The Inverted Hen-Delta 6m Antenna

Improved version of the popular 6m Hentenna. Easier to build – Easier to tune – Better performance when ground mounted – Made from home brew favorites: ½ in. copper and PVC pipe.

By John Portune W6NBC and Jim Bailey W6OEK

The Hentenna is the first choice of many fans of the magic band – a tall skeleton slot, developed for 6m in Japan in the 1970's. It is easily also scaled to other bands; a 2m and a 10m version are common. This re-design adds significant improvements, discovered while investigating a near-relative antenna, the HF kite, QST July 2019.

Changes

For the kite-shaped HF skeleton slot, it was noticed that the Hentenna' s rectangular shape is not optimum. The reason? Radiation cancellation that takes place in parts of virtually all antennas.

Figure 1: Pictorial and ground-mounted prototype

An inverted delta, Figure 1, is wider at the top than the bottom. This pushes the effective center of radiation upward. With higher RF radiation there is less soil loss and less ground sensitivity. Hence, performance improves when the antenna is ground mounted. Considering one's neighbors and HOA's, a low mounted antenna is an asset. Figure 1 is a pictorial and photo of the prototype Hen-delta.

Constructed of rigid copper water pipe, allows it to free stand without guys in a ground-mount tube with only a half-height PVC support. It is also at home in an under-wheel car mount for field day or portable operation, or clamped to the top of a mast, or in a rooftop tripod mount. A good in-ground mount is three feet of 2½ in. EMT/PVC electrical conduit simply buried in the soil (no concrete needed).

Elevated Radiation

Maximum radiation moves upward because of the proximity of the out-of-phase and equal-amplitude currents in the Hen-delta's lower conductors. They cancel most of the radiation. It is the same phenomenon that prevents open-wire line from radiating. The E-M wave from a Hen-delta, therefore, emanates mainly from the horizontal top section, and further is is horizontally polarized – unheard of in a vertical antenna. Yet as still a vertical, the Hen-delta has low angle radiation typical of a conventional vertical.

Performance

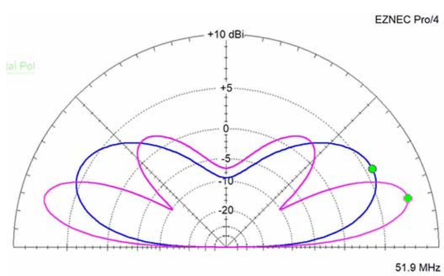

Figure 2: Elevation radiation patterns with gains in dBi, at 1 ft (blue) and at 10 ft. (violet)

Figure 2 shows the elevation radiation patterns at ground level over average soil, (blue) and at 10 ft. (violet).

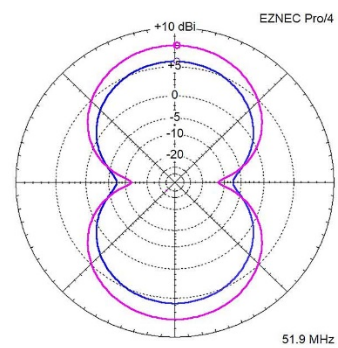

Figure 3: Azimuth (horizontal) radiation patterns at 1 ft (blue) and 10 ft. (violet)

The azimuth radiation patterns are shown in Figure 3. Radiation is perpendicular to the plane of the antenna. These patterns also reveal a further benefit – 6dBi of azimuth gain, even at ground level. 6m J-poles or a vertical dipole have roughly half the azimuth gain.

To achieve the azimuth gain of the Hen-delta, conventional verticals must typically be deployed in a phased multi-antenna array, such as a 4-square. Here, a single vertical has azimuth gain comparable to a small beam on a modest tower. It also is far less visible to the neighbors.

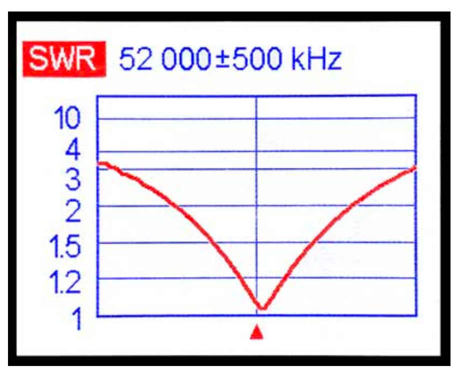

Figure 4: SWR/bandwidth curve

Figure 4 shows the 3 dB bandwidth, roughly 1 MHz. (RigExpert AA-1400).

If you would like to confirm these findings, send an e-mail to jportune@aol.com for an EZNEC model file: In EZNEC, perform an [FF PLOT] and look at [CURRENT PHASE] in [VIEW ANTENNA]. The radiation cancellation and the polarization are easily seen. For a more-complete explanation, see chapter 15 of Amazon/Kindle e-book: *Slot Antennas for Ham Radio*.

Figure 5 gives the essential dimensions. Table 1 lists the materials. Note the feedpoint and the moveable bars in the bottom section (details below).

Quan.	Item
2	10 ft. Type M, hard copper water pipe, ½ in.
1	33 in. Type M, hard copper water pipe, ½ in.
2	Elbow, 90 degree, close, copper, ½ in.
4	½ in. copper pipe straps, 2-hole,
1	10 ft. 1½ in. PVC SCH 40 or 80 pipe
2	1½ in. PVC SCH 40 or 80 pipe caps
1	1½ in. PVC SCH 40 or 80 slip tee
	Material for adjustment bars (see text)
2	1/4-20 x ½ in. stainless bolts, nuts and washers
1	1/4-20 x 3 in. stainless bolt, nut and washer
4	10-24 x ½ in. stainless bolts, nuts and washers
10 ft.	Mini-8 or RG-58 coax pigtail with connector
2	Ring terminals, #10 lug
1	(optional) 3D printed balun bobbin. Printer file at qst-in-depth and w6nbc.com/balun

Table 1: Bill of Materials

Construction

1. Use two uncut 10 ft. lengths of type M rigid copper water pipe for the side pipes (not the heavier types L or K). Cut an additional 33 in. piece for the horizontal top section and a 2½ in. pipe stub for the bottom of the delta.

2. Flatten 1½ in. of one end of the side pipes and both ends of the top pipe. A large bench vice works well for flattening. Drill ¼ in. holes for ¼-20 x ½ in. stainless bolts, ¾ in. from the ends, Figure 6.

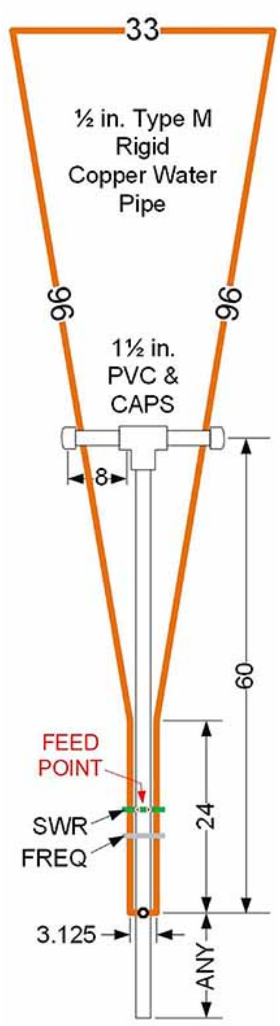

Figure 5: Essential dimensions.

3. Lay out the side pipes and the top pipe on a flat surface and bolt them together. Keep the entire assembly flat.

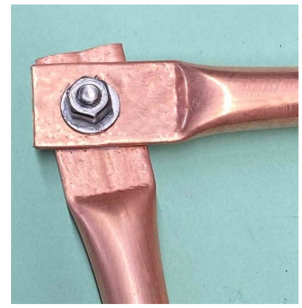

Figure 6: Flattened and bolted top corners

4. 24 in. from the bottom ends of both side pipes, partially, flatten the pipes with the tips of a Vice-Grip type pliers. Figure 7. The pipes will now bend neatly at the half-flattened points. Make certain, however, that the bends are rotated 90 degrees from flattened top ends at the so that the bottom 24 in. sections will lie parallel. (Figure 5 & 8). This permits the movable bars to slide freely on the side pipes.

5. Solder the bottom elbows and the short pipe stub onto the bottom ends of the side pipes. Re-adjust the bends before soldering to keep the 24 in. sections parallel and the whole assembly flat. Use a minimum of solder; water-tight connections are not required.

Figure 7: Bend at the half-flattened spot.

6. Drill a ¼ in. hole for a bolt to attach the antenna to the PVC support assembly, through the center of the short pipe stub at the bottom, perpendicular to the plane of the delta, Figure 5.

Mast snd Support Arms

1. Cut 1½ in. common white Schedule 40 or gray Schedule 80 PVC pipe to a length suitable for your mounting – mast or ground mount, and cut two additional 8 in. lengths for the cross arms.

2. Cut a lengthwise slot along the arms, 5/8 in. wide by 2¼ in. through the center of the outer end of each arm. Make certain that the slots in point toward the top of the delta.

3. Cement together the mast, the T coupling and the arms. Do not cement the end caps at this time.

4. Insert the copper assembly into the slots in the cross arms and adjust the height of the mast. The cross arms should be roughly 60 in. from the bottom and the side pipes should not bowed. Now cement the 1½ in. pipe caps onto the ends of the arms to secure the antenna to the PVC support assembly.

5. Drill a ¼ in. hole through the PVC mast at the bottom that lines up with the center hole in the short copper stub. Use the previously drilled hole in the short pipe stub to guide the drill. Secure the bottom of the antenna to the PVC support with a 3 in. 1/4 -20 stainless bolt, with a washer and nut.

Figure 8: Adjustment Area

Adjustment Fixtures

This re-design of the classic rectangular Hentenna implements easier tuning and matching, via movable adjustment bars, one for frequency (tune) and one for SWR (match). The bars slide along the parallel pipes for adjustment, Figure 5 and 8.

The adjustment bars connect to the parallel side pipes by common two-hole ½ in. copper water pipe straps screwed to the back of the bars, Figure 9. The pipe straps are available at most hardware stores in the copper fittings section. Be sure to purchase all-copper straps; some are plated steel and will rust. Test them with a magnet.

The SWR adjustment bar also contains the feedpoint. The bar, therefore, must be made of insulating material, e.g. plastic. The two inward screws are the feedpoint terminals.

The frequency bar may be aluminum or copper. Flattened ¼ in. soft metal tubing or PC board with all or part of the copper removed are suitable materials. Drill holes for 10-24 screws to attach the pipe straps to the bars.

Feedline and Balun

Prepare a 10 ft. coax pigtail of Mini RG-8 or RG-58 with a connector on one end. Fan out 3 in. of the the braid (shield) and the center conductor at the other end into two separate wires. Add heat-shrink tubing to the wires for weather proofing and install ring terminals for the #10 feedpoint screws. Crimp-on terminals are preferred.

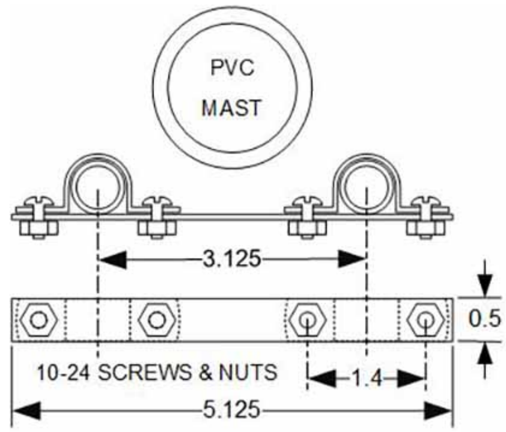

Figure 9: Adjustment bars

Downsteam of the pigtail, convert the remainder of the coax run to the shack to larger diameter coax such as RG-8 or LMR-400. RG-58 and mini-8 coax exhibit high loss in long runs at VHF. Weather-proof the barrrel connection.

Figure 10: 1:1 mini-8 coax choke balun on 3D printed bobbin

Also, provide a 1:1 choke balun near the antenna. It may be a commercial balun, several VHF ferrite sleeves or toroids, or clamp-on chokes.

For readers with access to a 3D printer, Figures 8 and 10 show a 6-turn Mini-8 coax balun on a 3D printed bobbin. The .stl 3D printer file is available at arrl.org/qst-in-depth and w6nbc.com/balun.

Alternately, 6 turns of the coax pigtail may simply be wrapped around the PVC mast just below the antenna and secured with holes in the mast or zip ties. Above the balun, the coax should loop out and away from the antenna by roughly an inch. Provide enough coax length to allow the feedpoint bar to be moved to the top of the adjustment area if needed. The coax may also be fed inside the mast, with the coax exiting through holes in the mast.

Tuning and Matching

With the antenna standing in its ground mount tube or temporarily attached to a non-metallic support at least 5 ft. above ground, adjust the tuning and matching with an antenna analyzer, portable VNA or transceiver and SWR bridge.

Adjust for a low SWR first, paying little initial attention to the frequency. The SWR will change little when you adjust the frequency. Move both bars as a pair to change the frequency, maintaining the separation. The tuning range of the prototype, ground mounted over average soil, was roughly 45-57 MHz – sufficient for a wide range of installations. EZNEC modeling vertifies, as predicted, that the Hen-delta has low ground sensitivity. Hence it changes frequency little if mounted higher.

Overall

With improved ground-mounted performance, horizontal polarization, low-angle radiation, less neighbor and HOA visibility and azimuth gain, this improved version of the 6m vertical Hentenna is a good choice for the magic band. It is suitable both for a permanent installation and for portable or field day operation. It is also scales easily to other bands. For greater neighbor approval, you might consider hanging a flag or two from the top bar.

My sincere appreciation to W6OEK Jim Bailey for his excellent contributions to this antenna. His keen insight improved the engineering and assembly instructions more than once. The result is now simple and easy to build.

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