Antenna - Island

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Sharbot Lake, Ontario, Canada lies a couple of kilometers south of the Trans-Canada Highway, about at the halfway point between Montreal and Toronto. It is perhaps 60 kilometers north of Kingston, which is at the northeast end of Lake Ontario. My grandfather bought a small island in Sharbot Lake in 1948, and I've travelled there regularly since I was 9 months old.

The island is about 150 meters long, but only about 25 meters wide. The long direction lies roughly northeast/southwest direction. There is a cottage near the northeast end. On official maps, the island is known as "Bradley's Island", but on some locally made maps it's known as "Rupert's Island" (Mr. Rupert was my grandfather). It's at 44 deg 46' north, 76 deg 42' west.

The island is wonderfully quiet in the radio spectrum. Our hydro (that's Canadian for AC power, eh?) and telephone connections are via underwater cables: this effectively blocks the noise that normally rides utility cables. There are no nearby cities or powerful radio transmitters. Ignition noise from passing motorboats is an occasional annoyance, but it's not a serious problem.

Even family members who are not radio hobbyists have for many years enjoyed "Medium Wave DXing": it's what you end up doing if you turn on an ordinary AM radio at night on the island. I've often brought my Sony 2001 up there for shortwave DXing. However, before this summer I had never brought a real communications receiver or the makings of a serious antenna system to the island.

This year I brought my Drake R8 and a bunch of antenna wire with me. Initially, I set up two antennas. Antenna #1 was about 120 meters of insulated wire, running nearly the length of the island, at a bearing of about 230 degrees. It was supported by trees at a height of 3-4 meters above the lake, 1-3 meters above the ground. 22 meters of bare copper wire submerged in the lake provided a ground, and an ICE Model 180 matching transformer coupled the antenna through 15 meters of cheap 75 ohm coax to the R8's input #1. Antenna #2 was about 8 meters of wire suspended almost vertically from a tree overhanging the cottage, connected directly to the R8's high impedance input #2. The ground for this antenna was provided by the grounded shield of antenna #1's coax: this arrangement is not good at rejecting noise from the power line, but with very clean power and few noise generating appliances it was usually acceptable (especially as I could always switch to #1). Antenna #1 was intended to be a nonterminated (bidirectional) Beverage, while #2 was intended to be omnidirectional. The following analysis assumes that #2 *was* omnidirectional.

Tests of the Beverage on shortwave were disappointing: while reception of many stations was excellent, there was very little difference in reception between the Beverage and the vertical. The orientation of the Beverage was such that I expected New Zealand to be in the forward lobe, and Europe to be in the back lobe. S-meter measurements in the 49 meter band revealed little difference between signal strength of RNZI, the Europeans, and other relatively distant stations on the vertical and on the Beverage, while relatively nearby stations such as WSHB and WWCR were substantially stronger on the Beverage. This implies that the Beverage had a strong preference for high angle radiation: this is not the way a Beverage is supposed to behave.

On the other hand, the Beverage showed substantial directivity on medium wave. Furthermore, the directivity was off the ends of the antenna, as it was supposed to be, preferring stations to the northeast and southwest over stations to the southeast (I didn't ID anything to the northwest: there's not a whole lot of civilization in that direction). This was rather surprising, since the Beverage was less than 1/2 wavelength long over most of the standard AM broadcast band! The Beverage was more efficient than the small vertical at MW also, so even signals off to the side were stronger on the Beverage. The front/side ratio was about 10 dB, which was enough to make a significant difference in many cases. For example, in the daytime the dominant station at 900 kHz on the Beverage was CHML in Hamilton, Ontario to the southwest, while on the vertical it was a station I never positively ID'd, but whose community service announcements referred to communities in northern New York, to the southeast. At night 1370 kHz was generally a confused mutter on the vertical, but the Beverage could usually pluck WXXI in Rochester, New York (more south than west, but still in the beam) out of the mess.

Despite the Beverage's directionality, the most distant mediumwave station I heard was best on the vertical: Radio ZIZ, St. Kitts on 555 kHz. A directional antenna only helps if it's pointed in the right direction!

Another surprise was longwave. I'd never really heard any longwave broadcasters before. From my home in Bedford, Massachusetts I can occasionally hear a word or two in between noise bursts and beacons, but never anything listenable. However, from the island I found that I could often hear European longwave broadcasters at night: I hadn't realized that they could be heard so far from the ocean. Here's my log from around 0300 UT on August 11:

Freq	SINPO	ID
252	22252	Clarkestown, Ireland
234	22252	Junglinster, Luxembourg
216	33353	Roumoules, France
183	24353	Saarlouis, Germany
162	22352	Allouis, France

All of the above were in French except for Atlantic 252 in English.

The Beverage didn't seem to be especially directional down there. I didn't really check it carefully, though: beacons aren't my thing, and the broadcasters were all in about the same direction. The vertical was just too short to adequately feed a 500 ohm input below 200 kHz, so the Beverage was the better antenna down there. The stations above 200 kHz sounded about the same on both antennas, although the signal from the Beverage was, of course, much stronger on the S-meter.

The unusually poor directivity of the Beverage at shortwave, and its unusually good directivity on mediumwave puzzled me. I guessed that the island itself must have something to do with this phenomenon. The ground under a Beverage is an important component of the antenna: could the island be acting differently from a more uniform surface? If the island was perturbing the behavior of the Beverage, could it be acting as an antenna all by itself? I realized then that there was a way to turn the island and the surrounding water into an antenna. A "slot" antenna is just a slot (usually 1/2 wavelength long) in a conductive sheet. The island could act as a slot in the conductive lake water! A slot antenna is usually fed by connecting a transmission line between the sides of the slot at its center. I didn't have enough coax to reach the center of the island, so I just fed it where I'd already put my "ground" connection into the lake, about 25 meters from the northeast end. I disconnected the Beverage, and ran an insulated wire about 15 meters long to the other side of the island. Having no additional uninsulated wire, I used a metal bait bucket as my contact in the water. I connected the feed wire to my matching transformer.

It worked pretty well! The signals from the slot antenna were weaker than those from the Beverage, but below 10 MHz the signal to noise ratio was generally about the ame. The slot was a poor performer above 10 MHz. It did not seem to be very directional on shortwave. On medium wave, the slot was noticeably directional, but in a rather different way from the Beverage. At the low end of the standard broadcast band, it seemed to have a "cardioid" pattern, with good response in every direction except northeast. The front to back ratio was about 10 dB. At the high end, the pattern was more like that of a dipole oriented like the island, with good response broadside, and poor response off the ends. CJCL 1430 in Toronto was especially weak, more than 15 dB down relative to stations off to the side (always using the vertical as a reference). Longwave was also good on the slot. I added Nador, Morocco at 171 kHz to my list of stations logged down there.

Although my antenna experiments were a bit of a bust at shortwave (nothing beat the simple vertical, no matter where the signal was coming from), shortwave reception was nevertheless very good at this quiet site. My home site in Bedford is also pretty quiet at shortwave, however, so there were few surprises in what I was able to hear. One exception was the main transmitter site of Radio Japan at Yamata. Asian stations are generally weak and unpredictable in eastern North America, but Yamata seems to be particularly bad in New England. Why this should be I don't know, but I've never positively ID'd it from the Boston area, despite trying for several years from two sites with several different antennas. However, from the island I could hear Yamata on 9535 kHz! For example, at 1720 on August 10, I had it at S4, SINPO 25332 on the vertical. Not a breathtakingly good signal, but *much* better than I'm used to!

I also believe I heard Papua New Guinea on 3220 one night, but I made the log entry on a piece of scrap paper in the dark (to avoid waking my wife), and I can't read the time or date now. It sounded a lot like Steve Byan's recordings. If you think the R8's ergonomics are bad normally, you should try operating it in the dark!

Analysis:

I think the reason that the Beverage lacked directionality at shortwave was that it wasn't arranged symmetrically with respect to the island. I tried to keep the antenna straight. However, the island, although it is long and narrow, is not perfectly straight, so the antenna was not centered on the island. The return current through the ground plays an important role in the function of a Beverage, and the unsymmetrical placement of the wire relative to the more conductive lake water undoubtably severely distorted the current pattern in the ground. Next time I may try running the antenna as close to the island's centerline as possible: it won't be quite straight, but it just might work better.

The use of an island as a slot antenna turns out not to be a new idea: I found a paper on it in a library at MIT. There was both theoretical and experimental work on the use of large islands as VLF antennas published around 1960. The paper I found (by Harold Staras of

Technion and RCA Laboratories) analyzed large islands in seawater, and concluded that they would make poor VLF antennas. His analysis makes sense, but he used some approximations that are only valid for large islands (kilometers in length) in seawater (much more conductive than fresh) at VLF, so his conclusion does not apply to my case.

For a smaller island in fresh water at LF/MF/HF the theory is much more complex since Staras's approximations don't apply (even with his approximations, the math in his paper was quite heavy). I have no conclusions to offer, except that this is an interesting area for experiment. The theory looks too complex to be a useful guide.

John Doty : "You can't confuse me, that's my job."

Pedersen ray propagation

By Robert Brown mailto:bobnm7m@cnw.com

Pedersen ray propagation takes place at the transition from one ionospheric region to another, the lowest being between the top of the E-region and the bottom of the F1-region while the highest at the F2-peak which divides the bottom and topsides of the F-region. This form of propagation happens when a ray which came up from below the transition region has been refracted such that it is finally moving parallel to the earth's surface at the ionospheric boundary and continues that way for some distance.

Pedersen ray propagation results in long hops for signals in the HF part of the spectrum but any change or gradient in the electron density in the top of the F-region, an increase or decrease, will refract the signal away from that direction, down to ground or up to Infinity from the F-peak. In practice, this mode is rather unstable and appears briefly (see p. 181 of Davies' recent book for experience on North Atlantic paths.)

Turning to 1.8 MHz signals, something resembling Pedersen ray propagation can take place at the top of the night-time E-region. In case you have missed it, I have written on this topic several times, pointing out that long E-F hops can take place, covering distances up to 3,000 km instead of the more familiar 1,000 km E-hops or 2,000 km F-hops. Such E-F hops are expected on theoretical grounds because of the nature of the electron density distribution, a deep valley above the E-peak developing after sunset. Experimentally, a valley distribution is well-documented and has been seen for years, by incoherent scatter radars from Puerto Rico to Northern Norway, leaving no room for any dispute.

Beyond the theoretical idea, one can explore the computational side of long E-F hops by means of ray-tracing of paths across the ionosphere. Mainframe computer programs developed in Boulder by the Department of Commerce radiophysicists in the 60's and 70's allowed such studies, even including the effects of the earth's magnetic field. Those programs have now been brought down to the PC level in the PropLab Pro program, available for use in amateur circles. (Let me recommend it to you!)

Briefly, such ray-tracings show that E-hops on a path are found at low radiation angles incident on the bottom of the E-region. Then, by advancing the radiation angle in small steps, one finds the E-hops become longer and longer til they go over to E-F modes where the path rises to a peak in the F1-region and then retraces itself down through the E-region to ground:

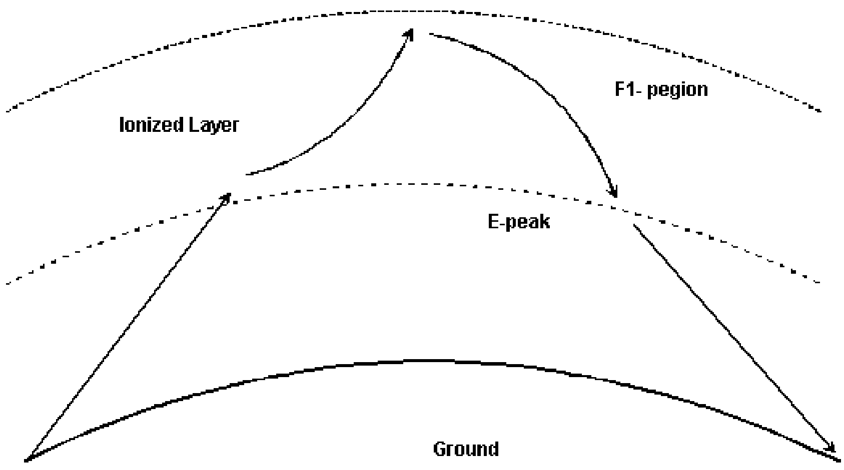

Figure 1

Finally, at slightly higher radiation angles, signals are propagated by F-hops instead of E- or E-F hops:

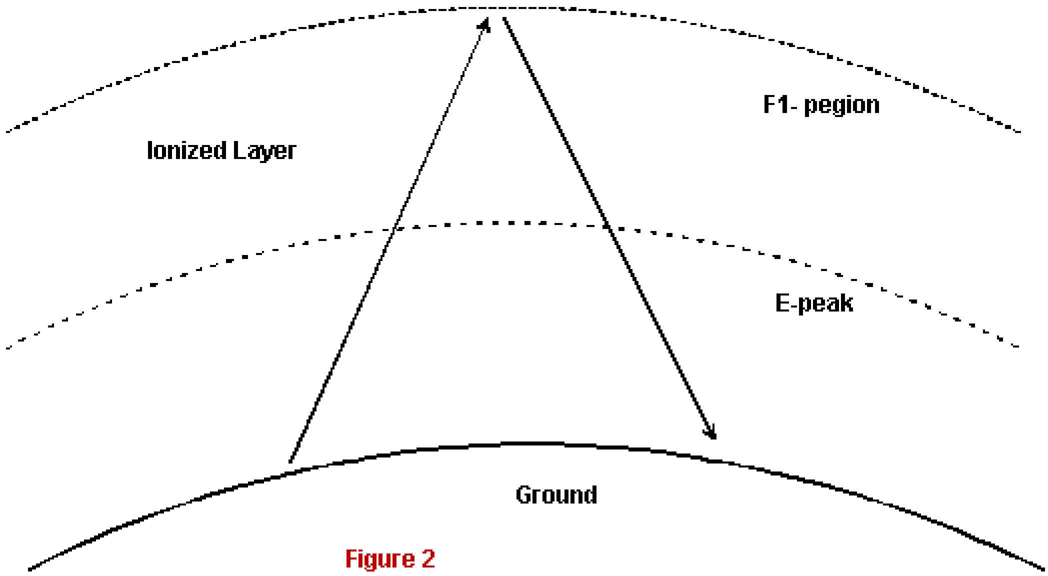

Figure 2

The fact that ray-tracings show 1.8 MHz paths are limited to the lower ionosphere, rising no more than about 200 km instead of to the 300+ km F-peak, stems from a fundamental result of ionospheric theory. Briefly put, only a fraction of the 1.8 MHz operating frequency is effective in carrying Top Band signals obliquely up into the ionosphere. That fraction is found by multiplying the QRG by the cosine of the angle by which the signal goes into the ionospheric region. Thus, for a 30 degree take-off angle, RF approaches the ionospheric layer with a 60 degree angle from the vertical and the effective vertical frequency would be 0.9 MHz.

So signals would peak at an altitude where the local plasma frequency is 0.9 MHz. Of course, that would depend on latitude but would not come close to the height of the F2-peak where plasma frequencies are always greater than 3 MHz, even at solar minimum.

Now everything that I have said above can be verified by using the PropLab Pro program in 2-dimensions. Just pick a path in darkness, start at a low radiation angle, say 10 degrees, and slowly increase the angle, 0.1-0.2 degree at a time. First you will see E-hops, then E-F hops and finally F-hops. Nothing to it!

Those simple paths would apply to Top Band propagation except for the presence of the geomagnetic field. The theory is much more involved now but the results are much the same, at least as far as how high Top Band signals rise in the ionosphere. With PropLab Pro, you can use the same incremental technique and explore paths. I have done it thousands of times!

What you see when you take the program to 3-dimensions is about like before: first, E-hops at low radiation angles, then E-F hops, then either F-hops at a slightly higher angle or a DUCTED PATH, slightly skewed, where the ducting amounts to a string of E-F hops in series. But that is Pandora's Box (in more ways than one) and I will have to stop right here.

This is obviously a complicated matter and I won't belabor the subject further. Simply let me say that HF ideas are quite out of place when it comes to Top Band propagation and a whole new approach is required if you still think that way. But this is not news; it has been around propagation circles for 50 years!

If you're interested in these matters, I have an article in the Spring '98 issue of Communications Quarterly as well as a shorter one in the Top Band Anthology published recently by the Western Washington DX Club. Background material may be found in issues of The DX Magazine, 1996 and onward. I had hoped these ideas, old as they are, would not continue to remain well-kept secrets but that seems to be the case.

Finally, I hope I haven't offended anybody. I didn't invent these ideas; I am the "messenger" and am just trying to tell it like it is, REALLY IS! With that I will hold my peace.

73,

Bob, NM7M

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