Installation Procedure

For K9AY loop Controller
By Hilltop Systems

The Terminated Loop Receiving Antenna was developed by Gary Breed (K9AY) and published in the September 1997 QST[1]. This antenna has proven itself to be an excellent way to improve receive signal to noise ratio on 160/80 meters in a small amount of space. The carotid reception pattern can be switched in 4 directions creating a deep null on the back side which can dramatically reduce atmospheric noise as well as interference from other stations. The basic antenna layout is depicted in the following drawing

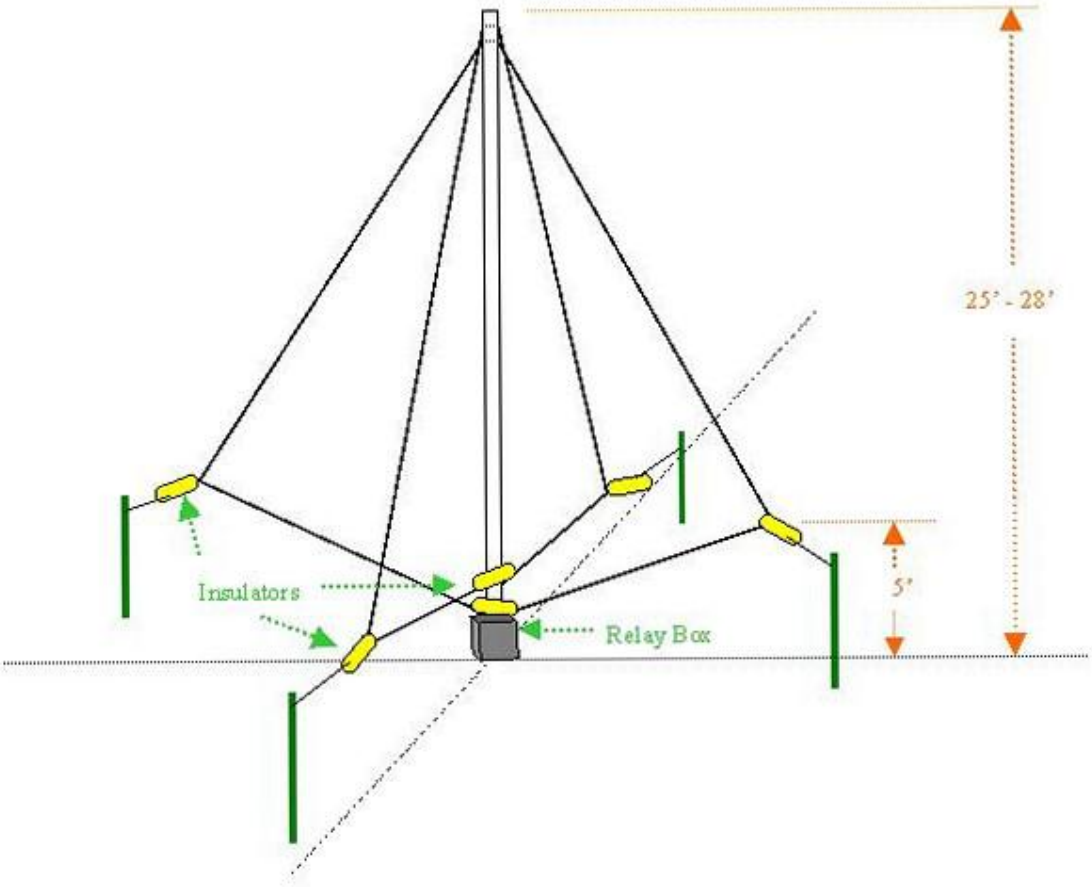

Figure 1. K9AY loop structure.

This document provides a general discussion of how to build the antenna, integrate the control unit with the antenna and includes some suggestions to help avoid problems along the way.

Materials Required:

- **2 pieces of wire** 85 ft. long each. 14 gauge wire works well, but any copper wire that is strong enough to support itself and the top of the mast will work. Either bare or insulated may be used.
- **A center support**. The top of the antenna can be suspended from a tree limb or on a central mast. If a tree limb is available in a convenient place about 25 ft. high, then all you need is some insulating material to hold the two loop wires up and keep them insulated from each other. If you use a mast, it should be 25' to 28' tall and strong enough to support itself without too much flexing. PVC pipe 1 ½" to 2" in diameter works well and the surplus fiberglass masts are excellent. A metal mast can be used, but it is best to keep this antenna away from all metal objects. If a metal mast is used it should be insulated from ground and the wires insulated from the top of the mast.
- **4 stakes or posts** to support the corners of the loop and the mast. T-Bar fence posts work well. Short tent stakes can be used, but they will have to be further out from the antenna to tension the bottom leg of the loop out from the center.
- **A ground rod**. A copper clad steel rod works well, but ¾" copper water pipe can also be used. In dry or sandy soil it may be necessary to add a few (4) short (15' – 25') radials to achieve a good ground. These can be any kind of wire, either insulated or bare. The radials are not resonant so the exact length is not important.
- **Insulators**. 6 insulators are required for the antenna as shown in figure 1. If the antenna is to be supported from a limb, then an additional insulator will be needed at the top. Strain type ceramic or plastic insulators will work well.
- **Rope or cord**. About 150' depending on the specifics of your site, of light weight nylon rope are required. 1/8" cord works well and is more than strong enough to support the antenna. An extra guy rope from above the center of the mast to each stake (not shown in figure 1) helps during assembly and provides a lot of stability to the mast.

Antenna Assembly

Support Structure

If you are using a tree limb or other center support, then the center insulators that hold the wire loops must be hoisted up to that point. The least damaging way to attach anything to a limb is to use a screw or eye bolt and pulley screwed directly into the wood. A rope around a limb will eventually cut into the bark and damage the growing layer of wood underneath. This will weaken or even kill the limb from that point outward. However you choose to support the top, find the center point of each of the 85' wires and pull each wire through the center support insulator to the midpoint of the wire. Hoist the center insulator up to the appropriate height.

If using a mast, assemble the mast on the ground and attach the center point of the wires to the top of the mast. The loop wires must be insulated from each other and secured to the mast so that they can't slide through and allow the mast to bend over. A good way to do this is to drill two holes all the way through the mast and perpendicular to each other and separated vertically by about an inch. The wires can be secured to the mast as shown in figure 2 with a short piece of wire wrapped around the outside of the mast and wound tightly around the wire on each side.

Next, attach the guy ropes to the mast somewhere near the middle, but not exactly in the middle. If the mast is guyed in the middle and the wind is just right, the top and bottom of the mast can begin oscillating in an "S" shape with the top going one way and the bottom going the other way creating excess stress on the mast. Oscillation cannot begin if the two halves of the mast are unequal lengths. One easy way to secure the ropes to a smooth mast is to use a hose clamp. Tie the ropes just above the clamp and the clamp assembly will hold the ropes in place. The insulators can be attached to the loop wires now or after the mast is erected.

Figure 2: Attachment of wires to mast.

If an assistant is available, erecting the mast is a fairly simple operation. One person holds the base to the ground while the other walks the mast up vertically. Then, while one person holds the mast, the other attaches the guy ropes to the anchor posts. One person can put the mast up by first attaching 3 of the midpoint guy ropes nearest the mast to the anchors and block the bottom of the mast against a solid object, walk the mast up into a position so that it leans a bit against the 3 ropes. Attach the fourth guy rope and successively adjust the other guys until the mast is in the correct position and vertical.

Loop Assembly -

Straighten the wires so the ends of each loop are going in opposite directions and they are not twisted at the top. Slide a corner insulator over each end of each wire loop. Attach the ends of each loop to one of the bottom insulators as shown in figure 3 while leaving 12” to 18” of wire loose for connection to the relay box. . It is good installation practice to solder or clamp the wires to eliminate any possible source of noise.

Figure 3: Attachment of the bottom of the loops.

Affix each insulator to the mast to hold it in the center. If you are supporting the loop from a tree limb, the ground rod can be a convenient place to attach the insulators. Use tie wraps or rope in a figure 8 pattern to secure the insulators to the center support. The attachment point should be about 1 ft. above ground. If the base of the antenna is elevated above ground by a significant amount the directivity of the antenna is lost. Figure 4 shows a comparison of the receive pattern from a loop 1 ft. above ground (K9AY_1) and the same antenna 6 ft. off the ground (K9AY_2). The extra elevation significantly reduces the front to back ratio of the antenna.

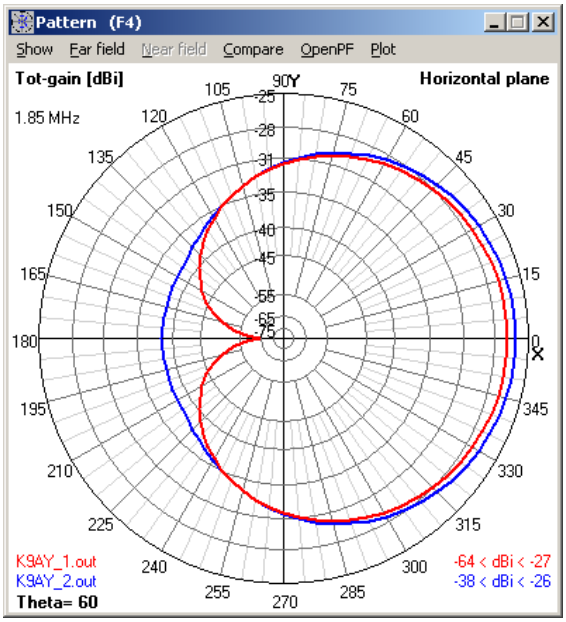

Figure 4: Pattern of ground mounted vs. elevated antenna

Next take each corner insulator and slide it out along the wire and pull each loop wire away from the center mast until the top and bottom halves of the loop are taught and the insulator is about 5 ft. above ground. Tie a rope on the insulator and attach it to the anchor stake. It is a good idea to secure the wire to the insulator so that it can't slide up or down the wire and make the loop non-symmetrical. One way to do this is shown in figure 5. Plastic insulated solid wire works well because it is stiff and the plastic grips the wire, but tie wraps or tape can also be used.

Adjust the tension on each corner insulator rope until they are equal, the wires are under a small amount of tension, and the mast is not bent over. The corner insulators can be higher than 5', but if the bottom leg of the loop is too close to the ground or nearly parallel to it, the performance of the antenna deteriorates.

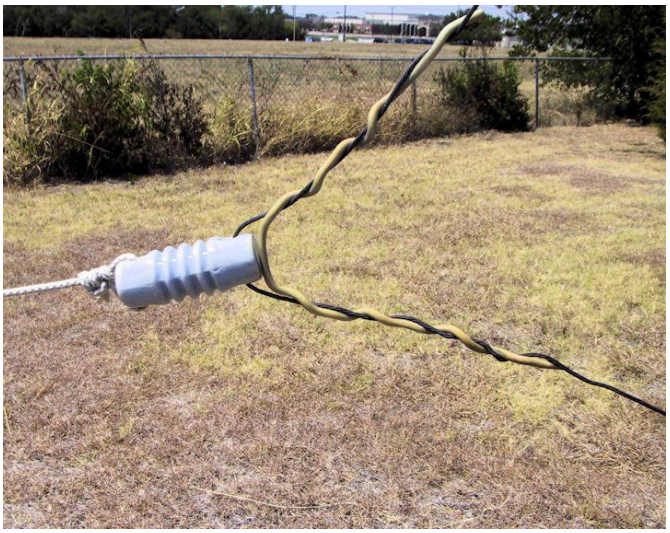

Figure 5. Corner insulator attachment.

Loop Control System

Relay Box

Attach the relay box to the mast or other support immediately under the insulators with tie wraps or rope, as shown in figure 3. To keep rain and dirt from entering the connectors at the bottom, **the relay box must be installed with the binding posts for the antenna connections at the top.**

Attach the antenna wires to the binding posts at the top. The binding posts are marked in each of the four directions, so connect the wire of the loop that goes North-West to the connector marked “NW” and the North-East wire to “NE” etc. Bend the wires around so that there is sufficient clearance between the wires and the adjacent loops that they can not short out in wind. Cut them off as needed to make a neat installation.

Attach a piece of wire to the ground (Gnd) binding post and connect it to the ground rod using a ground rod clamp or a stainless steel hose clamp. Keep this wire short and away from the antenna wires.

Connect the coaxial feed line to the SO-239 socket on the bottom of the relay box. The coax can be any type of coaxial cable that is available. **The shield side of the coax is not grounded in the relay box**. It is isolated from ground so that the only ground on the transmission line is the ground at the radio. This eliminates the possibility of different ground potentials causing common mode current in the shield and inducing unwanted noise into the radio. The feed line should be connected to the receive antenna input on the radio, or to an antenna relay controlled by the transmitter keying circuit so that the transmitter can never transmit into the K9AY loop antenna.

Finally connect the control cable to the relay box. This cable is common 24 gauge, four conductor telephone interconnect wire . The connector is a standard RJ-11 telephone snap in connector with gold plated contacts. Any type of cable will work and the pairing of the wires is not important as the signals are DC current. The cable wiring is one-to-one which means each pin on one end goes to the same pin on the other end. This type of cable is readily available at most hardware and electronics stores and many stores will crimp on the connectors for you. The crimp tool required to attach RJ-11connectors is relatively inexpensive and a standard tool for anyone who works on telephone systems.

An alternative to attaching connectors to your own wire is to use the test jumper supplied with the controller system, cut it in half and splice the wires on to the ends of your cable. Extensive insulation and waterproofing is not required because of the low voltages involved. Wrapping electrical tape around each wire and some more around the whole splice will be sufficient. Crimp-on splices are also available which eliminate the need to strip or solder individual wires.

Switch Box

The switch box controls the direction of the antenna and provides power to the system and should be installed in convenient location at the operator's position. The switch box has two connectors on the back. One is a 2.1 mm. round power connector that supplies 12 V. DC to power the relays and the other is the RJ-11 connector for the control cable to the relay box.

Any source of 12 volts DC can be wired to the plug that is included with this system or a plug-in "wall wart" type DC power source can be used. The polarity of the voltage does not mater, but typically the positive lead is on the center pin of the connector. The system will operate reliably with any supply voltage between 10 and 14 volts, so a regulated supply is unnecessary.

The control cable plugs into the RJ-11 socket which directs the 12 VDC to the appropriate relays in the relay box to control the direction of the antenna. The current carried by this cable is approximately 42 ma. per wire, so the voltage drop along this cable is quite small. Even a 1000' run of standard telephone wire would only experience a voltage drop of approximately 2 volts so the relays will still operate reliably. If a longer run is needed, then the supply voltage should be increased so the voltage as measured at the relays is within their operating range of 10 to 14 volts.

The switch box is designed to control an antenna that is oriented North-East and North-West. This orientation works well in most locations and led to this toggle switch arrangement for the switch box. If this is not acceptable, contact the manufacturer and other switch arrangements can be provided. Directions are selected by setting the two switches to the combination of directions desired. If you want the antenna to point South-East, then set the North-South switch to South and the East-West switch to East. This arrangement is intuitive to operate, can be operated by feel only and allows switching from any direction to any other direction without switching through other directions.

The default position of the relay box is North West, so setting the switches to North-West is effectively the off position.

Antenna Testing and Adjustment

The adjustable resistor on the bottom of the relay box provides a terminating resistance for the back side of the antenna equal to the characteristic impedance of the antenna. The termination of the antenna actually includes the resistor, plus the resistance of the dirt between the ground rod and "true ground". Also, the characteristic impedance of the antenna changes with frequency. For all these reasons the terminating resistor needs to be adjusted for each particular installation. Once set, the resistance does not change unless one of the above parameters is changed. That is, if the soil moisture content changes dramatically or the operating band changes, then this resistor may need to be readjusted.

One way to adjust this resistor is to listen to the AM broadcast band and find a weak distant station. This can be done during the day when 80 M. and 160 M. are not open.

Set the resistor to about 500 ohms (half way from stop to stop) and listen to the station with the antenna pointed alternately toward it and away from it. Adjust the resistor for maximum front to back signal strength difference between the two directions. This setting will be close to the optimum setting for 80 or 160 at night when the bands open up. During normal operating times, you can tweek the resistor while listening to a distant station on the desired band. *The front to back ratio may be different during twilight because the angle of arrival for distant signals is different during this time*.

An antenna analyzer has **not** been found to be a reliable method for adjustment of the terminating resistor. With the termination set properly, an analyzer will show some reactance and a resistance around 50 or 60 ohms.

The terminating resistor value can be measured with an ohm meter by selecting one of the loops with the switch box and disconnecting one of the ends of that loop from the binding post. Measuring the front side binding post to ground will read near zero which is the primary impedance of the matching transformer. The back side binding post to ground will read the actual resistor value. This procedure can also be used to test the relay contacts and switching. Set the direction of the antenna to each direction and verify that the front side binding post reads zero ohms to ground and the back side reads the resistor value. The other binding posts should be open with respect to ground.