E. Dallas Carter, W3PP

Vertical Array Solutions for Expeditions

IOTA 2008

Team C6APR activated Crooked Island (NA-113) in the Bahamas for the 2008 IOTA contest, employing phased vertical pairs on 80 through 10 meters (see Figure 1). The 80 and 40 meter verticals were full sized and equipped with a switching arrangement for endfire or broadside radiation. For 20 through 10 meters, we installed two pairs of Cushcraft R5 verticals at 90° to each other. One pair provided a northeast/southwest pattern while the other provided a northwest/southeast pattern. We separated these two broadside arrays by 100 feet to avoid any interaction and fed each with separate feed lines switched at the operating positions. The issues with the R5s were obtaining a proper match on each band and optimizing the pattern for 20 meters. The design problem for the 80 and 40 meter arrays was being able to switch the array's pattern from broadside to endfire via remotely switchable phasing lines. Since we were taking all of the equipment to the island on a private plane, weight was a key factor.

The R5s

Feeding a broadside array on a single band is relatively simple, and there are several ways to accomplish this. One common method is to feed each vertical via a quarter-wave (90°) 75 Ω coaxial transformer (series section). This raises the impedance of each antenna to 100 Ω, but connecting them with a T adapter provides a 50 Ω load for the transmission line to the shack. For a multiband antenna, however, this becomes a switching nightmare and requires separate quarter-wave sections for each band. In addition, it's only really possible to optimize element spacing for a single band.

To address the matching problem, we placed a 50 to 25 Ω CWS ByteMark, **www.cwsbytemark.com**, model UN-22-25 unun (unbalanced-to-unbalanced transformer) between the two verticals, which were then connected with equal lengths of 50 Ω coax (see Figure 2). Optimum spacing for 20 meters is about five-eighths wavelength (225°), and the patterns on 10 and 15 were not at all optimum. At one point during the development stage, we placed a passive half-wave element for 10 meters in the center of the array. This really cleaned up the pattern on 10 meters, but it was too sharp for a two-array system and left large areas with poor coverage. Consequently we abandoned that approach. The resulting patterns for 15 and 10 meters, however random, still provided good *azimuthal* coverage on those bands. We decided to leave the array optimized for 20 meters. Had we anticipated better conditions on the higher bands, though, we might have opted for something closer to half-wave (180°) spacing on 20.

Patterns

Figures 3a, 3b and 3c depict array patterns. The 20 meter patterns show a very clear distinction between the northeast/southwest array (gray) and the northwest/southeast array (white). On 15, antenna selection was not too effective in optimizing signals. On 10, it was extremely azimuth dependent and somewhat illogical. We used *Antenna Model* 2.0.0.660 and *EZNEC* to analyze the antennas and develop the patterns.

You must take care in tuning the antennas so that each has a nearly identical SWR pass-band response — that is, the *same SWR at the same frequencies*, not just the same SWR bandwidth. You could have the same bandwidth but different frequency

Figure 1 — Team C6APR user phased verticals while activating Crooked Island in the Bahamas for IOTA 2008.

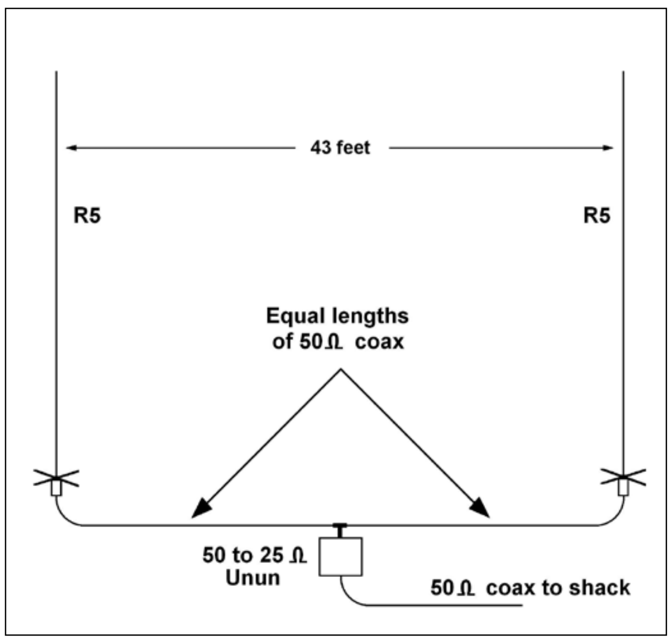

Figure 2 — System diagram for phased R5 verticals

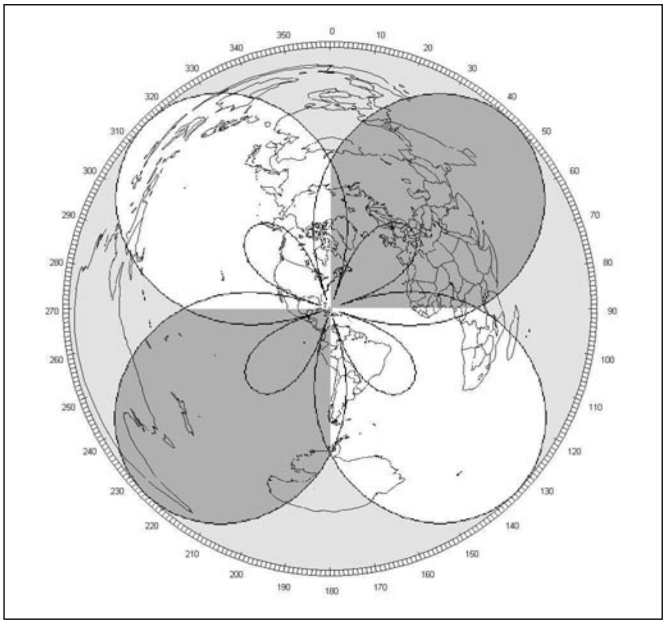

Figure 3a — The 20 meter pattern for the phased R5 verticals

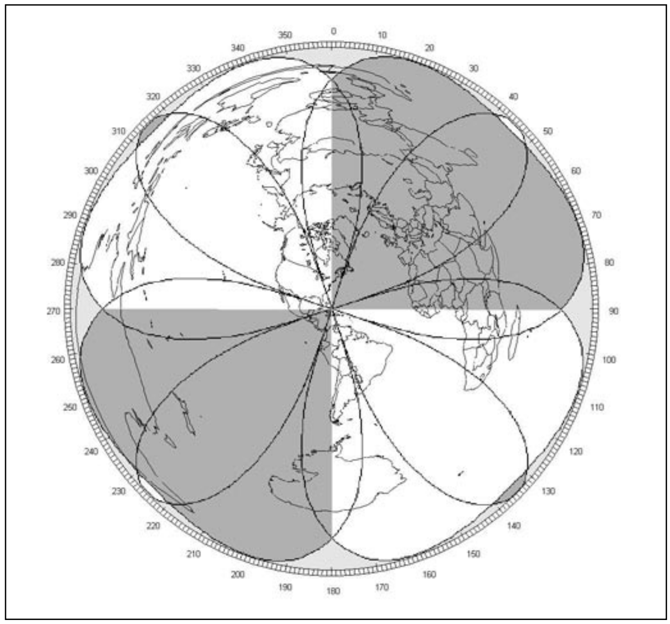

Figure 3c — The 10 meter pattern for the phased R5 verticals

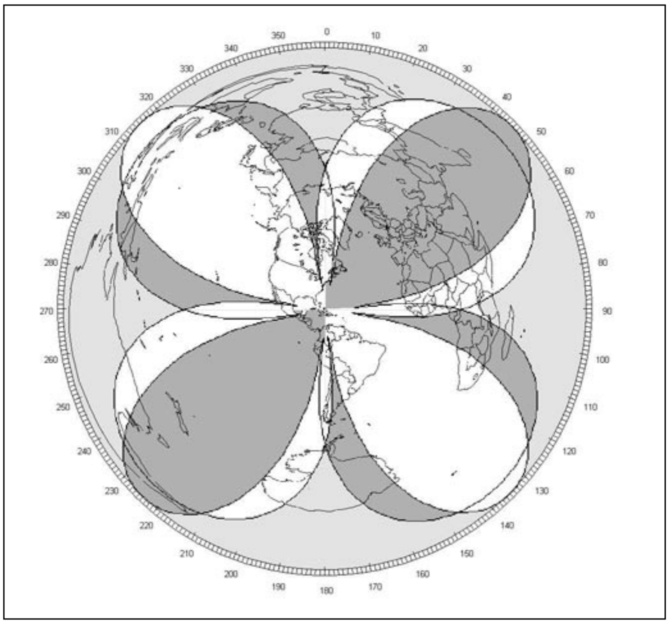

Figure 3b — The 15 meter pattern for the phased R5 verticals

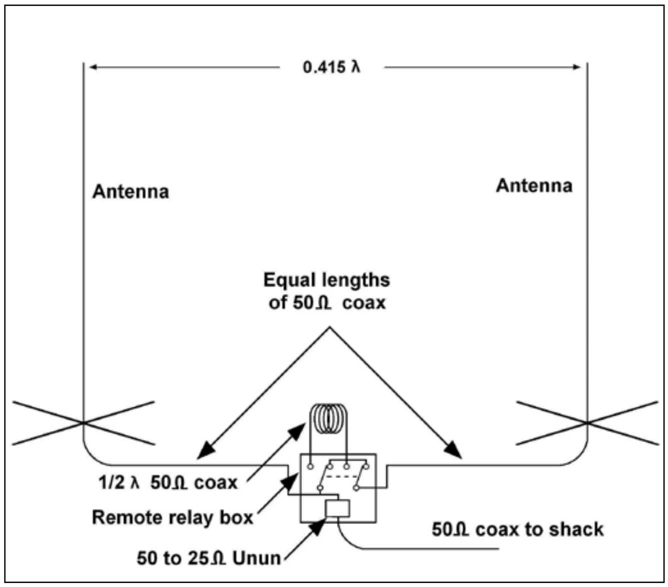

Figure 4 – System diagram for monoband phased 40 and 80 meter verticals

points, and the system would not work well. It's worth noting that staging the antennas inland resulted in performance that did *not* compare to the much lower radiation angle and significantly higher effective gain we experienced once the antennas were erected on the beach. That said, ground conductivity had little effect on antenna tuning. Once the system was tuned inland, we didn't have to touch it at C6.

All R5s were mounted on eight-foot poles to enhance the radiation angle. Because IOTA is a multi-mode contest, the antennas were tuned to band centers and, on 20 meters, had an SWR bandwidth of 1.8:1 from band edge to band edge. The bandwidth on 15 and 10 was much greater, and the SWR was 1.5:1 and 1.3:1 at band edges, respectively. For a single-mode contest, the SWR bandwidth would be less than 1.3:1 across the mode on all bands.

On-air performance evaluation of these arrays is somewhat subjective, since it's dependent upon test station location with respect to the opposing antenna and the angle of propagation at the time. The best case occurred with more distant stations (verticals are low-angle radiators). From C6 on 20, KH6 was just about in the null of the opposing antenna. In almost every case, the difference between the two antennas to KH6 was about four S units on both transmit and receive. Most of our 20 meter testing with stateside and European contacts showed a difference of from two to three S units. During the IOTA contest, I found that I could steer the pileups and pick out call signs much easier using judicious antenna selection.

The 80 and 40 Meter Arrays

On 80 and 40, we used quarter-wave

verticals. On those bands, the design philosophy was to use half-wave (180°) spacing for a switched endfire and broadside configuration. Because endfire and broadside gains differ, we reduced spacing to balance the patterns. The actual spacing on 80 was 112 feet; on 40 it was 57 feet. The feeders to each antenna were of equal length. We modified Ameritron RCS-4 remote antenna switches to switch in the half-wave phasing line for endfire and switch them out for broadside radiation. We again employed ununs, which eliminated the need for series sections. They fit nicely inside the remote switchbox. It's important to have the unun on the *relay* side of the coupling capacitors in the RCS-4 to avoid shorting the control voltage from the control box. Randy, K4QO, did a beautiful job modifying the RCS-4s for 80 and 40.

The 80 meter verticals were Hy-Gain ATM-65s extended to 55 feet and spaced 112 feet apart (ie, somewhat less than one-half wavelength). The 80 meter array had seven radials from 100 to 135 feet long beneath each antenna. We placed an antenna tuner at the base of each vertical to adjust the antenna to a center frequency of 3650 kHz; we needed a tuner in the shack to adjust for the CW or SSB band segments. On 40 meters, we deployed a pair of Butternut HF2Vs spaced at 57 feet. We didn't need tuners at the antenna bases. Each 40 meter vertical had six quarter-wave radials. Figure 4 is a schematic diagram of the final monoband arrangement for 40 and 80 meters.

These two arrays demonstrated about the same directional performance on the air as the R5s. Conditions on 80, however, were so poor that it was impossible to make any definitive endfire vs broadside comparisons. During the contest, switching between endfire and broadside on the 40 meter array again gave us the ability to steer the pileups.

Summary

It's possible to use multiband phased verticals effectively as broadside arrays with somewhat compromised patterns on some bands. Remote switching of phasing lines for single band arrays can provide an effective antenna system.

Acknowledgment

Thanks to Dennis Gazak, N3DG, who developed a systematic search for R5 verticals that successfully garnered one-half dozen units, from which matched pairs were used to meet our unique design and operating parameters.

NCJ