Notes on Hatted Vertical Dipoles for 10 Meters

L. B. Cebik, W4RNL (SK)

The search for compact antennas--especially vertically polarized antennas--has taken many turns. However, one of the simplest and cheapest to construct is the vertical dipole with so-called "capacity hats" on each end. Let's look at what is involved in designing and building such an antenna. The design is based on others that I have built, including horizontally polarized 2-element Yagis.

The dipole will be shorter than normal, and the hat assemblies provide the missing length to bring the dipole to resonance. Formerly called "capacity hats," it is now recognized that the terms grew out of a very loose calculating analogy and has no literal meaning relative to relevant antenna properties. In fact, the analogy produces results that are accurate only at VLF and LF. Several years ago, I developed a correction program for calculating hats for 4, 6, and 8 arms or spokes, with and without a perimeter wire, for HF (included with HAMCALC by VE3ERP). I have designed several antennas and arrays using vertical dipoles with hat assemblies. The 10-meter that we shall examine is simply a modified scaling of 40- and 30-meter models.

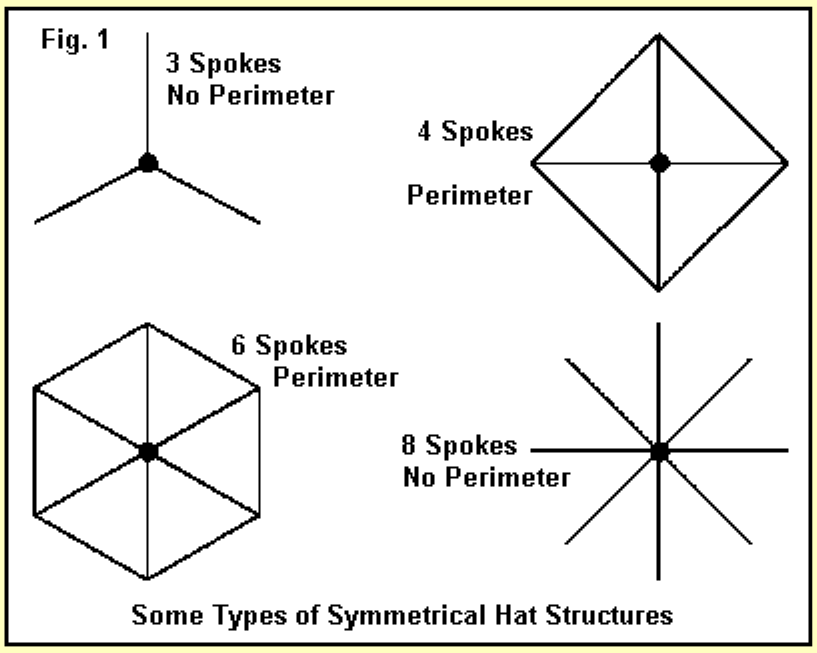
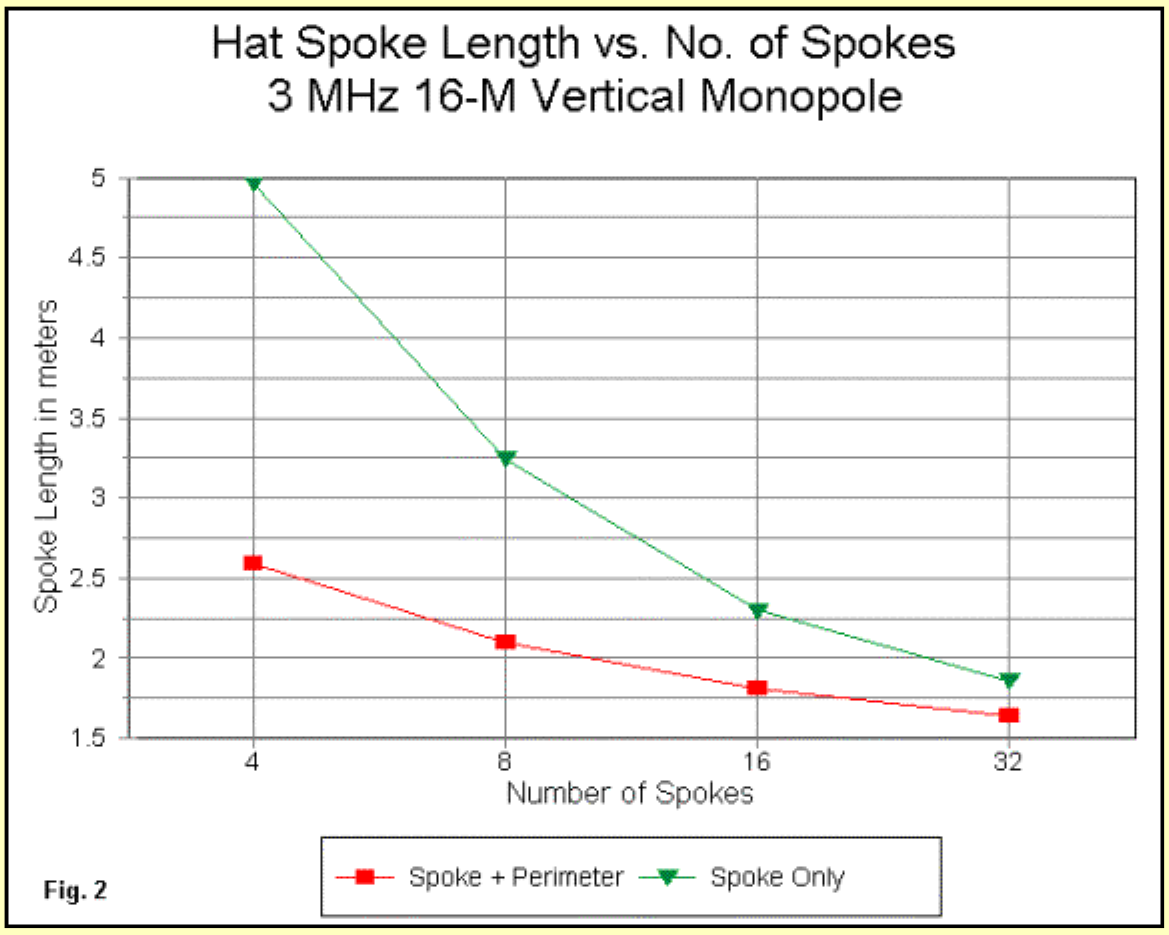


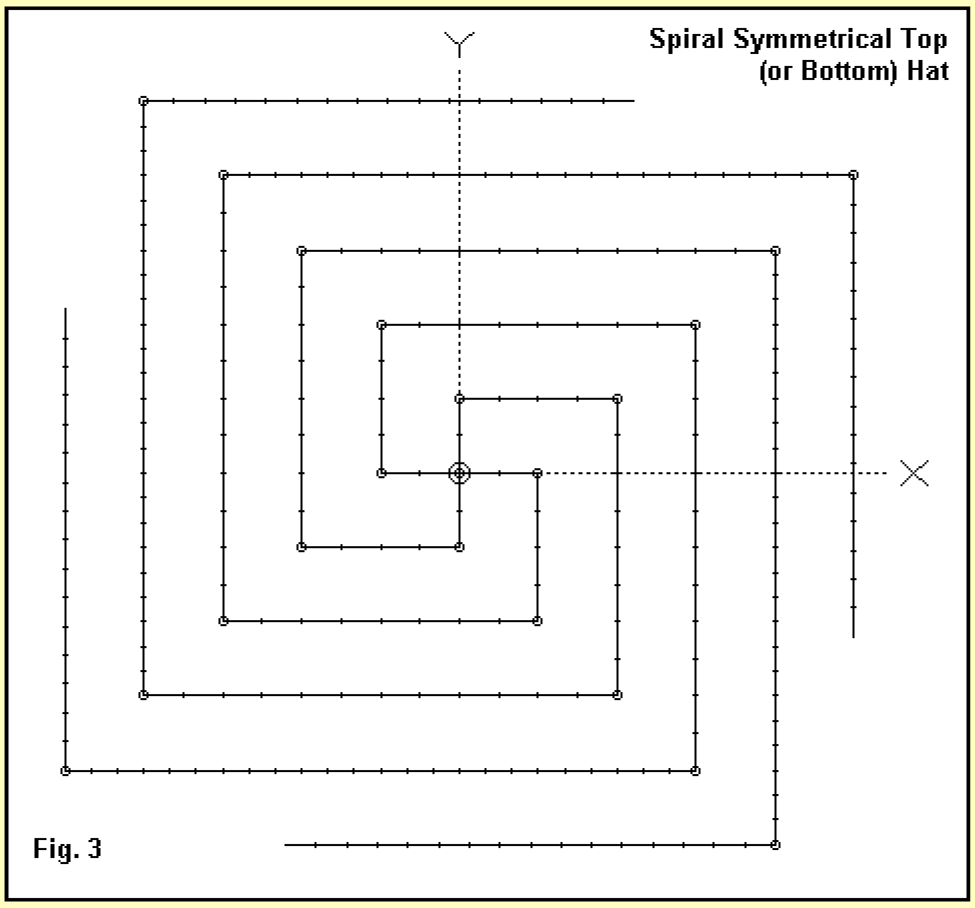
Fig. 1 shows several different styles of symmetrical hats that we may use. Note that we can use a number of spokes, a set of spokes plus a perimeter wire, or even a flat solid disk. We rarely use solid disks below the VHF range, because they tend to trap wind. A spoke system lets the wind pass through, almost unobstructed.

For a given shortened dipole length and a given frequency, the required length of the spokes/arms needed to bring the assembly to resonance depends on a number of variables. Foremost is the number of spokes. As the number of spokes increases, their required length decreases. In the vicinity of 64 radial spokes, the assembly approximates a solid disk. For any given number of spokes, if we add a perimeter wire, the spoke length decreases. The amount of decrease, relative to the length required without a perimeter wire, is close to (but not exactly) 1/2 the distance between spoke tips. As we approach the spoke limit of about 64 radials, the spoke lengths approach each other relative to the two types of assemblies. Intermediate perimeter wires--say halfway out each spoke--may serve mechanical functions but do not materially affect the required spoke length. **Fig. 2** will give some indication of the relative curves for hat system with and without perimeter wires. Each entry is for a resonant 3-MHz vertical monopole, but the same principles of hat structures apply equally to monopoles and to dipoles. In fact, one may design a hatted dipole by first modeling a monopole and then simply tacking two of the resulting designs together at the feedpoint.



The required length for the spokes also depends upon the ratio of the main element diameter and the spoke diameter. The current at the junction of the main element and the spokes divides into the individual spokes arithmetically. However, the actual current level in the section of main element immediately adjacent to the spokes will vary somewhat according to the circumference of the main element vs. the sum of the circumferences of the spokes. Hence, dimensions modeled for one set of elements may require change with changes of element diameters.

The spoke-and-perimeter structure of the hats that we have examined so far is not the only way to create a symmetrical hat. We may also use a spiral structure, such as the one outlined in **Fig. 3**. Note that not just any spiral will do. The 4 spiral arms all originate at the element and maintain complete symmetry at every point. A square shape is just a modeling convenience. Many applications--especially at VHF and up--may use continuous spiral curves.

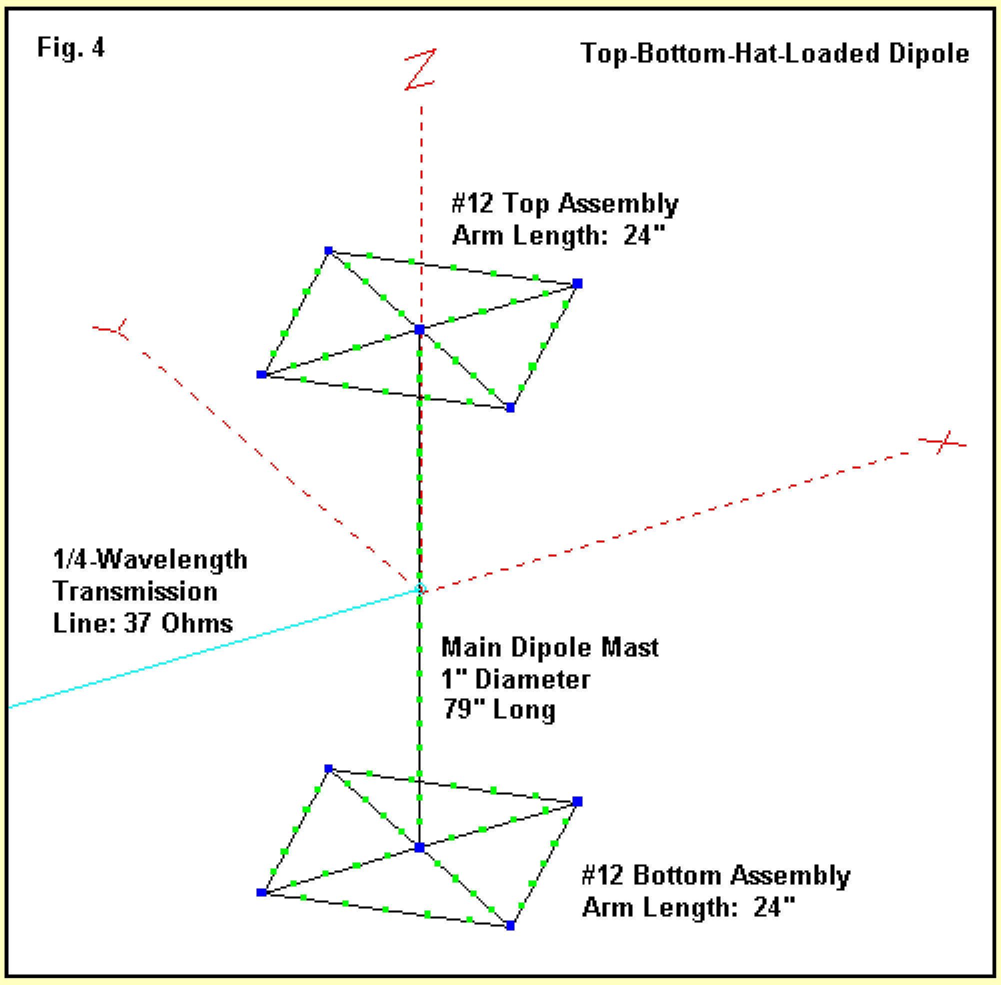


As one shortens a dipole by any means of loading, the feedpoint impedance decreases. A true symmetrical hat assembly yields the highest impedance for any type of loading with a fixed overall length. There are studies of various types of loading for a half-length monopole for 80 meters that will demonstrate this fact. As well, a true symmetrical hat assembly preserves the widest possible bandwidth of all loading means (except, of course, resistive loading, which is not relevant here). Finally, a true symmetrical hat assembly yields the highest gain level, since it preserves the distribution of current along the dipole up to the end, with the decreases associated with the tip region falling on the radiation-canceling hat assembly.

Because the net radiation from the hat assembly is negligible due to field cancellation, a hatted assembly will model accurately in both NEC and MININEC. NEC's weakness relative to angular junctions of wires of different diameters does not apply to situations where there is field and radiation canceling. However, if one wishes to model spokes with one diameter and a perimeter of another diameter, problems may arise in NEC, although they will generally be slight.

For further background on the subject of hats, you may wish to see one or more of the following items at my web site:

- "Capacity Hats and Yagis" (from *Communications Quarterly*): ../mu/mu8a.html
- "Half-Length 80-Meter Vertical Monopoles: The Best Method of Loading:" ../gp/linvert.html
- "Where Do I Hang My Hat?" ../gp/hatp.html
- "A Modeling Perspective on Ground Planes:" ../gp/gp.html

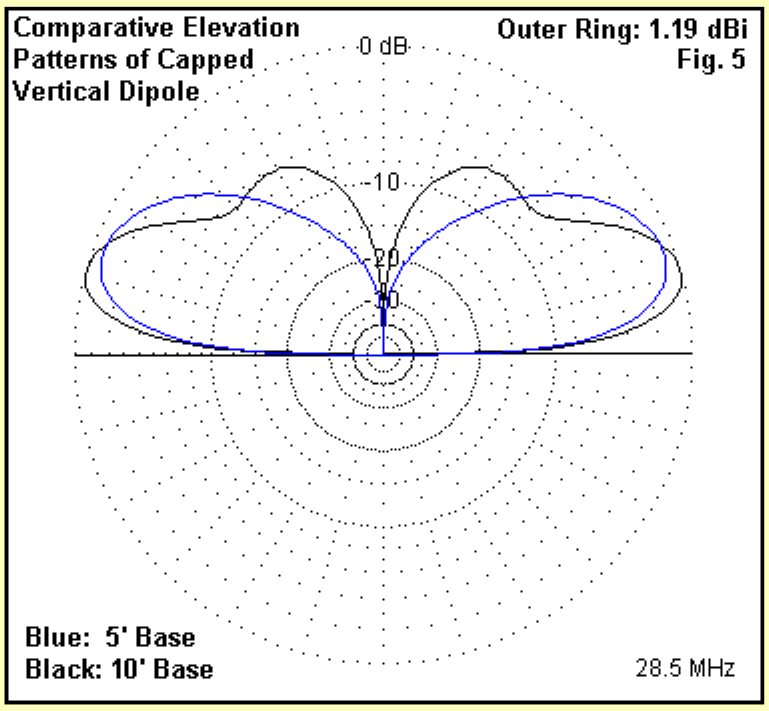


The subject antenna, shown in outline form in **Fig. 4**, was modeled in NEC-4. It consists of a main element 79" long with a 1" diameter. The spokes and perimeter wires are AWG #12. The spokes or arms are 24" long, resulting in a 4' corner-to-corner dimension or a side dimension of about 34". There is a reason for the selection of these dimensions.

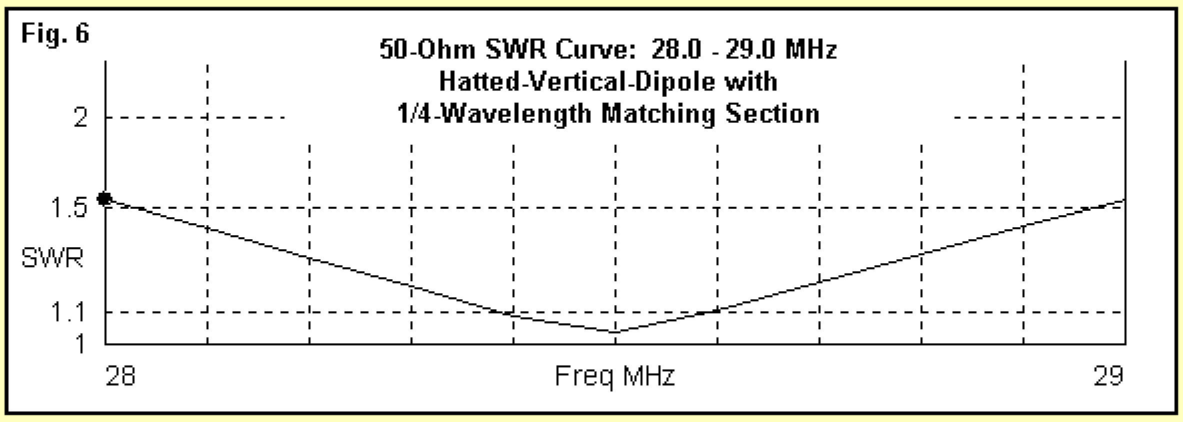
For any dipole diameter, the feedpoint impedance will decrease as we shorten the dipole. To hold resistive losses at the feedpoint to a minimum, it is usually wise to use an impedance in the region of 25 Ohms as a practical minimum. This value is also convenient, since one may make a matching system for a 50-Ohm coax feedline from parallel 1/4-wavelength sections of 70-75-Ohm cable.

The subject antenna's 79" length with a 1" diameter provides the requisite 25-Ohm impedance at resonance, as determined by the dimensions of the hat assembly. The hat assembly will grow smaller if we add further radial spokes, but the impedance of the dipole will not significantly changes with such changes in the hat. (There will be very small length changes due to the current distribution and division situation described above.)

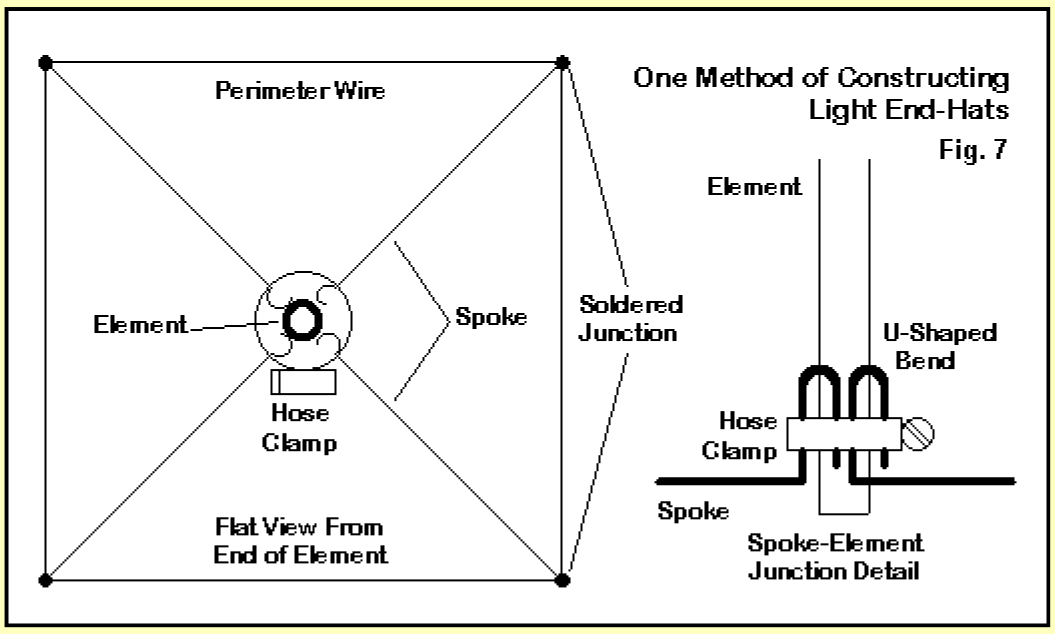
The free-space gain of the antenna is 1.82 dBi, about 0.3 dB less than a full size dipole. This is for a length comparison of 79" for the hatted version and about 200" for a full size version. Over ground, the gain is 0.57 dBi at 20 degrees elevation angle with a 5' base height and 1.19 dBi at 16 degrees for a 10' base height. **Fig. 5** shows the elevation patterns for the 2 heights.



With a 37-Ohm matching section, the free-space model of the antenna supplies the 50-Ohm SWR curve shown in **Fig. 6**. The 50-Ohm resonant impedance at 28.5 MHz changes to 42 + j 3 Ohms if the antenna base is 5' above average ground and to 54 + j 3 Ohms if the base is 10' above average ground. The basic SWR curve shows that there is adequate room for displacement for these different positions of the antenna while sustaining an SWR well under 2:1.



There are as many ways to construct a vertical dipole as there are builders. **Fig. 7** shows one simple way to pre-solder a 4-arm hat assembly from #12 copper wires and then to attach it to the main mast--both top and bottom--with hose clamps. Use one of the bi-metal protective compounds where the copper meets the aluminum. The hose clamp should be stainless steel throughout. The use of the hose clamp mounting system permits you to adjust the exact position of the hats as a means of adjusting the center frequency for maximum band coverage.



Of course, you may choose to use aluminum tubing or wire for the structure to avoid bi-metal contacts. However, fastening the corners at the spoke and perimeter-wire junctions may become more complex.

Ideally, the 1/4-wavelength matching section should come off the feedpoint at right angles and meet a 1:1 choke balun--perhaps a W2DU bead choke--and continue at right angles to the vertical for as far as possible. You may wish to try running the 1/4-wavelength matching section down the lower section of the dipole. However, depending on a number of situational variables, you may find it more difficult to eliminate currents from the braid of the main coax line. For a short (5') mast, Schedule 40 or 80 PVC is very good--if it is adequately UV protected in your area. A 10' mast is likely to call for a section of TV mast. You can create the needed spacing and insulation between the antenna element and the support mast with a series of PVC screw couplings.

The footprint and volume of the antenna puts it in the small category. The height (under 8' or less than 1/8-wavelength) make it easy to hide in restrictive neighborhoods. You can even work out a mounting so that you can raise it to about 20' and use it horizontally. A hand-rotated horizontal dipole can work the world when 10 meters is open.

Return to Index