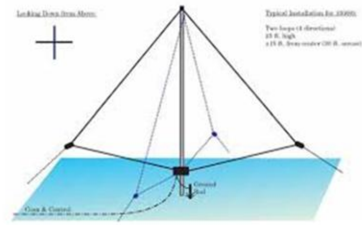

Low-Band Receive Antennas

Al Penney
VO1NO / VE1

Or how to hear that great DX that you’re missing on 40, 80 and 160!

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VO1NO

Aircraft detection system from the 1920s.

Today's Topics…

- Introduction
- Receiving Basics
- RX Loops
- Elongated Terminated Loops
  - EWE Antenna
  - Flag Antenna
  - Pennant Antenna
  - K9AY Loop
  - Dual Half Delta Loop
- Dual Active Delta Flag Array
- Beverages

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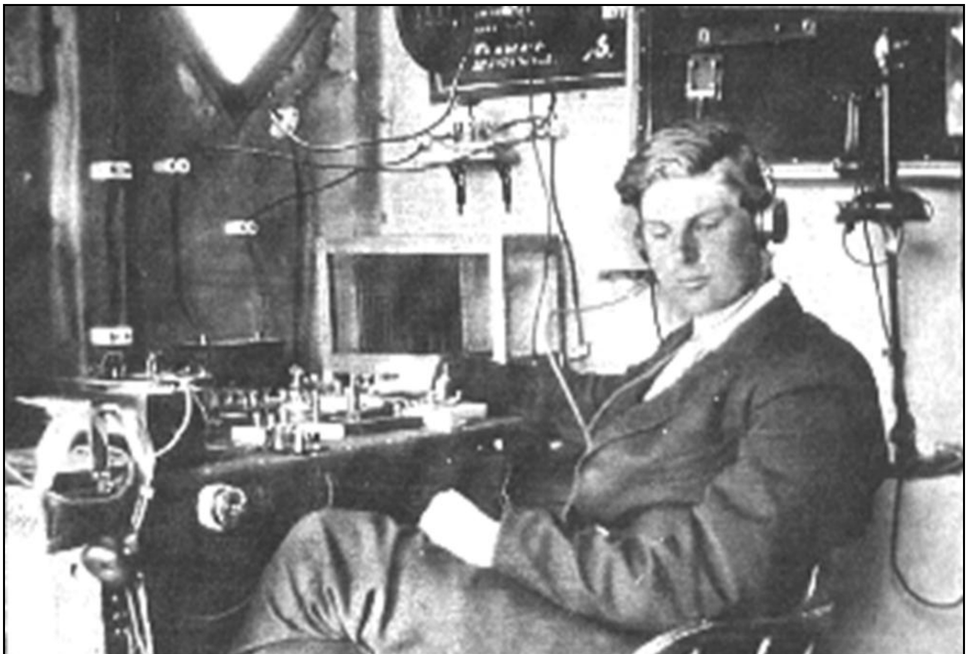
I'll discuss the following antennas today. I won't be talking about arrays of verticals, or the new Shared Apex Loop - There are many specialized RX antennas out there, and I can't cover them all today!

George VY2GF asked me to deliver this presentation on receive antennas. I found a picture of George when he was a young Ham….



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This is Harold H. Beverage at his Amateur Radio Station. Possibly at the University of Maine around 1915.

Most people think of Beverage antennas when they think of lowband receive antennas, but as we'll see today, there are others out there that offer good performance, even on small city lots.

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.

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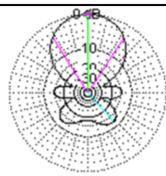
For a transmit antenna, we want maximum possible field strength in a given direction (or directions) at the most useful elevation (wave) angles. We cannot tolerate unnecessary power loss in a transmit antenna, because any amount of transmitting loss decreases signal-to-noise ratio at the distant receiver. Antenna efficiency is an important issue for transmitting. It is obvious that for a given elevation angle and direction the highest gain antenna will deliver the strongest signal to the target area. We really do not care if we are being heard in other directions (areas) or not, we are only interested in the target direction.

A receiving antenna on the other hand has a different design priority. The goal is obtaining a signal that can be read comfortably, which means having the minimum possible amount of QRM and noise. The important issue when receiving is *signal-to-noise ratio* (S/N). The receiving antenna providing the best performance can and will be different under different circumstances, even at the same or similar locations. There is no such thing as a universal “best low-band receiving antenna.”

An example might better illustrate the concept:

Diagrams from ON4UN's Low Band DXing



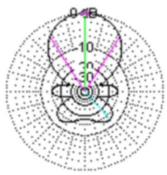
EZNEC

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 RX Antenna than Antenna A?

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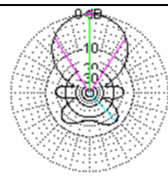
Diagrams from ON4UN's *Low Band DXing*



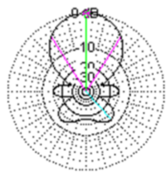
EZNEC

1.83 MHz

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.
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

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

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- 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?

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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.

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There are a few things we have to keep in mind:

1.) If noise is not evenly distributed (which is often the case) performance will depend on the gain difference between desired signal direction (azimuth and elevation) to gain in the direction of noise(s). A 20dB null on the noise compared to gain in the desired signal direction will actually improve S/N ratio by 20 dB, if the noise from the null direction totally dominates all other noises.

2.) If noise arrives primarily from the same direction and angle as the desired signal (and assuming polarization of signals and noise is the same), there will be no S/N improvement.

3.) If noise originates in the near field of the antenna, all bets are off. Anything can happen.

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.
- Minus 10 to minus 20 dBi Gain is generally fine for most occasions.

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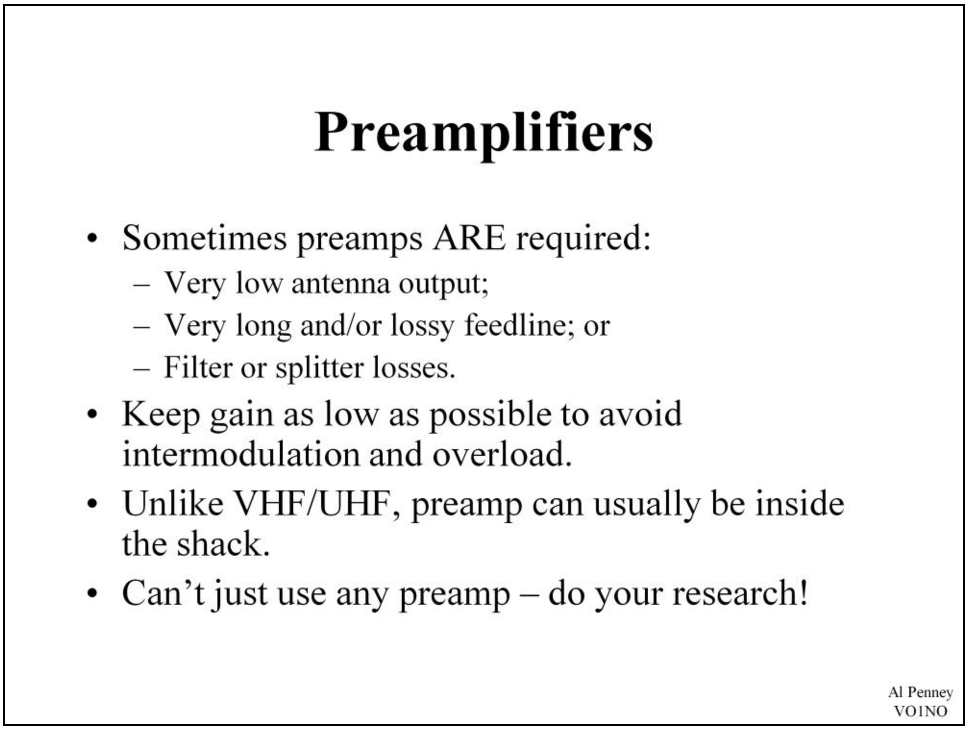


Antennas with a nominal gain of as low as –15 dBi will normally not require a preamplifier, unless you live in a very quiet rural area and have very long, lossy feed lines. That means that Beverages, even with feed lines of many hundreds of meters long, will—as a rule—not require a preamplifier. Unless of course you like to see you're S-meter dancing up and down like a yoyo. But signal readability has nothing to see with dancing S-meter needles. It is only a question of signal-to-noise ratio.

But we have also seen receiving antennas such as loops with gains of –30 dBi, and that is pretty low and does require some signal boosting. How do you know if you need a preamplifier? The rule is simple. During the quietest moment of the day (usually at noon on 160 meters), with your receiver set at the narrowest bandwidth you normally use, can you hear the noise go up significantly when you switch from a dummy load to your receiving antenna? If you can, then you have enough gain in your system.

If you hear the receiver's internal noise and not band noise, then you need a preamplifier. You have a problem because:

The antenna output might be extremely low (less than –15 dBi, for example).

The feed line might be very long and/or lossy.

You need to compensate for filter losses, splitter losses etc.

As a rule you should keep the signal level as low as possible to prevent chances of intermodulation and overload. This is also why our receivers

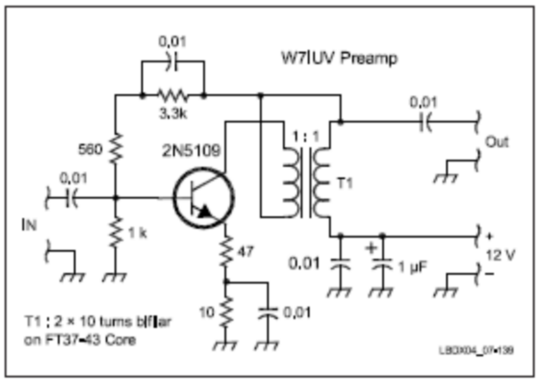
Preamplifiers

- Avoid untuned MMIC preamps – poor IMD.
- Larry W7IUV and Sergio IK4AUY have excellent designs online.
- DX Engineering, ICE, Array Solutions, Advanced Receiver Research and others have excellent products.

MMICs have poor IMD performance and are also very poor with even-order harmonic distortion. They have a fixed gain, which is usually way too high anyhow. Last but not least, they withstand little abuse.

W7IUV Preamp

- Excellent IMD performance.
- 2N5109 transistor runs hot – heat sink!



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Larry, W7IUV, has published a 160-meter preamplifier design with excellent characteristics. Go to his Web site (w7iuv.com) for further details on this very popular amplifier. The design of this popular preamp changes as he discovers ways to improve it. Please check his website for the latest information.

Diagram from ON4UN's Low Band DXing

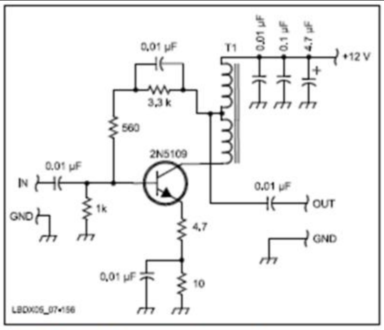

Fig 7-156 — The March 2009 version of the popular W7IUV preamp.

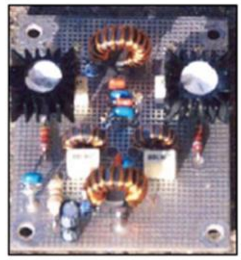

Fig 7-158 — The IK4AUY preamp, modified from the design by Ulrich Rohde, N1UL.

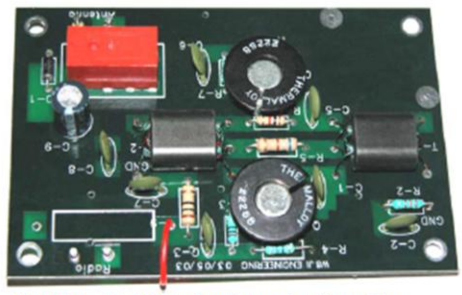

Fig 7-159 — The DX Engineering push-pull amplifier designed by Tom Rauch, W8JI.

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Sergio, IK4AUY, described an excellent preamplifier as part of his article "A High Level Accessory Front End for the HF Amateur Bands" in Apr/March 2003 *QEX* . The schematic of his preamplifier is shown in Fig 7-157. The performance data are just short of spectacular:

- 3rd order intercept (IP3): +43 dBm
- 1 dB compression: +24.5 dBm
- Gain: 12 dB (1 to 30 MHz)
- Noise figure: 3.9 dB at 30 MHz

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 (phasing)
  – Height (less corona current)

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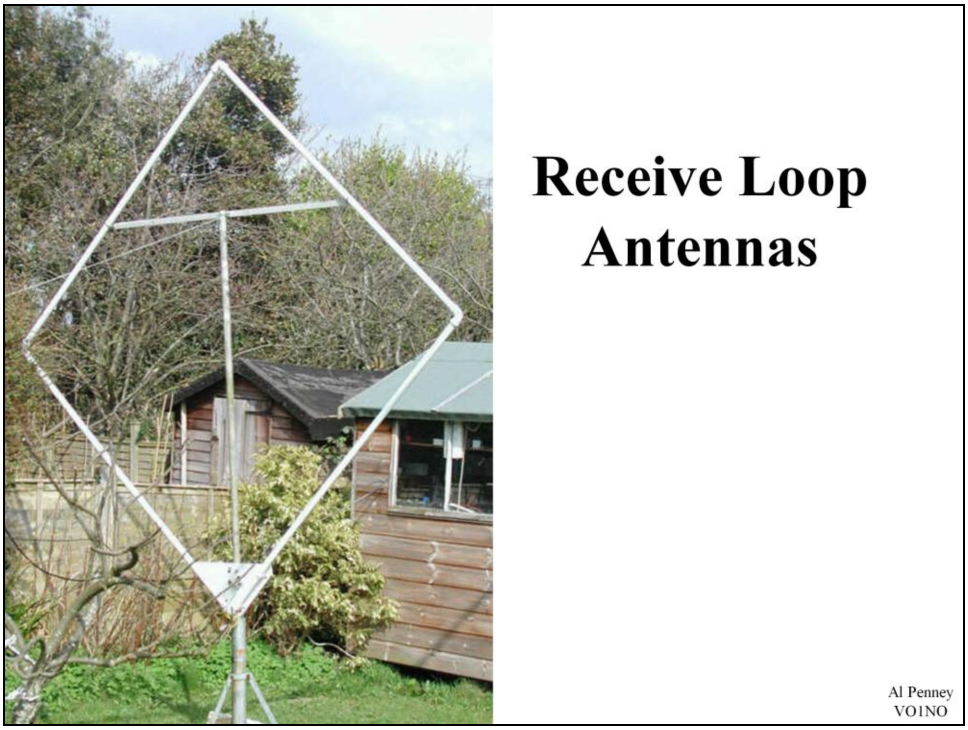
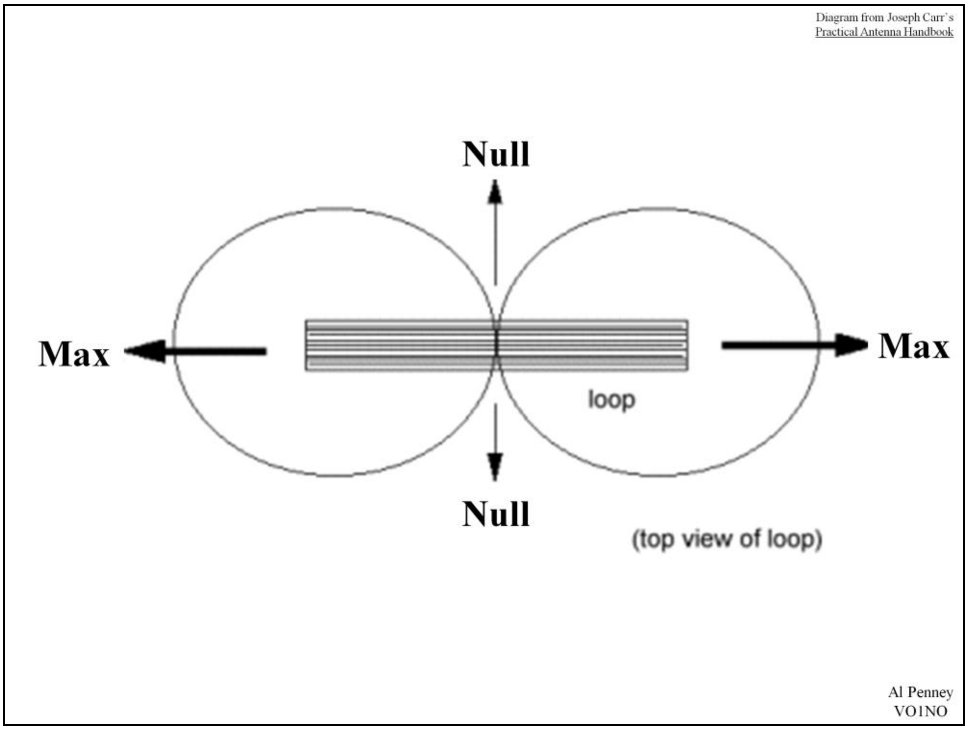
While often attributed to charged particles (such as water droplets) hitting an antenna, most precipitation static is actually caused by intense electric field gradients in the area surrounding the antenna. Such conditions commonly appear during inclement weather, when movement of particles or moisture causes concentrated areas of charges. The strong electric fields are responsible for noise-producing *corona discharges*. The noise comes from low-current corona discharges from sharp or protruding objects. (St. Elmo's Fire)

Using an antenna at a lower height reduces corona current—The electric-field gradient is smaller close to the wide smooth surface of the earth. Vertical antennas are particularly sensitive to precipitation static; they have pointed ends protruding upwards towards the oppositely charged sky.

Beverages on the other hand, being near earth, will have fewer corona discharge problems. They also have low surge impedances. This means the low-current high-voltage arcs transfer very little noise power into the antenna. Beverages are thus



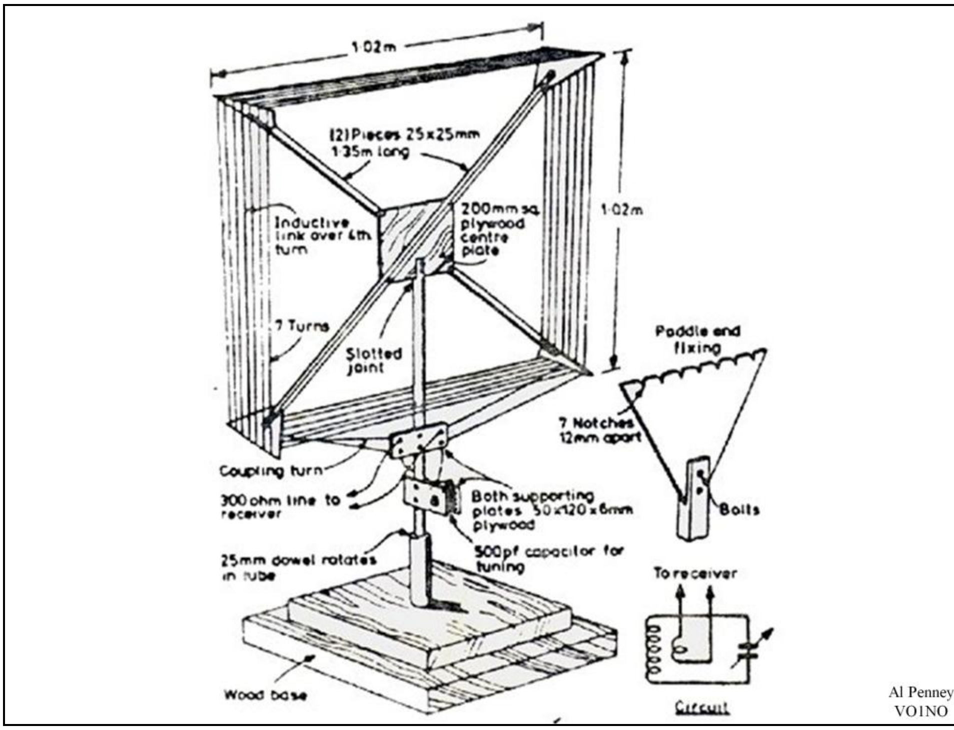
How many of you have built loop antennas for receive?



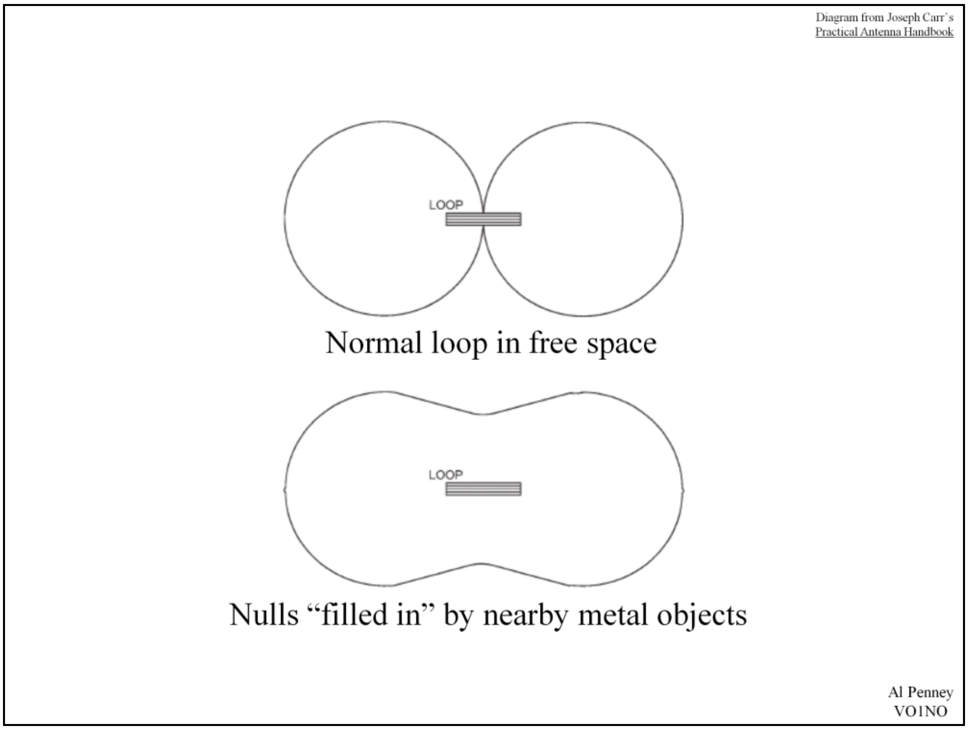
Unlike a large loop antenna (greater than 0.5 wavelength), a Receive Loop is much smaller (most are less than 0.1 wavelength), and exhibits a much different antenna pattern. RX Loops deliver strongest signals in the direction of the plane of the loop, and sharp nulls broadside to that plane.

Signals broadside to the loop induce the same voltage throughout the wire of the loop. Because all sections of the wire are at the same potential, no current can flow. Signals off the ends of the loop induce different voltages in the loop wire as they travel through it, allowing a current to flow.

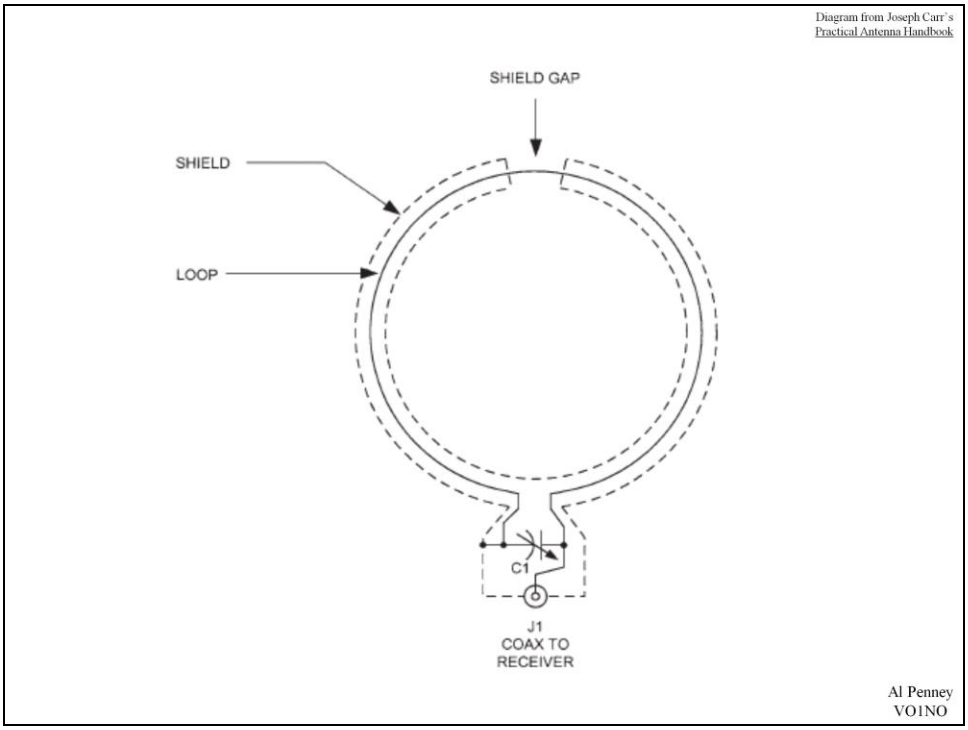
The advantage of the RX Loop is the sharp null. Careful positioning can block out an interfering signal or noise, and permit the desired signal to be heard.



A typical homebrew RX Loop. Note the use of a separate loop inside the main winding. It presents a better impedance match to the receiver. It also prevents the main loop from being too heavily loaded by the receiver. This would destroy the Q of the circuit, allowing strong, off-frequency signals to enter the receiver's front end.



The presence of metal objects near a loop antenna can upset the balance of the system, causing the null to “fill in”. This sort of distortion can eliminate the advantage of an RX loop – the sharp null that can be used to block an interfering signal or noise.



This can be eliminated by shielding the loop as shown. This ensures that the loop remains balanced with respect to ground despite the presence of nearby metal objects. It has nothing to do with receiving the magnetic component of an EM wave – this is a common misconception! Check out the website of W8JI (www.w8ji.com) for an in-depth explanation. In reality, the shield becomes the actual antenna, not the wire inside the loop. There are many good and bad ways to feed and shield an RX Loop. Points to remember:

•The shield is the actual antenna

•The shield must be perfectly symmetrical away from the inner wire exit point

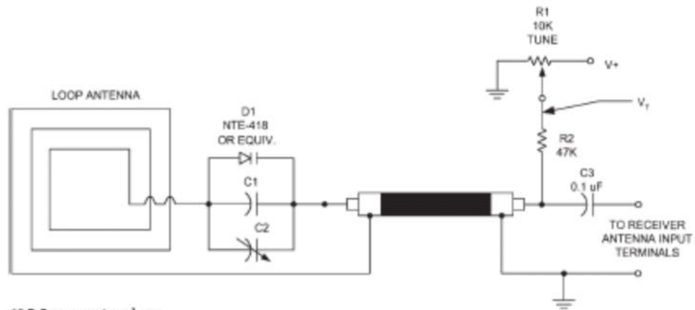
•The gap in the shield must be exactly opposite the grounded point

•The ground must be at the inner wire exit point

•The shield will not make an unshielded loop that is properly balanced any quieter

•***The shield only is a tool to help you balance the system IF the shield is properly implemented***

Diagram from Joseph Carr's
Practical Antenna Handbook

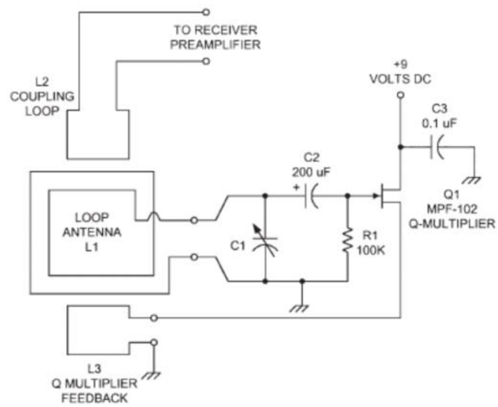


15-7 Remote tuning scheme.

Al Penney
VO1NO

RX Loops mounted in the shack can be tuned manually with variable capacitors. Tuning remote loops can be more problematic. I have tried slow speed electric motors to turn the variable capacitor. The electric noise from the motor makes it difficult to peak the antenna. Varactor Diodes, which exhibit a changing capacitance as the voltage is varied, can be used instead. The voltage is fed up the coax, using a DC blocking capacitor to protect the receiver.

Diagram from Joseph Carr's
Practical Antenna Handbook



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You can use a feedback loop to increase the gain and the Q of the loop. This circuit is essentially an Armstrong oscillator that doesn't quite oscillate. The signal provided by the feedback loop must be adjusted until the circuit is on the verge of oscillating. At that point, the gain increases and the bandwidth narrows. It takes some skill to use this type of RX Loop, but it is apparently an excellent accessory. Some sort of potentiometer might be necessary to better control the amount of feedback.

You can use a magnetic loop with a broadband current amplifier in lieu of the usual resonating components. Jeff VE1ZAC built the loop seen here. His antenna utilizes an aluminium 1 meter diameter loop with dual “Hoops” to make it look fatter and attain a lower self-inductance. It measures at 1.48 uHy which is apparently quite good for a loop like this. It is mounted on a 2 M mast and sits on a TV rotator allowing remote control from inside the shack. It uses two aluminum flat bars 3.1 meters long, 1 1/4″ wide and 1/8″ thick. 1 m diam. L= 1.45 uH

inductance is critical. The ideal loop is fat with very low inductance. Fatter is better, but it is not strictly necessary to have a full metal loop to get the improved low inductance result. A second loop place parallel to the first and offset by about 8” produces a lower inductance through mutual coupling.

The amplifier is built by LZ1AQ at Active Antennas. It actually has three receive modes built in, all controlled from the remote shack end switches. You can have one loop, a second crossed loop or other combinations. Plus, the built in switching allows using your two loops, or one loop and a short wire as a small dipole connected to a voltage amplifier. In Jeff’s case he used the loop mast for the second element. It works very well. The entire system is well made and arrived complete and intact in a timely fashion via airmail. The units are checked out and adjusted before leaving Bulgaria, and there is excellent documentation showing how to hookup and test the system. All connectors and hardware are provided. You are responsible for the loop, some shielded CAT5 cable to hook the unit up, and a power supply.

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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

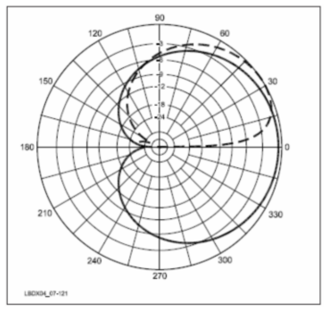
Receive loops can be a useful tool in some situations, but are probably better suited for SWL and BCB/LF Beacon DX'ing. The newer amplified broadband loops may be better.

Al Penney
VO1NO

Because of the poor sensitivity compared to many other RX antennas, conventional RX Loops are probably better suited for SWL, Broadcast Band and LF Beacon DX'ing, where signals are going to be stronger than on the Amateur bands. The newer amplified broadband loops seem to offer better performance, and may be worth checking out.

Elongated Terminated Loops

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



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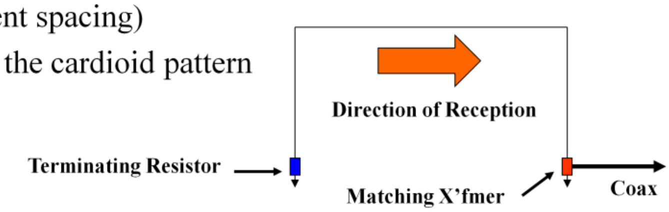
Theory of Operation

- 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



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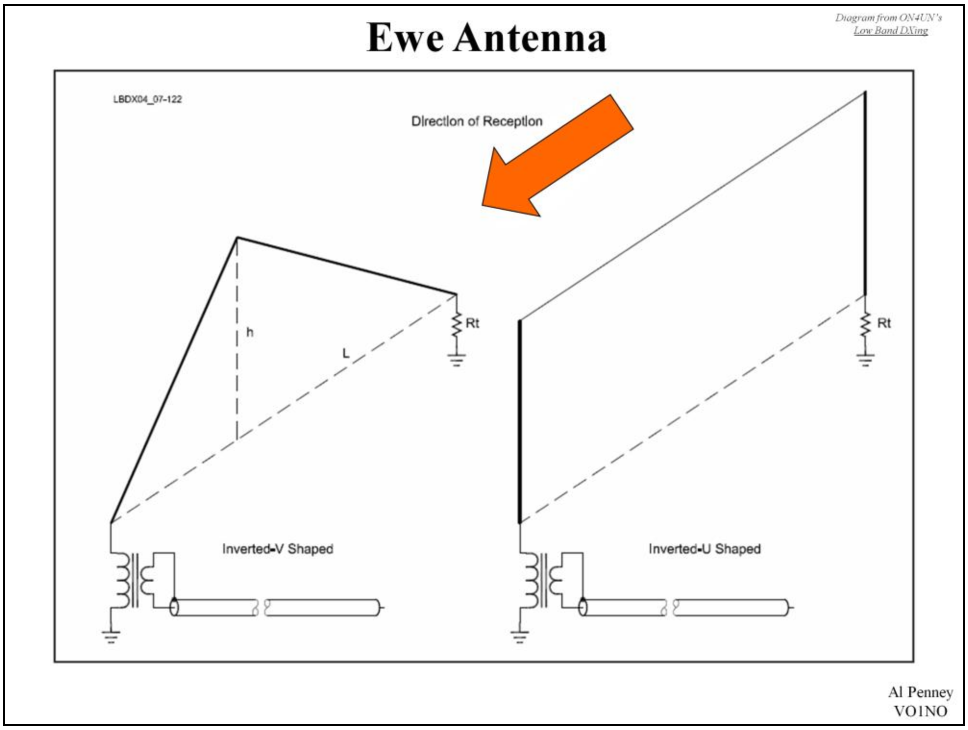
These elongated terminated loops are really a simple pair of verticals with a horizontal feed line, one being basefed, the other being fed via the top wire. That provides crossfire phasing. When the element spacing is less than λ/4, this always fires towards the feed point end of the array. When properly terminated the loops show nearly constant current at all points on the loop. This constant current is achieved by terminating the far end of the loop in the same impedance as the feed point. Thus, the portions considered to be the vertical "elements" have equal current, with a phase equal to 180° plus the electrical length of the connecting wires, which is slightly more than the element spacing.

In other words, the terminated loop is like two constant current verticals with classic end-fire phasing. The only difference is the horizontal component in the radiation due to the radiating delay line (sloping or horizontal) of the terminated loops. This is the operating principle for the entire family of elongated terminated loops. Sloping (inclined) wires used in some of the designs are just like a horizontal wire in combination with a vertical wire, and the same reasoning as above can be used.



Floyd Koontz, WA2WVL, is the originator of the EWE. His QST articles are must-reads on this novel receiving antenna. Incidentally, the curious name “EWE” came about because Floyd noted that his new antenna looked very much like an upside-down letter “U.” He jokingly submitted a drawing of a female sheep—a ewe—to headline his February 1995 *QST* article, which he impishly titled with the triple entendre “Is This EWE for You?”

A EWE is small, requires little engineering, and can be designed to cover 80 and 160 meters. Moreover, the EWE is low profile and can be built for little money. In appearance, the EWE resembles a very short Beverage, though in fact it as an array of two short vertical antennas.

The horizontal wire is only about 5 to 15 meters long and is about 3 to 6 meters above ground. In other words, an EWE can fit in many tiny yards. The original description by WA2WVL uses 3-meter high “elements” with a spacing going from 4.5 to 18 meters, depending on the band (80 or 160 meters).

A good rule of thumb is to build an EWE where the length is twice the height. This rule can be followed for elements going from 3 to 6 meters in height, and will result in an optimum termination resistance of approximately 1000 Ω for both bands. The smaller the array, the easier it is to obtain a good deep null, but the lower the output level. The larger versions will be near the cut-off frequency, where a deep null cannot be obtained.

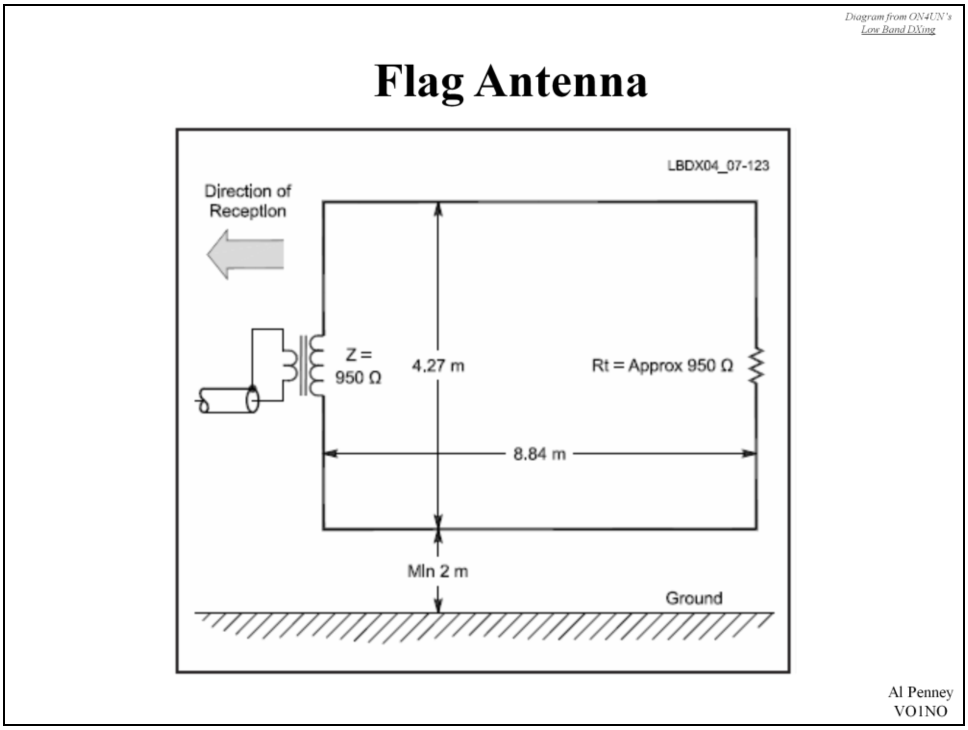
The output (gain) of the antenna depends on its size. The gain for 160 meters varies typically between –20 dBi and –30 dBi over average ground, and is about 9 dB higher on 80 meters. The inverted-V shaped EWEs looks quite attractive and can easily be made into a “hand-rotatable” receiving antenna: Just walk out in the garden and anchor the sloping wires to a different set of ground rods. It should be useful for DXpeditions as well.

The value of the terminating resistor is quite critical if you want to obtain a good notch in the back response. Since the ground resistance is part of the terminating resistance, a good low-impedance, stable ground is required. The ground resistance of a single ground rod may vary from as low as 50 Ω to as much as several hundred Ω. Although

Ewe Antenna at KC4HW

It has been reported that the best way to tune an array for best F/B is to find a medium-wave BC transmitter in the back of the antenna. Using a medium-wave signal during day time ensures that you will receive it on ground-wave, and as such have a constant and stable signal source. Tune the terminating resistor for a full notch, striving for a minimum of 25 dB. This value will be very close to the best value for 160 meters and close to what's best on 80 meters.

You should use broadcast stations between 1600 and 1700 kHz to do the null adjustment if you can. It is impossible to reliably adjust the termination resistance using signals arriving by skywave. You could also use a nearby local ham (in-line off the back) or set up a small signal generator off the back, using a small vertically polarized antenna, at a distance of at least 1 λ from the EWE (which means outside its near field).



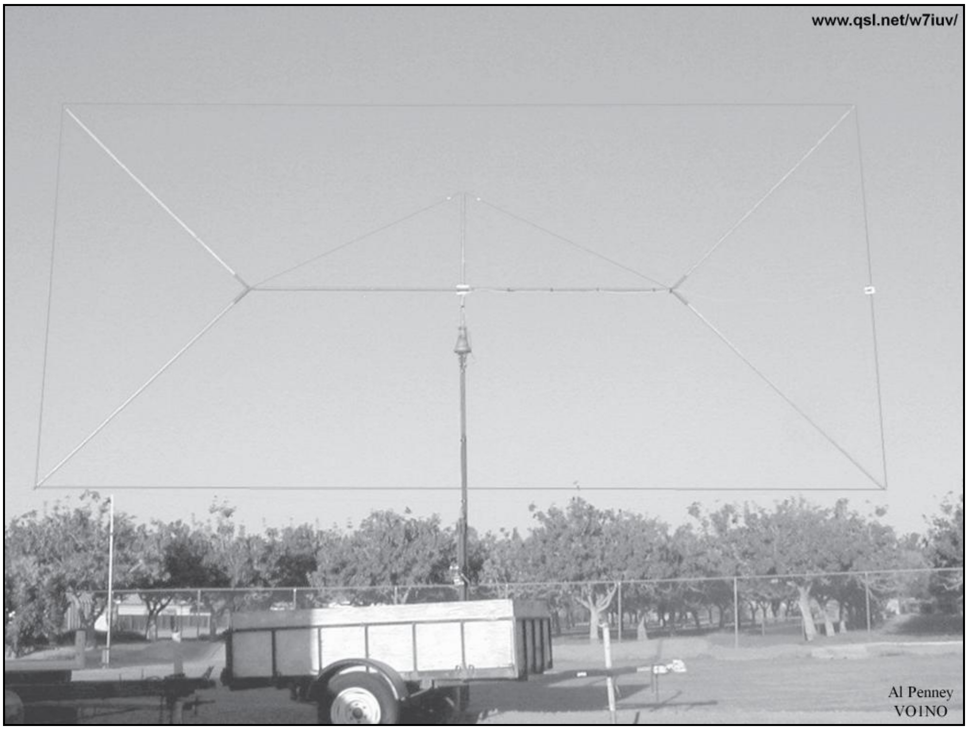
A major drawback to the EWE is its extreme sensitivity to any change in the local soil conductivity. EA3VY was the first to come up with the idea of adding a ground wire between the bottom of the two verticals as an effective way to minimize the effect of different soil conductivities.

Many dimensions will work but only the optimized ones provide the best directivity over the largest frequency range with a single termination resistor. These standard values developed by EA3VY and K6SE are 4.27 meter (14 feet) high by 8.84 meters (29 feet) wide, with a bottom wire height of 2 meters (6 feet) above ground. These dimensions result in an antenna that has excellent characteristics from 7.5 MHz down.

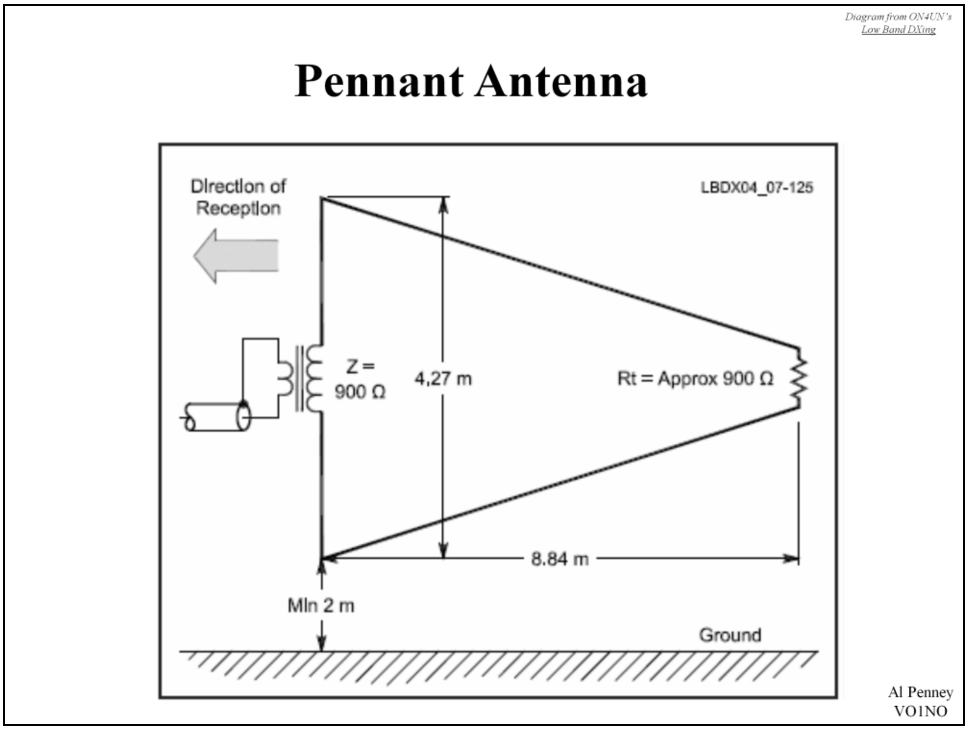
This configuration has a gain of approximately −28 dBi on 160 meters, −18 dBi on 80 meters and –10 dBi on 40 meters. The loop is terminated with 950 Ω and fed in the centers of opposite vertical sections. Its input impedance on 160 meters is 950 Ω with a small reactive component (10 to 50 Ω).

A properly designed Flag exhibits a high F/B ratio over any type of soil and at virtually any height above ground without need to change the dimensions or termination value.

K6SE, who has thoroughly tested all shapes and sizes of elongated terminated loop antennas, reports that the Flag antenna is probably the best of all configurations from the standpoint of being broadbanded and having gain. It has about 6 dB more gain than an equal-sized Pennant.

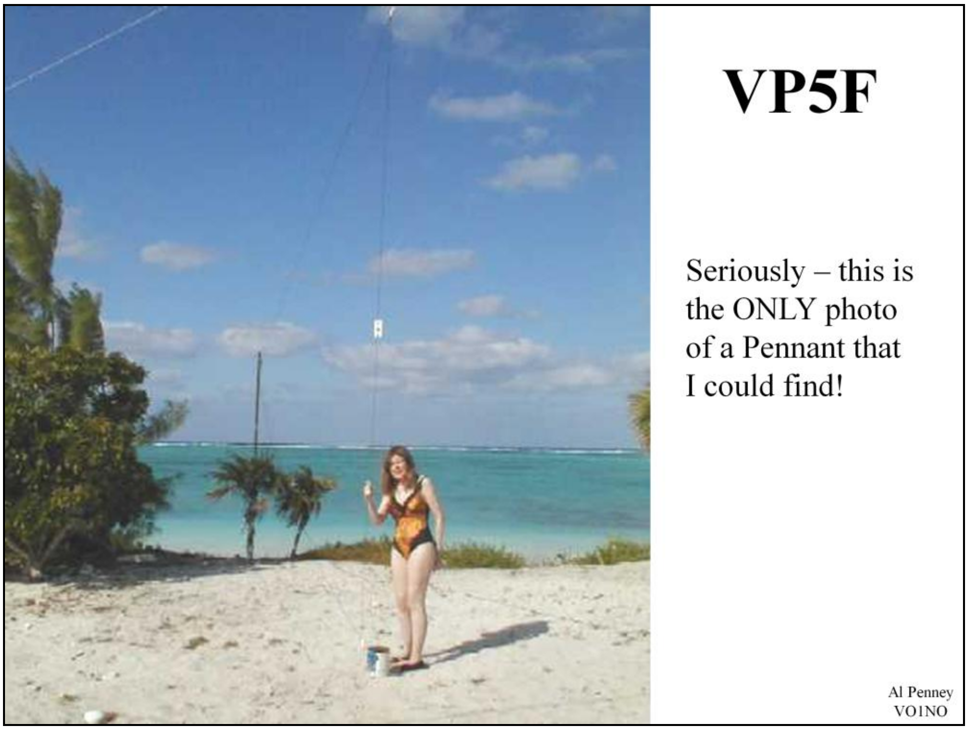


The shape and the size of this loop makes it attractive for a rotatable version. W7IUV describes such a design on his website (**www.qsl.net/w7iuv/**).



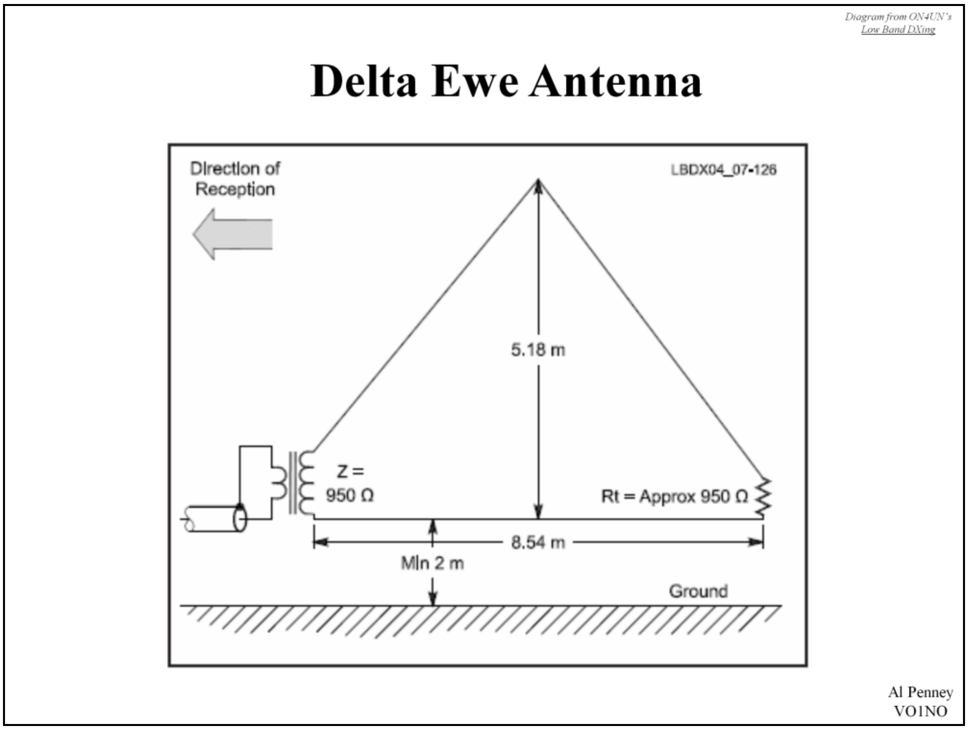
While optimizing the flag, K6SE and EA3VY developed the triangular-shaped loop. He named it the *Pennant* because its triangular shape resembles a flag pennant. The loop is fed in the center of the vertical section, while the load is situated where the sloping wires meet.

The correct termination resistor for the Pennant is about 900 Ω, which can be placed either at the point of the Pennant or in the center of the vertical section—the results are identical. The feed point is at the opposite end. Gain on 160 meters is about –34 dBi (which is 6 dB less than the Flag), −24 dBi on 80 meters and –16 dBi on 40 meters. The exact values depend on local ground conductivity. Note that the 6-dB lower signal level is proportional to the difference in area enclosed by the loop, which is half as much as the Flag: $^{1}/_{2}$ voltage = $^{1}/_{4}$ power (−6 dB).



Evaluation of the Pennant by Jeff VE1ZAC:

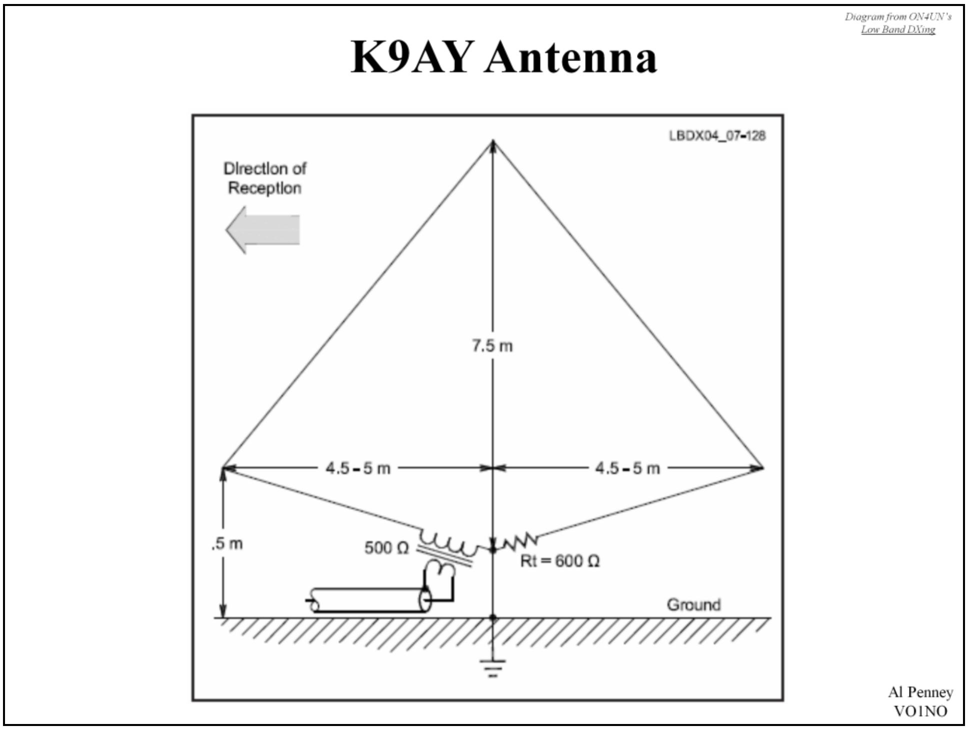
“This is probably the simplest, cheapest, least complex and best performing receive antenna out there. It has a 30 foot footprint and only needs 15 to 20 feet of height to work. And work it does. It does interact with its own feed line and with other antennas, but if you are careful with these things, it is a stellar performer. It is not unreasonable to get 30 dB F/B with one of these, on 160 M. A perfect antenna to aim into the SW or NE for 160M contests. Best of all worlds ?.. have two of them, one for each direction. This antenna plays well with fishing pole and short tree supports. Nearly every low band ham aficionado on a small lot can setup one of these. It also works well over crappy grounds.. like my QTH and much of Halifax. It looks like a triangle on its side. I used this in several 160M contests with good results. Best bang for the buck receive antenna. It is very simple to build and erect.”



A EWE in the shape of a Delta loop has every bit as clean a pattern as the more classic ones. I think this antenna is really attractive for DXpeditions and for semi-rotatable setups. Just moving the base line around is all you have to do to change directions. During modeling it appeared that the best F/B was obtained with the terminating resistor mounted approximately 20% from the bottom corner of the Delta loop. The antenna is fed in the opposite bottom corner.

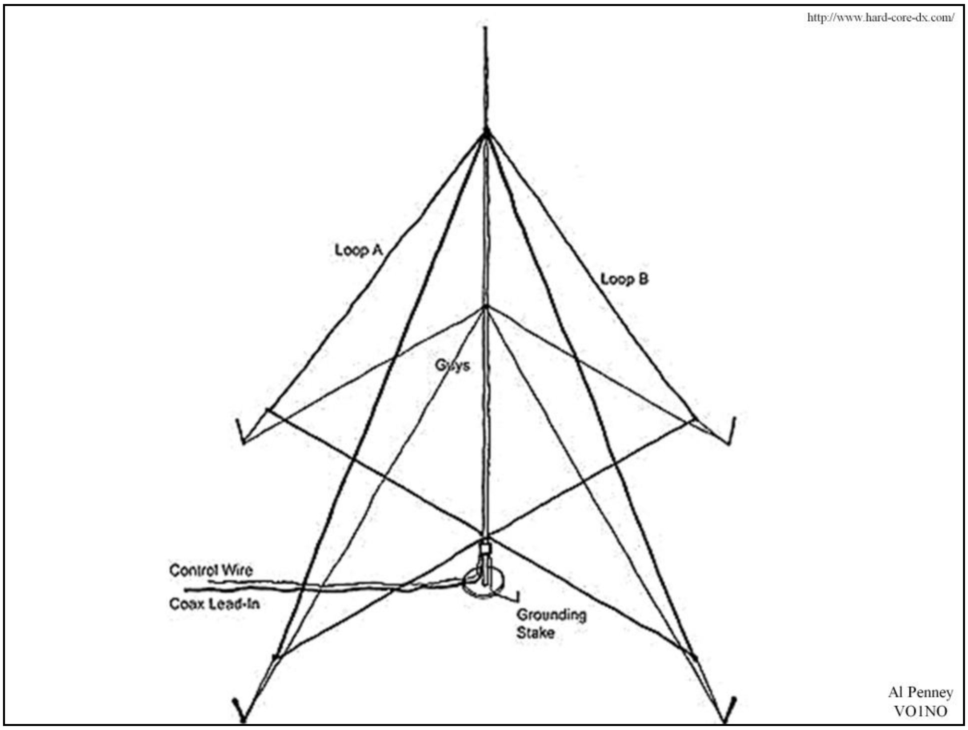
The FOØAAA Clipperton Island DXpedition used this antenna in their operation. It is the only design that requires only one support and can be easily rotated manually, a very desirable feature for DXpedition use. The Clipperton team found the antenna to be very successful and many other subsequent DXpeditions have also used the Delta configuration.

The optimum termination resistance for this design is also 950 Ω. The antenna was optimized for 160 meters and its output is about –33 dBi on 160 meters, −22 dBi on 80 and –12 dBi on 40 meters.



Gary Breed, K9AY, described this loop very well in his Sep 1997 *QST* article (Ref 1265). This is another variant of the EWE, where the bottom wire of the loop is grounded in the center. See **Fig 7-128**. He pointed out in his article that the loop can really be any shape. The diamond shape K9AY used was dictated by practical construction considerations rather than anything else. All of the K9AY loops can be used on both 160 and 80 meters, although optimal performance may require slight adjustment of the terminating resistance, as K9AY pointed out in his article.

While in all the previously described loops the feed point and the termination are separated by distance (they are at opposite ends of the elongated loops), in the K9AY loop “separation” is achieved by grounding the loop between the adjacent feed and termination points. Having the feed and termination so close to one another makes it easy to switch directions from a single box.



Using the proper relay switching setup, it is possible to insert the matching transformer and termination relay as necessary so that 4 different directions can be selected.

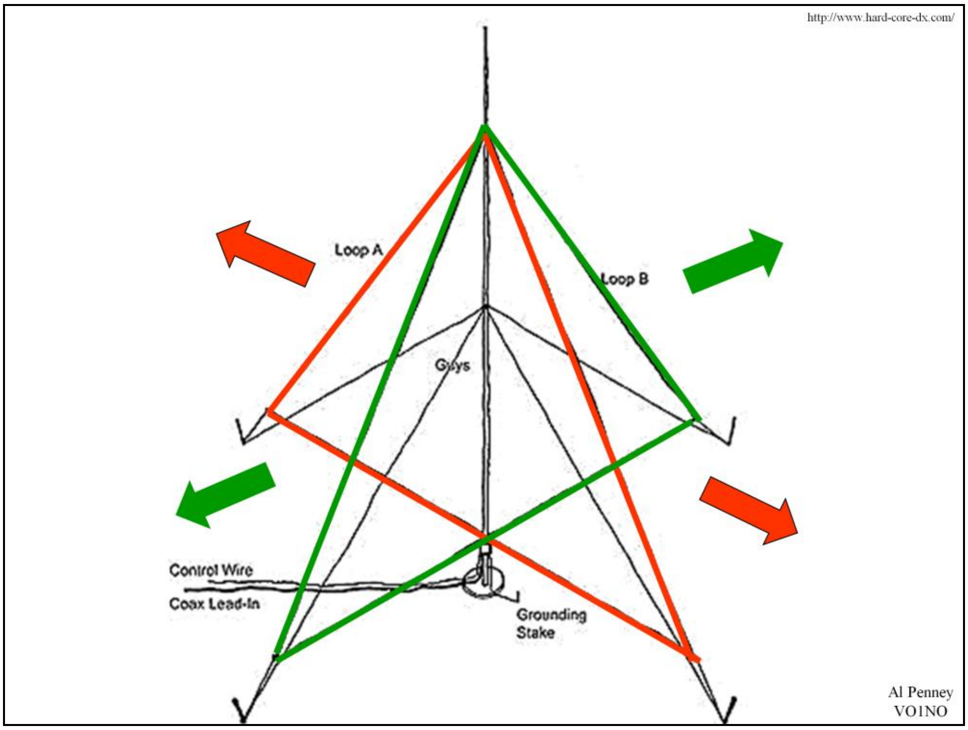

http://www.hard-core-dx.com/
Loop A
Loop B
Guys
Control Wire
Coax Lead-In
Grounding
Stake
Al Penney
VO1NO

Diagram from ON4UN's Low Band DXing

K9AY Switchbox

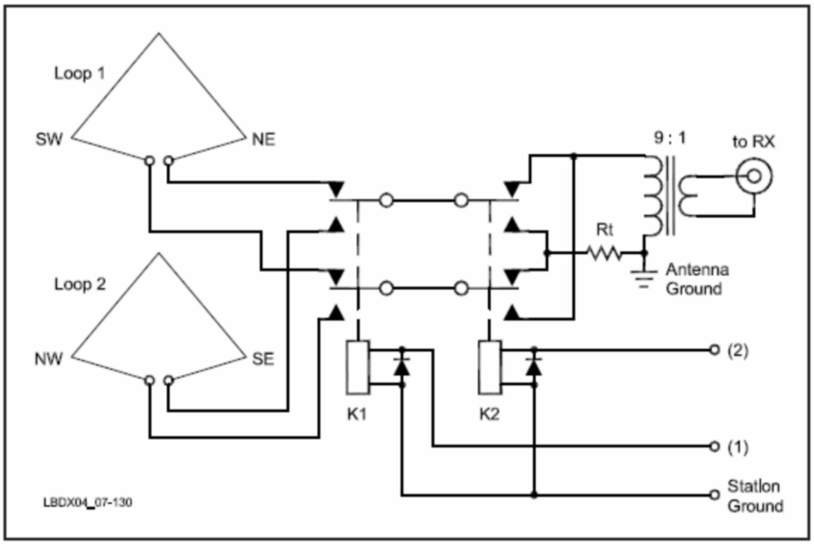


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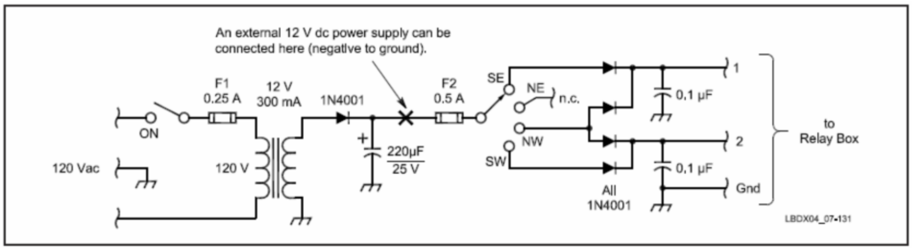
Diagram from ON4UN's Low Band DXing

K9AY Control Box



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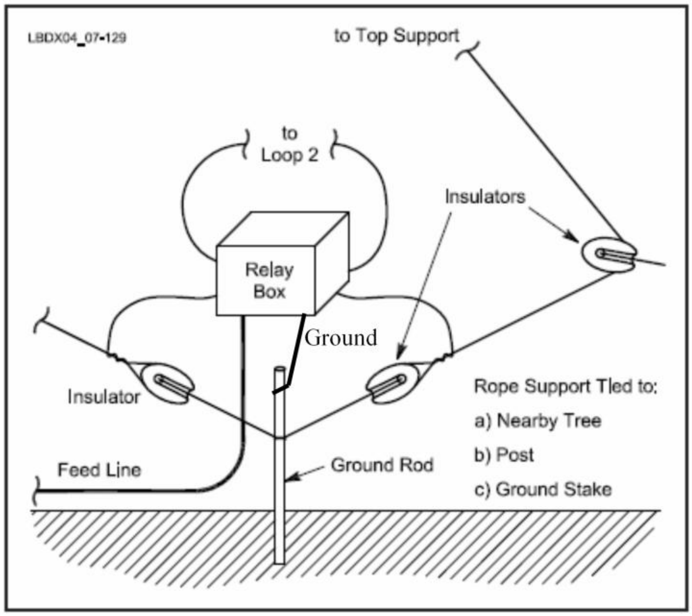

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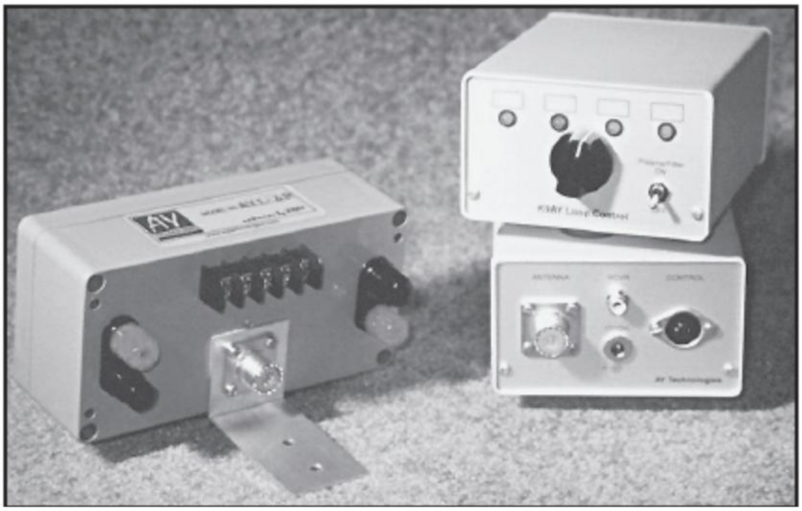
Photo from ON4UN's
Low Band DXing



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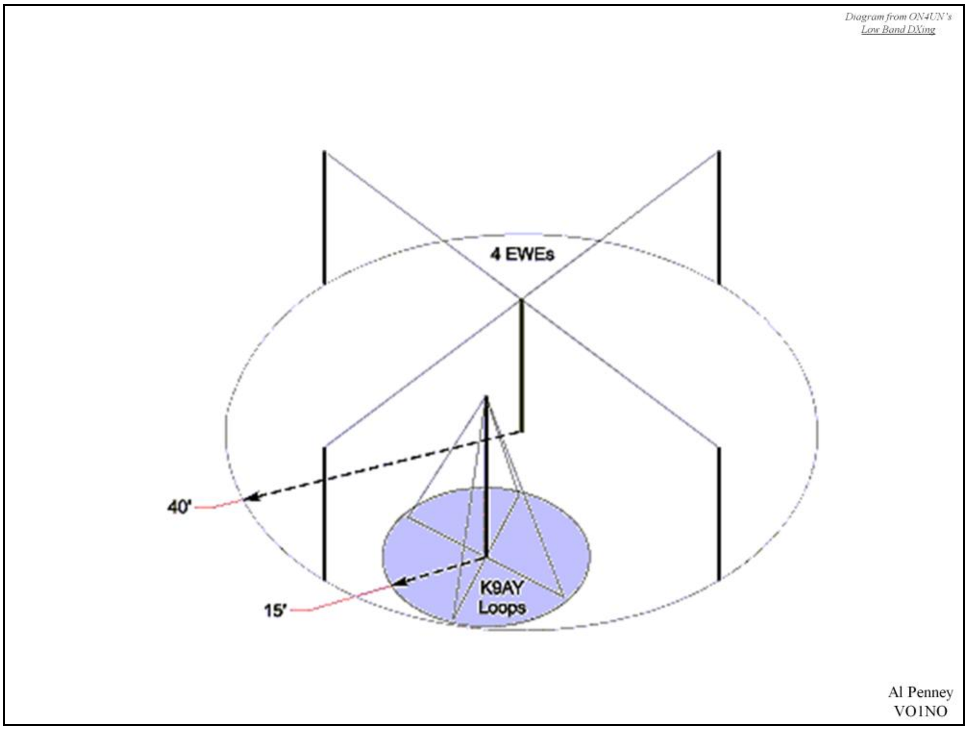
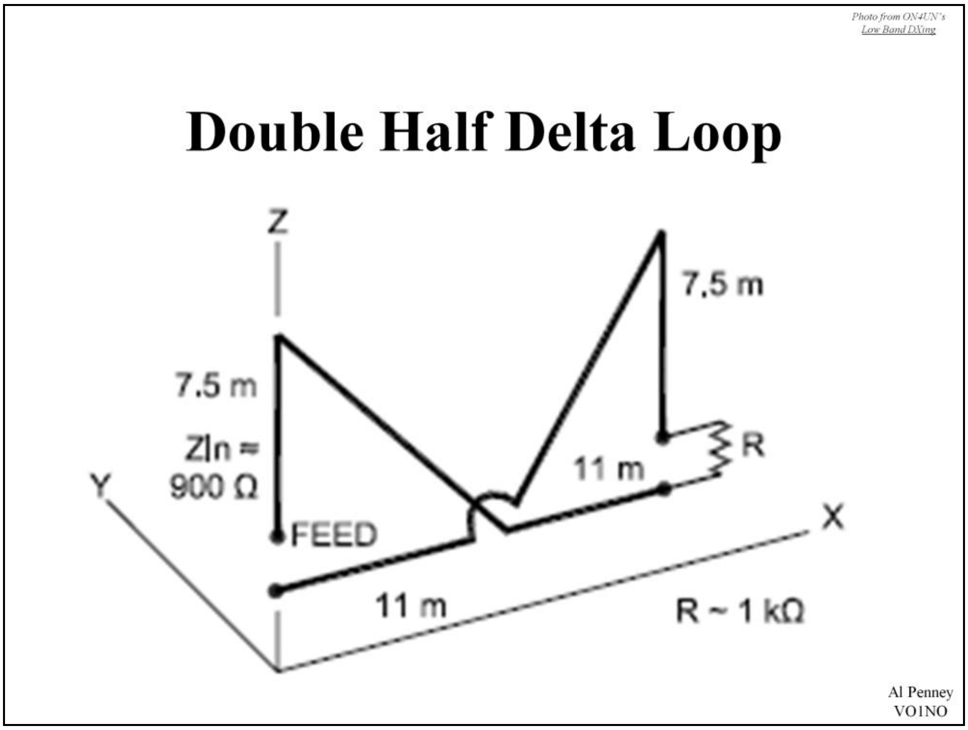
K9AY offered by AY Technologies.

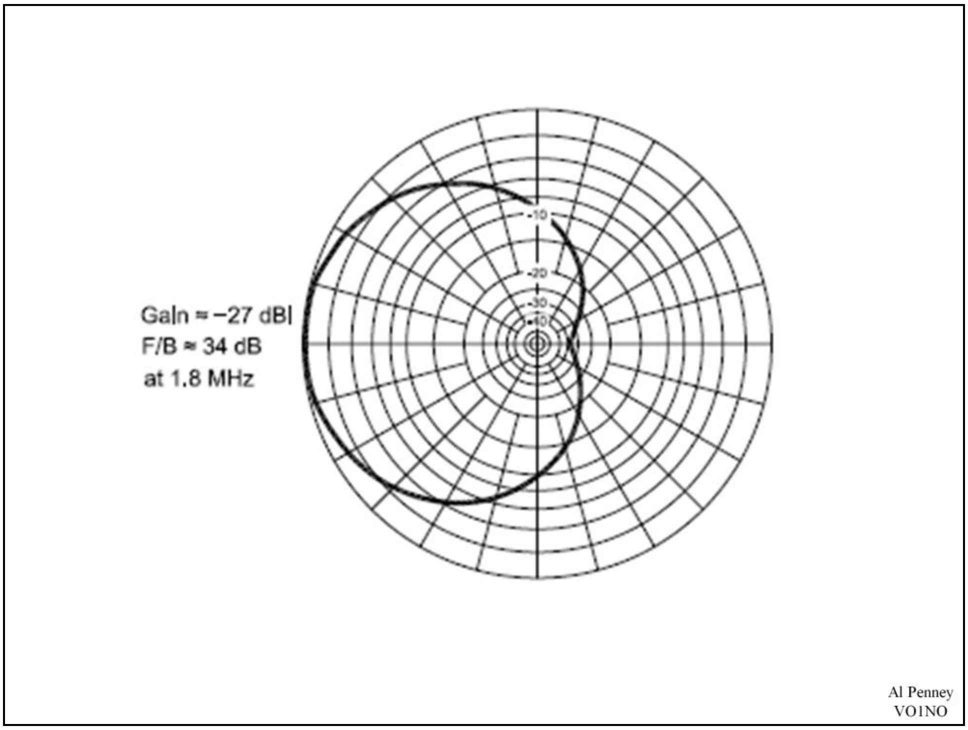


K9AY has a much smaller footprint than 4 Ewes.



George Wallner AA7JV's "Double Half Delta Loop" antenna is the latest of the terminated loop designs. It requires two support poles, separated by approximately 22 meters, as shown in the diagram.

The bottom wire is at approximately 1.5 meters above ground, and the higher this wire, the less noise it will pick up. As the antenna is ground independent, you can just move the whole thing up a few meters without changing anything else.

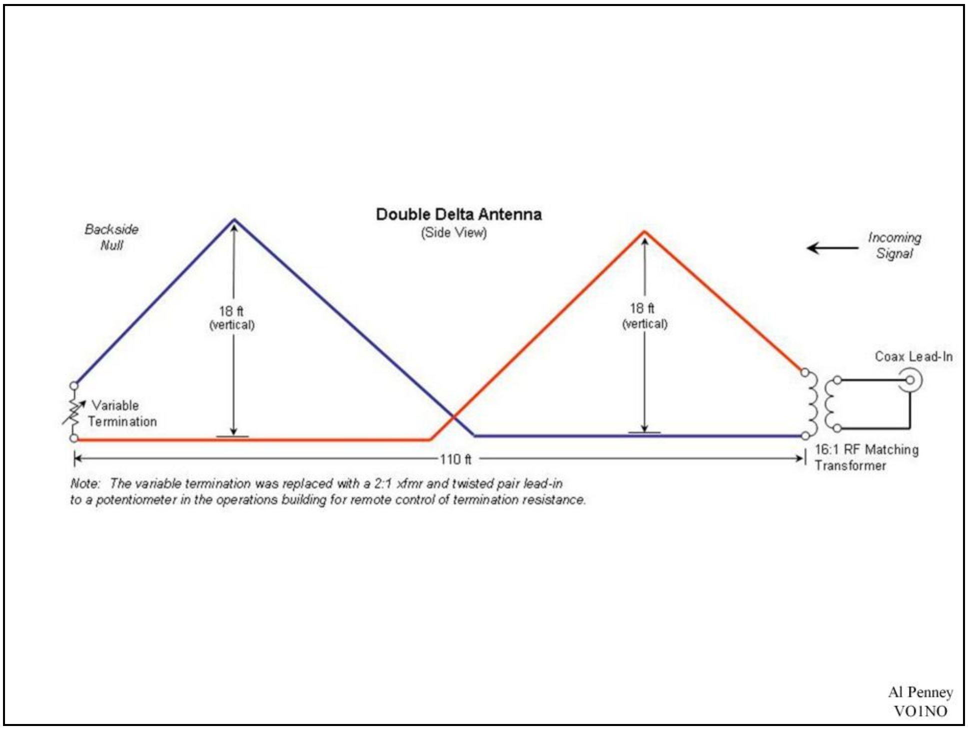


It is important to remark that this “double” loop has a much narrower –3 dB forward lobe angle (~100°) than the earlier described elongated loops (~140°). Hence the significantly better RDF figure as well.

Note that there is nothing special about the dimensions or exact shape of this antenna. The more area the wires enclose, the larger the signals (higher gain), but the RDF may get slightly worse. Also, the larger antenna will not work on the higher bands. (The upper cut-off is approximately where the total wire length

reaches 1⁄4 wavelength.)

Note that thermal noise will eventually overtake signals as the antenna is made smaller, so it is not possible to build a miniature antenna and use a preamp to bring the signal levels up.



This version of the Double Half Delta Loop is used by BCB DX'ers. It is larger to offer better performance on the AM broadcast band. These dimensions would be a good starting point for use on the new 630m band.

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

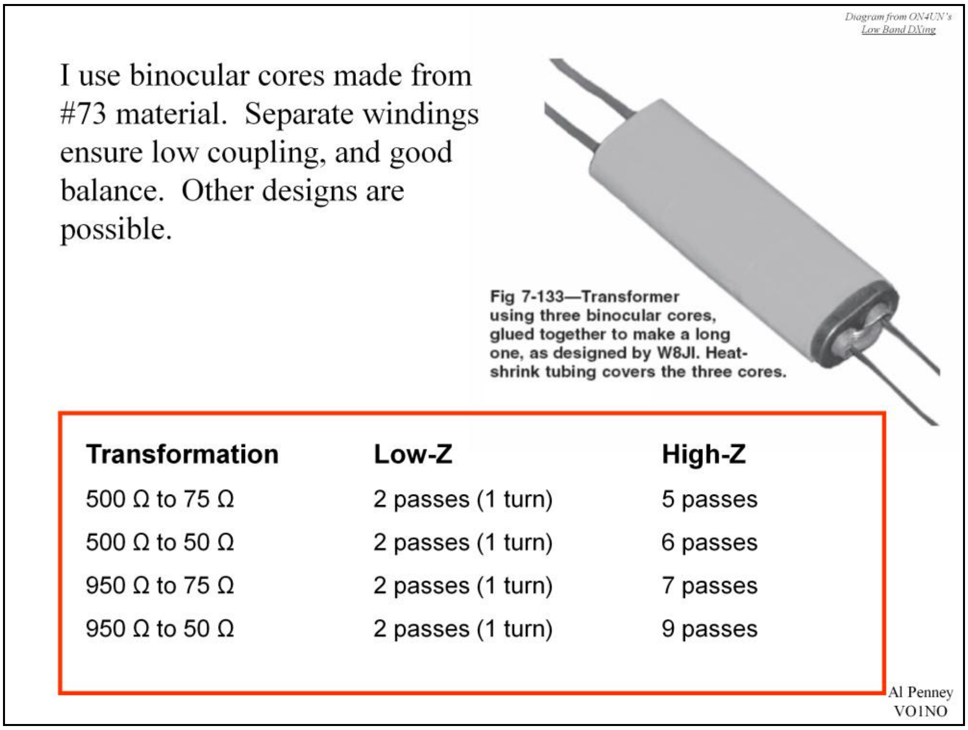
Al Penney
VO1NO

The essential characteristics of a good transformer for a loop antenna are:

Lowest possible capacitance coupling between primary and secondary windings.

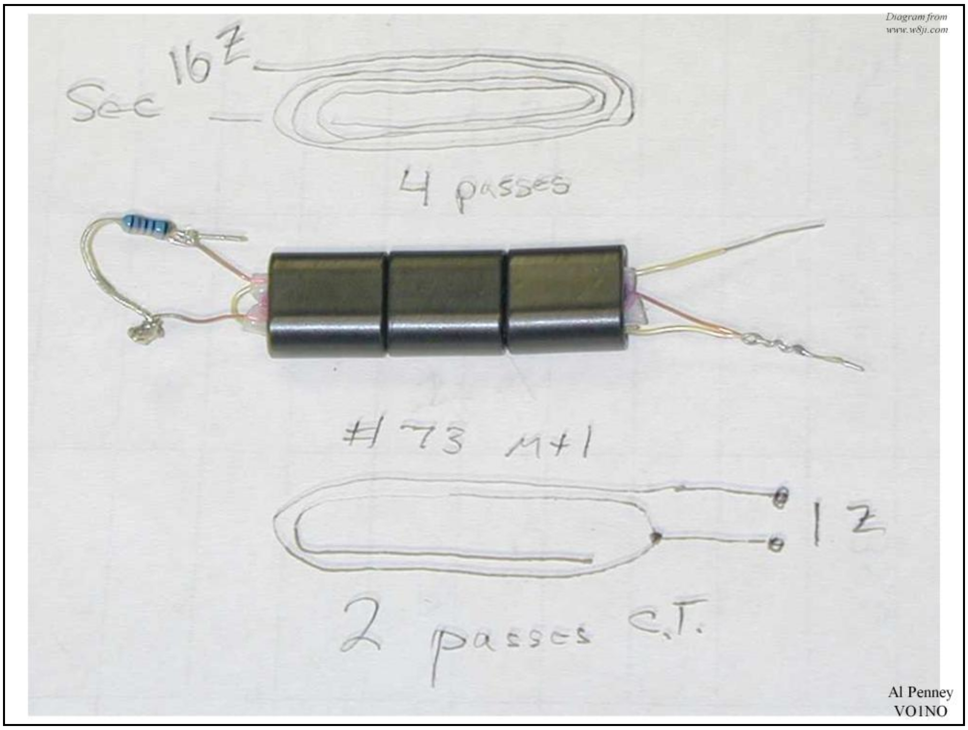
Low loss because signals are very low-level.

Good SWR is *essential* if you want to phase such antennas (you want the phase angle to be the determined by the cable length!)



Winding Data for Binocular Transformer

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
950 Ω to 50 Ω	2 passes (1 turn)	9 passes



Summing Up, Feeding Elongated Receiving Loops

- Make sure your loop is as physically balanced as possible.
- It's better to have the loop 5 meters high than 2 meters.
- Use a transformer with separate primary and secondary windings.
- Use a transformer with the lowest possible capacitive coupling between primary and secondary windings.
- Do not use a metal box to house the transformer.
- Run the feed line along the symmetry axis of the loop for several meters.
- Drop the coax down to ground, where you ground the shield to a good ground system. Insert a common-mode choke at that point (between the ground rod and the shack).

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.

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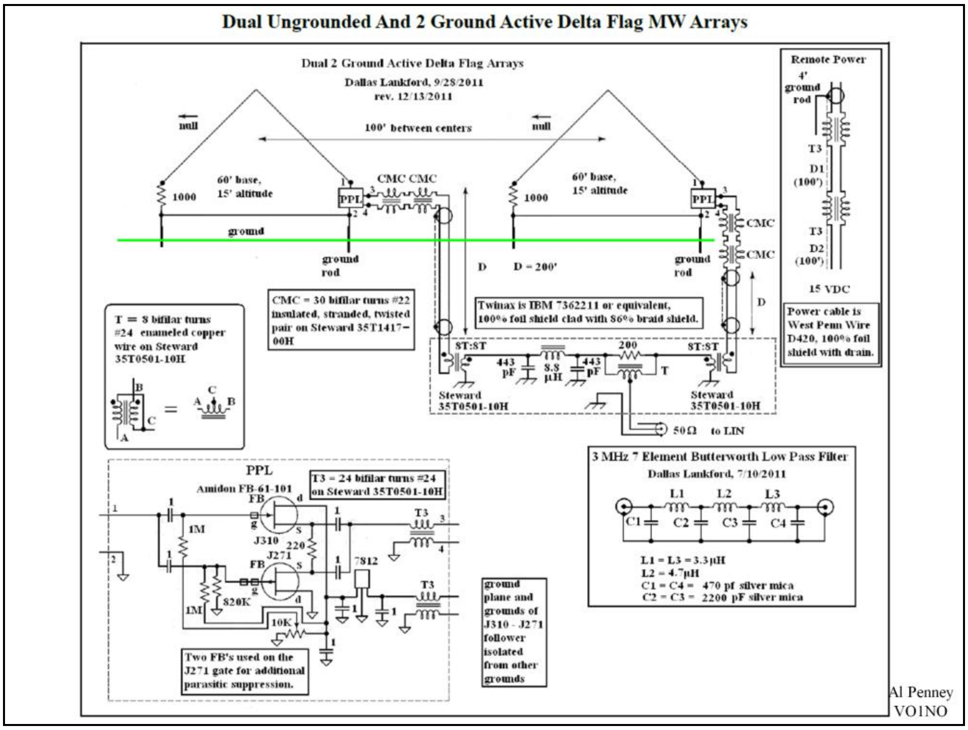
Dual Active Delta Flag Array

- Array of two Delta Flag antennas
- Uses FET Followers to transform output to 50 Ohms, so no matching transformers
- Described as a “Beverage Killer”!
- Developed by Dallas Lankford for MW Dxing
- http://groups.yahoo.com/group/thedallasfiles2

Al Penney
VO1NO

The dual active delta flag array is a dual delta flag array which is activated by high performance FET followers. The FET followers basically transform the open source voltages of the flag elements directly to 50 ohm outputs. No antenna transformers are used, so there is no reduction of signal levels. This is equivalent to attaching 15 dB gain very low noise figure amplifiers directly to the flag elements. In other words, low signal level output flag antennas and flag arrays are converted to high signal level output flag antennas and flag arrays.

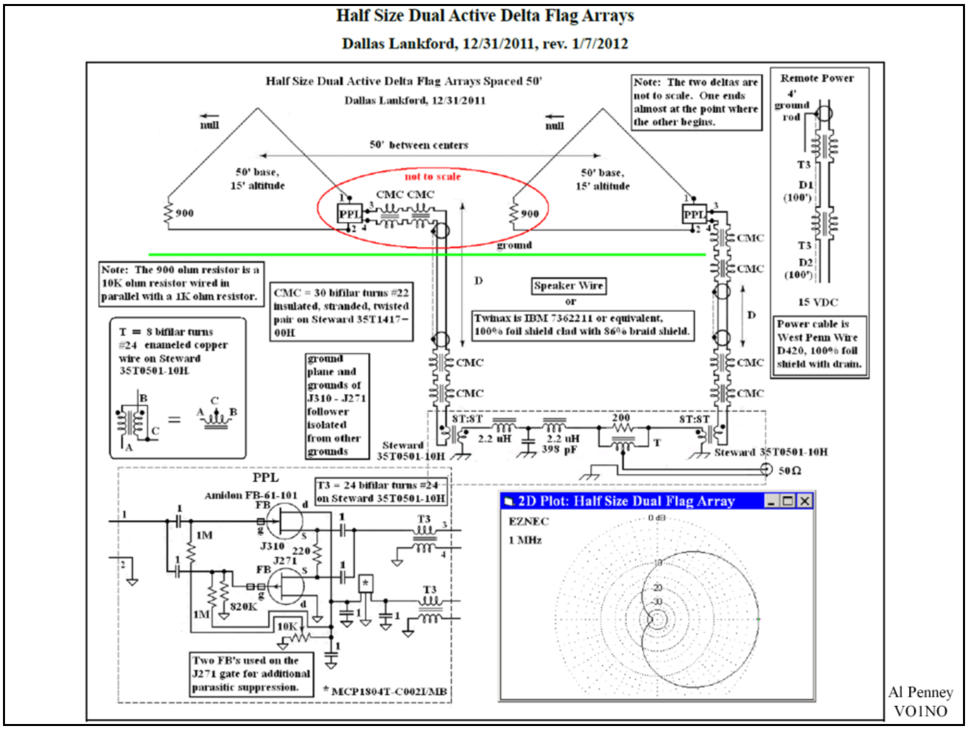
Developed by Dallas Lankford, a MW Dxer. He had done a lot of research into receive antennas – check out his articles at the link.



The dual active delta flag array is a dual delta flag array which is activated by high performance FET followers. The FET followers basically transform the open source voltages of the flag elements directly to 50 ohm outputs. No antenna transformers are used, so there is no reduction of signal levels. This is equivalent to attaching 15 dB gain very low noise figure amplifiers directly to the flag elements. In other words, low signal level output flag antennas and flag arrays are converted to high signal level output flag antennas and flag arrays.

The high performance FET follower is in the box labeled PPL (which is an abbreviation for “preamp per loop”). It is not really a preamp, and the antenna element is not really a loop, but never mind. Doug NX4D coined the term PPL, and Dallas uses the term now..

Grounding the flag elements converts them into EWE elements with 6 dB additional signal output. Single EWE elements generally have poor patterns which are ground dependent. But dual EWE arrays have much better patterns and are more or less ground independent, just like dual flag arrays. Thus before sunset when greater gain is needed, the array can be operated as a dual EWE array, while near and after sunset the array can be changed to a flag array with superior splatter reduction. The reverse is done at sunrise.



The half size active dual flag array described in the graphic above requires only 100' (30.5 meters) of linear space, and so it is an excellent choice for MW DXers with limited space for antennas. Although small compared to previous high performance MW antenna arrays, it is a state of the art MW receiving antenna array, primarily because it uses true active delta flag antenna elements.

According to Jeff VE1ZAC: "I can confirm, they work as advertised, or better, are easy to build, and simple to put up. I happen to have one line to the NE that I can just fit the 100 feet needed for this short version of the antenna, and it is a crowd pleaser(well.. me). It works on 160 M quite well too, but Dallas tells me it would be better on 160 if it was cut for 160. I may try that next. It is really fun to pick out all the Eu MW stations you can hear most evenings.. I can easily detect or hear maybe 40 or 45 any particular night. Very cool. I am looking forward to trying on 160M DX this winter. As a happy coincidence, the plasma TV noise source is in the null of this antenna to the SW of me. I can't hear it at all. On bad side, because of that TV source, there isn't much point in reversing this thing as that plasma TV is going to dominate the band to the SW."

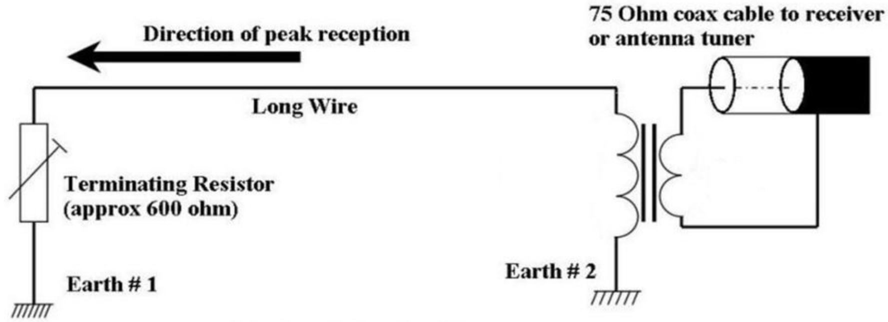
Dr. Harold Henry "Bev" Beverage (14 Oct 1893 in North Haven, ME - 27 Jan 1993) is perhaps most widely known today for his invention and development of the wave antenna, which came to be known as the Beverage antenna and which for the last few decades has seen a resurgence in use within the amateur radio and broadcast DXing hobbyist communities. Less widely known (outside of the community of science history researchers) is that Bev was a pioneer of radio engineering and his engineering research paralleled the development of radio transmission technology throughout his professional career with significant contributions not only in the field of radio frequency antennas but also radio frequency propagation and systems engineering.

[edit] Biography

Harold Henry Beverage received a B.S. in Electrical Engineering from the University of Maine in 1915, and went to work for General Electric Company the following year as a radio-laboratory assistant to Dr. Ernst Alexanderson. In 1920, he was placed in charge of developing receivers for communications at the Radio Corporation of America in Riverhead, New York. Three years later, at the age of 30, he received the IRE Morris N. Liebmann Memorial Prize "for his work on directional antennas."

RCA named Beverage chief research engineer of communications in 1929, a position he held until 1940. At that time, he was promoted to vice president in charge of research and development at RCA Communications Inc., a subsidiary of the Radio Corporation of America. He retired in 1958 from that position and as director of radio research, but continued to work in communications as a consultant.

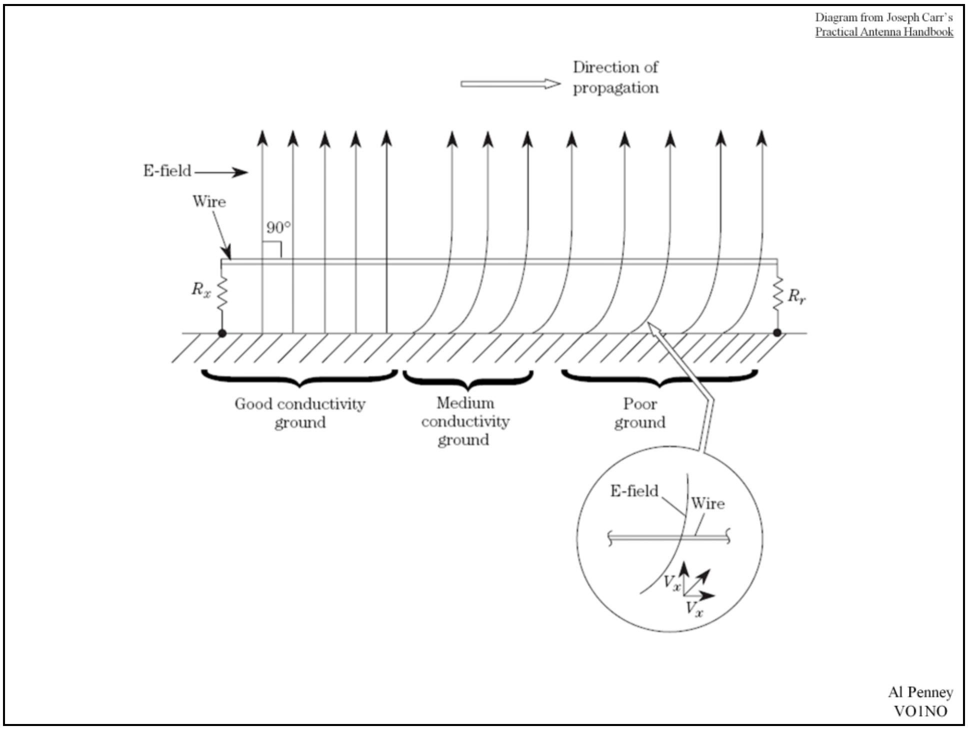
In 1938, the Radio Club of America presented him with its Armstrong Medal for his work in the development of . The Beverage antenna, the citation said, was "the precursor of wave antennas of all types." Beverage was awarded the IRE Medal of Honor in 1945, "In recognition of his achievements in radio research and invention, of his practical applications of engineering developments that greatly extended and increased the efficiency of domestic and world-wide radio communications and of his devotion to the affairs of the Institute of Radio Engineers."[1] In awarding him its Lamme Medal in 1956 the American Institute of Electrical Engineers cited him "for his pioneering and outstanding engineering achievements in the conception and application of principles basic to progress in national and worldwide radio



A basic uni-directional Beverage antenna

Al Penney
VO1NO

Harold Beverage discovered in 1920 that an otherwise nearly bidirectional long wire antenna becomes unidirectional by placing it close to the lossy earth and by terminating one end of the wire with a non-inductive resistor with a resistance approximately matched to the surge impedance of the antenna. This was the fundamental discovery in his 1921 patent.



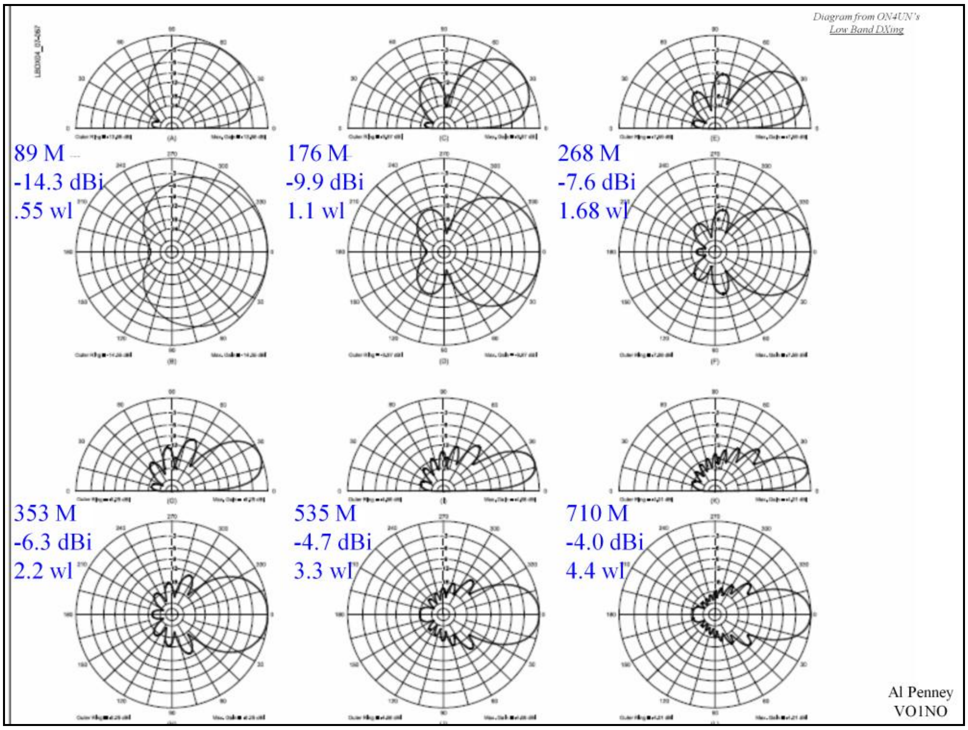
The Beverage Antenna relies on "wave tilt" for its directive properties. At low and medium frequencies, a vertically polarised radio frequency electromagnetic wave travelling close to the surface of the earth with finite ground conductivity sustains a loss that produces an electric field component parallel to the earth's surface. If a wire is placed close to the earth and approximately at a right angle to the wave front, the incident wave generates RF currents travelling along the wire, propagating from the near end of the wire to the far end of the wire. The RF currents travelling along the wire add in phase and amplitude throughout the length of the wire, producing maximum signal strength at the far end of the antenna where a receiver is typically connected. RF signals arriving from the receiver-end of the wire also increase in strength as they travel to end of the antenna terminated in a resistor, where most of the energy propagating in that direction is absorbed.

Radio waves propagate by the ionosphere at medium or high frequencies (MF or HF) typically arrive at the earth's surface with wave tilts of approximately 5 to 45 degrees. Ionospheric wave tilt allows the directivity inducing mechanism described above to produce excellent directivity in Beverage antennas operated at MF or HF.

While Beverage antennas have excellent directivity, because they are close to lossy earth they do not produce absolute gain (typically -20 to -10 dBi). This is rarely a problem, because the antenna is used at frequencies where there are high levels of atmospheric radio noise. The antenna has very low radiation resistance (less than one ohm) and will rarely be utilised for transmitting. The Beverage antenna is a popular receiving antenna because it offers excellent directivity over a broad bandwidth, albeit with relatively large size.

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



Note how the pattern sharpens, and gain increases as the length is increased. The lesson would seem to be that the longer the better for Beverage antennas. This is not true in actual practice however!

Maximum Effective Length

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

where

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

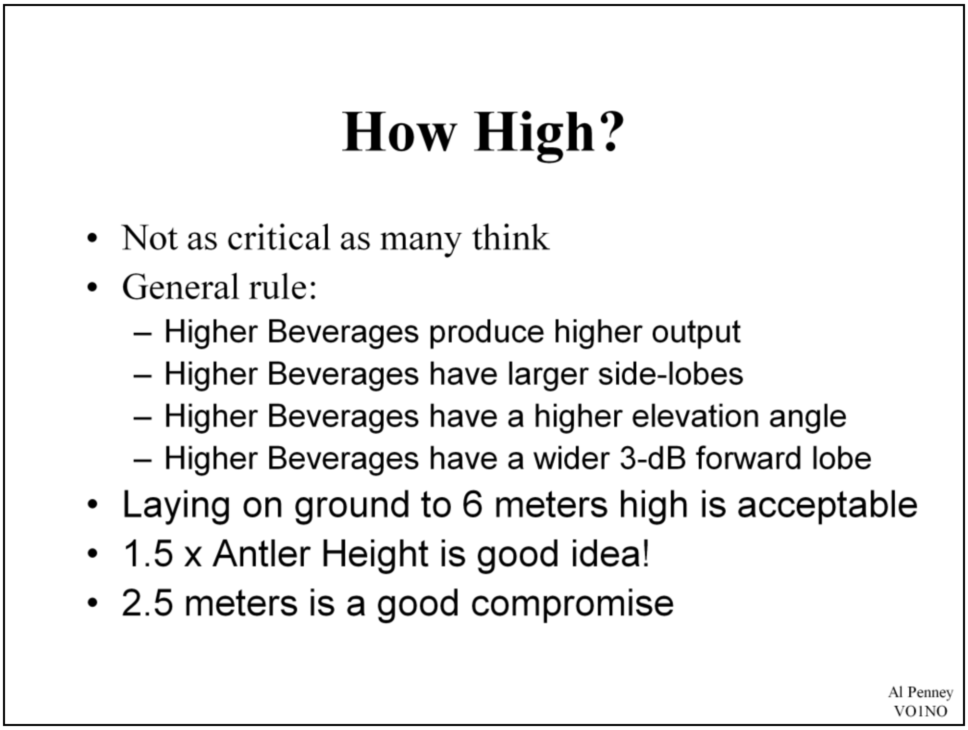
Al Penney
VO1NO

One limiting factor is the phase difference that will occur between the EM wave in free space, and the slower induced EM wave in the antenna. As the antenna is increased in length, that phase difference grows until the EM wave in free space is actually subtracting from the induced wave in the antenna. Of course, the slower the wave in the antenna (ie: the lower the velocity factor), the shorter the antenna will be before that point is reached.

The velocity factor of a Beverage will vary typically from about 90% on 160 meters to 95% on 40 meters. These figures are for a height of 3.0 to 3.5 meters. At a 1-meter height the velocity factor can be significantly lower, depending on ground quality. BOGs (Beverages on ground) may have a velocity factor around 60%, which means that very short, very low Beverages can exhibit radiation patterns similar to higher Beverages that are much longer.

This equation is used to calculate a maximum effective length based on the velocity factor. If we use a VF of 90% for a 160M Beverage (assuming 3 meters above the ground), then the MEL is 360 meters, or 2.25 Lamda. For a wire laying on the ground with a VF of 60%, the MEL is 60 meters, or 0.375 Lamda.

Even before this MEL limit is reached in antennas with a high VF however, there is another limiting factor. There is such thing as *space diversity*, which means that wave characteristics change with place. As long as you stay within a radius of approximately two wavelengths, this usually does not cause any problems. This is the reason why very large arrays and very long Beverages, may actually behave differently from what the model tells us. "*Longer is better*" does not hold true for Beverages (as for any large receiving array). Besides, we have already seen that gain is not an important factor in RX antennas – directivity is.



The general rule is as follows:

- 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

The height is not all that critical. Below 2 meters, Beverages can be a hazard for men and animals. If you must cross a driveway or small street, you can put your Beverage up to 6 meters high and still have a working Beverage. You can also slope the Beverage gently up from 2 meters to 6 meters to cross the obstacle without much harm at all. Tom, W8JI, writes on his Web page (**www.w8ji.com**): "I*'ve found very little performance difference with height, unless the Beverage is more than 0.05 λ high."*

If the Beverage can be constructed on terrain that is inaccessible to people, deer and other animals, then you can consider using Beverages at a height of 0.5 or 1 meters for added high-angle discrimination and reduced omnidirectional pick up.

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

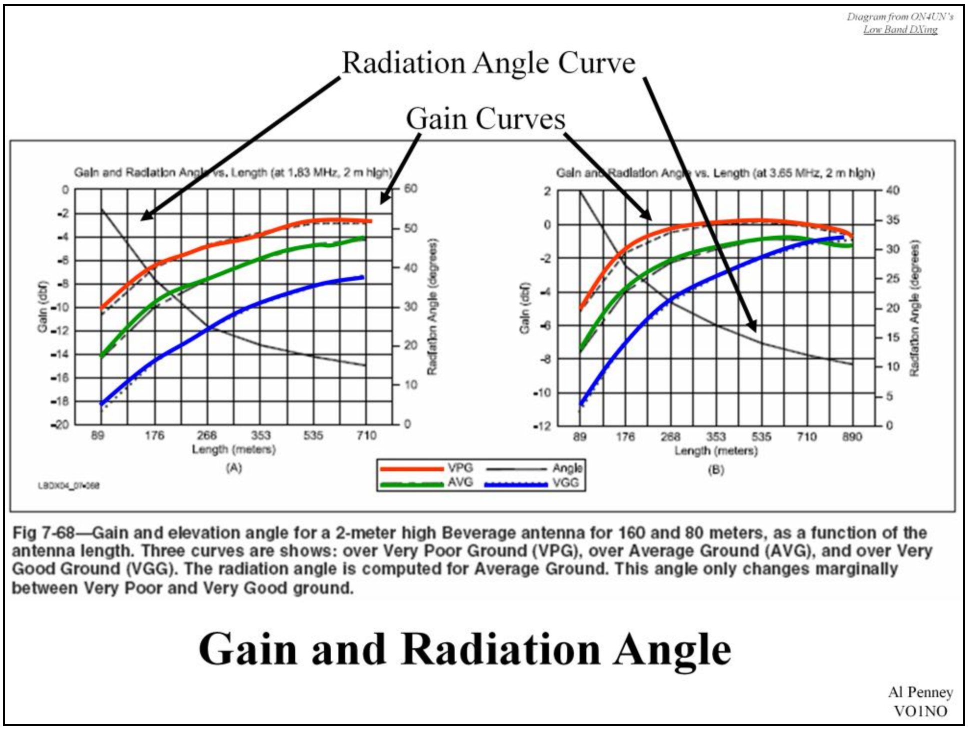
Al Penney
VO1NO

- The better the ground, the lower the output from the antenna (around 6 to 8 dB difference between very poor ground and very good ground). But even over very good ground Beverages have more than enough gain.

- The peak elevation angle changes only slightly with ground quality. For example, a 300-meter long Beverage peaks at 27° over Very Poor Ground. The response at 10° elevation is down 3.4 dB from the peak. Over Very Good ground, the lobe peaks at 29°, and the response at a 10° elevation angle is down 2.8 dB from the peak response.

- The poorer the ground quality, the less pronounced the nulls will be between the different lobes. This is similar to what we notice with horizontally polarized antennas over real ground.

- The directivity factors (DMF and RDF) of a Beverage antenna remains almost constant for grounds ranging from Very Good to Very Poor.



The elevation angle: The radiation angle only changes marginally (a few degrees) between very poor ground and very good ground. The elevation angles shown in Fig 7-67 are for Average Ground. Note the large difference in elevation angle between long and short Beverages: 17° for a 3-λ long antenna and approximately 40° for a 1-λ long antenna!

Gain: **Fig 7-68** shows gain curves vs length, over very poor ground, average ground and very good ground. As indicated above, the gain figures may be a little optimistic, a known flaw with *NEC-2* for antennas close to the ground. From these curves it may seem that maximum usable length is determined by the way gain diminishes beyond a certain length. This is not important because gain is not an important parameter with receiving antennas.

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

Al Penney
VO1NO

- Insulated wire may be better if antenna can rub against tree branches. Insulation can also hide a broken conductor.

-Long spans may be necessary, so pre-stretch soft-drawn copper wire.

-Multi-conductor wire fine – solder ends together and use all conductors.

Theoretical Surge Impedance

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

Where:

h = height of wire

d = wire diameter (in same units)

Typical value is 450 to 500 Ohms

Al Penney
VO1NO

The theoretical impedance values calculated using this formula assume perfect ground. They are useful for estimating the terminating resistor for a single-wire Beverage and for designing matching transformers and networks. Note that the impedance does not change drastically with height or wire size.

Over real ground however, the surge impedance appears to be higher than over perfect ground. This is because the electrical ground is not the surface of the ground, but a little deeper. The following correction figures can be used:

Good ground: +12%

Average ground: +20%

Very poor ground: +30%

Typical values range from 300 Ohms for a Bev laid on the ground, to 650 Ohms for very thin wire at 5 meters height. Practical values are usually 450 to 500 Ohms.

Photo from ON4UN's Low Band DXing

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

Al Penney
VO1NO

Riki, 4X4NJ, described such a homemade spark gap: "*The spark gap consists of heavy solid wires—about 10 AWG, soldered to teardrop terminals that are placed under the screws going to the antenna and ground. The ends of the wires are cut with "side cutters" leaving a nice "knife edge," and I position the two edges very close to each other. A piece of paper makes a nice "feeler gauge" for this purpose. It is very effective, most simple, and negligible cost*."

Photo is of K9DX Beverage termination. Using fuse clips allows resistors to be replaced easily if burnt out by nearby lightning strike.

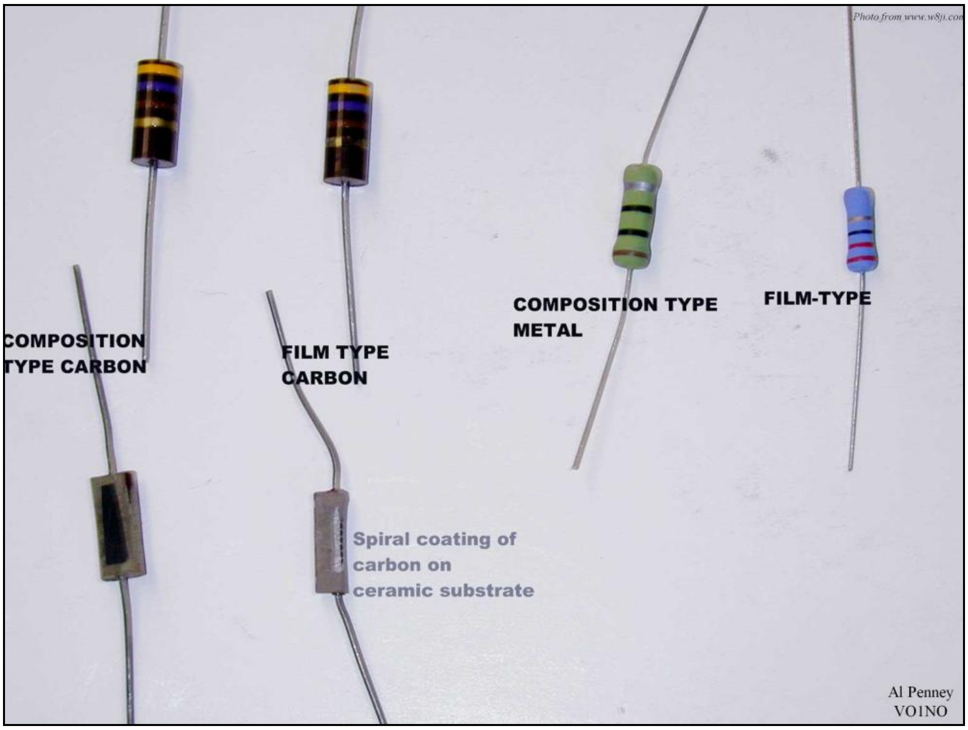
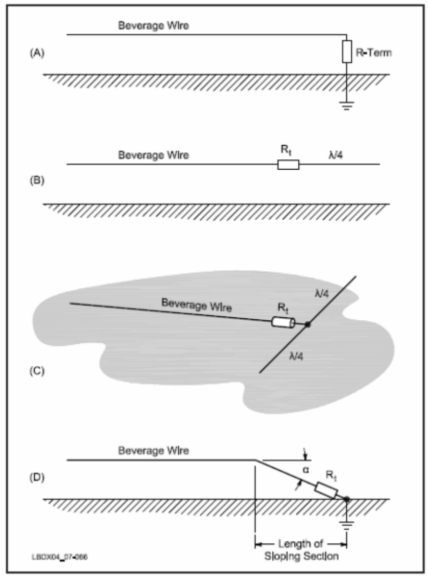


Photo from www.w8ji.com
COMPOSITION TYPE CARBON
FILM TYPE CARBON
COMPOSITION TYPE METAL
FILM-TYPE
Spiral coating of carbon on ceramic substrate
Al Penney VO1NO

Diagram from ON4UN's
Low Band DXing



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VO1NO

Methods to terminate a Beverage antenna.

Different terminating systems for Beverage antennas. The version at A suffers from stray pickup because of the vertical down lead. At C, two in-line quarter-wave lines terminate the Beverage, by which the radiation from these lines is effectively canceled. This is not a very practical solution because of its area requirements. This configuration is used through the book for modeling Beverage antennas, however. At D, the method most widely used with real-world Beverages. Using a long sloping section is thought by many to reduce omnidirectional pickup.

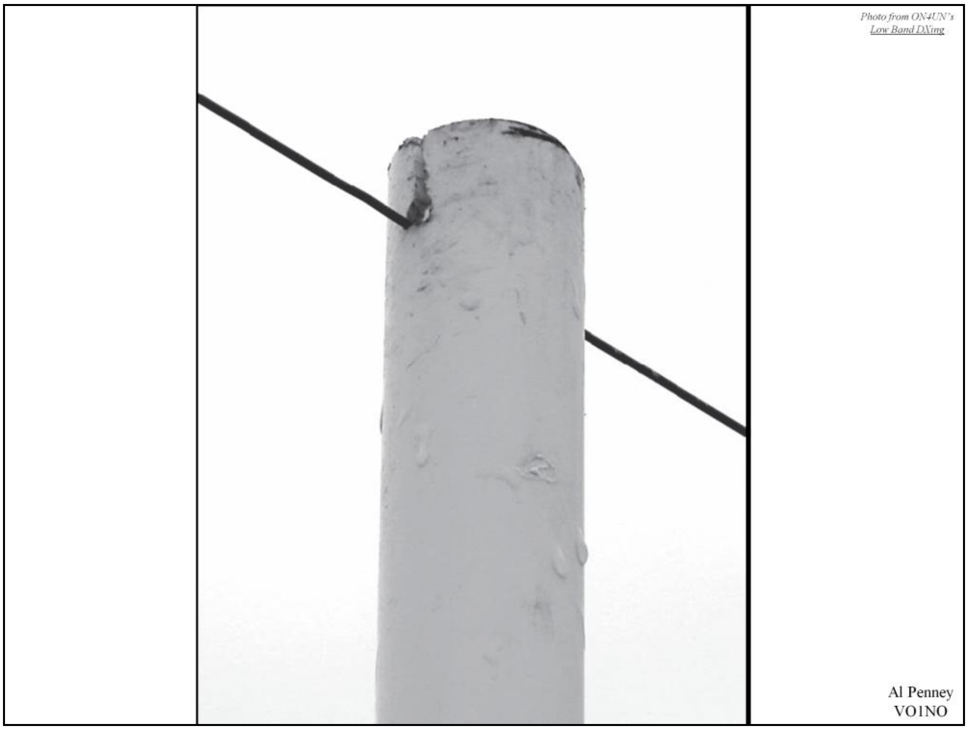
In reality, vertical drop is vertical drop, no matter if it is over 20 meters, or straight down. If it weren't, then the K9AY and similar antennas would not work!

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

Al Penney
VO1NO

If the terrain is irregular, minor ups and downs in height or dips or valleys will not ruin your Beverage performance though. If your terrain is not flat, follow the contour of gradual slopes and go straight across ditches or narrow ravines without following the contour.



PVC pipe with slot sawn in the top.

Photo from www.w8ji.com

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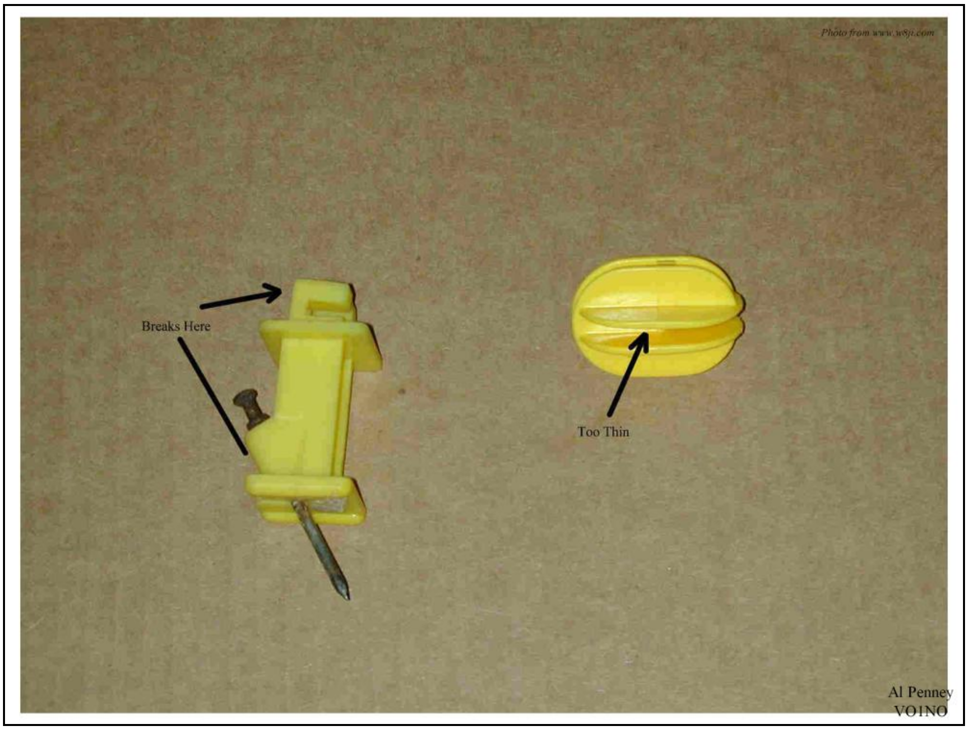
VO1NO

Recommended by W8JI

Try to have the wires able to slip through insulators. Easier to detect a wire break, and lessens the chance of the wire actually breaking.

Recommended by W8JI



Not recommended by W8JI (though I use the same type of standoff insulator!)

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.)

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VO1NO

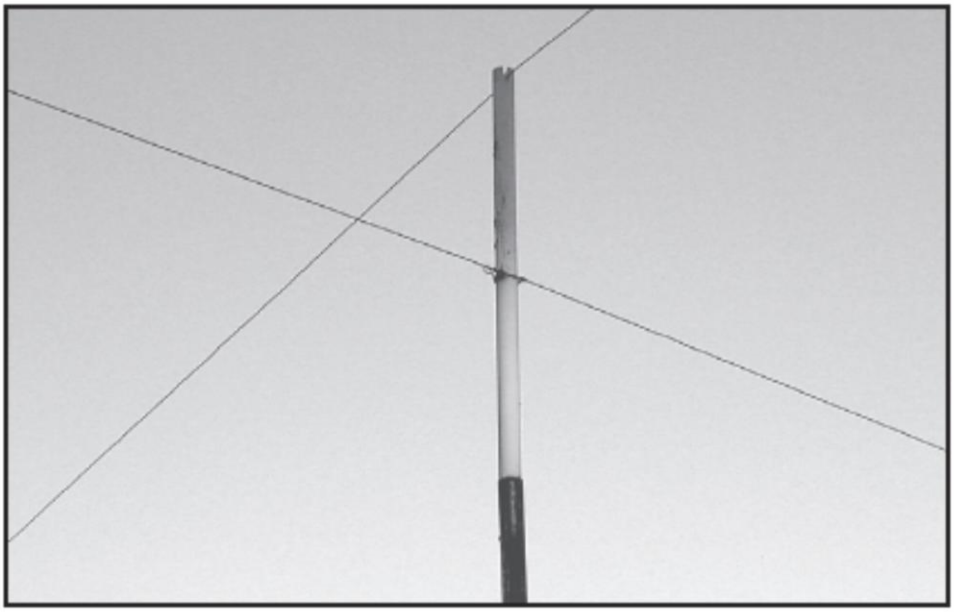
Parallel Beverages

Beverages are non resonant and exhibit very little mutual coupling. The rule of thumb is to keep two parallel Beverages separated by a distance equal to their height above ground. This separation guarantees a decoupling of at least 30 dB.

Crossing Beverages

Beverage antennas for different directions may cross each other if the wires are separated by at least 10 cm (4 inches). Beverage antennas should also not be run in close proximity to parallel conductors such as fences, telephone lines, power lines (even if quiet) and the like.

Photo from ON4UN's
Low Band DXing



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A field expedient way to separate two crossing Beverage antennas when I discovered that the top wire had sagged down onto the lower wire. There was 4 feet of snow on the ground when I discovered this, so I wasn’t about to put up another pole to hold them apart!

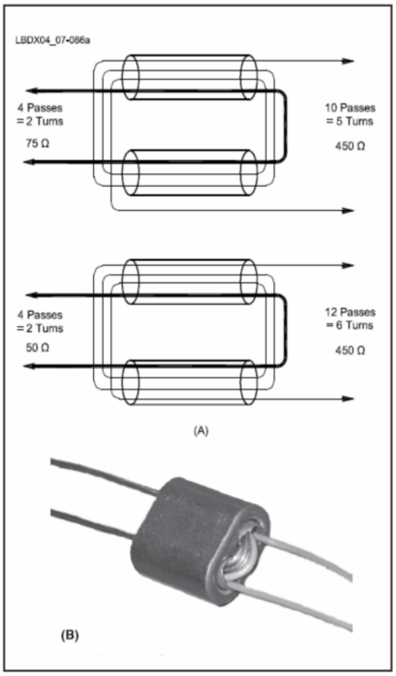
Matching the Beverage Antenna

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

Al Penney
VO1NO

ON4UN has a discussion on the various matching transformers that could be employed. I prefer the binocular cores recommended by W8JI. Separate windings help prevent spurious signal pickup on the coax shield.

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)

Al Penney
VO1NO

Coax

- Can use 50 or 75 Ohm cable
- Some now use CAT5 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?

Al Penney
VO1NO

- Even with inexpensive TV quality 75 Ohm cable, losses in runs of several hundred feet are acceptable.

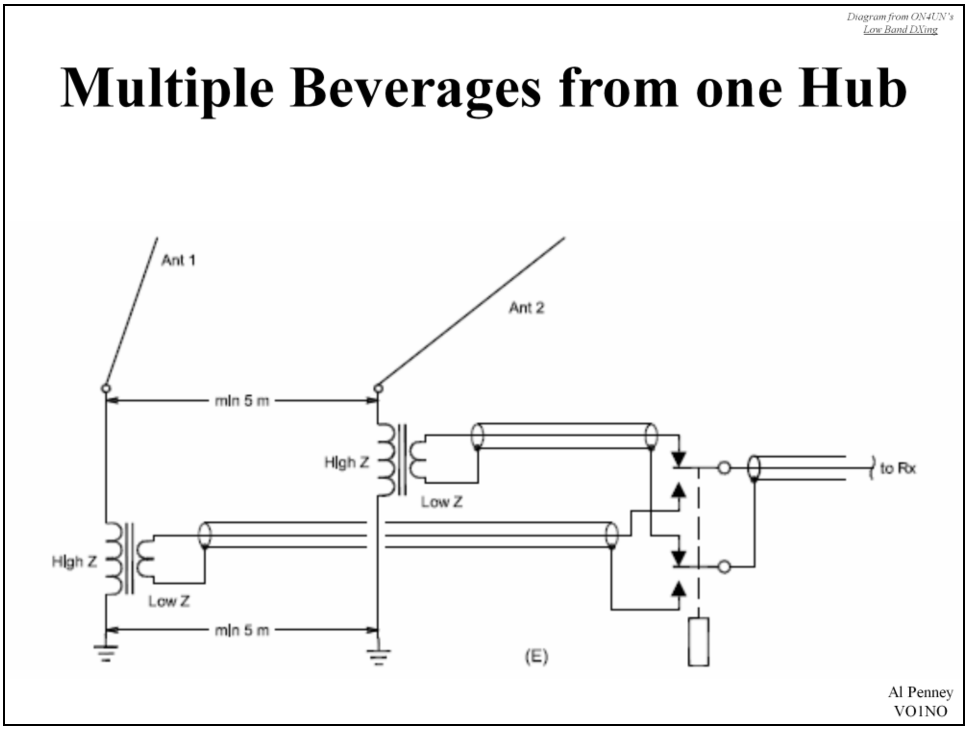
-Do not suspend coax – keep on ground to prevent signal pickup on shield.

-Use flooded cable if critters a problem.

-Use RF chokes to keep signals off shield - Five turns of miniature coax through a FT150A-F core (μ = 3000 and A^L = 5000) achieves an impedance of 1500 Ω (7 turns = 3 kΩ on 160 meters).

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



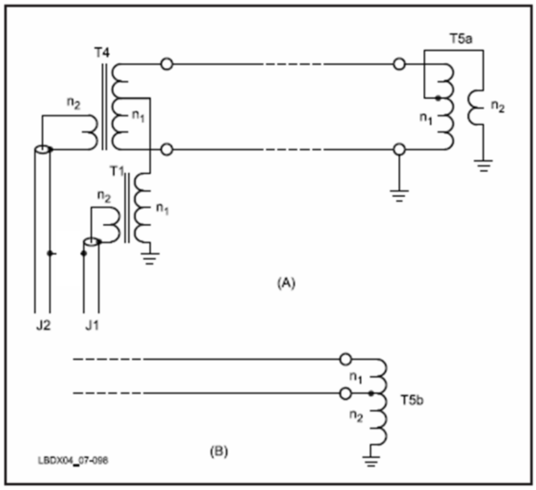
Make sure you always switch both the inner conductor and the shield of these feed lines. Do *not* connect the shields of all these feed lines together or to a common ground. If you want to ground them, do so at a distance of 5 meters from the switch box, to individual ground stakes that are well separated.

If at all possible I suggest using widely separated end posts for the Beverages, with at least 5 meters separation and separate grounds (Fig 7-92E). Avoid using the antenna ground of one antenna as the termination ground of another one that might be running in the opposite direction.

Little or no coupling occurs between the antenna wires, unless they are parallel and quite close together. I have not noticed any problem with antennas arriving at one point under a 30° angle.

Diagram from ON4UN's Low Band DXing

Two Directions from one Beverage



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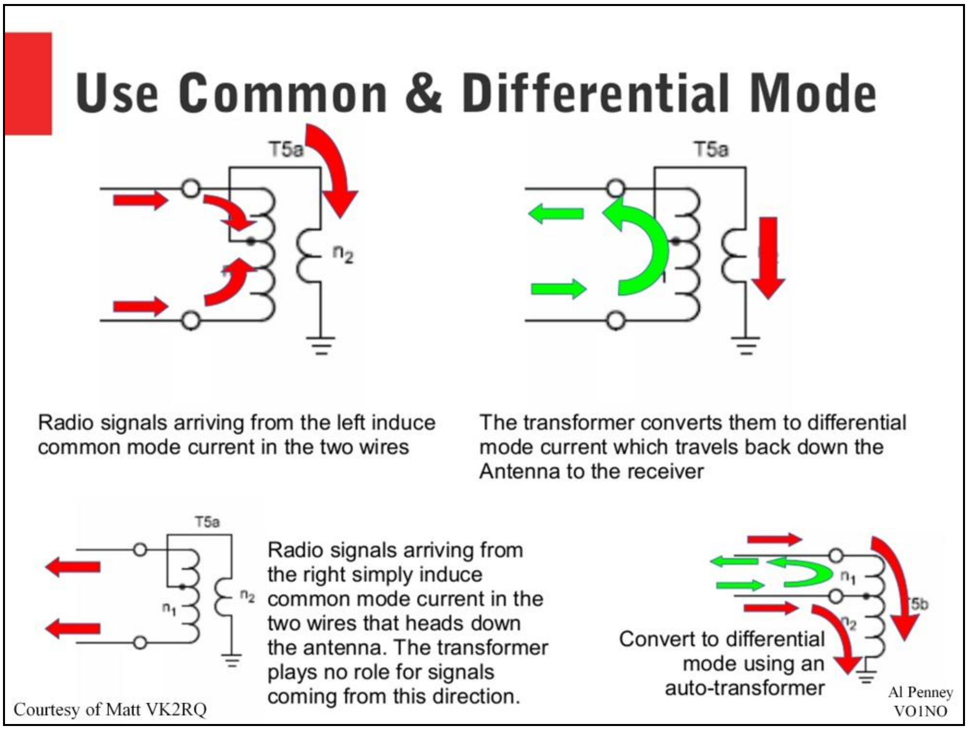
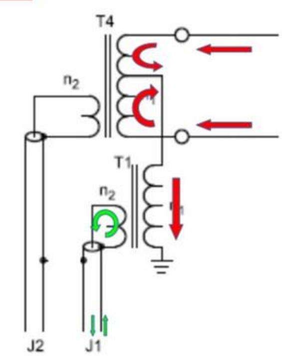
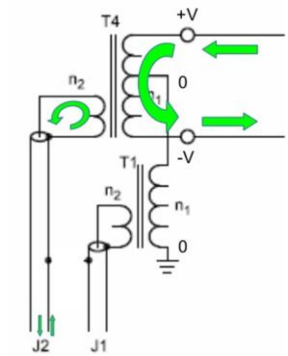
At A, open-wire two-direction Beverage antenna. This uses reflecting transformers to obtain both reflections and proper impedance matching (see text for details). At B, an autotransformer is used for the same purposes.


Use Common & Differential Mode
T5a
n2
T5a
Radio signals arriving from the left induce common mode current in the two wires
The transformer converts them to differential mode current which travels back down the Antenna to the receiver
T5a
n1
n2
Radio signals arriving from the right simply induce common mode current in the two wires that heads down the antenna. The transformer plays no role for signals coming from this direction.
n1
T5b
n2
Convert to differential mode using an auto-transformer
Courtesy of Matt VK2RQ
Al Penney VO1NO

Separating CM & DM currents





Common mode currents cancel in T4 primary winding, so nothing induced in T4 secondary. Common mode currents flow through T1 primary, induce a differential mode current in T1 secondary, which is available to a receiver connected to J1

Differential mode current in T4 primary winding induces differential current in T4 secondary winding, which is available to a receiver connected to J2.
Because antenna is a balanced line, centre tap on T4 primary is at 0V ground potential, so no current flows through T1 primary.

26

Courtesy of Matt VK2RQ

Al Penney
VO1NO

Diagram from ON4UN's
Low Band DXing

Another Method…

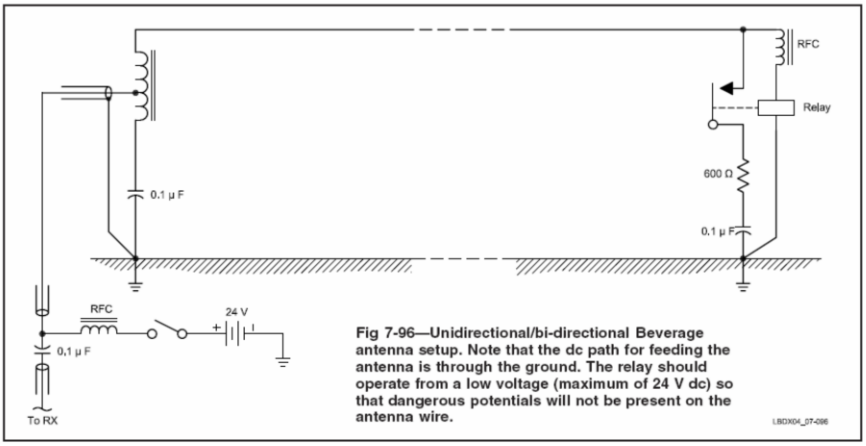


Fig 7-96—Unidirectional/bi-directional Beverage antenna setup. Note that the dc path for feeding the antenna is through the ground. The relay should operate from a low voltage (maximum of 24 V dc) so that dangerous potentials will not be present on the antenna wire.

Al Penney
VO1NO

When the Beverage antenna is not terminated, the directivity will be essentially bi-directional. In real life the unterminated Beverage is not a true bi-directional antenna. The SWR and the loss on the antenna make it have some F/B. F/B is related to standing waves on the antenna; that is, to the reflection making it back to the receiver. There is slight attenuation from the back direction because of the extra loss of the reflected wave in the wire.

A method of switching the Beverage from unidirectional to bi-directional is shown here. A relay at the far end of the antenna wire is powered through the antenna wire and the earth return via an RF choke and blocking capacitors.

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

Al Penney
VO1NO

Can you really improve Beverages by phasing them? Theoretically you can achieve a narrow forward lobe (and hence a very high DMF) using a very long Beverage. To achieve the same 55° frontal lobe beamwidth as from an 8-Circle antenna (Section 1.30), you would need a 3-λ long Beverage (~550 meters on 160 meters), which poses two problems:

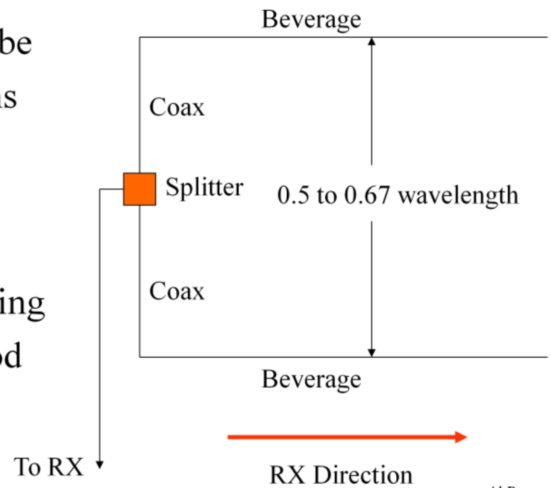
Not many have that much room for such long Beverages.

You run into space-diversity problems with this long an antenna, and you will never reach the results predicted by modeling.

The only way to achieve a similarly narrow forward beam and hence a very high RDF is to use a broadside array of Beverages, exactly the same as what we did with short verticals in Section 1.11. You can obtain excellent results with shorter Beverages (1 to 2 λ long) but these require a broadside spacing of a little over λ/2. There is no free lunch!

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!



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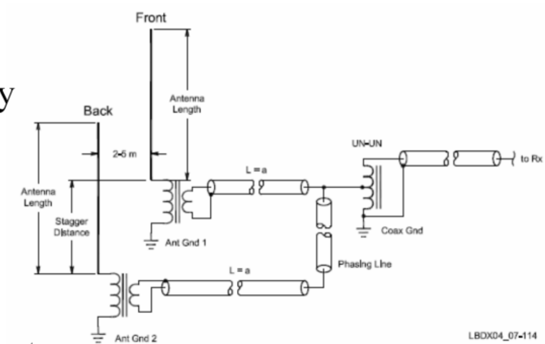
If the spacing is too wide, phase differences caused by space diversity will negatively impact directivity.

Diagram from ON4UN's
Low Band DXing

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



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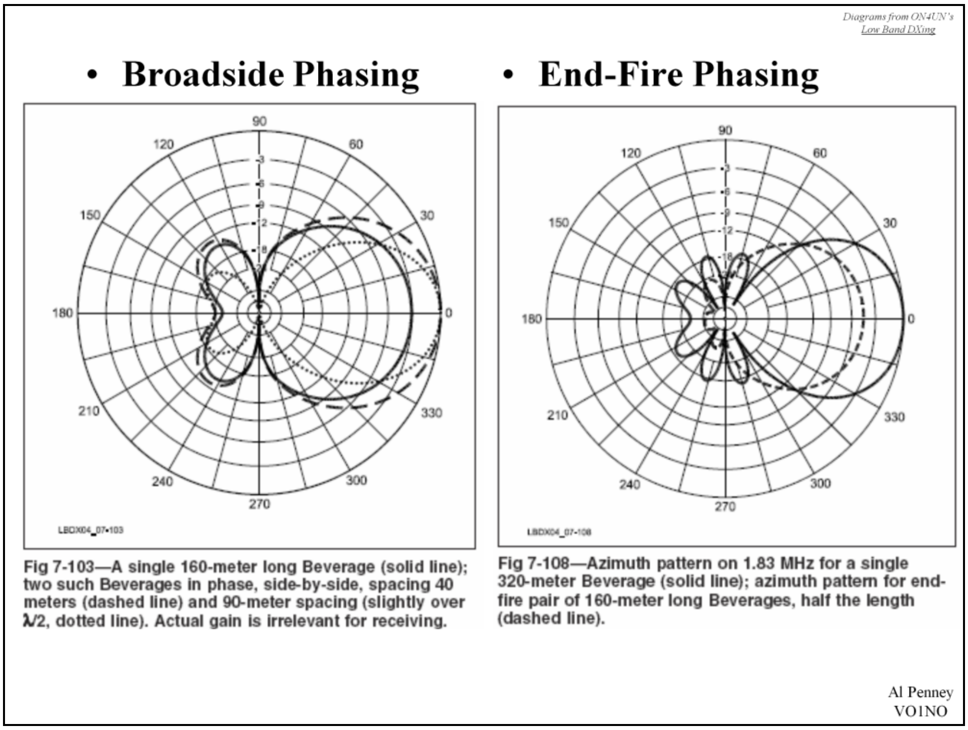
This method requires a phasing line, and is therefore limited to one band. There is a simpler method that permits multi-band use however.

End-fire phased Beverages at W3LPL

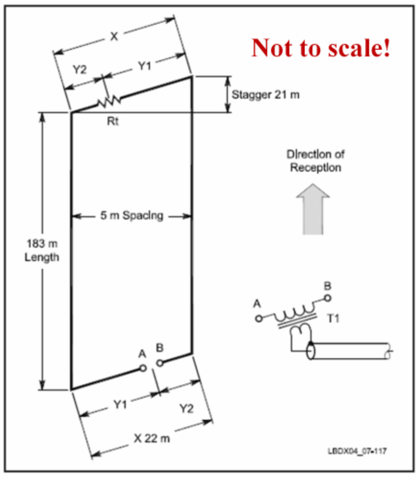


Broadside Phasing - **A single 160-meter long Beverage (solid line); two such Beverages in phase, side-by-side, spacing 40 meters (dashed line) and 90-meter spacing (slightly over λ/2, dotted line). Actual gain is irrelevant for receiving. Note very little little change in pattern with 40-meter spacing other than 3 dB improvement in gain (irrelevant for RX). With 90-meter spacing the frontal lobe is much sharper.**

End-Fire Phasing - **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). Note that while gain is greater with the long single beverage, the side and rear lobes are very sharply reduced on the end-fire pair of shorter Beverages.**

Diagram from ON4UN's
Low Band DXing

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

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VO1NO

Here is the W8JI's description of the antenna: "*Although it looks like a large horizontal loop, this antenna actually is an array of two ground-connection-independent end-fire staggered Beverages. The short end wires form two single-wire feed lines at each end. One end-wire is series terminated with exactly twice the resistance of a normal Beverage, while the short wire at the opposite end is the feed-point.*

Stagger and spacing determines feed and termination location, the offset at the two ends being mirror images. A top view, looking down from straight above the antenna is given in **Fig 7-*117***.

Notice the feed point is offset towards the termination end (front) of the antenna, and away from the null direction. This is typical for crossfire phased arrays. Crossfire arrays respond away from the delay line direction, exactly opposite conventional arrays. The termination is offset the same amount, but moves towards the feed-point end of the antenna.

The feed-point terminals, being floated (push-pull), provide 180-degree phasing between the two elements. The extra line length to the forward (left and front) element provides the "Stagger" delay. Consider the actual wire length of a "short side" called "X" (which is the same as Y1+Y2). This length is the same on both ends of the antenna. The difference between Y1 and Y2 must equal or be slightly less than stagger (S).To determine the offset of feed point and load:

1. Measure length of the end-wire, length "X."

2. Measure stagger in the end-fire direction, "S"

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

Al Penney
VO1NO

In the shack I have a control box with a knob surrounded by 8 LEDs. As the knob is rotated, a direction is selected, and the corresponding LED is illuminated. I have two coax cables running from the control box to three remote switchboxes in the field (one switchbox feeds into another), and coax running to the receive input on my rig. The switchboxes use relays to switch both the center conductor and braid of the coax to select the proper antenna i.e.: direction. Switching both conductors is important - directivity can be lost if this is not done. As a particular direction is chosen in the shack, the appropriate coax is selected, and the proper control lines energized so as to activate the required relays in the remote switchboxes. Also, 24VDC is applied to the center conductor of the coax that runs to the remote switchbox. More on that in a moment.

I use a Kenwood TS-950SD on HF. It has two RCA plugs on back – RX Ant Out and RX Ant In. Normally they are connected with a jumper, but they can also be used to connect a separate RX antenna. I run a cable from both to the control box. Using the knob in the lower right, I can connect the Beverage antennas, or several other RX antennas, including my K9AY. I can also bypass the RX antennas, feeding the RX Ant Out into the RX Ant In. This makes it easy to use other antennas when I go to higher bands.

The control box also takes a feed from the PTT line. When I transmit, a relay is keyed to ground the input from the active Beverage. It might not actually be needed, but better safe than sorry! There is also room for a pre-amp if I ever need one.

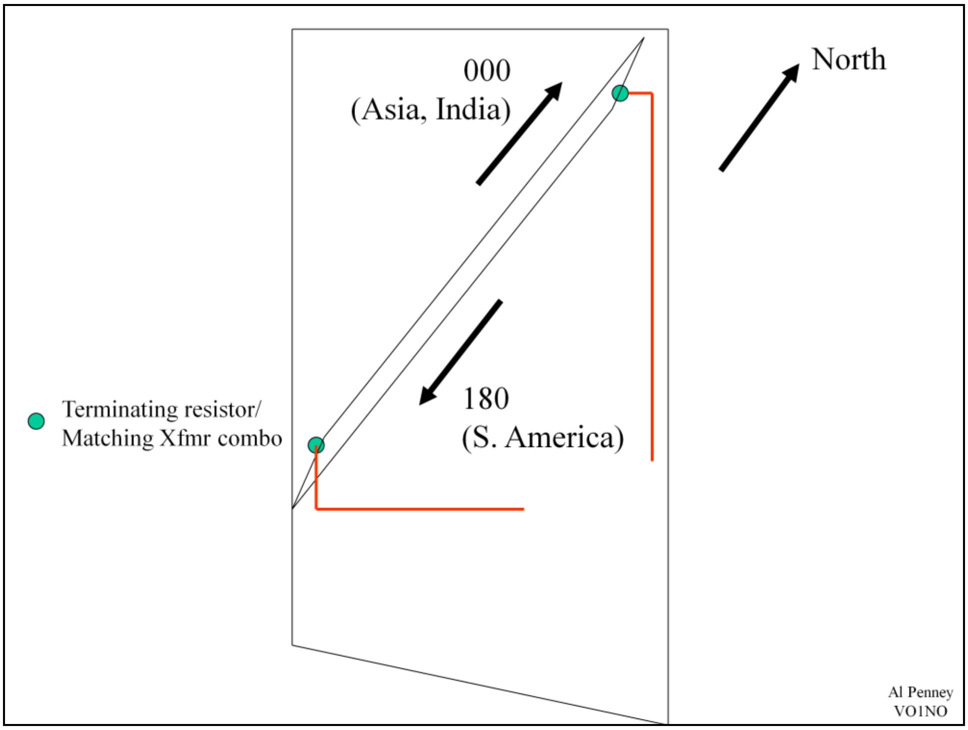
Why did I use 24VDC? I had lots of 24VDC relays and a 24 VDC power supply. It also suffers from less I2R losses in the control lines and coax center conductor.

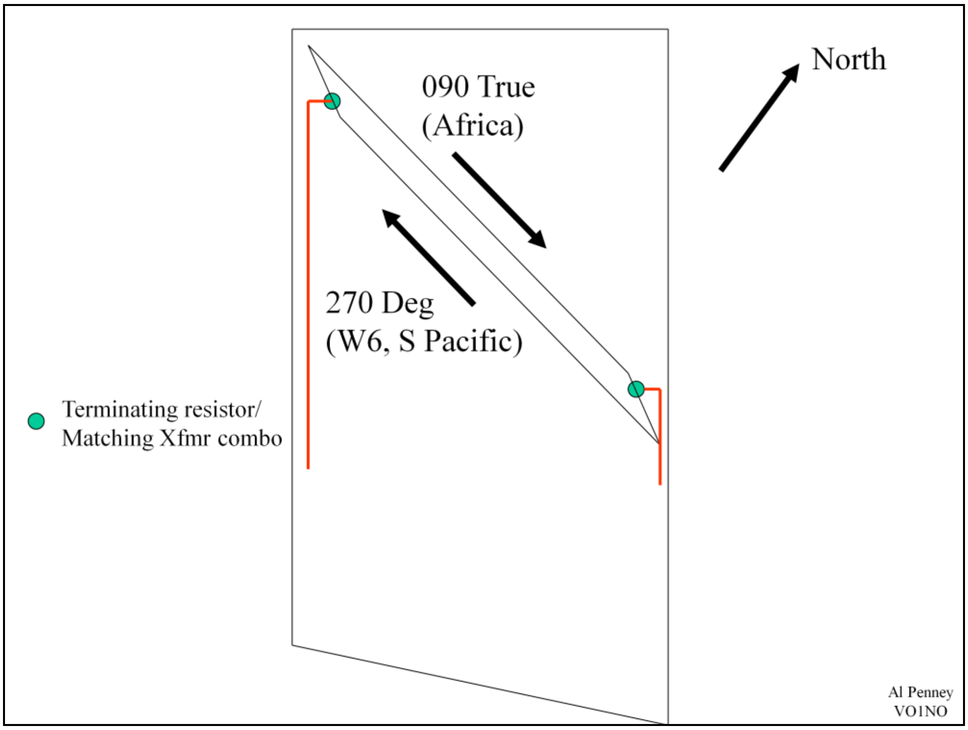
I use end-fire phased Beverages, using the crossfire phasing method. Because of the symmetry of the feedpoint and termination resistor, I can get two directions from each pair. Each end of the array is fed with 75 ohm cable. The antenna feedpoint at each end is connected to a terminating resistor through a relay in a termination box. As described in the previous paragraph, when a particular direction is chosen, the appropriate relays are activated to connect the coax from the proper antenna array to the coax running from the control box. When this happens, 24 VDC is present at the termination box at the end of the antenna. That voltage is used to activate a relay that switches the termination resistor out, and the matching transformer in. Voila - the receiver is now connected to a pair of staggered phased Beverage antennas! Of course, DC blocking capacitors are used in the appropriate locations in the termination boxes and control box.

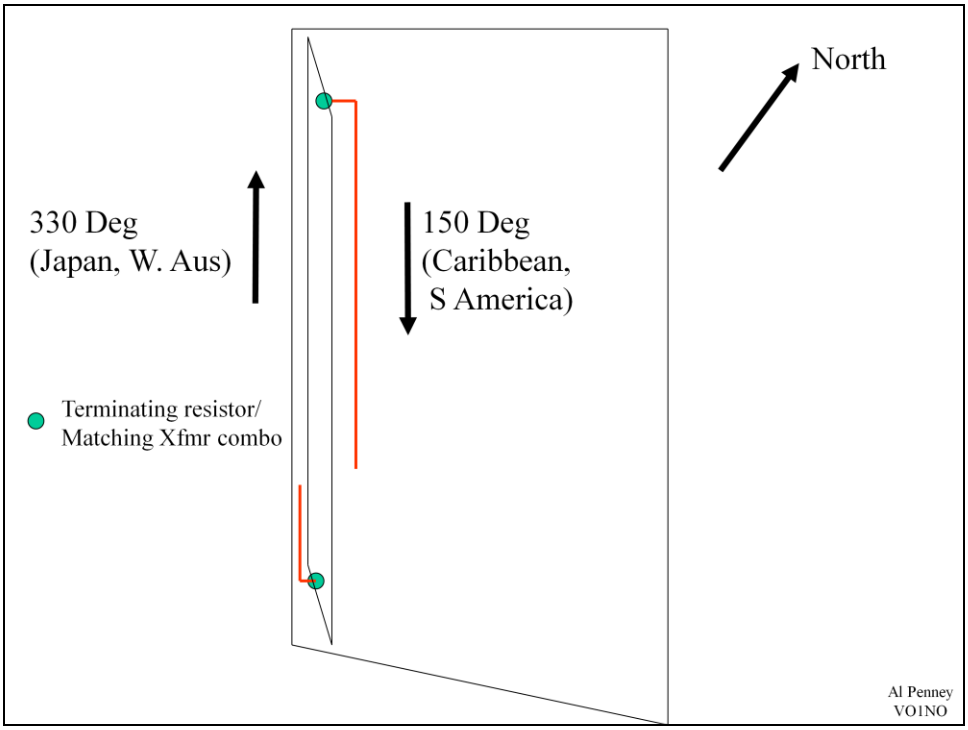
I found a use for empty anti-perspirant containers! Spray painted to protect from UV radiation, they make great boxes for housing the terminating resistor, matching transformer, relay and associated circuitry. The bottom is left open to allow moisture to drain. Although not apparent in the photo, the termination boxes and coax switchboxes have LEDs to indicate when voltage is applied. This makes troubleshooting easier.

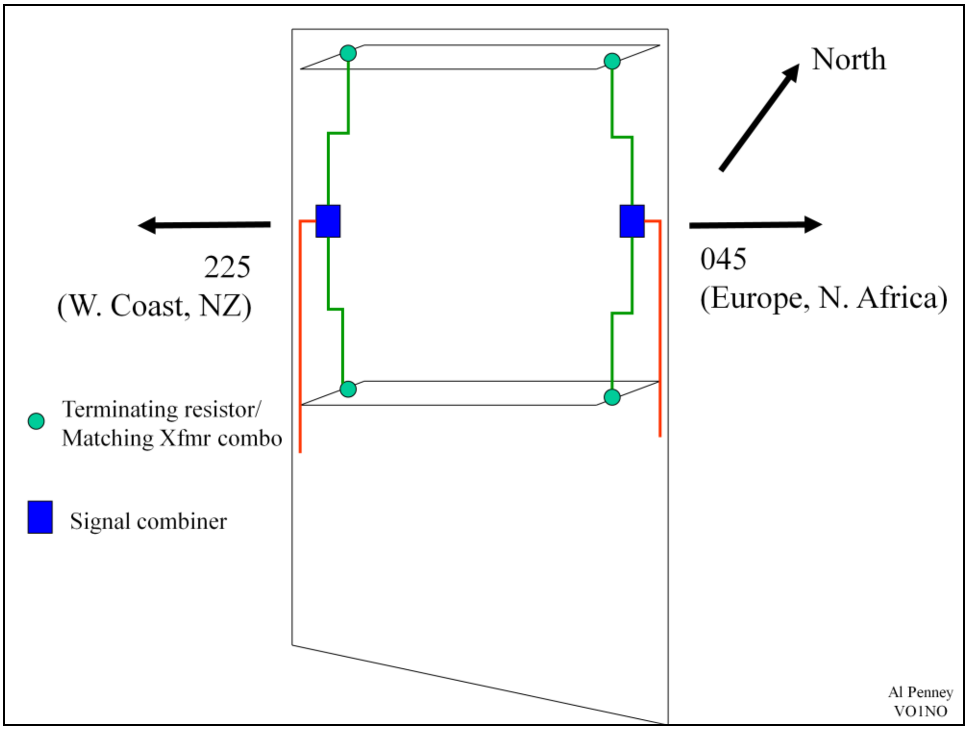
Most of this was put up in the winter, with 1 meter of snow on the ground! It will be tidied up this fall.

I use 8-foot long 2x2 pieces of lumber, attached to shorter pieces driven into the ground. Supports at the 4 corners are backed up with guy lines. Note the coax coil RF choke. It needs several cores to increase the choking effect.


000
(Asia, India)
North
Terminating resistor/
Matching Xfmr combo
180
(S. America)
Al Penney
VO1NO


North
090 True
(Africa)
270 Deg
(W6, S Pacific)
Terminating resistor/
Matching Xfmr combo
Al Penney
VO1NO


North
330 Deg
(Japan, W. Aus)
150 Deg
(Caribbean,
S America)
Terminating resistor/
Matching Xfmr combo
Al Penney
VO1NO



Unfortunately, the direction to Europe corresponds to the narrowest dimension of my property, about 320 feet. To improve performance here, I am broadside phasing two pairs of echelon phased Beverages i.e.: I have two sets of echelon phased Beverage pairs, spaced at 300 feet, and fed with equal lengths of coax into a signal combiner - a total of 4 Beverages for these two directions. I can also select just one pair of echelon phased antennas if necessary.

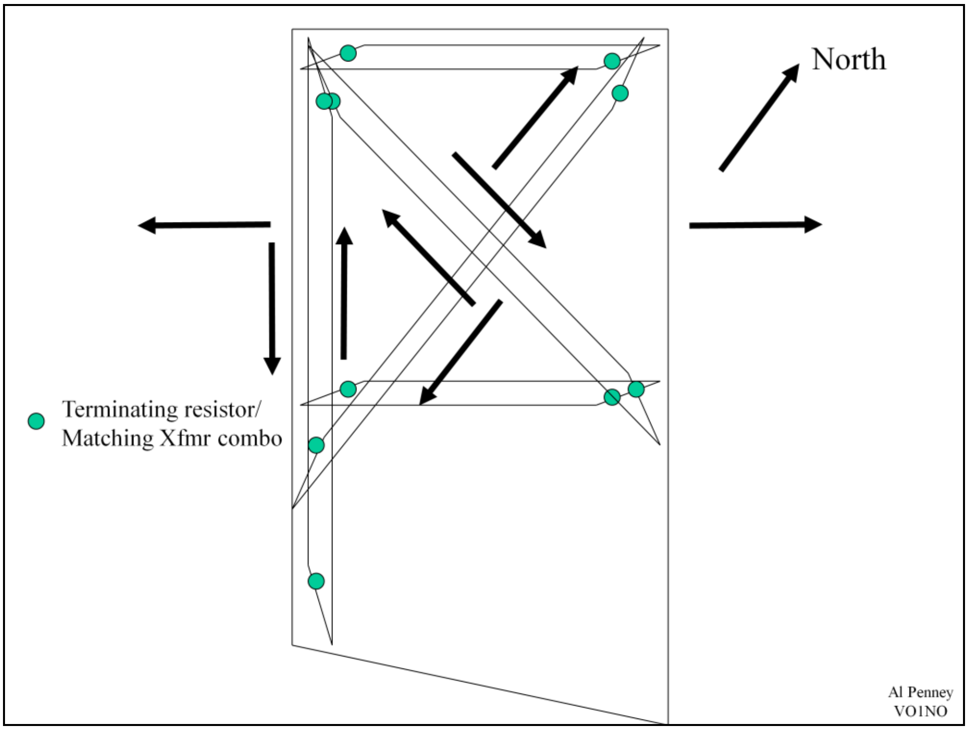
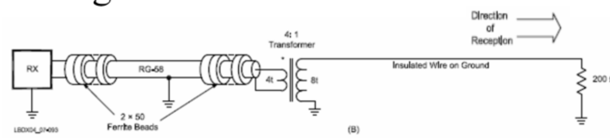

North
Terminating resistor/
Matching Xfmr combo
Al Penney
VO1NO

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



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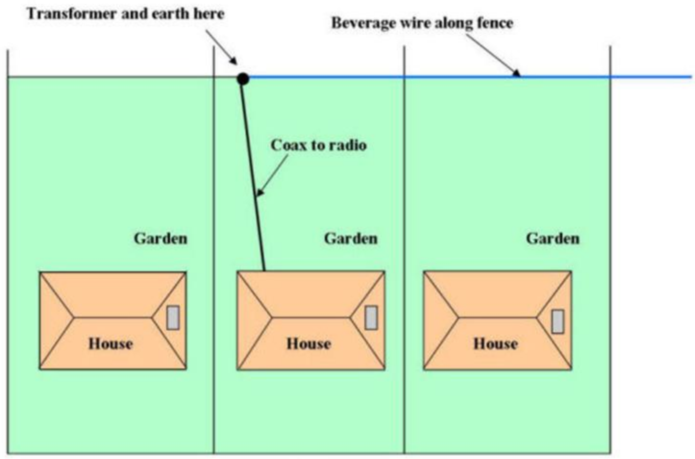
Note that the length of a BOG will be less than that required for a Beverage supported off the ground.

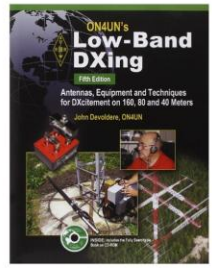


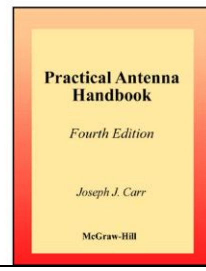
Example of an urban beverage installation

Al Penney
VO1NO

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.





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Questions?

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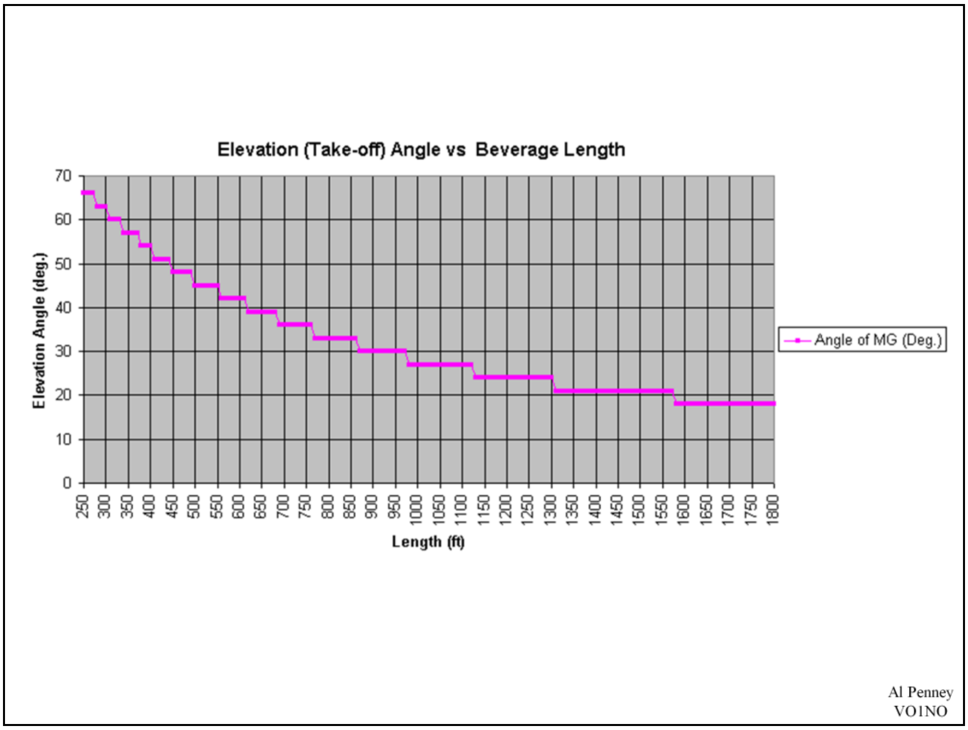
Extra Slides

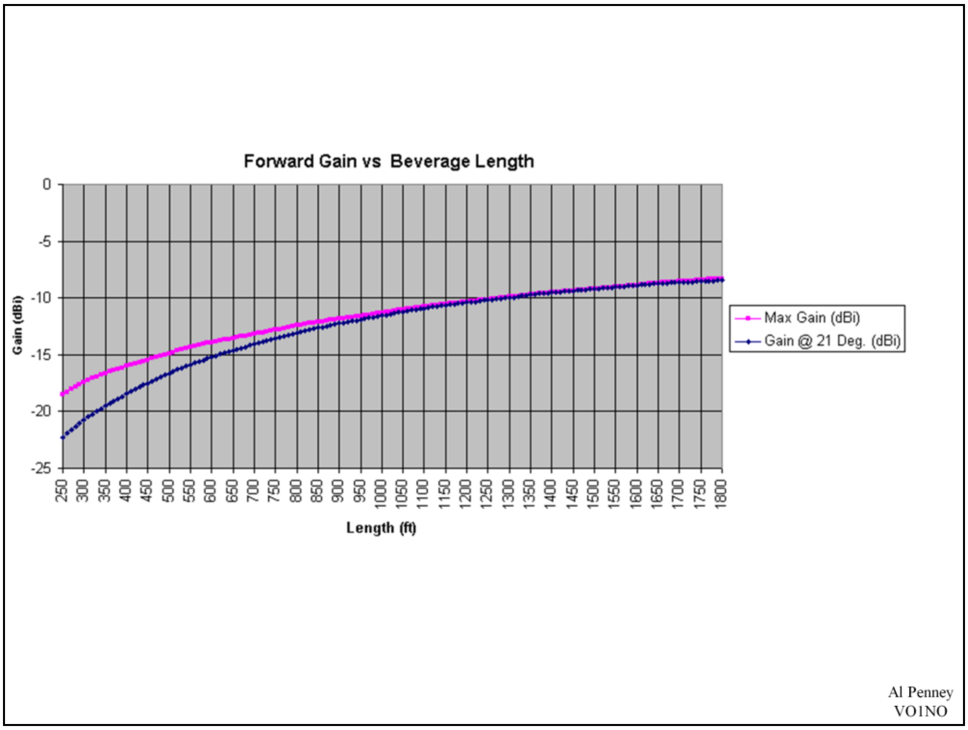


As the Beverage becomes longer, the angle of maximum gain monotonically drops. When the length is 250 feet, the take-off angle is 66 degrees, a high angle that is not usually useful for DX. Usual DX take-off angles range between 10 and 30 degrees.

The first thing we notice about this graph is that it is not continuous, but steps in units of 3 degrees. This is due to the simulation parameters, and the selection of the angular spacing in the three-dimensional grid (EZNEC *step size*). In other words, this graph is an approximation of the real data. Samples are computed every 3 degrees. If you draw a smooth curve through this graph you will have the actual elevation angle.

As we have seen before, the rate of change is faster at shorter antenna lengths. The half-way point between 66 degrees and 18 degrees is 42 degrees. The take-off angle reaches 42 degrees when the antenna is 570 feet long.

The elevation angle continues to drop as the Beverage becomes longer. At a length of 8000 feet, the take-off angle is 6 degrees. It clearly cannot go below 0 degrees, and I do not know if it stops before 0 degrees.



I recorded the forward gain in two different ways. First, I measured the absolute maximum forward gain. As the Beverage becomes longer, the maximum gain always increased. But, the elevation (take-off) angle of maximum gain slowly drops, from 66 degrees to 18 degrees. In dBi, the gain goes from -18.53 dBi to -8.31 dBi. Now we can see why a Beverage is usually not used for transmitting. A half-wave dipole or quarter-wave vertical, even a poor one, probably has a positive gain with respect to an isotropic radiator. This is a difference of approximately 10 to 20 dB, which is a substantial difference.

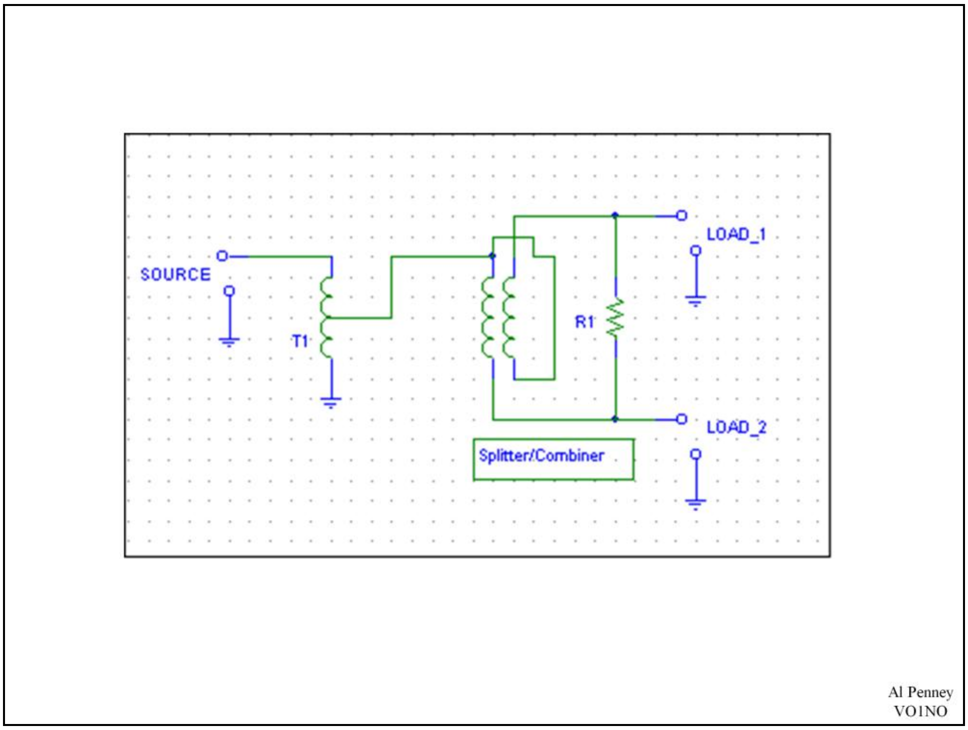
I also measured the forward gain at a take-off angle of 21 degrees. I selected this angle because it is a typical DX angle.

At the 250 foot length, the maximum gain is -18.53 dBi. At that same length, the gain at a 21 degree take-off angle is -22.27 dBi. As the Beverage gets longer, the two curves slowly overlap, since the take-off angle of maximum gain drops to 21 degrees (and eventually goes under 21 degrees). For all practical purposes, the two curves start to overlap at approximately 1200 feet. At 1800 feet, the maximum gain is -8.31 dBi, at an elevation of 18 degrees.

As the antenna becomes even longer, the gain continues to increase, and the elevation angle continues to drop. The gain peaks at a length of 6000 feet. The gain at that length is -5.38 dBi, and the take-off angle is 9 degrees. 9 degrees may be too low of an angle for typical DX conditions. If we consider the gain at 21 degrees, the gain peaks at an antenna length of 2500 feet. The gain at that length, at 21 degrees take-off, is -7.82 dBi.

As we move from a 250 foot to 1800 foot Beverage, the gain at a typical DX take-off angle increases by approximately 14 dB. The gain increase is monotonic. Gain always increases, it never decreases, either at the maximum gain angle, or at 21 degrees.

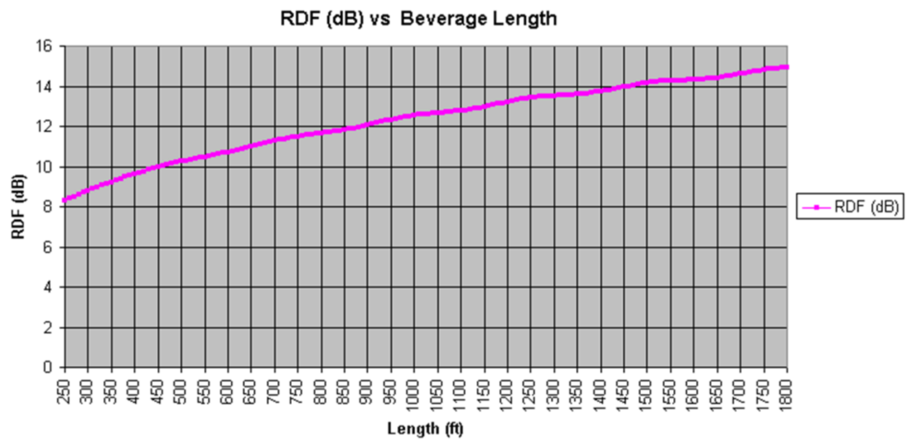
As with the RDF, the rate of change of the gain slows down with increased antenna length. If we select a length so that we achieve one-half of the overall gain difference, that length would be 590 feet (-22.27 dBi + (14 dB/2) = -15.27 dBi).



T1 is a 7-turn transformer tapped at 5 turns (1.4:1 turns ratio, 2:1 impedance ratio) step-down transformer. 73 material binocular cores are ideal for 100kHZ to 30MHz applications.

The magic T transformer is 5 to 10 turns of twisted pair wire through a 73 material binocular core. Configured as a center-tapped winding.

R1 is twice the expected load impedance. For 50- ohm systems use a 100 ohm resistor.



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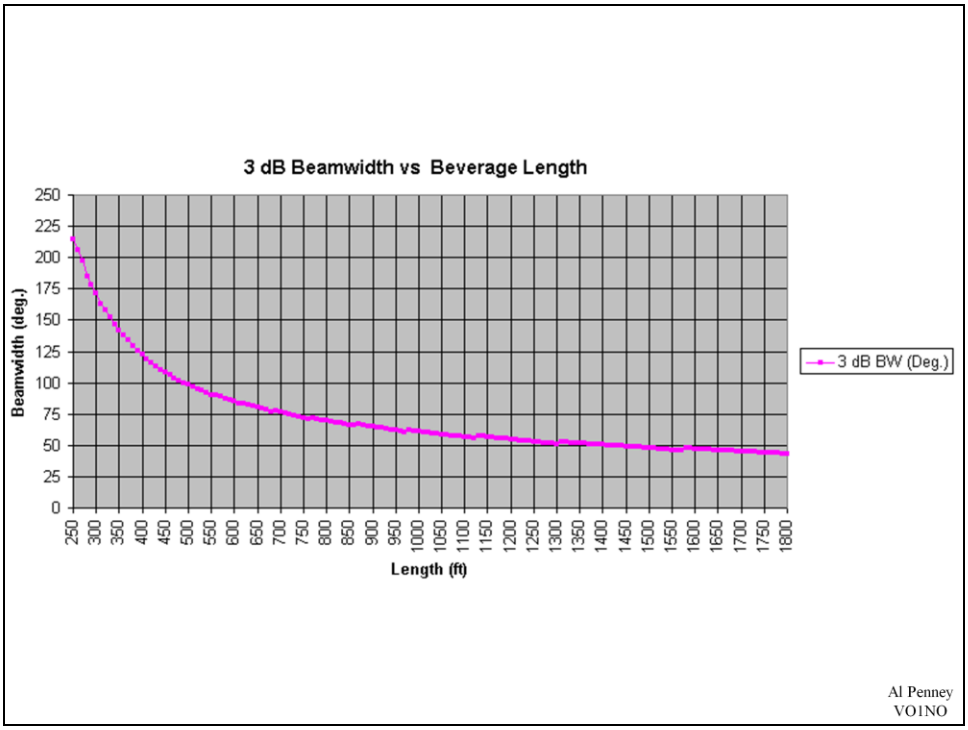
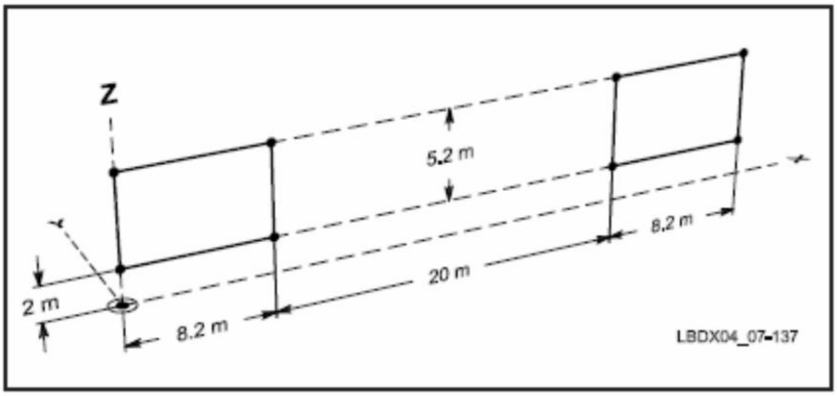


The 3 dB beamwidth is a measure of the size of the forward lobe in the azimuth plane. It is an angle, measured in degrees, and is the angle necessary for the maximum gain to fall off by 3 dB in each direction

The beamwidth starts off quite wide, 215 degrees for a 250 foot long Beverage. The beamwidth drops to 43.2 degrees for an 1800 foot Beverage.

It is interesting to note that unlike all previously presented measurements, which changed monotonically, the reported beamwidth does actually back up a few degrees from time to time. These are the very small spikes on the graph. I do not know if this is a true characteristic of the antenna, or, some artifact of modeling and simulation. I would tend to believe the latter.

It is also possible to measure the 3 dB beamwidth in the elevation plane. Although I did not record that data, the trend is the same as for the azimuth plane. The lobe narrows as the antenna becomes longer. If you combine the azimuth and elevation beamwidths with the take-off angle, the picture that emerges is of a rather large front lobe that both narrows and tips down as the antenna becomes longer.



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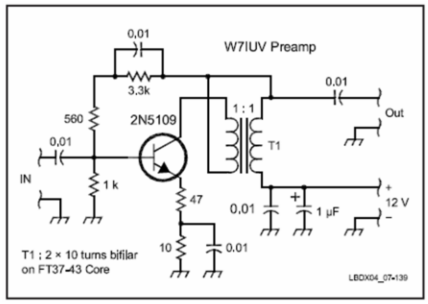

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Table 7-47

Arrays of Short Verticals

	DMF	RDF	3-dB Angle	Gain dBi	Ref
2 Ele End-Fire λ/4 Spacing, φ = 135°	16.1	9.3	132	−12	Sect 1.8
2 Ele End-Fire λ/8 Spacing, φ = 155°	17.7	9.8	120	−16	Sect 1.14
2 Ele End-Fire λ/16 Spacing, φ = 165°	17.9	9.8	121	−21	Sect 1.14
4-Square Side λ/4, φ = 120°	24.0	11.6	86	−8	Sect 1.23
4-Square Side λ/8, φ = 140°	25.9	11.9	86	−15	Sect 1.23
4-Square Side λ/16, φ = 160°	27.6	12.0	85	−23	Sect1.23
6-Ele Stone-Hex 305-m Diameter	27.4	11.7	79	−19	Sect 1.28
8-Circle, φ = 120°, Diameter 0.594 λ	22.6	12.3	55	−8	Sect 1.29
Broadside 2 Ele Bidirectional	(#)	9.7	47	−10.5	Sect 1.11/1.2.2.1
Broadside 4 Ele Bidirectional	(#)	12.4	25	−7.9	Sect 1.11/1.22.2
Broadside/End-Fire 4 Ele	21.3	12.7	46	−4.7	Sect 1.12/1.22.3
Broadside/End-Fire 8 Ele	27.1	15.7	24.5	+0.7	Sect 1.12/1.22.4
Beverages and Arrays of Beverages					
80-m Long Single Beverage	11.1	7.3	90	−16	Sect 2.16.2
160-m Long Single Beverage	19.0	10.2	78	−10	Sect 2.16.2
300-m Long Single Beverage	21.3	12.9	62	−5	–
Broadside 80-m Beverages, 90-m Spacing	14.4	9.6	48	−13.3	Sect 2.1.6.2
Broadside 160-m Beverages, 90-m Spacing	21.3	11.9	48	−7	Sect 2.1.6.2
Broadside 300-m Beverages, 90-m Spacing	23.1	14.2	44	−2	Sect 2.1.6.2
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 = 30 m, φ = 140°	33.8	13.9	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	−6.4	Sect 2.16.4
Loops and Arrays of Loops					
Elongated Terminated Loop (EWE, Flag, K9AY etc)	~11	7.5	~145	−29	Sect. 3
2 End-Fire Loops	21.5	9.9	89	−30	Sect 3.11

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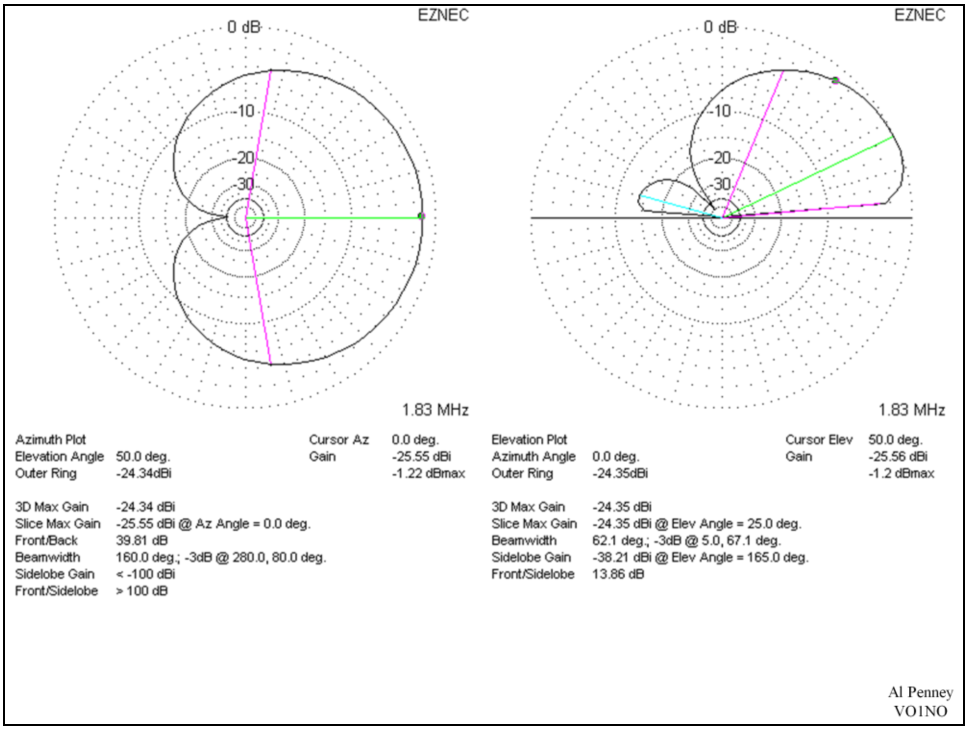
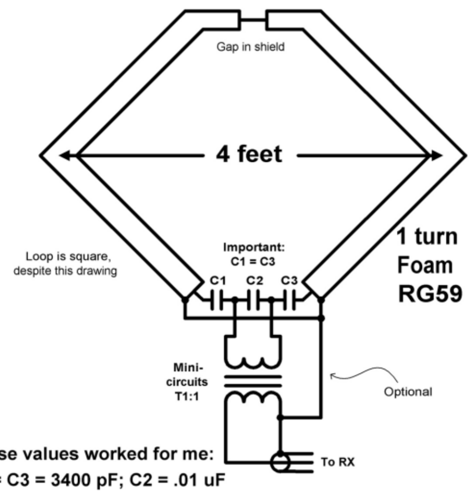


K9AY antenna at W8WWW

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.

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