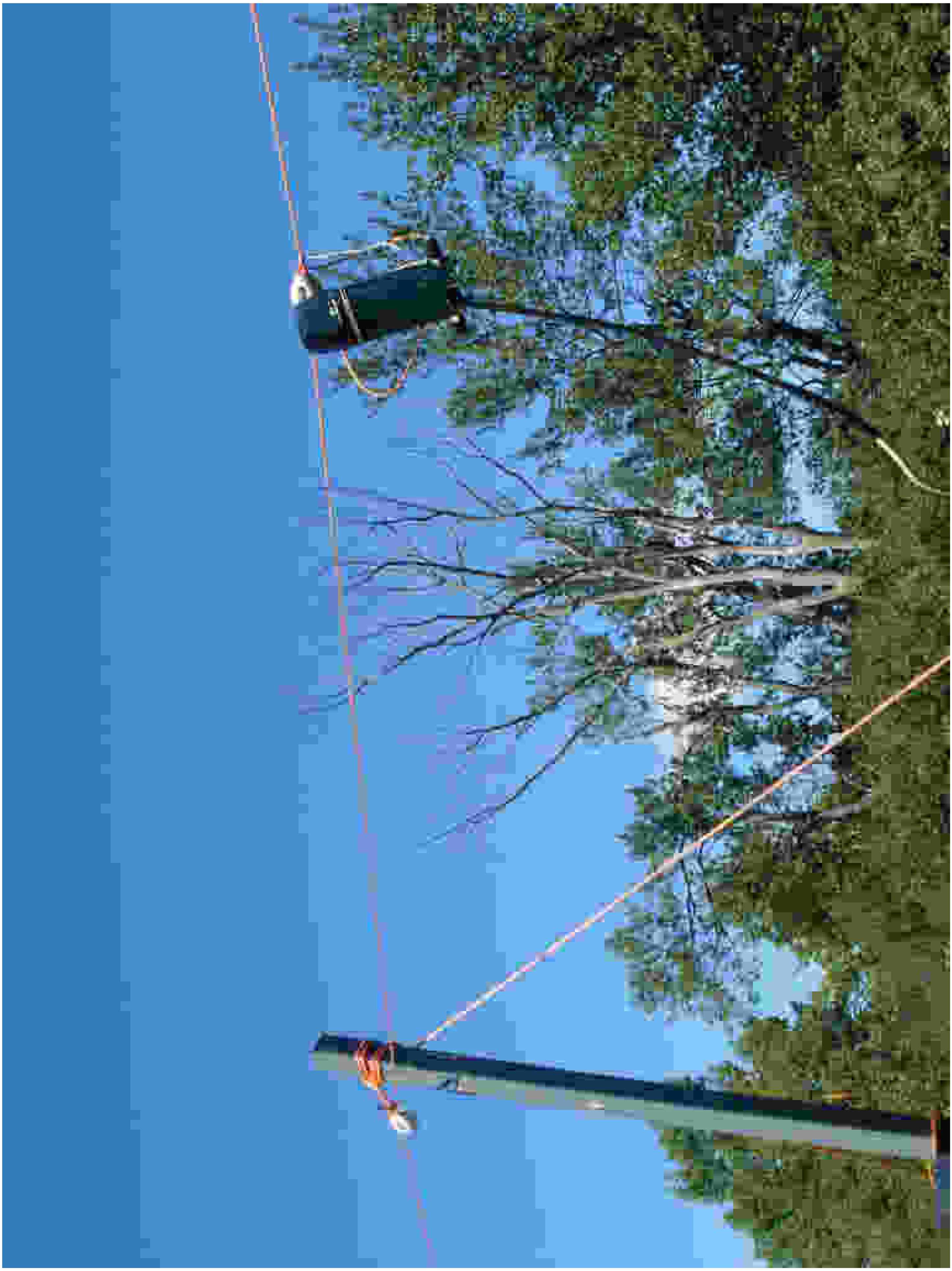
Crossfire Phasing

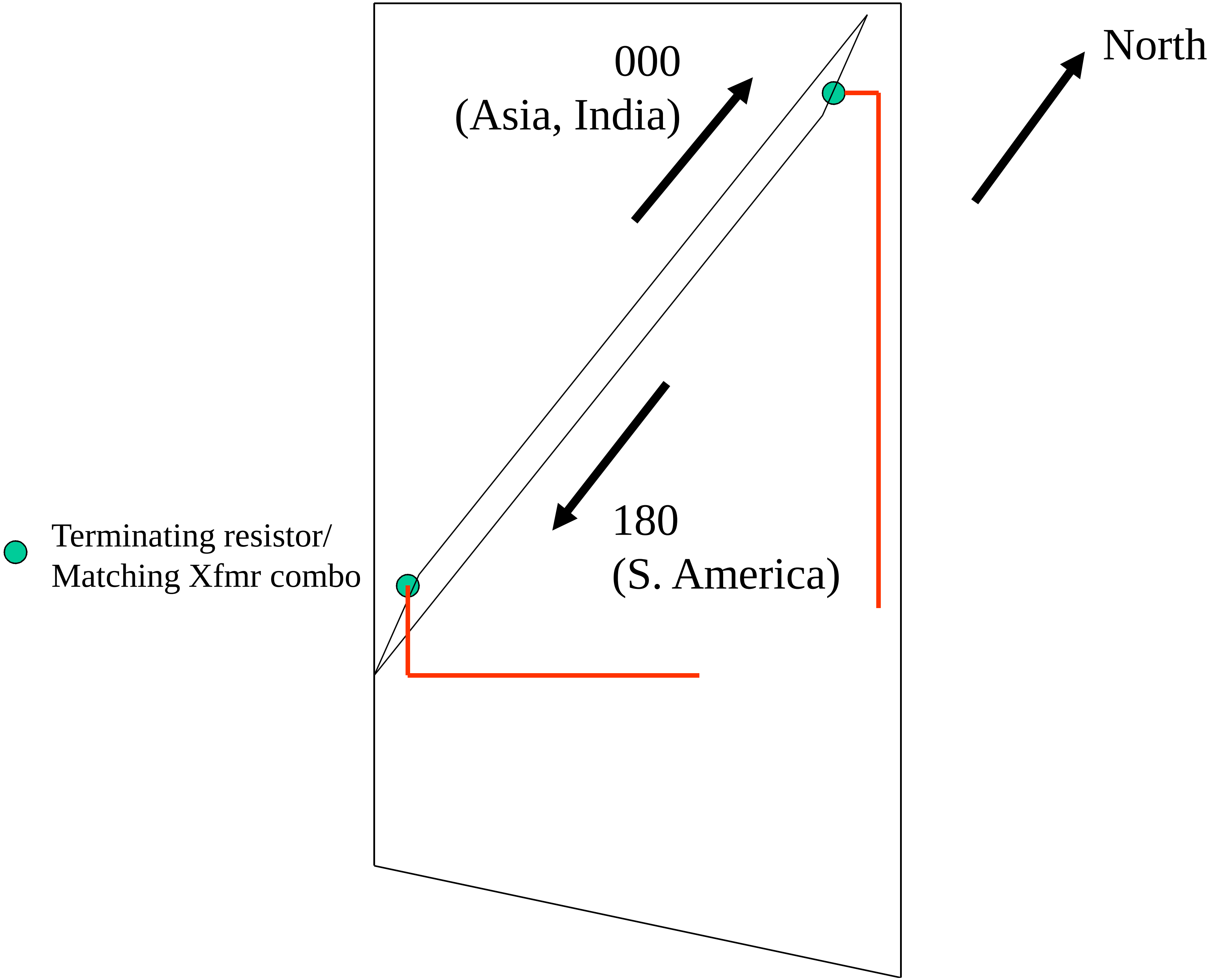


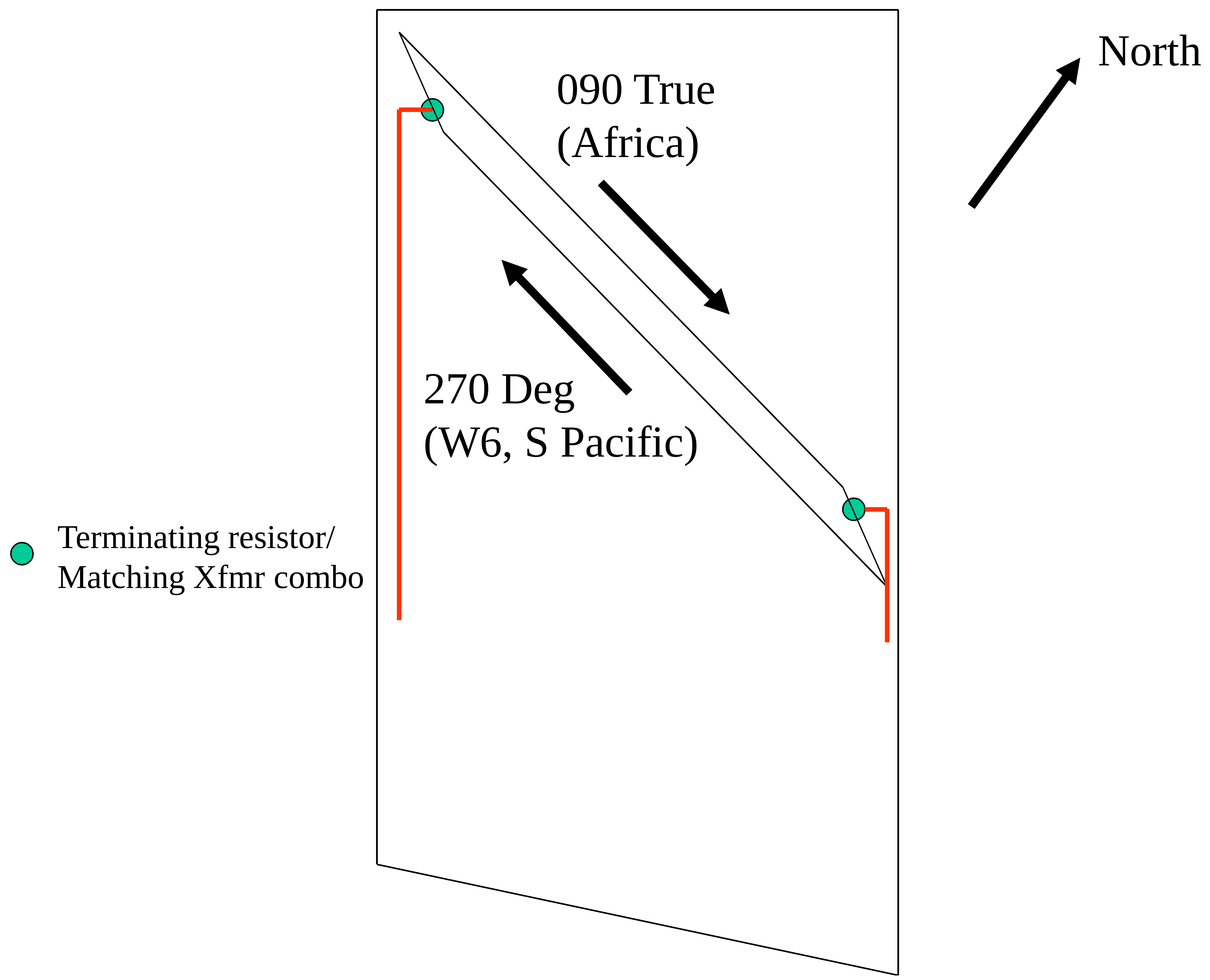
- Simple end-fire feed system developed by W8JI
- Usable over several octaves
- Termination value = twice that of single Bev
- 16:1 matching transformer used (900 Ohms)
- (X – S)/2 = Y2
- Y1 = X – Y2

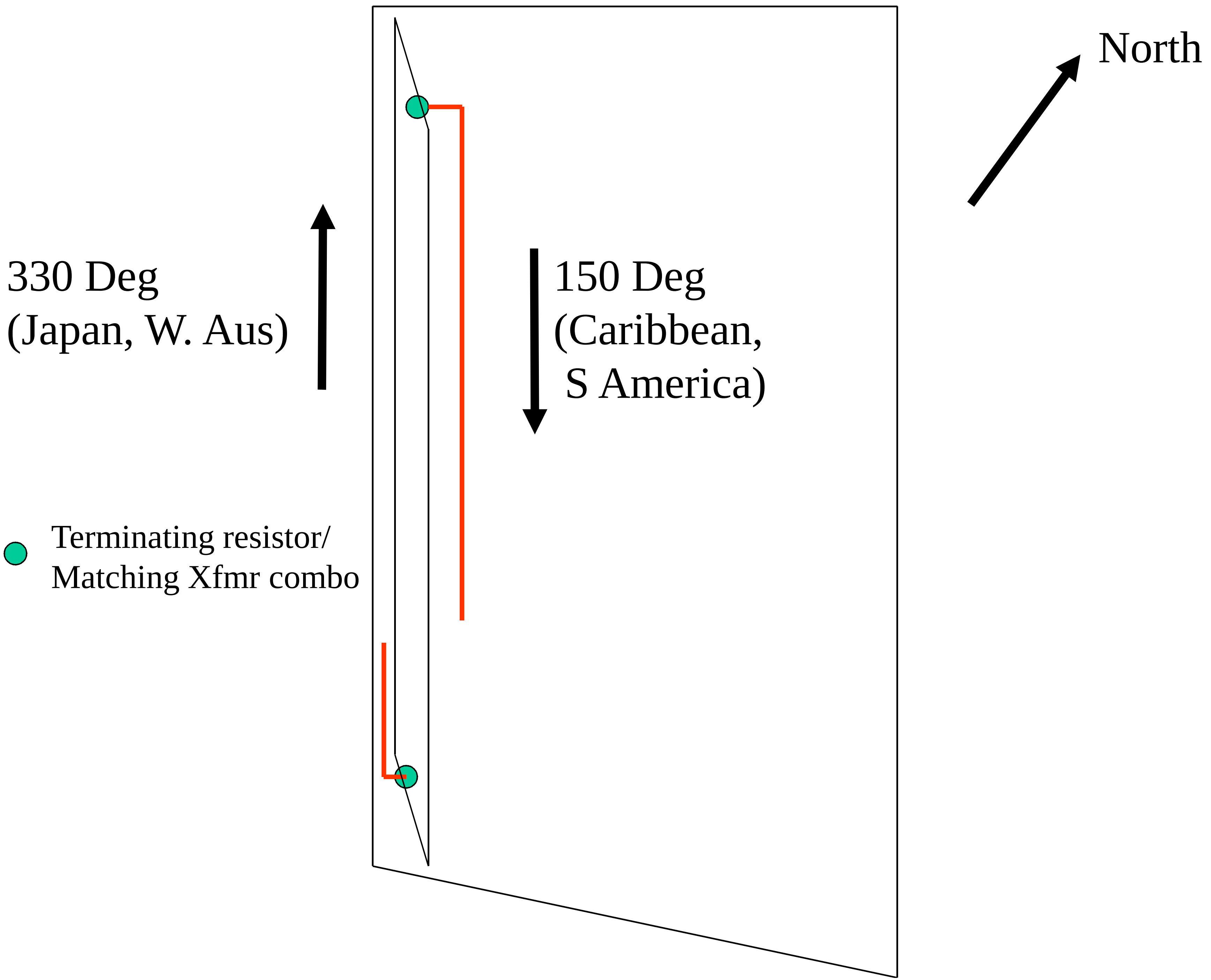
Beverage Antennas at VO1NO/VE3

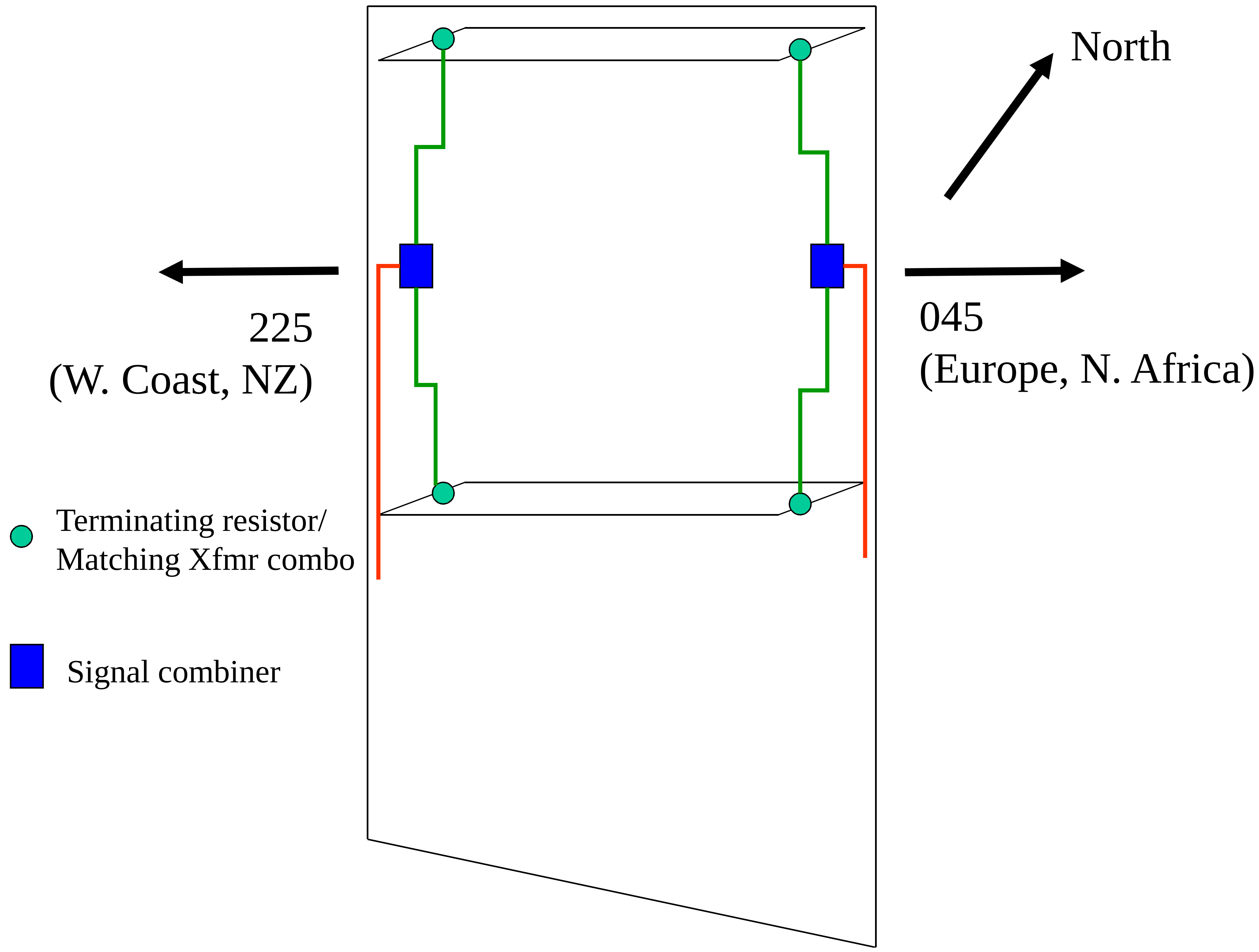
- 5 acres near Merrickville
- Dimensions ~ 650 x 320 feet
- 8 directions using end-fire phased Beverages
- Control Box in shack, with 3 switchboxes in field




000
(Asia, India)
North
180
(S. America)
Terminating resistor/
Matching Xfmr combo


North
090 True
(Africa)
270 Deg
(W6, S Pacific)
Terminating resistor/
Matching Xfmr combo


North
330 Deg
(Japan, W. Aus)
150 Deg
(Caribbean,
S America)
Terminating resistor/
Matching Xfmr combo


North
225
(W. Coast, NZ)
045
(Europe, N. Africa)
Terminating resistor/
Matching Xfmr combo
Signal combiner

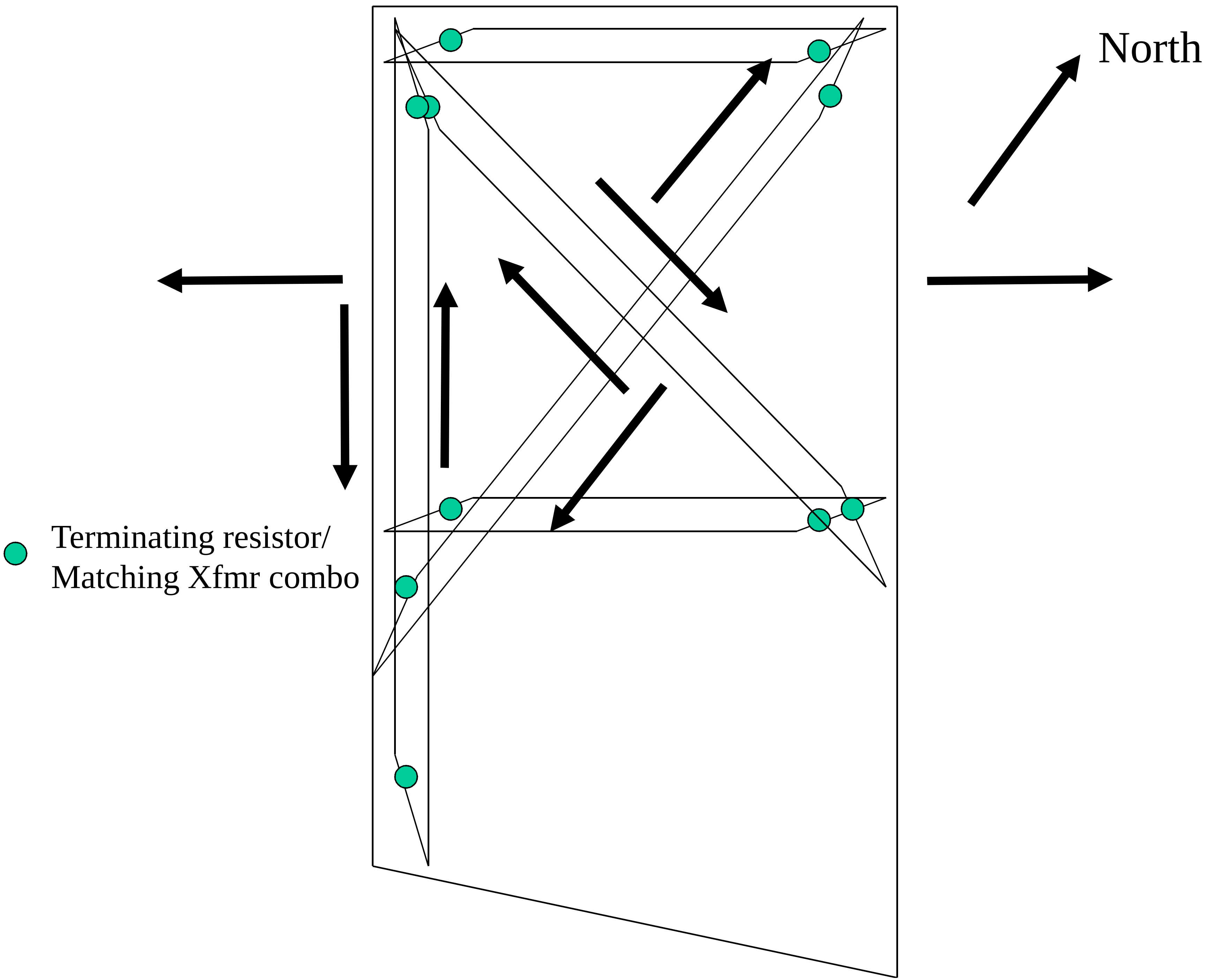
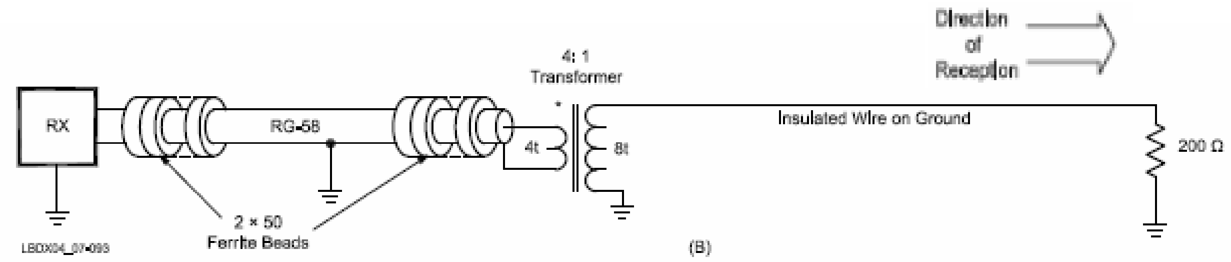
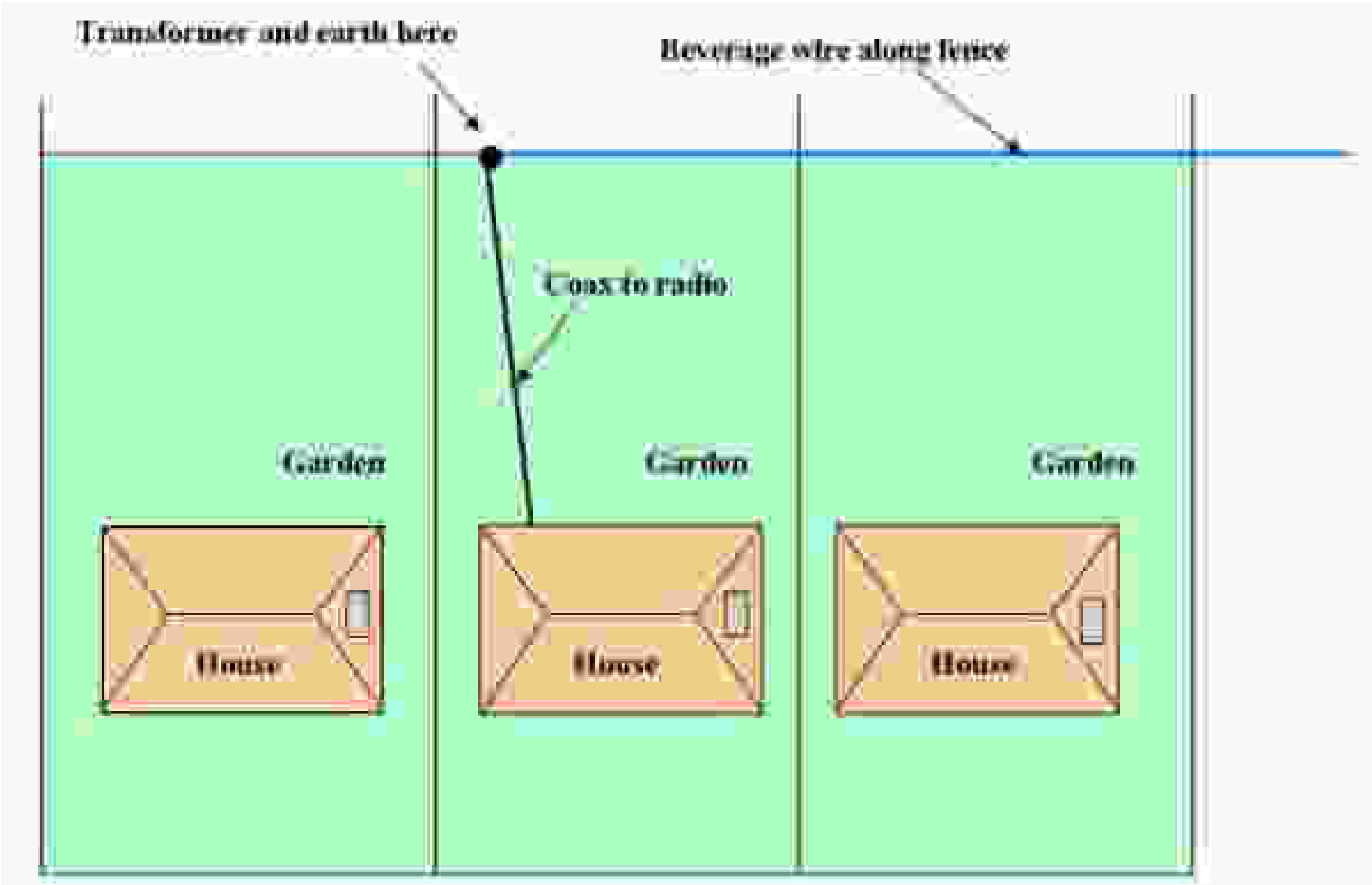

North
Terminating resistor/
Matching Xfmr combo

Diagram from ON4UN's
Low Band DXing

Property too small?

- Try a BOG (Beverage On Ground)
  - Termination ~ 200 to 300 Ohms
  - Need a 4:1 matching transformer
  - Use ferrite beads to decouple feedline
  - *May* require a preamp
  - Beverage's first antennas were laid on the ground



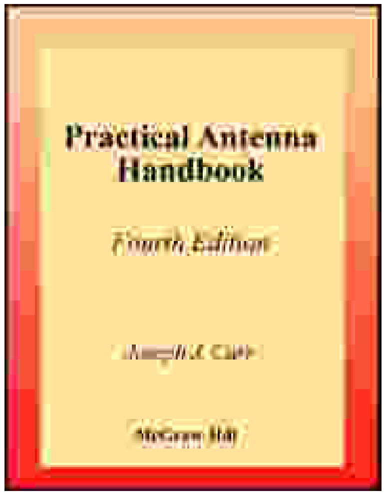


Example of an urban beverage installation

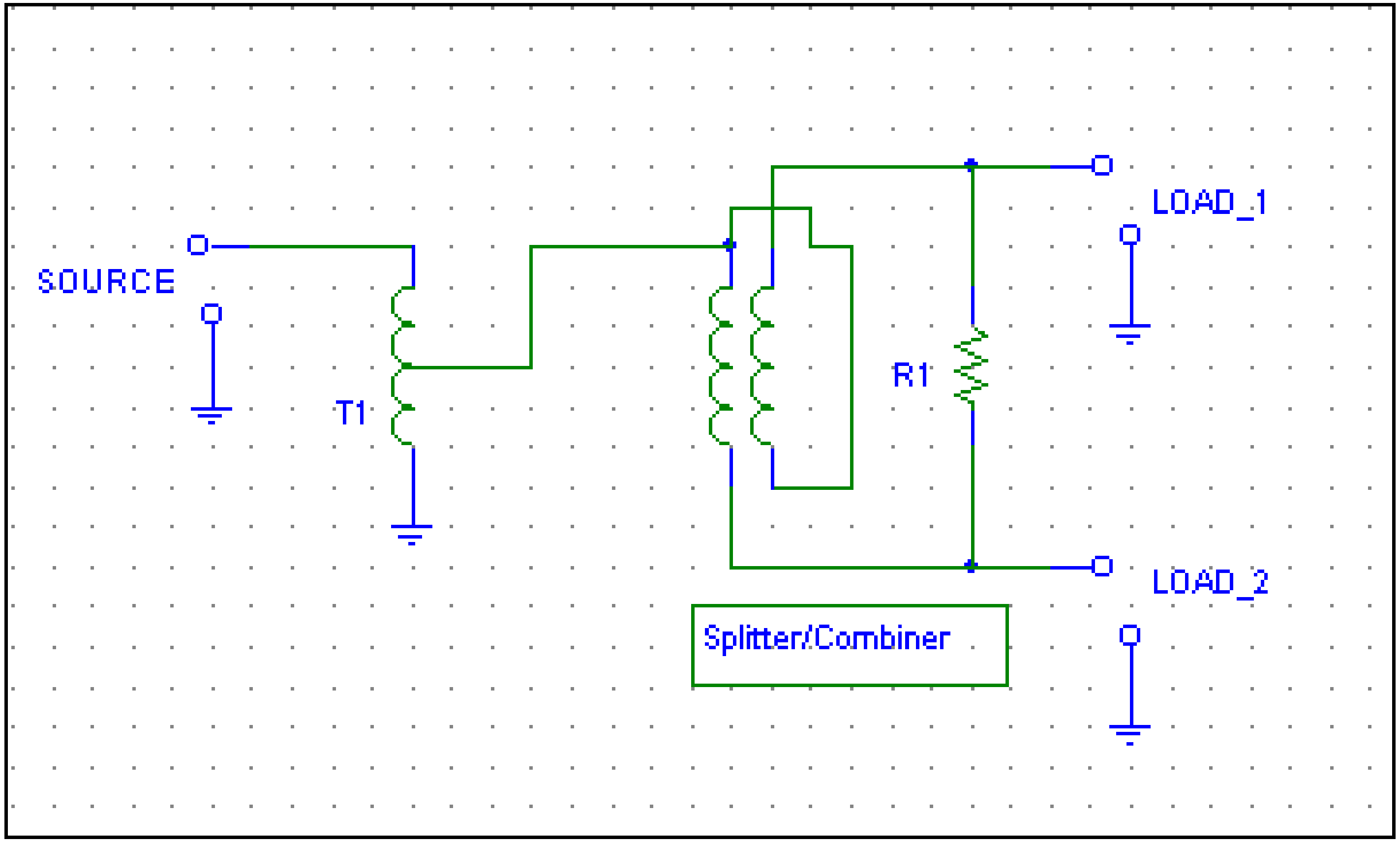
For more Information…

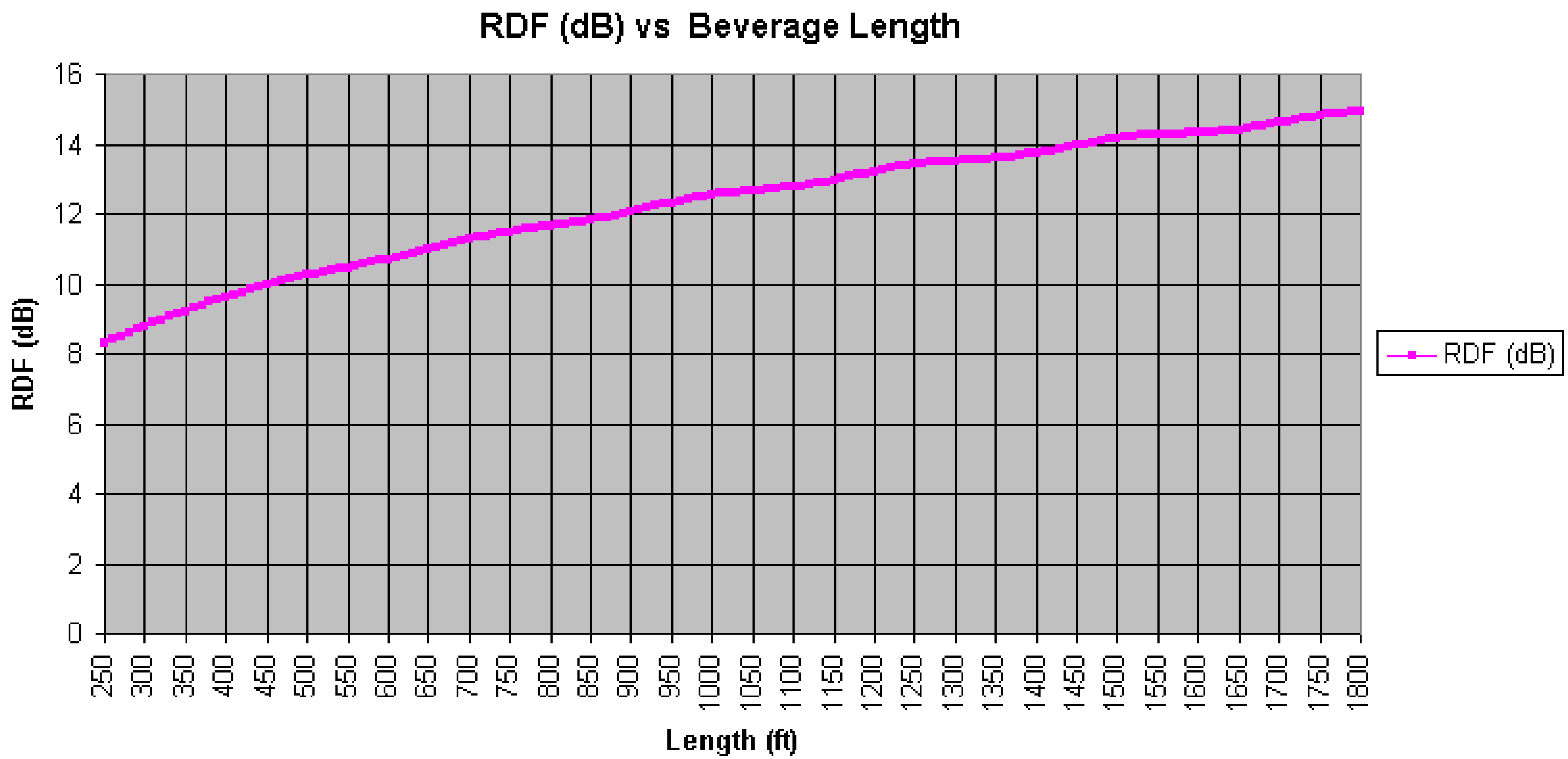
- The “Bible”!!

- Also check the website of Tom Rauch, W8JI:
  - http://www.w8ji.com
- Try the Topband Reflector as well:
  - http://lists.contesting.com/_topband/
- Joseph Carr’s book also has lots of good stuff.

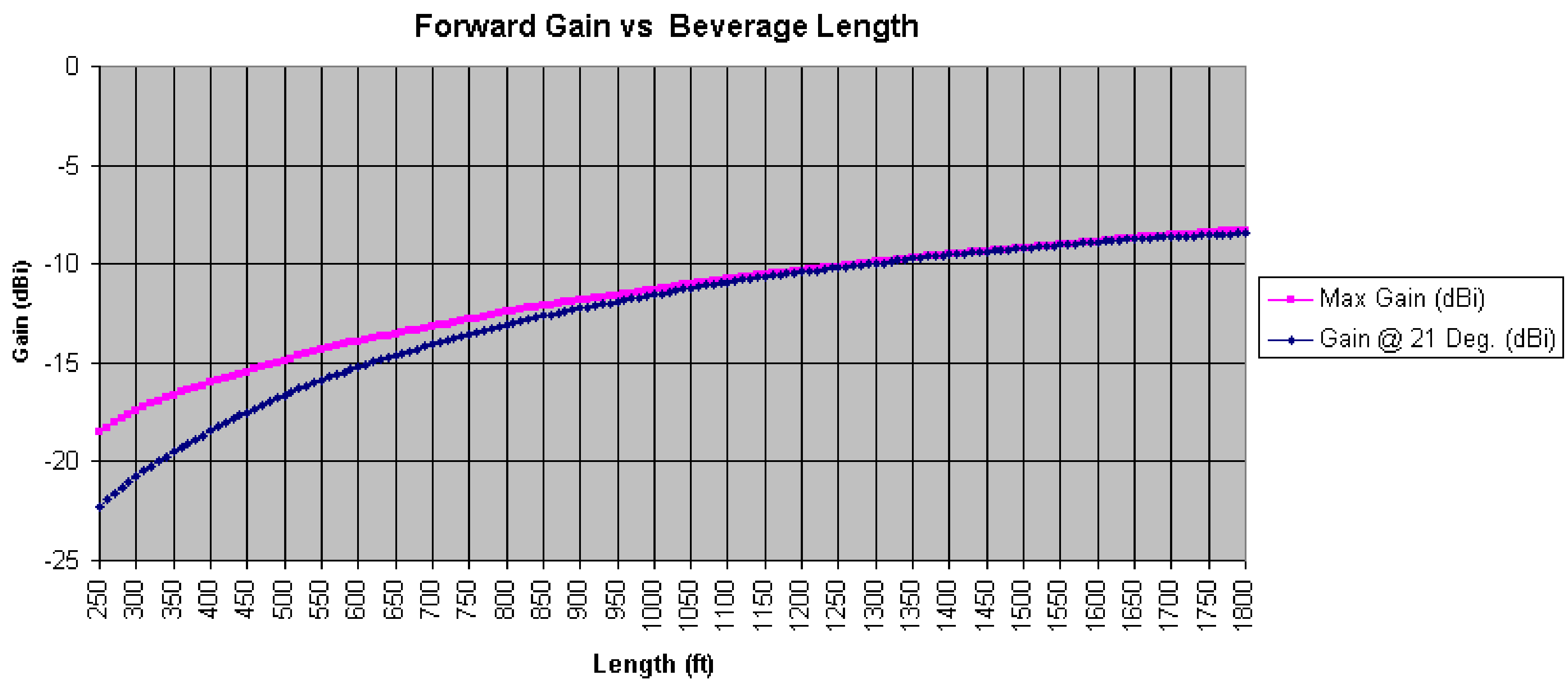


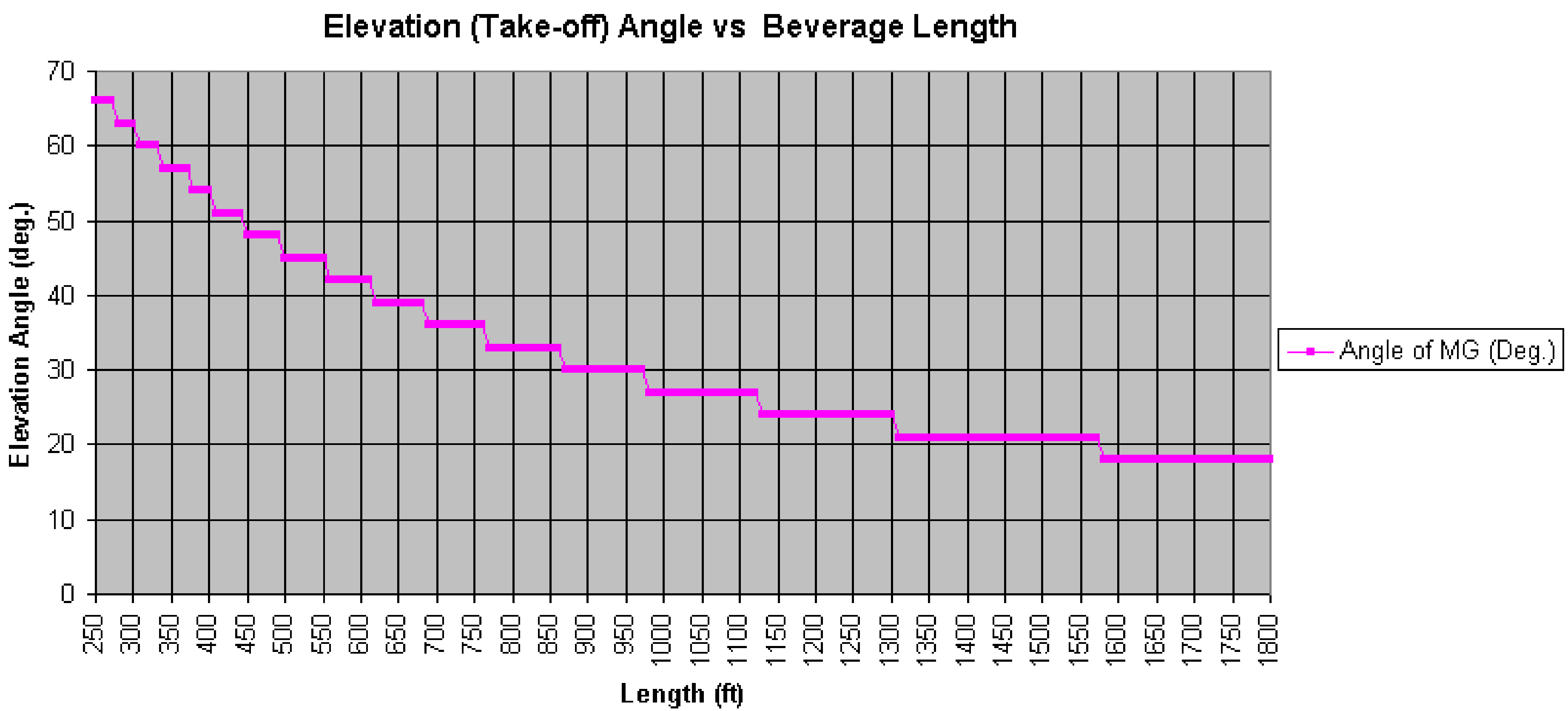
Questions?

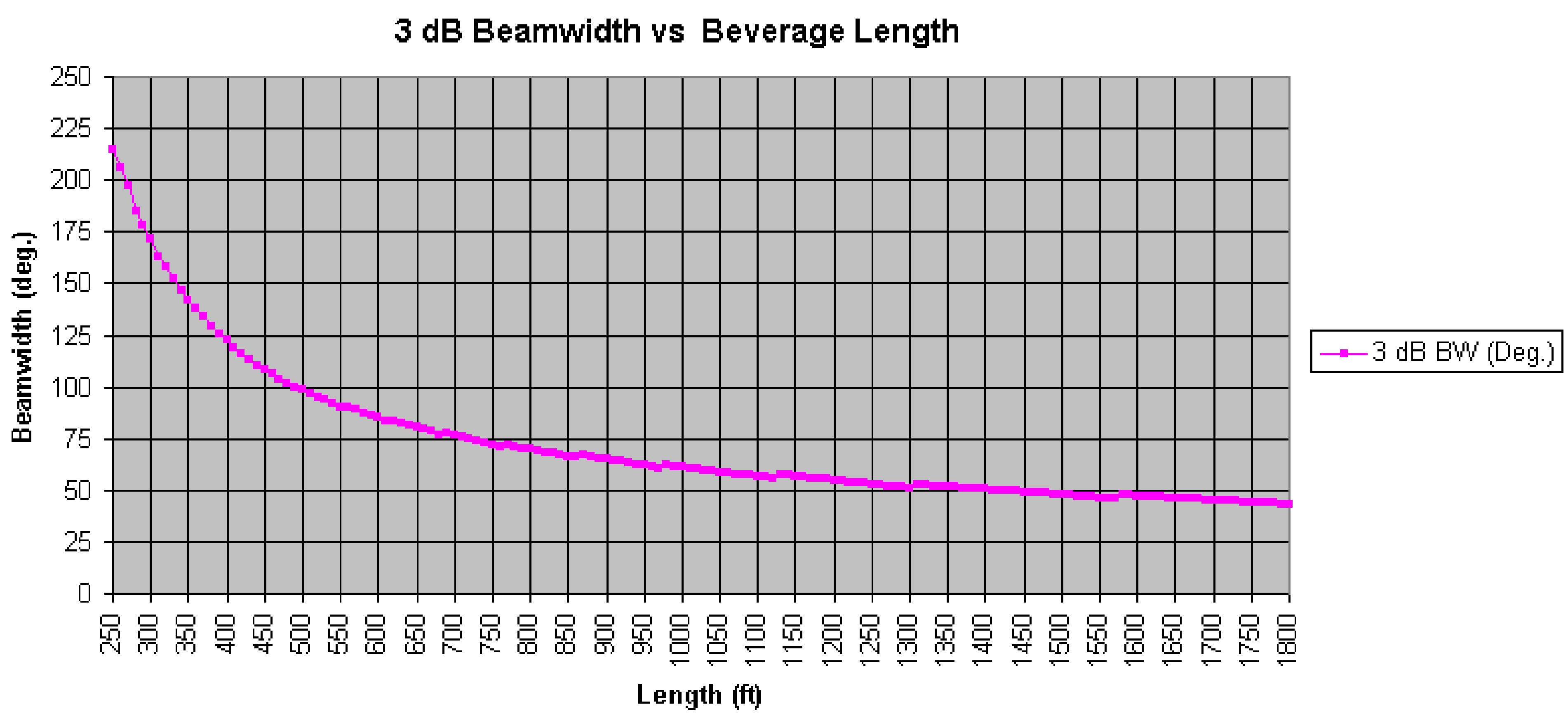

SOURCE
T1
R1
LOAD_1
LOAD_2
Splitter/Combiner



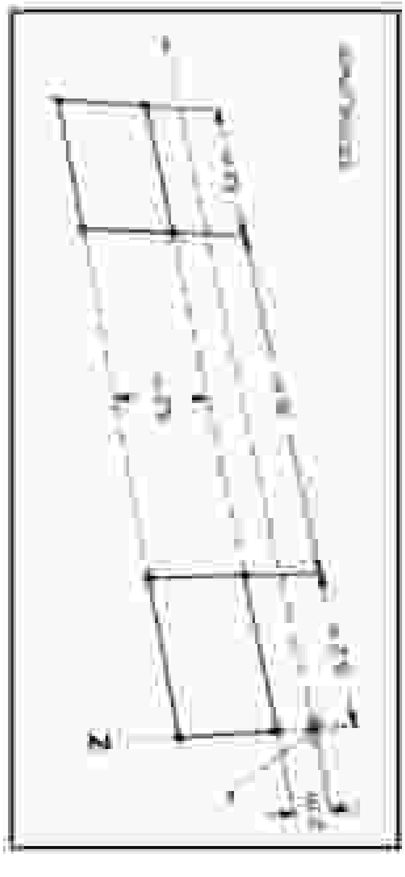
RDF (dB) vs Beverage Length
RDF (dB)
16
14
12
10
8
6
4
2
0
250
300
350
400
450
500
550
600
650
700
750
800
850
900
950
1000
1050
1100
1150
1200
1250
1300
1350
1400
1450
1500
1550
1600
1650
1700
1750
1800
Length (ft)
RDF (dB)


Forward Gain vs Beverage Length
Gain (dBi)
0
-5
-10
-15
-20
-25
250
300
350
400
450
500
550
600
650
700
750
800
850
900
950
1000
1050
1100
1150
1200
1250
1300
1350
1400
1450
1500
1550
1600
1650
1700
1750
1800
Length (ft)
Max Gain (dBi)
Gain @ 21 Deg. (dBi)


Elevation (Take-off) Angle vs Beverage Length
Elevation Angle (deg.)
70
60
50
40
30
20
10
0
250
300
350
400
450
500
550
600
650
700
750
800
850
900
950
1000
1050
1100
1150
1200
1250
1300
1350
1400
1450
1500
1550
1600
1650
1700
1750
1800
Length (ft)
Angle of MG (Deg.)



3 dB Beamwidth vs Beverage Length
Beamwidth (deg.)
250
225
200
175
150
125
100
75
50
25
0
250
300
350
400
450
500
550
600
650
700
750
800
850
900
950
1000
1050
1100
1150
1200
1250
1300
1350
1400
1450
1500
1550
1600
1650
1700
1750
1800
Length (ft)
3 dB BW (Deg.)



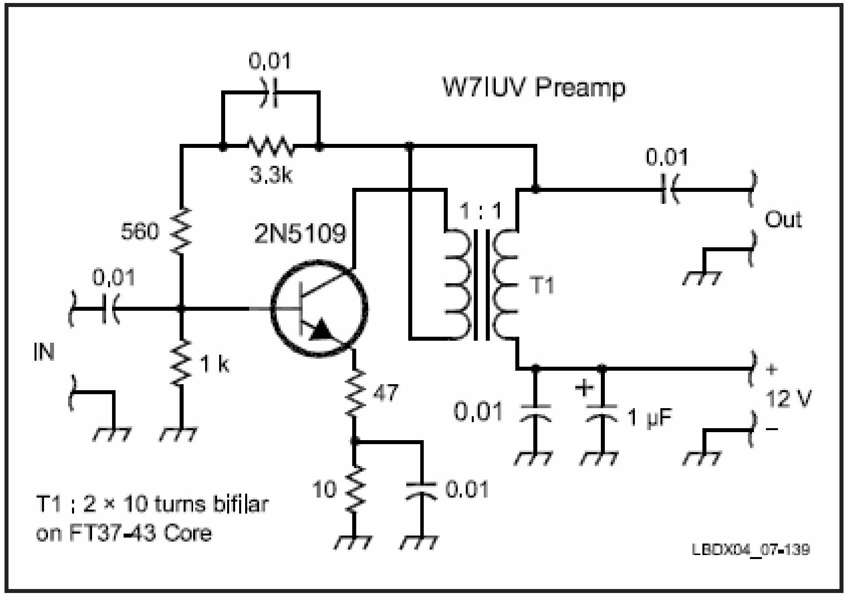

W7IUV Preamp
0,01
3,3k
560
2N5109
0,01
IN
1 k
47
10
0.01
1 : 1
T1
0,01
Out
+
12 V
–
0,01
1 µF
T1 ; 2 × 10 turns bifilar
on FT37-43 Core
LBDX04_07-139

Table 7-47

Arrays of Short Verticals

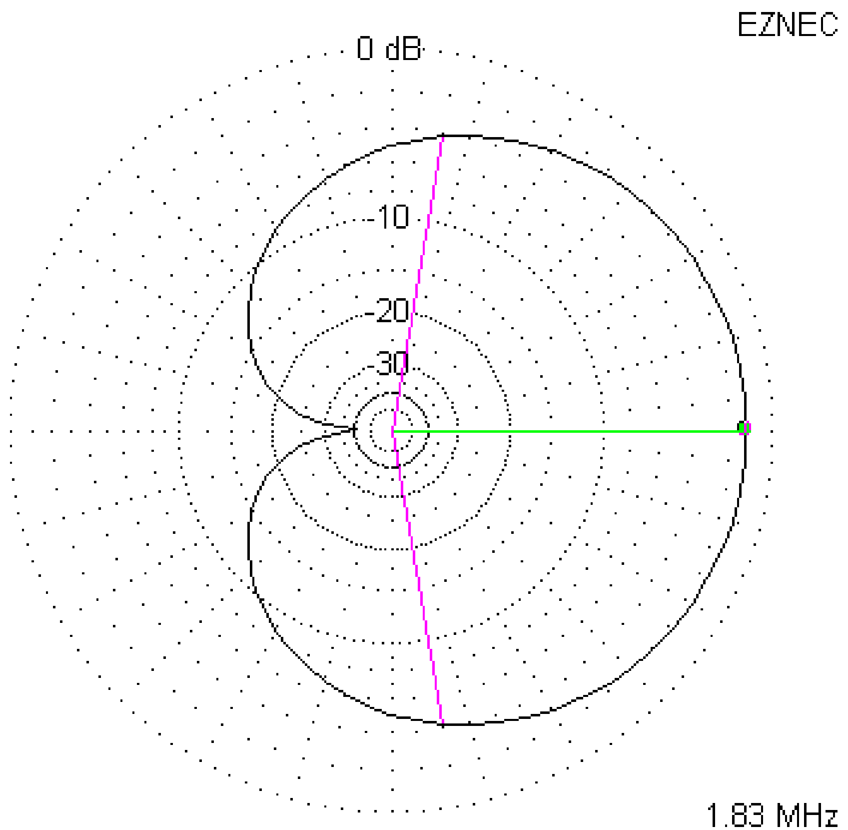
	DMF	RDF	3-dB Angle	Gain (dB)	Ref
2 Ele End-Fire λ/4 Spacing, φ = 135°	16.1	9.3	132	−12	Sect 1.6
2 Ele End-Fire λ/8 Spacing, φ = 155°	17.7	8.8	120	−16	Sect 1.14
2 Ele End-Fire λ/16 Spacing, φ = 165°	17.5	9.3	121	−21	Sect 1.14
4-Square Side λ/4, φ = 120°	24.0	11.6	88	−8	Sect 1.23
4-Square Side λ/8, φ = 140°	25.9	11.9	86	−16	Sect 1.23
4-Square Side λ/16, φ = 160°	27.9	12.0	85	−23	Sect 1.23
8-Ele Simple-Hex 305-m Diameter	27.4	11.7	73	−19	Sect 1.28
8-Circle, φ = 120°, Diameter 0.594 λ	22.6	12.3	55	−8	Sect 1.28
Broadside 2 Ele Bidirectional	(*)	9.7	47	−10.5	Sect 1.11/1.22.1
Broadside 4 Ele Bidirectional	(*)	12.4	35	−7.8	Sect 1.11/1.22.2
Broadside/End-Fire 4 Ele	21.3	12.7	46	−4.7	Sect 1.15/1.22.3
Broadside/End-Fire 8 Ele	27.1	15.7	24.5	+0.7	Sect 1.32/1.22.4

Beverages and Arrays of Beverages

	DMF	RDF	3-dB Angle	Gain (dB)	Ref
80-m Long Single Beverage	11.1	7.3	90	−16	Sect 2.16.2
160-m Long Single Beverage	19.0	10.2	75	−10	Sect 2.16.2
300-m Long Single Beverage	21.3	12.0	62	−5	-
Broadside 80-m Beverages, 90-m Spacing	14.4	9.8	48	−15.5	Sect 2.16.2
Broadside 160-m Beverages, 90-m Spacing	20.2	11.9	48	−7	Sect 2.16.2
Broadside 300-m Beverages, 90-m Spacing	25.1	14.2	44	−2	Sect 2.16.2
80-m Long End-Fire Beverages, Stagger = 30 m, φ = 140°	20.0	9.7	77	−15.5	-
160-m Long End-Fire Beverages, Stagger = 30 m, φ = 140°	30.1	11.6	69	−9	Sect 2.16.3
300-m Long End-Fire Beverages, Stagger = 80 m, φ = 140°	33.8	13.0	57	−4	Sect 2.16.3
160-m Beverages in End-Fire/Broadside Array (*1)	34.0	13.0	46	−6.4	Sect 2.16.4
160-m Beverages in End-Fire/Broadside Array (*2)	34.7	14.1	34	−8.4	Sect 2.16.4

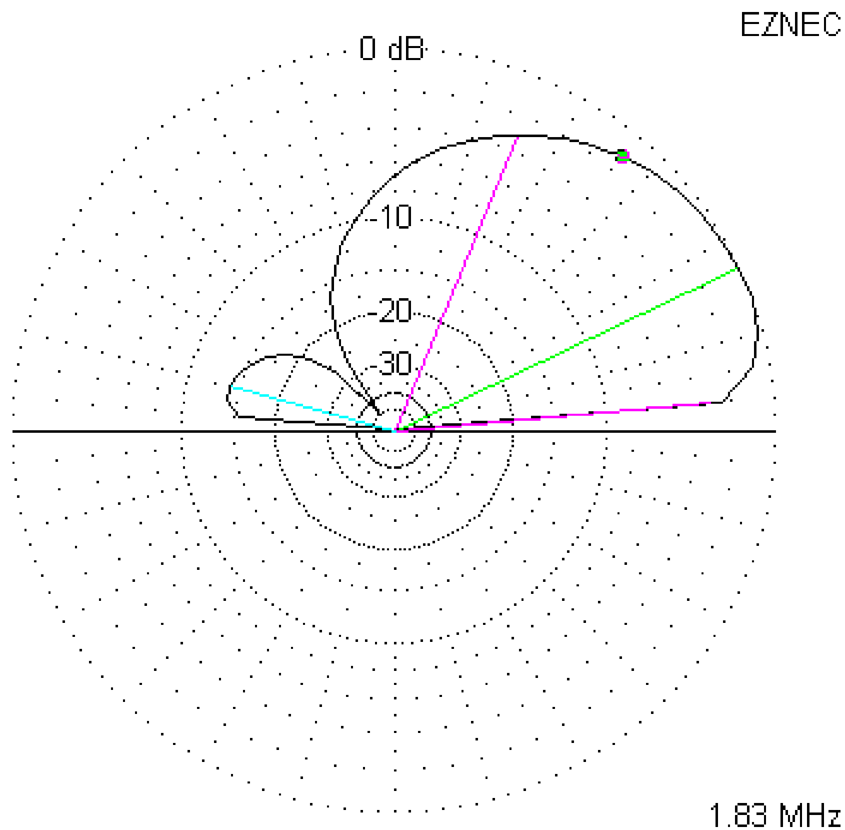
Loops and Arrays of Loops

	DMF	RDF	3-dB Angle	Gain (dB)	Ref
Elongated Terminated Loop (EWE, Flag, K9AY etc)	~11	7.5	~146	−29	Sect. 3
2 End-Fire Loops	21.5	9.9	89	−30	Sect 3.11



Azimuth Plot		Cursor Az	0.0 deg.
Elevation Angle	50.0 deg.	Gain	-25.55 dBi
Outer Ring	-24.34dBi		-1.22 dBmax

3D Max Gain	-24.34 dBi
Slice Max Gain	-25.55 dBi @ Az Angle = 0.0 deg.
Front/Back	39.81 dB
Beamwidth	160.0 deg.; -3dB @ 280.0, 80.0 deg.
Sidelobe Gain	< -100 dBi
Front/Sidelobe	> 100 dB



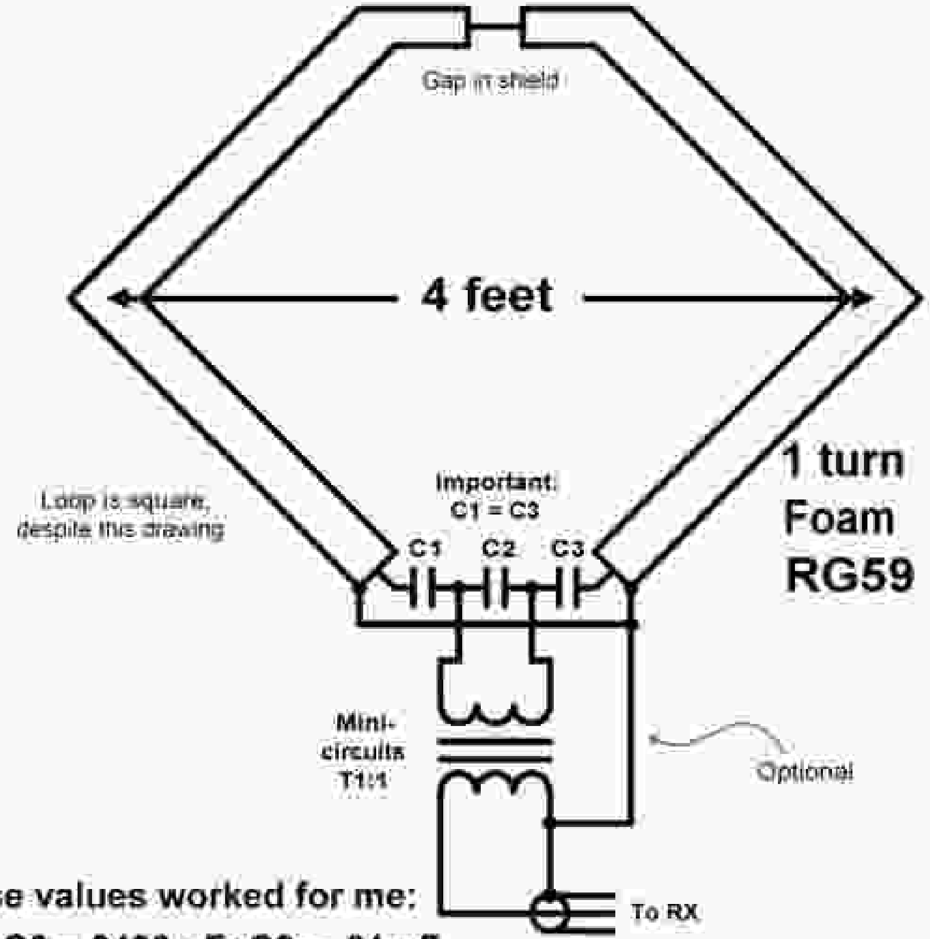
Elevation Plot		Cursor Elev	50.0 deg.
Azimuth Angle	0.0 deg.	Gain	-25.56 dBi
Outer Ring	-24.35dBi		-1.2 dBmax

3D Max Gain	-24.35 dBi
Slice Max Gain	-24.35 dBi @ Elev Angle = 25.0 deg.
Beamwidth	62.1 deg.; -3dB @ 5.0, 67.1 deg.
Sidelobe Gain	-38.21 dBi @ Elev Angle = 165.0 deg.
Front/Sidelobe	13.86 dB

www.n6rk.com

N6RK 160 meter receiving loop antenna used in 2007 Stew Perry contest

Jan 1, 2008



These values worked for me:

C1 = C3 = 3400 pF; C2 = .01 uF

Tune C1/C3 until impedance at output connector is resistive at 1830. Then tune C2 to get 50 or 75 ohms at the output connector. Increasing C2 lowers impedance. These is some interaction, requiring an iterative method