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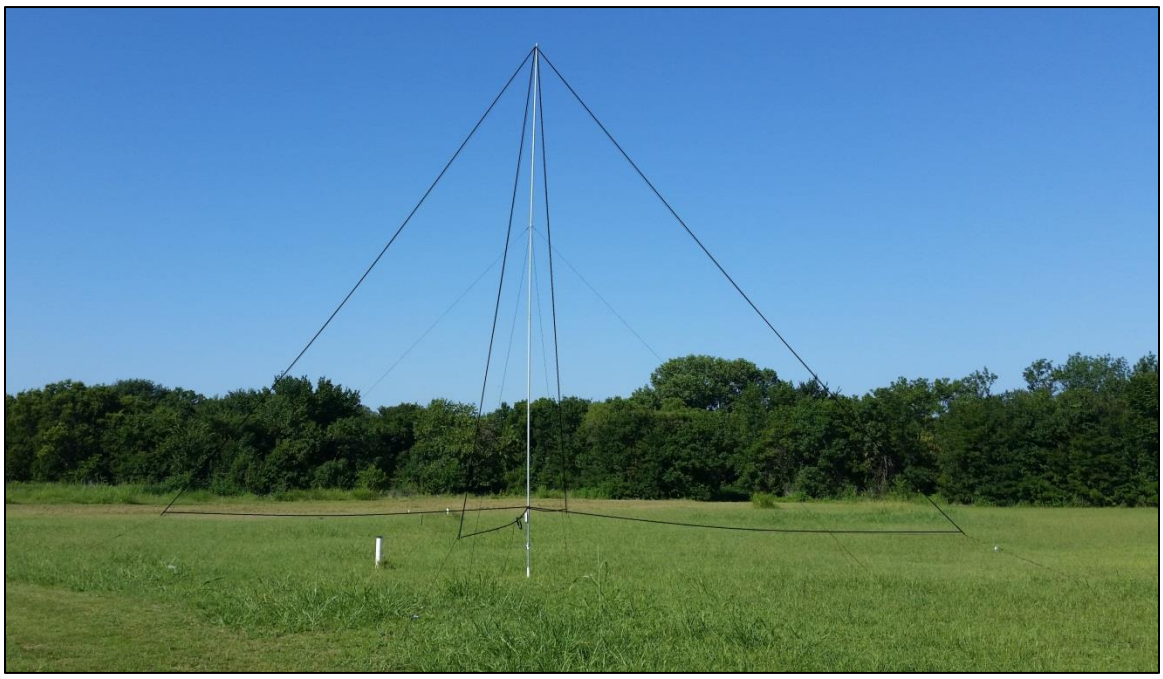
Model AS-SAL-12/20/30 - Mark II
8 Direction Receiving Loops Antenna System

Manufactured and marketed under United States Patent No. 8,350,776 and additional patent pending.



Introduction

The Array Solutions Shared Apex Loop™ Array (**AS-SAL-12 Mark II**, **AS-SAL-20 Mark II, and AS-SAL-30 – Mark II)** is an improved version of the new type of receiving antenna that delivers exceptional directivity in a compact package and is useable over a wide range of frequencies without need for adjustment. This array opens the door to a new class of compact, high performance, wideband receiving antennas developed for both amateur and professional users.

In 2009, **Mark Bauman (KB7GF)** developed a working model of the array to improve his listening experience in a suburban neighborhood in southeast Washington State. From testing, he found that the array provided exceptional bandwidth in a compact size

and provided good front-to-back and front-to-side ratio especially for local interfering signals.

The design of the array countered conventional wisdom by spacing a pair of loops only inches apart when state-of-the-art designs called for spacing on the order of around ¼ wave length (over 100 feet on 160 meters). Numeric modeling of the array showed that, for closely spaced loops, the spacing between the loops was much less important than the location of the feed point along the base of each loop. This provided the opportunity to simplify the installation because all of the loops could be held in place by a single non-conductive mast that acted as both a spacer and support.

In addition, inserting ferrite beads along the base of the loop to form transformers provided a convenient method of signal coupling as well as a great way to test various coupler locations. Modeling also showed a correlation between the coupler location and the response pattern and backward elevation null angle which was also verified during testing.

Utilizing the inherent front-to-side rejection of small loops made it possible to achieve both front-to-back and front-to-side rejection using signals from only two loops and a single delay line. This simplified the signal combining task, and made it possible to locate all the signal processing electronics at a single position at the base of the array.

Next, testing commenced on two orthogonal pairs of loops and switching circuits were developed to provide electronic rotation of the pattern. This testing showed that eight individual directions could be obtained using the four loops. These switching circuits included a multiplexing scheme where the switching commands and power were sent on the same feed line that returns the signals from the array. This technique greatly simplifies the installation.

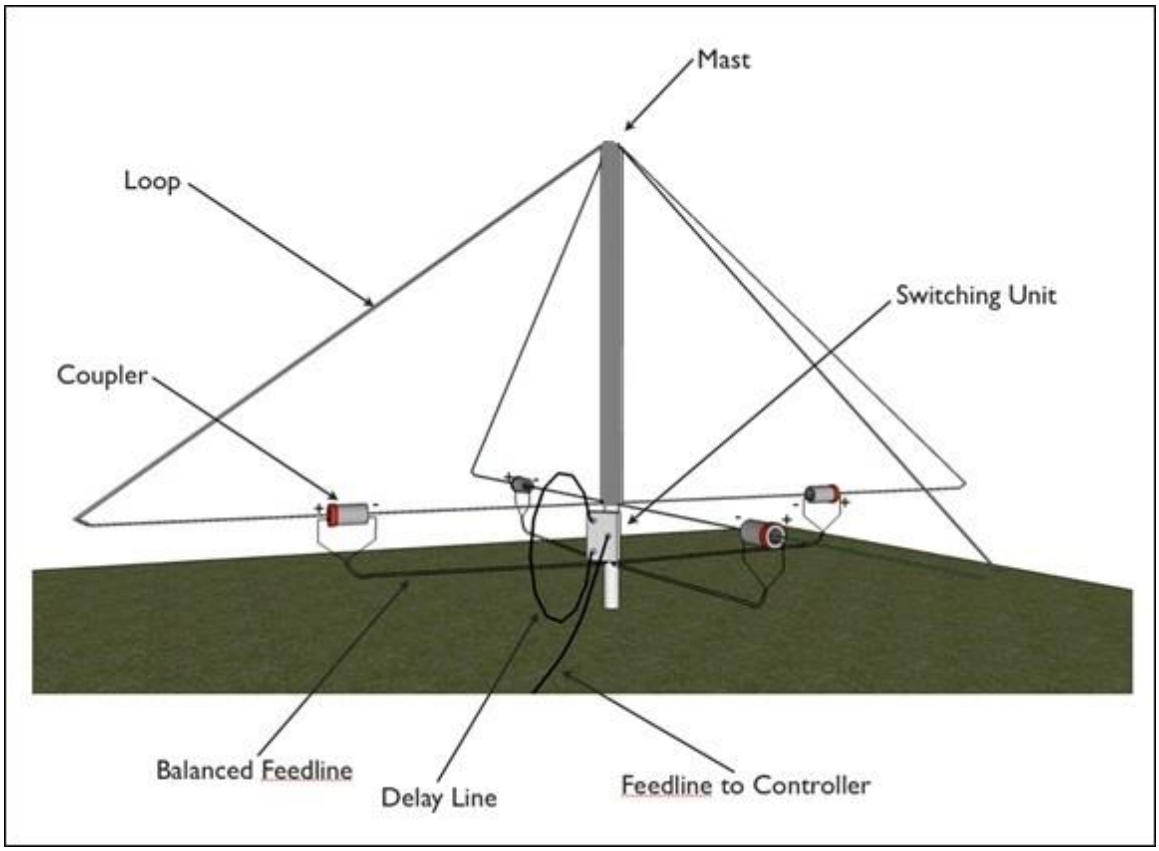
Challenges remained, however before a commercial array could be made available. Designing the amplifier chain was especially difficult because of competing constraints. These included the need for closely matched input impedance over a wide frequency range (to ensure accurate timing), very low noise (because of negative forward gain), good gain (to overcome signal cancelation), and acceptable linearity. Finally, on 2013, though, after a period of extensive testing and improvement, the Shared Apex Loop™ array was ready for production.

Mark's constant experimentation has kept the SAL antenna evolving and this new version that replaces the four vertical wires of the loop running along the non-conductive mast for one common vertical conductor. This allows the use of aluminum tubing in place of the four wires with an aluminum base section insulated from the common conductor. This opens the possibility of building experimental SAL antennas with bigger loops that would favor very low frequencies (VLF) and the benefit of the structural improvement that makes the antenna easy to install even by of one person.

Description

In principle, the array provides directivity by summing signals from one loop with delayed signals from an oppositely phased and positioned loop. Both the delay and loop phasing are largely frequency independent providing a directive pattern over a wide frequency range.

The array consists of four identical right triangle shaped wire loops that its vertical side is common to the four loops in the form of an aluminum mast insulated from the base section. The loops are arranged around the mast so that one loop points towards the northeast, another to the southeast, another to southwest, and another to the northwest.



The direction and directional mode of the array is commanded by a controller that connects directly to your receiver. The controller has buttons for changing the direction, flipping to the opposite direction, and selecting the directional mode. The directional modes include a Single or UNI-directional mode as well as a dual or BI-directional mode. Visual indicators show the currently selected direction and directional mode. A remote interface is included that enables the controller to be commanded by a computer.

A single RG-6 coaxial feed line connects the controller to the array to power and command the array as well as transport the received signals from the array to the controller.

Ferrite couplers are located along the base of each loop at a specific distance from the mast and connected to balanced feed lines that bring the signals to a switching unit

mounted on the mast. Relays in the switching unit route signals from the appropriate combination of loops in response to commands received from the controller. A single delay line also connects to the switching unit to provide the necessary true-time-delay so that signals can be properly combined to achieve the desired directive pattern. The switching unit has a socketed dual stage preamplifier that provides a buffered and matched load for the combiner and boosts the summed signals before they are sent to the controller.

The **AS-SAL-12 Mark II** should provide a directional pattern up to 28 MHz. The **AS-SAL-20 Mark II** should provide a directional pattern up to 14 MHz, and the **AS-SAL-30 Mark II** up to 7 MHz.

The Shared Apex Loop™ design provides the following benefits:

- Competitive Front to Back/Side rejection in eight directions especially on low angle vertically polarized signals and local interference
- Compact footprint that is ideal for small yards
- Easy setup for tactical applications
- Wideband operation without need for adjustment that is great for SDR, Skimmers and military
- Ease of Construction, and quick deployment, DX-peditions, military, seasonal take down is easy
- No RF ground at the antenna required
- Modular design – easy to replace parts
- Field upgradeable - amplifier stage is socketed
- No control cables; control and powered over the RG-6 coax feed line from the controller, very smart and cost effective design.
- The SAL Controller can be interfaced to a PC for remote operation.

SAL-12 Mark II Package Contents

SAL-12 Mark II Antenna Material List	
QTY	**ITEM**
1	Aluminum 16 ft mast kit with eyehooks and hardware
10	2" x 1/4"-20 bolts with safety hex nuts
2	6 ft (1.83 m) 1-1/2" (38.1 mm) OD aluminum tubing
1	4 ft (1.83 m) 1-1/2" (38.1 mm) OD aluminum tubing (double wall)
1	Insert couplings 1-3/8" x 7" (34.9 mm x 182 mm) aluminum tubing
1	Insert coupling 1-3/8" x 4-3/4" (34.9 mm x 121 mm) aluminum tubing
1	Insert coupling 1-1/4" x 7" (31.75 mm x 182 mm) fiberglass insulator
8	Solder eye lugs for 1/4" bolts
4	29' (10.36 m) cables for loops
4	Anchoring Stakes
40	ft of rope to cut as follow*s: 4 x 10 ft (3.05 m) guying ropes
2	Hose clamps 2"
1	PVC Mast base
4	Couplers with 7 ft (2.13 m) 120 ohm TX lines
4	Guy rope tensioners
1	7 ft (2.15 m) RG-6 coaxial cable delay line
1	Control Switch
1	Combiner/Pre-amp
1	Power supply

* Suggested cutting lengths may vary depending on site's topography.

SAL-20 Mark II Package Contents

SAL-20 Mark II Antenna Material List	
QTY	**ITEM**
1	Aluminum 22 ft mast kit with eyehooks and hardware
14	2" x 1/4"-20 bolts with safety hex nuts
3	6 ft (1.83 m) 1-1/2" (38.1 mm) OD aluminum tubing
1	4 ft (1.83 m) 1-1/2" (38.1 mm) OD aluminum tubing (double wall)
2	Insert couplings 1-3/8" x 7" (34.9 mm x 182 mm) aluminum tubing
1	Insert coupling 1-3/8" x 4-3/4" (34.9 mm x 121 mm) aluminum tubing
1	Insert coupling 1-1/4" x 7" (31.75 mm x 182 mm) fiberglass insulator
8	Solder eye lugs for 1/4" bolts
4	44' (10.36 m) cables for loops
4	Anchoring Stakes
40	ft of rope to cut as follows*: 4 x 10 ft (3.05 m) guying ropes.
2	Hose clamps 2"
1	PVC Mast base
4	Couplers with 10 ft (3.05 m) 120 ohm TX lines
4	Guy rope tensioners
1	11 ft (3.35 m) RG-6 coaxial cable delay line
1	Control Switch
1	Combiner/Pre-amp
1	Power supply

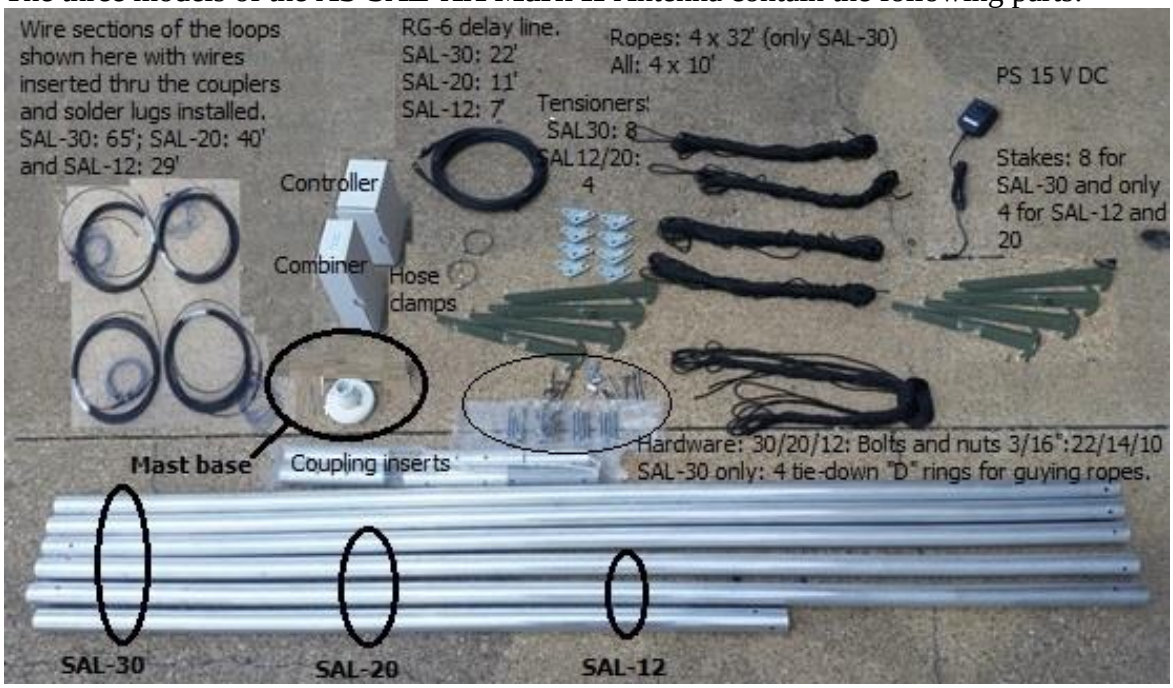
* Suggested cutting lengths may vary depending on site's topography.

SAL-30 Mark II Package Contents

SAL-30 Mark II Antenna Material List	
QTY	**ITEM**
1	Aluminum 30 ft mast kit with eyehooks and hardware
22	2" x 1/4"-20 bolts with safety hex nuts
5	6 ft (1.83 m) 1-1/2" (38.1 mm) OD aluminum tubing
1	4 ft (1.83 m) 1-1/2" (38.1 mm) OD aluminum tubing (double wall)
2	Tie-down "D" rings with plates for 1/4" bolts
4	Insert couplings 1-3/8" x 7" (34.9 mm x 182 mm) aluminum tubing
1	Insert coupling 1-3/8" x 4-3/4" (34.9 mm x 121 mm) aluminum tubing
1	Insert coupling 1-1/4" x 7" (31.75 mm x 182 mm) fiberglass insulator
8	Solder eye lugs for 1/4" bolts
4	65' (19.81 m) cables for loops
8	Anchoring Stakes
180	ft of rope to cut as follows: *
4	10 ft (3.05 m) guying ropes for outer stakes
4	35 ft (10.67 m) guying ropes for inner stakes
2	Hose clamps 2"
1	PVC Mast base
4	Couplers with 17 ft (5.18 m) 120 ohm TX lines
8	Guy rope tensioners
1	21.75 ft (6.55 m) RG-6 delay line
1	Control Switch
1	Combiner/Pre-amp
1	Power supply

* Suggested cutting lengths may vary depending on site's topography.

The three models of the **AS-SAL-XX Mark II** Antenna contain the following parts:



SAL-30 Mark II parts. Quantities for the three models specified on the texts.

INSTALLATION

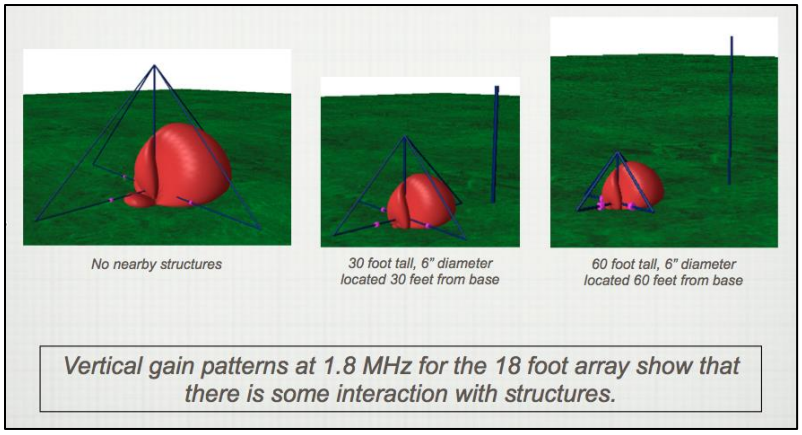
**** WARNING! INSTALLATION OF ANY ANTENNA NEAR POWER LINES IS DANGEROUS : Do not locate the antenna near overhead power lines or other electrical circuits where the antenna could come in contact with these circuits. When installing the antenna, take extreme care not to contact electrical power lines or circuits, because they may cause serious injury or death!**

Site Selection

The Shared Apex Loop™ array works by summing signals from oppositely positioned and phased loops. For proper operation, it is essential that each loop in each loop pair have identical signal response. Factors that can impact the signal response include:

- Size of the Loop
- Shape of the Loop
- Orientation of the Loop
- Distance of the Loop to the Ground
- Distance from the Loop to other metal objects

The ideal location for the array is on flat ground, away from any other objects. From our testing so far, we are finding that the Shared Apex Loop™ array is somewhat tolerant to the presence of both metal and non-metal objects positioned near the loops. However, numeric modeling shows that there are limits to this tolerance.



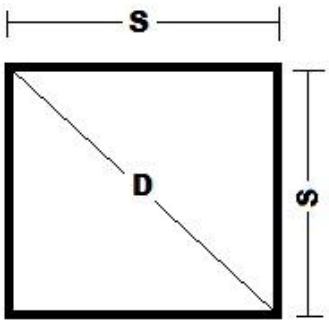
Based on this, here are some things to keep in mind:

- If the ground is uneven, try to mount the base of the loop at least 5 feet above the ground. You will need additional mast pipe to accomplish this.
- Keep antenna away from large metallic structures like towers, and your transmit antennas. We recommend at least 1/4 Wavelength distance at the lowest frequency of use.
- If needed, to avoid damage by people, animals or vehicles you can elevate your installation. Simulations show that optimal height is ¼ W.L. at a given frequency.

As an example of an AS-SAL-12 Mark II that has good directivity from 300 kHz to 28 MHz, it is located with the edge of the array located 50 feet (15.24 m) from a house, 90 feet (27.43 m) from overhead power lines, 30 feet (9.14 m) from ground mounted 36 foot (10.97 m) vertical with ground radials close to the edge of the array, 10 feet (3.05 m) from metal clothesline, and has an 8 foot (2.43 m) tall bush growing near the center.

Required Area

SAL-30 Mark II approximately a clear flat 50 feet (15.24 m) square.
SAL-20 Mark II approximately a clear flat 36 feet (10.97 m) square.
SAL-12 Mark II approximately a clear flat 26 feet (7.92 m) square.
NOTE: If insulated posts are used to anchor the outer corners of the loop, the footprint can be reduced notoriously. See table and drawing below for comparison.



SAL Antennas Footprint with and without outer stakes

Model	With Stakes		With posts under outer corners		Unit
Dimension	S	D	S	D	
SAL-30	46.67	66.00	35.40	50.00	ft
	14.23	*20.12*	*10.79*	*15.24*	*m*
SAL-20	36.10	51.00	24.75	35.00	ft
	11.00	*15.54*	*7.54*	*10.67*	*m*
SAL-12	26.00	37.00	14.85	21.00	ft
	7.92	*11.28*	*4.53*	*6.40*	*m*

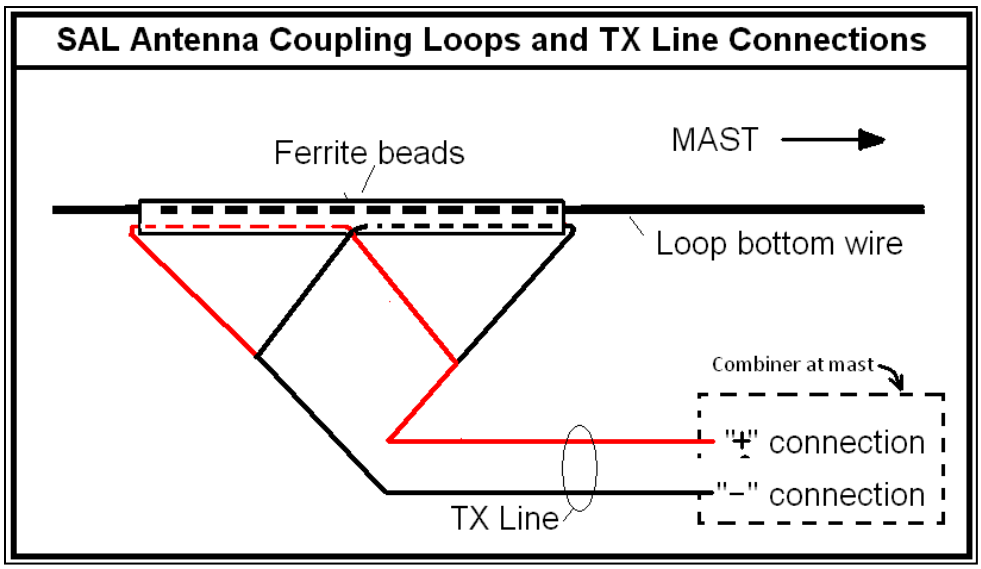
Installing the solder lugs and couplers on the wire sections of the loops.

The solder lugs come in the hardware bag or attached to the 3/16" bolts that come with the mast. Two are needed per loop, one at both ends of the wire section of the loops. First install and solder the lug at the end that is going to be attached at the apex (top) of the antenna. Use rubber tape or other material like shrink tubing to protect the connection of the stainless steel lug with the copper of the #14 wire and the solder applied to it.

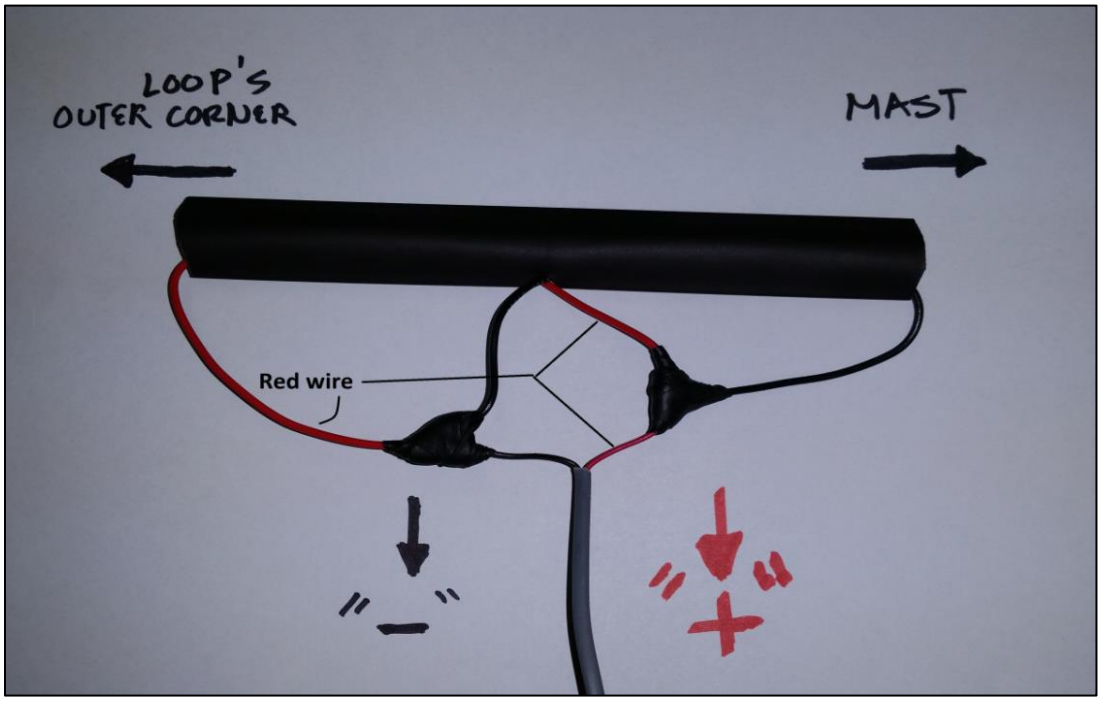
Crimped and soldered lug.

Solder lug and wire connection protected with shrink tubing. Rubber tape can be used as well.

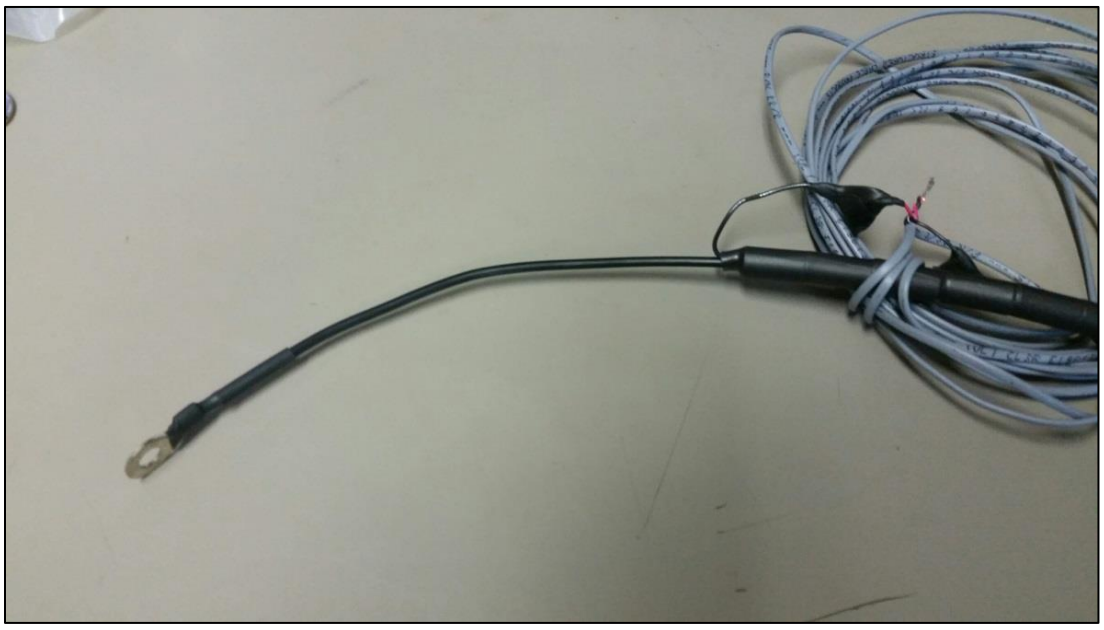
Before proceeding to install the solder lugs at the bottom ends of the wire section is important to pass the wire through the couplers, to install the couplers in the right way is IMPORTANT TO INTRODUCE THE WIRE BY THE END OF THE FERRITES TUBE THAT HAS THE RED WIRE coming out of it. This way, the couplers will be oriented with the red wire towards the outer corner of the loops. Refer to the drawing and the following picture below:



The wires used may be different colors just make the orientation of each set of balanced transmission lines to be the same for each of the 4 loops. The polarity of the loop couplers should be symmetrically oriented on all 4 loops.
NOTE: If this is the black and white printout of the manual sent along with the antenna, please refer to the manual with color pictures and drawings available on our webpage for clarity.



Detail of couplers connections and orientation. For B&W printouts, note the wires marked “red”. The other wires are black. Positive sign, “+” is red.


The end shown is the bottom end of the wire, note the black wire of the coupler coming out of the end of the coupler.

Tips to thread the wire through the couplers:

-Do not attempt to pass the #14 wire through the coupler's ferrites tube after removing the plastic insulation from the wire. The wire is made of seven strands semi-rigid solid coper wire and the strands could peel off the insulation of the #22 wires installed in the coupler, this will cause a short and the coupler won't work as intended.
-Best option is to remove about 1/2 inch (12.7 mm) of insulation and, keeping the strands together, apply solder to it, this will make passing the wire easier than doing it with the insulation covering the copper to the end of the wire.
-Be careful in order to avoid any damage to the inner red and black #22 insulated wires.
-After passing the wire through the coupler the second solder lug can be installed.

Connecting the wire sections to the top of the mast.

Align the holes of the short insert of aluminum tubing that goes at the top of the top section of mast. Insert one 3/16" bolt through the top end lug of one of the wires orienting the lug in a way that its flat side will be against the aluminum tubing.

Pass the bolt through the holes of the tubing and attach the opposite loop wire lug keeping its flat face towards the aluminum. Use one of the hexagonal nuts to secure the connections and keep the wires oriented towards the bottom of the tubing while tightening the nut.

Do the same with the second pair of wire sections, when the four wires are attached to the top section, use one of the two hose clamps provided and install it in such a way that it removes the stress from the solder lugs. The clamp should be over the wires and not on any part of the solder lug. When finished, it should look like in the picture below:

The four top ends of the wires connected to the apex of the antenna, and the hose clamp used to relieve the tension from the connection lugs.

It is recommended that the connections here are protected. It is highly suggested that Noalox® or a similar product should be applied between the lug and the aluminum tubing to protect the connection from galvanic corrosion between the stainless steel and the aluminum. Also cover the connections with rubber tape or any other material to protect them from the weather.

Connections at the bottom

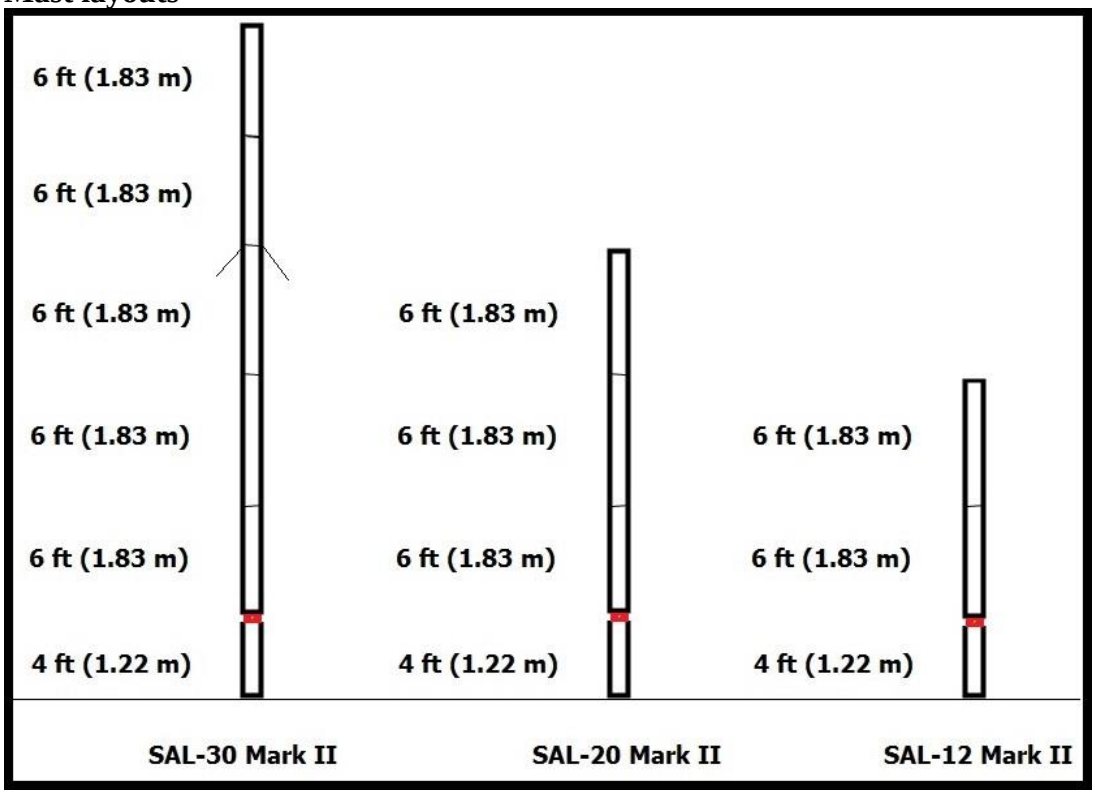
Depending on the antenna model and the number of persons involved on the installation, you may decide to connect the bottom ends of the wire sections before or after assembling and erecting the mast. Proceeding like with the antenna top connections, do the same at the bottom, just above the insulated coupling on top of the 4 feet base mast section. Wires should be, again, oriented downwards while tightening the hex nuts. Refer to the picture to see how it should look when finished. It is highly recommended to protect these connections from the weather elements.

Detail of bottom connections.

Assembling the Mast

It is time to assembly the mast with the corresponding number of aluminum sections depending on your model. Please refer to the drawing below:

Mast layouts



First, install the corresponding inserts on top of each mast section following the pictures below.

There is a base section 4 ft (1.22 m) long, install the fiberglass insert on top of it and use two of the 3/16" x 2" bolts and corresponding hexagonal safety nuts to secure it.

The first section above the base is 6 ft (1.83 m) long and has a riveted insert at the bottom to match the wall thickness of the base section in order to accommodate the fiberglass insert that connects them.

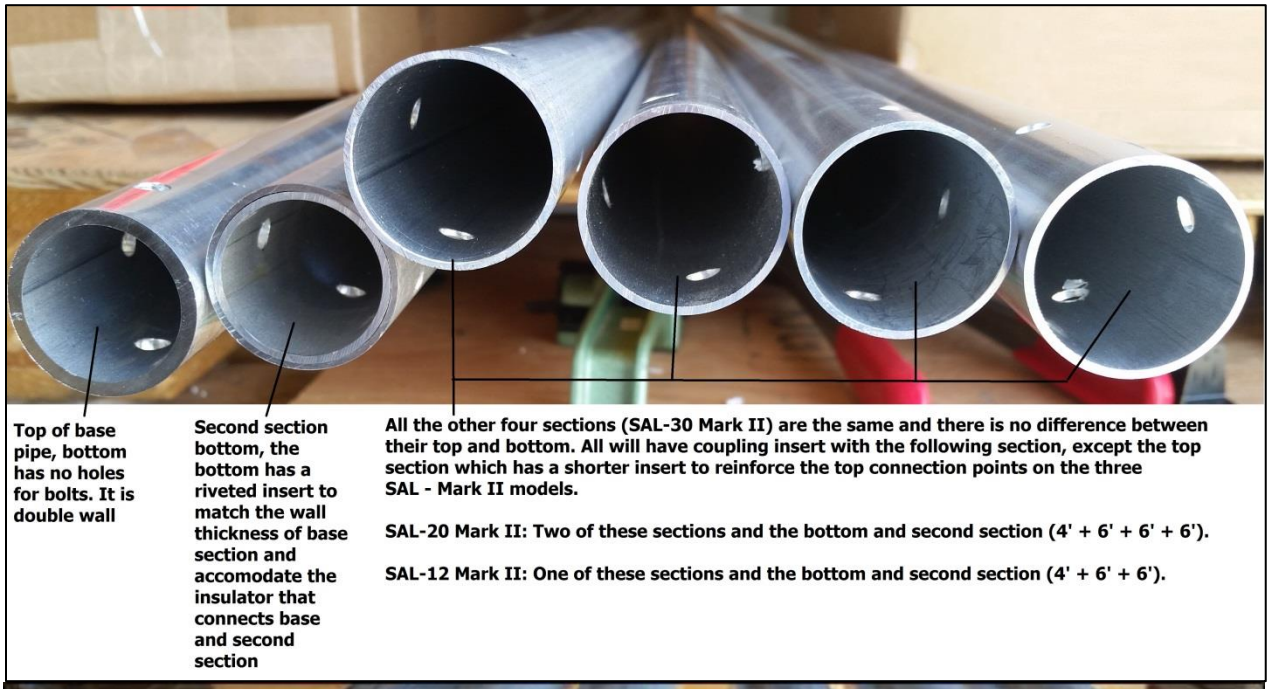
The rest of sections use the 6" aluminum inserts except for the top section which uses the shorter aluminum insert and most be installed flush with the end of the top section.

After the first section above the base mast section the different models have the following number of 6 ft (1.83 m) sections:

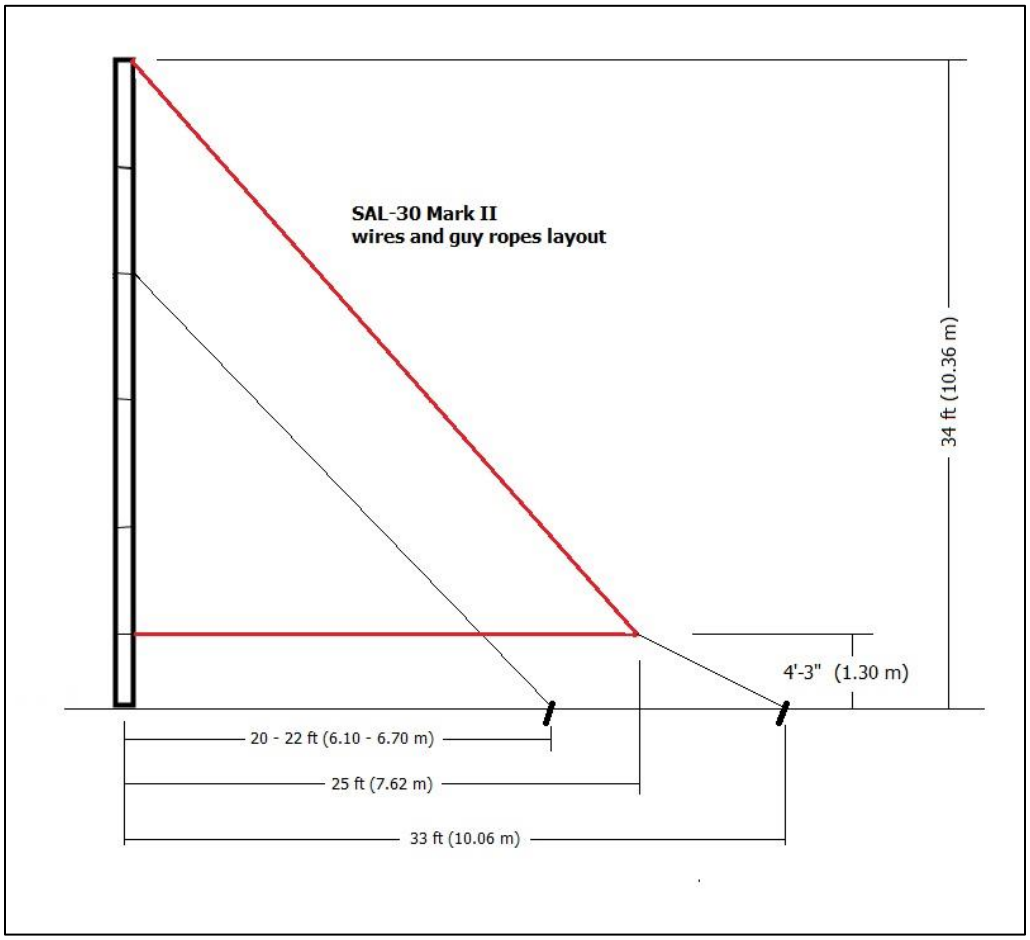
SAL-12 Mark II: One section (the top one with the shorter insert)
SAL-20 Mark II: Two sections (Including the top section with the shorter insert).
SAL-30 Mark II: Four sections (Including the top section with the shorter insert).

For a graphic reference, please see the different "Mast Layouts" above.

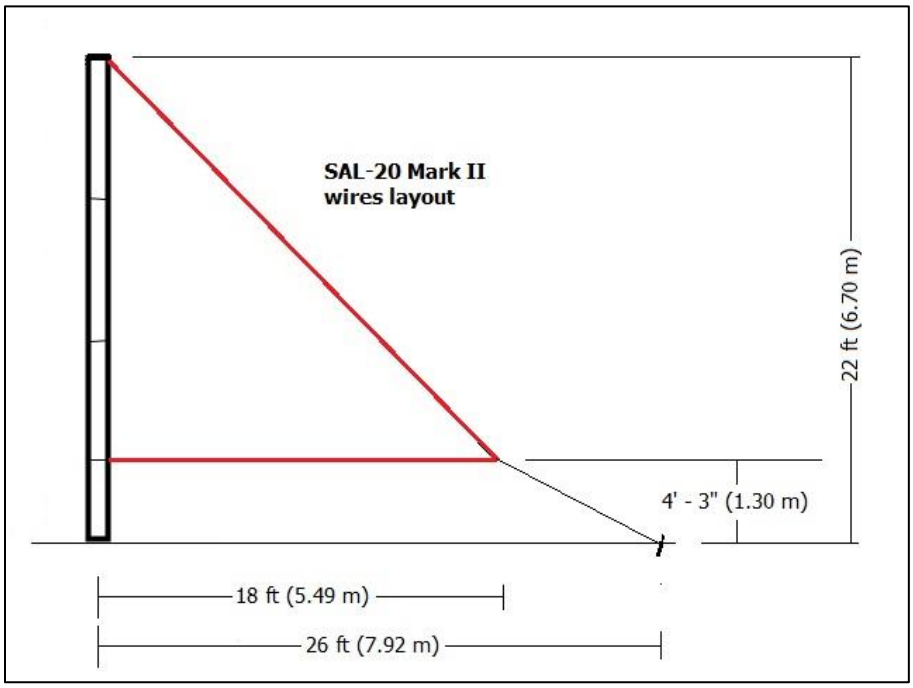
Coupling inserts. Leftmost is the fiberglass insulator for the top of the base mast section. Short one is 4-3/4" (120 mm) for the top section. The rest are 7-1/8" (182 mm) long.



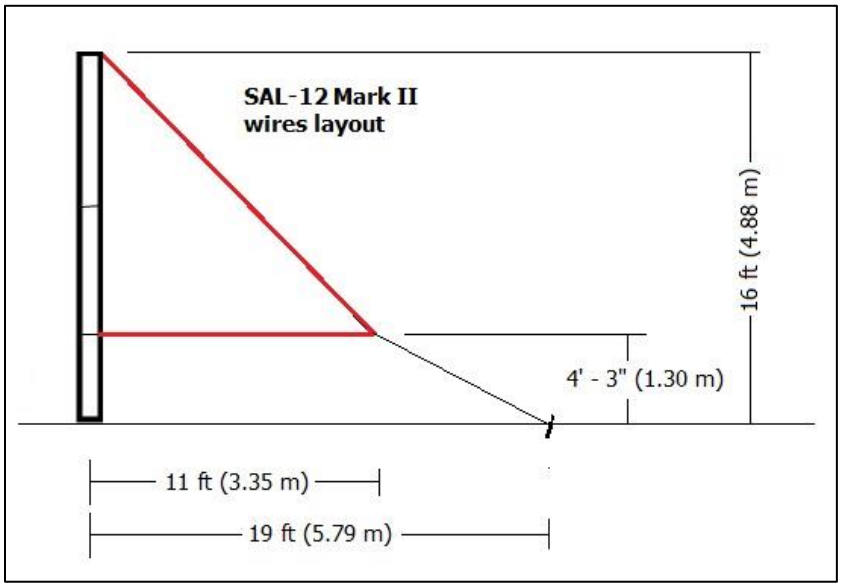
Mast sections with its coupling inserts attached at their tops. Note the two tie down "D" rings for guy ropes at the top of the fourth section (SAL-30 Mark II only) and the shortest insert to reinforce the tubing at the connection point at the antenna apex, it is flush with the top section's end.



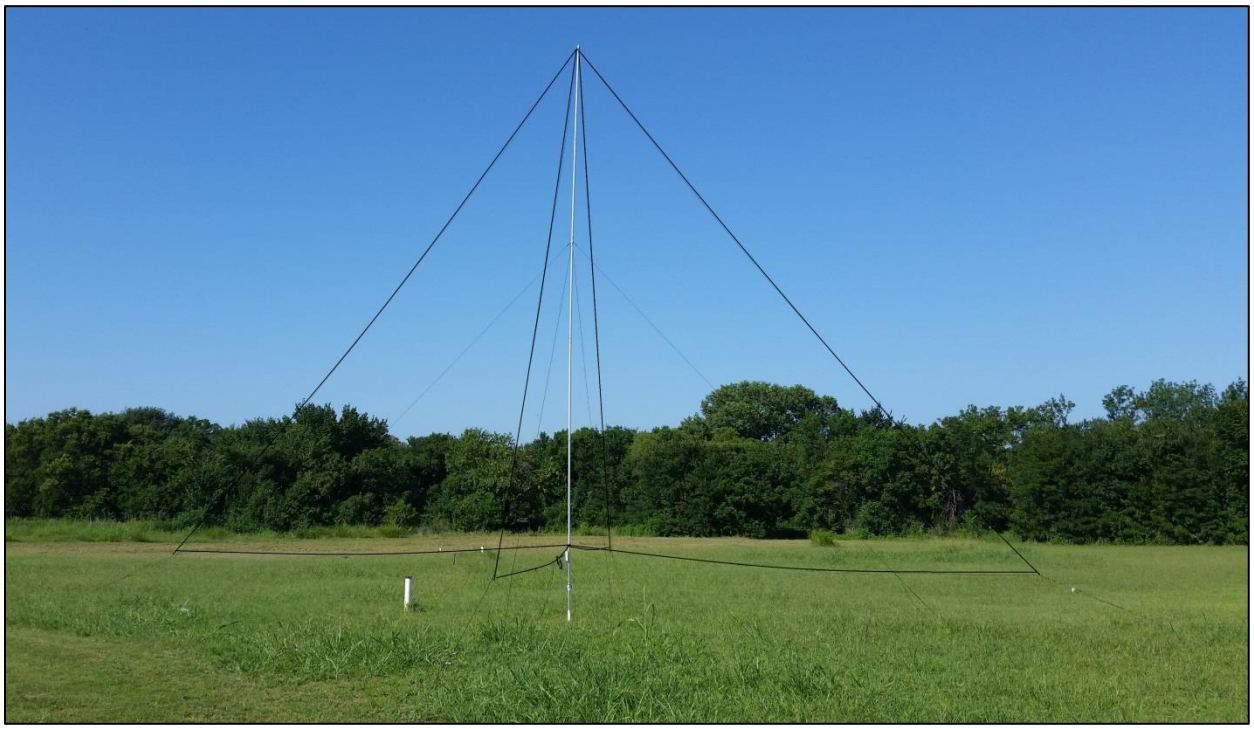
SAL-30 Mark II wire loop section and guy ropes layout. Wires are in red.



SAL-20 Mark II wire loop section layout.



SAL-12 Mark II wire loop section layout.



View of the SAL-30 Mark-II antenna. The loops' wires have been edited thicker for clarity. The thin lines are the guying ropes.

**** WARNING! INSTALLATION OF ANY ANTENNA NEAR POWER LINES IS DANGEROUS! ****

Installation Instructions

- **Site Preparation**
  - Prepare the location that the mast will mount. This may include installing a sleeve in the ground to receive the mast, preparing a hole, or pouring a concrete, etc. Do not yet raise the mast as you will need access to the top of the mast.
  - Select the location for the mast. Then, measure (33 feet for the SAL-30, 25.5 feet for the SAL-20 and 18.5 feet for the SAL-12) in a northeast direction and drive a loop stakes into the ground. Repeat this for the southeast, southwest, and northwest directions, stakes. Verify that each stake is in line with the center and its opposite stake. Please see Appendixes 2a and 2b, suggestions on how to establish perpendicular lines on the field

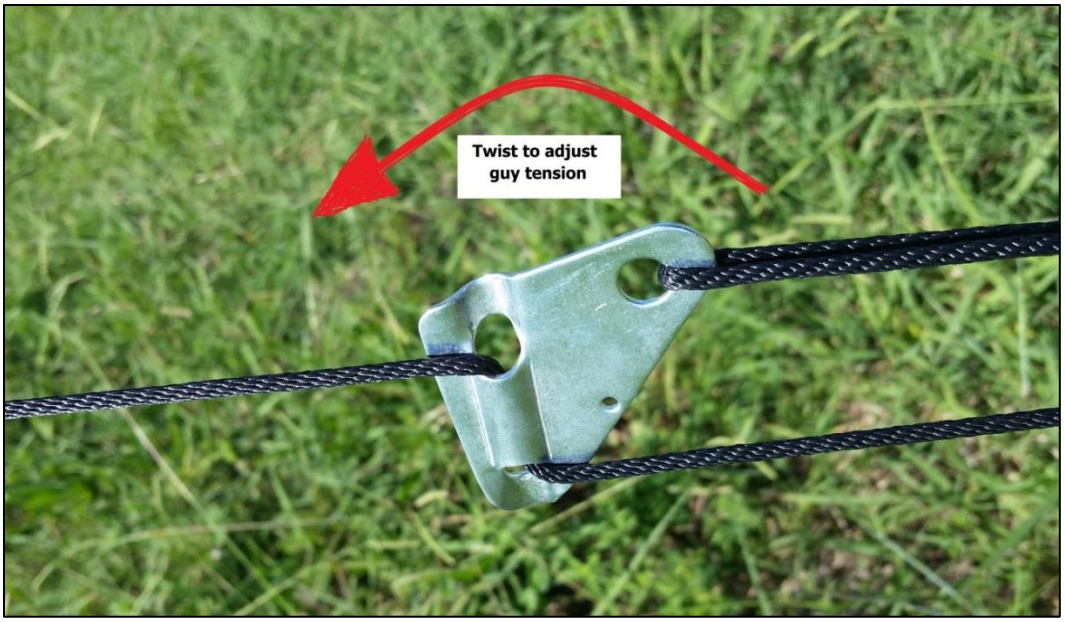
    Note: These measurements are for ground mounted installations. For raised installations, the stake distance will need to be adjusted to properly tension the loops.

- **Loop installation**
  - The loops should have a right angle triangle shape to it when finished. The lower horizontal will have to have the loop couplers slid onto it. The **polarity should be the same on all the couplers. All must be oriented so that the red wire or "+", or positive, that enters into the ferrites tube by one of its ends faces away from the mast on all of the couplers. This red wire should be connected to the corresponding "+" terminal in the combiner box. The black wire is the "-" or negative, is the one entering by the end of the ferrite tube that should be closest to the mast and connected to the corresponding "-" terminal.** *(Please refer to either the drawing or the picture on page 10)***.** Make sure that the loop is not tangled with any of the other loop wires. Next, repeat these steps for the remaining three loops.
  - Next, prepare the four tether ropes, each being about 10 feet long. Form a loose fitting knot around each of the four loops near the outer corner of each loop. A bowline knot works well. Also string on a rope tension device on each rope as shown in the picture.

The tensioner pictures below show how the triangular tensioners work by rotating it enough to make the long branch of the rope straight (in this picture it would be counter clock wise) and then moving the tensioner up or down the rope if more tension or less tension is needed correspondingly.

Outer corner of loop, once you have the horizontal dimension set, put tape tightly or use tie-wraps to avoid the rope from slipping and changing the dimension of the horizontal side of each loop.

Triangle Tensioner: The one shown in the picture, when rotated counter clock wise will straighten the long branch of rope allowing the adjusting of the guy rope tension.



Mast installation

- Next, raise the mast with the attached wires sections of the loops, gathering appropriate help if needed to hold the mast in place while the loops are being anchored to the stakes which you drive into the ground with a hammer **(In the case of the SAL-30 Mark II secure first the guy ropes and the inner set of stakes, the four ropes are tied to the two tie-down D rings at the top of the 4th section)**. Loop the tensioner bail over the stake and adjust tension on the tether rope. Tie off any excess rope around stake so the tensioner will not accidentally slip off in high winds.
- Then, adjust the mast and the tethers so that the mast is vertical and that the loops have the same size and shape.
- **The Horizontal part of each loop must be leveled and not sloping away or towards the flat ground.**
- Measure and adjust the distance from the mast to the tether point so that this distance is the same for all of the loops. Also, adjust the tension on the tethers on each loop to minimize sag.
- Verify again that the mast is vertical. Repeat previous step until all loops are the same size and shape, **and horizontal sections of loops are horizontal.**
- If the ground where the antenna is not flat and even, and there is the need to elevate the outer corners, make the slope and length of the lower wire equal for all four loops. The couplers may need to be positioned closer to the mast, therefore start at the recommended distance for the horizontal case and try to optimize the F/B of the antenna moving the couplers towards the mast.
- The horizontal length, mostly on the largest model, the SAL-30, **is about 25 ft (7.62 m), not an exact dimension that depends on the wire sag and tension applied to it. Just pull the wire and adjust the length while keeping it**

horizontal until a reasonable tension is applied to the diagonal wire going to the top of the mast. *This applies to the smaller models as well.*

- *Failure to make the loops closely the same size and shape will result in less than optimal results, especially below 4 MHz!*

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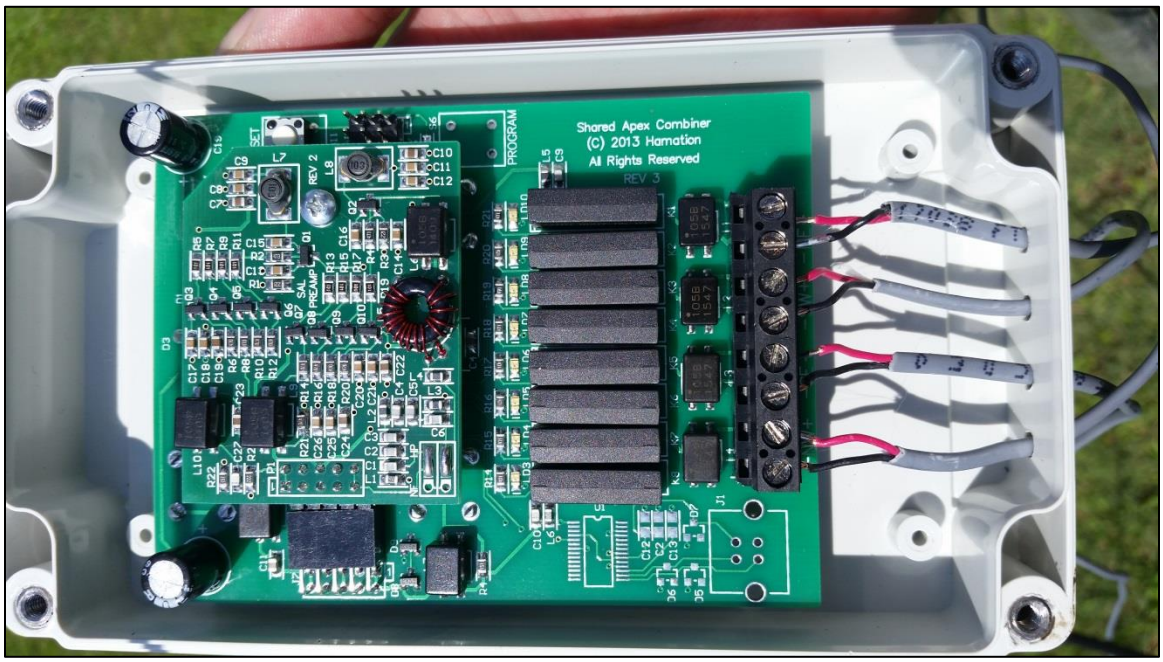
- **Switching unit (combiner) installation**
  - Remove the cover of the switching unit so that the loop terminals are exposed. See picture on next page.
  - Route the northeast loop balanced line through one of the holes in the bottom of the switching unit. Connect the red (+) wire to the NE+ terminal and the black (-) wire to the NE- terminal.
  - Route the southwest loop balanced line through one of the holes in the bottom of the switching unit. Connect the red (+) wire to the SW+ terminal and the black (-) wire to the SW- terminal.
  - Route the southeast loop balanced line through one of the holes in the bottom of the switching unit. Connect the red (+) wire to the SE+ terminal and the black (-) wire to the SE- terminal.
  - Route the northwest loop balanced line through the remaining hole in the bottom of the switching unit. Connect the red (+) wire to the NW+ terminal and the black (-) wire to the NW- terminal.
  - Verify that the balanced lines are connected to the appropriate terminals. You should see a repeating pattern of wire colors (i.e. red-black - red-black - red-black - red-black).
  - *Note: The array will NOT be directive if the balanced lines are not connected in the proper order!*
  - Reinstall the cover onto the switching unit.
  - Mount the switching unit to the mast with a couple of tie wraps, the bottom guy bracket makes a nice place for the top tie-wrap. See picture.
  - Connect the ends of the RG-6 delay line to the two **side by side at the same level** F- female connectors on the front of the switching unit (see picture below).
  - Connect the RG-6 feed line to the controller to the F-female top connector on the front of the switching unit. It is the connector on upper part of the box.
  - Is recommended the use of coax tape on the RG-6 connectors to protect them from the weather.

WARNING!

Do not insert any device in the RG-6 or the transmission line between the Combiner and the Controller of the SAL antenna. Most devices are a short circuit for DC and the command pulses and 15 V DC are sent to the combiner using the transmission. This can damage the device, the Combiner and Controller of the SAL antenna.

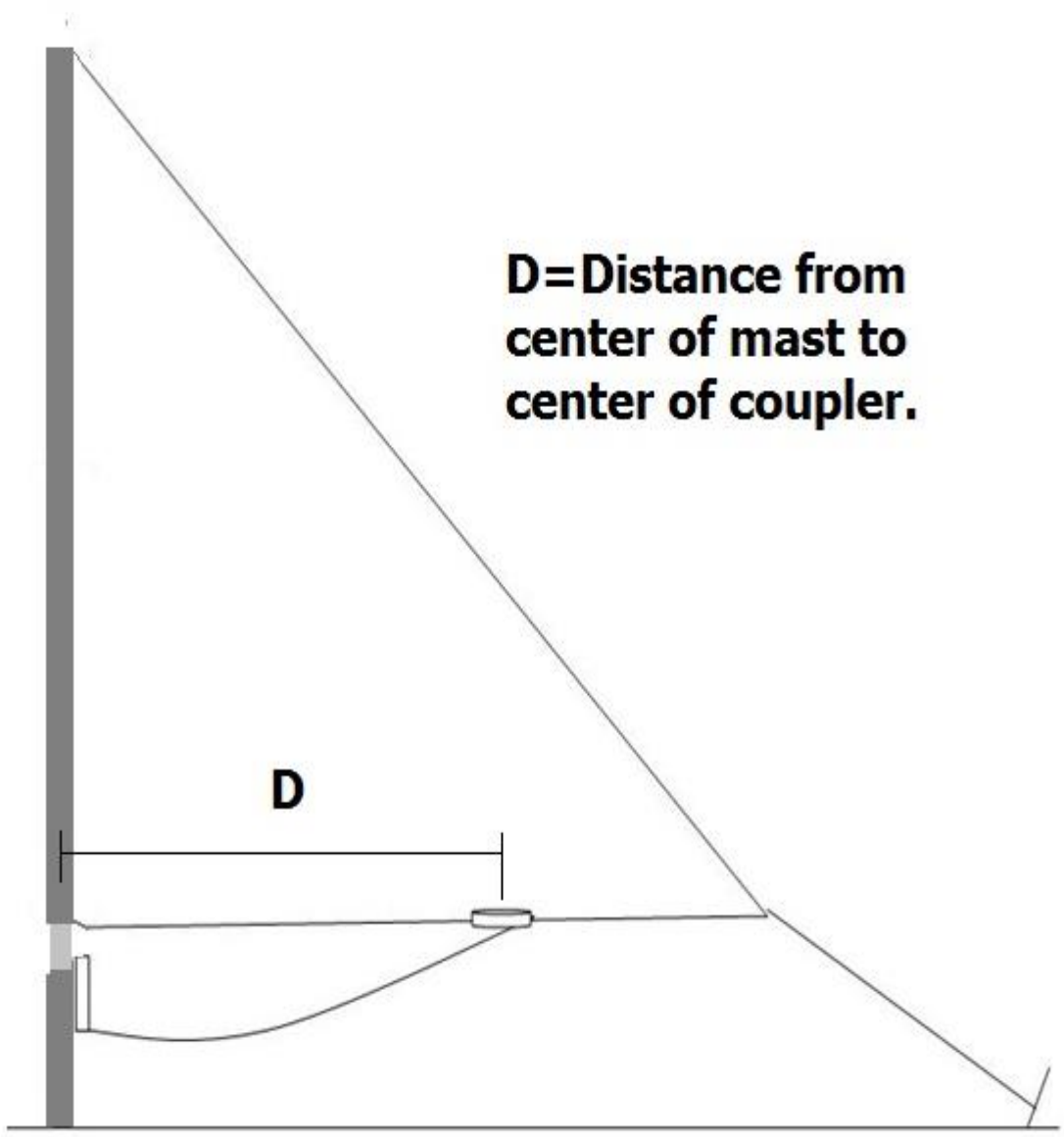
Close up views of combiner and connections. The PVC four way 1-1/4" coupling (not supplied) is a suggestion of what could be used to keep the couplers transmission lines away from themselves, the RG-6 cables and from the metallic mast. You can use wooden stakes or PVC pipes driven in the ground or any other non-conductive material structure to find your own solution for the TX lines routing.



Transmission lines connections into the combiner terminals.

Coupler Positioning

- **For each loop, position each coupler per the diagram and table below.**
- Allow the balanced line from the coupler to freely drape from the coupler to the controller being careful that it does not touch the ground or wrap around the loop. Keep the line well away from the ground. You can use string or tie-wraps to suspend it up in the middle to the horizontal loop wire.
- *Note: The delay line length and coupler position largely set the directional pattern.* ***But you can adjust the null angle off the back by moving the couplers on the loop. One trick is to use a small RF source like an antenna analyzer perhaps located 500 feet away or even up your tower at an angle of say 15 degrees to the SAL Array. Then adjust the SAL for maximum F/B ratio by moving the couplers positions six inches at the time. When further optimization is needed move couplers in three inches steps. Each coupler must be moved the same amount towards or away from the mast. See the Optimization section of this manual. A reliable signal source like a broadcast station which its position relative to the SAL antenna is known can be used to optimize the front to back of the antenna. Keep in mind that at times near dusk and down the propagation will change and incoming wave angles will do as well and the front to back can vary a great amount while this propagation conditions are changing.***



	SAL-30	SAL-20	SAL-12
Length of Vertical wire section	356" (904 cm)	222" (564cm)	136.5" (347cm)
Hor. section Length	300" (762 cm)	210" (534 cm)	126" (320 cm)
Total loop Length	1122" (2849 cm)	744" (1890cm)	456" (1158 cm)
Coupler Distance (From vertical wire of loop to center of coupler)	153" (388 cm)	86" (218cm)	60" (152cm)

NOTE: If you apply the Pythagoras formula to the triangles' dimensions shown above, keep in mind that the formula will work with straight lines drawn on a paper which does not include the wire sag and the lack of perfect straightness. What is important is that the loops have the same perimeter and are installed as symmetrically as possible within reasonable practical limits, regardless of their lengths as long as they are equal.

Connecting the Controller

- Connect the RG-6 cable from the array to the back of the controller.
- Connect the receiver to the RCA connector at the back of the controller.
- Connect the power, it is a 2.1 mm DC coaxial jack connector. Array Solutions has included a 1 A – 12 to 15 V DC RF-quiet power supply.
- The NETWORK plugs are to daisy chain in and out the ShackLan ™ buss. This will allow controlling the array from a PC for remote operation. The Control Center software is a free application from Array Solutions.
- *Note: A good RF ground at the receiver is helpful to for optimum reception. You may also connect the chassis of the receiver to either the shield of the RCA connector or the RG-6 cable if this results in lower noise operation.*
- *NOTE: ENSURE THAT THE CONTROLLER IS ONLY CONNECTED TO A RECEIVER AND THAT NO TRANSMITTED RF CAN ENTER THROUGH THE RCA CONNECTOR. FAILURE TO DO THIS WILL RESULT TO DAMAGE OF THE CONTROLLER AND SWITCHING UNIT.*
- *NOTE: IT IS THE RESPONSIBILITY OF THE USER TO ENSURE PROPER LIGHTNING PROTECTION TO ENSURE THAT LIGHTNING INDUCED CURRENTS DO NOT DAMAGE PROPERTY.*

- **WARNING!**

  Do not insert any device in the RG-6 or the transmission line between the Combiner and the Controller of the SAL antenna. Most devices are a short circuit for DC and the command pulses and 15 V DC are sent to the combiner using the transmission. This can damage the device and the Combiner and Controller of the SAL antenna.

Initial Checkout

- *Note: The controller has been designed to provide loop diagnostic capabilities to assist in initial checkout as well as troubleshooting.*
- Ensure that the controller is connected to a receiver and that it is connected to the supplied power source. Enable the noise blanker on the receiver (if available).
- Turn on the controller by pressing the PWR button. The LED's should all light and a line should rotate through the directions.
- Run the Loop Strength Test and the Loop Polarity and Array Delay Test outlined below.

The Loop Strength Test

The purpose of this test is to determine how well each pair of loops are matched. In the BI-directional mode, you are listening to only one loop at a time. This provides a convenient way to listen individually to each loop.

1. Press the BI button to select the BI-directional mode.
2. Press the direction change arrow so that the LED's point to both the northeast and southwest direction.
3. Tune to an AM Broadcast station coming from either a northeast or southwest direction that has a steady signal.
4. Observe the signal strength from the station. Then press FLIP button while observing the signal strength. Then, press the FLIP button again. **The signal from the station should be EXACTLY the same**
5. Next, press the direction change arrow so that the LED's point to the northwest and southeast direction.
6. Tune to an AM Broadcast station coming from either a northwest or southeast direction that has a steady signal.
7. Observe the signal strength from the station. Then press and hold the FLIP button while observing the signal strength. Then, release the FLIP button. **The signal from the station should be EXACTLY the same.**

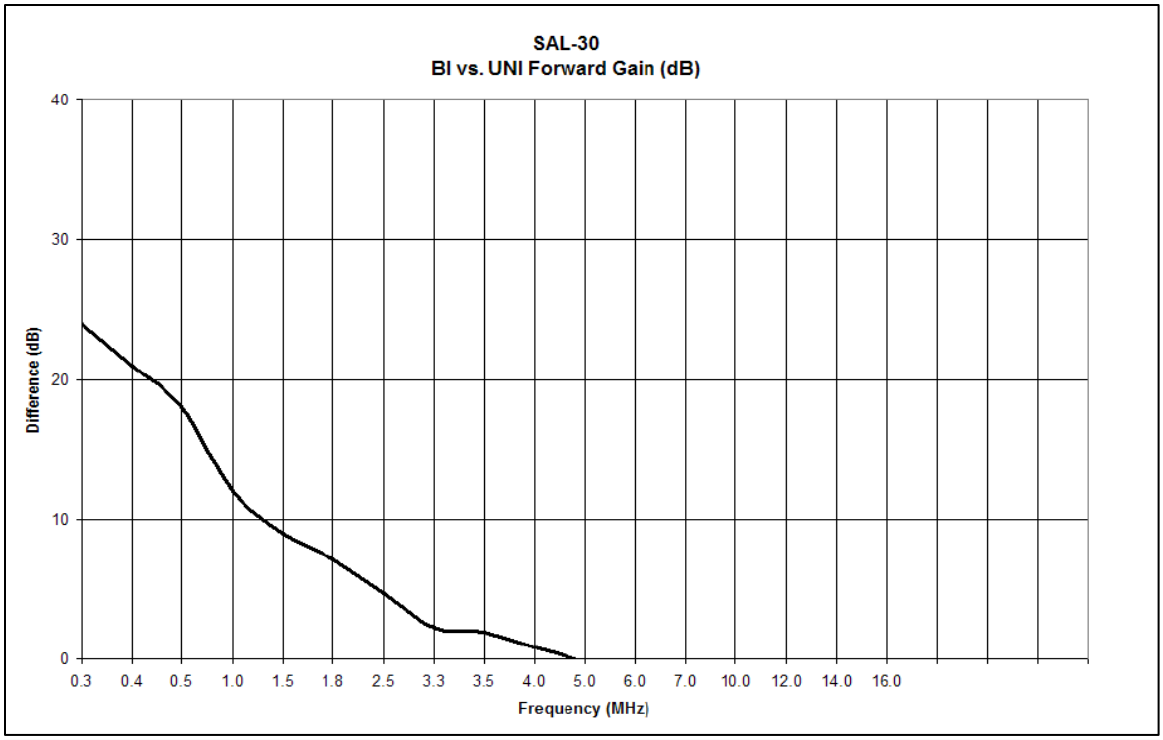
- *NOTE: If the signal strength levels are not the same, then the loops are not matched and directivity will be disappointing, especially on frequencies below 4 MHz!*

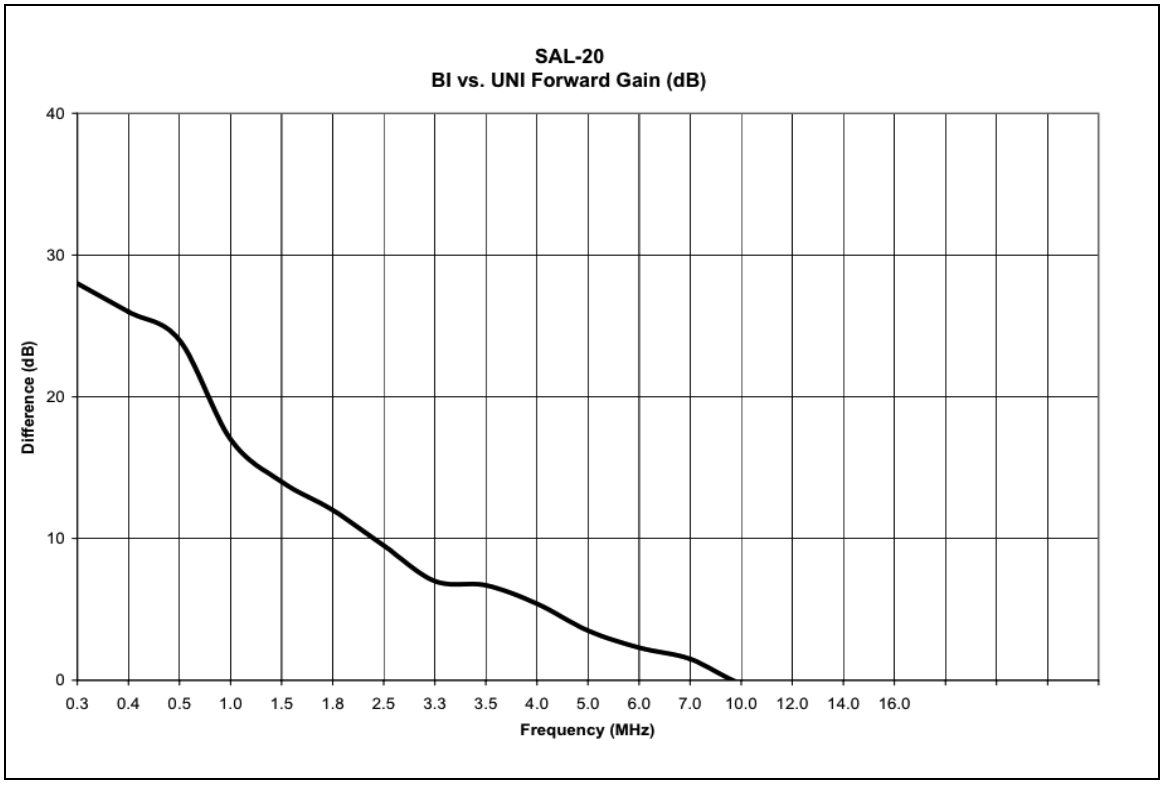
The Loop Polarity and Array Delay Test

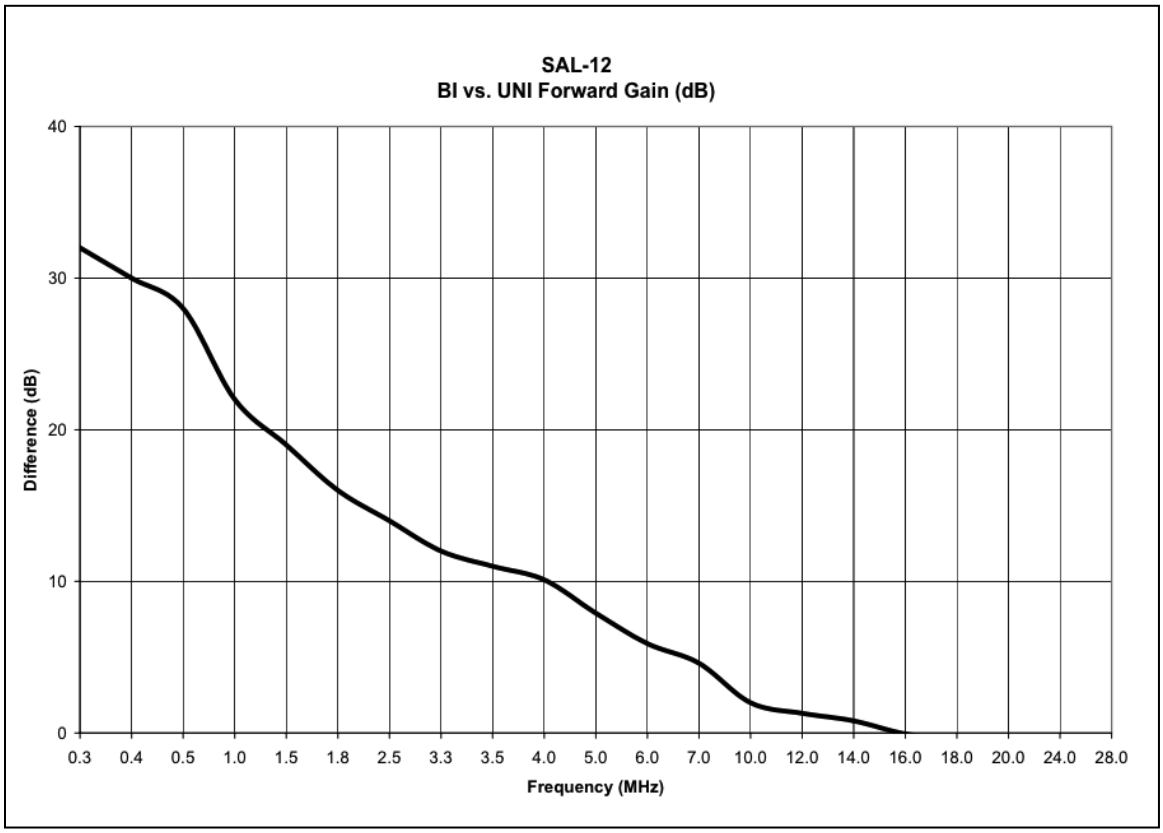
The purpose of this test is to measure the difference between signals in both the UNI-directional and BI-directional modes and compare the results to the expected results based on experience and modeling using the factory provided dimensions.

1. Press the UNI button to select the UNI directional mode.
2. Press the direction change arrow so that the LED's point to the northeast direction.
3. Tune to an AM Broadcast station coming from a northeast direction.
4. Observe the signal strength from the station.
5. Now, press the BI button to select the BI directional mode and observe the signal strength.
6. The signal in the BI mode should be much STRONGER than the UNI mode. Refer to the graphs below for your array to see what this difference should be. Note that the difference is based on the frequency For example, at 1000 KHz, the difference for the AS-SAL-20 should be 16dB and for the AS-SAL-12 should be 22dB.
7. Press the direction change arrow so that the LED's point to the northwest direction.
8. Tune to an AM Broadcast station coming from a northwest direction.
9. Observe the signal strength from the station.
10. Now, press the BI button to select the BI directional mode and observe the signal strength.
11. Refer to the graphs below for your array to see what this difference should be. Note that the difference is based on the frequency For example, at 1000 KHz, the difference for the AS-SAL-30 should be 12 dB, for the AS-SAL-20 should be 16 dB and for the AS-SAL-12 should be 22 dB.

- *Note: If you don't see a difference in the signal strength, then either the balanced feed line polarity is incorrect for the respective loop, there is a problem with the delay line connection, or the couplers are not located at the correct distance from the mast.*


SAL-30
BI vs. UNI Forward Gain (dB)
Difference (dB)
40
30
20
10
0
0.3
0.4
0.5
1.0
1.5
1.8
2.5
3.3
3.5
4.0
5.0
6.0
7.0
10.0
12.0
14.0
16.0
Frequency (MHz)


SAL-20
BI vs. UNI Forward Gain (dB)
Difference (dB)
40
30
20
10
0
0.3
0.4
0.5
1.0
1.5
1.8
2.5
3.3
3.5
4.0
5.0
6.0
7.0
10.0
12.0
14.0
16.0
Frequency (MHz)


SAL-12
BI vs. UNI Forward Gain (dB)
Difference (dB)
40
30
20
10
0
0.3
0.4
0.5
1.0
1.5
1.8
2.5
3.3
3.5
4.0
5.0
6.0
7.0
10.0
12.0
14.0
16.0
18.0
20.0
24.0
28.0
Frequency (MHz)

Optimizing the F/B

To maximize the F/B start the following procedure. Set up a transceiver on a test table 40-50 feet away from the loop and bring the feedline to the radio.

1. Start with the couplers in the suggested positions and listen to an AM or MW broadcast signal which is steady and off one of the diagonal directions. Note the F/B by using the "Flip" button to reverse the pattern.
2. Move all the couplers 6 inches closer to the mast, you may see the F/B increase or decrease. Note the F/B again,
3. Now move the couplers in the opposite direction away from the mast by 12 inches. Note the F/B. If it is worse than the other two positions put the couplers back towards the mast by 12 inches. And move the couplers 3 inches in towards the mast. Repeat until you find the maximum F/B.
4. Secure the couplers in this position.
5. It has been found that the lower frequencies are the most critical. Higher frequencies will have good F/B once you find the low frequency best F/B spot.

- NOTE: *A reliable signal source like a broadcast station which its position relative to the SAL antenna is well known can be used to optimize the front to back of the SAL antenna. Keep in mind that at times near dusk and down the propagation will change and incoming wave angles will do as well and the front to back can vary a great amount while this propagation conditions are changing.*

OPERATION

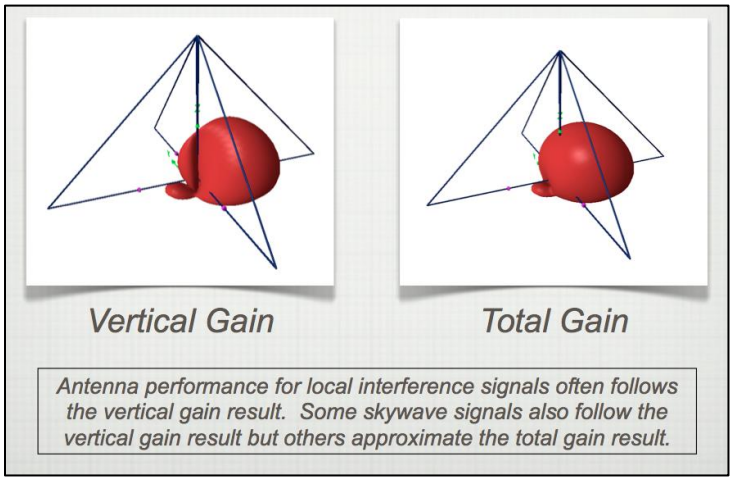
There are several buttons that you will easily use in operating your array.

1. Yellow counter clockwise and clockwise buttons will electrically steer the array, the LEDs will show the direction you are listening. Eight directions are possible.
2. FLIP white button will flip the direction 180 degrees to allow easy F/B measurements.
3. FLIP Automatic – Holding the FLIP button for 2 seconds will cause the array to flip back and forth 180 degrees every 2 seconds. Very handy for F/B measurements over time.
4. UNIDIRECTIONAL sets the array in single direction mode.
5. BI-DIRECT button places the array in Bidirectional mode. Handy for listening in opposite directions. Signals will be much stronger in this mode at lower frequencies, so it is also useful for weak signal work at low frequencies.
6. Power – power on/ power off. When off the center LED is always lit. Minimal current is being drawn (approximately 10 mA).

Important note:
When you first install your Shared Apex Loop™ system, we recommend that you spend plenty of time listening to gain an understanding about how the antenna works. Good sources of test signals are WWV at 2.5 (at night), 5 and 10 MHz of course, ham radio signals in the 40, 80 and 160 meter bands. AM radio stations in the broadcast band are also good, but remember that local stations may not show as much front-to-back as distant stations. In the AM broadcast band you should be able to detect two and

sometimes three or more signals on the same frequency just by changing directions. Do your testing at night when the low bands are open to see the greatest performance.

Also, vertically polarized signals will exhibit both good front-to-back as well as front-to-side ratios. Often local interference sources are vertically polarized and can be attenuated by pointing the antenna away from the source.



Ionospheric conditions can impact the apparent directivity when listening to sky wave signals. Expect degraded directivity (less front-to-back and front-to-side ratio) during active and stormy geomagnetic field conditions.

If conducted shack noise is a problem, try running a short wire from your receiver to **either** the shield of the RCA cable at the controller, the RG-6 cable connector, or the (-) side of the DC power connector.

Enjoy your Array Solutions Shared Apex Loop™ System.

Specifications:

Antenna type:	Four right angle triangular loops sharing a common vertical side that doubles as part of the mast.
UNI-directional Pattern:	Slightly sharper than a cardioid pattern for horizontally polarized signals and much sharper than a cardioid pattern for vertically polarized signals. Electronically steerable on eight directions.
Peak front-to-back:	Greater than 30 dB (35-40 dB for SAL-30 Mark II
RX antenna impedance:	50 ohms nominal (At the controller's RCA output to the radio)
Delay Line impedance:	75 ohms
*Frequency range**:***	AS-SAL-12: 500 kHz to 28 MHz AS-SAL-20: 300 kHz to 14 MHz AS-SAL-30: 100 kHz to 7 MHz Note that the antennas do work below and above these frequency ranges to some extent with less gain or a different pattern.
Number of Directions:	Eight directions
Direction control:	Through feed line coax, no control lines
RF connection (antenna):	Type-F (RG-6) connectors at control box and outdoor relay box.
RF connection (radio):	RCA connector output to receiver external antenna input
Power requirements:	+12 - 15 V DC, 1000 mA linear regulated RF-quiet power supply provided, 2.10 mm coaxial jack
Switching Unit Preamp:	Socketed Dual Stage Preamplifier
Size:	AS-SAL-30: 33 ft (10.06 m) tall, 33 ft (10.06 m) radius AS-SAL-20: 22 ft (6.71 m) tall, 25.5 ft (7.77 m) radius AS-SAL-12: 14 ft (4.27 m) tall, 20 ft (6.10 m) radius

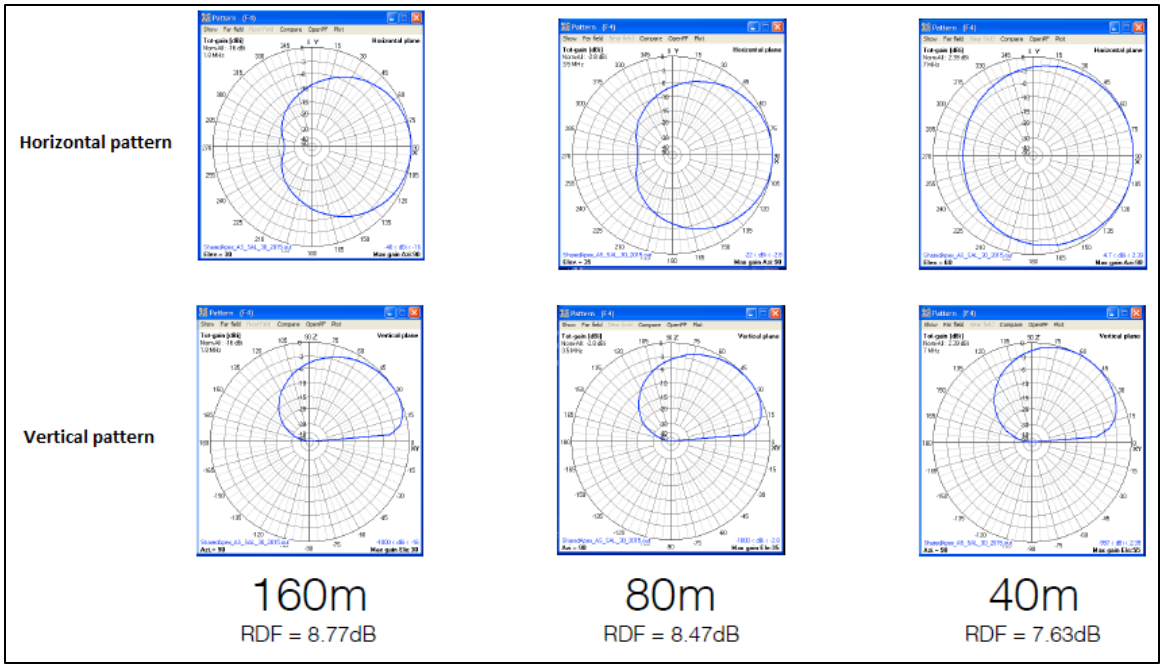
NOTE: If the outer stakes are not used and non-conductive posts are used to anchor the loops' outer corners, the footprint of the antenna can be reduced as follows:

AS-SAL-30: A square of 35.4 feet (10.79 m) on a side

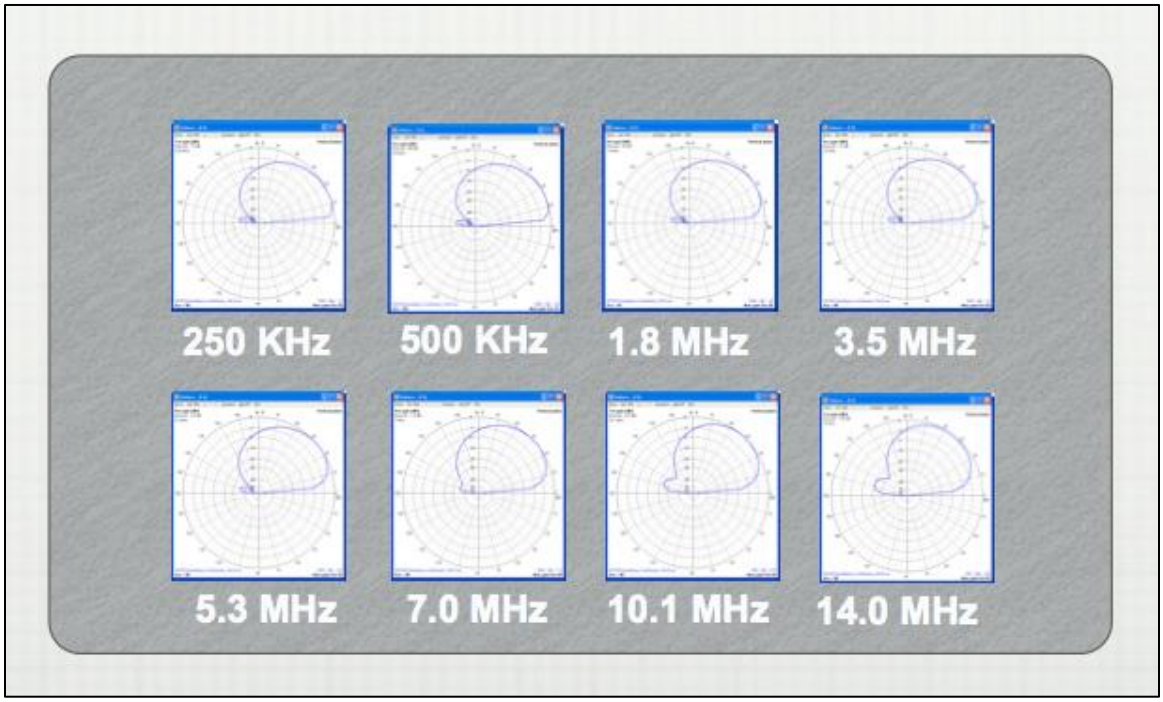
AS-SAL-20: A square of 24.75 feet (7.54 m) on a side

AS-SAL-12: A square of 14.85 feet (4.53 m) on a side

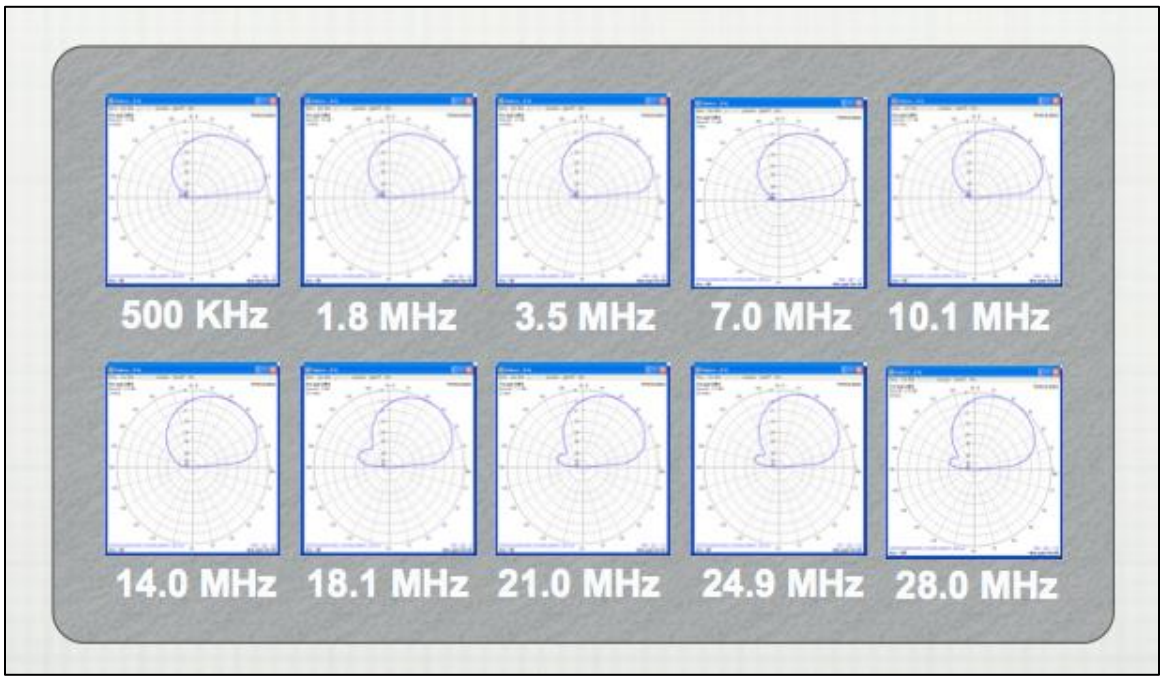
AS-SAL-30 Example Elevation Response Patterns



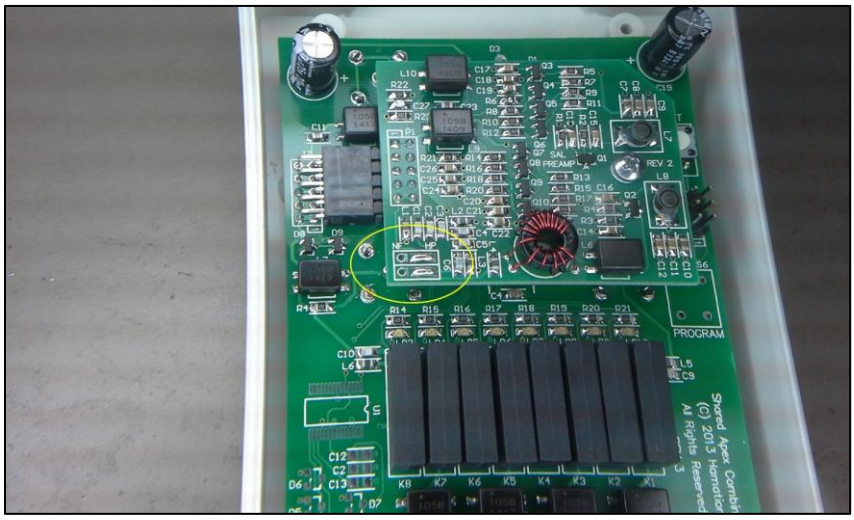
AS-SAL-20 Example Elevation Response Patterns



AS-SAL-12 Example Elevation Response Patterns

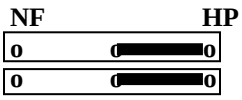


Appendix 1.
Bypassing the High Pass Filter of the SAL preamplifier.

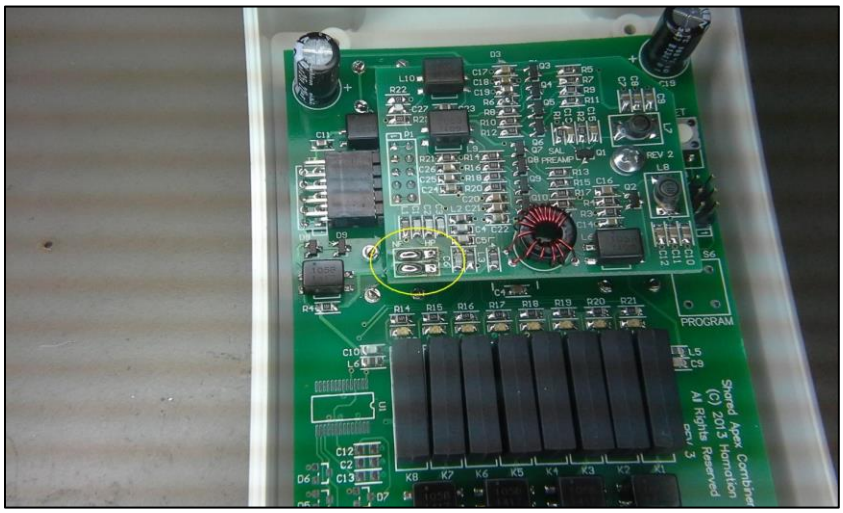


HPF Connected.

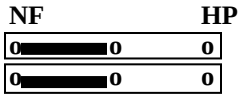
It can be seen in the image above, that there are two solder lines in place on the lower left corner of the small "daughter board", between the center contacts and the HP (High Pass) contacts.

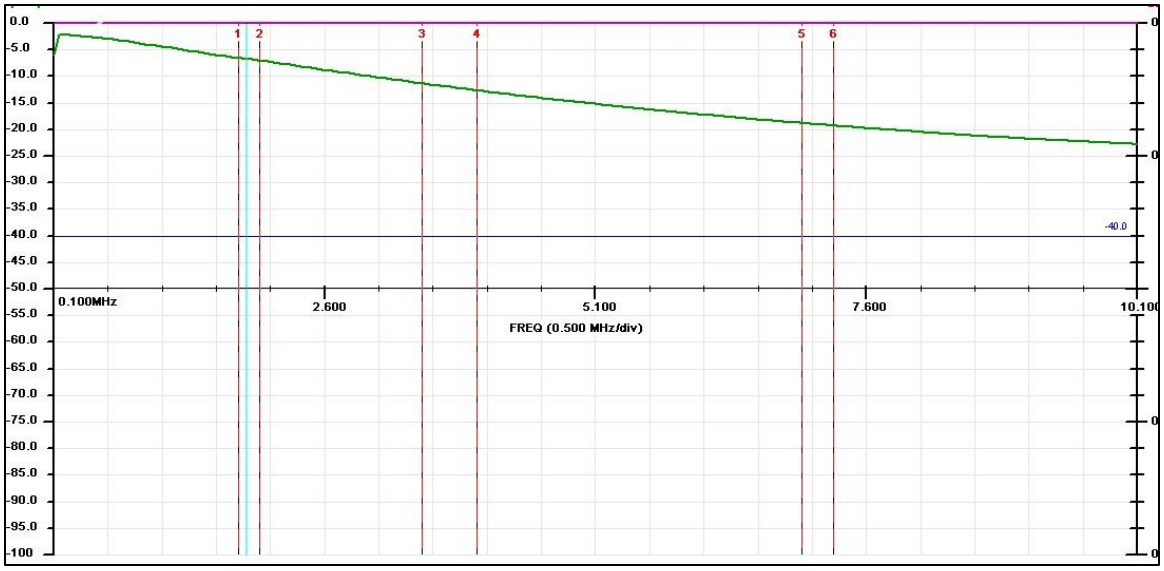


To bypass the filter, remove the solder with a wick or a solder sucker, use minimal heat.
Then, solder jumpers or make a trace with the solder from the center contacts to the NF (No Filter) contacts.

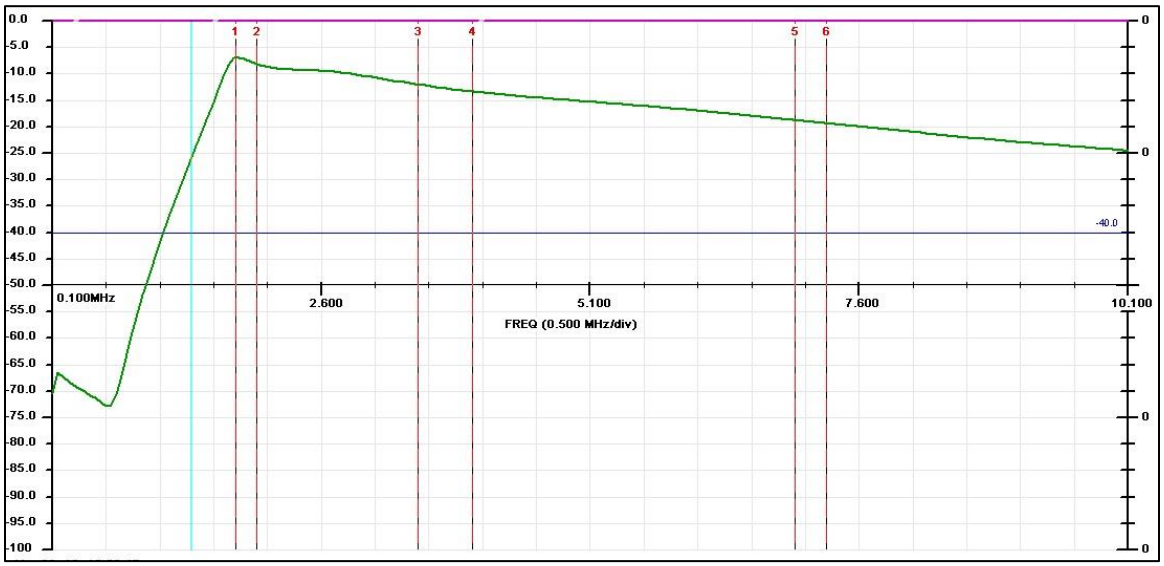


HPF Bypassed.





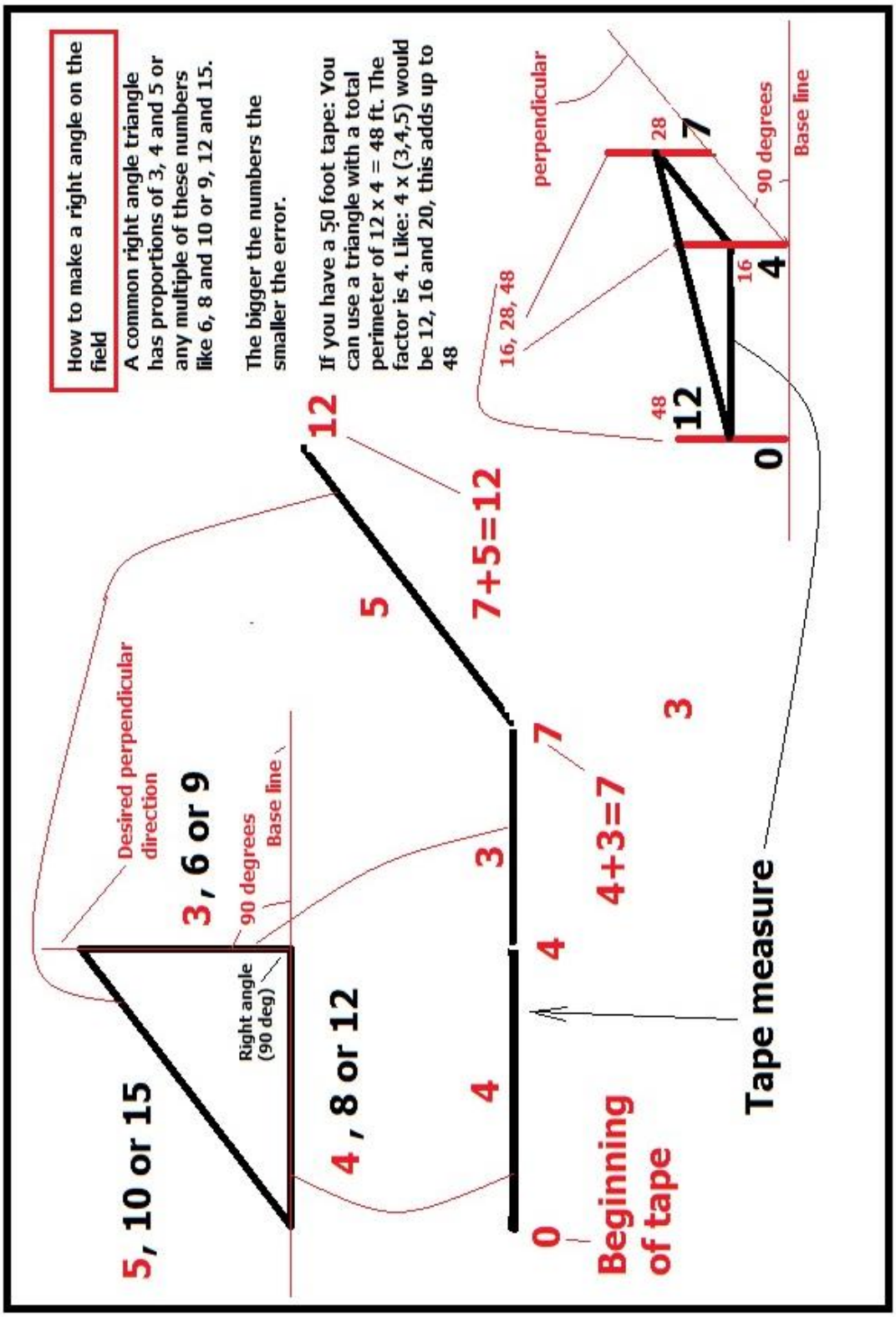
SAL antenna response with no BCB High Pass Filter. The plots have been padded down because of the preamplifier gain, therefore, add 40 dB to the numbers.



SAL antenna response with BCB High Pass Filter. The plots have been padded down because of the preamplifier gain, therefore, add 40 dB to the numbers.

Appendix 2a : How to establish a perpendicular to a baseline.

You can use this surveyor's trick to establish the perpendicular lines where the loops of the SAL antenna are going to be positioned.



Appendix 2B: How to establish a perpendicular line from a baseline