HOW TO RADIATE A BIG SIGNAL FROM

A SMALL LOT

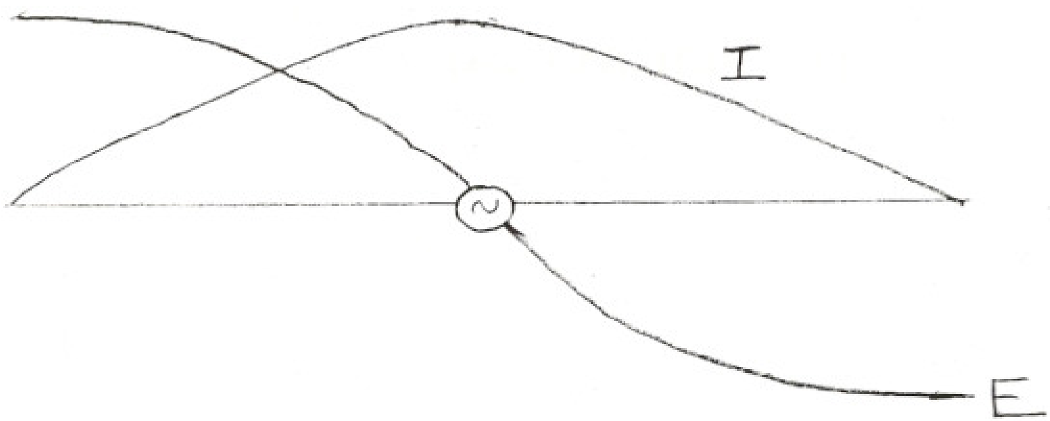
(The W6TC DX Loop)

W6TC

Maxwell's Equations

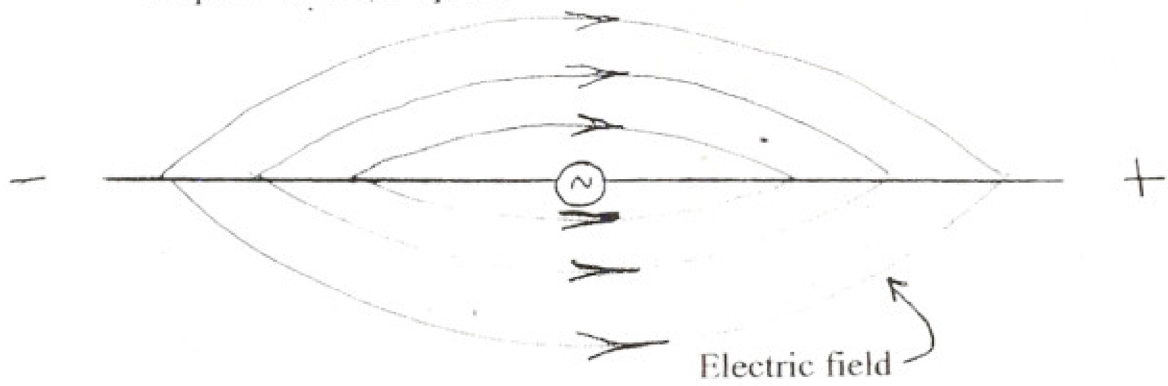
Electromagnetic Radiation is a true miracle

- Dipole antenna, grandfather of most H.F. Antennas
- We are constrained by our environment

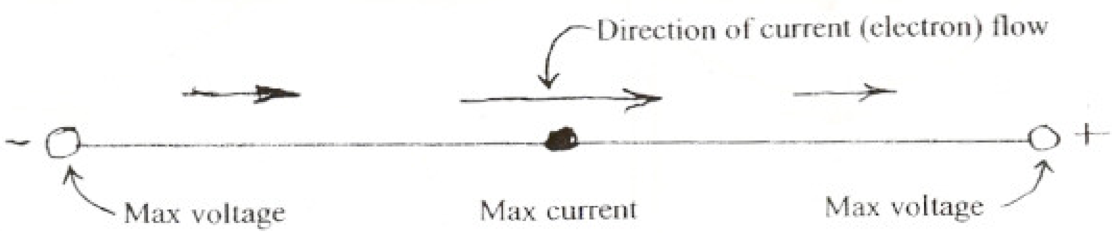


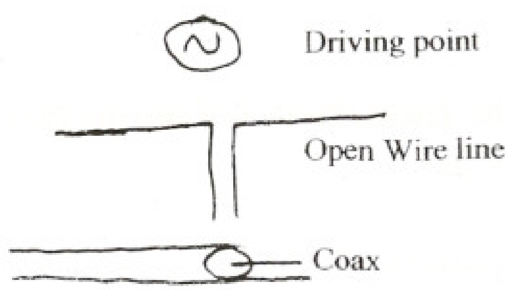
- Resonant Dipole
- Radiation proportional to current
- Current must be zero at the end of a wire

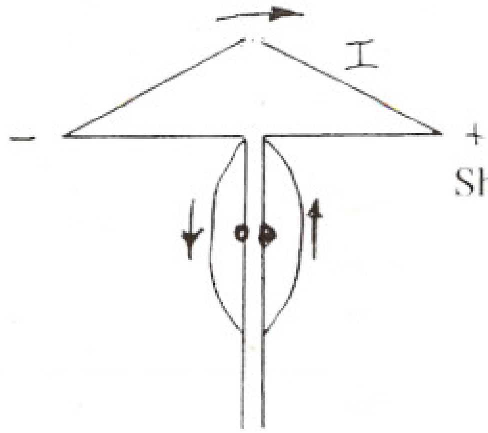
Dipole in Free Space



Conventions

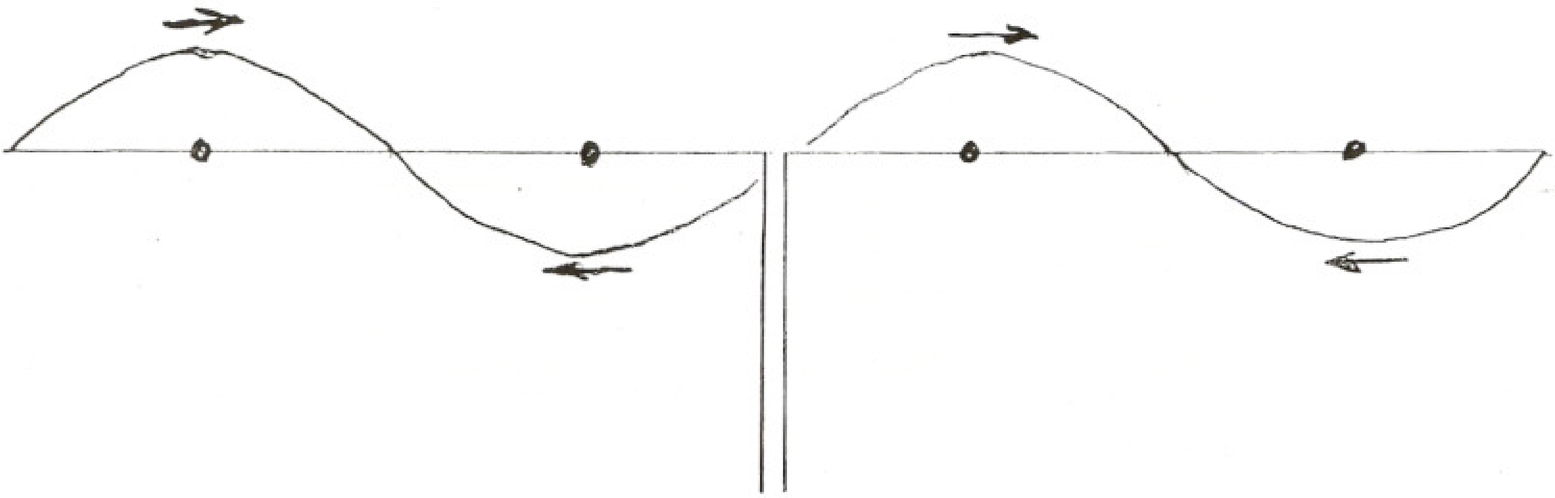






Short Dipole

Long Dipole



- Maximum current (maximum radiation) points are forced to move along the wire.
- Spoils radiation pattern

- Current near the ends of a dipole is small so radiation from the ends is small.
- Dipole ends are therefore useless from a radiation point of view.
- Ends create resonance.
- Dipole can be shortened provided resonance is achieved some other way.
- As dipole size is reduced, bandwidth and radiation resistance are reduced.

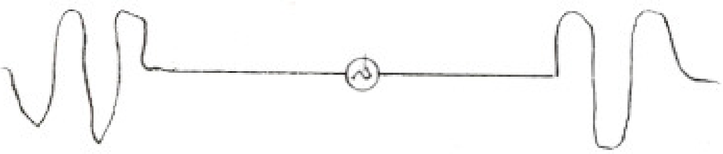
3 Desirable characteristics of an antenna:

Efficiency
Small Size
Bandwidth

} you can accomplish 2 out of the 3, but not all 3

Evolution of the W6TC DX Loop

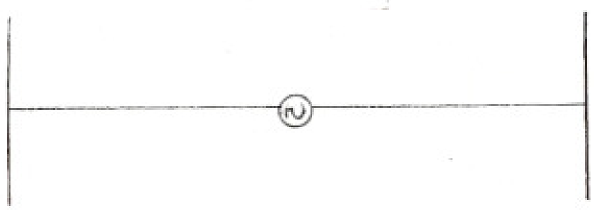
Full size, ½ wave dipole



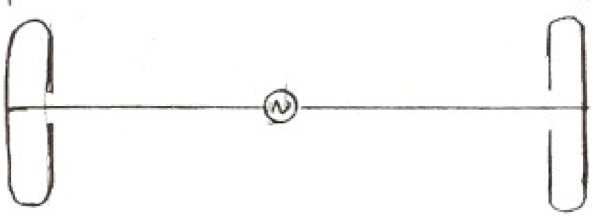
Arbitrary folding at the ends,
Short but still resonant

Coil traps

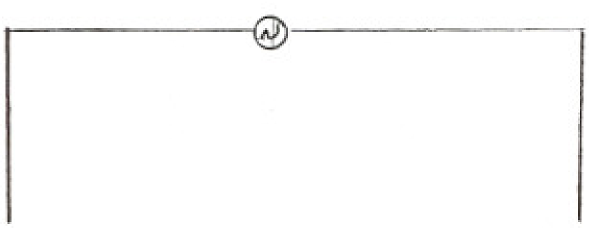
SteppIR



SteppIR add-on for
40 by KL7CW
QST June 2007

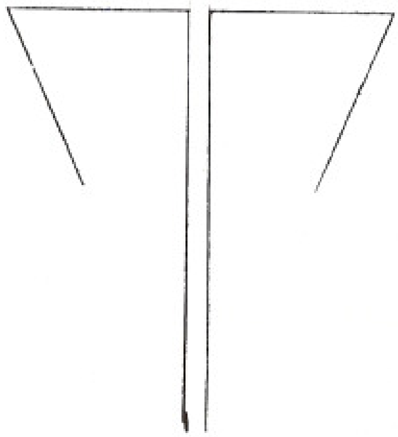


New "Dream Beam 36"
80 meter add-on

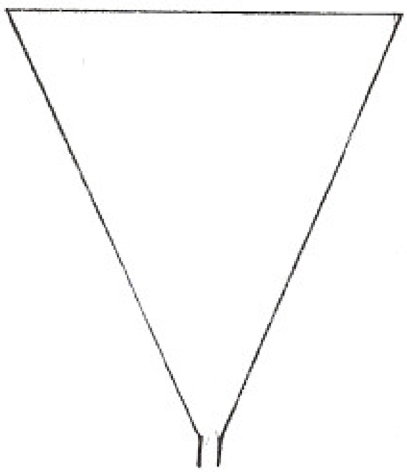


End folded down, up or
Sideways

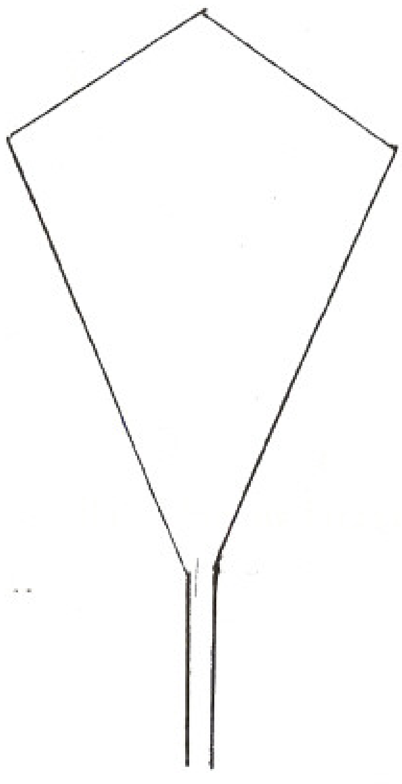
Short Resonant Dipoles



Center fed end
Loaded dipole

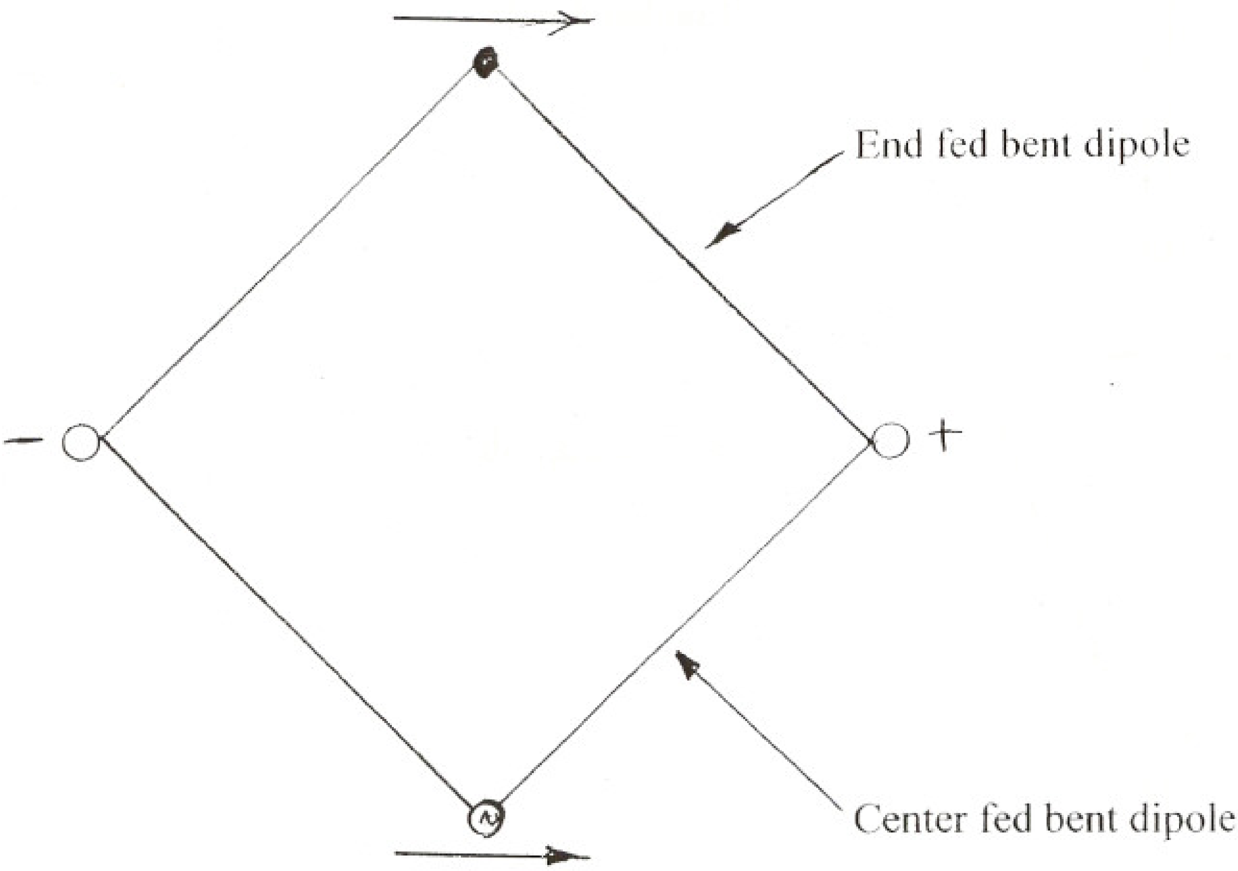


End fed dipole



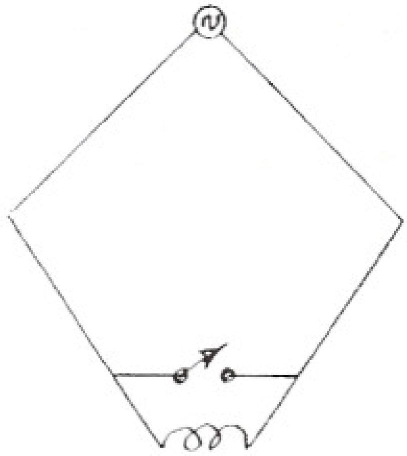
W6TC Loop

The Quad Loop



Consists of a center fed bent dipole (bottom) and an end fed bent dipole (top) connected at the ends.

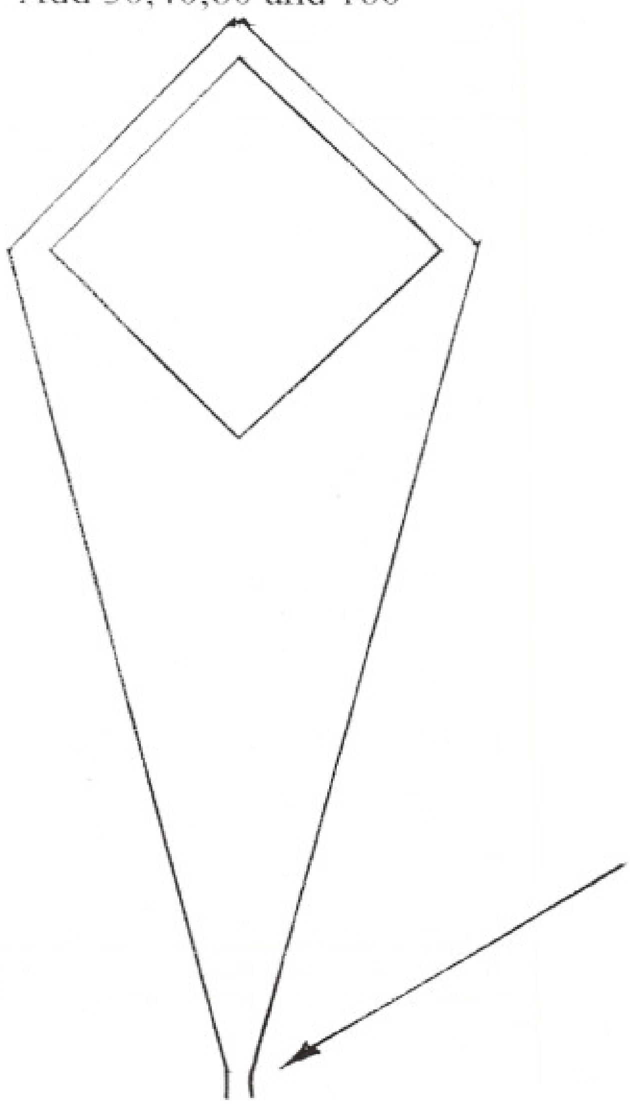
Add the WARC bands



10 ---- 12M
15---- 17M

Reflector the same,
Parasitically fed

Add 30,40,80 and 160



5B DXCC
5B WAZ

Matching networks
At ground level

compact loop antenna
for 80 and 40 meter DX

By **George M. W. Badger, W6TC**, 341 La Mesa Drive, Portola Valley, California 94025

hr october 1979

Quad loops make good low-band DX antennas for those with restricted space — a look at several loop configurations and their advantages

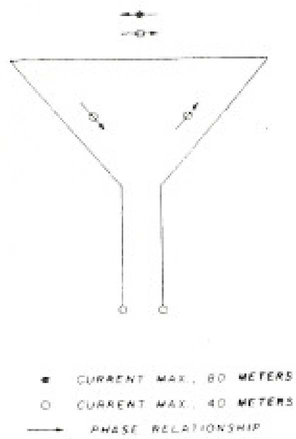


fig. 3. The full-sized loop further distorted into the familiar delta-loop configuration. The 80-meter current maximum is at the top. The 40-meter current maxima add in phase.

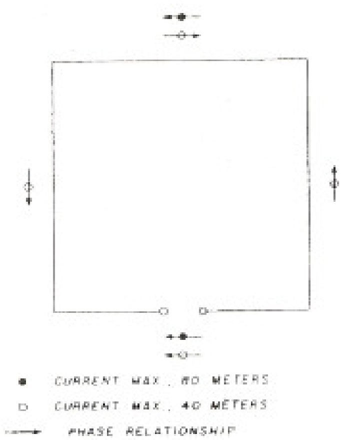


fig. 1. Full-sized 80-meter quad loop showing current maxima for 80 meters (solid circles) and current maxima for 40 meters (open circles). Arrows show relative **phase.**

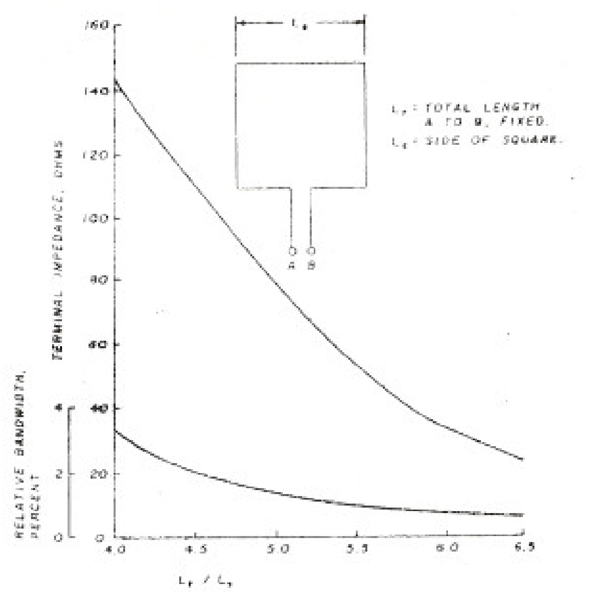


fig. 11. Input terminal impedance as a function of loop side length to total length ratio. Measurements taken on 80-MHz scale model at resonance with an HP Vector Impedance Bridge.

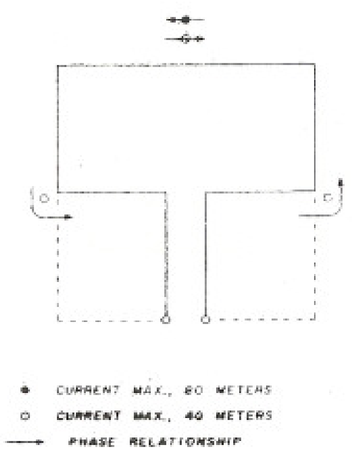


fig. 2. Lower corners of the full-sized loop folded toward the center, forming **a 1/2-area loop plus an open-wire line.**

10

WILLIAM ORR, W6SAI

The W6TC Compact Quad Loop for 40 and 80 Meters

At 80 meters, the full-size Quad loop requires supports that are about 70 feet (21 m) high. An antenna of this size is out of the question for amateurs restricted to small lots. A smaller loop that seems to work almost as well as the full-size version has been designed by W6TC and is shown in Figure 9. The sides of the normal Quad loop are folded back, reducing the overall height of the loop and making a portion of the loop into a two-wire transmission line. Since the area of the loop is reduced,

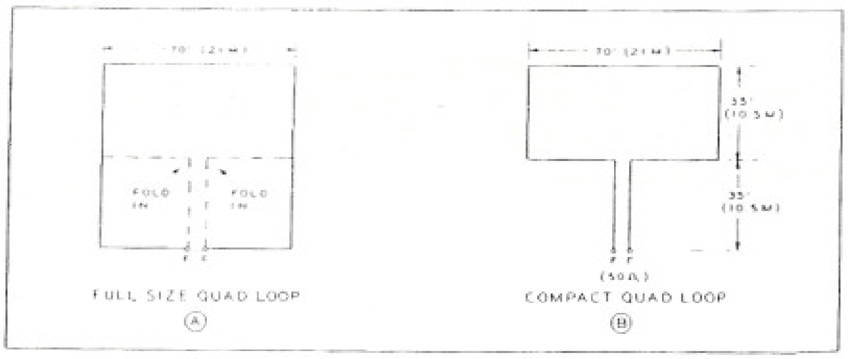
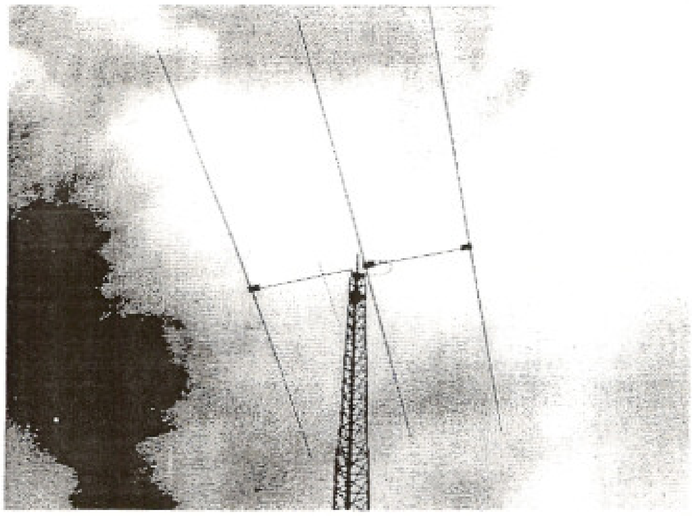


Fig. 9 Full-size 80 meter Quad loop (A) is folded back along dotted lines to form half-height loop (B). Lower portion of loop is made into a two-wire transmission line. Radiation resistance of compact loop is about 50 ohms making direct feed from a coaxial line possible. For 40 meter operation divide dimensions by two.



SteppIR Antennas

23831 S.E. Tiger MT. RD.   Issaquah, WA 98027

Tel: 425-391-1999   Fax: 425-391-8377   Toll Free: 866-783-7747

Web: www.steppir.com   **5/05/05**

12

Problem – How to adjust element lengths from the ground.

Solution – The SteppIR antenna.

- Motor driven element lengths controlled by a microprocessor in the shack.
- Automatically adjusts every 50kHz., 20 to 6M.
- Tracks your transceiver.
- 180 deg. direction reversal.
- Bi directional mode.

SteppIR Design

Currently, most multi-band antennas use traps, log cells or interlaced elements as a means to cover several frequency bands. All of these methods have one thing in common–they significantly compromise performance. The SteppIR™ antenna system is our answer to the problem. Resonant antennas must be made a specific length to operate optimally on a given frequency.

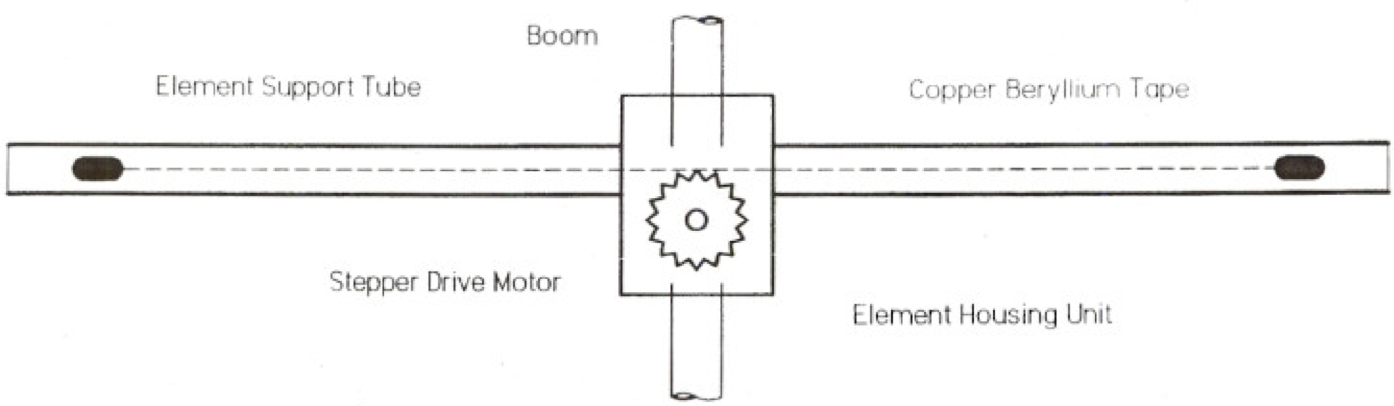
So, instead of trying to "trick" the antenna into thinking it is a different length, or simply adding more elements that may destructively interact, why not just change the antenna length? Optimal performance is then possible on all frequencies with a lightweight, compact antenna. Also, since the SteppIR can control the element lengths, a long boom is not needed to achieve near optimum gain and front to back ratios on 20 - 10 meters.

Each antenna element consists of two spools of flat copper-beryllium strip conductor mounted in the antenna housing. The copper-beryllium strips are perforated to allow a stepper motor to drive them simultaneously with a sprocket. Stepper motors are well known for their ability to index very accurately, thus giving very precise control of each element length. In addition, the motors are brush less and provide extremely long service life.

The copper-beryllium strip is driven out into hollow, lightweight fiberglass support elements (see below), forming an element of any desired length up to 36' long. The fiberglass poles are telescoping, lightweight and very durable. When fully collapsed, each element measures 48" in length.

The ability to completely retract the copper-beryllium antenna elements, coupled with the collapsible fiberglass poles makes the entire system easily portable.

The antenna is connected to a microprocessor-based controller (via 22 gauge conductor cable) that offers numerous functions including dedicated buttons for each ham band, continuous frequency selection from 20m to 6m, 17 ham and 6 non-ham band memories, 180° direction reversal or bi-directional mode in just 3 seconds (yagi).



14

Problem – How to add the low bands, 30-40-60-80-160 to the SteppIR.

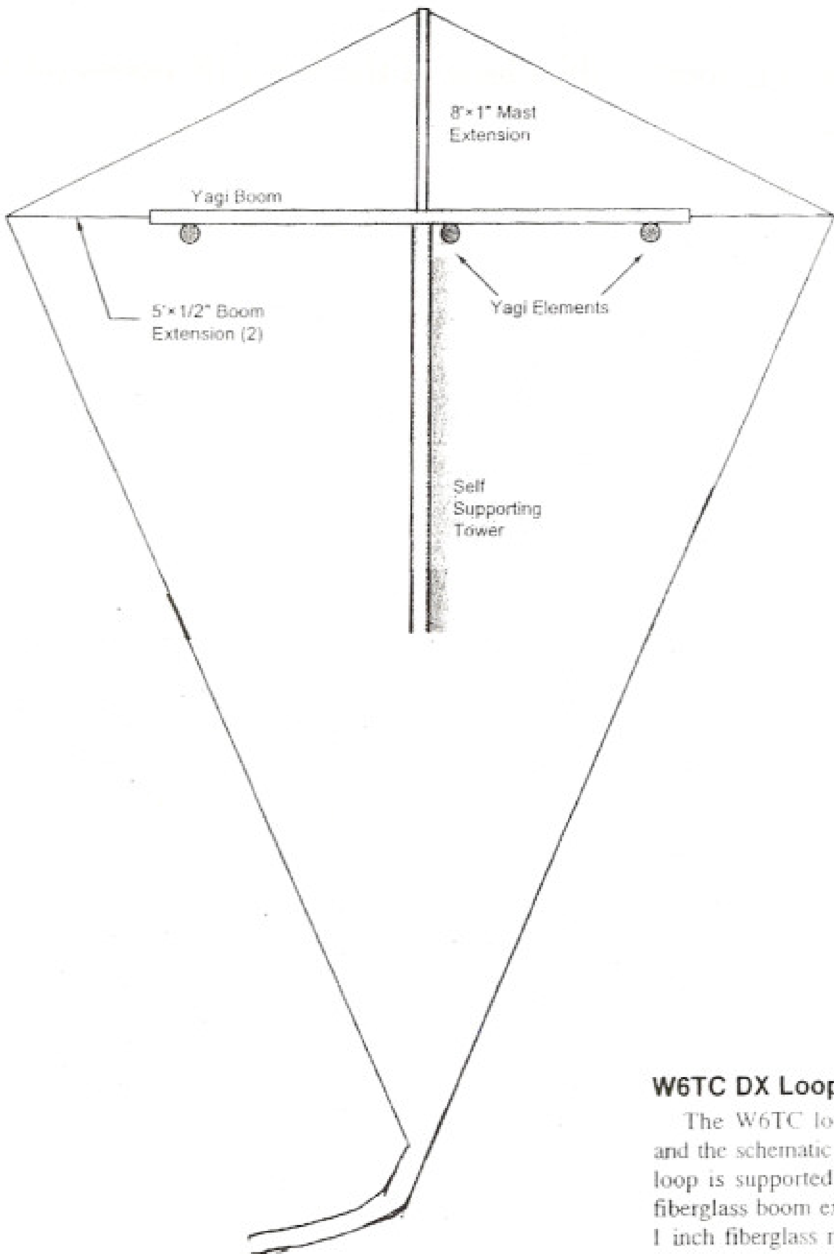
Answer – Put the W6TC loop in the plane of the SteppIR boom (at right angle to the elements)

There is no interaction.

The W6TC DX Loop

An easy way to add 30, 40, 60, 80 and 160 to your SteppIR — or any Yagi.

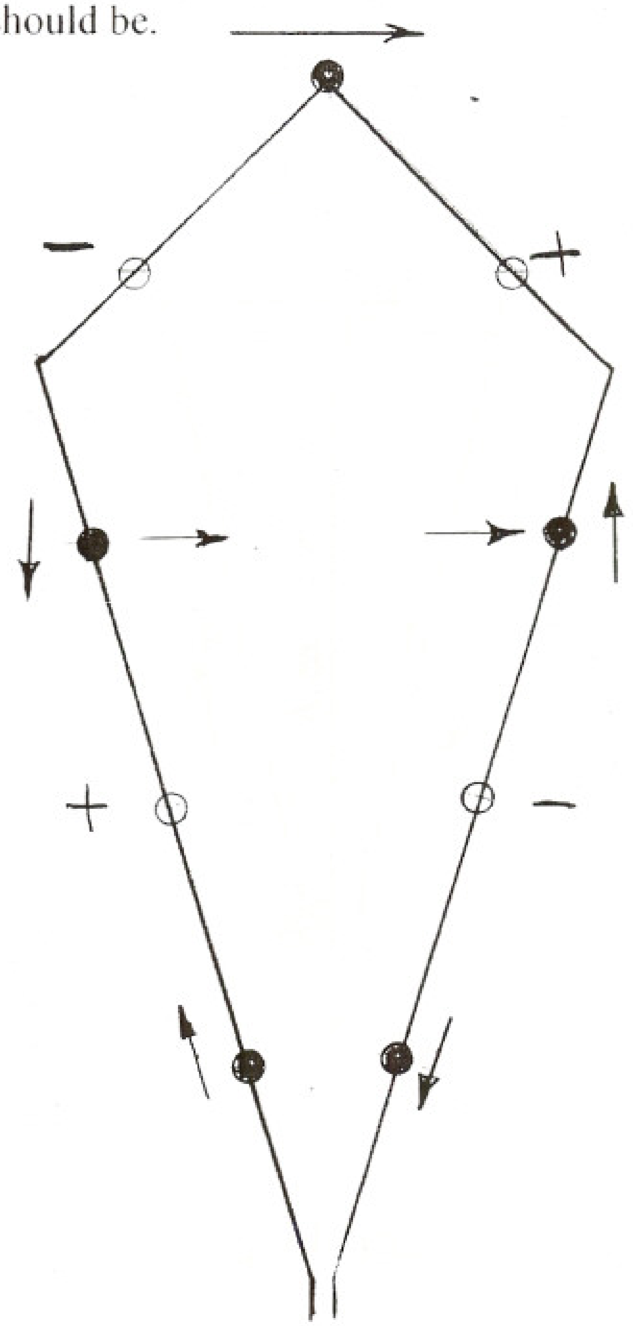
George Badger, W6TC



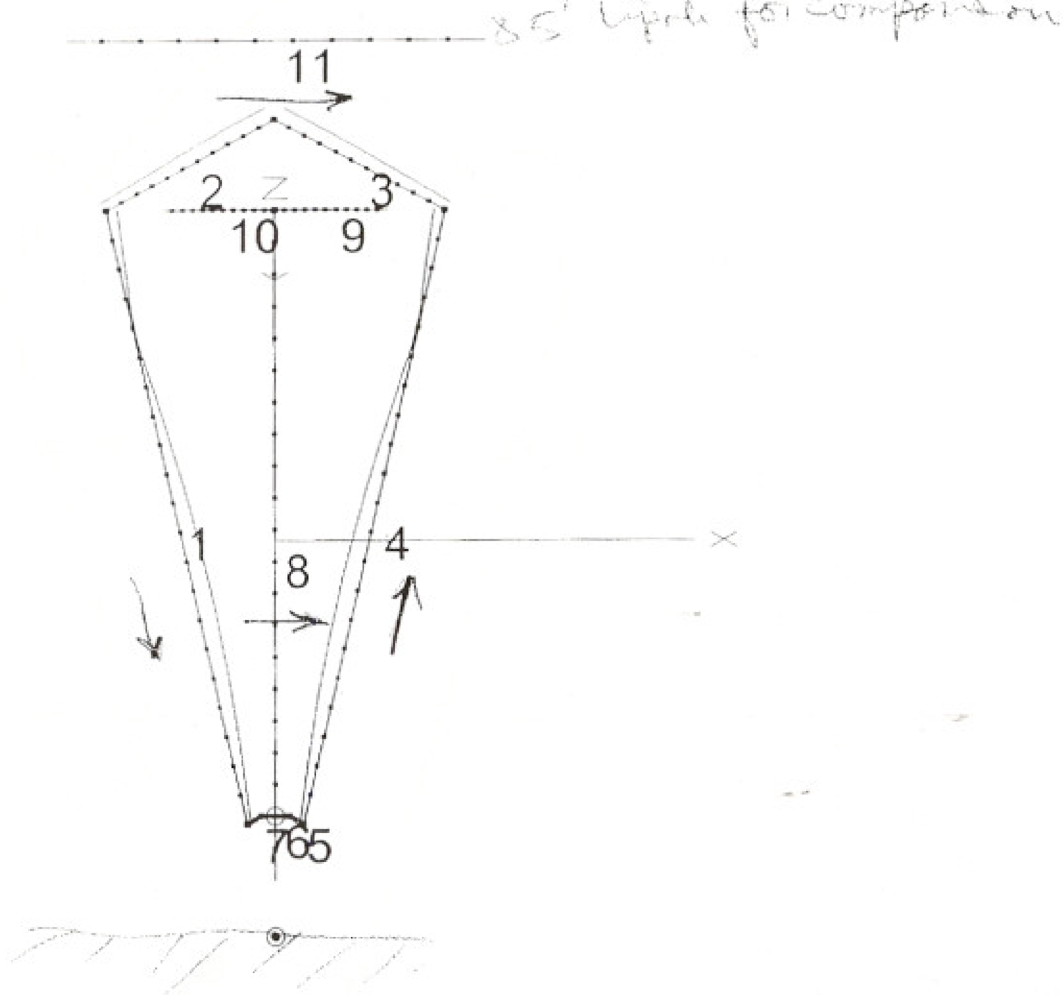
W6TC DX Loop

The W6TC loop is shown in Figure 1 and the schematic diagram of Figure 2. The loop is supported on two 5 foot × ½ inch fiberglass boom extensions, and an 8 foot × 1 inch fiberglass mast extension. The wires from the ends of the boom extensions extend downward and terminate at the base of the tower. Figure 2 is a schematic diagram of the W6TC DX loop.

The very significant thing about the W6TC loop is that regardless of the size of the loop of the operation frequency, there is always a maximum current (maximum radiation) point at the very top of the antenna, where it should be.



Further, the vertical components of radiation from the side wire all cancel and the horizontal components of the top side wires are in phase and add to the maximum radiation at the top of the antenna

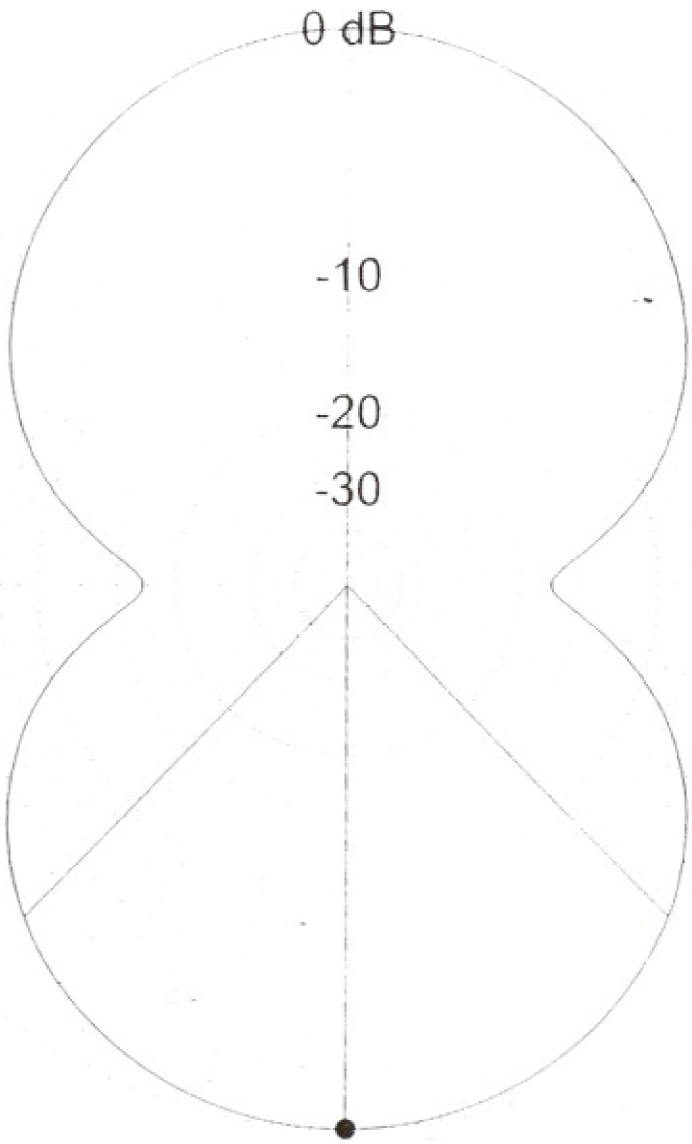


10.1 MHz.

w6tc loop

EZNEC+

18



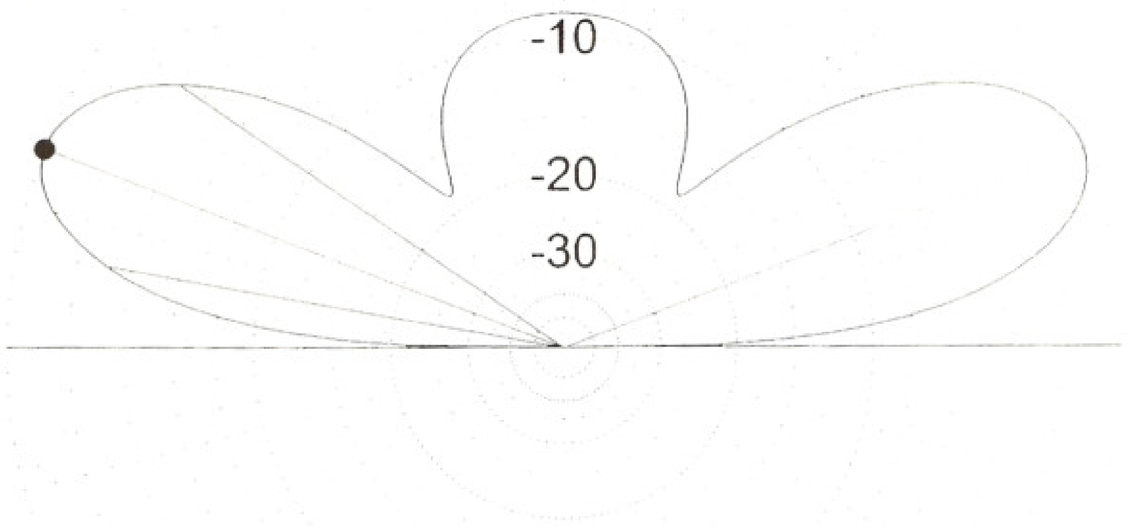
10.1 MHz

w6tc loop

Azimuth Plot		Cursor Az	270.0 deg.
Elevation Angle	21.0 deg.	Gain	8.03 dBi ←
Outer Ring	8.03 dBi		0.0 dBmax

Slice Max Gain	8.03 dBi @ Az Angle = 270.0 deg.
Front/Side	17.1 dB
Beamwidth	87.0 deg.; -3dB @ 226.5, 313.5 deg.
Sidelobe Gain	8.03 dBi @ Az Angle = 90.0 deg.
ront/Sidelobe	0.0 dB

19 ✓



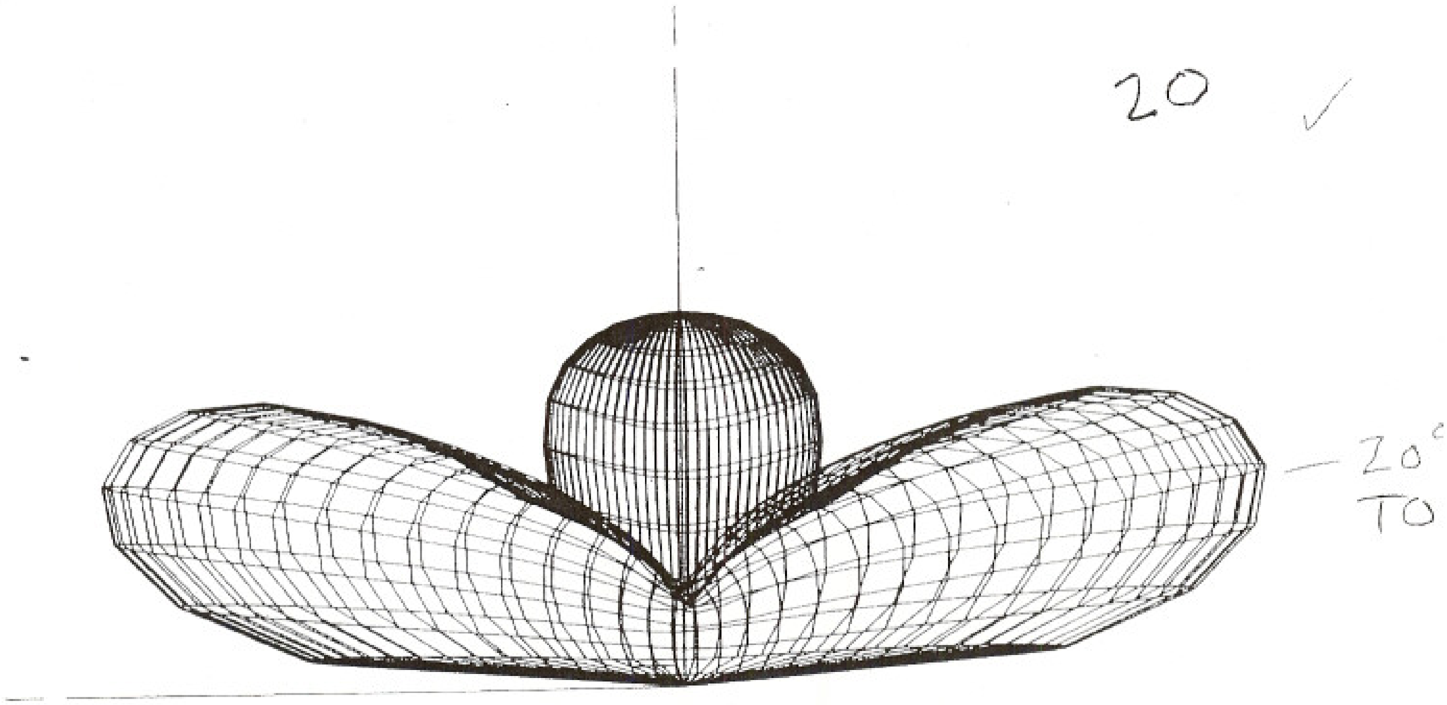
10.1 MHz

w6tc loop

Elevation Plot		Cursor Elev	~~159.0~~ 21 deg.
Azimuth Angle	90.0 deg.	Gain	8.03 dBi ←
Outer Ring	8.03 dBi		0.0 dBmax

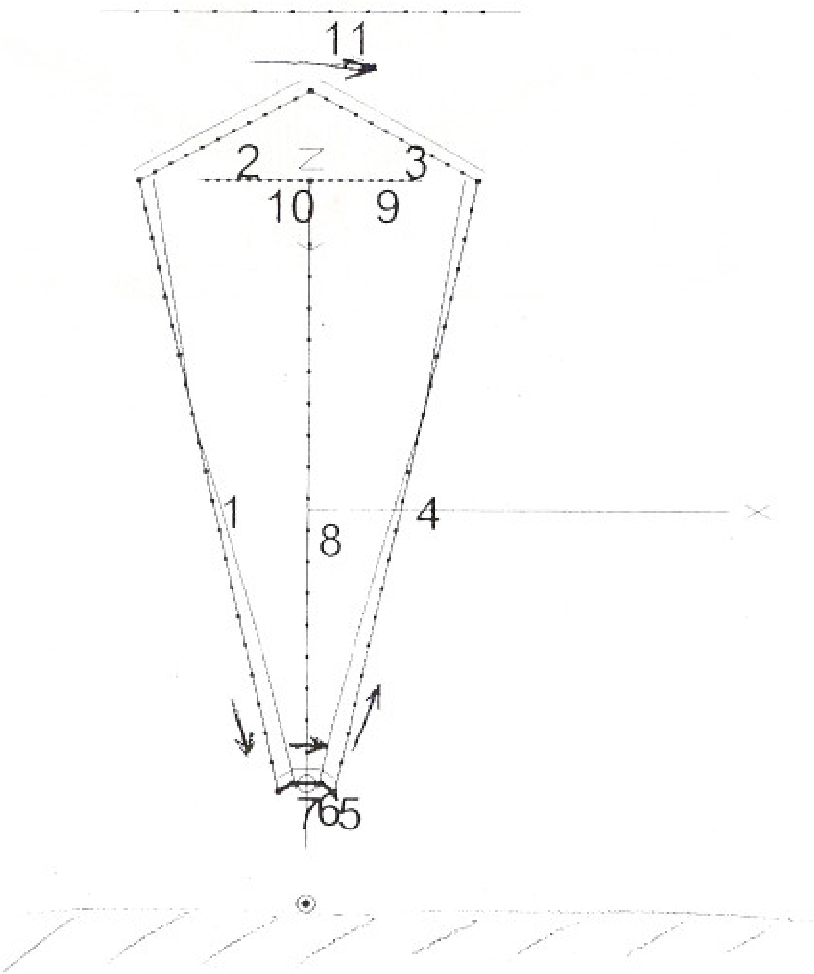
Slice Max Gain	8.03 dBi @ Elev Angle = 159.0 deg.
Beamwidth	24.2 deg.; -3dB @ 145.6, 169.8 deg.
Sidelobe Gain	8.03 dBi @ Elev Angle = 21.0 deg.
Front/Sidelobe	0.0 dB

20 ✓



30M
Y Z plane

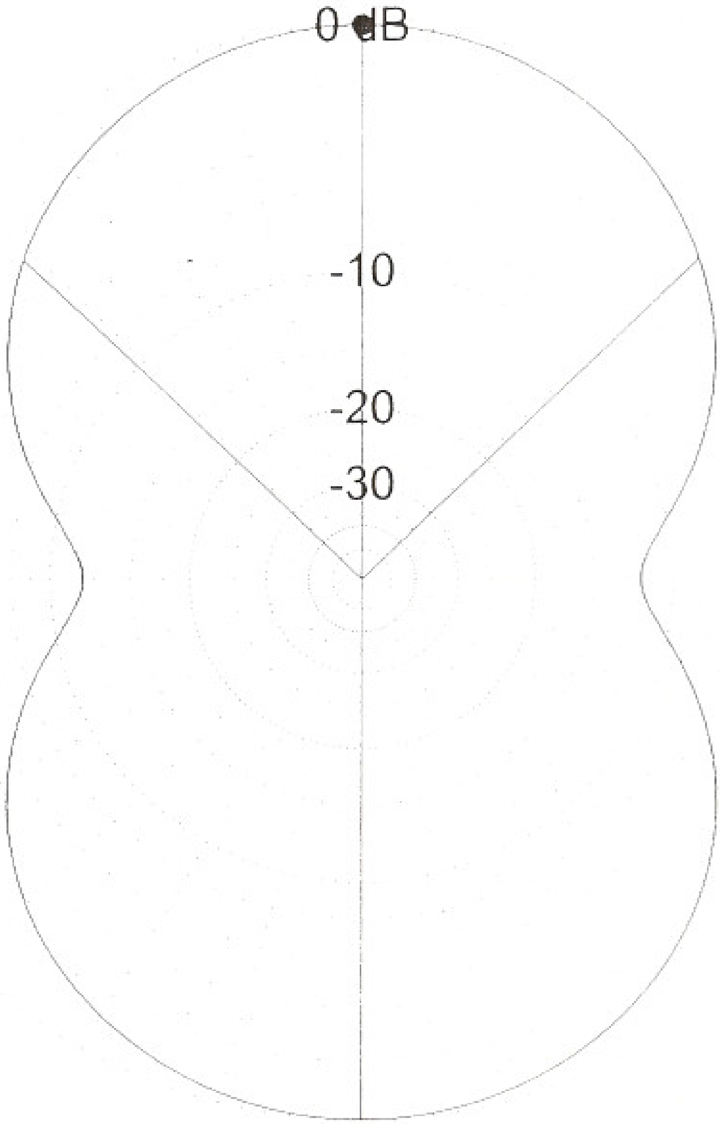
w6tc loop



w6tc loop

7.1 MHz.

22

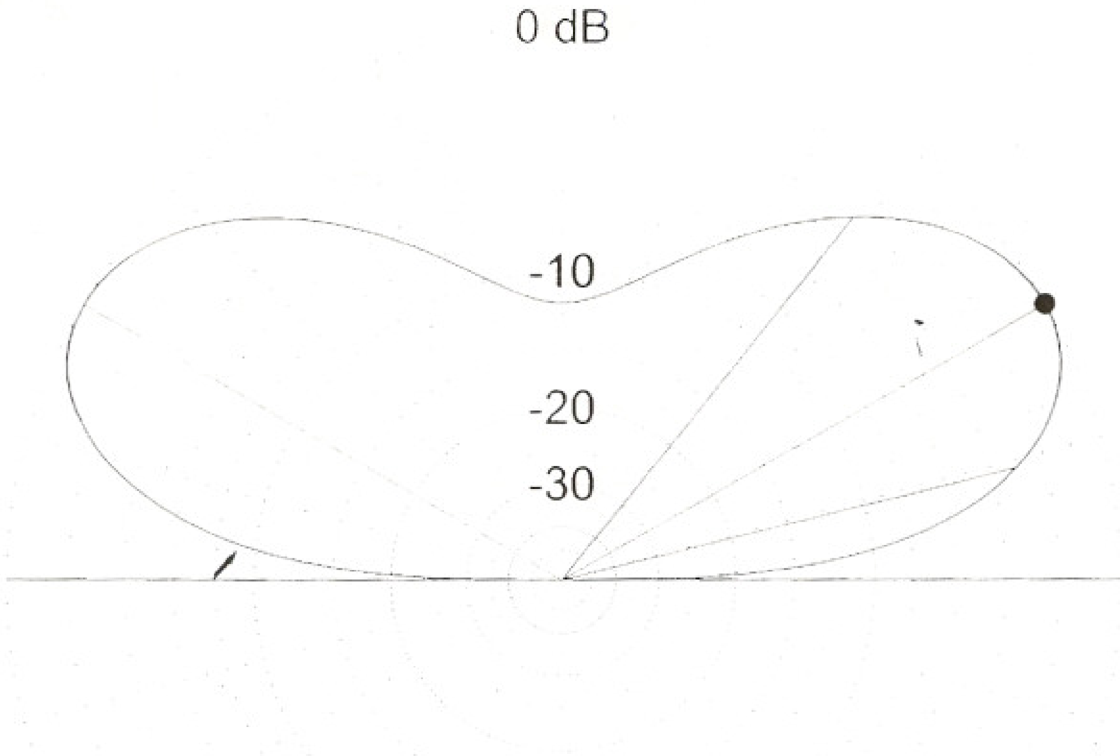


7 MHz

w6tc loop

Azimuth Plot		Cursor Az	90.0 deg.
Elevation Angle	30.0 deg.	Gain	6.15 dBi
Outer Ring	6.15 dBi		0.0 dBmax

Slice Max Gain	6.15 dBi @ Az Angle = 90.0 deg.
Front/Side	11.84 dB
Beamwidth	92.6 deg.; -3dB @ 43.7, 136.3 deg.
Sidelobe Gain	6.14 dBi @ Az Angle = 270.0 deg.
Front/Sidelobe	0.01 dB



7 MHz

w6tc loop

Elevation Plot		Cursor Elev	30.0 deg.
Azimuth Angle	90.0 deg.	Gain	6.15 dBi
Outer Ring	6.15 dBi		0.0 dBmax

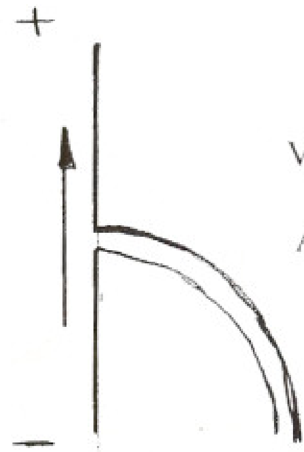
Slice Max Gain	6.15 dBi @ Elev Angle = 30.0 deg.
Beamwidth	37.4 deg.; -3dB @ 14.1, 51.5 deg.
Sidelobe Gain	6.14 dBi @ Elev Angle = 150.0 deg.
Front/Sidelobe	0.01 dB

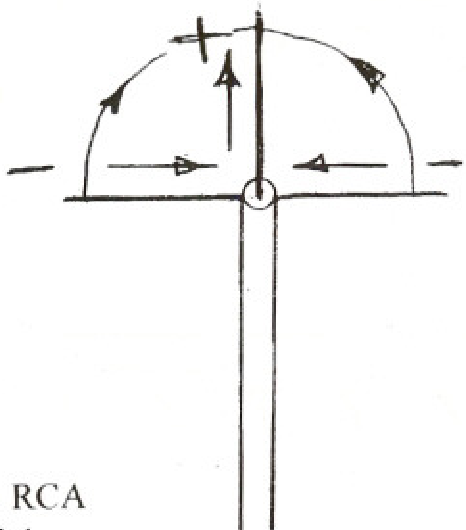
VERTICAL ANTENNAS

Omni Directional

Vertical dipole

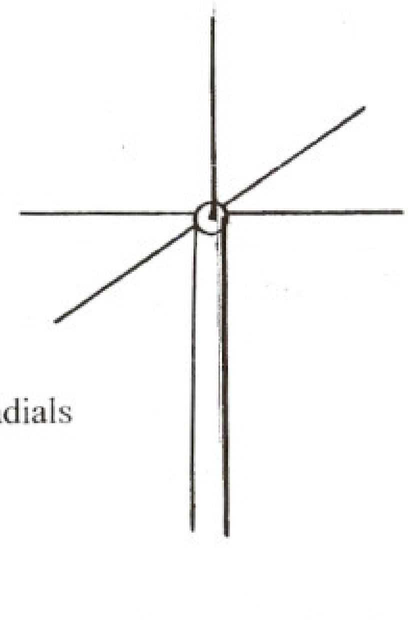
Asymmetrical





- Ground plane
- Symmetrical

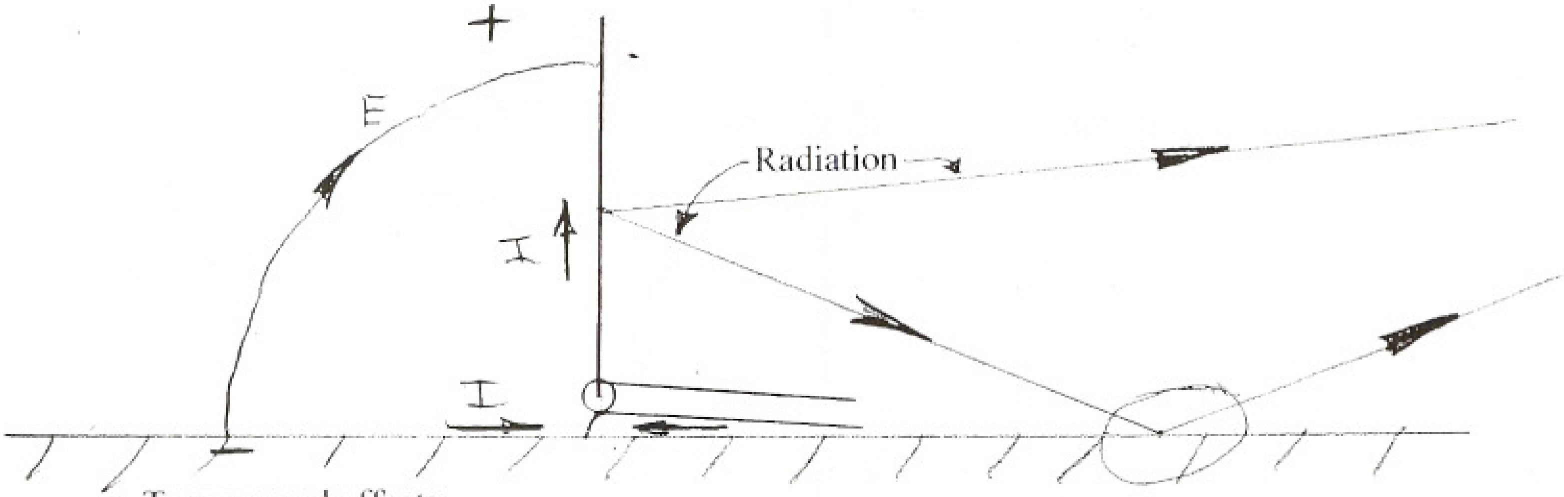
- Dr. George Brown RCA
- VHF Design, 2 radials



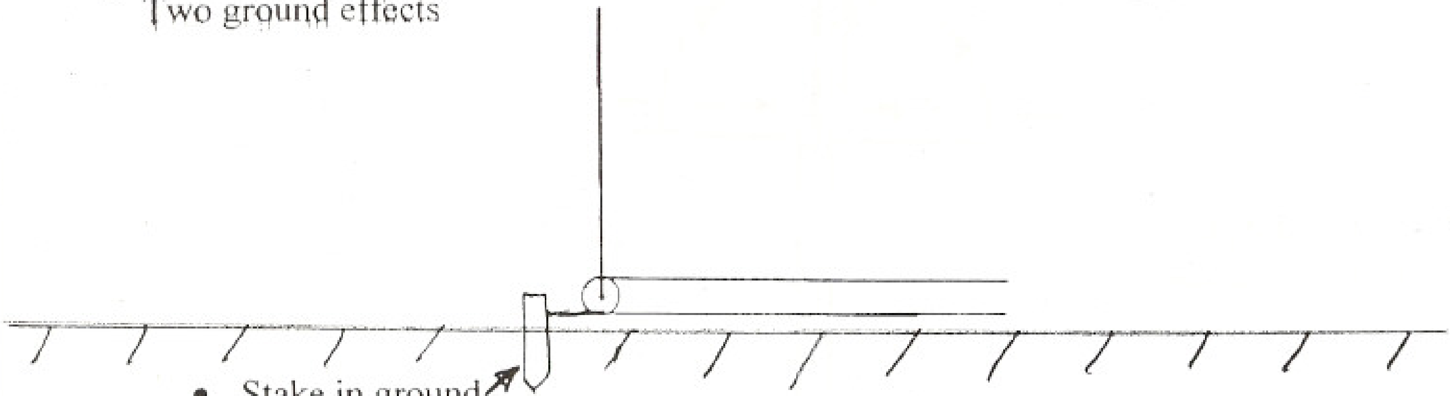
- Marketing design, 4 radials

What about Ground?

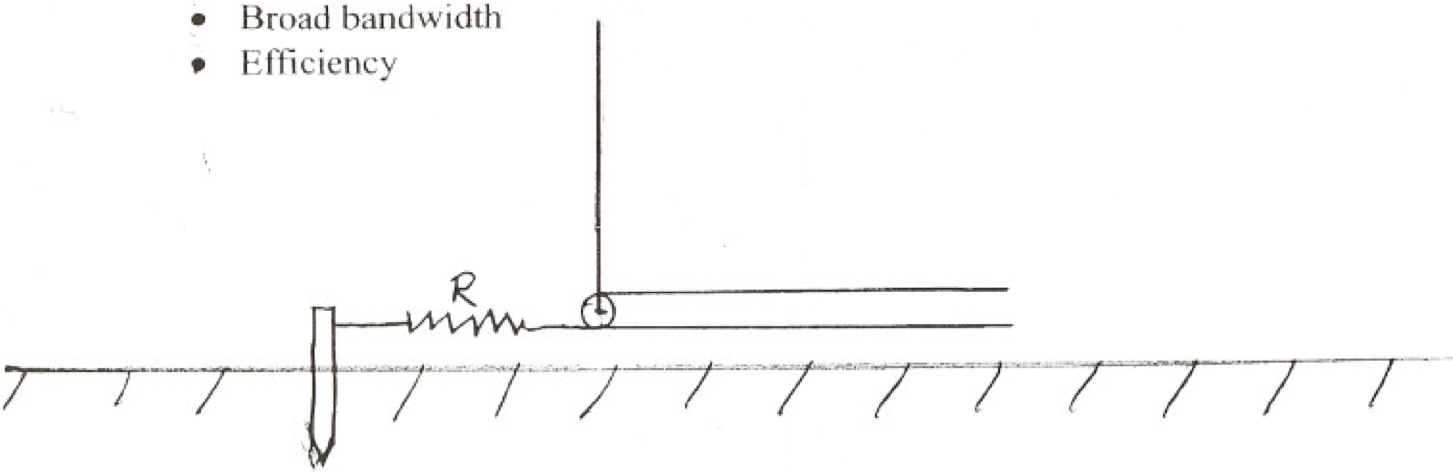
Because of their size, most vertical antennas are near ground.



Two ground effects

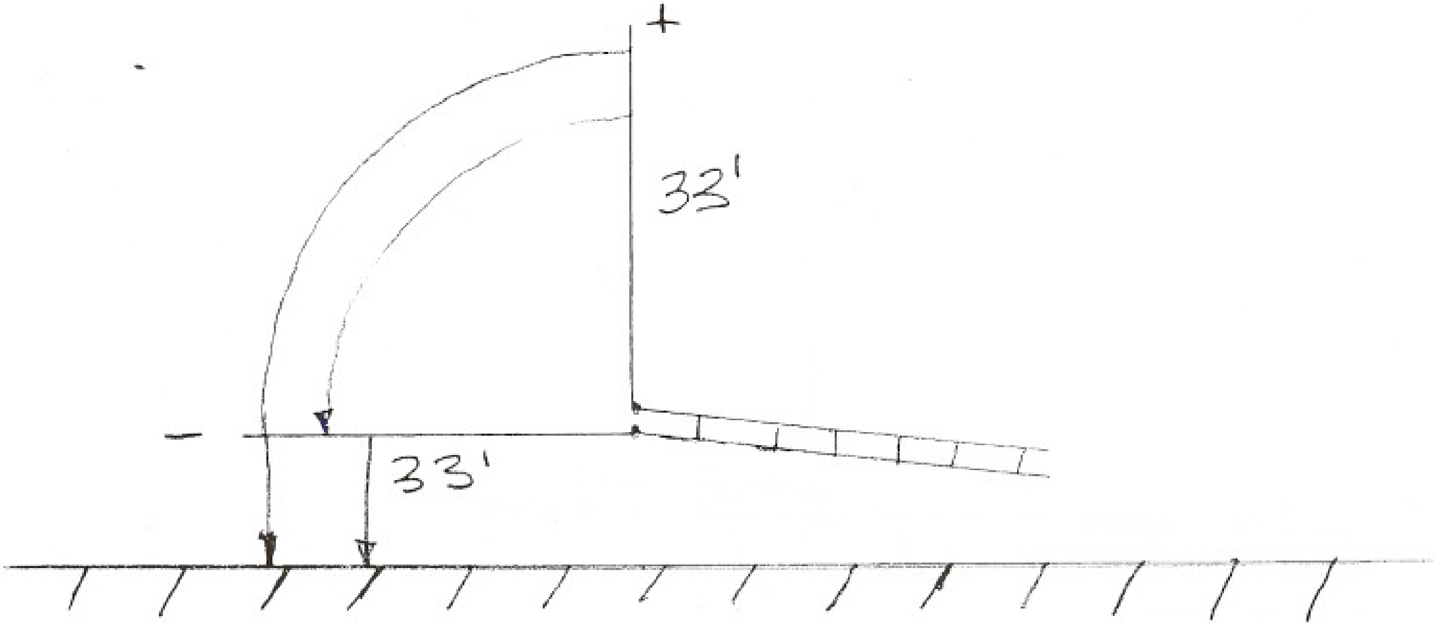


- Stake in ground
- Good VSWR
- Broad bandwidth
- Efficiency



The "33 up and 33 out antenna"

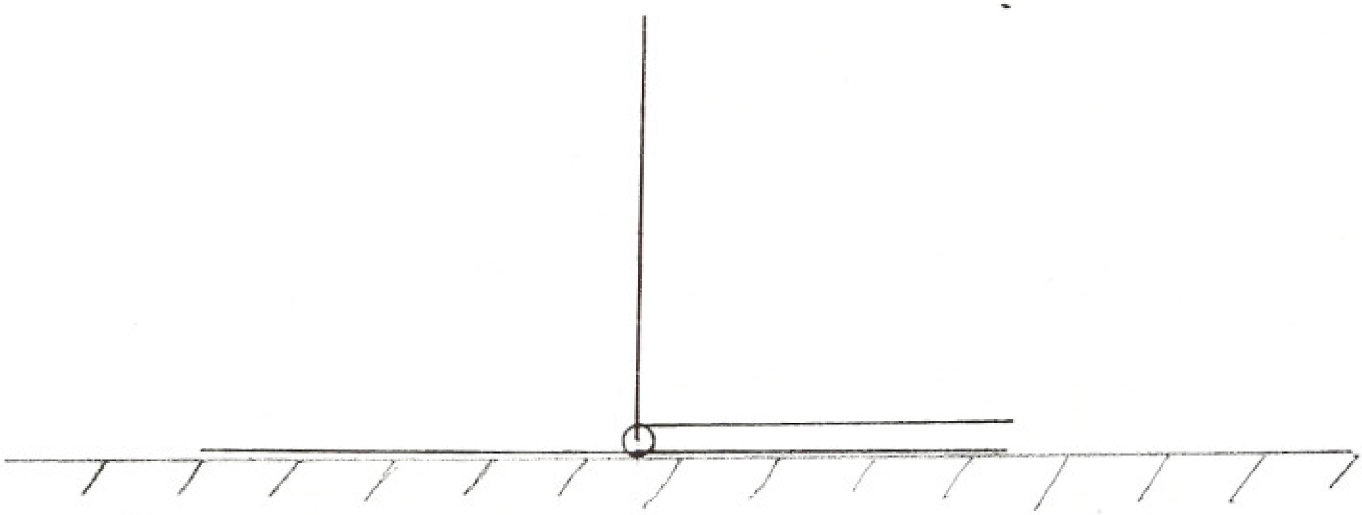
- Very popular in the '30s.



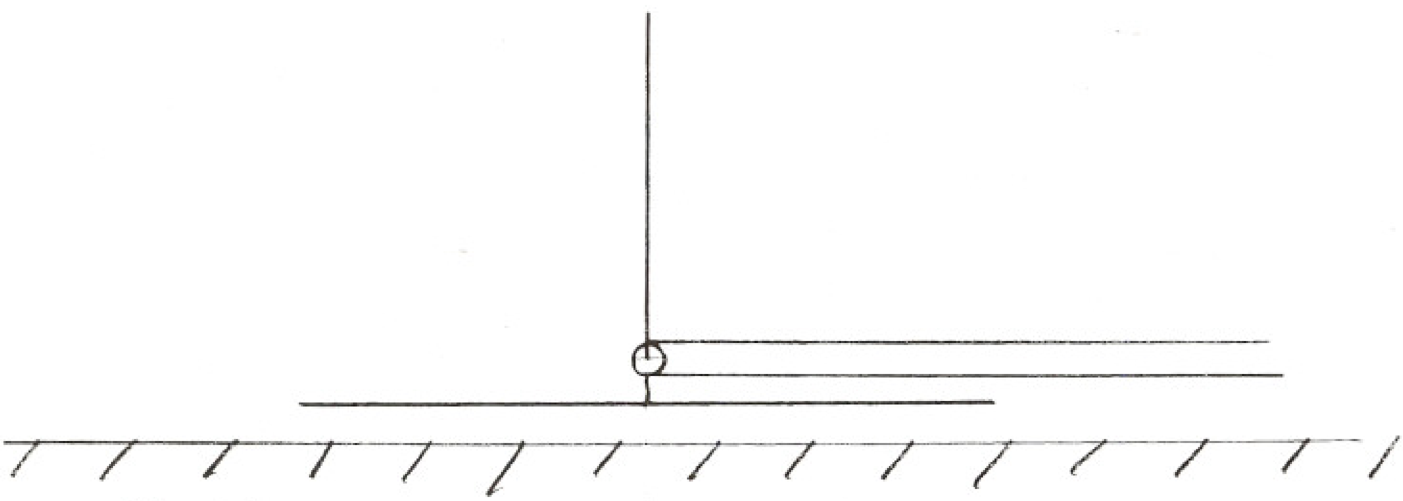
- Another way to make the bottom half of a vertical antenna
- Electric fields terminate on the ground.
- Ground losses.

Because of size, low band vertical antenna are usually near ground.

- Two ways to make up the bottom half of the vertical dipole near ground.



- Non resonant
- Capacitance to ground
- Dr. George Brown RCA
- 120 ¼ wave radials on the ground
- Became FCC rule
- Current amateur practice – 60 radials



- Elevated resonant
- Few radials
- "Counterpoise"
- How many depends on how far from ground

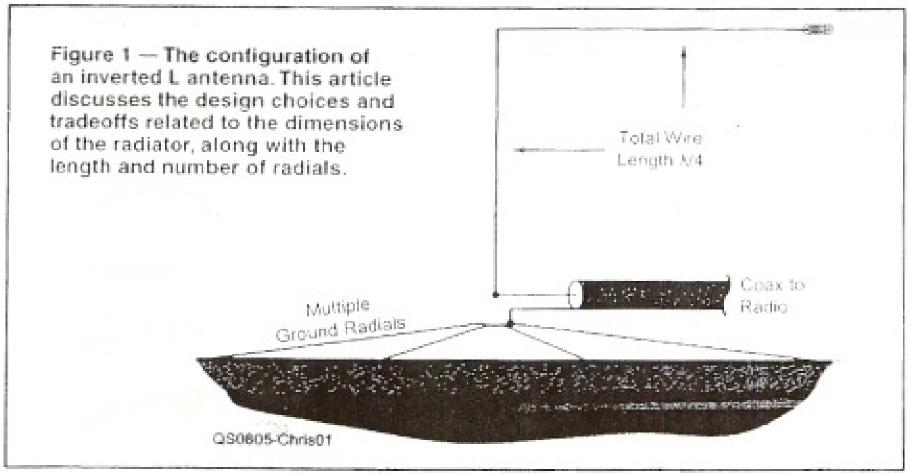
Computer Simulation of 160 Meter Inverted L Antennas

How this popular 160 meter antenna performs over real ground.

Al Christman, K3LC

30 May 2008 QST

Figure 1 — The configuration of an inverted L antenna. This article discusses the design choices and tradeoffs related to the dimensions of the radiator, along with the length and number of radials.



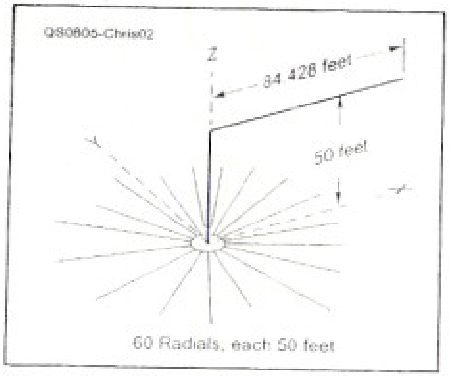


Figure 2 — This inverted L antenna uses a ground screen composed of 60 buried radials, each of which is 50 feet long. The height of the vertical section of the radiator is 50 feet, and the horizontal portion has a length of 84.428 feet, which resonates the antenna at 1830 kHz. The resulting TOA for this case is 30.1°, while the FBR is 1.42 dB and the FSR is 0.77 dB.

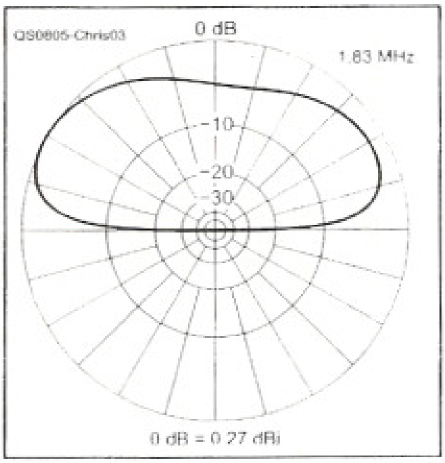


Figure 3 — This is the elevation-plane radiation pattern of the antenna shown in Figure 2 in the plane containing the inverted L wire. Note that the front of the main lobe is directed toward the left, opposite to the position of the horizontal section of the radiator element. The peak gain is 0.27 dBi at 30.1° take-off angle, and the front-to-back ratio is just 1.42 dB.

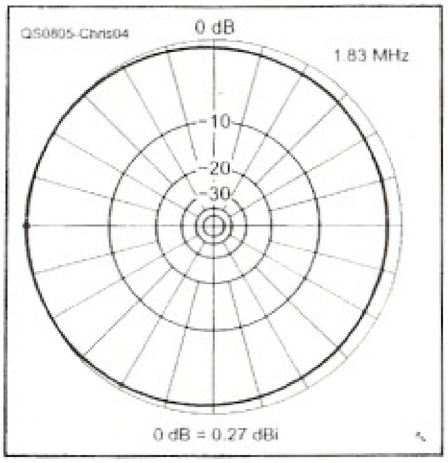


Figure 4 — Azimuth plot of the configuration shown in Figure 2.

When deciding which antenna to use, look at your property and available supports first.

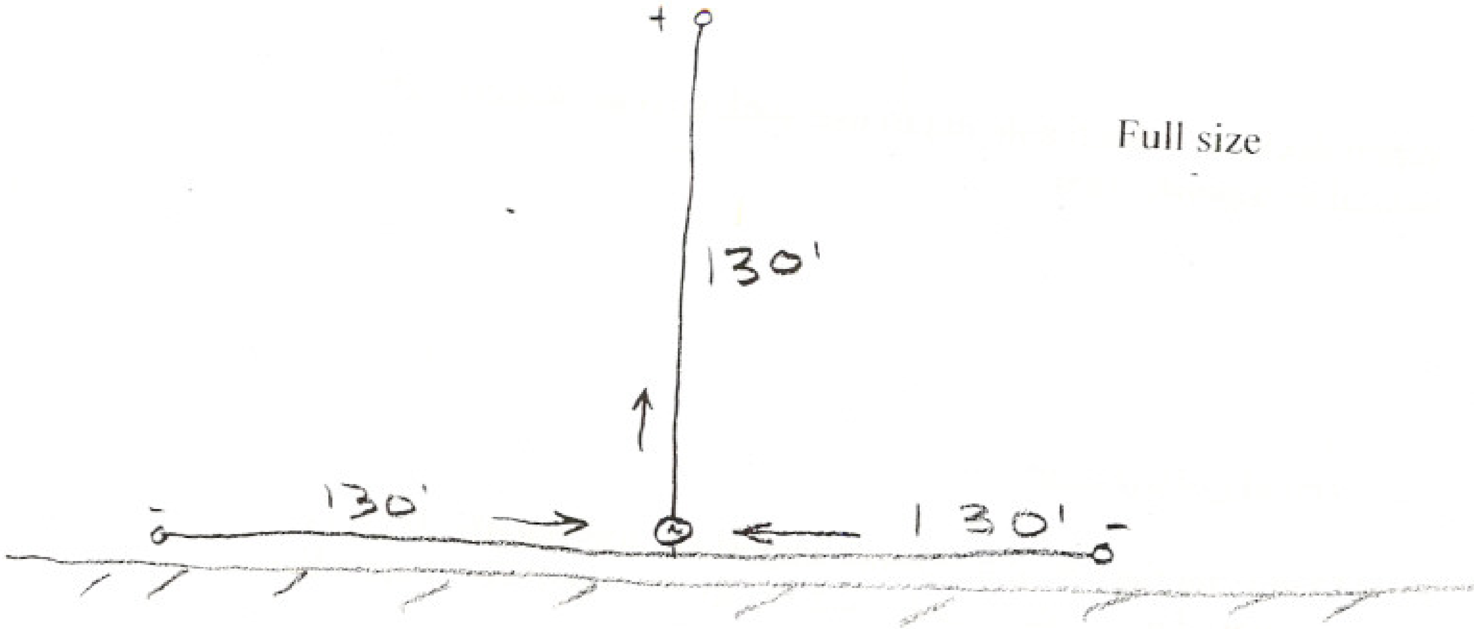
Horizontal polarization

For DXing, antenna height is more important than length. If you can get a short wire higher, end feed it W6TC style. It will be a better DX antenna.

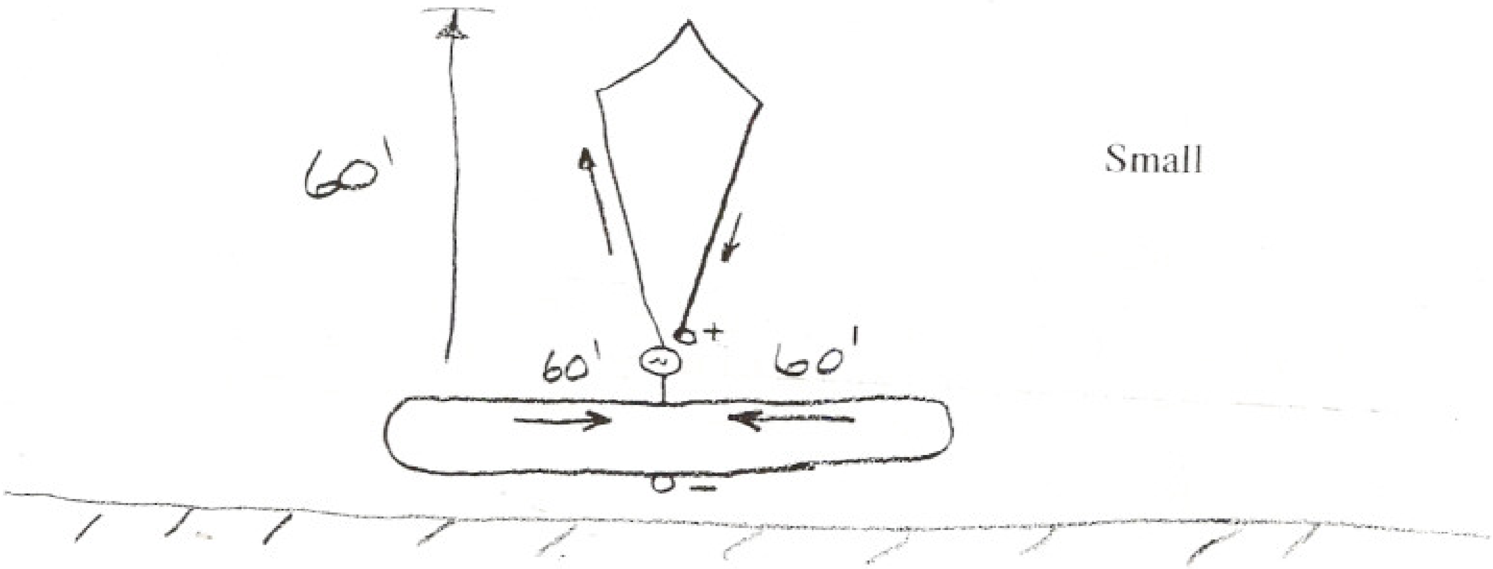
Vertical polarization

To keep the height within your limits, fold the vertical ¼ wave length back on itself. If you have room for many radials on the ground, OK. If not, use a W6TC loop counterpoise. Keep the high voltage part of the loop far from ground.

Small 160 M Antenna



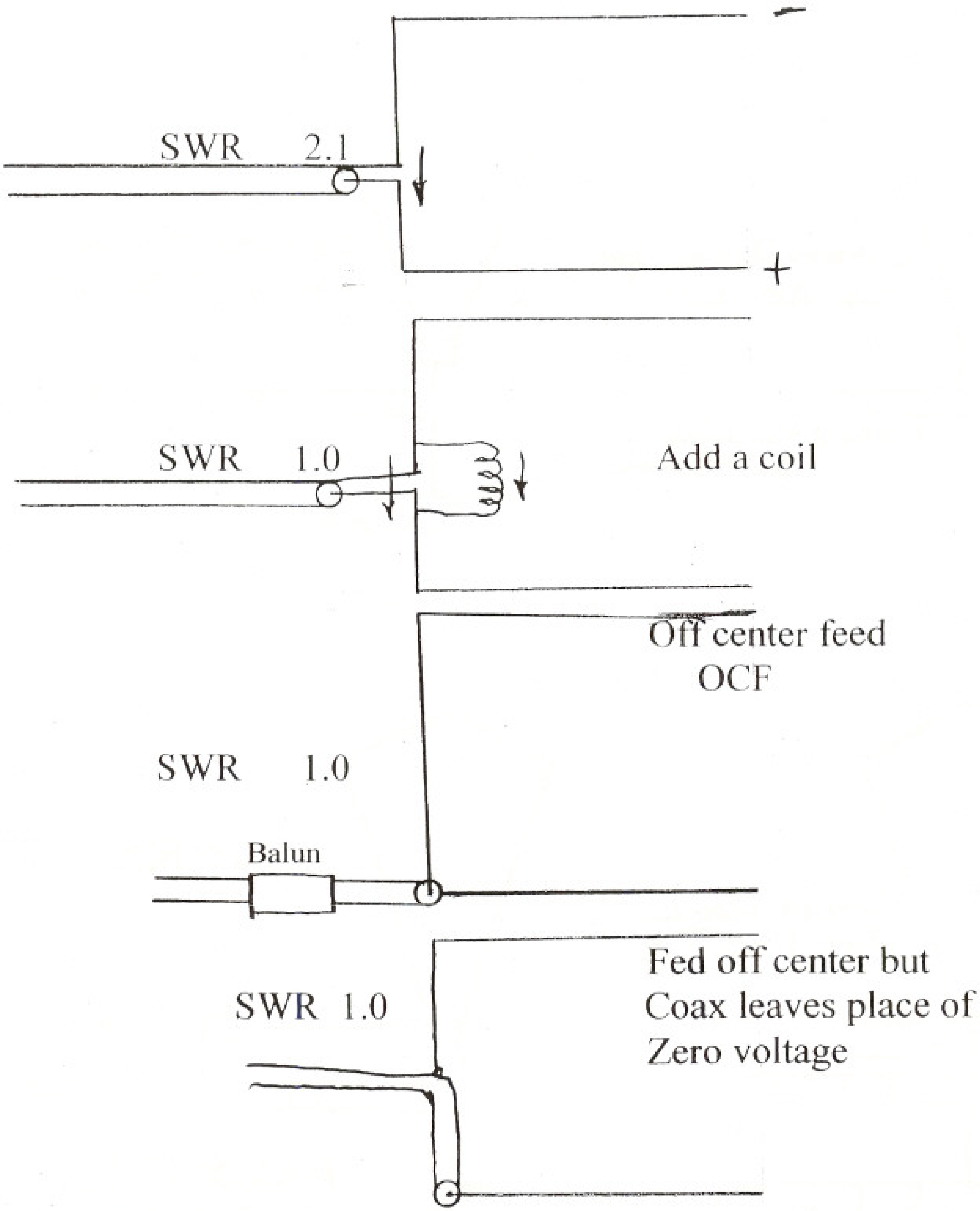
Full size



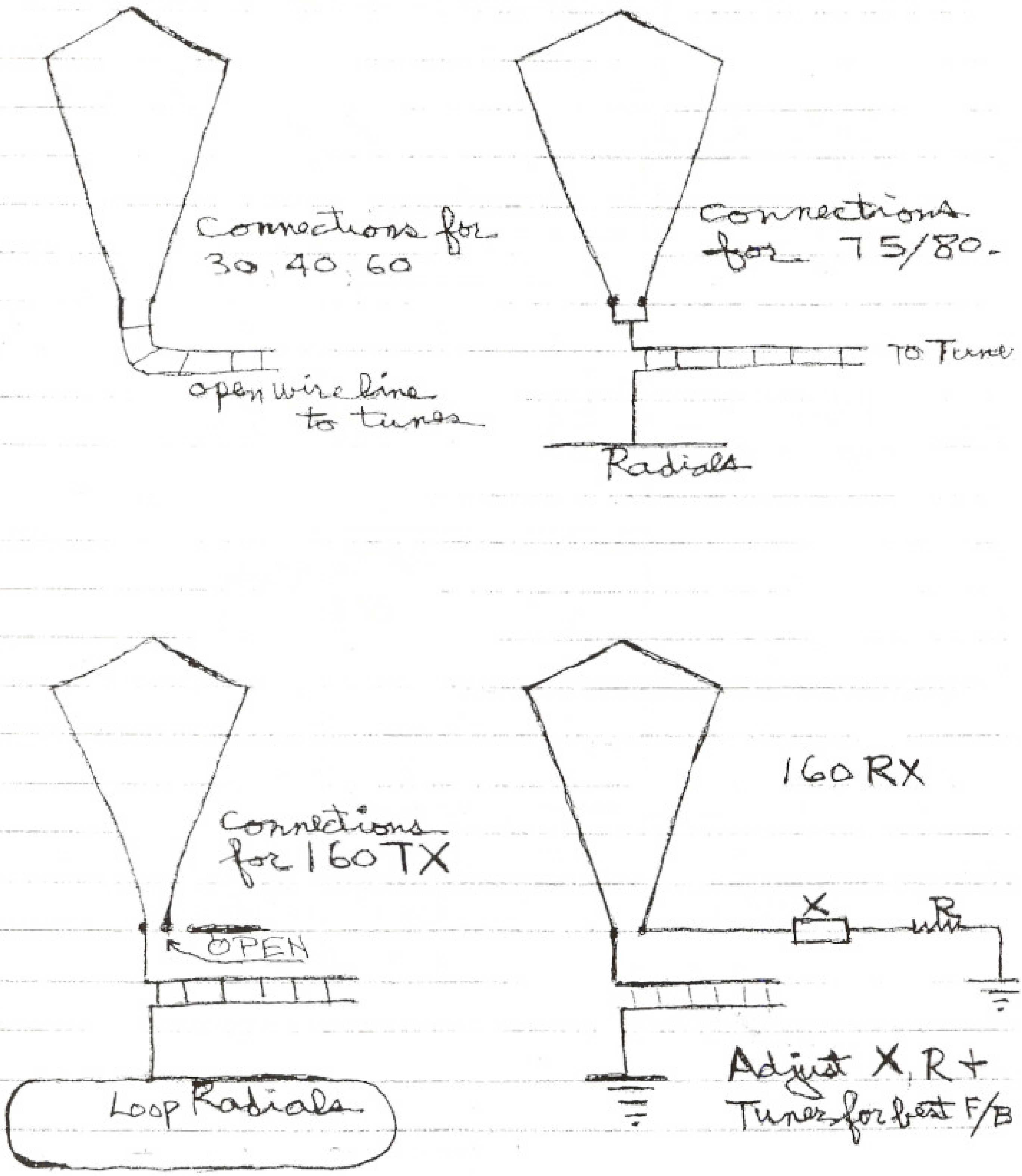
Small

W6TC loop connected for 160 M

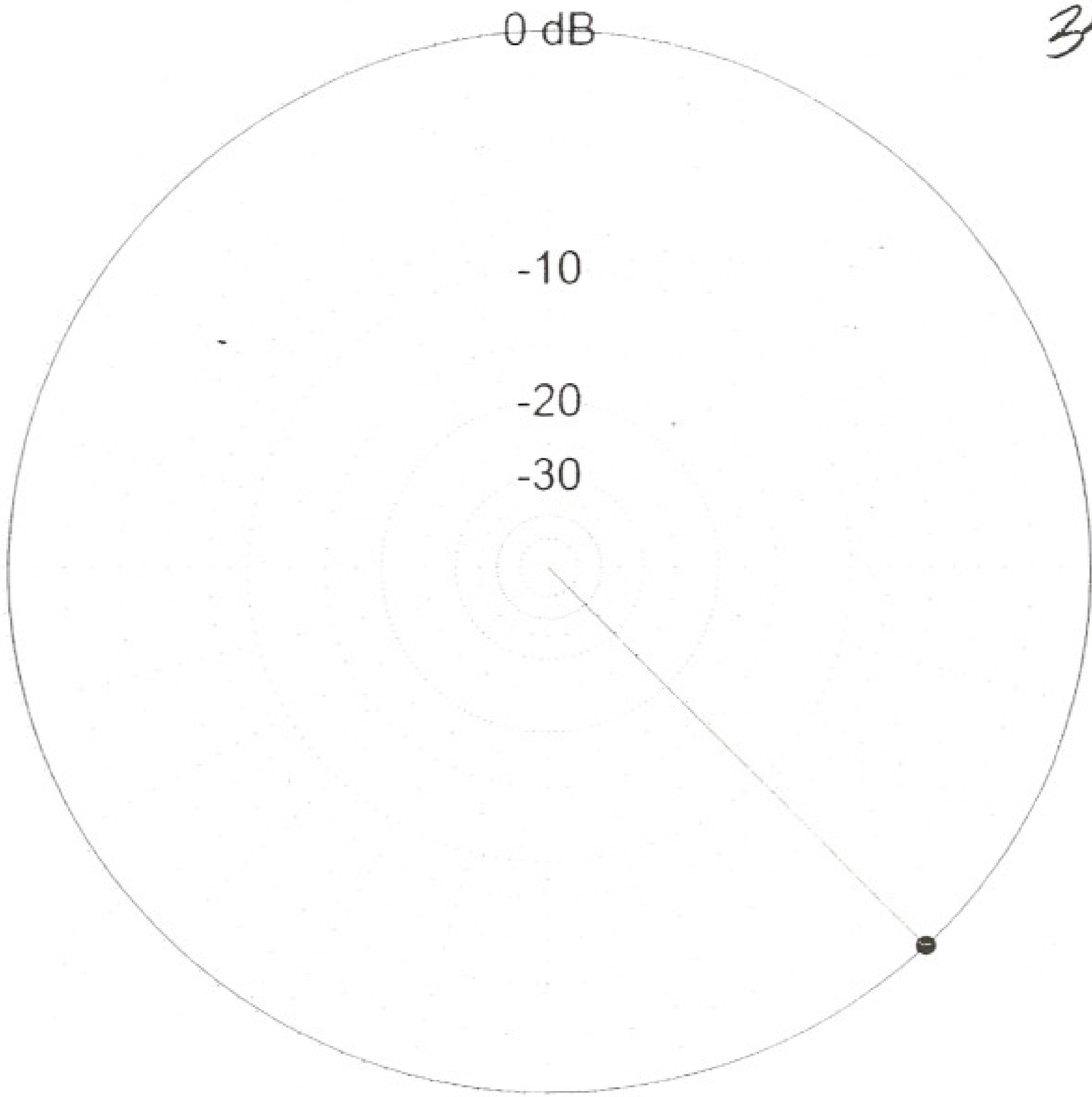
How to feed small antennas



W6TC DX LOOP Connections for 30, 40, 60, 75/80, 160



3A ✓



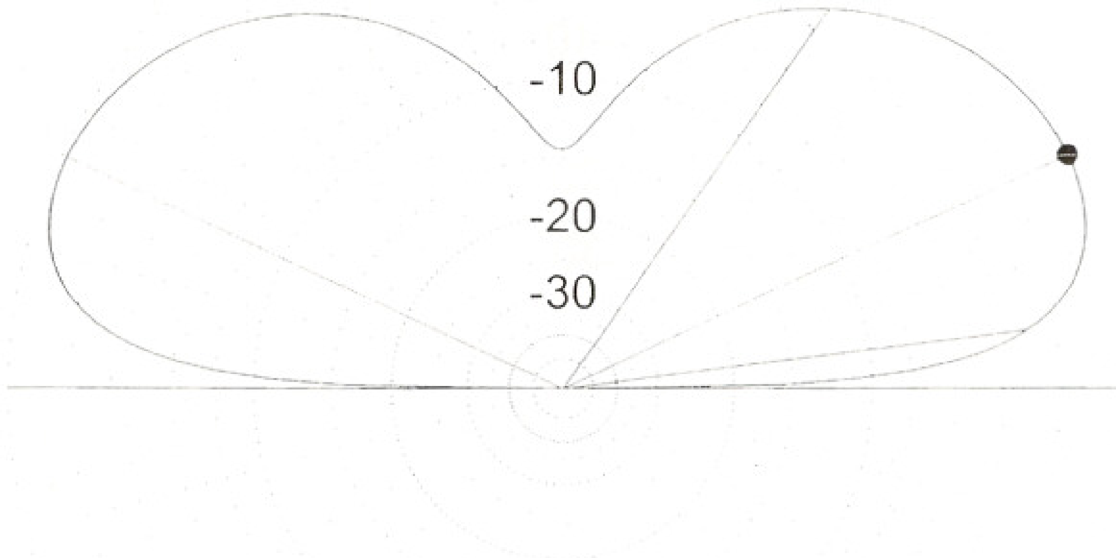
1.83 MHz

w6tc loop as 160 vert

Azimuth Plot		Cursor Az	314.0 deg.
Elevation Angle	25.0 deg. (30.1)	Gain	1.49 dBi (.27)
Outer Ring	1.49 dBi		0.0 dBmax

Slice Max Gain	1.49 dBi @ Az Angle = 314.0 deg.
Front/Back	0.13 dB ← (1.42)
Beamwidth	?
Sidelobe Gain	< -100 dBi
Front/Sidelobe	> 100 dB

35

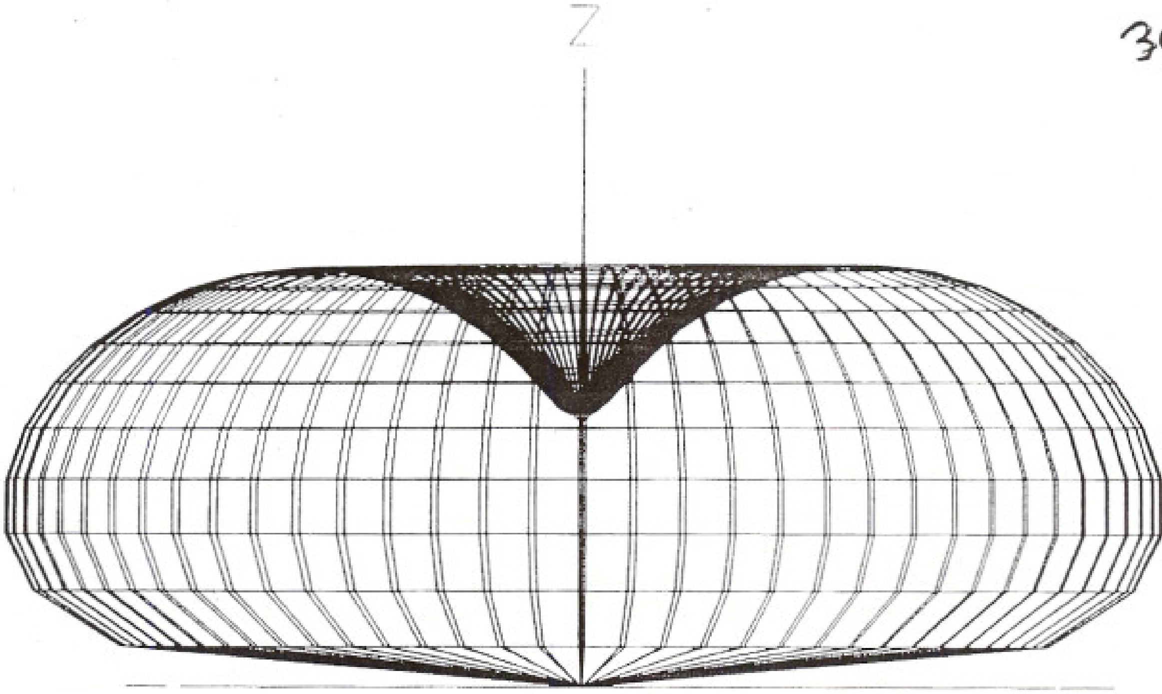


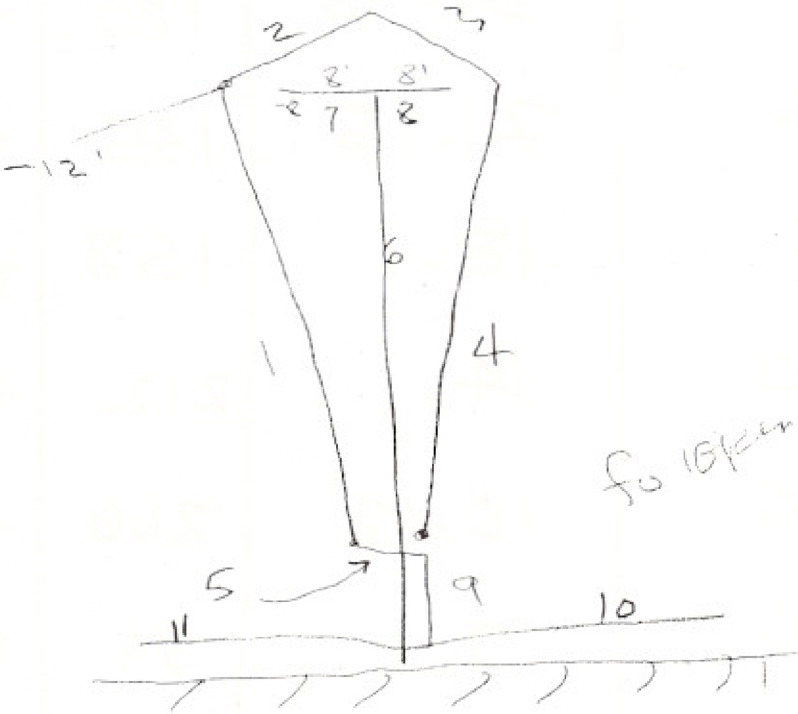
1.83 MHz

w6tc loop as 160 vert

Elevation Plot		Cursor Elev	25.0 deg.
Azimuth Angle	0.0 deg.	Gain	1.49 dBi
Outer Ring	1.49 dBi		0.0 dBmax

Slice Max Gain	1.49 dBi @ Elev Angle = 25.0 deg.
Beamwidth	47.4 deg.; -3dB @ 7.3, 54.7 deg.
Sidelobe Gain	1.33 dBi @ Elev Angle = 155.0 deg.
Front/Sidelobe	0.16 dB





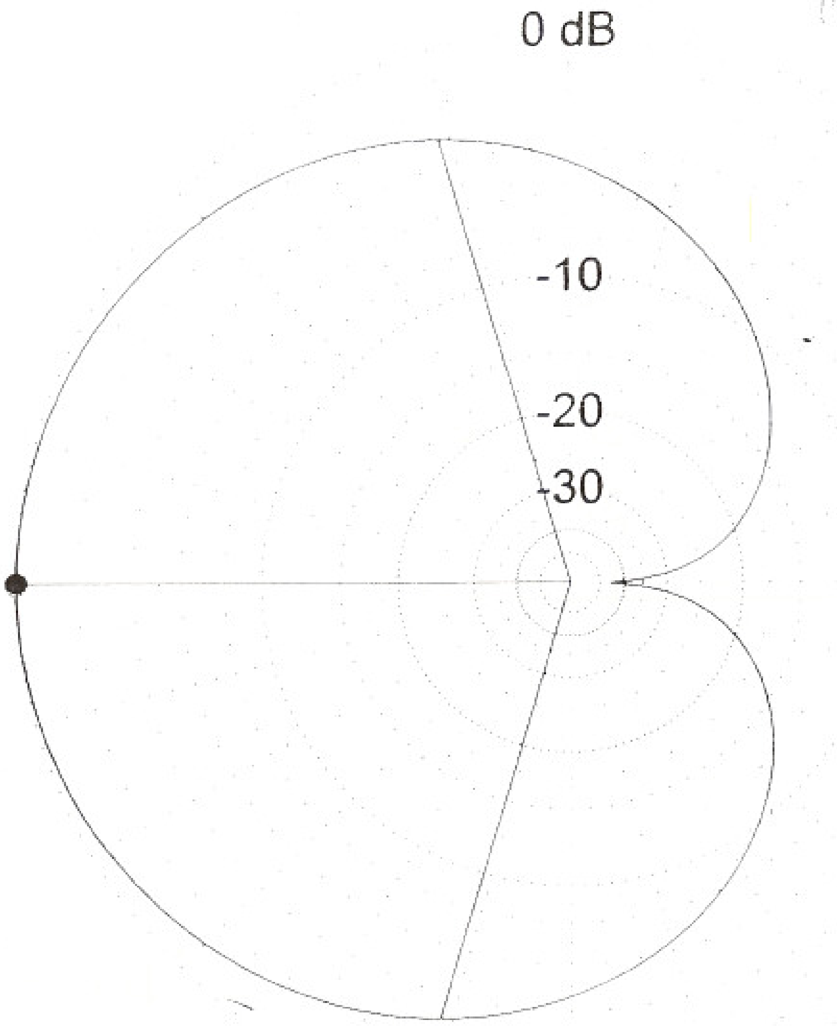
w6tc loop as 160 vert

BW abt same as inverted L!!

Table I

WbTC Loop Impedance

Band	frequency	R	X	Connection
10	28.3	304	+J181	fig. 3H
12	24.95	133	−J40	fig. 3H
15	21.15	135	+J215	fig. 3H
17	18.1	158	+J92	fig. 3H
20	14.1	212	+J89	fig. 3H
30	10.12	266	−J305	fig. 3H
40	7.1	34	+J39	fig. 3H
60	5.35	460	−J216	fig. 3H
80	3.6	42	−J73	Fig 3 I
160	1.85	19	+J12	Fig 3J



W6TC LOOP AS RX ANT.

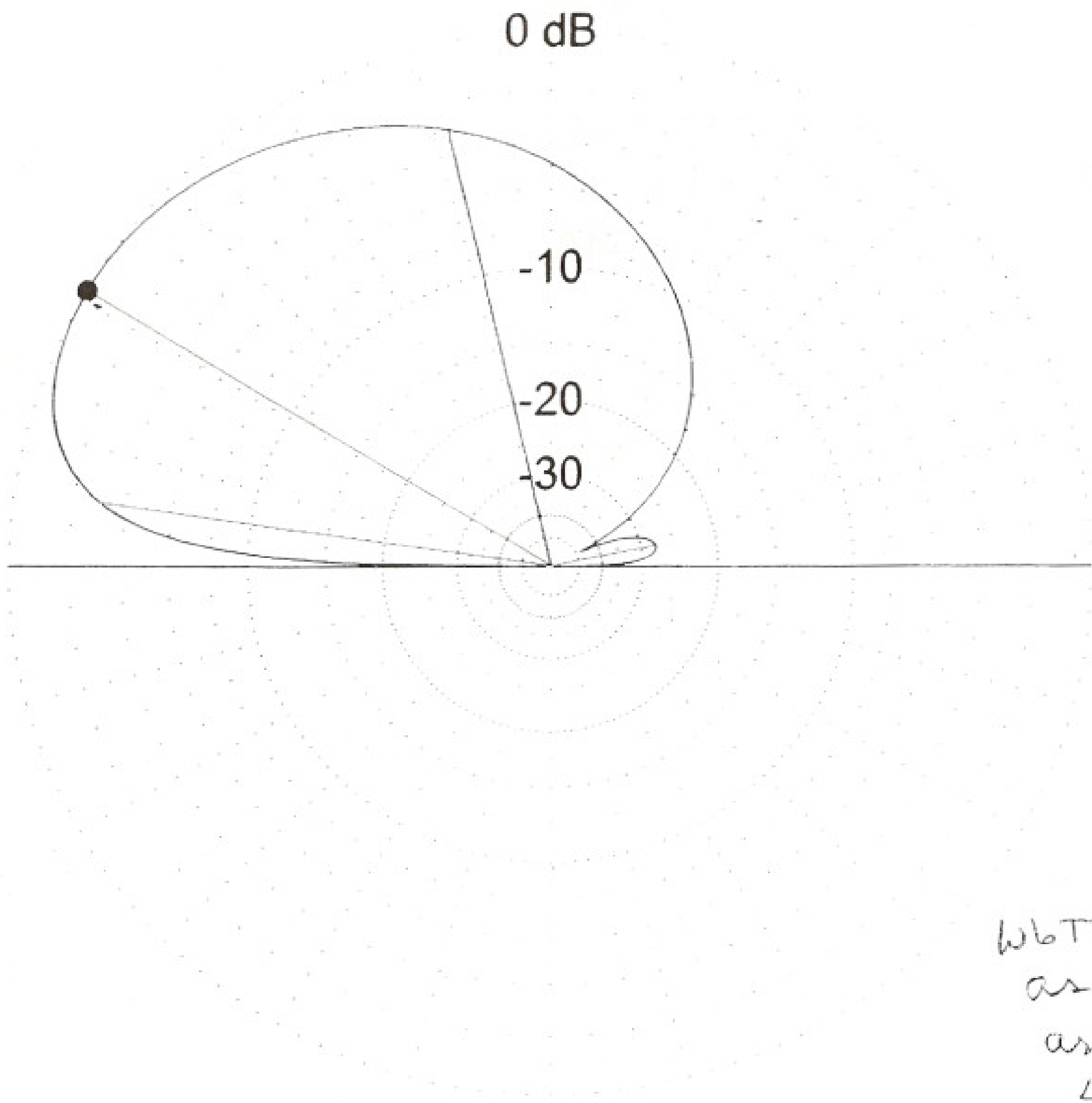
W6TC loop over SteppIR a 160 RX array 44.9dB F/B

1.8 MHz

w6tc loop k9ay rx

Azimuth Plot		Cursor Az	180.0 deg.
Elevation Angle	25.0 deg.	Gain	-30.04 dBi
Outer Ring	-30.04 dBi		0.0 dBmax

Slice Max Gain	-30.04 dBi @ Az Angle = 180.0 deg.
→ Front/Back	44.9 dB ← !
Beamwidth	146.9 deg.; -3dB @ 106.6, 253.5 deg.
Sidelobe Gain	< -100 dBi
Front/Sidelobe	> 100 dB



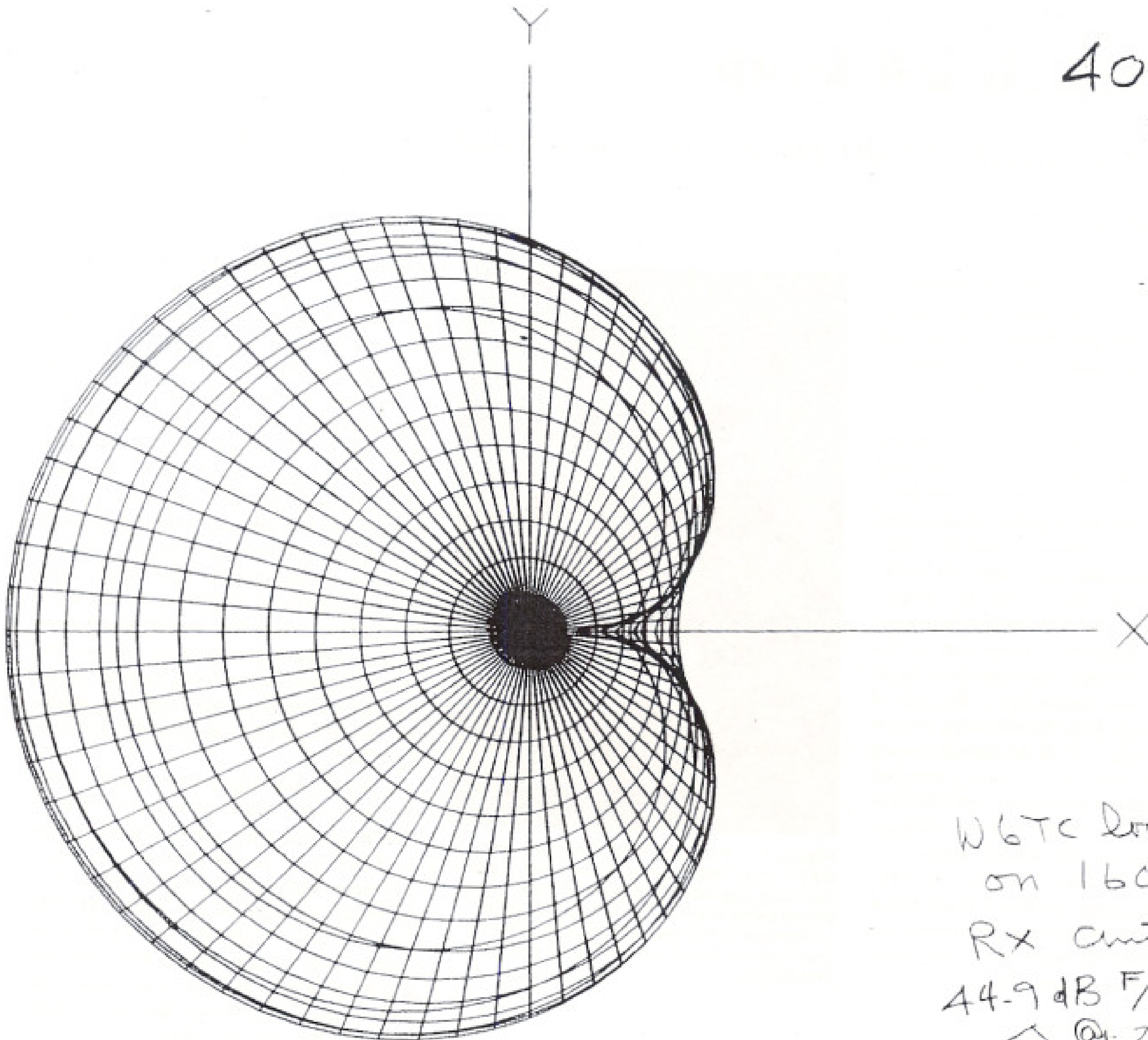
W6TC loop as 160 Rx array 44.9dB F/B

1.8 MHz

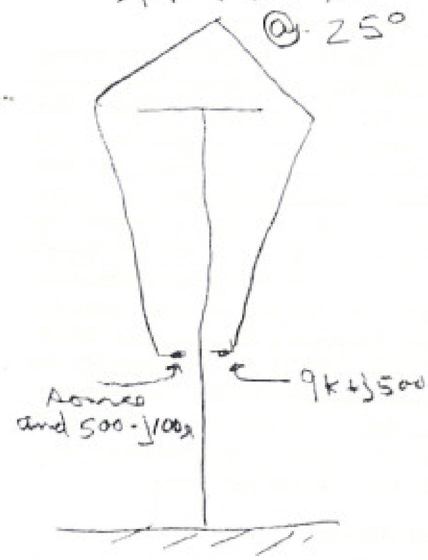
w6tc loop k9ay rx

Elevation Plot		Cursor Elev	149.0 deg.
Azimuth Angle	0.0 deg.	Gain	-29.88 dBi
Outer Ring	-29.88 dBi		0.0 dBmax

Slice Max Gain	-29.88 dBi @ Elev Angle = 149.0 deg.
Beamwidth	68.5 deg.; -3dB @ 103.3, 171.8 deg.
Sidelobe Gain	-57.42 dBi @ Elev Angle = 11.0 deg.
Front/Sidelobe	27.54 dB



W6TC loop
on 160 as
Rx ant
44.9 dB F/B
@ 25°



w6tc loop k9ay rx

The W6TC DX Loop

An easy way to add 30, 40, 60, 80 and 160 to your SteppIR — or any Yagi.

George Badger, W6TC

The sunspots are at their minimum so the low bands are where the DX action is. Soon the high bands will become increasingly important. Now is the time to have an antenna system with all-band capability.

I have been building quad antennas for some years. The 5BDXCC and 5BWAZ awards provided incentive to add low band capability. I found that large kite-shaped quad loops worked very well on 30 and 40 meters, and as explained later, on 80 and 160 meters as well. I mounted these loops on extended quad spreaders in the diamond configuration.

These low-frequency loops were in the plane of conventional diamond quad loops and extended to a tuning box at the base of my 60 foot tower. Thus the wire loops were in the shape of a kite, wide at the top and coming together at the base of the tower. I matched these large loops with remote controlled networks to cover 30 and 40, and with changes to loop connections, 80 and 160 meters.

I vividly remember looking up at my high-band quad elements, wishing I could tweak their dimensions to optimize performance on each band. However, there was no way to do that from down on the ground.

The SteppIR Appears

And then along came the SteppIR antenna. t was the answer to my dreams. Imagine motor driven Yagi element lengths, adjustable from ny operating position! Imagine an antenna hat tracks transceiver frequency, and autonatically optimizes performance every 50 kHz across all the bands from 20 to 6 meters! The ads sounded too good to be true. The SteppIR eemed to be electrically and mechanically complicated, so I was concerned about reliability. However, I have two good friends, V6OD and N6ATD, who have SteppIRs, and have had no problems. They convinced me to nstall the three element version. The SteppIR as lived up to my fondest expectations. It is a reat antenna for the high bands.

Low Bands

But what about the low bands? I have only one tower, and I live on a relatively small uburban lot, with neighbors sensitive to the ppearance of our neighborhood.

Would my new SteppIR preclude operaon on 30, 40, 60, 80 and 160 meters? I knew from my experience with the quads that the large low-band loops interacted with the high-band loops (they were in the same plane). They coupled and therefore required compensating adjustment.

I wanted to put a large loop on the same tower but I did not want the loop to spoil the superb performance of the SteppIR. For this reason I decided to mount the loop at 90° to the SteppIR elements, in the plane of the boom. This turned out to be a good decision, as discussed later.

Notes appear on page 39.

Figure 1 — Three element SteppIR with W6TC loop. The loop wire is barely visible. The loop extends from ground level to the boom extension on the left, to the mast extension at the top and back to ground level via the boom extension on the right. See Figure 2.

W6TC DX Loop

The W6TC loop is shown in Figure 1 and the schematic diagram of Figure 2. The loop is supported on two 5 foot × ½ inch fiberglass boom extensions, and an 8 foot × 1 inch fiberglass mast extension. The wires from the ends of the boom extensions extend downward and terminate at the base of the tower. Figure 2 is a schematic diagram of the W6TC DX loop.

End Fed Dipole, aka Delta Loop

Figure 3A shows a basic dipole, the grandfather of most antennas. The current in a resonant dipole is sinusoidal. Most of the current (and therefore most of the radiation) is from the central portion of the dipole. Current at the ends of a conventional dipole at any frequency is always zero, so there is little contribution to the radiation from the ends. The major useful contribution made by the ends is to bring the antenna to resonance. The ends can be placed in any shape or position (Figure 3B) with little effect on the radiation efficiency or pattern. Figure 3C depicts loading or traps typically used in shortened dipoles and triband Yagis. Figure 3D shows the configuration of the SteppIR 30/40 meter add-on, which is proven to be an excellent radiator.[1] Note that the dipole ends are folded back almost to the center. Figure 3E depicts the SteppIR element end-loaded dipole by KL7CW.[2]

The end loaded dipole of Figure 3F shows the dipole end wires extending downward. The end loading wires can be extended downward farther so that the antenna evolves into a symmetrically end-fed dipole W6TC loop (as found in Figure 3G and Figure 3H). The dipole is fed at both ends instead of in the middle. The slanted vertical wires serve as end-loading near the top of the loop, and evolve into a transmission line as the wires come together near the bottom.

Note from Figure 3G that the feed point is now at the bottom. This is convenient because all tuning and matching for all bands can be accomplished from the ground (no more tower climbing). Further, when it is used in the Figure 3G configuration, supported at the ends, there is no requirement for a heavy transmission line. Most of the radiation comes from the center, so you do not want to sacrifice height by weighing down the center.

Wideband Pattern

One of the very important characteristics of the W6TC loop is that there is always a maximum radiation point exactly opposite the feed point regardless of loop size and frequency. Because the loop is fed in the center at the bottom, there is always a point of maximum radiation at the top center, the highest point on the antenna, at any frequency. I published an article explaining this in some detail in 1979.[3] Bill Orr also describes my loop antenna in his *Antenna Handbook*.[4]

The importance of the centered symmetrical current distribution of the W6TC

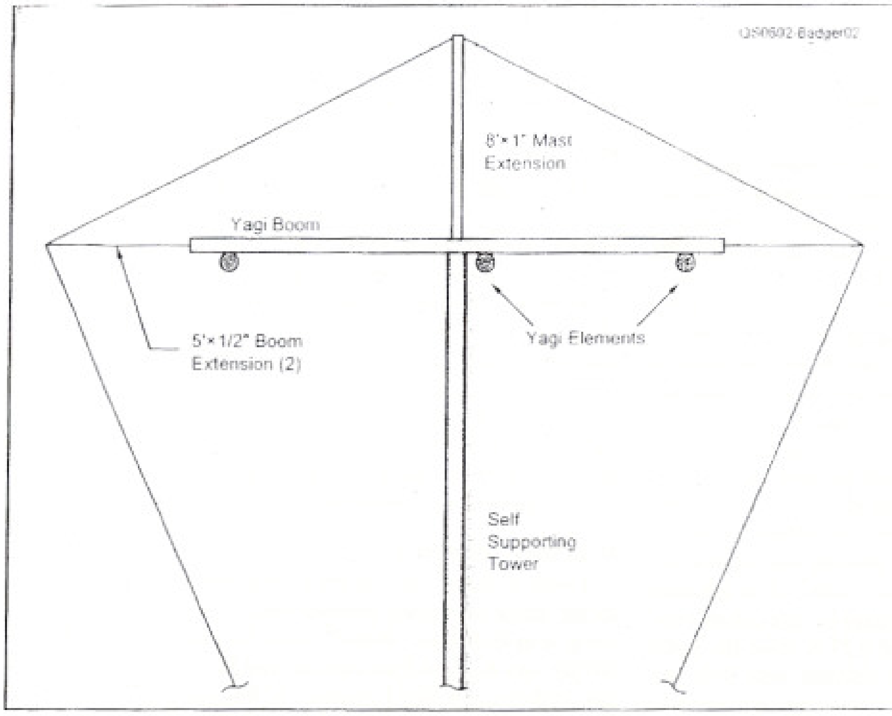


Figure 2 — Schematic diagram of the W6TC loop over SteppIR.

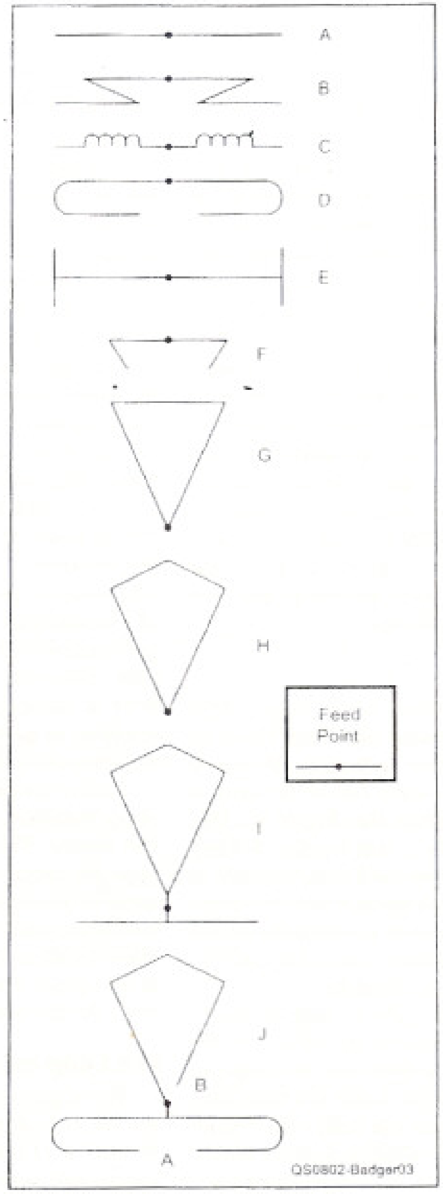


Figure 3 — How the W6TC DX loop evolved from the basic dipole.

loop antenna cannot be overemphasized. The radiation pattern over a wide frequency range is clean and stable. By comparison, the pattern of a conventional center fed dipole is far from clean as the frequency is increased over a wide range. Not only does the W6TC loop always have a maximum radiation point at the top center, the vertical components of the maximum current points on the vertical wires always cancel, regardless of frequency. The horizontal component of the radiation from the vertical wires nearest the dipole aids the radiation from the top horizontal wire, as explained in my 1979 paper.[5]

Loop Pattern Compared to that of a Wideband Dipole

A conventional multiband dipole simply does not work this way. Current at the ends is always zero, so the maximum radiation points are forced to move across the dipole, spoiling the radiation pattern at high frequency.

Dipoles or inverted Vs on the same tower with a Yagi should be avoided.[6] They should be low on the tower to prevent adversely affecting Yagi performance. Low band antennas should be as high as possible, not below the Yagi.

For DXing, antenna height is more important than length. If you can get a short wire higher, end feed it W6TC style. It will be a better DX antenna.

Rotatabilty Makes All the Difference

Having a rotatable dipole is a vast improvement over a fixed dipole, because you can move the major lobe to favor your target and use the side nulls to reduce interference and noise. *EZNEC* shows that the W6TC loop has a superb bidirectional broadside radiation pattern. On 30 meters, the gain is 8 dBi, the front to side ratio is 17 dB and the takeoff angle is 21°. On the air it feels like a beam because of the high-gain, deep-side nulls and low takeoff angle. Performance is also good on 40 meters.

Of course the W6TC loop does not have to be over a SteppIR. It can be mounted over any Yagi, regardless of boom length and height, because the loop dimensions are not critical. As a matter of fact, the loop does not have to be over a Yagi. It can be supported between trees as in Figure 3G or centered on a metal tower as in Figure 3H.

Feeding the Beast

I mounted a metal box that contains separate matching networks for each band, near the ground on my rotating tower. It is remotely controlled from the shack. Remote tuning is required in my location because open wire line cannot be installed through my house, so I went with coax feed.

A simpler way to feed the antenna is with open wire line, or ladder line, using a balanced tuner or conventional tuner with balun. As an experiment, to simulate a typical installation I temporarily installed a 75 foot open wire line to the tuner at my radio location. The W6TC loop is easily matched on all bands, 10 through 160 meters, using a basic L network tuner. Arrangements must be made to keep the line at least one line width away from the tower as it rotates.

Non-rotating Version

If your tower is fixed and is self-supporting, you can still install the W6TC loop. To prevent the vertical wires from wrapping around the tower, short lengths of PVC pipe fastened low on the tower and free to flex and rotate with the loop may be used.

Isolation, Loop to SteppIR

To show that isolation between the loop and SteppIR is adequate, I tuned both to resonance at the same frequency at which the coupling is the strongest. I matched and energized the loop on 20 meters. I then swept the SteppIR elements through the same frequency. I tried this on several frequencies and never could detect the slightest change in SWR on the loop or the SteppIR. I am satisfied that the performance of the SteppIR is not compromised by the loop.

80 Meters

Vertical polarization is preferred for

42

transmitting on 80 and 160 meters so connections at the feed point of the W6TC loop are changed. On 80, the total height of the loop is about 3λ/4 wavelength, so for vertical polarization the two ends of the loop are connected together and brought near resonance with a raised two wire radial system in the crawl space under my home (see Figure 3I). Of course, the radial system should be more extensive, but the two opposing radials utilize the only space available. In my case, because the total loop height is somewhat more than λ/4, and because it is, in effect, top-loaded, the maximum radiation point is well above ground level, away from nearby obstacles.

With *EZNEC* I found that almost as much current is flowing in the tower as in the two vertical wires. I was concerned that radiation efficiency would suffer because of resistance at the base of the tower. However, I modeled various resistances there and found that overall efficiency is satisfactory.

160 Meters

For 160, I could have used a large coil for baseloading the 80 meter connection. However, baseloading has low radiation efficiency. Instead I elected to leave one of the vertical wires open at the bottom (see Figure 3J). This is, in effect, a form of top-loading. Folding the monopole back on itself is an example of Figures 3D. The high voltage end of a monopole folded back does not substantially detract from the radiation pattern, but it does serve to bring the monopole to resonance.

The antenna height is substantially reduced with no significant effect on the pattern. There is a decrease in radiation resistance compared to a full λ/4 high vertical. However, because the total wire is more than λ/4, maximum radiation is above nearby obstacles. There is high voltage at the open end, so use a switch with high voltage hold-off. I use vacuum relays.

A popular form of toploaded 160 meter antenna is the inverted L. For comparison, I modeled the W6TC loop connected as in Figure 3J and modeled a classic inverted L at the same height. I modeled both over perfect ground and over two wire radials 2 feet above ground. The W6TC loop radiation pattern is better. *EZNEC* predicts that the W6TC loop is omnidirectional within 0.1 dB, whereas the inverted L is not symmetrical by more than half a dB.

EZNEC has a very useful feature. It calculates efficiency comparing total radiated power to total input power. The W6TC configuration of Figure 3J over a two wire resonant raised radial system over ground is 43% compared to 36% for the inverted L, probably because the horizontal section of the inverted L is more exposed to ground. Current in the tower is small because the tower is far from resonant. Thus the W6TC 160 meter vertical has better performance than the inverted L in most respects and requires only one support.

The W6TC Loop Radial

There is not enough space in my basement for two full λ/4 160 meter raised radials. To achieve a resonant radial system, I folded the two radials back on themselves as shown in Figure 3J. The radials are not symmetrical, so I was concerned that the current in them would not be equal. Because the ends of the two radials are physically close together and because the voltage and phase at the ends of the radials should be the same, I connected them together at A in Figure 3J forcing the voltage at the ends of the radials to be the same. The two radials are now more electrically symmetrical and therefore cancel better. I have modeled the loop radial simulating the asymmetry by placing one radial one foot closer to ground. With 1 A at the base of the monopole, current in two radials were predicted at 0.73 and 0.27 A. With the radial ends connected, the currents were 0.51 and 0.49 A, indicating almost perfect balance resulting in good cancellation of any radiation from the radials.

I have two raised resonant radial systems in my basement, one for 80 and the other for 160 meters. The 80 meter system has two opposing radials open at the ends. The 160 meter system has two opposing radials folded back and connected at the ends. With my MFJ clamp on RF ammeter, I measured the current in the radials. The 80 meter currents differ by 40%, the 160 meter by 11%.

The Loop as a Receiving Antenna

The loop receives well on 30 and 40 meters but the vertical polarization is too noisy on 80 and 160. I found that the 30 and 40 meter horizontally polarized connection is a quieter receiving antenna on 80 and 160 meters.

Thinking about the K9AY Loop, I discovered, working with *EZNEC*, that the 160 meter connection with a 10 kΩ resistor connected at B in Figure 3J has a 17 dB null.[7] I found that adding reactance increased that to more than 30 dB. I modeled both 80 and 160 meter antennas, using different ground models and received those results consistently. The same results were obtained in free space as well as over perfect ground by adjusting the impedance parameters at both ends of the loop.

The *EZNEC* results seemed too good to be true! Imagine having that kind of results in the real world. It was clearly time for real world validation. My friend Bob Alper, W6KT, at a distance of 10 miles, put a 160 meter signal on the air. After trying different resistance and reactance values, I obtained the results *EZNEC* predicted. The actual values for a particular location can not be determined by *EZNEC* because of ground variability and the effect of the tower. In my case, the load at Figure 3 J with the tower as ground was 161 pF in series with 1.24 kΩ. The front-to-back bandwidth covered the entire CW sub-band.

Having a rotary receiving beam with superb performance is very satisfying.

Results

The SteppIR works better than I expected, and so does the loop. The loop is easy to make, conservatively handles 1500 W, is easy to match on all bands and does not compromise the performance of the SteppIR. It is also excellent on the air. To show that it gets out well, I reviewed my log since August 2006 when we installed the SteppIR and loop. I have worked world-wide DX stations on each of the 160, 80, 40 and 30 meter bands using this antenna, most with just 100 W. I am very pleased with the results.

Acknowledgments

I wish to thank Michael Bach, WB6FFC, for his major role in my antenna installation along with Bob Alper, W6KT; Larry Moore, W6OD, and Richard Baldwinson, N6ATD. I also wish to thank Roy Lewallen, W7EL, for his technically superb and exceptionally user-friendly *EZNEC* antenna modeling software and L. B. Cebik, W4RNL, for his ARRL modeling course. Special thanks to my wife, Nancy, for her patience with my passion for antennas, building things and DXing, and her encouragement on the subject of this paper.

Notes

[1]SteppIR Antenna Systems, **www.steppir.com**, 2112 116th Ave NE, Bellevue, WA 98004.

[2]R. Dwight, KL7CW, "Add a 30 and 40 Meter Dipole to Your SteppIR Yagi," *QST*, Jun 2007, pp 37-39.

[3]G. Badger, W6TC, "Compact Loop Antennas for 80 and 40 meter DX," *Ham Radio*, October 1979, p 24.

[4]W. Orr, W6SAI, *The Amateur Antenna Handbook*, 1993, p 120.

[5]See Note 3.

[6]"The Doctor is IN," *QST*, Apr 2006, p 61.

[7]G. Breed, K9AY, "The K9AY Terminated Loop — A Compact, Directional Receiving Antenna," *QST*, Sep 1997, pp 43-48.

George Badger, W6TC, was originally licensed as W6RXW in 1939 and has been a member of the ARRL continuously for 68 years. After WWII service with the 89th Infantry Signal Company in Europe, George graduated from the University of California at Berkeley with a degree in electrical engineering. He holds seven patents on microwave tube design and was Marketing Director for EIMAC, President of Svetlana, and now consults for CPI Econco. He has published many technical articles professionally and in the amateur press. He is a fellow in the Radio Club of America. His Amateur Radio interests include building equipment, antennas and working DX. He holds DXCC Honor Roll #1, 5BDXCC and 5BWAZ.

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