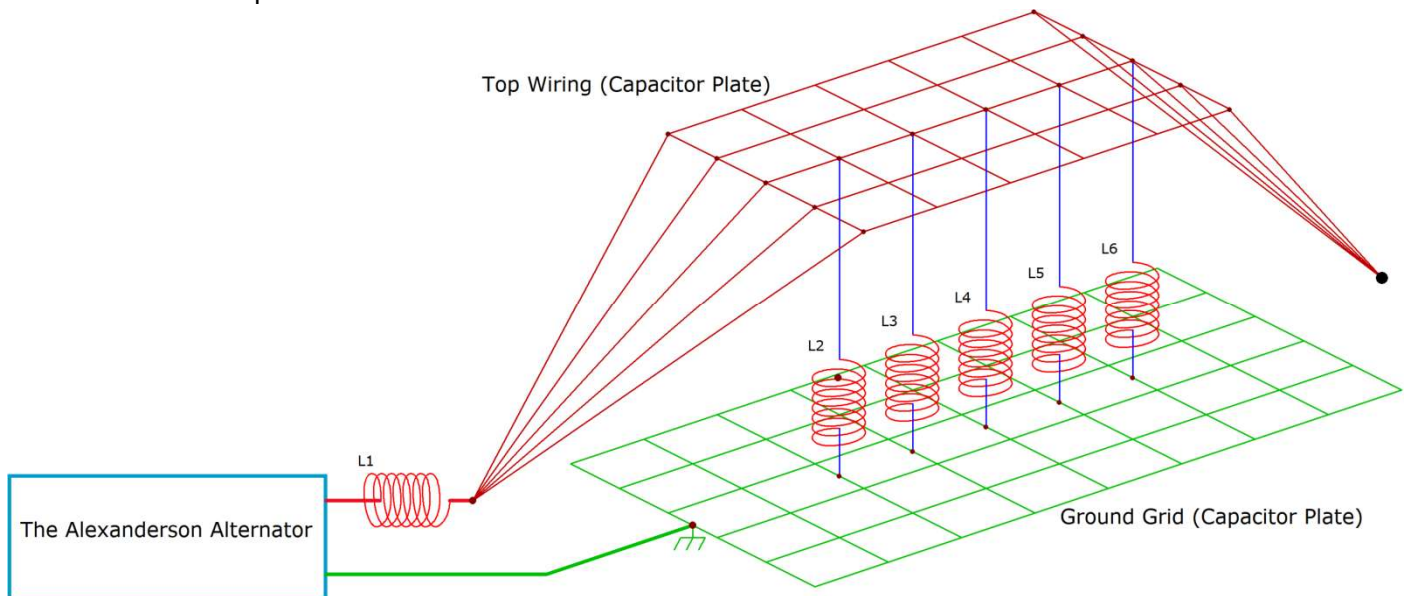


A brief description of the SAQ Transmitting Antenna

There are six antenna towers, each 127 meters tall to support the Top Wiring that becomes a plate of a giant capacitor. Power is fed from the Alexanderson Alternator via inductor L1 to the Top Wiring. It then flows through five vertical wires, through inductors L2 to L6, and flows to Ground via the Ground Grid.

The Ground Grid becomes the second plate of the giant capacitor. It is buried in the ground and is also the return current path to the Alexanderson Alternator.



When the Alexanderson Alternator is transmitting it generates electrical power at a frequency of 17.2kHz. The six inductors L1 to L6 and the giant capacitor make a strongly parallel resonant electrical circuit designed to resonate with the Alternator and to resonate at the Alternator frequency of 17.2kHz.

The very high voltages and currents flowing in the vertical conductors, much increased by resonance, radiate powerful electro-magnetic waves (EM waves) with the E-field (lines of electric force) in the vertical plane and lines of Magnetic Flux circulating in the horizontal plane. Thus EM waves, in accordance with Maxwell's equations, at the very low frequency of 17.2 kHz, are created and therefore must transmit away from the antenna at the speed of light. The EM waves transmitted are vertically polarized because the E-field is in the vertical plane.

Each of the vertical conductors, the vertical component of the lead in wires and to some extent the vertical component of the lead out wires all transmit. Because the wavelength at 17.2 kHz is very long (about 17.442 Km) all of these vertical radiators add together and appear as one radiator with close to an omni-directional transmission pattern.

This type of antenna was designed by E F W Alexanderson and he patented his design in 1920.

In this part of the spectrum the EM waves transmitted are referred to as VLF (very low frequency) transmissions and can propagate huge distances.

SAQ Receiver Antennas

There are several ways to design and build a receiving antenna for VLF transmissions. As a general rule antennas for VHF, UHF and above are designed to capture energy from the Electric field component of the EM wave, whereas most antennas designed for VLF, specifically SAQ, capture energy from the Magnetic field component. Both types of antenna are used for frequencies between VLF and VHF.

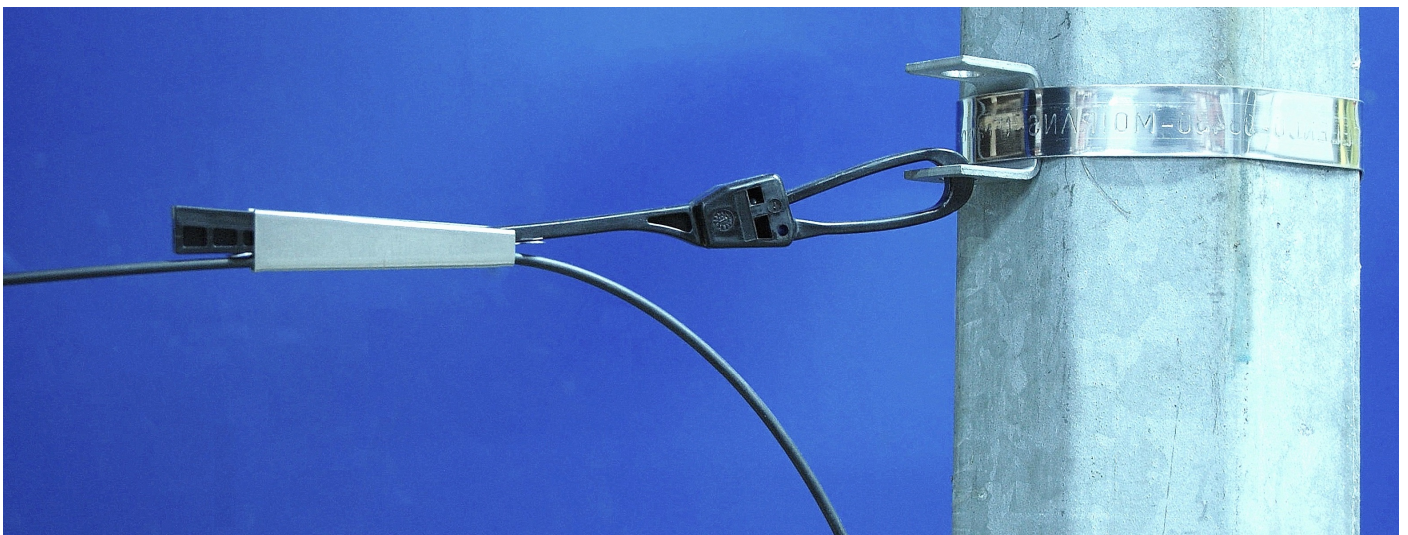
Designing and building your own antenna and then receiving SAQ can be an exciting project. Most of the antennas described here are designed to capture energy from the Magnetic field component of SAQ transmissions so that means they all essentially must form a loop or a coil of wire. As the horizontal lines of Magnetic flux from SAQ intersect the axis through the loop or coil small currents are generated much like what happens in a transformer or a dynamo. The one exception is the Vertical Rod Antenna that is sensitive to the vertical Electric Field component from SAQ.

Where long wires are used outside, safety has to be the first consideration. There are good safety practices to follow if you build an outside antenna. There is keeping your antenna well away from power lines, domestic or otherwise, power installations and solar panel installations.

Also what can happen in a Lightning storm has to be considered. You should research and study aspects of Antenna safety before building an outside antenna. Good working practices, power line safety and Lightning storm safety are essential. Make sure that your antenna is not the highest point around, that there are buildings, trees or other structures nearby that are taller than your antenna.

Always use good quality well insulated cable for outside antenna. It can be cable that has Silicon insulation or other high quality UV resistant insulation. It can have Kevlar inside for strength. It can be purpose bought antenna cable, good quality mains extension lead cable, telephone cable for outside use or even Solar panel cable. Your cable should have strength, should be very well insulated and highly resistant to UV light. If you use antenna cable that cannot support its own weight over a long distance run Kevlar rope alongside it fastened to it using nylon cable ties.

There are many different types of clamps, drop clamps, cable ties and other fixtures and fittings to secure your antenna. It's possible to buy clamps designed and marketed for antennas or choose from a wide range of clamps used in the telecoms industry. The clamp must be long lasting, provide a strong mechanical attachment, must be an excellent electrical insulator and must be UV resistant. ABS plastic and Polyethylene are ideal materials for antenna clamps. As an example of a good and low cost clamping arrangement here is a Telenco Hypoclamp attached to antenna cable.



If your antenna cable is well insulated static electricity will not build up to the same extent. You must always connect your antenna electrically to a high quality electrical Ground. It's best to keep your Ground connection or connections separate from the domestic electricity earth system so Ground Rods are your best option. The Ground connection provides a safe pathway for excess static electricity to dissipate harmlessly into the ground. Properly installed Ground Rods help to protect people and electrical equipment from potential harm caused by lightning strikes or power surges. They can also make your Antenna more sensitive to VLF. There are other important safety features to protect against Lightning strikes such as Surge Arrestors and Ground Disconnect Switches. It is up to you to research what is needed for your installation.



Ground Rods are an essential part of an outside VLF antenna. The Ground Rod has two purposes. Firstly it provides a safe pathway for excess electricity, static electricity to dissipate safely into the ground. This protects people and electrical equipment from potential harm caused by static electricity or power surges. Secondly Ground Rods complete an electrical loop circuit for VLF antenna types.

All of the antenna types listed here are directional except for the Vertical Rod Antenna. For the portable antennas if you think of the winding or windings as a wheel, then the axis of the wheel shall not point directly towards the SAQ transmitter. The received signal will be at its strongest when the axis is at a 90 degree angle to the transmitter. For long outside antennas ideally the antenna should point towards SAQ along its length. These VLF antenna types make a large electrical loop and the horizontal lines of Magnetic flux from SAQ intersect the axis through the loop thus making small currents flow in the loop.

If you don't live too far away from SAQ, let's say a few thousand kilometres at the most, you can probably get enough signal strength from relatively small and portable antennas or from a Vertical Rod Antenna. People have built many designs over the years. In fact a big advantage of a portable antenna is that you can take your equipment and antenna with you and find a good place to receive SAQ. For example by getting away from the electromagnetic interference of a city or by finding some high ground where the signal strength may well be better.

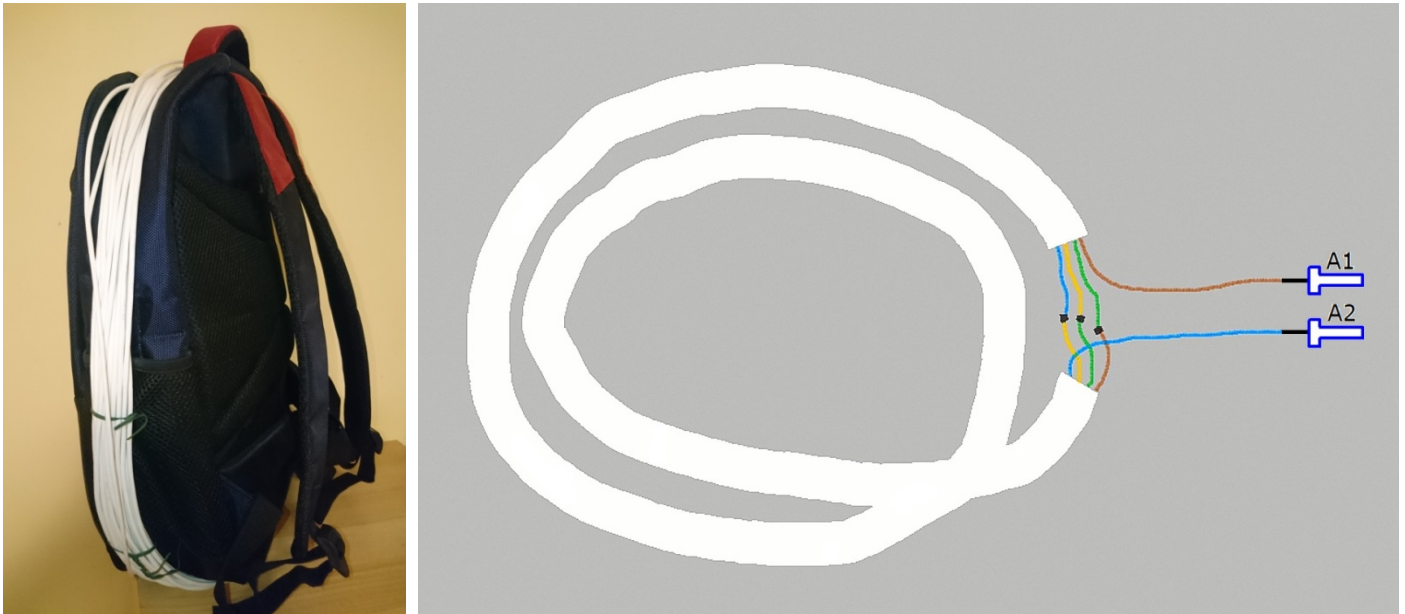
If you live a long way away from SAQ, over a few thousand kilometres, you will most likely need an outside antenna to get sufficient signal strength. Before you build any outside antenna make a plan for your antenna and study all the safety information here and elsewhere to be sure that you work safely and comply with regulations, standards, legal matters, Lightning safety and anything else that's relevant.

Here are some of the best examples of portable antennas and outside antennas. Portable antennas are usually easier to construct than outside antennas and can often give very good results.

Compact Loop Antenna – Backpacker's Antenna

You will need cable ideally with several wires inside. For example you can use mains extension lead cable (with Live, Neutral and Earth wires inside), four core telephone extension cable or even Ethernet cable with eight cores (four twisted pairs inside). In this example we are using four core telephone cable or telephone extension cable.

To construct, wind twenty turns of cable loosely around your backpack, secure the turns to each other and to the backpack by using nylon cable ties. Now join and insulate the wires as shown in the diagram below. By joining the wires as shown you have made the twenty turns into eighty turns and thereby increased the sensitivity of your antenna. The more turns the stronger the signal strength will be.



You can also make a stand-alone version of Compact Loop Antenna. Typically you would choose a diameter anything from 300mm to even over a metre in diameter. Follow the same basic method as for the Backpacker's Antenna above and use cable ties to hold all the loops of cable together.

Some people have even built a frame for their Loop Antenna (usually a wooden frame) so that they can conveniently rotate the frame and align the antenna so as to get the maximum signal strength from a station.

To use the Backpacker's Antenna connect it to your sound card input, receiver or amplifier using one of the six connector types shown below.

For the Backpacker's Antenna if you think of the windings as a wheel, then the axis of the wheel shall not point directly towards the SAQ transmitter. The received signal will be at its strongest when the axis is at a 90 degree angle to the transmitter.

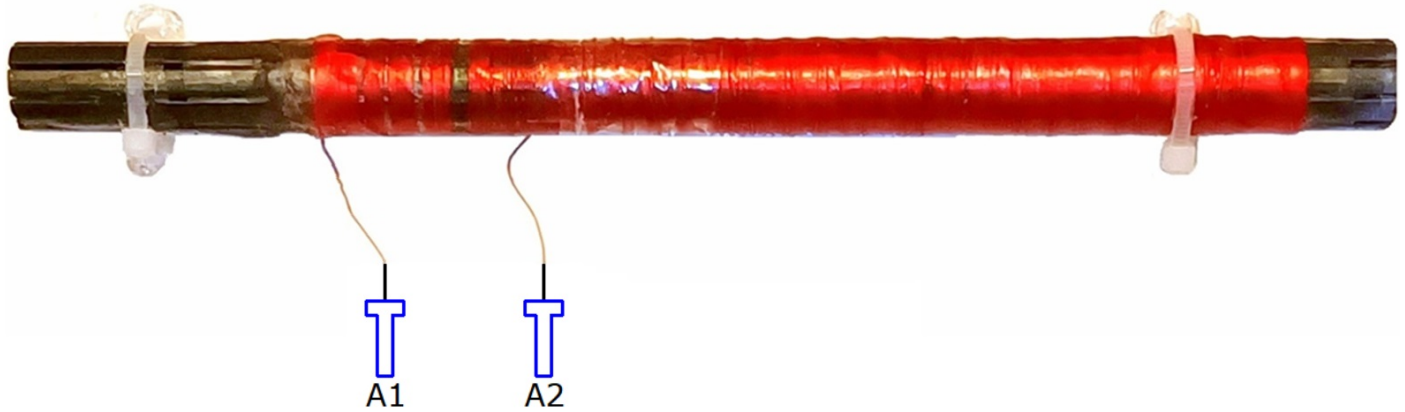
As the Magnetic Flux circulating in the horizontal plane from SAQ passes through the loop tangential to its axis, current is induced in the loop and the antenna works.

If the Magnetic Flux lines are tangential to the plane of the loop no current will be induced in the loop. If the plane of the loop is aligned horizontally there will again be no current in the loop because SAQ does not radiate any Magnetic Flux circulating in the vertical plane.

Ferrite Rod Antenna

To construct this antenna you will need a Ferrite Rod (ideally at least 200mm long and typically 10 to 14mm in diameter). Ferrite rods are commonly used in industry for HF welding and they are also used to build MW/LW radio receivers.

You will also need enamelled copper wire with a diameter of between 0.1mm and 0.35mm. Wind a coil of about 300 turns of wire onto the Ferrite Rod and secure the turns with candle wax or tape.



To use the Ferrite Rod Antenna connect it to your sound card input, receiver or amplifier using one of the six connector types shown below.

For the Ferrite Rod Antenna if you think of a line running through the centre of the Ferrite Rod along its length, this is the axis of the Ferrite Rod. The axis shall not point directly towards the SAQ transmitter. The received signal will be at its strongest when the axis is at a 90 degree angle to the transmitter.

As the Magnetic Flux circulating in the horizontal plane from SAQ passes through the Ferrite Rod tangential to its axis, current is induced in the coil of wire and the Ferrite Rod Antenna works.

If the Magnetic Flux lines are tangential to the length of the Ferrite Rod no current will be induced in the coil of wire. If the length of the Ferrite Rod is aligned vertically there will again be no current in the coil of wire because SAQ does not radiate any Magnetic Flux circulating in the vertical plane.

Outside Ground Loop

This is a very easy and relatively safe antenna to make but unfortunately it does not significantly receive SAQ.

It does however receive several other VLF stations with good signal strength so you can test out your receiver with an Outside Ground Loop. Also it is less affected by radio frequency interference and lightening storm interference.

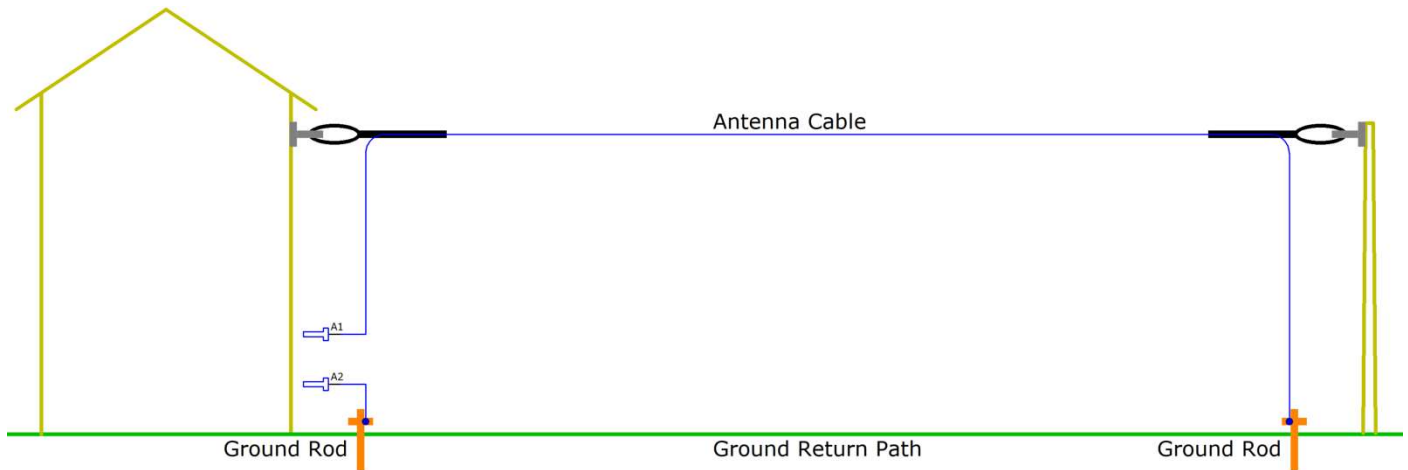
You will need a length of antenna cable, typically 35m, and a safe place outside where the antenna cable is not a trip hazard. Lay the cable on the ground in a 10m diameter and wire it in the same way as the Outside Loop Antenna is wired.

To use the Outside Ground Loop connect it to your sound card input, receiver or amplifier using one of the six connector types shown below.

Outside Long Wire Earth Loop

A Long Wire Earth Loop Antenna can be any reasonable length. Between 10m and 50m are not uncommon antenna lengths with 25m being a good length to aim for if you have enough space.

For reasons of safety and convenience the antenna height should be around 2.5m to 3m. The Antenna Cable must be well insulated.



Ideally the antenna should point towards SAQ along its length. If your available space does not allow such an antenna, even partly to point towards SAQ, it will not work well or will not work.

The Ground Return Path and the Antenna Cable make a very large electrical loop and the Magnetic Flux circulating in the horizontal plane from SAQ intersects this loop thus causing current to flow in the loop. Of the antennas described here this antenna will provide the strongest signal for the amount of single conductor antenna cable used.

The Ground Return Path is completed by connecting both ends of the antenna to Ground Rods as shown. The far end of the Antenna Cable should itself be brought down to the Ground Rod, connected securely electrically to it and should be fastened securely.

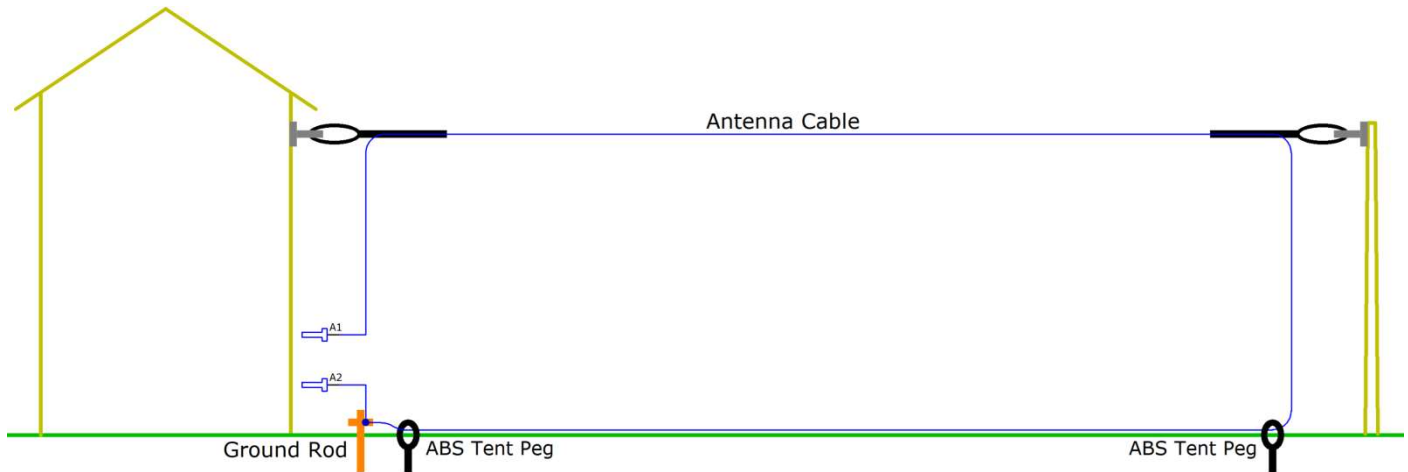
The Ground Rods should be installed correctly for the type of ground you have. You may decide to have them installed by a qualified electrical contractor. This is important because the Ground Rods are essential for safety.

To use the Long Wire Earth Loop Antenna connect it to your sound card input, receiver or amplifier using one of the six connector types shown below.

Outside Loop Antenna

A Outside Loop Antenna can be any reasonable length. Between 10m and 50m are not uncommon antenna lengths with 25m being a good length to aim for if you have enough space.

For reasons of safety and convenience the antenna height should be around 2.5m to 3m. The Antenna Cable must be well insulated.



Ideally the antenna should point towards SAQ along its length. If your available space does not allow such an antenna, even partly to point towards SAQ, it will not work well or will not work.

Secure the Antenna Cable returning along the ground at both ends using ABS plastic Tent Pegs or similar (don't use metal pegs). Find ways to make sure the returning Antenna Cable will not get damaged and that it will not be a trip hazard.

The Antenna Cable runs in one or more complete loops. It makes a very large electrical loop or coil and the Magnetic Flux circulating in the horizontal plane from SAQ intersects this loop thus causing current to flow in the loop or coil. Normally single conductor antenna cable is used and single conductor antenna cable is shown here. That said it is also possible to use multi-conductor antenna cable and wire it as described for the Backpacker's Antenna. More turns will strengthen the received signal because Inductance increases proportionally to the square of the number of turns.

Regardless of the number of turns the Antenna Cable must be connected securely electrically to the Ground Rod and should be fastened securely.

The Ground Rod should be installed correctly for the type of ground you have. You may decide to have it installed by a qualified electrical contractor. This is important because the Ground Rod is essential for safety.

To use the Outside Loop Antenna connect it to your sound card input, receiver or amplifier using one of the six connector types shown below.

Outside Vertical Rod Antenna

The only type of antenna that can receive the vertical Electric Field component from SAQ is one that is a vertical conductor, typically the Vertical Rod Antenna.

The Vertical Rod Antenna can be any practical and reasonable vertical length. Longer than about 3 metres becomes difficult to support but 5 metre rods are not uncommon.

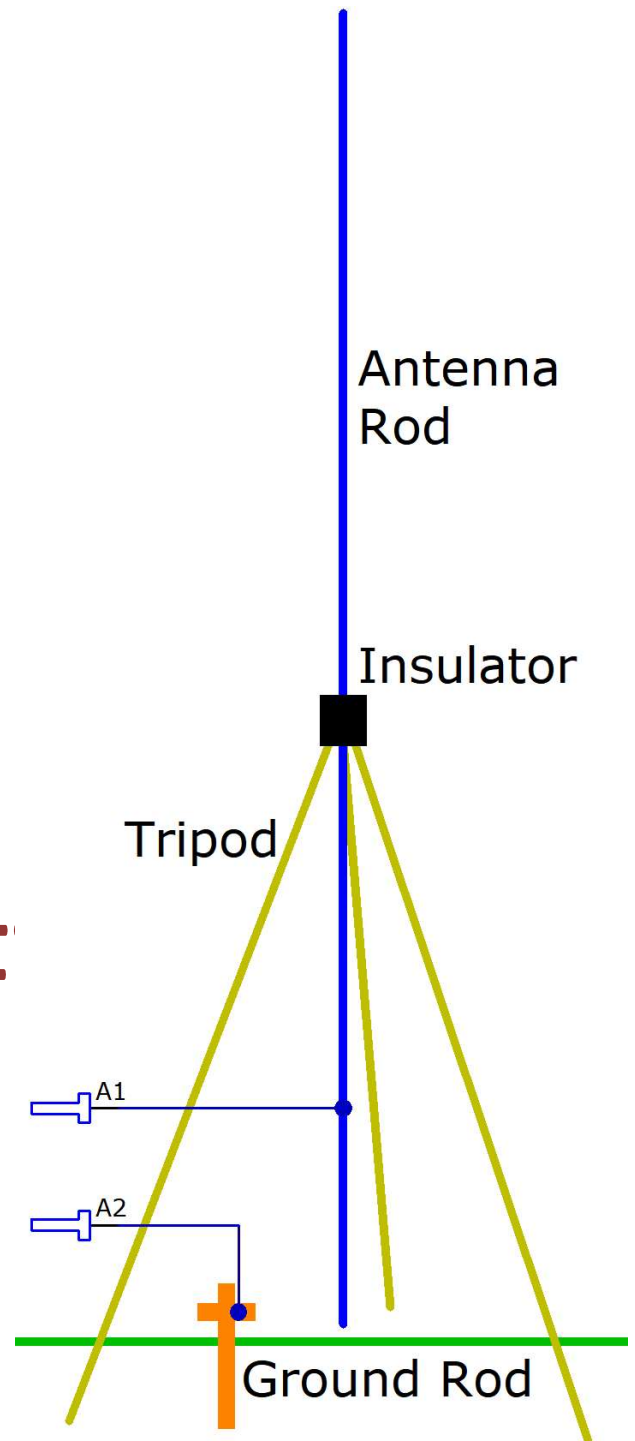
Remember that increasing the height of the vertical rod increases the risk from Lightning strikes. For safety reasons there should be buildings, trees or other structures nearby higher than the Vertical Rod Antenna.

The rod should be well insulated. ABS plastic or Polyethylene are ideal for this. The Tripod should be strong and also a good electrical insulator, examples of suitable materials for the Tripod would be Carbon fibre rod, Glass fibre rod or even well varnished hardwood. The Tripod should be firmly anchored to the ground.

There must be a Ground Rod to provide a current return path and as a path for static electricity. The Ground Rod is essential for safety and will dissipate static electricity charge that can otherwise build up on the vertical rod.

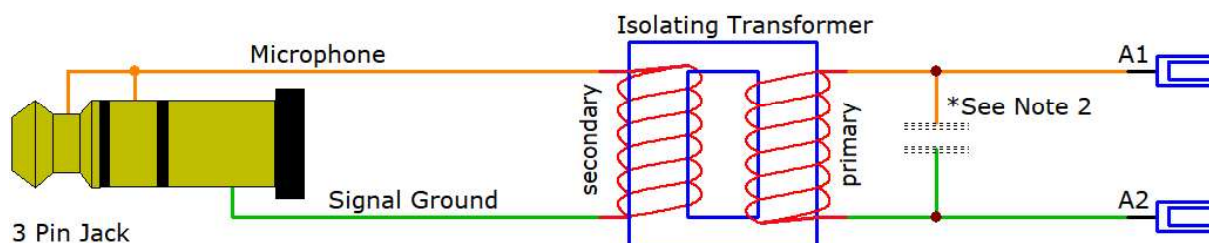
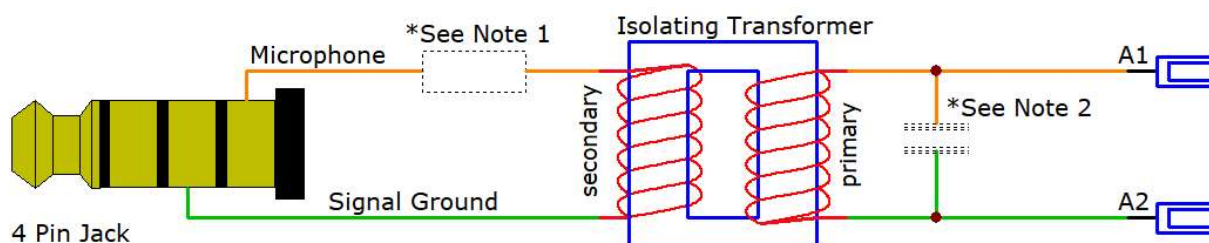
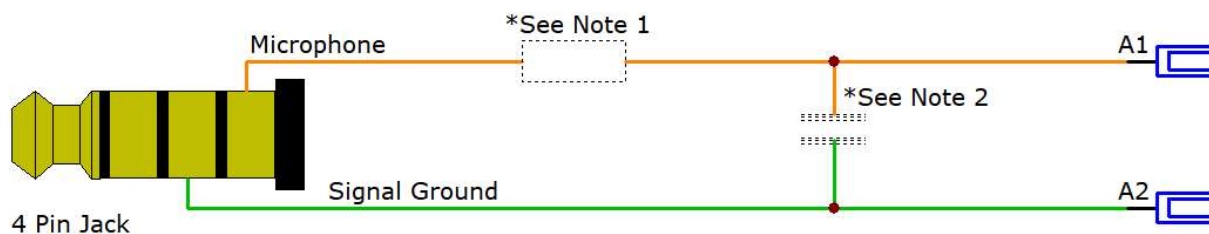
The vertical Electric Field component from SAQ creates a potential gradient along the length of the rod. This causes charge (in this case, electrons) to bunch up at one end of the rod. As the electrons continue to move they create a current flow even though there is no closed circuit loop. You can think of the process as a capacitor with only one plate. The other plate is the Electric Field.

To use the Vertical Rod Antenna connect it to your sound card input, receiver or amplifier using one of the six connector types shown below.



Connectors

For all antenna types described above we have shown two connections A1 and A2. A1 is the antenna live, if you like, and A2 is the Ground return path. To help you connect to a sound card, a receiver, or an amplifier, here are typical schematics for a range of connectors or connection methods. You may need to adapt the connector to suit your equipment and particular setup.



*Note 1 - Some Sound Cards need a Resistor - Typical Value 330 Ohms

*Note 2 - A correctly chosen Capacitor will resonate the Antenna at 17.2 kHz

Finally

You can find many antenna designs on the internet – try searching with keywords such as **VLF**, **Loop**, **Ferrite rod** and **Antenna**.

Whatever you find and decide to construct remember that the internet is not always a safe place, not always a place for good safe advice, so be sure to follow all the safety procedures we have outlined above and study the safety aspects of your antenna before building it.

Please do not build your outside antenna if you are not completely sure that it is a safe design, it is safe for you to build and that it will be safe in operation, safe even in a Lightning storm, also that it will be positioned well away from any kind of power lines, power installations or solar panel installations and that it complies with regulations, standards, legal matters and anything else that's relevant.

Good luck with receiving SAQ and when SAQ is not transmitting there are other stations on VLF that can be interesting to receive.

DRAFT