The Bent Dipole

Do you lack the open space for a wire dipole antenna? Why not bend it to fit?

By Nizar A. Mullani, K0NM

Have you ever wanted to erect a dipole antenna, but discovered that you didn't have enough space to stretch it out to its full length? I have. And if you're like me, you probably bent the wires at the ends and let them droop down to the ground level (or close to it). What always amazed me is that my modified antenna seemed to work so well. By using my antenna tuner I could get the SWR low enough to keep my transmitter happy, and I was making plenty of contacts.

Well, my scientific curiosity finally got the better of me. I wanted to find out what was really happening when I shortened the horizontal length of the dipole by folding the ends down in the form of an inverted **U.** What did this do to the radiation pattern and the impedance?

Computer Modeling

Thanks to modern PCs, it's possible to *model* antennas before you actually build them. You just plug in the parameters of your antenna-to-be and let the software do the analysis. If you've chosen good software and have supplied accurate information, the results will tell you how your antenna is likely to work in the "real world." You'll even see the predicted radiation pattern.

I began by modeling a standard half-wavelength dipole at a height of one half-wavelength above ground using software known as *AO*. The results showed a classic figure-eight radiation pattern with an impedance of 70 Ω at the feed point. So far so good.

Then I changed the model to create a bent antenna. **Figure 1** shows the regular full-size dipole and the bent dipole below it. Parameters A and B add up to one-quarter wavelength, such that the total length of the antenna is one-half wavelength. The "percentage of bend" is the ratio of length A to length A+B. I computed the gain, radiation pattern, and impedance of the bent dipole for different percentages of bending. Since the bent parts of the antenna come closer to the ground than the top parts, ground effects could become important. To get a better simulation of this antenna, I used *NEC-2* software with an average ground configuration. I processed all the models again using this more accurate program.

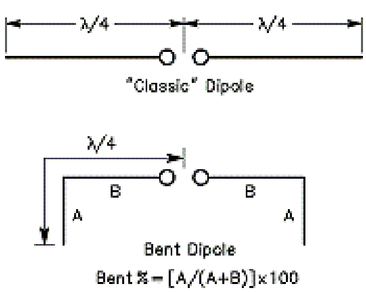

Figure 1—A comparison of a full-sized dipole antenna and a bent dipole antenna. The total length of the bent dipole is one-half wavelength and the percentage of bend is defined by the ratio of A divided by A+B.

Computer Modeling Results

The results of the computer simulations of the bent dipole were astonishing. The gain of the dipole is reduced the more the antenna is bent, as shown in **Figure 2**. Even so, the reduction amounts to only about 0.6 dB when the overall horizontal length is reduced to one-half of the original. The feed-point impedance of the antenna is reduced as more and more of the antenna is bent downward, as shown in **Figure 3**. The impedance match to 50-Ω coax becomes better when the dipole is bent downward by 40 to 50%, or approximately half the total span of a full-sized dipole.

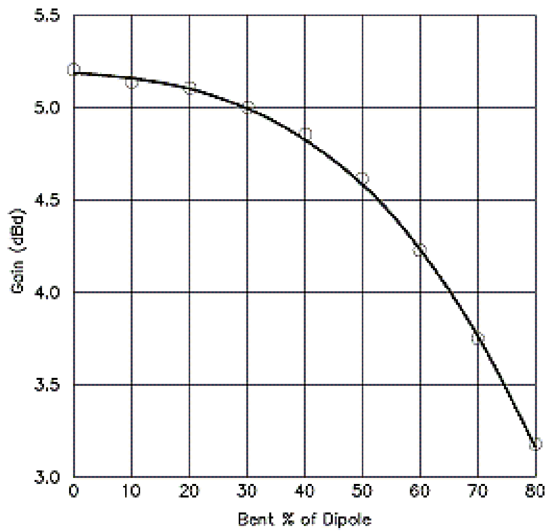

Figure 2—The gain of the bent dipole as a function of the percentage of bending. The full-sized dipole is at zero bend and a 50% bend reduces the antenna to one-half the original horizontal size. The antenna is modeled at a height of one-half wavelength.

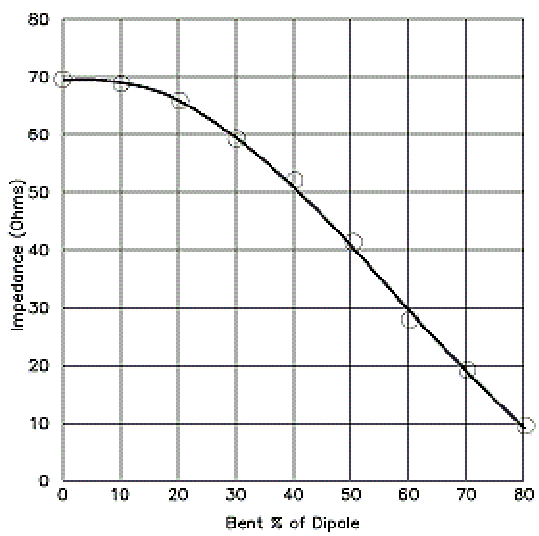

Figure 3—The bent dipole feed-point impedance as a function of the percentage of bend. There will be some variation as a function of the height above ground. This model assumed a height of one-half wavelength above ground.

When the dipole is bent to squeeze into half the horizontal space required for a full-sized dipole, the radiation pattern is remarkably unchanged. The only difference between the full-sized dipole and a 50% bent dipole is approximately 0.6 dB less radiation from the main lobe and some broadening of the main lobe (which is at 90° to the antenna). At a high bend percentage, the radiation pattern becomes more elliptically shaped, and then eventually circular as the vertical components start radiating more energy in the directions off the ends of the dipole.

The computer simulations also confirmed one of the inviolate laws of physics, which is paraphrased as follows: “You don’t get something for nothing.” So, what do you lose and what do the simulations tell us?

Well, the first thing is obvious to most people who have built antennas: Antennas close to the ground radiate up to the sky and warm the clouds (so to speak). Also, a fair amount of energy is coupled into the ground, which helps to keep the worms cozy during cold evenings. Neither situation lends itself to good performance!

The second thing is that the bent portions of the antenna suffer from the effects of ground coupling losses when the overall height of the antenna is low. Fortunately, the part of the antenna closest to the ground has zero current in the bent dipole design, and most of the current is elevated at the maximum height. But, you still need to be at least a quarter-wavelength high to avoid the major ill effects of low antennas. The higher the antenna, the better it is for producing low-angle radiation and long-distance contacts.

Testing a 20-Meter Bent Dipole

The computer models were too good to believe, so I had to see for myself. I took a 20-meter dipole and drooped the ends down so that the total span was about one half of the original horizontal length. I got out my slingshot and rope, and within a half hour I had the bent dipole dangling from the limbs of a tree in my back yard, running east to west. I adjusted the length of the wires at the dangling ends for a 1:1 SWR on 14.1 MHz and fired up my ICOM 738. I didn't even need to use my tuner.

I compared the bent dipole to my 20-meter ground plane and found that it was consistently better by about one S unit from my home in Houston to New York, Georgia, Ohio, and Florida. As expected, the signal reports were worse by about two S units to Colorado because the radiation off the ends is reduced considerably. I enjoyed many conversations with this antenna. Not bad for a dipole that occupies only 17 feet horizontally!

Conclusion

From the computer simulations, and the results from the 20-meter test antenna, it seems that a bent dipole is an excellent way to make the best of a difficult situation. Even hams who live on postage-stamp lots can put up a bent dipole for at least one of the popular HF bands. For example, instead of requiring 135 feet for an 80-meter dipole, you can erect an 80-meter bent dipole in less than 70 feet of horizontal space. Just try to keep the horizontal center part of your bent dipole at least one-half the length of the "full sized" dipole.

The magic of the bent dipole is in the current distribution. The current distribution in a dipole is shaped like a half-cycle of a sinusoid, with maximum current at the center and zero current at each end. Bending the ends down causes the portions of the antenna with low current levels to be vertically phased, but does not change the total harmonic length of the antenna. Therefore, the antenna is still the *same electrical length*, but its horizontal span is reduced. The radiation pattern from the horizontal part is only reduced by a small amount, because a majority of the current is still distributed on the horizontal section. The SWR bandwidth decreases, but that's a trade-off most hams can live with.

So don't be afraid to bend your dipole antennas if you're cramped for space. If you are really imaginative, how about building a *bent Yagi*? Imagine dangling some wires off the ends of a 20-meter Yagi and converting it to a 40-meter Yagi. Or, taking an 11-meter CB beam and converting it to a 15-meter beam in the same fashion?

Acknowledgments

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