New 3-Element 160-Meter Array at KC1XX

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The elves have been busy this past summer in southern NH at KC1XX (http://www.kc1xx.com/). The 'XX team members are never at a loss for new antenna ideas and stationmaster Matt (KC1XX) is only too happy to help us make our fantasies come true! This year we decided to upgrade the 160-meter antenna system. The single Rohn 25 vertical we had been using until now was an excellent performer, but it was time for something with more firepower, particularly with the expectation that 160 meters would play an increasingly important role in the DX contests of the next few years.

In April of this year, we broke ground on a new system, consisting of three ¼-wave verticals in an inline configuration. Several considerations led us to this layout. To reduce the amount of new tower work, the existing 160-meter vertical was included as one of the array elements. We also decided to convert our "spot" tower, a 100-footer located 224 feet away, to one of the array elements. (The spot tower supported several HF Yagi's used by our multiplier station during contests but we found they picked up too much interference from the main transmit antennas. We replaced the spot Yagi's with simple ground-mounted verticals that were much less susceptible to the interference). Finally a third brand new tower was added midway between the first two towers, resulting in an array of three inline elements, each spaced 112 feet apart. To make room for the third tower, a major tree-clearing effort was undertaken first. The woods were so dense that it was quite difficult to walk through the area until it was thinned out.

The axis of the array runs northeast (65 degrees to be exact) to southwest. Photo #1 shows the three towers, poking above the tree line. They each consist of 109 feet of Rohn 25, topped by a 28-foot aluminum-tubing "stinger". All guy wires are Phillystran.

Photo 1: The three inline verticals (photo by KM3T)

One of the issues we confronted was whether to use ground-mounted or elevated radials. Both approaches have their advocates. We ended up doing both. Our reasoning for using elevated radials went as follows: The vertical at the southwest end sits very close to KC1XX's property boundary and it is not possible to run radials of any significant length over that boundary. However, two elevated radials run parallel to the boundary would still be inside the property line, so that's what we did. My computer modeling work indicated that there was no advantage to using more than two such radials. In fact, using more of them actually degraded the radiation pattern because the coupling between the additional radials upset the antenna current distributions. Also, although it's not obvious from Photo #1, the verticals sit on the side of a hill, with an upslope in the northeast direction. The vertical at the bottom of the hill is nearly 40 feet lower in elevation than the one at the top. We figured that elevating the feedpoints would help offset this handicap. We installed the elevated radials at an average height of about 30 feet. Photo #2 provides a view of the tower leg insulators at the feedpoint before the elevated radials were added.

Photo 2: Tower leg insulators at elevated radial feedpoint (photo by W1FV)

There's more to the radial story, however. ON4UN's book, *Low-Band DXing*, describes the performance enhancement that can be realized by adding a passive screen underneath an elevated radial system. My modeling results confirmed this idea. Consequently we also deployed a ground screen that spanned nearly 3 acres and consumed close to 20,000 feet of wire. We made the screen from bare copper wires laid out in a rectangular grid, with grid squares of 15 feet on a side. Every wire intersection was soldered. There is no electrical connection between the screen and the elevated radials. Laying the screen took most of the summer and was the real "grunt" work of the project. All of us who were involved had the cuts, scrapes, mosquito bites, poison ivy rash, and sunburn to prove it!

The antenna has two modes of operation. The first is a unidirectional end-fire mode in which the array is operated as a director/driven-element/reflector parasitic array that can beam either northeast or southwest. The calculated gain over a single element is 5.5 dB, about the same as a 4-square. (We had considered both phased and parasitic array designs for the end-fire mode, but decided on the parasitic approach because it is much easier to get working and actually has a slight forward-gain advantage). The second mode is a broadside configuration in which the two end elements are driven in phase. The middle element is "floated" and not driven. It produces a bidirectional pattern that fires northwest/southeast with 3 dB of gain. Either configuration can be selected remotely from the shack.

Feedlines from all three elements are brought into a central control box located at the base of the middle tower. Photo #3 shows the box being mounted on the tower inside its own protective shelter.

Photo 3: Mounting the control box; left to right: KC1XX, K1GQ, W1FV (photo by KM3T)

Photo #4 is a close-up view of the interior of the control box. The chassis contains the direction and mode switching relays, two tunable L-networks for impedance matching the end-fire and broadside modes to 50 ohms, and two more L-C networks used to tune the parasitic elements to resonance. If the air variable capacitors in the photo look rather undersized in terms of plate spacing, rest assured they handle the full legal power limit. The circuits are all low-impedance so no high voltages are present.

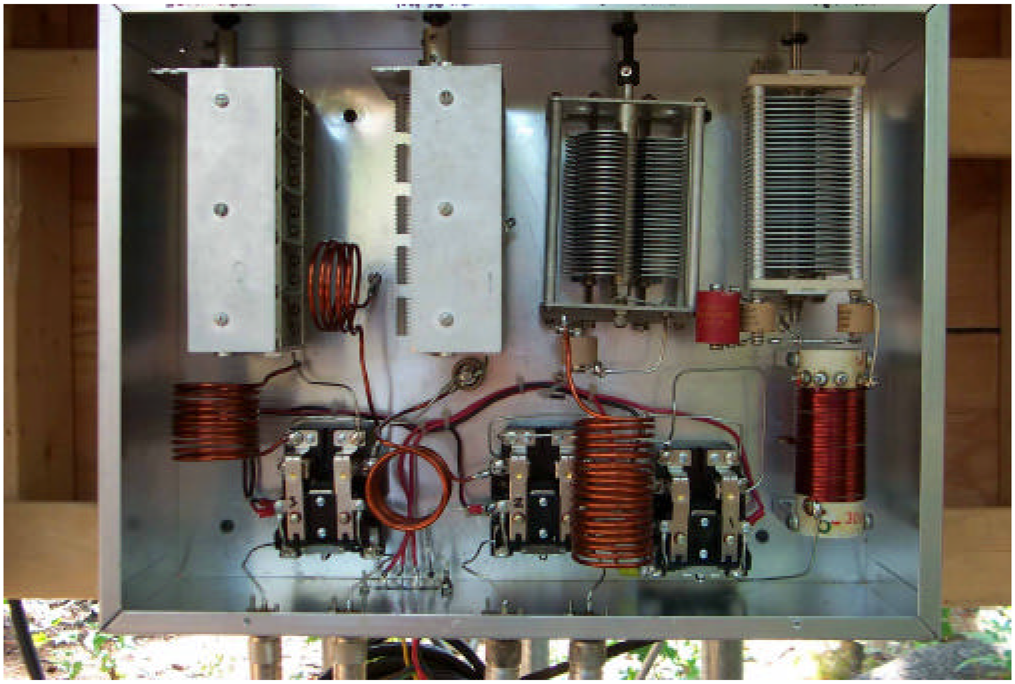

Photo 4: Close-up of the central control box (photo by W1FV)

In end-fire mode the feedlines from the director and reflector elements are connected to continuously tunable reactive terminations. These terminations, transformed back to the base of the verticals through their feedlines (75-ohm hardline), present adjustable inductive and capacitive loading to the reflector and director elements respectively. To optimize the array tuning, we set up a low-power signal source in the field, about 1000 feet away from the antenna and took S-meter readings at a receiver located at the antenna. We used an AEA antenna analyzer for the source and connected it to a makeshift 15-foot transmit vertical antenna. The AEA put out a clean, stable signal that worked well for this application. Sweeping through the adjustments, we were easily able to identify the maximum gain and maximum F/B settings. Those two settings don't coincide, but this is not surprising—the modeling predicted exactly this result. We opted for the maximum gain setting, at the expense of some F/B. Nonetheless we still saw about 3 S-units (nearly 15 dB) of F/B, in very good agreement with my modeling results. The element spacing is a bit too large to yield really large F/B ratios but on the other hand, with closer spacing we would not be able to realize as much broadside gain.

So, how does the system perform? As I write this, the North American autumn season is just getting under way and there's been so little DX activity that it's too early to tell. However, we should know by the CQWW contest weekend in October! Stay tuned…

In closing I am happy to acknowledge the hard work of my fellow 'XX team members in this project: Dave KM3T, Bill K1GQ, Jim AD1C, Matt KC1XX, helpers Andrew Toth and Stoil Stoilov and, of course, Matt's XYL Christine who has been a patient, gracious hostess to a bunch of dirty, sweaty guys throughout the summer.