A Multi-Band Array For The Burbs

By Paul Veal, NØAH

In the winter of 2002, I relocated my family from our small ranch in the southeast corner of Wyoming to the south Denver suburbs. For my hobby, it was a difficult relocation as I had to give up my antenna farm made of numerous towers, antennas and, in particular, my 4 square arrays for 40 and 80 meters. These arrays were used primarily for my own science studies regarding short and long path DX propagation during the winter months.

By relocating, I was going from 160 acres to a home development lot that offered a backyard that was only 40 feet wide by 86 feet long. My front yard was 20 feet higher in elevation than my backyard, somewhat putting my backyard antenna location in a hole. I knew that my low-band days using arrays were over. But at least I had zero covenant restrictions against antennas. Thus, my mulling began as soon as we unpacked, mainly trying to figure out a way to install an 80-meter bidirectional array.

For the first two years I tried to work the long path propagation with a single vertical with no luck. I had some success trying various antennas for DX QSOs on the short path, but I could not hear weak signal DX being reported either way. Suffering from S9+ ambient RF interference made it nearly impossible to work anything worth mentioning.

So, I decided to do some things in the shack. It started with replacing my existing rig with an ICOM IC-756 Pro III with its new noise reduction technology. My ambient noise levels were cut on average by 2 S-units and the noise reduction was very helpful in pulling out DX.

Then, I was intrigued by the new antenna that Cushcraft was introducing. It was called the MA8040V. It was designed to be small, quiet, self-supporting, effective and able to take at least 1.5 kW on either SSB or CW. It offered two bands: 80 and 40 meters. That was all I needed to hear. Soon after, I ran to Ham Radio Outlet here in Denver and checked things out.

The Cushcraft MA8040V is a very well thought-out product. Per Cushcraft, it is a compact dual-band monopole vertical antenna that features automatic band-switching for the 40 and 80 meter bands. Independent top-mounted resonators are configured in parallel for negligible cross band interaction. Each resonator uses a combination of capacitive and inductive loading that has been proportioned to optimize efficiency and provide a favorable feed-point SWR.

Tuning the antenna is fairly simple. The adjustable top-section "stinger" is used for 80 meters. Some fine tuning on 80 meters also can be done by adjusting the length of the eight capacitance rods directly below the 80 meter coil.

Forty meters is tuned only by adjusting the lengths of the four capacitance hat rods directly below the 40 meter coil. I did not notice any effect on either band's SWR by tuning the other.

The MA8040Vs are small in size, self supporting anywhere from 23-27 feet, with large $2^1/_2$-inch loading coils that use #12 copper wire for high efficiency and power handling capability. Each coil is wisely encapsulated with a tough UV resistant Anchor Seal™ epoxy that introduces negligible RF loss and provides critical weather protection.

The antenna is built to survive. The 21 foot main radiator elements are made of T6061-T6 0.058-inch wall aluminum tubing. RF-current distribution along this portion of the array would be relatively uniform with no intervening structures to introduce loss. Even all the hat rods were well thought out. For both bands, the hat rods are made of resilient 0.1-inch tempered stainless steel that will resist damage from environmental hazards.

For DX, the design of the antenna provides a low take-off angle to favor working long distances. The antenna has a high angle pattern null to reduce interference from local atmospheric noise and QRM. The antenna comes with a 400 foot roll of radial wire to help in setting things up. I thought this was a nice touch by Cushcraft. At my home, the antenna was at least one half to a full S-unit quieter in reception of ambient noise than my previous multiband vertical.

The Array Journey Begins, But Challenges Ahead

Now with materials in hand, I had to install the initial antenna at least 7 feet back from my fence line to meet our municipal code requirements. That was the only red tape I had locally. With an odd shaped lot, I was able to get as far away from my house as possible—right next to where all my neighbors parked along the street. It was over 20 feet from the home's foundation, but unfortunately further down into the hole of my backyard.

Getting the idea that I might actually be able to phase these antennas together for 80 meters, I measured out the distance to put up a second MA8040V. By just a few feet, I had enough room to put this antenna in place. But due to space limita-

The 80/40-meter array in NØAH's backyard. That's a Cushcraft MB1020 beam on the roof of the house.

Paul, NØAH, owner of the 80/40-meter array, at the rig.

tions, it would have to be 6 feet from my house and next to my electrical box outlet. It also was near a clump of trees.

My reason for this spacing and orientation were simple. I had to space the antennas exactly east and west from one another since setting these up with an ideal NE/SW was not possible due to constraints of the yard.

Since my array was going to be designed for 80 meters, I spaced the antennas a quarter wavelength apart at around 63 feet. This was a tight squeeze. Now with the antennas installed, what was the next step if I wanted to phase a multi-band vertical system together using both 40 and 80 meters? I just didn't think it was going to be possible.

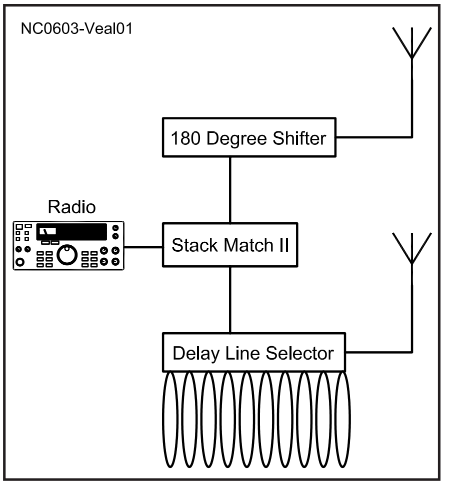
But I contacted Jay, WXØB, at Array Solutions (**www.ArraySolutions.com**), and hoped he had some ideas. Jay told me he had the product already in inventory. It only had to be customized for my bands. And when it arrived, I was surprised by the look of the equipment.

The package contained a WXØB Stack Match II, a 180 degree phase shifter and a coaxial phase shifter unit with a total of 14 SO-239 reciprocals awaiting 14 PL-259 plugs, sufficing room for the six enclosed phase lines and feed-lines. I felt like the Coyote opening up an ACME wood crate out in Moab.

The W9AD Multi-Band Array Answer

This system is known as the Array Solutions W9AD Vertical Multi Band Phase System and it consists of three main components. For more details, check out **www.arraysolutions.com/images/W9AD2elsystem.pdf**.

The first component is the WXØB Stack Match II that power splits the RF power from the rig. You can select antenna A or B for omni-directional use, or both antennas for use in the array.



A simplified block diagram of the 80/40-meter array.

The second component is the 180 degree Phase Shifter to feed antenna A. In the array system, this device plays a large part in determining the directional patterns of the lobes.

The third component is the Coaxial Phase Shifter to feed antenna B. This device controls pattern characteristics of the array. The coaxial phase shifter contains six relays that control the degree of phasing. Six 50 Ω coaxial lines are attached to the outside of the coaxial phase shifter with lengths determined by modeling the array. With all of these coax lines, the cabinet becomes somewhat heavy, but is supported by strong mounting materials.

Jay provides you *EZNEC* patterns so that upon arrival you get a good idea what the array can do.

Once all three components are attached to one another on a mounting pole, short coaxial cables are used to connect both the phase shifter and coaxial phase shifter to the Stack Match II. Inside the shack, you have two control boxes for operating the coaxial phase shifter and phase shifter to utilize the array system.

The array will produce a broadside pattern and an end-fire pattern, as well as other lobes and nulls in various directions as you change the combinations. Testing things out during the summer, the end-fire pattern on 40 meters was most effective at my location.

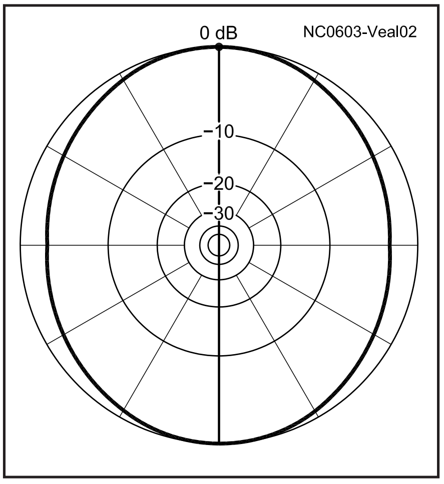
Over the late summer and into fall, the array proved worth its weight in gold for 40 and 80 meter strong signal F/B and F/S dB stateside studies. All selected patterns had notable differences in reception depending upon patterns selected and changes in propagation. The F/B is 15 to 20 dB (plus) and the F/S can peak up to 10-15 dB. Due to heavy QRN, I was unable to really test the system for DX, but it did show excellent promise for short path into Europe and long path possibilities around the globe.

Small Yard, Big Radial Field

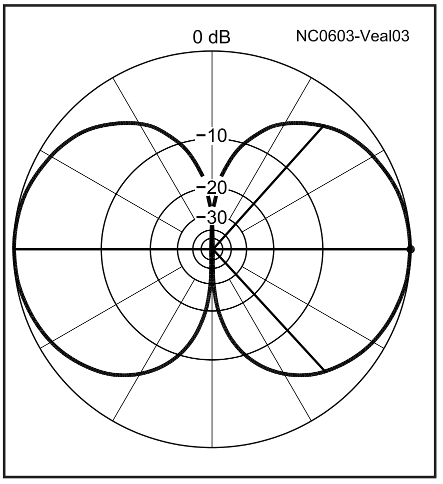
One of the bigger challenges I had in putting the system together was setting up an effective radial field in my small backyard. I only had enough room to fan out my radials in about a 40 degree pattern. But I did two things that made the radials into a decent field.

First, most of my radials were folded back. This way I could take a 60 foot radial and use up thirty feet of space by folding it back towards the antenna. Second, I tied the radials from both antennas together. I had a total of thirty 32 foot radials, and twenty 64 foot radials.

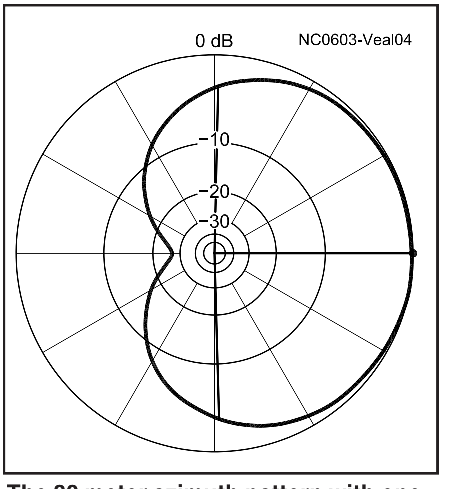
Then, where I could find room under bushes and along my home's foundation, I laid out ten more radials. These ranged in lengths from 4 feet up to 100 feet going under my fence to run along the side



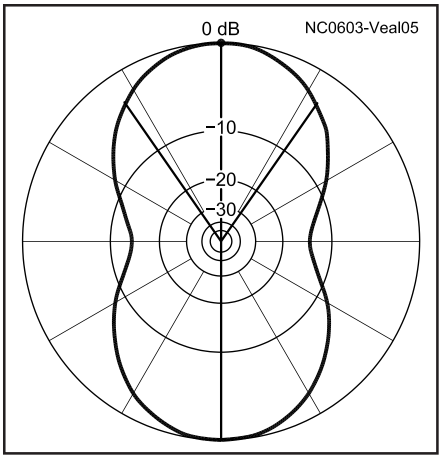
The 80-meter azimuth pattern with the radiators fed in phase.



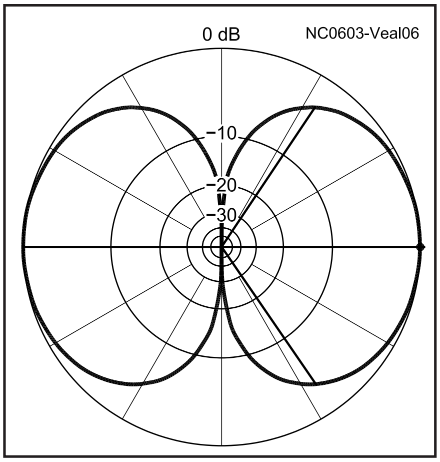
The 80-meter azimuth pattern with the radiators fed out of phase.



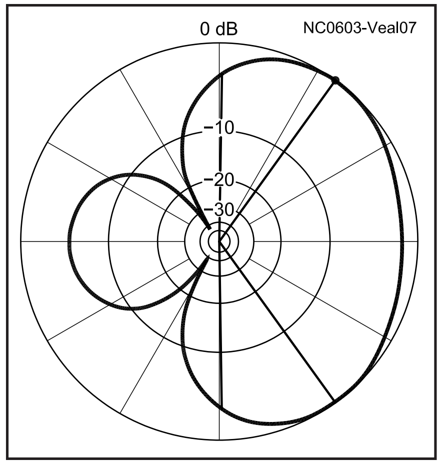
The 80 meter azimuth pattern with one radiator delayed 90 degrees from the other.



The 40-meter azimuth pattern with the radiators fed in phase.



The 40-meter azimuth pattern with the radiators fed out of phase.



The 40-meter azimuth pattern with one radiator delayed 90 degrees from the other.

of my house. The results of these efforts began exposing the natural impedance mismatch of the coax to the antenna. I was satisfied.

"Sure It Can Work This Way" Tuning Syndrome

Out of the box, the antenna's 2.5:1 SWR bandwidth readings on 80 meters performed close to specifications. I was getting around 80 kHz, but I was concerned. My SWR at resonance was 1.7:1, narrowing my bandwidth edges. Forty meters was fine with a minimum SWR reading at resonance of 1.1:1 and a 2:1 bandwidth covering the entire band.

Knowing that I really wanted to enhance the 80 meter bandwidth and resonant SWR reading, I called WXØB to explain my concerns. He suggested that I use a 4-inch-diameter hair pin coil across the feed point made of 6 AWG copper and turns spaced around a half inch apart. This worked great on 80 meters as it brought down my minimum SWR point to a 1:1.1 match. But there was a reverse effect on 40 meters.

Unfortunately, the feed point coil dropped my 40 meter resonant point by over 200 kHz to around 6.900 MHz and gave me a minimum SWR reading of 1.4:1. So what was I to do about 40 meters now? That turned out to be a loaded question, but I found a very simple solution in the manual.

With the antenna being top loaded with capacitance rods and sealed inductors, 40 meters can only be tuned by changing the lengths of the 40 meter capacitance rods. I had to cut my four 40 meter capacitive rods from their original 25 inch length to 22 inches.

After cutting the rods, my 40 meter resonant point jumped to 7.150 MHz. That was the effect I was hoping for, but it was too much. So I exchanged one of the cut capacitance rods with a full-length replacement rod. With just 3 inches added to one rod, my final result was a resonant point at 7.005 MHz. And with the 80 meter SWR being at 1.1:1, I decided to just live with the 40 meter SWR issue.

The higher SWR reading on 40 meters was a small sacrifice for a lower SWR reading and wider bandwidth on 80 meters. I believe that the feed-point coil suggested by WXØB was a good idea to peak the performance of the antenna on 80 meters.

Switching Between 80 Meter DX Windows

Tuning the MA8040V is a lot easier straight out of the box. But why do so many array builders try to get more out of antenna system than what can be expected? Do we ever read manuals that clearly tell us to pick out a portion of the band and tune the antenna for that spot?

My attitude to array tuning can be summarized as follows: "I'm not getting out of this chair to retune my array for 80 meters…during DX or a contest. It could be cold out there and besides, I never wear shoes when my amplifier is on—for good luck. There has to be another way to jump in between DX windows."

The answer to this problem started with a phone call to WXØB. We discussed the placement of an inline custom-made relay-activated tuner that would drop the array from the phone DX window down to the CW DX window. It was suppose to be an easy flip of a relay controlled from inside the shack. After several tests, all it did was drop the 40 meter resonant point down 400 kHz and the 80 meter resonant point by a mere 20 kHz.

The lack of effect on the 80 meter band was due to the high impedance found at the base of the 80 meter coil, with extremely high impedance found at the top of the coil. In other words, my 80 meter section of the antenna was not affected by the tuner.

Chuck Cullian, KØRF, pointed this out to me after studying the antenna schematics. This is why Cushcraft had a stinger above the top of the 80 meter coil for tuning in conjunction with the capacitance rods.

One alternative that did work was to simply start removing individual 80 meter capacitance rods one at a time to raise the antenna's resonant point. By the time I had removed three rods, I was right in the phone window, moving up from the CW window. This obvious solution was already explained in the manual. Yes, the manual is there for more than a makeshift log book under a coffee mug.

But I thought, forget removing the rods. I decided to just spend 10 minutes re-tuning the stinger lengths by adjusting them about 40 inches or so when going from either window. In my case, one inch of adjustment on the stinger length changed my resonant point on an average of 7 kHz. I ended up making something very simple into something very difficult.

Warning! Using an antenna tuner for 80 meters with an amplifier can create voltages that could cause harm to the WXØB system. Using an antenna tuner can also cause added loss in the feedline. Tune the antennas in the array by manual adjustment of various components per the manual.

Results: Winter Low Band Long Path Performance

I know that we all have that special QSO, or QSOs, that makes the struggles of the low-band season worth the effort. For me thus far, the special QSO occurred when I worked YO9HP on 22 December 2005 on 40 meters long path along each one of our gray lines. He was at or below my noise level the entire time, but this is what it's all about with long path DX.

His sunset and my sunrise are around 20 minutes apart and we're both near twilight. With his station so far to the south and to the east of where I normally work

Scandinavian stations, this was a scientific marvel to me.

Here is what he had to say about our QSO in an e-mail exchanged shortly afterwards:

"*Hi Paul,*

Thank you for the details regarding our 40 m QSO, via long path. Well, when I replied to you, I thought we could not make contact because your signal was very weak. This is why I only guessed …who was calling me. But the conditions improved while talking to you. So at the end I copied very well the call-sign. The report should have been 339 and 559 at the end. I was running "close to legal power" and a 3 element Yagi at 25 m height using a 17 element Optibeam OB7-4. Rig is an IC-756 Pro II with ACOM amp. I would say the propagation was poor today, but I am very glad we made it. 73, Alex YO9HP"

The next morning another interesting 40 meter QSO occurred. It was with UA9SC at 1344Z. Zone 17 for long path is very difficult to work from Zone 4 here in Colorado.

Long path this December on 80-meter phone also has had its rewards. At my sunrise times in mid month, I worked or at least was heard with good reports from stations including those in Scandinavia. I even worked a VK6, which is a long distance up the hill from my location. But it has not been a cakewalk due to the noise on my side.

On a good morning, I can pull 80 meter long path phone signals from EU out of the noise. But even when I am heard there, reception remains difficult. For the rest of this season, I plan to operate mostly in the less crowded 80 meter CW window and to continue with good luck on long path on 40 meters.

Conclusion

Regardless of the path, we are not talking about multiple S-units in my application when comparing weak or poor signal copy on 40 or 80 meters, thanks to the 57-59 RF noise levels at my location. For all I know, in a quieter environment these signals could be ten dB over nine, just 2 S units over my typical noise. It really comes down to one simple fact: when using the W9AD Multi-Band Array by Array Solutions, I hear and work stations that I cannot hear on a single vertical. This includes both short and long path propagation around the globe.

The process for me has been worth the effort. I hope this article will help those who may be thinking about trying experiments from a difficult location using a low profile, effective, multi-band array. Be it for DX, contesting, or any other reason, innovative technology is making effective low-band operating a reality for almost anyone.

Typically, antennas within an array have to mirror each other exactly. But in the suburbs, you'll have to grapple with a number of variables that may cause you to fall somewhat short of the ideal. Don't be discouraged. Instead, maximize the positives at your control. That's the key to building your backyard array. You may be faced with many obstacles too numerous to mention, but look at what you can do to minimize these problems by maximizing your tools at hand, including your experience and drive to succeed.

I would like to thank those who provided me with more than I could have expected in terms of time and effort. Everyone's situation differs, but with hard work, and the help of experts in the hobby, you can continue the fine ham tradition of doing what they say can't be done! NCJ