Improving Medium Wave Reception

Simple Loop Antennas

By TWR Bonaire Engineering

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The Problem with listening to distant medium wave radio stations

Radio stations on the "Medium Wave" (MW), or AM band, are can be difficult to hear clearly. Weak incoming radio signals, low power transmitters, as well as noise from thunderstorms, electrical wiring and all kinds of electronic devices all combine to make reception difficult at times.

In most cases a major cause for poor reception lies within the receiving radio itself. The antenna inside the average portable radio is very poor. In this article, we will discuss a very low, or even zero, cost antenna that can be easily built that will dramatically improve medium wave (MW) reception. The antenna we will talk about is only for MW, not for shortwave or FM. The antenna we are talking about is the "**Tuned Loop Antenna**". This article will describe the problem, and how to build your own loop antenna at very low cost with very little technical skills.

In this article, we will also use some "technical talk" that hopefully will help you understand the problem and the solution a bit better.

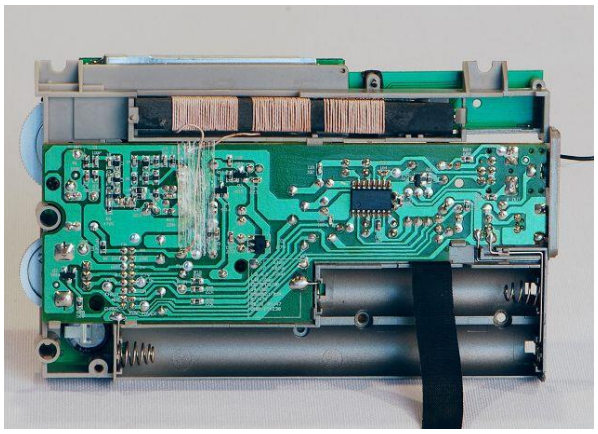
Understanding Signal to Noise ratio

In order to have good, listenable reception where we can understand the programs, we need to maximize the desired radio station signal while reducing the noise and interference which make listening difficult. If you think about it then, our goal is not to get the strongest signal, but rather to get the strongest signal AND reduce the "noise" which is any signal we don't want. Noise can come from electrical wiring, appliances and computers, thunderstorms, and even other radio stations on the adjacent frequency or even right on the same frequency that we want to listen to. In engineering terms, what we want is the best possible "Signal to Noise Ratio" (S/N ratio, or SNR). So, signal we want, noise we don't want.

So how do we improve Signal / Noise ratio?

Well, the transmitter could increase power, but that is expensive and not likely to happen. If changes are not possible at the transmitter, all the improvements will have to be at the receiver end. Now part of the problem with small portable radios is that the built-in antennas are usually very, very poor. They are physically small, and we say that they have a “small capture area”. There is just not much antenna there to grab, or capture, the signal out of the air. This small capture area does not pick up the signal well, so reception is weak. Another problems is that the small antennas are not very directional. This “directivity” is a useful tool that can help reduce unwanted interference.

The little antennas inside the radios are called “loopsticks” because they are made from loops of fine wire wrapped around a rod of ferrite material. The pictures below show two typical small loop stick antennas. These loopsticks are typically 3-9 cm long.



How they work is that any loop of wire has a magnetic field. When that magnetic field picks up the magnetic field energy lines from the transmitter signal, some of that energy is converted into electricity and fed into the radio amplifier circuits.

Improving the radio antenna

What we need is an antenna with a much bigger “capture area”, something that can pull more of the transmitter signal out of the air. We could consider outdoor antennas but they are more visible, attract attention, are expensive to build, and most radios don’t have a way to connect them to the radio anyway. At the low frequencies used for medium wave broadcasting, good outdoor antennas are quite big. They should also be cut to a certain size to work efficiently for each given station’s frequency, and are very hard to adjust. What we need is a good, small, cheap indoor antenna.

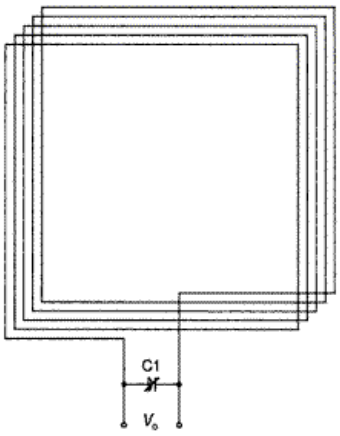
The “loop” in the typical radio’s loopstick actually does a surprisingly good job for its size. We just need a bigger loop. That would give us more capture area and can be used indoors with very god results. For a loop antenna to be really efficient, it needs to be adjusted, or “tuned” to the specific frequency of the station you want to listen to. The specific antenna we will focus on is a “Tuned Loop Antenna”

The Tuned Loop Antenna

Loop antennas have been used for more than 100 years. Tuned loop antennas were first popularized in the 1940s. There are numerous designs and variations, as well as commercial products, but they all follow the same basic design. The tuned loop antenna is easy to build at home.

The tuned loop antenna provides a dramatic improvement in reception quality, often 10-100 times better than a loopstick. Weak or barely detectable stations can become easy to listen to.

Tuned loop antennas consist of a loop or coil of wire (the "inductor") and a "capacitor". Together the loop and capacitor form a "tuned circuit" that is "resonant" on a specific frequency. By adjusting the size of the coil of wire and the capacitor, the resonant frequency can be "tuned" to the frequency of the radio station you want to listen to. When the loop is resonant, it is vastly more efficient in picking up signals on that specific frequency. As it is not practical to vary they size of the loop of wire, it makes more sense to vary the capacitor, a task that is quite simple to accomplish with a "variable capacitor". One other component is needed, a frame of some kind to support to coil of wire making the loop. The electrical schematic of a tuned loop antenna is shown to the right.



There are hundreds if not thousands of tuned loop antenna designs already published. If you have Internet access, a quick search on "AM Loop Antenna" or "MW Loop Antennas". The published information ranges from the simple to the complex, the basic practical to the very technical. For the person who is not experienced with electronics, the perceived complexity of building a loop can be overwhelming. Certainly many of the articles show you how to build the best loop possible, but in reality, building a tuned loop antenna can be very basic and easy, using parts you can make yourself, and it will still work amazingly well. Not perfect, but entirely adequate. Here are a couple of pictures of typical loop antennas.

You can clearly see the loop of wire, the supporting frame, and the variable capacitor used to adjust the tuning.

The Problem with most loop antenna designs

Traditional tuned loop antenna designs have a number of problems for the unskilled builder who just wants better reception. These include:

- Complicated frames
- Variable capacitors are hard to find, or expensive
- Some loops are hard to build
- Lots of complicated and very detailed plans to follow exactly.

We need a simpler design. Here are the design goals for a “Simple Loop” antenna.

The Simple Loop

A simpler design loop antenna for MW reception should meet the following goals:

- Work almost as well as big loops
- Very cheap to build (free is better!)
- Only 30 minutes to build
- No hard to find or expensive parts
- No special tools
- Very forgiving design with no specific dimensions
- No connections inside the radio

These goals are very easy to meet.

The Simple Loop really only has three main parts:

- A loop of wire
- A frame to support the wire loop
- A variable capacitor to tune the loop.

We will now take a closer look at each part.

The Wire Loop

The Simple Loop requires about 20-25m of wire. A little more is okay, but not less. It needs to be insulated with plastic or even varnished enamel like transformer wire. The wire should be 0.5-1mm diameter (26AWG-18AWG). Bigger wire is hard to bend but works okay, and smaller wire can break more easily. Stranded wire is also better than solid wire as it is more flexible. This makes connections to the variable capacitor more reliable. None of these details are very exact. Basically use what you can find.

The Frame

The frame supports the wire in the loop shape. The "loop" can be square, rectangular, diamond shaped or even round. The exact shape is not critical. The most common designs published use a wooden X-shaped frame as shown earlier in some of the pictures. The frame should be made of insulating material. Wood or plastic works fine, metal will not. The exact shape or size is not critical.

The traditional materials and designs can be difficult to build mechanically. What we want is something very simple and inexpensive. The Simple Loop uses a cardboard box. Suitable sizes are 40x40 cm to 100x100 cm. The box should be at least 10-20 cm wide as the turns of the wire loop are 1 cm apart. A bigger box will need fewer turns to use up the 25m of wire, so can be thinner. The box can also be rectangular rather than round, such as 30 x 50cm. If you only have small boxes, tape them together to make a bigger box. Basically, just use what you can find.

Bigger loops will be more sensitive than smaller loops, and pick up weaker signals. The bigger loops will also do a better job of reducing interference from other stations.

The Variable Tuning Capacitor

The variable capacitor is usually the most difficult to find or expensive part of the loop antenna. Some loop builders recycle old ones from old MW radios. A variable capacitor is really just two or more metal plates or surfaces sliding past each other, very close but not touching.

Fortunately, a variable capacitor is actually very easy and cheap to build. Our variable capacitor is going to be built with envelopes, stiff paper or cards, and aluminum foil. The foil wraps around a piece of card stock. The card is placed inside an envelope. We will make three plates and put them together like a sandwich, with one sliding in and out inside the other two fixed envelopes.

Background Summary

So, that is the background on the Simple Loop. Expert builders might find the fancier designs work a bit better, but our goal is to build an antenna that works quite well at low or even zero cost, our of parts and pieces you can find in a remote location. In addition, it can be built by listeners with no specials tools and skills in radio engineering.

Let's now actually build our Simple Loop antenna.

Building the Simple Loop

What will we need?

The Simple Loop is made of just a few items that you can hopefully find for free or very low cost. Here is a list of the materials we need.

- ❑ A cardboard box, 40x40 - 100x100cm, by 20cm thick
- ❑ 25m of small insulated wire
- ❑ 3 business size envelopes
- ❑ 3 pieces of stiff card stock
- ❑ 2 small nuts and bolts
- ❑ Some adhesive tape
- ❑ Wire cutter
- ❑ Knife or hacksaw
- ❑ Pair of scissors
- ❑ Screwdriver
- ❑ Pen

The Assembly Steps

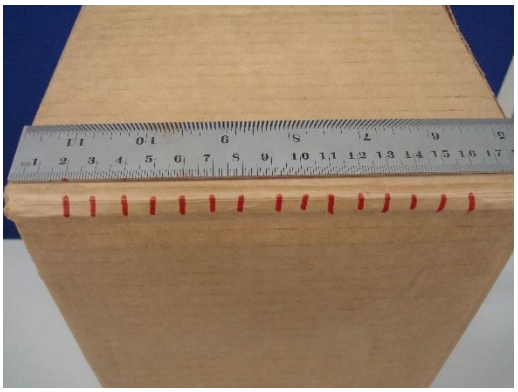
Now that we have gathered our parts, let's actually build the Simple Loop Antenna. We will divide the tasks into four steps.

1. Preparing the frame
2. Winding the wire loop onto the frame
3. Building the capacitors
4. Putting it all together

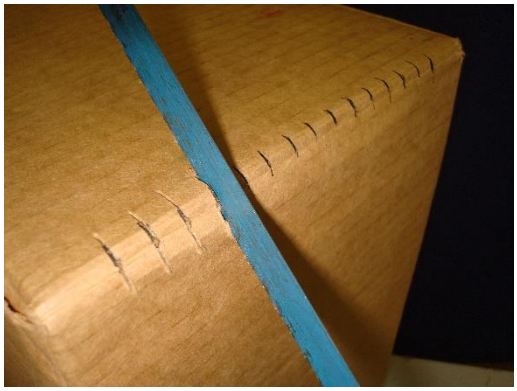
Preparing the frame

The first step is to prepare the cardboard box to act as the frame for the loop.

- ❑ Get a cardboard box, about 40x40cm – 100x100cm by 10-20cm thick. A square box is best but a rectangle shape is okay as long as long as two sides are reasonably close to the same length.



- ❑ Mark the four short 10-20cm edges with lines every 5-10mm apart so you have about 15 lines.



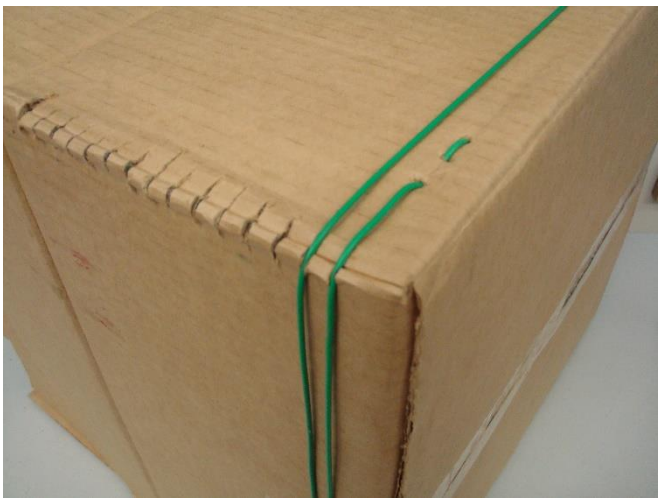
- ❑ Cut small slits on each line on all four short edges with a knife to hold wires in place. A hacksaw works well as it makes a wider slit. The slits only need to be 5-10 mm deep.
- ❑ Make three small holes 1cm apart near one corner by the first slit. You can see the small holes with the wire through them in the next picture below.

Winding the loop

Once the cardboard box frame has been marked and the edge slits cut, the wire loop can be wound onto the frame.

- ❑ Use 20-25m of wire for 550-1100 kHz range, or 15-20m of wire for 1000-1700 kHz range.
- ❑ Starting from the outside of the box, pass 50cm of wire through one of the three holes into the box. Loop it back out the second hole, and then through the third hole back into the inside of the box. This will hold the wire in place, and exit inside the box for now.

- ❑ Wind the wire around the outside of the box. Start from the hole where you pushed it through in the previous step, around the circumference of the box in the first row of slits. As you complete the first loop or “turn”, move the wire to the second row of slits, and so on. Continue around the box as if you were winding a screw thread. It makes no difference if you wind the wire clockwise our counterclockwise. Pull it down into the slits on the edges to hold in place.

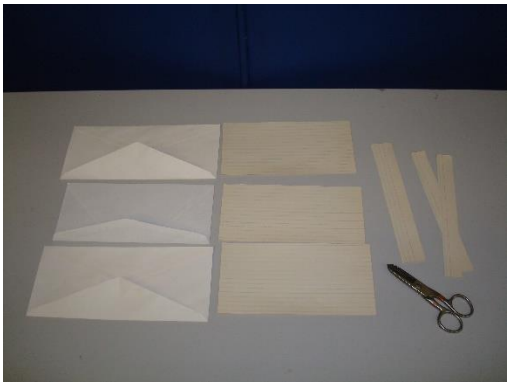


- ❑ When you have 1m left, make three more small holes under that wire.
- ❑ Loop this last 1m of wire through those three holes to secure it as you did earlier for the other end. This wire will also exit inside the box.
- ❑ Set the box aside for now while we build the variable capacitor.

Making the Capacitor

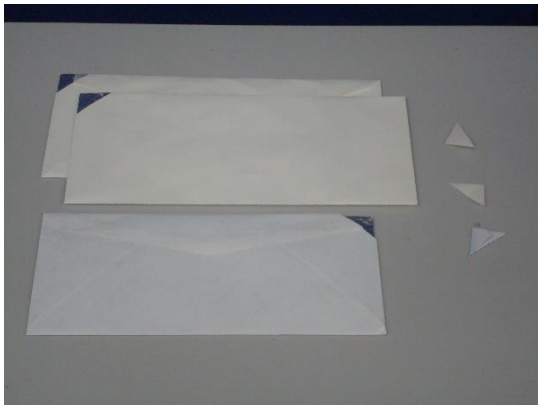
The next step is to build the variable capacitor that will be used to adjust, or tune, the frequency of the loop antenna. The capacitor consists of three identical plates. The plates will be stacked on top of each other. The outside two parts are fixed, and the middle one slide in and out like a trombone to get the adjustment. First, we will make the three “plates”. Then in the next step we will assemble them into a working capacitor.

Making the Capacitor plates



- ❑ Get three business size envelopes. If one envelope is slightly smaller than the other two, it will be easier to slide in and out and adjust the final capacitor.
- ❑ Cut three pieces of card stock to fit inside the envelopes. The card should fit with a 2-3mm to spare all around.

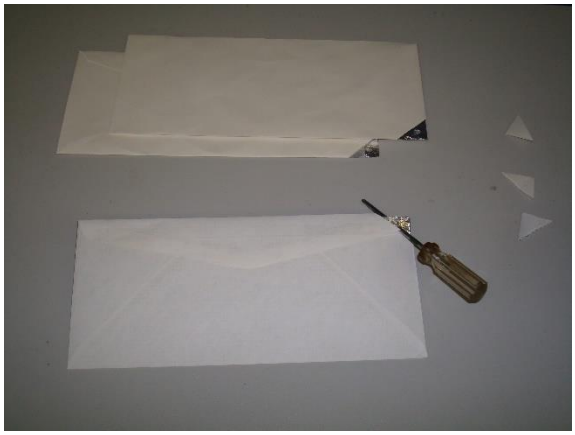
❑ Wrap the three thin pieces of card stock with aluminum foil all the way around both sides. Press down to flatten and then tape the edges of the aluminum foil. It is easiest if the seam where the foil comes together is in the middle of the card stock rather than right on an edge. You want to have foil-to-foil contact all the way around.

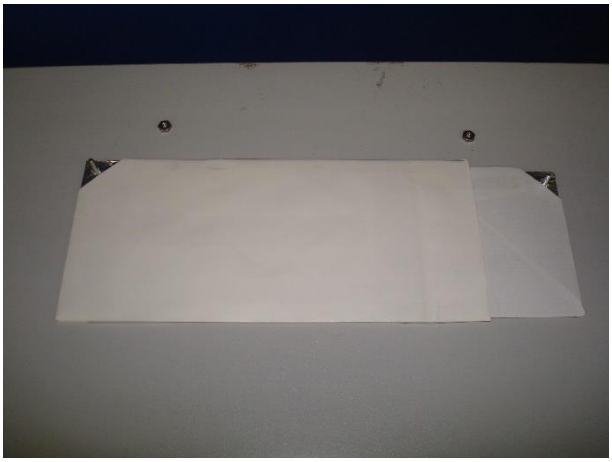


- ❑ Cut off one diagonal corner of all three envelopes by 2cm.
- ❑ Put a foil covered card inside each envelope so the foil is seen through the cut off envelope corner. Tape it down inside the envelope so it cannot move.
- ❑ Seal the envelopes.

Assembling the capacitor

- ❑ Place two envelopes on top of each other with the exposed foil corners together.
- ❑ Slide the third envelope (the smaller envelope if you were able to get one) inside the first two envelopes. The exposed corner should be on opposite long end of the exposed corner of the two outside envelopes.
- ❑ Make a hole through the foil parts of the two cards big enough for the small machine screw to fit through. Push a screw through each hole. Save the nuts for later use.



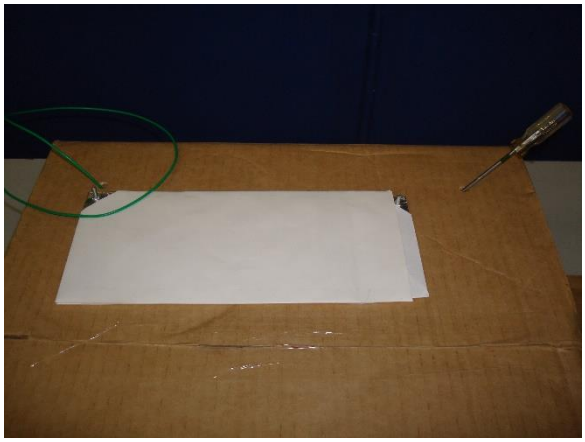


- ❑ Make a hole through the foil part of the third card for the other screw.
- ❑ Tape the two outside envelopes together on the long sides. You should be able to slide the inside envelope in and out between the other two envelopes.

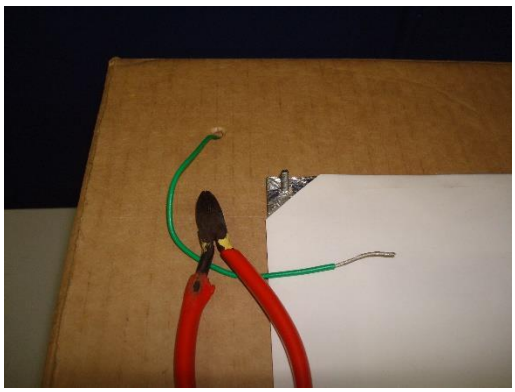
Final Assembly

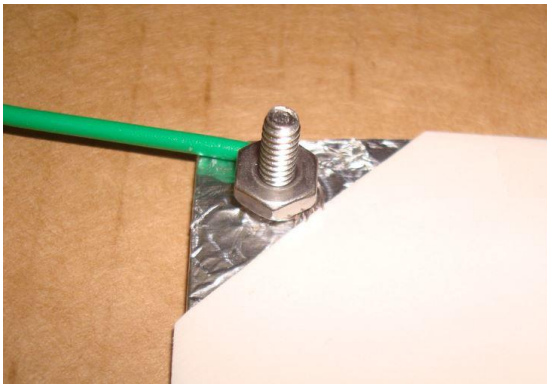
We will now begin assembling the loop antenna. We will attach the capacitor to the front of the cardboard box, and attach the loop wires to the capacitor.

- ❑ Make two small holes in the broad face of the box.
- ❑ Lead the ends of the loop wires out of the holes.



- ❑ Position the envelopes in roughly the desired location so you can see how long to cut the wires.
- ❑ Cut the wire to the “fixed” double envelope end 10cm longer than needed.
- ❑ Strip off 2-3cm insulation of the wire end.





❑ Wrap the wire end around the screw. Push it through the hole in the fixed envelopes. Tighten on the nut.

❑ Lead the other loop wire end to the moving part envelope of the capacitor.

❑ Cut the wire long enough to reach the screw as the moving envelope is moved all the way out.

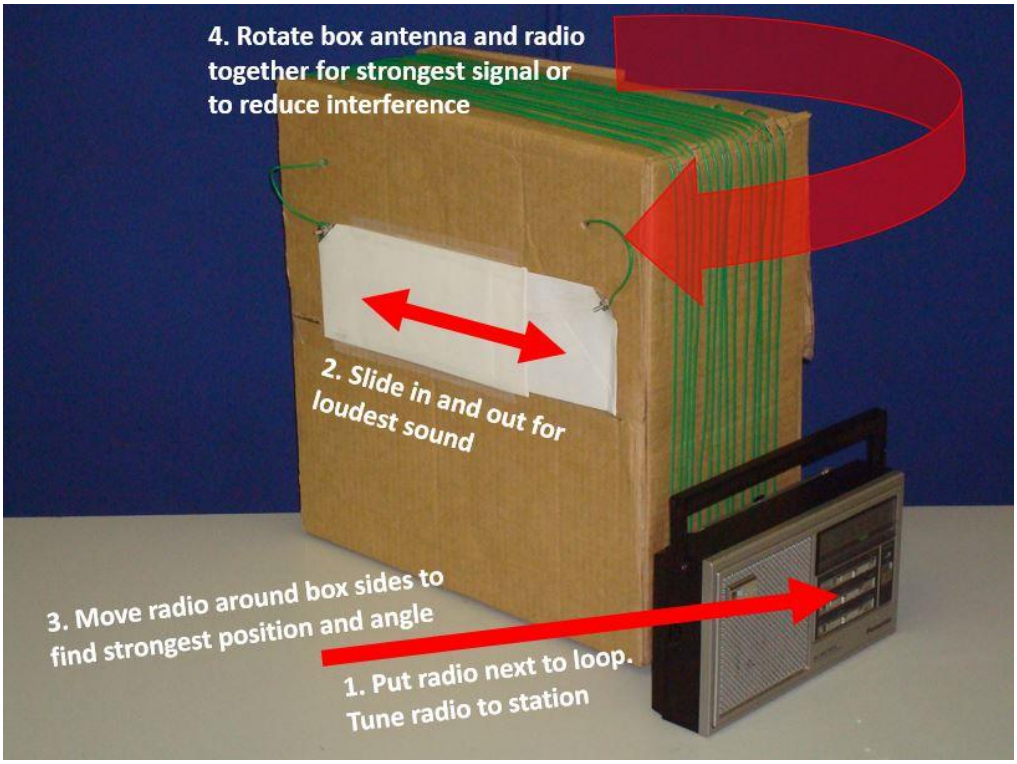
- ❑ Strip off 2-3cm insulation of the wire end.
- ❑ Wrap the wire end around the screw. Push it through the hole in the fixed envelopes. Tighten on the nut.
- ❑ Tape the fixed capacitor envelopes to the front of the cardboard box frame with the nuts facing out.
- ❑ Close or tape up the back side of the box.

Congratulations! The loop antenna construction is complete!

Using the loop antenna.

Now that you have built your loop antenna, we need to learn how to use it.

- ❑ Put the loop antenna on a table so the wires are upright.
- ❑ Push the movable capacitor envelope all the way in between the fixed envelopes.
- ❑ Turn on the radio. Turn up the volume of the radio, even if you just hear noise or hiss.
- ❑ Tune to the desired frequency (*Step 1 in diagram*.)
- ❑ Put the radio alongside the wires of the loop. Try it first with the back of the radio laying alongside the loops of wire.
- ❑ Slowly pull the movable envelope out. At some point the sound out of the radio will get louder. Carefully adjust the movable envelope back and forth for the loudest sound. You may need to turn the volume on the radio down (*Step 2 in diagram*.)
- ❑ Now move the radio around the loop in different positions to see if the sound gets even louder (*Step 3 in diagram*.)
- ❑ Rotate the loop and radio together to get the best reception or reduce interference. The reception is strongest in the direction of the wire in the loops, and weakest at right angles to the loop. This means you can adjust the loop direction for the strongest signal that you want to receive, or broadside to reduce the interference from another station (*Step 4 in diagram*.)
- ❑ Many times even a hiss with no signal will now be a very strong signal from the radio station.



- Congratulations. Enjoy your loop antenna and have a wonderful time listening to stronger signals.
- The picture below shows a collection of different loop antennas. You can see the wide variety of sizes and shapes. The bigger antennas are more sensitive, but even the little 30x30 cm loop makes an amazing difference.