ANTENNAS FOR TROPICAL BAND DXing

Some Neglected Considerations

Tony Ward, VE3NO

Short-Wave Listeners and DXers have been somewhat slower than amateur operators to appreciate the delights of high-performance antennas– and not without good reason. For international shortwave broadcasting station powers are high and getting higher. And if coverage is a problem the chances are a major broadcaster will bring the signal to you via a local relay. Peak listening periods– breakfast, and early evening– coincide with the best band conditions. If a piece of wire out the window works well enough there seems little incentive to move to a better antenna design. Hams have different problems to solve. Many of them of course are quite content to stay with local coverage, but the hard-core ham DXers have always pushed the envelope of sophisticated antenna design in order to maintain reliable two-way contact with distant areas of interest, using far more modest power than the major broadcasters. The feeding-frenzy that results when a DX station turns up for a spin on one of the low bands in particular, provides a very public showcase for successful antenna setups, and this is a powerful incentive to improve system performance. Listening DXers have more in common with ham DXers than with SWLs. Perhaps they have a tendency to work in greater isolation from their peers than is the case for hams, but many of the lessons to be learned are the same. So please bear with the ham-radio examples, and assess the thoughts that follow in conjunction with the article by David Clark and myself on Tropical Band Propagation, elsewhere in this volume.

There are other ways than antenna improvements to increase the quality of one or two-way contact, and the pages of Proceedings document many of them; both simple and esoteric. Narrow-band transmission and reception– ssb for example– or the use of filters, make easier the detection of the faint and distant signals that are the meat and potatoes of our DXing interest. Which are the best radios; the best filters; these are the stock-in-trade of many a fine conversation between DXers. And now here come the new generation DSP's hot on the heels of het-killing notch filters! We need all these goodies of course (as our loving spouses *all* agree!), but nothing can beat improvements in antenna efficiency ahead of the receiver. For DXers the horizontal and the vertical directivity of an antenna are among its most important attributes, particularly when trying to understand the vagaries of propagation . The horizontal payoff is fairly obvious and generations of DXers at their homes– if they are lucky– or at least on DXpedition have erected arrays of travelling-wave antennas to enjoy the benefits that long wires can bring.

ARRIVAL ANGLES, DIRECTIVITY AND POLARITY

While there are many different kinds of antennas designed with special aims in mind– saving space, or low visibility for example– few of these make good DX weapons. The often extreme sensitivity of modern solid-state receiver front-ends allows surprising performance from unelaborate designs, but it should come as no surprise that there is a price to pay. Very little can beat a long piece of wire pointed in the direction you want to hear. DXers interested in ultimate no-compromise performance, and in analyzing the behavior of the signals they hear, need both horizontal *and* vertical directivity however. The first of these factors has received by far the most attention. We shall revisit it, but I wish to stress the importance of the angle of arrival of DX signals, and the vertical directivity of antennas here. Some of the references appended cover these and more general topics in greater detail, and give construction details omitted in the present article.

Horizontal directivity accomplishes at least 3 major goals. 1) It allows the targeting of specific areas, 2) it permits nulling unwanted stations, and differentiation for example between Africa and South America, and 3) it often facilitates discrimination against atmospheric noise. Vertical directivity accomplishes the above goals also, and often very dramatically. In addition, if an antenna can be persuaded to concentrate its sensitivity on signals arriving at low angles it will very often outperform– perhaps dramatically– antennas that receive high angle signals best. And the top-gun DXer's edge comes mostly from the low-angle performance of their antennas. Once you have made the step from a simple directive long-wire array, switchable to select directions of interest, the next logical move is to add the ability to null signals arriving at high angles. You should choose your antenna with the above in mind, and should ideally erect a number of antennas to perform clearly differentiated tasks. As conditions change, so should your choice of antennas. What works may vary from year to year, season to season, and even minute to minute. There are some signals you would kill for that may make it to your location for a matter of minutes per year. And the message here is that waiting for them, properly equipped, is *not* just a matter of blind luck– though it surely does not hurt.

Polarity of the antenna is of great importance to DXers. The incoming rays are themselves randomly polarized after even a single encounter with the ionosphere, but the type of antenna you choose gives you some control over the incoming angle best received. There are two major types of polarization to consider also; horizontal, and vertical, and despite the similarity of terminology these should not be confused with either directivity (above) or even whether the antenna itself is largely vertical or horizontal (below). Loop antennas may look identical in either case for example, but their polarity is determined by the location of the coax feed-point. And the famous Beverage antenna– a long horizontal wire– in fact performs as if it were responding to vertically polarized incoming waves.

VARIOUS APPROACHES

From the humble dipole to the elaborate yagi the quarter wave horizontally polarized wire or tube is the most common antenna variety. The main advantage is relative simplicity. The main disadvantage is that improvements in low angle performance come only from raising the antenna height. A dipole at one quarter wave above ground or less is most receptive to signals arriving from directly above. The lower the frequency, the greater the ground loss, and the more difficult it becomes to get the wire up high enough to perform well. I do remember full well butting heads on 40 meters with a New Zealand farmer who had a dipole strung between two hills 300 or more feet above ground, facing off down a broad valley to Europe. The dipole easily outperformed my two element rotatable beam, and opened and closed the band– when signals arrive at their lowest angles– most convincingly.

But since the high road is not open to many of us, serious DXers should concentrate their attention on vertically polarized setups. The Beverage is (perhaps surprisingly) the best example of a vertically polarized antenna. Incoming waves are tilted by electrical ground resistance and build signal voltage in the horizontal wire. The theoretical butterfly wing pattern of lobes fills in off the ends because of proximity to the ground, and unlike almost any other antenna, they work best over poorly conducting earth– as is the case at David Clark's DX barn for example. Terminating them in their characteristic impedance makes them usefully unidirectional, or more elaborate two-wire arrays allow easy direction switching. On the minus side of the ledger vertical polarization is particularly efficient at picking up man-made electrical noise, which makes such antennas noisy for receiving weak signals in urban environments. This is another reason why travelling-wave (long-wires) seem to fly so much better on DXpedition. But if you live in a subdivision with buried reticulation backing onto a ravine, as I do, or in rural splendor as David did till recently, it is very hard to beat 4 or more low wires one to two wavelengths long pointed in major directions, as a receiving setup. The directivity varies enormously from night to night as conditions vary, but I usually see 3 and (rarely) as many as 5 S-units discrimination between say Africa (bearing 105 degrees, 500 feet of wire 10 to 20 feet above ground) and South America (175 degrees, 500 feet, 10 feet height). And a powerful argument can be made for making such antennas unidirectional with David's evolution from 'auroral donut short path believer' to 'prophet of the long path' between 1989 and the present. Most of the epiphany was accomplished by terminating his bidirectional long-wires. Interestingly perhaps my experience with yagi beams on 40 meters, and a 2-element vertical switchable array on 80m in New Zealand allowed the expectation of afternoon Indonesian reception from Toronto as the norm, rather than the exception, and to anticipate that these signals would be coming via longpath. And when signals arrive along a broad horizontal front– often the low-band case– concentrating on vertical directivity may accomplish more than improving azimuth gain when seeking improved signal strength. Note also that while a long-wire extension of two-wavelengths seems about the optimum length-for-gain trade-off, longer arrays show improved low angle performance. Legend attributes better DX characteristics to Beverages than they fully justify, as low-angle receptors at least. This is no doubt in part because the cogniscenti invariably set them up as close to saltwater as possible, where low angle performance is much enhanced.

The erection of large yagis remains a fantasy for most DXers, although there is of course no intrinsic reason why this should be so. Committed hams have erected 3 and 4 element full-sized beams on 80 meters after all, and the results are dramatic, and well above that to be expected by the theory of moving from a one- to two- to three- element design. Just how much can be gained, and why? From my Auckland NZ ZL1AZV site I operated on 40m with a vertical mounted on a tin roof for excellent elevated ground conductivity, and compared signals with Mike (now ZL1HY) frequently on his regular weekly sunset schedule over the high-absorption South African path. I was typically S2, and Mike S9+5 dB. I built a fair copy of the linear-loaded KLM design 2-element double driven beam— that Mike also used in two stages, and put it up at the same 65 foot mark on the tower. The first week I tried a single element version– basically a shortened rotatable dipole. My signal jumped to S7. The following week I had the second element in place, and the beam tuned– boy have I left out a few details here!– and now my signal was equal to Mike's over this difficult path. Don't be misled by the theoretical gain figure of 5.6dB for a 3-element yagi over the humble dipole. When the angle of signal arrival is taken into consideration the difference may often be 5 S-units or more. This is also why monoband yagis comfortably outperform even well-designed tri-band beams. In a single-band design cancellation of unwanted high angle lobes is much more completely realized than in the multiband beam– or in the wide-band many-element log periodic design favored by the military and some international broadcasters.

My most dramatic illustration of this effect came when I mounted a tri-band beam above a highly optimized 4-element 20m monoband beam prior to a Chatham Island trip discussed elsewhere in this Proceedings volume. On the morning longpath ragchew into Maritime Canada over Australia the Sydney regulars in the 3-way were S9 on the (higher) tribander, and S3 on the 20m mono-band beam. At the business end of the path in Canada the results were reversed, with the mono-bander far the better performer. But even that antenna was put to shame in comparisons with Mike's very long-boom 5-element mono-bander, on the particularly tough long path from New Zealand, west three-quarters of the way around the world to the high pampas of Argentina. While height alone controls the actual angle of lobes leaving an antenna, the intensity of these lobes is affected by the interaction between the elements. Signal leaving at high angles is lost to the more desirable lower angle lobes. Long-boom designs are much easier to tune for this than those with shorter booms, or compromised for multiband operation. No gain without pain!

FAVORITE SKYWIRES

Fewer SWL DXers specialize in single spectrum stretches than do hams of course, and thus the task of erecting monoband antennas to cover a wide range of frequencies tends to inhibit experimentation. Optimizing a monster for 4800 to 5060 kHz is not beyond the resources of everyone however, and there are other routes than the big yagi to consider. Loop antennas– deltas, quads, squares, rectangles– have shown a lot of promise. The delta loop supported at two points, apex down, and fed at either of the upper corners favors an arrival angle of a bit less than 30 degrees. That this is a vast improvement on the performance of a dipole at a similar elevation– and little more difficult to mount– I have demonstrated to my own satisfaction many times. Closed loops tend to be quiet antennas also, and this makes them good for listening in particular, even though they should be in vertical polarization configuration for DX use. The single-band bob-tail curtain is a deserved favorite for low-band work, and it has simpler variants that require little attention to ground conditions. I recently erected the commercially available Carolina Beam and its impressive performance on low angle signals is discussed in a review by Guy Atkins, elsewhere in this publication, that contains some of my comments. This is a multiband design with great promise. I hope to explore the possibility of a 2-element version optimized for 90 through 60m that could be phased to give a switchable pattern. Similarly, should you have two high trees aligned suitably it is not difficult to experiment with multi-loop arrays favoring suitable directions. A high rope supported by pulleys to the trees allows easy access for the inevitable fiddling, maintenance, and tuning.

Verticals and arrays of verticals are easier to work with than most believe. Their main drawback is the requirement for an extensive ground system, but even this is not too difficult for the weak-signal impaired. A loop of #6 copper wire with radials about one-quarter wave long each braised to the loop and laid over the ground is all that is required. Lay that down before the first flush of spring, and pin the end of each radial taut with a nail, and the earthworms will bury them for you in weeks in any humid climate. I have had friends who used chicken mesh successfully as a ground net! Low angle performance is again the payoff for effort. The better the ground system the lower the ground loss and the more efficient the antenna's performance– particularly at the lowest angles. Radials should number 16 or so to start, if possible, and if you add more, double the number each time– to 16, then 32, then 64 and so on. The poorer the earth (dry, stony, bedrock) the more attention needs be paid to the ground. As with dipoles there is more payoff than you might expect from doubling the array to two, and then four elements, and once again low angle performance is the chief beneficiary. Amateur switching networks to phase 2- or 4-element vertical arrays are fairly easy (though not cheap) to come by.

Using phased verticals in 80 meter band contests gave spectacular results for me as ZL1AZV. There is one condition though which makes an interesting point. I had the good fortune to operate on both 160 m and 80 m using a 200 foot (temporarily) disused broadcasting tower from New Zealand. This was at a site fairly close to the ocean, with full Broadcast standard ground radial system. On 80 meters this tower was close to 5/8 wave tall, which gives a fine low angle lobe. And when the band went long you could hear the difference, against almost any other antenna– it was quite spectacular. But some careful comparisons under a range of conditions with Mike, who was using a traditional quarter wave vertical with an adequate radial system (when the goats left it alone!) showed that for much of the time under moderate sunspot number conditions the shorter, higher angle radiator, performed as well or even better than the big stick. As the MUF drops with the sunspot cycle too low an angle of radiation (or reception) can fail to get a signal off to a good launch. I am sure that at sunspot minimum (close, at present writing) such an antenna would enjoy more success more of the time.

In general antennas should be full-sized when possible for DX purposes. Some compromise is of course possible and may be essential for the low-bands where size is getting to be a problem. Verticals can be capacitively (top-hat) loaded with little performance loss for example. Wire and/or tubing sizes should be large where possible. Taper of aluminum tubes is an acceptable compromise. Greatly shortened antennas are ticklish to match, and easily detuned by metal objects around them. This is less of a problem for receiving than transmitting, but still always a consideration. Low efficiency antennas may show improved Signal/Noise ratio, and provided the signal is there in the first place, this can be a benefit– as in the classic broadcast loop. The T2FD design , as has been noted by Guy Atkins, is a neglected loop variant with interesting DX characteristics, and the very low profile DDR antenna is another design to consider. Both of these antenna types have been explored in previous Proceedings volumes. Variants on the sloper have been used to good effect by many– including me– but it is often forgotten that this is really one half of a dipole fed at the top. It thus is missing the second side to work against. In a typical ham installation comprising a series of wires draped off the tower below a tri-band beam– providing an inverted ground-plane– the antenna can be expected to exhibit far better characteristics than the "solo on a wooden pole" configuration adopted by many SWLs.

Thus a ripe field for DX research remains antennas. While there are still many lessons to be learned about the azimuth of arriving signals I suspect some real gains are to be made concentrating on vertical angles of arrival, perhaps by experimenting with some of the new phasing networks becoming available. For many of the weak paths of interest to the Tropical Band DXer low and very low angle receiving antennas are an essential tool. And it is after all impossible to have *too* many antennas to choose from...

REFERENCES

Devoldere, 1986, *Low Band DXing*, ARRL

Knitter, Michael G. (Ed), 1991; *Beverage and Longwire Antennas Design and Theory*, NRC Publications

Lawson, James L., 1986, *Yagi Antenna Design*, ARRL

Misek, Victor A., 1977, *The Beverage Antenna Handbook*, self-published but available from ARRL

Moxon, L.A., 1990, *HF Antennas for all Locations*, RSGB

The ARRL Antenna Book, published regularly and updated by the ARRL

Plus see the (currently) three ARRL Antenna Anthologies of *QST* articles in print.