THE DELTA LOOP

AN ALTERNATIVE ANTENNA FOR TROPICAL BAND DXING

DAVID CLARK

Introduction

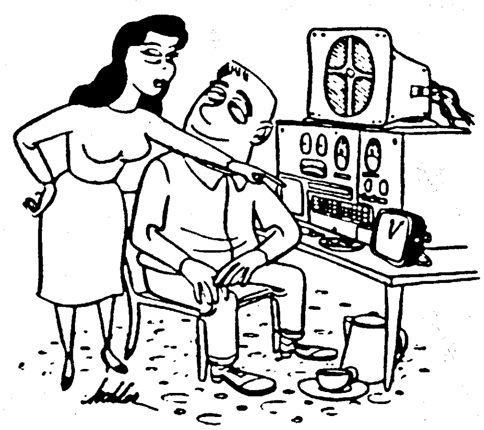
Wouldn't life be wonderful with a wide-band rotatable log periodic antenna? Unfortunately, such is well-beyond the practical and financial limitations of all but a privileged few. So, many SWL's and DXers "make do" with a simple 50-100 foot random wire. What do we do if we want a better antenna?

For the higher frequency international SWBC bands it is possible (even with relatively limited acreage) to erect one or more resonant antennas high enough to achieve greater gain and directivity. The half-wave Dipole or the inverted V are examples that come to mind. Commercially available multi-band antennas such as the Alpha Delta perform quite well and can be erected as a sloper, requiring only average backyard space. Even commercial or homebrew directive arrays can be considered. Beverages, however, are usually out of the question for lack of sufficient space.

Many serious DXers who have turned their attention to the Tropical Bands cannot find the space for a resonant wire antenna such as the half-wave dipole or a Windom, never mind a Beverage.

Furthermore, it is often quite impossible to erect the antennas high enough to take advantage of their full potential (the Beverage being the only exception this criterion). Because of this, many DXers have settled for the random wire, a compromise at best.

But as the ham radio fraternity says: "You can't work 'em if you can't hear 'em"! The best chance of hearing and perhaps QSLing the more challenging DX on the Tropical Bands comes with an effective antenna system, ideally one that is resonant, has a low noise factor and is directional. So what does one do?



"So it's only 9 p.m. in the Fiji Islands! Get out of your dugout canoe and come to bed!"

The purpose of this article is to describe a more effective alternative to the general purpose random wire for Tropical Band DXing. In many cases, this antenna can be erected (invoking some compromise in symmetry, if necessary) in space where even the half-wave dipole cannot be accommodated. The antenna in question is the Full-Wave Delta Loop (sometimes referred to as a Triangle Antenna) which strangely enough, seems to have been largely ignored and thus remains quite unfamiliar in the SWL/DX hobby.

Propagation Considerations

There are a number of considerations which recommend the Delta on the part of Tropical Band DXers. First, a review of some propagation basics in order to better appreciate its most important characteristic.

Everyone is acquainted with the traditional pictorial model which shows how shortwave signals are propagated by the ionosphere from transmitter to receiver. Single hop transmission takes place at distances up to 2500 miles (4000 km) for F2 refraction - somewhat shorter for F layer (night-time) or E layer refraction, I believe.

Beyond this distance, the angle of radiation decreases (approaches zero) and communication such as we as DXers are interested in takes place by multiple hop refraction. The angle at which a radio wave enters our listening post depends to a large extent on the distance from the transmitter; the greater the distance, the lower the angle of entry will be.

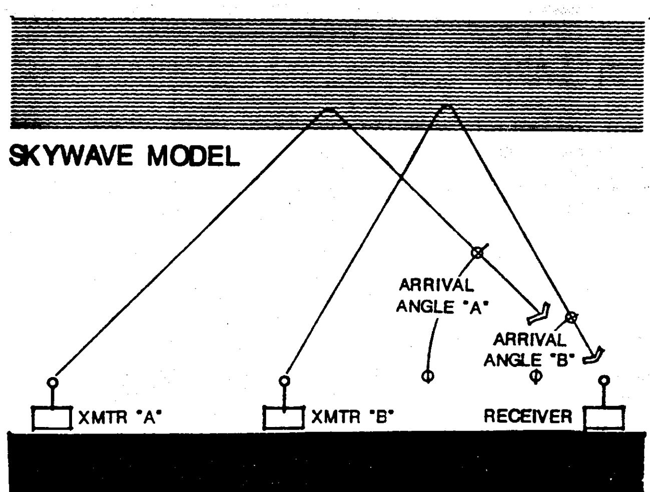


ILLUSTRATION 1

Illustration 1 assumes only a single hop but more importantly, demonstrates the principle that the angle of entry is reduced as the distance between transmitter and receiver is increased.

As a general rule, the lower the angle of entry the more efficiently a radio wave can be received. The manner in which signal refraction takes place in a grayline propagation situation (resulting in a lower angle of entry and an attendant increase in signal strength) is perhaps the best proof of this.

Characteristics of the Full-Wave Delta Loop

(a) Polarization and Wave Angle Response:

If we expect to receive the better DX signals on the Tropical Bands, it is important that our antenna be sensitive to signals coming in at low angles (say from 10 to 40 degrees above the horizon). This is especially important because most of our antennas are erected at compromise heights. Given the distance from point of origin which our target signals have travelled, they will have been refracted a number of times by the ionosphere and thus will usually arrive at our location at a low wave angle above the horizon.

The full-wave Delta Loop can be erected so that it is horizontally or vertically polarized. When vertically polarized, the Delta exhibits maximum sensitivity at low vertical angles - even when mounted at low heights. This is crucial for superior DX performance.

Furthermore, while the Delta is classified as a single element antenna, it has one leg in a horizontal position and two legs in a vertical or vertically sloping position. Because of this shape, even when configured for vertical polarization, it also exhibits moderate horizontal polarization at somewhat higher wave angles. Skywave signals arrive at the receiving antenna with both horizontally and vertically polarized components as a result of the "scattering" effect of ionospheric propagation. The Delta will respond favourably to signals which may arrive at a variety of wave angles.

In summary, the vertically polarized full-wave Delta Loop exhibits useful sensitivity at all important angles above with horizon but its maximum sensitivity at low wave angles, even when mounted near the ground, makes it an ideal, limited-space antenna for DXing purposes on the Tropical Bands frequencies.

(b) Basic Configuration:

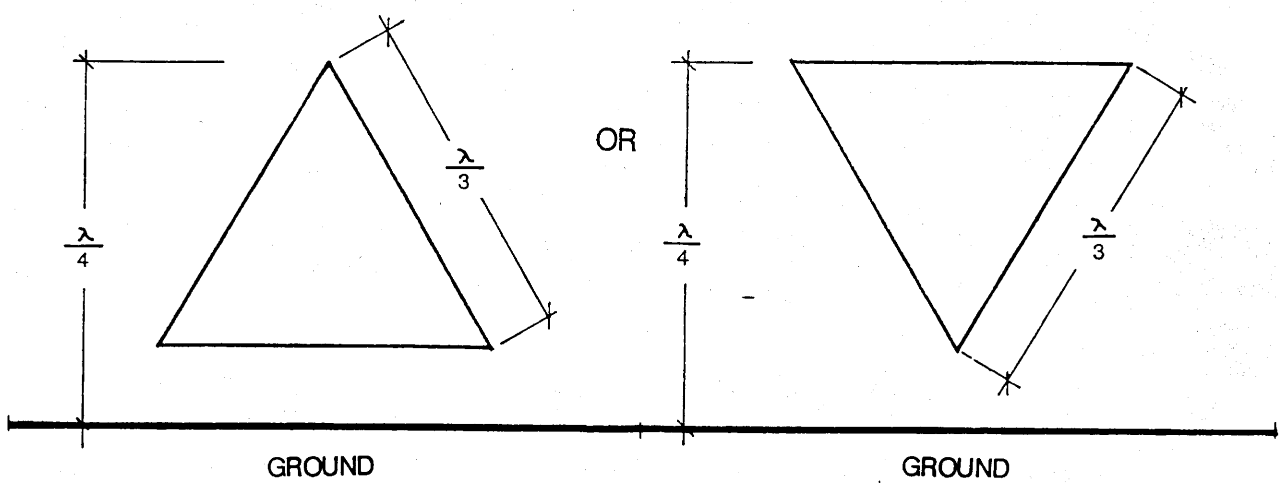
The basic configuration of the Delta Loop is that of an equilateral triangle with each side being one-third of one full wavelength for the intended resonant frequency.

[L (feet) = 1005/f (MHz)]

Notice that the apex may be at the vertical height (requiring only one high suspension point) or the triangle may be inverted with the apex at the bottom (two high suspension points required). {see illustration 2 - next page}

ILLUSTRATION 2

DELTA LOOP CONFIGURATIONS



In either case, maximum directivity is broadside to the plane of the antenna at resonance. For best low angle pickup of DX signals), vertical height should be about 1/4 wavelength above the ground.

Placement for the coaxial (or open line) feedpoint is the critical factor which determines whether the Delta will be basically horizontally or vertically polarized and this in turn governs the primary signal pickup pattern of the antenna. A number of variations will be described.

(c) Comparison to Quad Loop:

There is another form of loop too, although the focus of this article is on the Delta because it is more likely to meet the space constraints of suburban DXers. The Quad Loop is in the shape of a square instead of a triangle. Each side is 1/4 wavelength for a total length again of one wavelength at the intended resonant frequency. Its operating characteristics are essentially the same as the Delta except that the Quad affords slightly better gain than the Delta because it occupies a greater area in free space. In like manner, the Quad can be fed to provide either a horizontal (high angle sensitivity) or vertical (low angle sensitivity) polarization.

Carl Huffaker down Mexico way advises that he uses Quad loops mounted parallel to the ground in order to null the noise from overhead powerlines. He adds that this arrangement provides good omnidirectional reception with excellent response at low wave angles.

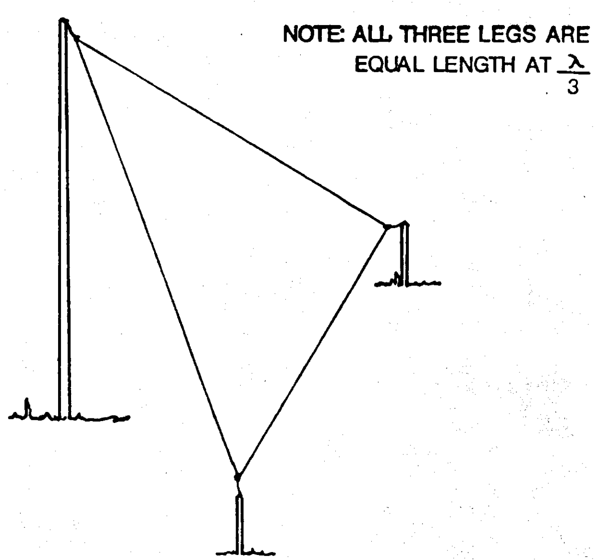
(d) Comparison to Ground Plane:

The Delta exhibits most of the positive characteristics of other vertically polarized antennas (such as the Ground Plane) but without the negatives. I believe it is useful to draw this comparision to understand the characteristics of the Delta. Verticals do not enjoy a stellar reputation in SWL circles and are seldom used by shortwave DXers, even for the higher bands.

Like the Delta, the Ground Plane with a satisfactory array of radials to achieve an efficient "image" antenna, picks up signals at a low angle and thus is effective for DX work. It is truly an omnidirectional antenna, whereas the Delta, while providing satisfactory response for all compass points, is moderately bi-directional (broadside to its plane, especially at the resonant frequency) and thus can be "pointed" to favour an intended target area. For example, in Ontario, a Delta erected in a NE-SW orientation would favour signals arriving on great circle paths from Southeast Asia (NW) and Southern Africa (SE).

The Ground Plane actually works best when mounted close to the ground. The Delta functions well when erected at low heights. Although a height of 1/4 wavelength above ground is considered desirable, this is probably impractical, especially when a Delta cut for resonance on 120 or 90 meters. Two solutions are at hand (see illustrations 3 and 4) which do not seriously detract from its overall performance in terms of directivity or low wave angle response, as far as I know.

On the one hand, where it is not possible to get the Delta 1/4 wavelength above the ground and keep the vertical legs are at 90 degrees to the ground, the legs may be sloped away from the high point at a convenient angle of say 45 degrees. Make sure that the lowest point remains reasonably above the ground (10 feet would be a good objective, if possible). Best efficiency is assured by maintaining the equilateral shape.

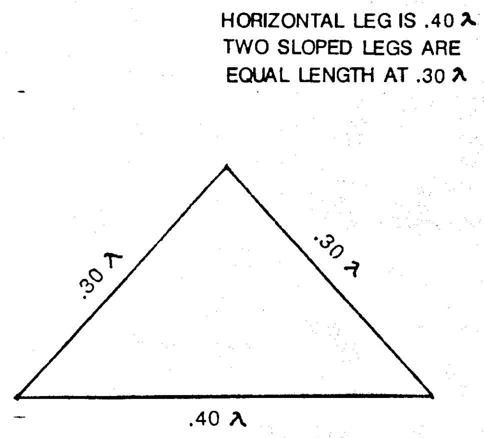


BASIC DELTA LOOP CONFIGURATION

ILLUSTRATION 3

Alternatively, it is acceptable to save on vertical height by distorting the equilateral triangle by moderately shortening the two vertical sides (in equal amounts), thus creating a proportionately longer horizontal side. In this case, however, you should make sure that the longer leg does not exceed more than .4 of a wavelength, thereby leaving .3 wavelength for each of the other two sides. This configuration also has some affect on the impedance but more on that later.

ILLUSTRATION 4



ALTERNATE LOOP PROPORTIONS

(e) Comparison to Horizontal Antennas:

Turning to horizontal antennas for a moment, everyone is familiar with the general advice that they should be mounted in the clear and as high as possible. Actually, the horizontal half-wave dipole must be mounted at least 1/2 wavelength above the ground to achieve any semblance of sensitivity towards signals arriving at low angles. This would amount to ridiculous heights in the hundreds of feet for 120 and 90 meters! Thus, in this respect the Delta Loop significantly outperforms horizontally polarized antennas such as Dipoles, Windoms and the random wire, given the relatively low heights at which it would be practical to mount any of these antennas for Tropical Bands work.

(f) Noise Response:

The major negative of vertically polarized antennas is that they tend to pick up electrical interference and RF static - most of which is vertically polarized. This can be a rather serious drawback for city folk and might otherwise dictate a horizontal antenna with a shielded feedline.

Happily, the vertically polarized Delta Loop is most assuredly an exception to the rule. It is actually a very low noise antenna and this I can state from practical experience! The Delta is generally acknowledged to be very much quieter for receiving purposes than most types of verticals and indeed some horizontal antennas. This is typical of a closed loop. (At my location, only the Beverages (unterminated) with a length of 600-800 feet seem to be consistently quieter.) I have yet to find a technical explanation of why this is so; perhaps the interaction of the horizontal and vertical elements serves to cancel out or reduce pickup of vertically polarized interference that would be more noticable with other forms of vertically polarized antennas.

(g) Other Performance Characteristics:

The Delta enjoys a modest gain advantage over the half-wave dipole (about 1.5 to 2 dB) and even more so over a Ground Plane, Windom, Inverted V or a simple random wire. Naturally, other forms of highly directive antennas such as three or four element Yagi or Quad beams afford vastly greater gain than the Delta but how many 60 or 90 meter beams have you seen lately?

While I have no hard data to back this up, various texts indicate the Delta is reasonably broadbanded. With proper impedance matching, I wouldn't be surprised if an SWR of 2:1 or less were to be exhibited for up to 150-200 kHz away from resonant frequency. Of course, this criterion is really only important to the amateur operator for transmitting purposes. As far as I'm concerned for receiving purposes, a 60 meter Delta cut to 4800 or 4900 kHz performs admirably for DXing anywhere from say 4500 to 5200 kHz, especially in the two favoured directions - broadside to the plane of the antenna.

The Delta will also perform reasonably well and seems to be more omnidirectional on frequencies other than those for which it is cut. According to the textbooks, better multi-band performance can be realized by using a higher impedance open-wire (balanced) feedline (instead of unbalanced 52 ohm coax) together with an antenna tuner to match to the input impedance of the receiver. I have no personal experience to date with the use of balanced feedlines on which to base any further comment.

In my own case, even using coaxial feedlines, I find that the 90 meter Delta works well on all of 31, 41 and 19 meters, while the 60 meter version is quite good on 41 and 25 meters. On 60 meters, the 120 meter Delta provides a lower gain than a 60 meter version (both are oriented to favour signals arriving from North and South) but nonetheless a distinctively good S/N ratio.

Radiation Patterns

How might a one-wavelength Delta Loop be constructed to achieve that all-important low angle pickup pattern desirable to improve the chance of logging those weak Tropical Band Indo's?

For a given configuration, placement of the coaxial feedline determines whether the antenna will be horizontally or vertically polarized. Only when the antenna is high enough up in the air - at least 1/2 wavelength of the resonant frequency - does polarization become less of a consideration. This is hardly possible, however, for the Tropical Bands. And so, one should opt for vertical polarization which will provide the desired maximum sensitivity to the low wave angle signals.

First let's examine two of the possible configurations of the full-wave equilateral Delta which will result in horizontal polarization. With the apex up, in one case the feedline is placed at the apex; in the other case, the feedline is at the mid-point of the base (see illustration 5).

Notice that maximum sensitivity is at undesirably high wave angles (close to 90 degrees) similar to both the Inverted-V and horizontal half-wave Dipole mounted at a corresponding height of 1/4 wavelength (see illustration 6). In all cases, there is only limited sensitivity to DX signals arriving at angles of 40 degrees or less above the horizon.

HORIZONTAL POLARIZATION

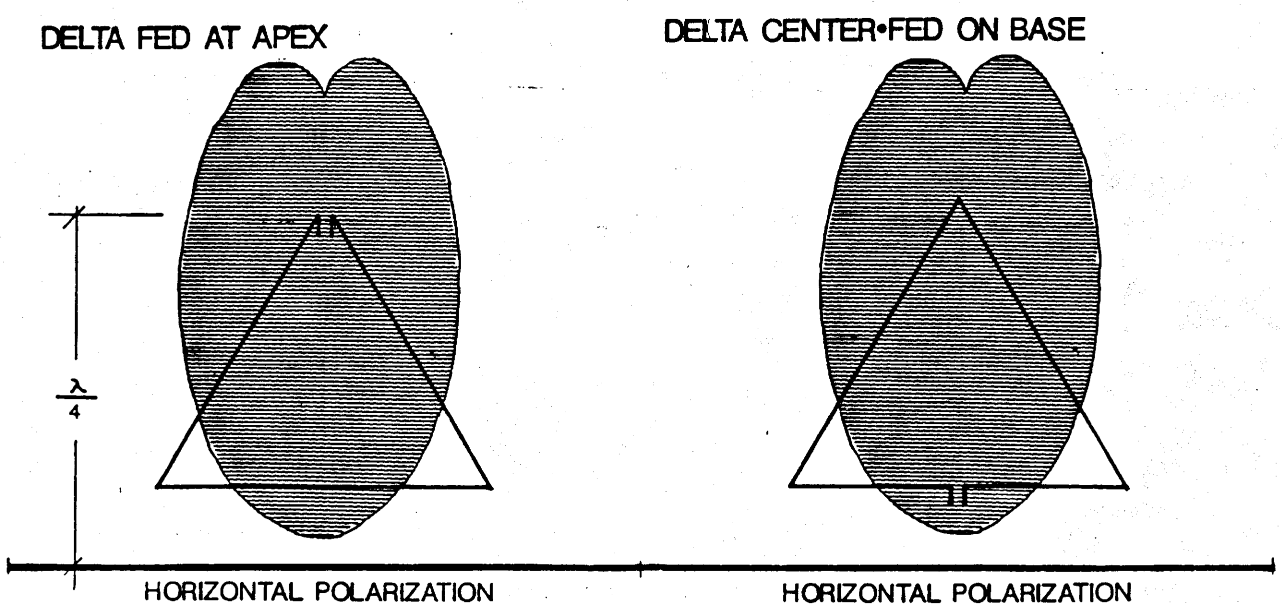


ILLUSTRATION 5

HORIZONTAL POLARIZATION

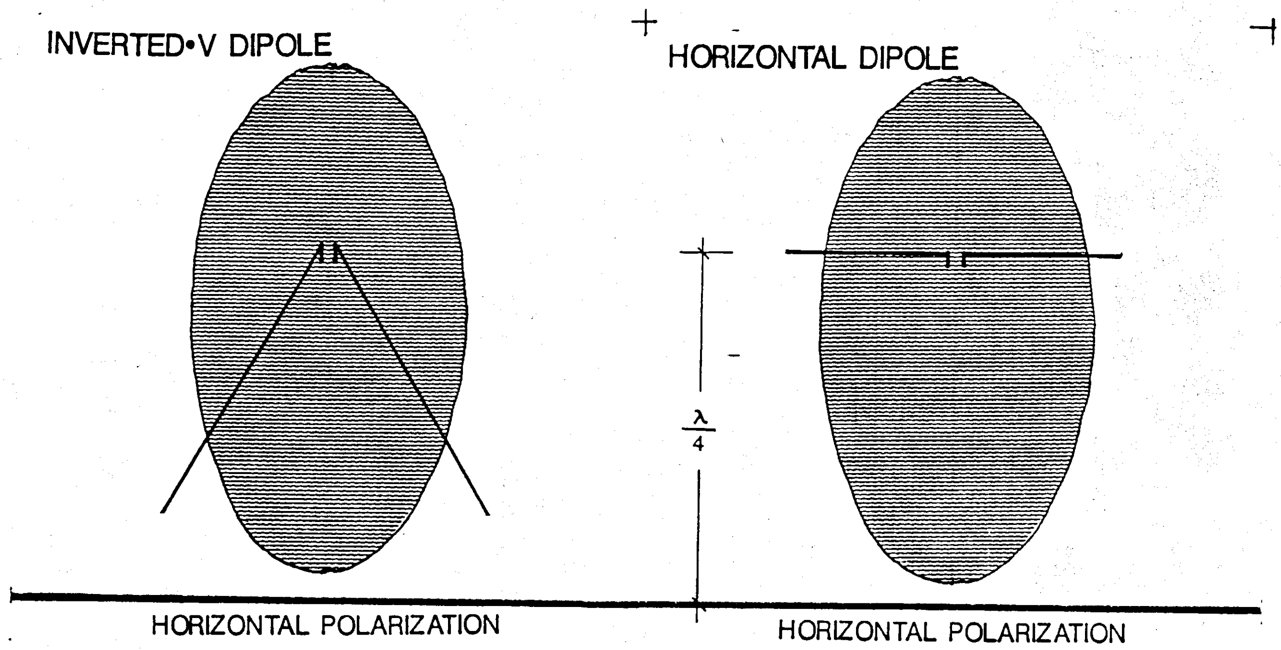


ILLUSTRATION 6

Compare the two examples of horizontal polarization in illustration 5 to the following three situations where the Delta is fed to emphasize vertical polarization. If the antenna is fed at a corner, the apex may be up or inverted (see illustration 7). It may also be fed at the point of an inverted apex (see illustration 8).

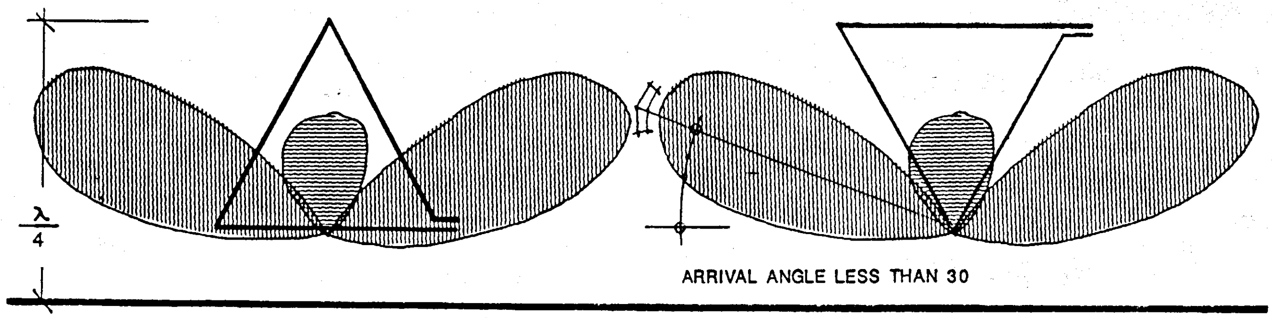
When corner fed, the vertical radiation lobe angle (sensitivity pattern for receiving) is reduced to 25 degrees or less. When fed at an inverted apex, the angle is about 30 degrees (quite similar to an ordinary Vertical - see illustration 9).

Any vertically polarized arrangement is is much more satisfactory for Tropical Bands DXing where typical wave angles are in the range of 10 to 40 degrees above the horizon as we receive the signals. The key advantage with the Delta lies in obtaining this response at a relatively low antenna height.

VERTICAL POLARIZATION

DELTA CORNER•FED ON BASE

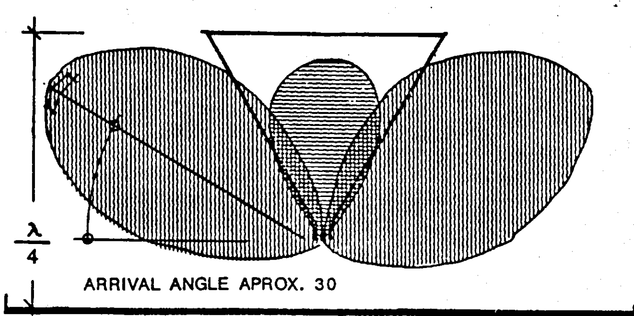
INVERTED DELTA FED AT UPPER CORNER



VERTICAL POLARIZATION
WITH SMALL HORIZONTALLY POLARIZED HIGH ANGLE LOBE

ILLUSTRATION 7

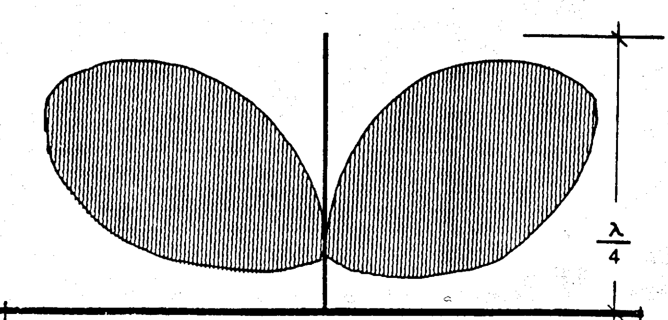
INVERTED DELTA FED AT APEX



VERTICAL POLARIZATION
WITH HORIZONTALLY POLARIZED HIGH ANGLE LOBE

ILLUSTRATION 8

1/4 WAVE VERTICAL



VERTICAL POLARIZATION

ILLUSTRATION 9

Conventional wisdom holds that the inverted corner-fed Delta (illustration 6) is the optimum configuration to emphasize low angle sensitivity. Of course, apex up and corner-fed at the horizontal base would probably be easier to mount for most users with no perceptible difference in performance.

In his most recent book, 'Low-Band DXing', however, John Devoldere (ON4UN) describes a refinement of the corner fed arrangment to achieve maximum vertical polarization and thus, maximum sensitivity to DX signals arriving at a very low wave angle. Instead of being taken directly from a corner adjoining the horizontal leg, the feedpoint is calculated as .08 wavelength away from the corner on a vertical leg, in other words, 1/4 wavelength away from the apex of an equilateral Delta (see illustration 10). Apex up (easier to erect) or inverted would seem to be equally acceptable from a performance viewpoint.

A feedpoint of .08 wavelength away from a horizontal corner should also be used for the non-equilateral Delta having an extended horizontal leg (as in illustration 4).

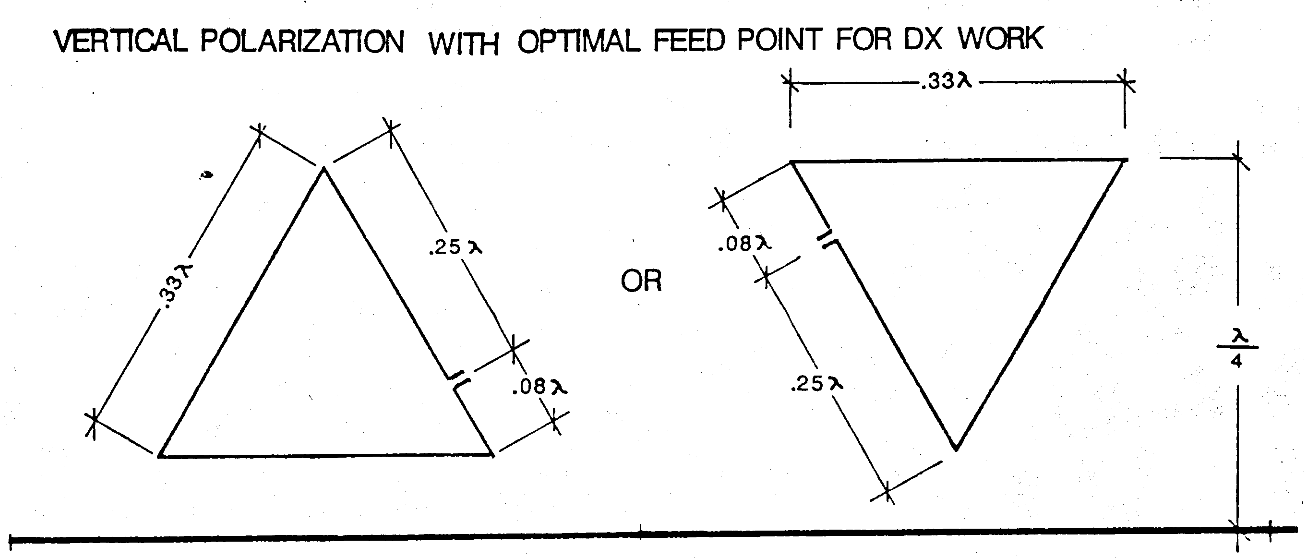


ILLUSTRATION 10

Impedance Matching

I have made reference to the possible use of a balanced open wire feedline (such as 300 ohm unshielded TV twin lead or 450 ohm open ladder line), together with a suitable antenna tuner (such as a Transmatch), to improve multi-band performance. This would be a "natural" in the sense that the Delta loop is a balanced antenna.

A disadvantage of unshielded feedline, however, is that it is more susceptible to noise-pickup. This might be of concern to the majority of readers. Furthermore, since our focus is on the use of the Delta cut for a particular Tropical Band, I have assumed that multi-band performance is of lessor concern. For these reasons, we shall concentrate on using a feedline consisting of unbalanced coaxial cable.

The characteristic impedance of the equilateral full-wave Delta (erected at 1/4 wavelength) is between 100 and 150 ohms at feedpoint. Use of a quarter-wave 75 ohm transformer is thus recommended. The appropriate length of RG-11A/U or RG-59A/U coax (the latter is much cheaper) will suffice for this purpose. An excellent match to the standard low impedance RG-8/U or RG-58A/U coaxial line is thus achieved. This low impedance line (length is not critical) is then connected directly to the low impedance antenna input of your receiver.

The coaxial transformer actually forms that part of the feedline which is connected to the antenna. For best low angle sensitivity, Chuck Rippel has clarified the importance that the "hot" wire (centre connector) be connected to an ascending (vertical) leg and that the shield (outer connector) be connected parallel to the adjacent horizontal leg (ie. parallel to the ground). Refer to illustration 11 (apex up configuration). Note that the same criteria apply for connecting the coaxial transformer .08 wavelength from an upper corner in the inverted Delta configuration.

The length of the coaxial matching section of the feedline is determined according to the following formula:

L (feet) = 234/f (MHz) X velocity factor of feeder

The rated velocity factor (which associates the physical length with the electrical length of a particular feedline) is .66 for for both the RG-11 and RG-59 lines. Thus, for example, using 3.300 MHz as the point of resonance, a 90 meter delta would require a coaxial feed line of 234 / 3.3 X .66 = 46.8 feet. Refer to the table following.

Splice the other end of the coaxial transformer to the RG-8 line leading to the receiver using a PL-258 coupler and seal if this connection point is outdoors.

As height above the ground is reduced (below 1/4 wavelength), the antenna impedance at feedpoint of the equilateral Delta becomes somewhat lower but I believe the matching transformer is still desirable.

COAXIAL TRANSFORMER FABRICATION

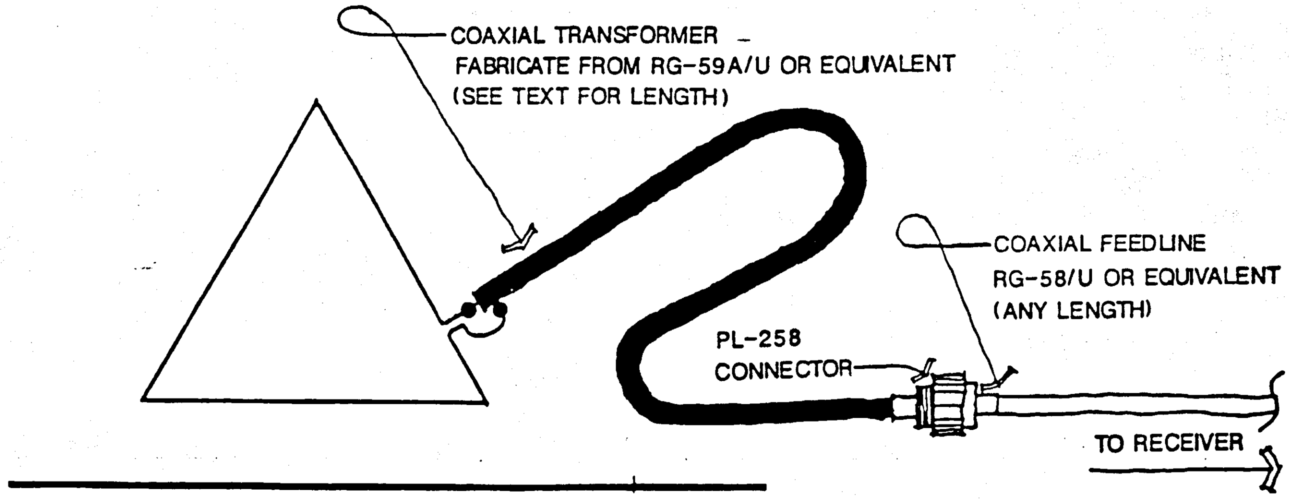


ILLUSTRATION 11

In the case of the non-equilateral Delta erected at 1/4 wavelength (or perhaps less) above ground, the antenna impedance at feedpoint is already close to 50 ohms so the matching transformer is not required.

Dimensions for Tropical Bands Delta Loops

The table on the page following shows appropriate lengths for each of the three legs (ie. L1 = L2 = L3) and the coaxial transformer (L4) for an equilateral Full-Wave Delta cut for about centre frequency for each of the respective Tropical Bands. Lengths are specified in feet.

Band	Freq (MHz)	L1	L4
120	2.400	139.6	64.3
90	3.300	101.5	46.8
75	3.950	84.8	39.1
60	4.900	68.3	31.5

Concluding Observations

I hope this article will encourage a broader interest in the minds of senior DXers as to the potential for enhanced Tropical Bands reception possibilities afforded by the Full-Wave Delta Loop. There is ample room for experimentation with various configurations and I for one would certainly like to see more documentation on the subject in the DX journals. Even most urbanites should be able to cope with the dimensions for a 60 meter Delta and I sincerely urge you to give it a try!

Being in the happy position of residing on 10 acres in the countryside, I have the good fortune of having an "antenna farm" consisting of a number of Delta Loops and Dipoles (all of which are cut for the Tropical Bands), as well as several Beverages so at least I can cite some practical experience as a guide to others.

I presently have four Full-Wave (equilateral) Delta's in place on the property, all of which were erected before I became acquainted with the relative advantages of vertical and horizontal polarization. As it happens, the 120 and 60 meter antennas (apex down) are fed to provide vertical polarization but without the coaxial transformer. The two 90 meter antennas (apex up) are fed to provide horizontal polarization with a coaxial transformer.

There is no discernable difference in noise sensitivity although the comparisons cannot be considered too conclusive as they are cut for different frequencies. I might add that in all cases, my Delta's are erected such that the vertical legs slope away from the vertical height at about a 45 degree angle. Furthermore, they all fall closer to ground level than they really should and yet, I am very enthusiastic about their performance.

It is not advisable to erect two Delta's running at right angles to each other from a common support. This causes mutual coupling (ie. a loss of isolation) which will skew their performance characteristics. In my case, the 120 and 60 meter Delta's are erected more-or-less concentrically. They are well-separated from the two 90 meter Delta's which, however, are also erected almost concentrically. I have no data to evaluate what affect, if any, results from the proximity of two Delta's in a concentric configuration. If possible, I imagine total isolation of each antenna would be the best policy.

While the Delta's generally provide the most consistent results on the bands for which they are cut, it is difficult to predict which antenna, be it a Delta or otherwise, will be the "right" antenna in certain circumstances - especially during periods of unusual propagation conditions. In fact, I am convinced that space-permitting, one simply can't have too many different antennas!

I would like to conclude by recounting a few interesting recent experiences of my own in this regard, some lending credence to my enthusiasm for the Delta Loop, others demonstrating the versatility of an antenna farm with various different types of aerials.

During February and March, 1988 (the last occasion being March 23rd), I managed three solid loggings of Radio Enga (2410.1 kHz). On two of those three occasions, the 120 meter Delta brought in very substantial signal levels but in both cases I ultimately settled on taping these receptions using the 60 meter Delta. With admittedly less gain, the S/N ratio was much superior. The Delta isn't even supposed to be good performer at one-half the resonant frequency to which it is cut.

On the same March 23rd morning, the PNG opening extended to Irian Jaya but not much further to the west. Between 1115 & 1130, RRI, Manokwari (3986.2), an infrequent visitor here, was noted at "best ever" levels. Best antenna: 90 meter Delta pointed at PNG. Later, at 1200, RRI, FakFak (4790.3) was 2nd best Indo on the 60 meter band (competing with Ujung Pandang for top honors). In this case - best antenna was the 60 meter dipole. The real news, however, was my first-time logging of RRI, Nabire on 5055.4 (a rare catch, at least in eastern North America). It was parallel with the Jakarta news relay to 1214, then into local program. Best antenna: that 60 meter Delta again (only slightly weaker but with much less noise than the dipole which was doing a good job with FakFak).

On April 4th, 1988, at the height of a major geomagnetic storm, Radio Television Hong Kong on 3940 kHz was logged from 1125-1142 s/off with extraordinarly strong signals over-riding the co-channel Chinese regional which was also audible. Of the eleven available choices, a 90 meter dipole, oriented N-S (and thus directive E-W) was clearly the superior antenna. Considering that my great circle path to Hong Kong lies at about 350 degrees West of North (ie. directly over the region of the North Magnetic Pole), this seemed to be a classic case of "Donut-Hole" reception...but why that antenna? Perhaps the path of least resistance for the signal was not the great circle path after all but rather a crooked path.

To continue the April 4th saga, my local sunrise on this date is just prior to 1100. After the excitement associated with the South China Sea Yacht Race weather broadcast had died down a little, I continued checking S.E. Asian channels on the 60 meter band past 1200. To my surprise, many channels were still showing fair audio over the ever-increasing band noise using my two "best" antennas (a 60 meter dipole oriented for maximum directivity over the magnetic pole into Java; the other a 60 meter Delta running E-W to also favour reception from "over the top".

Checking WWV at 1218, I learned that the 1200 K index was = 6! This is an unually high number, indicating that a major geomagnetic storm is in progress. As 1230 approached, the signals were pretty much lost to band noise until I happened to switch to the 120 meter Delta (also running E-W to favour N-S broadside reception). Low and behold, the noise level was cut to a fraction of its former self and numerous of the Indo's and Chinese regionals were again clearly readable, albeit at relatively weak levels. RRI, Jakarta (4774.8) held up sufficiently well such that I taped their SCI at 1258, precisely two hours after sunrise! Strike up one for a two-wavelength Delta.

Finally, an observation regarding some of the lower-frequency Sumatra outlets which are sometimes audible during the afternoon window available to DXers in the eastern part of the continent. From November until mid-March, 1988, starting just prior to 2200 (subject of course to sign-on times) and extending to as late as 2330, a number of RRI outlets were heard on more than one occasion peaking to amazingly solid audio levels. These included: Bukittinggi (3231.8), Bengkulu (3264.7), Tanjungkarang (3395.2) and Padang (4002.7). A 600 foot (unterminated) Beverage of about two wavelengths, appropriately pointed N-W vis-a-vis their great circle positioning for me, was always the best antenna bar none - very quiet too. If you have the space, obviously the Beverage has its place! One of these fine days, I'm going to get a 90 meter Delta in the air which is oriented in the same direction. I suspect this would make for some very interesting comparisons.

For the record, my primary receiver is the NRD-515 (look for a user review elsewhere in Proceedings from Kirk Allen and myself) which has certainly stood me in good stead. At the same time, I sincerely feel that the preceding experiences, some of which were quite thrilling to me, clearly vindicate my belief that every Tropical Band DXer should seriously consider the merits of the Full-Wave (vertically polarized) Delta Loop.

There's still time before the 1988-89 season begins in earnest - DO IT!!

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