By Albert Pion, KK7XO

The NVIS— A Low Antenna for Regional Communications

Ask a ham how best to set up an antenna and you are liable to hear "Try to get it up as high as possible." KK7XO demonstrates that it ain't necessarily so. Here's the lowdown on a low-to-the-ground antenna that can provide good regional coverage, day or night.

I check into several regional emergency preparedness nets on 40 and 75 meters daily and it amazes me how many times stations cannot hear the Net Control Station (NCS). They may be in the net control's skip zone if he is using a high dipole or especially a vertical. Both of these antennas have low take-off angles and produce wide skip zones.

An NCS often needs to make contacts in the range of zero to several hundred miles without any skip zones. VHF is great for making local contacts, especially if you live where the land is flat. Here in southern Oregon and northern California, however, we have flat desert land mixed with mountainous regions. VHF simplex works well in some places but not in others. Repeaters help, but if you need to contact someone 300 miles away in rugged terrain, most repeaters fall short. The answer is to use HF and Near Vertical Incidence Skywave propagation, NVIS for short.

Why NVIS?

NVIS works for frequencies lower than the vertical incident critical frequency—the highest frequency for which signals transmitted vertically are reflected back down by the ionosphere.[1] At or below the critical frequency the ionosphere will reflect an incident signal arriving from any angle, including straight up. Because the critical frequency is low, you must usually operate 40, 80 or 160 meters or possibly 30 meters to use NVIS propagation. Under most conditions you can easily obtain coverage on one of these bands from zero to 350 miles or more with no skip zones. On 75 meters with 100 W and an antenna 15 feet high, I have

[1]Notes appear on page 30.

One of the tree supports and insulators. I'm using high-voltage electric fence insulators here. The tie down rope passes through a big screw-eye screwed into the tree.

The feedpoint of the 160 meter horizontal loop mounted about 15 feet above ground. The photo shows the twin-lead feed line and support rope. The center insulator was made using PVC pipe, end caps and screw-eyes.

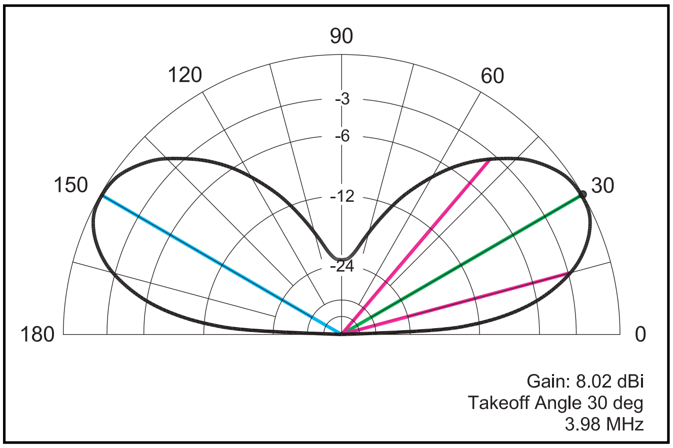

Figure 1—Elevation pattern of a 75/80-meter dipole 120 feet above average ground broadside to the antenna.

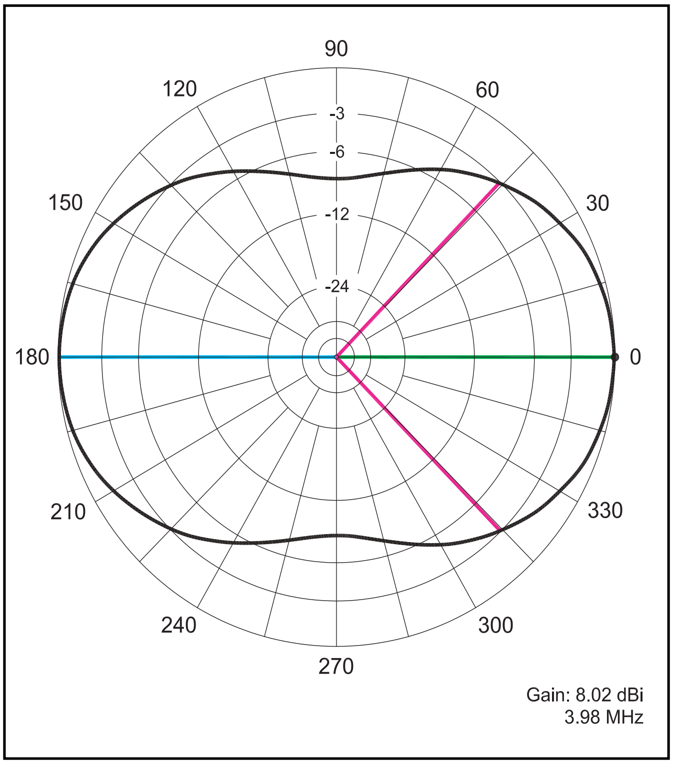

Figure 2—Azimuth pattern at an elevation of 30 degrees for the antenna of Figure 1.

often contacted stations over 1000 miles away and have received excellent signal reports!

Characteristics of Low Antennas

You don't need a special antenna to operate using NVIS. To convert an ordinary dipole into an excellent NVIS antenna, all you need to do is to lower it to $^1/_8$ wavelength or less above ground. When you lower an 80-meter dipole to 30 feet, for example, several interesting things happen. Figures 1 and 2 are far field pattern plots prepared using *EZNEC* for a 122 foot long center-fed dipole at 120 feet (about $^1/_2$ wavelength) over average ground.[2] Figure 1 shows the elevation pattern broadside to the antenna. Notice that the elevation angle of maximum radiation is about 30 degrees and there is very little radiation in the vertical direction. Figure 2 shows the azimuth pattern at 30 degrees elevation. It exhibits the characteristic hourglass shape one would expect from a dipole. At this height, the antenna provides a good match (1.4 to 1 SWR) to 50-Ω feed line.

Figures 3 and 4 show the same plots for the same antenna lowered to 30 feet (approximately $^1/_8$ wavelength). There are no distinct lobes in the vertical pattern, the overall gain is slightly less, and maximum gain occurs in the vertical direction. The azimuth plot at an elevation of 45 degrees shows that the hourglass is gone and has been replaced by a less directional oval pattern. The gains displayed for the elevation and azimuth plots are different in Figures 3 and 4 because the maximum gain is at 90 degrees, which does not appear on the azimuth plot. The SWR of this antenna for 50-Ω feed line is nearly 3 to 1. However, the low antenna now radiates quite well in all directions and for vertical angles above 20-30 degrees.

In general one can expect the following results when lowering a dipole to $^1/_8$ wavelength or less above ground:

- The azimuth radiation pattern becomes less directional, becoming more omnidirectional as the antenna is lowered.
- The vertical pattern becomes more uniform with respect to elevation as the lobes disappear. Most of the power is radiated straight up.
- The gain of the antenna at lower angles of elevation is reduced.
- The antenna typically exhibits a higher SWR and probably will not provide a good match to 50-Ω feed line.

Since the SWR goes up when you lower the antenna, you need to match it to the 50-Ω output of your transmitter. While you could change the antenna's length to bring it back into resonance with zero reactance at the feedpoint, the remaining low feedpoint resistance of the low antenna will still present a high SWR. You could match the antenna at the feedpoint using an L network or similar solution but such techniques are invariably single-band solutions. The best matching solution is to use an antenna tuning unit (ATU).

NVIS Antenna Systems

An ideal NVIS antenna system for many hams is to erect a dipole or G5RV about 20 feet high, fed with twinlead or open-wire line and matched to the transmitter with an ATU. This permits one to change bands quickly and easily. With such an antenna on 80 or 40 meters NVIS operation is quite good. Although 160-meter operating isn't often needed, the antenna can be used on that band by connecting both sides of the feed line together at the ATU and driving the antenna against the station ground as a flat-top vertical. [This requires good station grounding and can result in RF in the shack.—*Ed*.]

At higher frequencies (20 meters and above), the antenna's electrical elevation now becomes greater compared to the wavelength and lobes reappear in the vertical pattern. The higher the frequency used, the lower the angle of the lobes will be, and the antenna can provide acceptable communication out to several thousand miles with the usual resulting skip zone.

Another good antenna solution for NVIS is the "horizontal loop," such as the Loop Skywire presented in *The ARRL Antenna Book*.[3] See Figure 5. This is the antenna I use. My loop is about 15 feet above ground, and is over 500 feet in circumference. I feed it with 300-Ω twinlead running all the way from the antenna feedpoint to the balanced feed terminals on my ATU. This arrangement

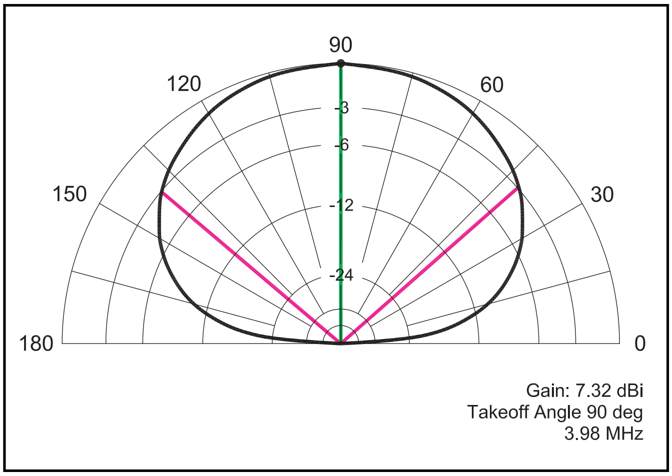

Figure 3—Elevation pattern of the antenna of Figure 1 when lowered to 30 feet.

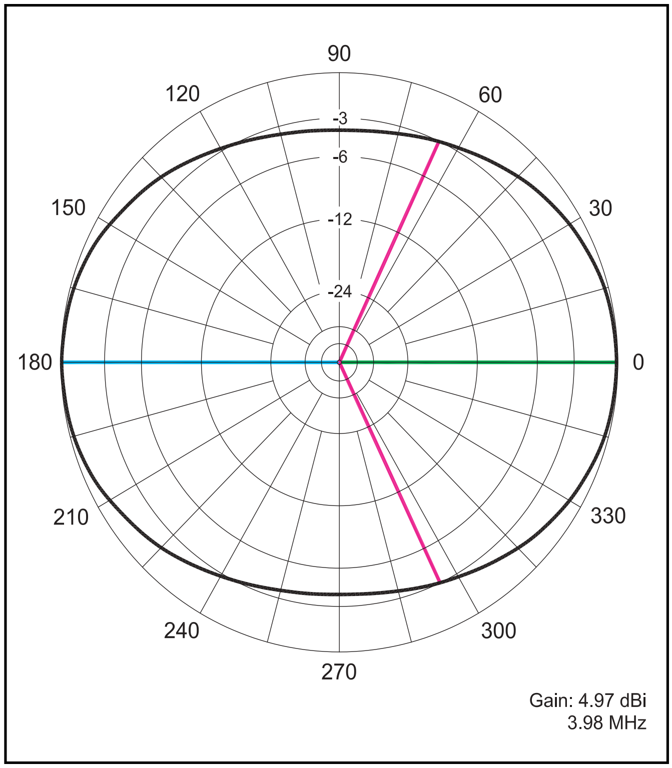

Figure 4—Azimuth pattern at an elevation of 45 degrees for the antenna of Figure 3.

has another advantage: it is an excellent receiving antenna. Many DXers use exactly such an antenna for reception because of its low-noise characteristics.[3] They don't use it for transmitting because it beams a substantial portion of the signal straight up—exactly what you don't want for DXing, but exactly what you do want for regional communications. Be careful not to get it too low, however. Eight feet is a practical minimum for a hanging wire for safety reasons. You don't want people, animals, or vehicles to run into it.

NVIS Propagation

When using NVIS propagation you will probably need to use different bands depending on the time of day or night and the propagation conditions. It pays to be able to change bands easily. For example, during the day 40 meters usually works pretty well, but sometimes the band "goes long" and your near-vertical component is not effectively reflected back down. This causes a skip zone of 50 to 200 miles around your station. In that case switch to 75/80 meters. Other times the absorption is too high on 75/80 during the day and 40 meters works better.

At night, 40 meters usually goes long and your best bet for NVIS is 80 meters, but if 80 goes long then 160 meters is often a good bet. The absorption on 160 meters is usually too great to make it very useful during the day.

If you are trying to establish reliable regional communication, you can often do better with a low elevation dipole and 100 W than you can with a vertical antenna and a linear. So get out there and put up a *low* antenna!

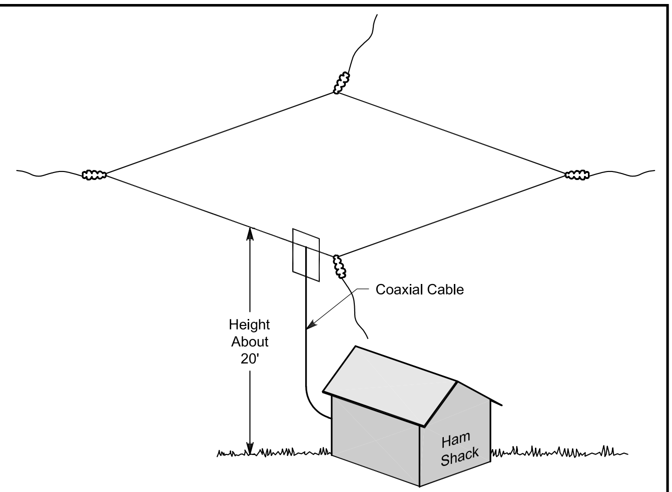

Figure 5—The author's version of the Loop Skywire is but 15 feet above the ground.

Notes

[1]R. D. Straw, Ed., *The ARRL Antenna Book*, 19th Edition (Newington, CT: ARRL, 2000), p 23-21.

[2]*EZNEC* is available from Roy Lewallen, W7EL (**w7el@eznec.com**; **www.eznec.com**).

[3]G. Hall, Ed., *The ARRL Antenna Book*, 16th Edition (Newington, CT: ARRL, 1986), p 5-16. Note that the antenna should be erected at 20 feet instead of 40 feet for better NVIS performance. The original Nov 1985 *QST* article by Dave Fischer, WØMHS, is available to ARRL members at **www.arrl.org/members-only/tis/info/pdf/8511020.pdf**. It also appears in recent editions of *The ARRL Handbook for Radio Amateurs* (through the 2001 edition).

[4]*ON4UN's Low-Band DXing*, Third Edition (Newington, CT: ARRL, 1999), p 10-1.

Albert L. Pion, KK7XO, is a retired electrical engineer, and holds a professional engineering certification in the state of California. He worked as an employee and consultant in the San Francisco Bay area until retiring to southern Oregon last year. He has over 30 years of experience in hardware and software design and holds an amateur extra license. He has recently volunteered for and has been appointed to the position of ARES DEC for Oregon District 5. You can reach the author at PO Box 1039, Keno, OR 97627, tel 541-273-1080; **kk7xo@arrl.net**.