For the low-band DXer who waits patiently along the game trails of the ionosphere or the contesteer who spends hours enduring static crashes and various manmade noises in search of multipliers, these are good times. In the past few years, the design of receiving antenna systems has advanced steadily, raising DXCC totals and lowering blood pressures across the land. The DX Engineering AAPS3-1P Active Antenna Phasing System, featuring the NCC-1 Receive Antenna Phasing Controller (Figure 7), is one such advance.

**Noise Rejection vs Noise Canceling**

As explained in the April 2014 issue of *QST*, receiver sensitivity is not the issue at HF and MF.¹ What is the issue is the ability to reject the noise that may come from any direction. The best way to reduce noise is to simply not receive it in the first place!

Receiving antennas such as the Beverage improve the signal-to-noise ratio (SNR) not through receiving more signal but by receiving less noise from unwanted directions.² Beverage antennas for 160 through 40 meters, hundreds of feet long, are not practical for most hams. Small receiving arrays such as the phased dipoles of K6STI and the EWE and loop-style K9AY and Flag antennas that act as a pair of short verticals were a step forward.³ – ⁷

Another advance has been to combine signals from external antennas in an adjustable desktop box to cancel the noise and leave the signal, assuming they arrive from different directions. Noise canceling systems have been available since the mid-1990s but the associated electronics have been susceptible to strong-signal overload, incomplete and interacting phase and amplitude adjustment, and poor ergonomics. This has led to a reputation for erratic, not-ready-for-prime-time performance.

The DX Engineering system reviewed here takes antenna system design another step forward through improvements in the antennas themselves and in the electronics that combine the signals. The two-antenna system I reviewed consists of a pair of the ARAV3 active antennas (a 102-inch stainless-steel whip and buffer amplifier) and an NCC-1 controller as shown in Figure 8. Signals from each active antenna are fed through 75 Ω RG-6 coaxial cable to the NCC-1 controller or a bias tee. If sequenced to avoid overload is required due to the filter is followed with a unity-gain, low-noise FET voltage follower to couple the signal from the whip’s highly-capacitive feed point impedance to the 75 W coaxial cable. The active circuit stabilizes antenna performance over a wide frequency range, from 100 kHz (where the 102 inch antenna is only 0.00087 l long) to 30 MHz (½ λ long). (Schematics are not available for the ARAV3 or NCC-1.)

Power for the conditioning amplifier is supplied through the coaxial feed line by the NCC-1 controller or a bias tee. If sequencing to avoid overload is required due to

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**Bottom Line**

The DX Engineering AAPS3-1P receiving array provides high-quality noise cancelling performance at MF and HF that makes reception of weak signals easier in the presence of strong signals and noise.
high-power transmit operation, the antenna is grounded when power is removed. Coupling between the outer surface of the feed line shield and the antenna can greatly affect array performance — the ARAV uses feed line isolation to prevent noise on the shield’s outer surface from getting back into the feed line (“noise ingress”).

**Receive Antenna Phase Controller — NCC-1**

The block diagram of the NCC-1 is shown in Figure 10. There are provisions for adding high-pass, low-pass, and bandpass filters but those were not used for this review. The NCC-1 amplitude and phase adjustments are completely independent. The signal from each antenna passes through a 0/10/20/30 dB switchable attenuator (confirmed by ARRL Lab testing) with a continuously-adjustable BALANCE control. Amplitude adjustment takes place before any phase shifting. The channels can also be swapped with a front-panel NORM/REV INPUTS switch.

Each channel is then phase-shifted by a pair of complementary phasing bridge circuits that minimize amplitude errors when adjusting the phase, according to the manual. Amplitude errors during phase adjustment are undesirable because they require readjustment of the amplitude control, creating inconvenient interacting adjustments. Having used noise cancellers that don’t use this design, I can attest this scheme is an improvement. Finally, the phase of the B channel can be inverted with a switch for additional phase adjustment range or to turn a null into a peak as described in the manual.

Regardless of what external antennas are used, pattern nulls will appear either inline with a two-element array or symmetrically on either side of the array axis. As the phasing is adjusted, nulls will rotate around the center of the array from one end to the other with the full 360 degrees of adjustment. The PHASE knob calibration scale does not correspond to null direction or even the number of nulls. Those are determined by array spacing.\(^8\)

Note that the NCC-1 does not amplify signals. In fact, the ARRL Lab measured 7 dB of loss through the system from the active antenna input to the transceiver receive antenna output signal. Not amplifying the signals keeps the system as linear as possible to avoid creating intermodulation and other distortion products. If additional gain is required, an external preamp can be used or the transceiver preamp can be turned on.

Because the preamp follows the controller, it will be amplifying the signal with optimized SNR, not adding to noise power at the controller input.

The NCC-1 can be configured through internal jumper settings to provide power for active receive antennas, or a combination of active or passive receive antennas. In my evaluation, I configured the system to use the pair of active antennas. A companion sequencing unit (TVSU-1A) is available to control power to the antennas and amplifier keying signals. I did not use an amplifier during this testing.

The NCC-1 is flexible in that the external receive antennas can be of almost any type, including those that require power for active electronics. You can use Beverages, loops, dipoles, or verticals as your circumstances permit.

**Installation and Performance**

I was able to test the array first in a quiet rural location and then in a noisy urban location. Setup was straightforward — because I read both the array manual and the controller manual first. Before installing antennas for the array, you must decide which bands you’re going to use it on, and whether you want to optimize it for sensitivity or “spatial selectivity” (phasing precision to create the deepest nulls). Consider whether you have a preferred direction. The spacing and orientation of the elements affects the array’s sensitivity and nulling ability. It helps to sketch out your options (if you have options) and evaluate what you are trying to create on the bands you expect to use. For example, ¼ wave spacing on 160 is ½ wave spacing on 40 — you can’t simultaneously have the best performance across multiple octaves of frequency. This is discussed in the manual.

Complete all configuration of the controller and of the active antenna circuitry before you begin installing the system. I completely assembled the mounting plate and active antennas with all ground wires and clamps before taking them out to the field — then I just had to slip the U-bolts...
over the ground rod, tighten them up, and install the stainless-steel whip.

Similar suggestions apply to the coaxial cable. I used the recommended RG-6 cable with the DX Engineering connectors, coax prep tool, and compression fitting installation crimping tool. If you haven’t installed compression fittings, there are a number of “how-to” videos and instructions sheets on the Internet. I unrolled the cable completely and simply cut it in half, even though I didn’t need all of the length to get to the antennas. At MF and low HF, the extra loss is negligible. While the NCC-1 can compensate for unequal cable lengths, using the same lengths of cable and identical antennas simplifies the balance and phase adjustment.

At the rural location, two 4-foot long, ½-inch diameter copper-clad ground rods were installed 135 feet apart, roughly along the compass bearing to Europe. As recommended to stabilize the RF ground, I attached four 15-foot radials to the provided ground lug, arranged symmetrically around the antenna. The coax was attached and run to the station along the ground. No common-mode choke was deemed necessary with the combination of ground rod and radials.

**On the Air Performance**

I first tried the array during the CQ Worldwide 160 Meter CW contest in January. My transmit antenna is a full-size inverted-L about 400 feet from the active antennas. Signals on the array were weaker by 10 to 20 dB, which is to be expected. Signals were generally audible on both antennas but SNR was almost always somewhat better on the array. I did not have to use the pre-amp on my transceiver. While there were a lot of nearby S-9 +20 to +40 dB signals, I did not detect any spurious signals being generated by the active antennas.

The degree to which I could attenuate signals was striking. It was not unusual to be able to take an S-9 signal to S-5 or less (20 – 25 dB or greater null depth) using only the PHASE control once BALANCE had been set between the antenna channels. Peaking signals worked just as the manual suggested: first null the signal, then reverse the NORM/REV B PHASE setting: The signal pops right back out of the noise and signals in other directions take a dive.

Having used other noise cancelling devices, I immediately understood the benefits of the phase knob’s large size and smooth action. Adjusting a null for maximum depth is a sensitive adjustment and having a large control that turns smoothly makes that process as easy as possible. As a result, when trying to maximize readability of a signal, I didn’t even have to look at the controller and could concentrate on the signal. Operation was intuitive without interacting phase and amplitude adjustments.

Switching back and forth to the transmit antenna, I could clearly hear the SNR improvement, particularly on weak signals that were undergoing fading. I could “ride” the PHASE control and often keep them audible throughout a fade cycle. As far as background noise, there was a consistent setting of the phase control that reduced it by an S unit or two and that made tuning for weak signals a lot easier.

Another unexpected benefit was being able to attenuate strong adjacent frequency signals to hear a weak caller more clearly. For example, while calling CQ, a very strong station also decided to CQ just 300 Hz higher (not uncommon during a crowded contest). The signal was clean but strong enough to affect my receiver gain. By using the array to null the interfering station, I was able to hold my frequency and continue to work stations at a good rate, even relatively weak ones that I would have struggled to copy with the transmit antenna.

During the FT5ZM expedition in February, I used the array quite a bit on both 80 and 160 and valued the ability to optimize SNR almost continuously. This was important because originating near my antipode, the signal’s peak direction was constantly shifting. Another benefit was being able to aim the null at any station that decided to tune up on FT5ZM’s transmit frequency. Knocking a jammer down a peg or two is quite satisfying! The wide bandwidth of this system (100 kHz to 30 MHz) may also be useful for AM broadcast band and shortwave listeners trying to null out constant same-channel interfering signals from other directions.

The general reduction in noise and easier copy under trying conditions reduces
operator fatigue greatly. After I got used to operating with the array, switching back to the transmit antenna alone was actually unpleasant due to the higher noise and more difficult copy.

Urban Listening
Pulling up stakes, I moved the array back to my urban location in St Charles, Missouri, where the background noise level is three or four S units higher on a good night. There is the ever-present power line buzzing and a variety of appliances and gadgets that make noise. Would the array make a difference here?

I repeated the setup, although with only 65 feet of separation. One antenna was sandwiched between houses with about 10 feet of clearance on either side and the other was about 15 feet to the side of an overhead 1 kV ac distribution line. This was about as good as I could do on a city lot and my expectations were low.

Suffice it to say that I was pleasantly surprised! Connecting the NCC-1 to my transceiver, it took less than a minute to make my power line noise simply disappear on 80 meters. Admittedly, it wasn’t one of those S-9 nights, but taking an offending buzz from S-5 to “gone” was pretty good! That success was repeated all or partially on other interfering signals. For example, on 80 meters some PHASE control settings knock down the background noise by a couple of S units, although the power-line buzz partially returns. On 40 and 30 meters I hear birdies and 20 meters has Ethernet warbles — all were at least partially cancelable. On higher frequency bands, antenna spacing was too wide, generating a pattern with too many nulls to be practical.

Realistically, here in town, noise sources are everywhere and the system can only null out one or two at a time. Nevertheless, it’s definitely an improvement and the results are repeatable from day to day so you can record your settings and be close to optimum right away.

Summary
The NCC-1 is easily the best noise canceling unit I have ever used. It works as you expect with little or no control interaction, repeatable settings, and clean response. All sorts of antenna systems can be used due to its configurable options. I was also pleased with the active antennas which were easy to configure and deploy. The system has enough adjustment range to make worthwhile improvements in both rural and urban locations. It can put the low bands back in play for you.