160-Meter Monster Array

By John Battin, K9DX
jbattin@msn.com

The array described in this article became operational in October 2002. Since then, John, K9DX (in northern Illinois), entered the 2002 ARRL 160m Contest and the 2002 Stew Perry Top Band Distance Contest. His claimed score for these events place him in Third place in SO HP (behind VY2ZM and AA1K) for ARRL 160m and in Second place in SO HP (behind FM5BH) for SP.

This array is patterned after the 80-meter WØUN design shown in the Third Edition of ON4UN's *Low-Band DXing*. Thanks to the effort of my friend Bill Rapshys, K9WR, the antenna was modeled for 160 meters with shortened tapered verticals.

Figure 1 shows the modeled horizontal and vertical patterns of this array. The array has 2.5 dB more gain than a 4-Square and about 8.0 dB more than a single vertical. The antenna is very large:

- Area: Covers 8 acres, including quarter wave radials.
- Antennas: Nine 110-foot Titanex verticals.
- Antenna placement: In a circle 210 ft in radius.
- Feed and phasing lines: One mile of buried 1-5/8 inch heliax.
- Radials: 100 quarter-wave radials on each antenna, 24 miles total.
- Guys: 1 and one half miles of Dacron rope.
- Ground system: Thirty 8-ft ground rods.

In the cover picture, you can see the nine antennas, the shed housing the feed system, and the trenches that were bare dirt at the time the photo was taken. The feed lines from the antennas do not go directly to the shed, but to the circular trench, where they go either clockwise or counterclockwise as required to balance their lengths before going into the shed. The phasing lines are also buried in the circle.

Figure 2 shows one of the nine verticals. Each antenna is a Titanex model 160HD that has been extended from the standard 90-foot length to 110 feet. Both the stock and extended length antennas were previously tried for my 160-meter 4-Square, and the longer antennas performed considerably better because of their higher feed impedance and lower overall Q.

Titanex markets both the 80HD and 160HD (67 and 90 feet respectively) as self-supporting antennas. With the high Chicago area winds, the antennas in this array and those in my 80-meter and 160-meter 4-Squares are guyed. The array

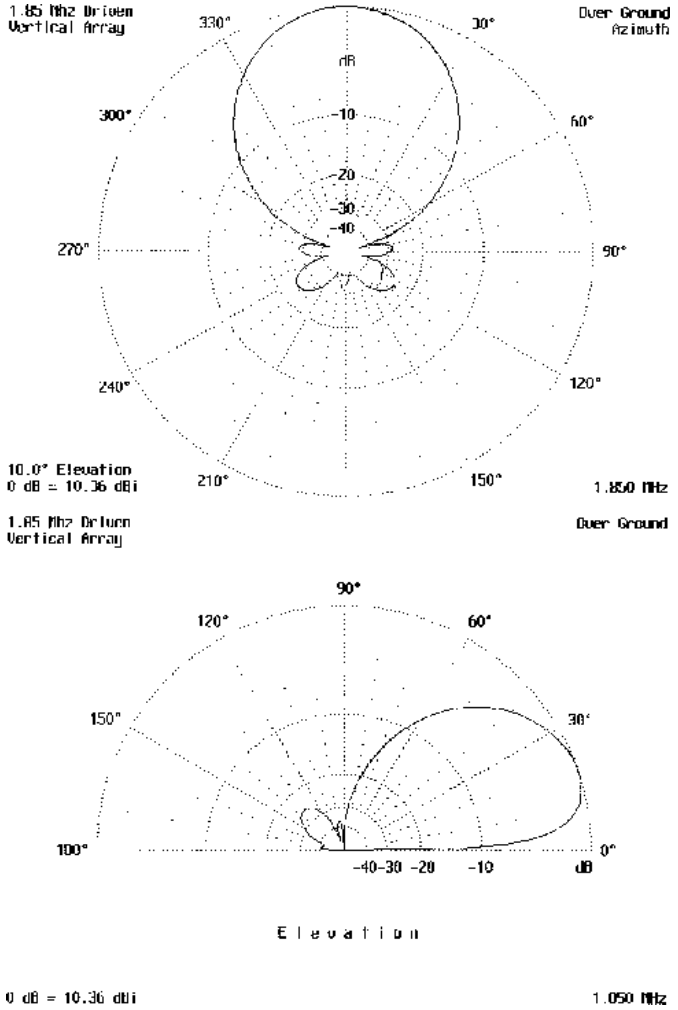

Figure 1—Horizontal and vertical patterns of the array.

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Figure 2—Titanex antenna, loading coil, radials and feed line.

Table 1

element	*A (see text)*	*B (see text)*
Dir 1 (element 2)	53.7 – *j*32.2	13.6 – *j*20.54
Dir 2 & Dir 3 (elements 3 & 4)	41.1 – *j*120	60.43 + *j*0
DE 1 (element 1—center)	18.7 – *j*120	128.0 + *j*0
DE 2 & DE 3 (elements 5 & 6)	30.3 – *j*135	66.0 +*j*31.38
Refl 1 (element 9)	-16.6 – *j*121	143.92 + *j*8.2
Refl 2 & Refl 3 (elements 7 & 8)	5.94 – *j*127	179.3 + *j*184.3

antennas are guyed at 40, 60 and 80 feet, leaving almost 30 feet waving in the breeze at the top. At one time this made me nervous, and contrary to advice from Titanex, a set of guys were placed 15 feet from the top. Rather than improving the situation, the downward pressure buckled and broke the tubing. So now they wave in the breeze and I just do not watch them when the wind is blowing hard.

These antennas are amazingly strong. They come with a winch that mounts near the top of the supporting channel iron and the steel cable attaches to the antenna about four feet above the bottom insulator. It is hard to believe that you can raise a 90-foot antenna by lifting it four feet from the bottom, but it works. In the case of these extended antennas, I used a gin pole attached about 20 feet from the bottom.

The radials are attached to a 4-foot diameter ring of copper tubing that is supported by three 8-foot ground rods. The 100-plus radials lay on the ground and are connected six at a time into solder lugs. These solder lugs are attached to the copper tube with self-tapping stainless screws and then soldered. The weight of the insulation on the stranded radial wire tends to make them follow the contour of the ground, and within several weeks the grass seems to absorb the wires.

The loading coils are edge wound, silver plated and about 4 inches in diameter. Most of these are refugees of Dayton and other hamfests.

Figure 3 is a basic schematic showing the feed currents and angles. The Center element is driven with 3 times the current of the other outside driven elements. The two close directors are driven with 1.66 times the current at –90 degrees and the one far director is driven at 1 times the current at –180 degrees.

The reflectors are the same but with the phase angles leading rather than lagging. All of the elements are fed with ¾-wavelength lines to take advantage of their constant current characteristic. The current in the antennas will be I = E/Z. E is the voltage into the feed line, and Z is its characteristic impedance. The WØUN design shown in *Low-Band DXing* makes further use of that characteristic, and adjusts the current to the elements by having two feed lines to each antenna, and switching between one or the other or placing them in parallel. In the design shown here, there is only one coax feed to each antenna, and toroid transformers are used to set the proper voltages (and therefore the currents).

With the elements set up to so that the array fires North per Figure 3, the impedance of each antenna is shown in Column A in Table 1. The negative sign on the far reflector shows that it is delivering power into the system. Column B shows the impedance looking into the 270° feed lines when a loading coil with a reactance of 120 Ω is placed at each antenna.

By paralleling Dir 1 and Refl 1 and shunting them with a 2.5 µH coil, we get an impedance of 65 Ω.

By paralleling Dir 2 & Dir 3, we get an impedance of 30.2 Ω.

By paralleling DE 2 & DE 3 and shunting them with 100 pF, we get an impedance of 40.0 Ω.

By paralleling Refl 2 & Refl 3 and

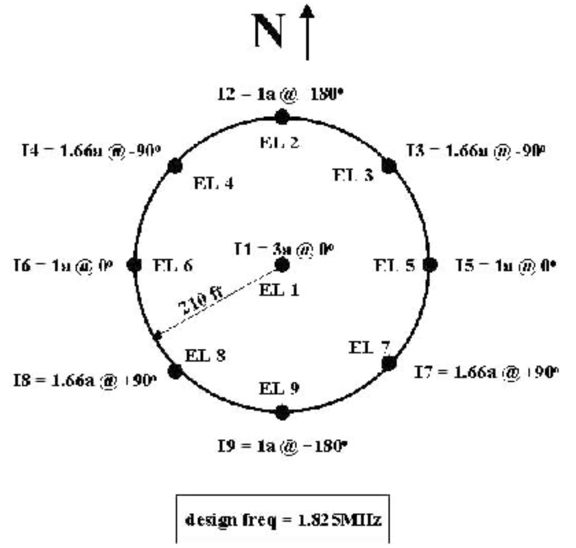

Figure 3—Feed currents and angles.

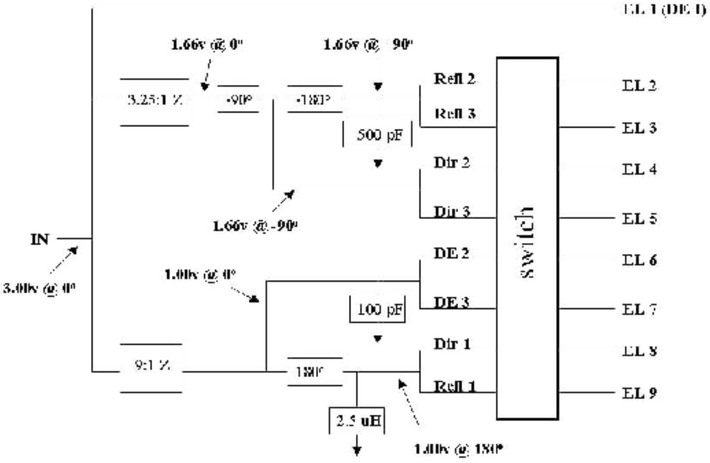

Figure 4—Simplified schematic of switching system.

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shunting them with 500 pF, we get an impedance of 184 Ω.

By feeding DE 1 (the center element) directly and the other elements through the transformers, we get an array driving impedance of 36 Ω, which produces an SWR of 1.4:1. An additional matching network or toroid transformer could be added if desired to bring it to 1.0:1.

Figure 4 is a simplified schematic of the switching system (with voltage magnitudes and phase angles shown based on a hypothetical 3 V at 0° at the IN port). The heart of the switching system is a 9-pole, 11-position ceramic switch. This switch was constructed from hamfest and junk box parts, but is available from Multi-tech Industries, Marlboro, New Jersey. Each wafer of the switch is assigned to an antenna, with the antenna connected to the wiper contact. The switch is wired so that as it turns, the antennas are connected to the proper sources to produce the eight directions. One position grounds all of the antennas. The ninth wafer on the switch controls the switch motor.

Figure 5 shows the switching system. The switching system is housed in an enclosure that is then mounted on the wall of the shed. It includes the switch, three relays to control the motor driving the switch, a timer relay to protect against continuous motor operation, the toroid transformers, the shunt capacitors and the shunt inductances. To avoid hot switching, there is a vacuum relay on the input that switches the transmitter to either a dummy load or another antenna whenever power is applied to the motor.

Switching to an alternative antenna (in my case the 4-Square) is nice because it avoids having a dead receiver while the motor is turning. The motor turns one revolution in three seconds, so if the direction change is only 45 or 90 degrees, the switching seems instantaneous. Twelve wires control the system: eight to select direction, one to ground the antennas, one for 24 V dc, one to select motor direction, and one ground. The system can be controlled with a simple rotary switch, or as in my case, by computer.

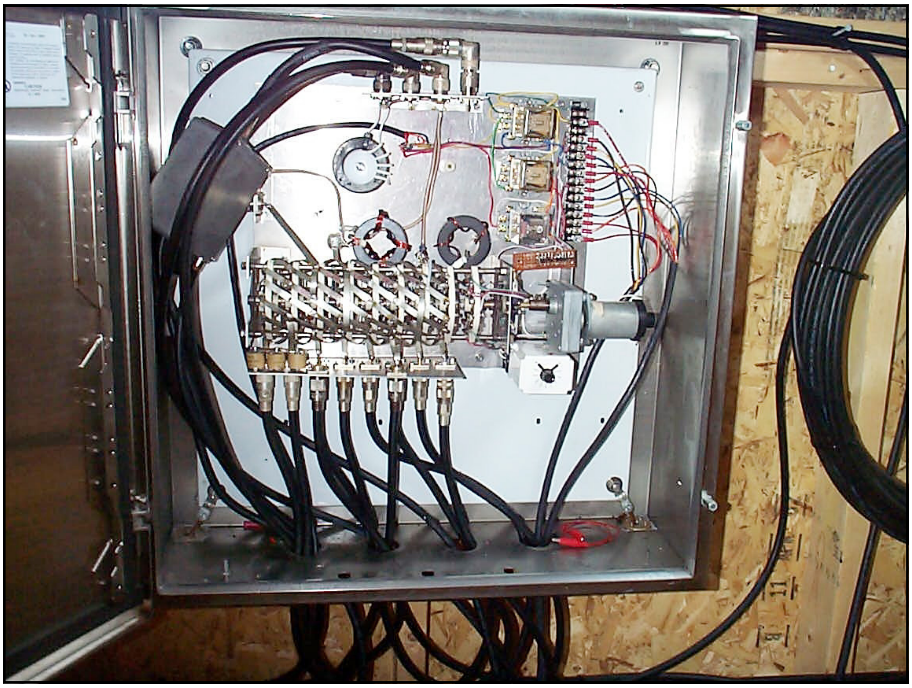

Figure 5—Switching system picture.

Notwithstanding its size, this antenna is not the killer that makes 160 meters behave like 20, nor will make a K9 think he is on the East Coast. It is, like most big antennas, an incremental improvement that from time to time makes the difference between making a contact or not. The results do confirm the computer model. It is 3 dB louder than the 4-Square at my home 30 miles away. Most DX stations report a one or two S-unit advantage. Signals from the side and back are consistently attenuated by more than 30 dB. In contest situations when the band is loaded with signals, key clicks, and QRN, weak signals are easier to copy on the array than with either the 4-Square or the Beverages.

If you desire more detailed calculations, schematics, or have other questions, please feel free to contact me at **jbattin@msn.com**. NCJ