Getting a Big DX Signal on 160-10 m from One Small, Low Antenna

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I live on a small lot in a dense, inner suburb of Boston and Cambridge. To support an antenna, I have no tower, and only two trees that aren't too close to a house. These trees are only 70 ft (21 m) apart, and too small to support anything higher than 33 ft (10 m) above ground. And they are at the bottom of a hole, at the deepest spot in a freshwater pond that was drained in 1952. The terrain slopes upward in all directions from my antenna! DX contesting from my QTH is a Sisyphean challenge. <http://en.wikipedia.org/wiki/Sisyphus#.22Sisyphean_task.22_or_.22Sisyphean_challenge.22>

If you are similarly challenged, read this article. It describes *the best* small and low antenna for HF DXing that I have found in decades of searching, studying, and testing. Fitting within my 70-ft horizontal and 33-ft height limits, above my very poor ground (σ = 0.0015 S/m, typical of Middlesex County, MA), this antenna kicks the butt of an equally high, full-size, half-wavelength, horizontal, broadside dipole on every band from 160 through 10 meters.

At 1.8 MHz, its power gain is 11 dB greater than the dipole's at low elevation angles (for DX). At 3.5 MHz, its gain is 3 dB higher. At higher frequencies, up to 30 MHz, its gain matches the dipole's. However, this antenna is better for contesting because its azimuth pattern, on every band from 160 through 10 m except 30 m, is cardioidal. That is, the pattern has one null, or notch. Except for this notch, which is in the same direction for every band, this antenna's gain is substantially uniform around the entire horizon.

A horizontal dipole, on the other hand, has two relatively broad nulls or notches, one off each end; and, if an ordinary dipole or "doublet" is used above about 2.5 times its half-wave-resonant frequency, its pattern has additional notches. The directions of these notches vary with frequency, so different directions are unworkable at different frequencies — bad for contesting!

I directed my antenna's single notch at the U.S. 2^{nd}, 3^{rd}, and 4^{th} call districts, because much QRM and few DX signals come from this direction. I can still work XE on all bands, because the distance is short, so ionospheric propagation involves few hops and high angles.

I feed my antenna with 45 ft (13.5 m) of open-wire line, from a balanced L-network tuner. I can transmit legal-limit power on 160 through 10 m without overheating or breaking the tuner.

Proof that it works

Why should you believe my claims for this antenna? Here are three reasons.

1. NEC-4 calculations

The Numerical Electromagnetics Code, v. 4.1 ("NEC-4") <http://en.wikipedia.org/wiki/Numerical_Electromagnetics_Code> is the computer software used by most antenna professionals to simulate and calculate the performance of MF and HF (and other) antennas near lossy ground, and its accuracy is well established. Ask me and I will send you, *via* e-mail, a NEC-4 input file that you can input to NEC-4 or EZNEC Pro/4 <http://www.eznec.com/eznecpro.htm> to calculate the current distribution, feedpoint impedance, power gain, pattern, etc., of my antenna for any frequency. (The more primitive NEC-2 or EZNEC programs can read this file and may also be able to calculate gain etc. with useful accuracy. However, Mike Loukides W1JQ has found that some versions of NEC-2 are unable to handle the large number of wire segments and/or the small angles between some of the wires in my antenna. Ask me and I may be able to help you get useful results from NEC-2.)

2. Contest results

My antenna has been up for 14 months. In this time I have used it for four DX contests: 2007 CQWW (SSB & CW) and 2008 ARRL (SSB & CW). My results in these contests are tabulated on the next page. Before looking at these results, you need to know that I am an unskilled, novice contester. In my entire life, I participated in only one 'phone and two CW DX contests before these. I am barely able to use a logging program; I have no DVK; and my Morse code speed is pathetic. So, unless you're also a novice, don't compare my results with yours. Instead, compare them with what you'd expect from an inexperienced and unskilled operator using a single, low, wire antenna for all bands and all directions, with very poor ground and adversely sloping terrain. I've included no 10-m results here because prop. was so bad, my numbers were insignificant.

	160-m QSOs	80-m QSOs	40-m QSOs	20-m QSOs	15-m QSOs	160-m MULTs	80-m MULTs	40-m MULTs	20-m MULTs	15-m MULTs	Claimed Score
CONTEST											
’07 CQWW SSB	0	68	95	196	209	0	37+16	53+17	83+20	71+19	493,592
’07 CQWW CW	15	158	130	168	78	7 + 6	61+18	58+19	70+20	47+19	497,448
’08 ARRL SSB	14	69	112	193	58	12	47	48	64	25	261,072
’08 ARRL CW	17	128	190	261	66	13	51	59	64	36	442,878

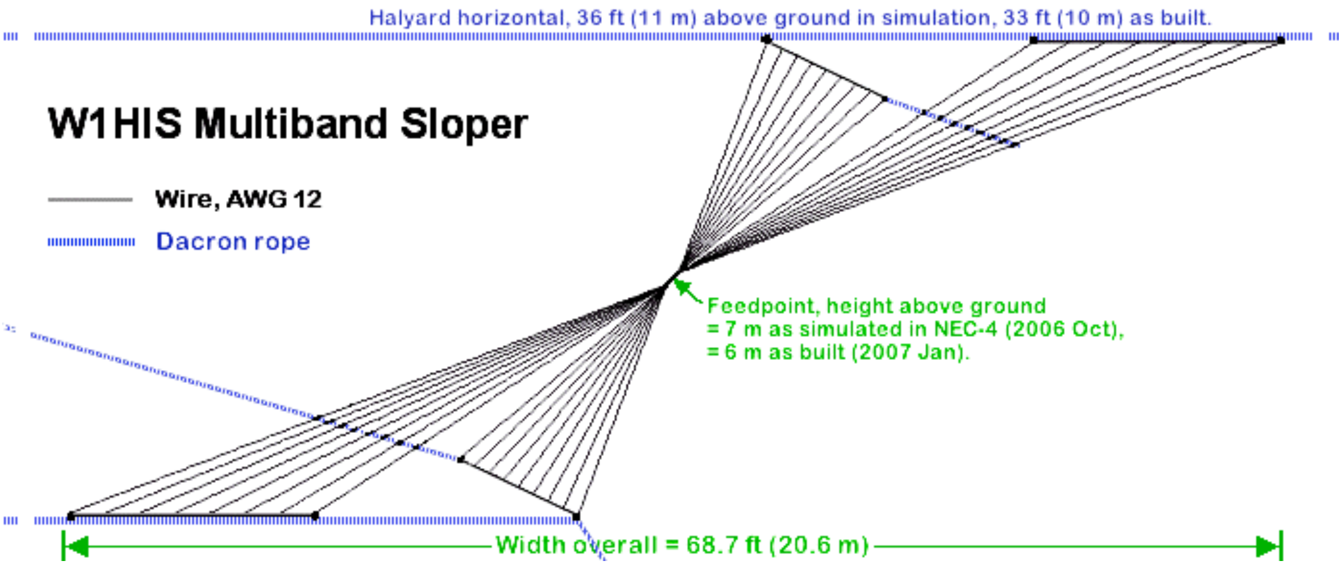
3. Unsolicited comments by DX ops in these contests

’07 CQWW SSB	’08 ARRL SSB	’08 ARRL CW
80 m, LN9Z: “Fine signal.” 80 m, F6CTT: “Very good signal.” 40 m, AO8A: “**Booming** signal.” 40 m, HC2AQ: “Very good signal.” 40 m, HB0/HB9AON: “**Fantastic** signal.” 20 m, M4U: “Good signal.” 20 m, OM5CD: “Big signal.” 20 m, TM6M: “**Very booming** signal.”	80 m, VP9/W6PH: “Big signal.” 40 m, IO3O: “Big signal.” 40 m, NP2I: “Nice signal.” 40 m, OE9MON: “**S 9 plus plus**. **About 40 over**. **Really good** signal.” 20 m, TM2B: “**Beautiful** signal.” 20 m, VP9/W6PH: “Big signal.” 20 m, 5C5W: “Very nice signal.” 20 m, TG9ANF: “**25 dB over 9**.”	80, 40, 20 m, OE4A (op K5ZD): “**The most surprising signal of the weekend** during my OE4A operation. I knew what you had as an antenna, yet you were well above average every time you called in.” 80, 40, 20 m, EE5E (op K1DG): “**Same thing from EE5E**. Chuck was **surprisingly loud**…. Near the end of the contest, we were running on 40 and getting our ducks in a row for a last band-change to… 80, and there was Chuck on 80, big as life, running Europeans. I told the EAs that [W1]HIS’ antenna is only 6-7 meters high, and they didn't believe me.” 160, 80, 40, 20 m, VP9/W6PH: “I had **the same experience** with W1HIS from Bermuda. Pretty big signal. We moved from 160 to 80 to 40 m….”

The Antenna

Here’s how it looks from a ground-floor window of my home during a snowstorm. (Snow sticking to the wires made them more visible. Normally, it’s hard to see.)

The photo is hard to understand, so here's a scale drawing. The black lines represent wires, and were drawn by the NEC-4 auxiliary program NECPLT. The thicker, blue lines represent Dacron rope halyards and were added by me. For scale: the antenna's overall width is 68.7 ft (20.6 m); the height difference between its top and bottom is 26.2 ft (8.0 m); and the longest wire is 35.8 ft (10.9 m). As erected in 2007 January, the center is 20 ft (6.0 m) above ground. I plan to raise the antenna by several meters this summer.



As you see, the antenna is a sloping, center-fed, doublet. It has 180° rotational symmetry about a horizontal axis through its feedpoint (perpendicular to the plane of this drawing). It would be electromagnetically balanced, except that one end (on the left in this drawing) is closer to ground. Like a single-wire, half-wavelength sloper, it radiates more strongly toward the horizon in the direction of its lower end, and less toward the horizon in the opposite direction.

But a single sloping wire does not work at all well as a multiband antenna. At higher frequencies, its radiation pattern breaks into multiple lobes, and little radiation may go in the desired direction, *i.e.*, toward low elevation on the lower (left) side. Whereas, at low elevation, *this* sloper has maximum gain toward the horizon on the lower side on all bands, 160 through 10 m, except 30 m.

In this sloper, the shorter and more nearly vertical triangular fans of wire carry more current and radiate more on the higher frequency bands, 20 through 10 m. The longer fans carry more current and radiate more on the lower frequency bands, 40 through 160 m. However, it is important to understand that this antenna is a low-Q structure. It does not exhibit sharp resonances. It is easy to match. I retune when I change bands, but not within a band except on 80 m and 160 m. In a CW contest, I do not retune within 80 m, and I would not retune within the 160-m band if I stayed within, say, the bottom 30 kHz.

My upper halyard is fastened to the tree on the right. It passes through a pulley fixed to the tree on the left, to a free-hanging weight that maintains tension in the halyard and allows both trees to sway in the wind. The lower horizontal halyard and the sloping halyard on the left pass through similar pulleys to similar but smaller weights. The short halyard that runs off the bottom of the drawing near the center is fastened to a stake in the ground. The two sloping ropes nearly collinear with the end wires of the short fans are fastened to all of the wires in the long fans, in order to maintain their spacing.

For further information…

I have asked YCCC Webmaster Mike Gilmer, N2MG, to link an extended version of this article in the "Antennas…" section of the Articles page <http://www.yccc.org/Articles/articles.htm>. Look there for plots of my antenna's power gain *vs.* azimuth at 10° elevation, elevation cuts in the plane of the antenna, and feedpoint and tuner impedance data for all bands 160-10 m, as calculated by NEC-4; also for a copy of my NEC-4 input file, and for construction details, including a list of all wire lengths. In addition I will describe common-mode chokes suitable for the open-wire feedline and able to handle legal-limit power on all bands 160-10 m.