QST Product Review – April 2014
Array Solutions AS-SAL-20 Shared Apex Loop™ Array
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My DX and contest efforts on 160m have mostly been using an inverted-L for both transmit and for receive. Even though I live in a quiet rural location, I know I could hear even better if I could improve the signal-to-noise ratio (SNR) in receive. See the Noise sidebar at the end of this review for more on noise. For a brief period of time I employed a short 270-foot bi-directional Beverage oriented NE/SW to help my receive efforts. But our property is not suited for multiple Beverages to cover the entire compass. Thus the Array Solutions Shared Apex Loop™ Array attracted my attention for three reasons: 1) it has a small footprint (40-foot diameter), 2) it offers eight directions and 3) it only needs a single coax to perform both the receiving function and the control function.

Brief Description of the Array

The Shared Apex Loop™ Array consists of four identical wire loops, each in a triangular configuration. The main support is a non-conductive mast in the center. Each loop is fed through a ferrite coupler, and the feed line from each loop goes to the mast-mounted switching unit. The RF signal from the switching unit goes to the shack via RG-6 coax, along with the commands from the controller box in the shack to the switching unit. The controller box in the shack allows selection of eight directions, and these directions are indicated with LEDs. See Figure 1 for a sketch of the installed array and Photo A for a picture of the controller box.

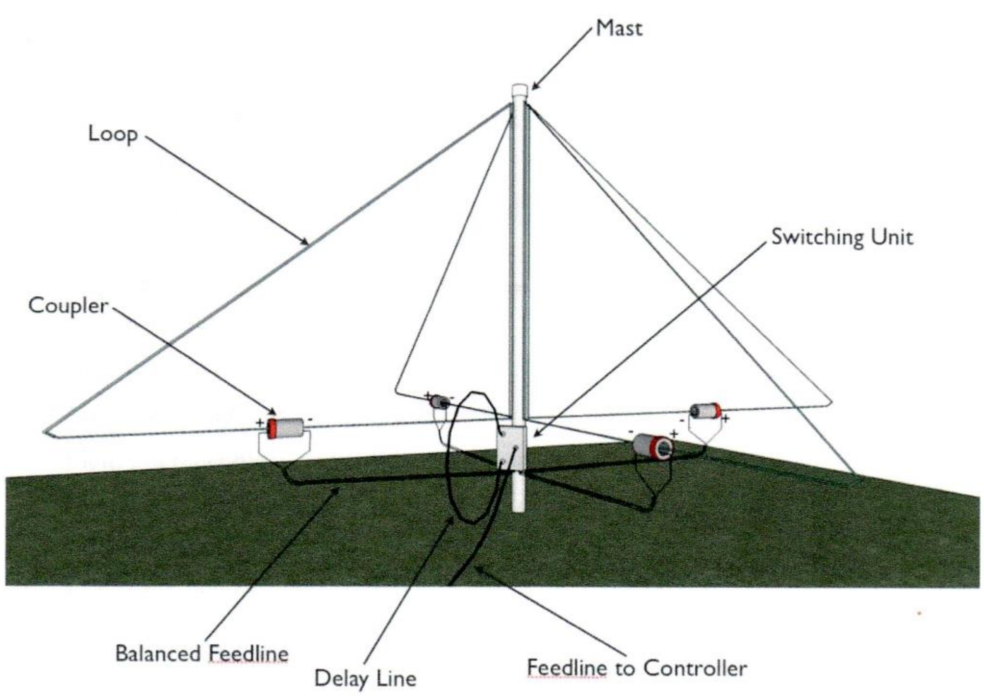


Figure 1 – Sketch of the Shared Apex Loop™ Array

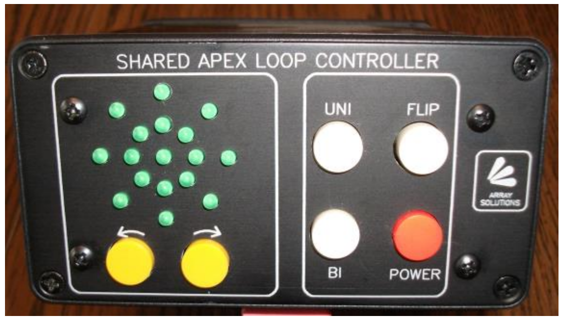


Photo A – The Controller Box in the Shack

The distance along each horizontal loop section is about 20 feet. Thus the array fits in a circle of approximately 40 foot diameter. The center mast is 24 feet tall, with the bottom of the array (the horizontal wires) about 42 inches off the ground. The switching unit contains the relays and combiner, along with a low-noise preamp (the low-noise preamp is in a socket for easy replacement for future product improvements).

Literature on the Shared Apex Loop™ Array

If you're interested in reading more about the design of the Shared Apex Loop™ Array, check out the following references.

1. *Introducing the Shared Apex Loop Array*; Mark Bauman KB7GF; **QEX**; September/October 2012

2. *The Shared Apex Loop Array*; Mark Bauman KB7GF; **QST**; October 2012

3. *Compact Directional Receiving Antenna*; Mark A. Bauman; **United States Patent**; US 8,350,776 B1; January 8, 2013

You can also learn much about the Shared Apex Loop™ Array from the Array Solutions web site at **http://www.arraysolutions.com/Products/sal_array.htm**. The **QEX** article referenced above is also available on this web site.

Assembling the AS-SAL-20

The AS-SAL-20 arrived in a 9-inch by 8-inch by 48-inch long cardboard box. Photo B shows the contents of the box.

Photo B – The AS-SAL-20 Components

I downloaded the manual from the aforementioned Array Solutions web site and proceeded to build the array. It took several hours to assemble and erect it. Assembly and erection is basically a one-man job – but it would help to have another person when you're standing up the 24-foot mast.

I chose to initially erect the Shared Apex Loop™ Array (hereafter referred to as the SAL) in our backyard. That put the outer-most extent of the loop wires only 10 feet or so from our aluminum-sided single-car auxiliary garage and about 20 feet or so from the aluminum-sided house. The result was poor front-to-back (F/B) performance. Thus I ended up moving the SAL to a location about 110 feet from the house. Heed the warning in the manual about locating the SAL too close to large metal objects!

In its new location, the SAL passed the three check-out tests described in the manual: 1) the initial checkout, 2) the loop signal strength test and 3) the loop polarity and array delay test. Photo C shows the installation at my QTH (the large piece of wood in the foreground is a mount for a rain gauge).

Photo C – The AS-SAL-20 at K9LA's QTH – Looking Northeast

Modeling

Mark KB7GF, the designer of the SAL array, sent me results from modeling the AS-SAL-20 on 160m, 80m and 40m using the free antenna analysis software 4NEC2 (available at **http://www.qsl.net/4nec2/**). Figure 2 gives the results of plotting the 160m data.

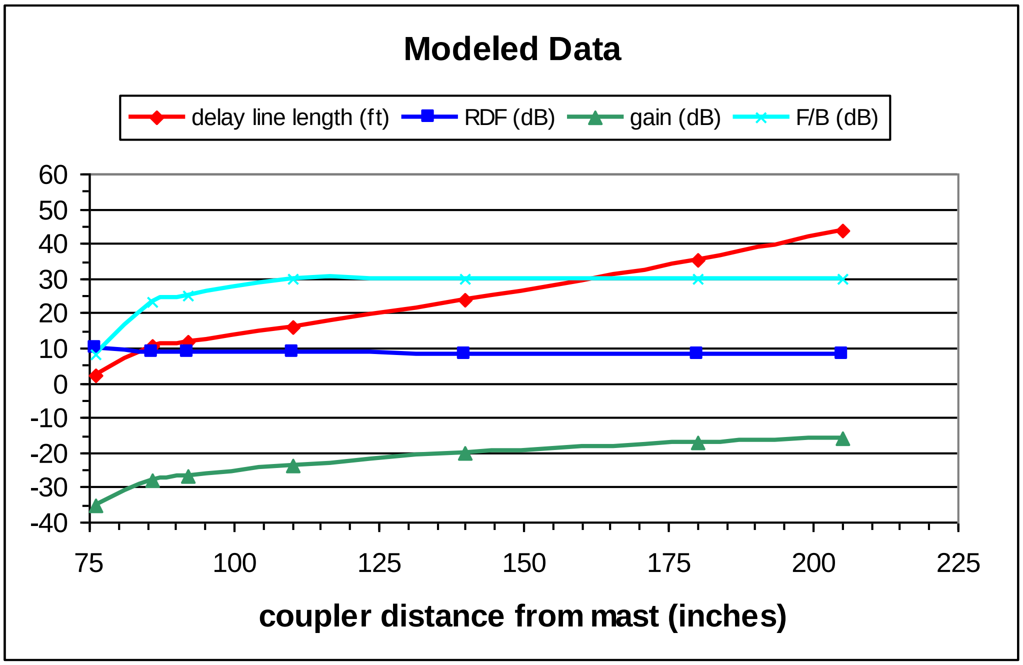


Figure 2 – Modeled Data on 160m

The data in Figure 2 shows performance agility in terms of RDF (see the RDF sidebar at the end of this review for a brief explanation of this parameter), gain (of the antenna alone – without the preamp in the switching unit) and F/B (front to back ratio) versus the distance from the center mast to each coupler. The distance from the center mast to each coupler also dictates the delay line length.

When the couplers are closest to the mast (which requires the shortest delay line length), the RDF is at its maximum (10 dB), the gain is at its minimum (-35 dB) and the F/B is at its minimum (8 dB).

When the couplers are farthest from the mast (which requires the longest delay line length), the RDF is at its minimum (8.16 dB), the gain is at its maximum (-16 dB) and the F/B is at its maximum (30 dB).

This trend of optimizing the parameter RDF or the parameters gain and F/B follows on 80m and 40m, too. Thus the user has latitude in optimizing the SAL for either maximum RDF and minimum gain and F/B, or for minimum RDF and maximum gain and F/B simply by sliding the couplers along the base of the loops and preparing a delay line of the appropriate length..

My Measurements

As mentioned in the **Modeling** section, the user has the choice of where to position the couplers with respect to the center mast, thus affecting RDF, gain and F/B. I chose somewhat of a middle position compared to the extremes, giving a compromise in the three performance parameters.

With the help of Jim KR9U here in Fort Wayne, I performed signal and noise measurements on my inverted-L and on the SAL on a night when atmospheric noise was evident (in other words, atmospheric noise was higher than my man-made noise level). With the SAL direction selected to be pointed at KR9U, Jim's signal level was noted on both the inverted-L and on the SAL. Then Jim de-keyed, and the noise on both antennas was measured (I should mention that my S-meter is calibrated in terms of power in dBm). The results in a 500 Hz bandwidth were per Table 1. Remember that the gain of the SAL compared to the TX Ant includes the preamp in the switching unit.

band	TX Ant	TX Ant SNR	SAL SNR	SAL improvement in SNR	SAL gain compared to Tx Ant
160m	inv-L	49 dB	52 dB	3 dB	-14 dB
80m	inv-vee	36 dB	44 dB	8 dB	-2 dB
40m	inv-vee	38 dB	46 dB	8 dB	-4 dB

Table 1 – K9LA's SNR Measurements

The improvement in SNR on all three bands is close to theoretical assuming RDFs for my transmit antennas per K7TJR's web site.

If you're wondering why the SNR improvement on 160m is lower than on 80m and 40m, the RDF for an inverted-L should be very close to the RDF of a vertical – which is around 5 dB due to the null in the elevation pattern at higher elevations angles (which inverted-vees do not have). This suggests that the atmospheric noise on that night was arriving at high angles on 160m – which the ionosphere can usually support since the F2 region critical frequency foF2 is greater than 1.8 MHz even at night during solar minimum.

Remembering my earlier comment about how real world noise arrives at your QTH, I have no doubt that these measurements would vary somewhat on a night-to-night basis.

Regardless of this caveat, I saw a definite improvement in SNR during my measurements – which is, in my opinion, the purpose of installing a low-noise receiving antenna.

ARRL Lab Measurements

Bob Allison WB1GCM at the ARRL Lab performed gain and third-order input intercept point (IP3) measurements on the switching unit using a DX Engineering 4:1 balun. Table 2 shows these results.

frequency	gain	input IP3
1.9 MHz	24 dB	-10 dBm
3.7 MHz	19 dB	-9 dBm
7.1 MHz	11 dB	+15 dBm

Table 2 – Gain and Intercept Point Measurements

My QTH is in a rural area in northern Fort Wayne, IN. There aren't any high-power AM broadcast stations nearby, and the closest low-band contest station is K9UWA about 2.5 miles northeast of me. I've never had an intermodulation distortion problem with the SAL when K9UWA has been operating on 160m (he runs the legal limit on 160m). Nor have I ever had a problem on the other bands with strong signals (again, K9UWA).

Based on the input IP3 measurements on 160m and 80m, I would consider adding a band pass filter on 160m and 80m if I was using the SAL in a multi-transmitter environment (a contest or in Field Day). But adding a filter would not be easy as it would have to be added before the preamp in the switching unit. The only way to do that would be to wire it in with external cables to the filter.

On-The-Air Results

I evaluated the SAL on 160m, 80m and 40m in several contests (for example, the Stew Perry Warm-Up last October and the ARRL 160m contest last December) and during several listening periods (there were many DXpeditions on the low bands in October and November last year).

The SAL allowed me to hear and work many stations that I couldn't hear on my transmit antennas. That increased my QSOs on 160m in the Stew Perry Warm-Up and in the ARRL 160m contests, and also enabled me to work several new countries and CQ zones on 160m, 80m and 40m.

Although this is a subjective comment, the SAL in a single direction appears to be equivalent to the short 270-foot Beverage that I earlier employed on 160m, 80m, and 40m.

For more details on my on-the-air evaluation, see the On-the-Air sidebar at the end of this review.

Final Comments

Photo A of the controller box shows several switching options in addition to the selection of direction. You can "turn" the array 180 degrees with a push of the FLIP button. You can also go bi-directional with a push of the appropriate button. If you're calling CQ during a contest, these buttons are handy to very quickly check other directions for calls.

When used in the UNI mode (unidirectional – one of the eight directions is selected), you should be able to tell from which direction a signal arrives. There a re some caveats here, though. A signal arriving from in between two of the directions (for example, a signal arriving from 125 plus or minus several degrees) would be equal on the East and Southeast positions. Also rapid QSB will make it tough to pin down the arrival direction. Even with these limitations, you should be able to determine the arrival direction at least to a quadrant.

From Table 1, the signal level on 160m on the SAL was about 14 dB down compared to my transmit antenna. Could the SAL use more gain on 160m? I added a low noise preamp between the SAL controller box and my OMNI VI Plus receiver, but I personally don't think I needed it. Yes, the signal level came up, but so did the noise. Remember that I set my couplers for a compromise in RDF versus gain and F/B. If you go for maximum RDF (minimum gain), I believe you would need a low-noise preamp.

The SAL also makes long listening periods more comfortable due to the improvement in SNR. I can't quantify this in terms of added comfort, but I can sure vouch for it.

There are other low-noise antennas that should out-perform the SAL due to a higher RDF parameter. Long Beverages (1000-footers), long phased Beverages and 4-Squares come to mind. But these systems require much more real estate – real estate that I just don't have.

Remember that I tuned my SAL for a compromise between RDF and F/B. If you have a stationary constant noise source, you may want to tune for maximum F/B. The Array Solutions web site has some nice videos with respect to the excellent F/B capability of this array. Tuning for maximum F/B may also help if you're extremely near an AM broadcast station (especially a high power one).

In my opinion, the AS-SAL-20 achieves a good balance between performance and footprint. And it opens up the next level in hear-ability for low band DXing and contesting efforts.

Price and Availability

The AS-SAL-20 is available from Array Solutions:

2611 North Beltline Rd Suite 109
Sunnyvale, TX USA 75182
Phone 214-954-7140
www.arraysolutions.com

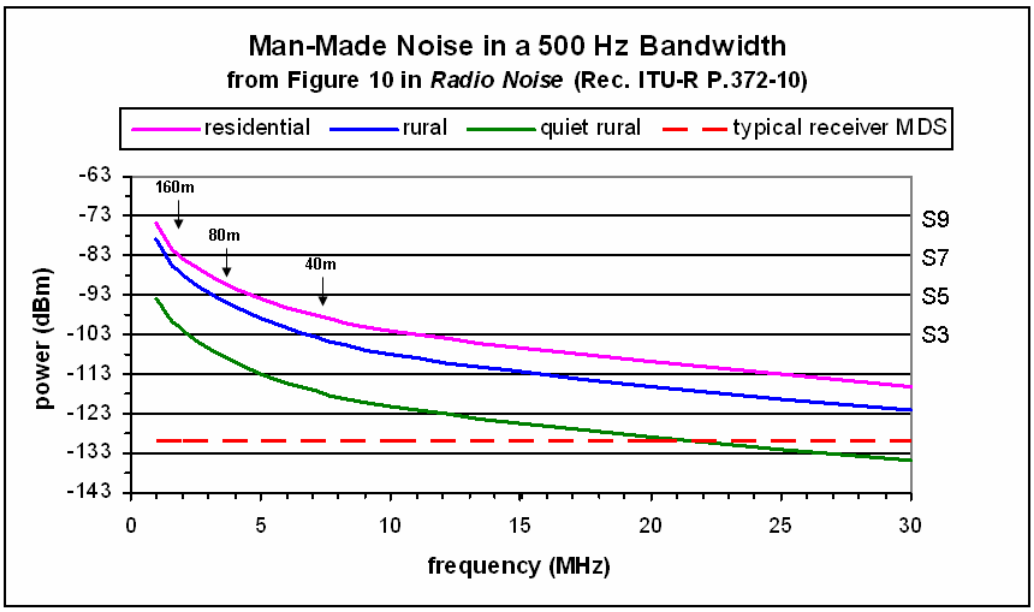
The AS-SAL-20 sells for $795 and gives performance from 0.5 MHz to 12 MHz.

A smaller version, the AS-SAL-12, fits in an approximate 24-foot radius, sells for $775 and gives performance from to 2 MHz to 24 MHz.

A larger version is also in the works. It’s the AS-SAL-30, and sells for $840. It gives more gain on the lower frequencies. There is also a kit to modify the AS-SAL-20 to the AS-SAL-30.

Noise Sidebar

Back in the 1970s, measurements were made of man-made noise versus frequency in different noise environments – residential, rural and quiet rural (my guess is there is more noise nowadays). Man-made noise can dominate at your QTH unless you have a quiet location – then atmospheric noise propagating into your QTH from distant lightning discharges can factor in. The accompanying figure plots man-made noise data from these measurements, and includes the sensitivity (in terms of the MDS – minimum discernible signal) of a typical Amateur Radio receiver in a 500 Hz bandwidth.



The noise power in the 500 Hz bandwidth is plotted in dBm (power referenced to 1 milliwatt using a dB scale) on the left y-axis, and is also plotted in S-units on the right y-axis (assuming S9 is 50 uV = -73 dBm, and an S-unit is 5 dB). Note that on 160m, your noise level could be around S7 if you live in a residential area (thus you may not even be aware of the generally lower level of atmospheric noise). If you’re fortunate to live in a quiet rural area, your noise level on 160m could be around S3. It’s easy to see that even in a quiet rural environment you’re giving up about 27 dB in your ability to hear (the difference between the S3 noise level and the typical receiver MDS).

Although 80m and 40m are successively better, you’re still limited in your ability to hear weak signals by man-made noise – not your receiver MDS. This is the reason why low band operators (DXers and contesters alike) employ low-noise receive antennas – to help them hear signals closer to their receiver MDS. The basic concept of low-noise receive antennas is a narrow pattern in the desired direction and not much response elsewhere so that it picks up less man-made noise and/or atmospheric noise from around the compass. With less noise picked up, the SNR (signal-to-noise ratio) improves – in other words, you can hear weaker signals.

RDF Sidebar

The acronym RDF stands for Receiving Directivity Factor, and was conceived by Tom W8JI. The RDF parameter compares the forward-lobe gain to the average gain of the antenna in all directions (both azimuth and elevation). This ratio is expressed in dB, and a higher RDF means the antenna should improve the signal-to-noise ratio (SNR) more.

Note that the RDF is calculated assuming noise arrives from all azimuths and elevations. In the real world this may not be the case, and thus translating theoretical RDF into real-world SNR improvement can be a tough job. Depending on how the noise arrives at your QTH, you may see different SNR improvements on different nights. But in general, the higher the RDF means you should be able to hear closer to your receiver's noise floor.

For more on RDF, check out ON4UN's Low-Band DXing book (5^{th} Edition, ARRL, 2010). Also check out K7TJR's web site (**http://www.k7tjr.com/rx1comparison.htm**) for a tabular comparison of RDFs for various antennas.

On-the-Air Sidebar

I evaluated the SAL on 160m, 80m and 40m in several contests and during several listening periods.

Stew Perry Warm-Up contest (October 19 and 20, 2013)

On Saturday evening of this 160m contest, there weren't many stations at my noise level on the inverted-L antenna. When I did find one, the SAL always showed a definite improvement in SNR from intermittent copy to Q5 copy. These were all North American stations. I heard no Europeans. I did hear KV4FZ and CN2R early in the evening, but the SAL showed no improvement. Later in the evening I ran across KV4FZ again, and this time the SAL showed an SNR improvement

On Sunday morning, there were many West Coast stations at my noise level on the inverted-L. The SAL made all of them Q5. The SAL also allowed me to work KL7RA and KL7KY – it would have been extremely tough (if possible at all) on the inverted-L. And KH6LC called me during one of my CQ periods – I could not hear him at all on the inverted-L, but he was good enough on the SAL to make the QSO.

Worked All Germany contest (October 19, 2013)

There were many DLs on 80m CW Saturday evening. Most were at my noise level (tough copy) on my 80m inverted-vee. They all showed a very nice SNR improvement to Q5 copy on the SAL.

There were some DLs on 40m, too. Those at my noise level on my 40m inverted-vee also went to Q5 copy on the SAL.

CQ WW DX Phone (October 26 and 27, 2013)

While most people were enjoying strong signals on the higher bands, I was down on 160m doing an Assisted High Power effort. I didn’t hear many Europeans, but the SAL definitely helped on all of them.

K9W DXpedition (November 2013)

The SAL helped me work this Wake Island DXpedition on 160m. The improvement in SNR compared to my inverted-L was enough to make the QSO.

The improvement in SNR of the K9W signals on 80m and 40m was more dramatic, as expected from the data in Table 1.

Other DXpeditions

During the evaluation period, several other DXpeditions were on – T33A, XR0ZR, W8A and J88HL. On 160m the SAL allowed me to hear T33A, XR0ZR and J88HL. I worked XR0ZR and J88HL, but not T33A. On 160m I couldn’t hear W8A well enough to call, even with the SAL.

CQ WW DX CW (November 23 and 24, 2013)

During this contest I did an Assisted Low Power 40m entry. Signal levels from Europe were so good that I did not need the SAL. But some of the other QSOs (for example, with zone 17 and zone 23) needed the SNR improvement of the SAL. And it definitely helped with a 40m QSO about one week after the contest with zone 26 (which finished off my 40m WAZ).

ARRL 160m Contest (December 6-8, 2013

The performance of the SAL in this contest mirrored the performance in the other contests. Many stations were strong enough on 160m to not need the SAL. But there were quite a few East Coasters, West Coasters, KH6 and KL7 that I couldn’t have worked without the SAL.

Summary – The SAL most of the time helped me make QSOs on the low bands that otherwise wouldn't have been made. Although this is a subjective comment, the SAL in a single direction appears to be equivalent to the short 270-foot Beverage that I earlier employed on 160m, 80m, and 40m.