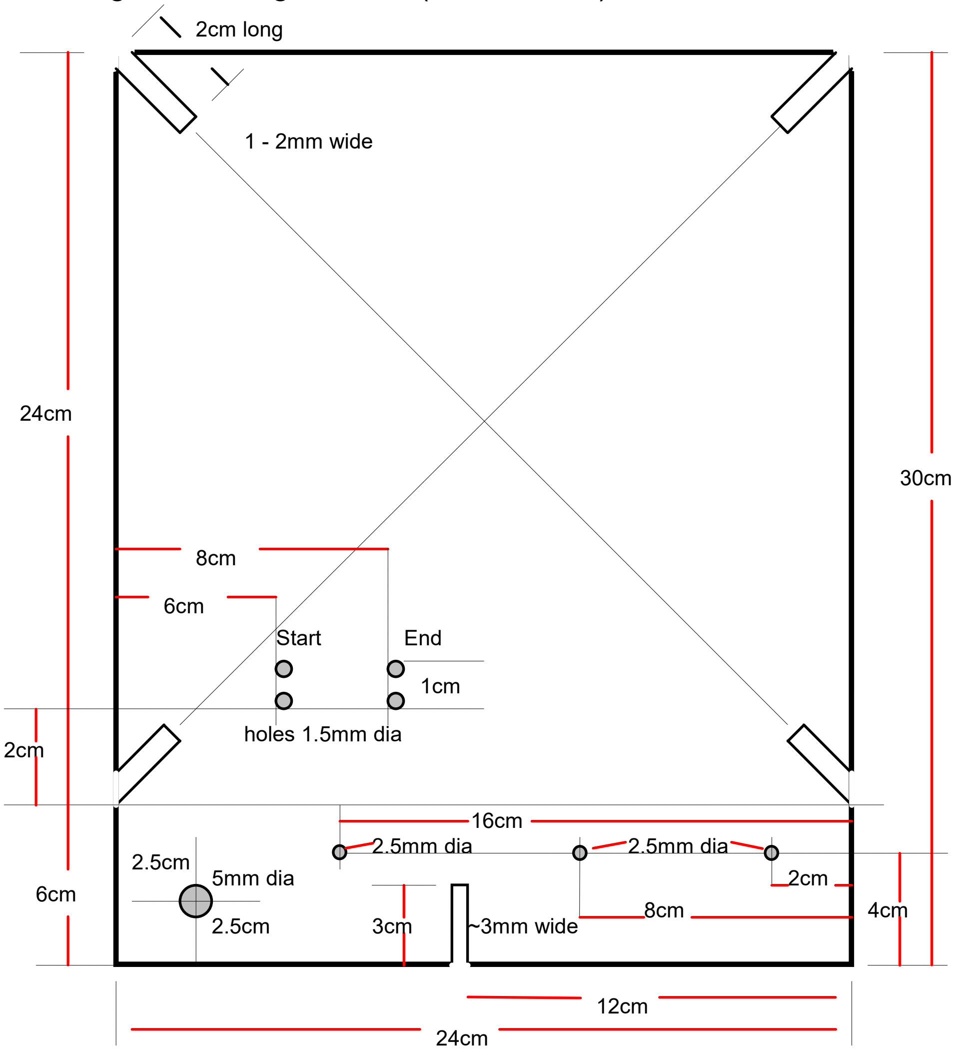
'Crystal-set' Radio.
Construction.

Section 1

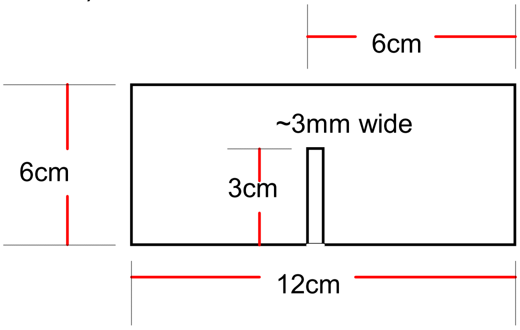
You will need:-

1 x hardboard base, 24cm x 30cm. The radio board.
1 x hardboard stand, 12cm x 6cm
1 x ~14m of ~0.31mm (30swg) enamel coated wire
Wire cutters

Radio board cutting and drilling details. (Not to scale)



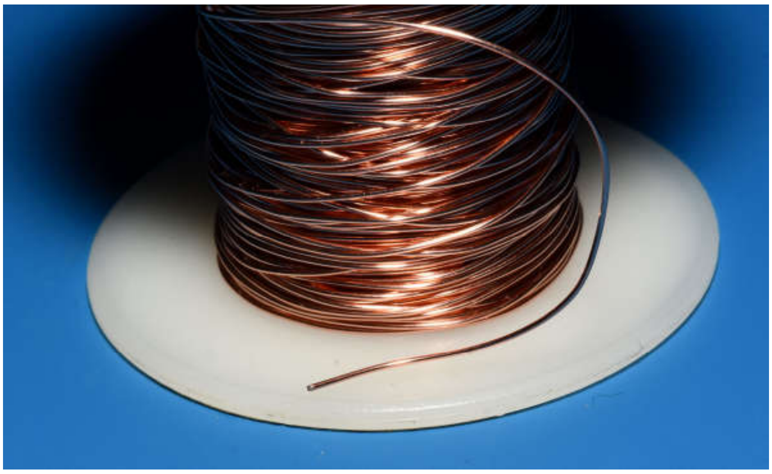
Radio board stand. (Not to scale)



Assembly.

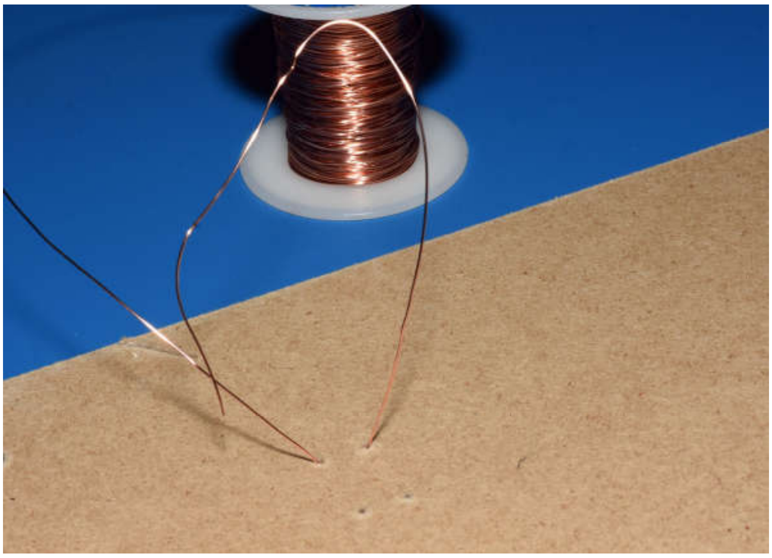
Winding the coil.

The wire is made from copper and coated with an enamel varnish to insulate the wire.

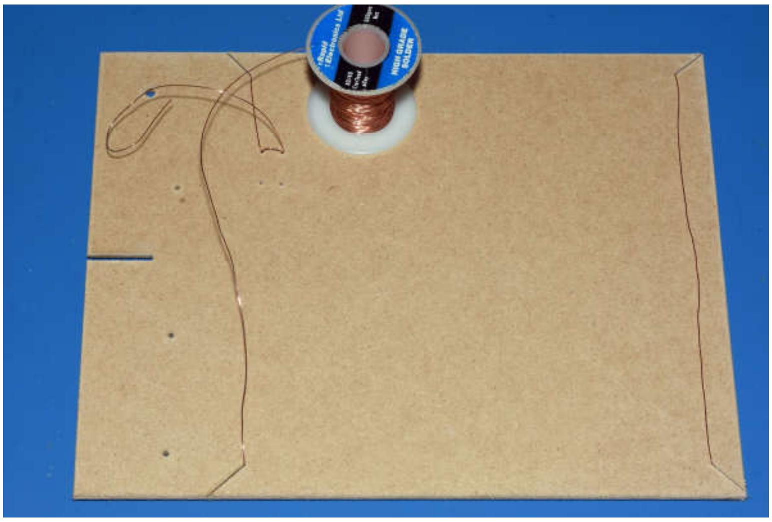


Take care to ensure that the wire does not become tangled and knotted.

Start by threading the wire through the holes as in the image below.



Loop the wire round again and then start to thread the wire around the slots in the edge of the radio board.

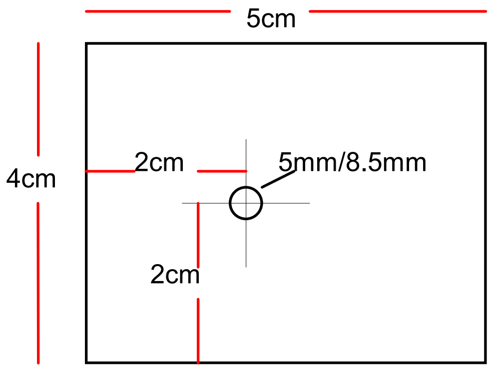


Keep the wire pulled tight and wind 15 turns around the slots.
End the coil on the 16th turn by threading the wire through the pair of holes next to the start of the coil. Leave around 20cm of wire at the end.

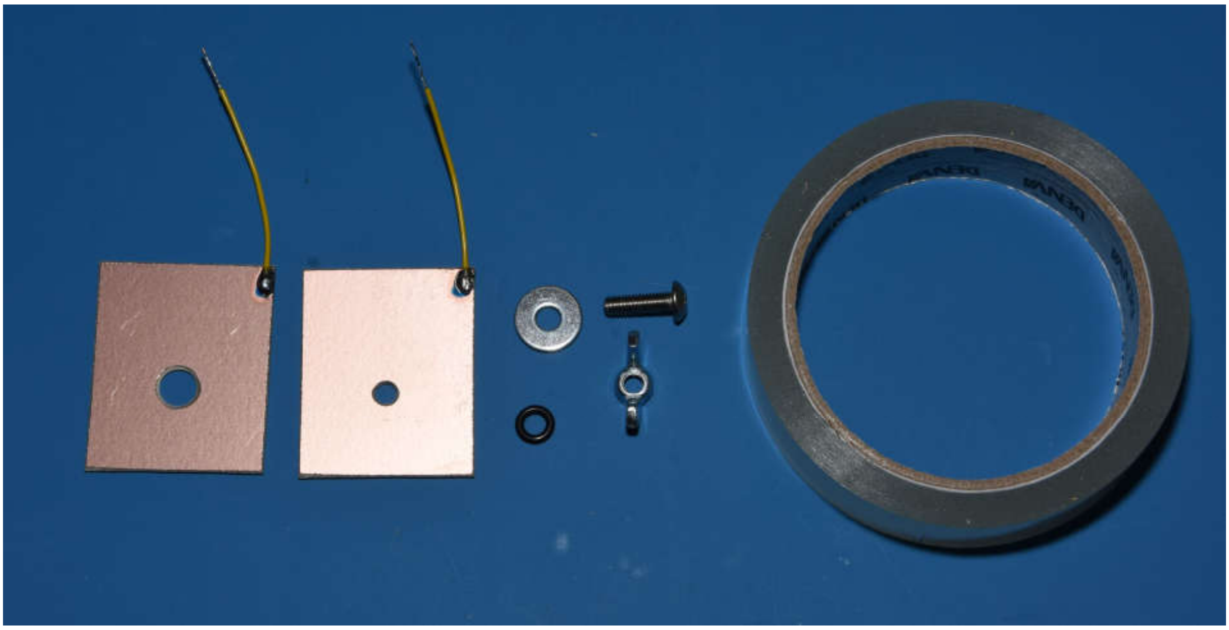
Section 2

You will need:-

1 x piece of printed circuit board (pcb) 4cm x 5cm drilled with a 5mm hole.
1 x piece of pcb 4cm x 5cm drilled with a 8.5mm hole.

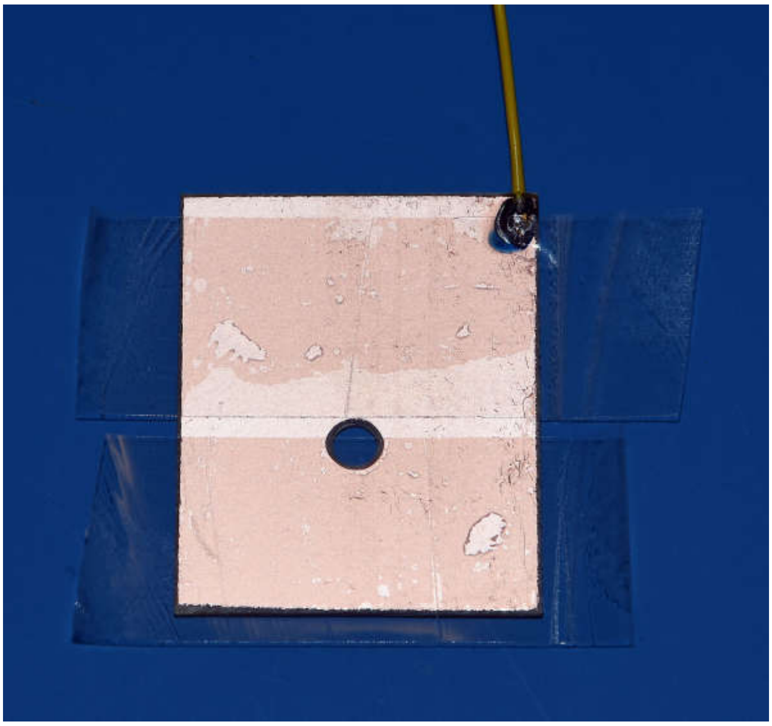


1 x 'O' ring, 5mm inside and 9mm outside diameter.
1 x M5 20mm bolt,
1 x large M5 washer,
1 x M5 wing nut,
Selotape,
Glue.

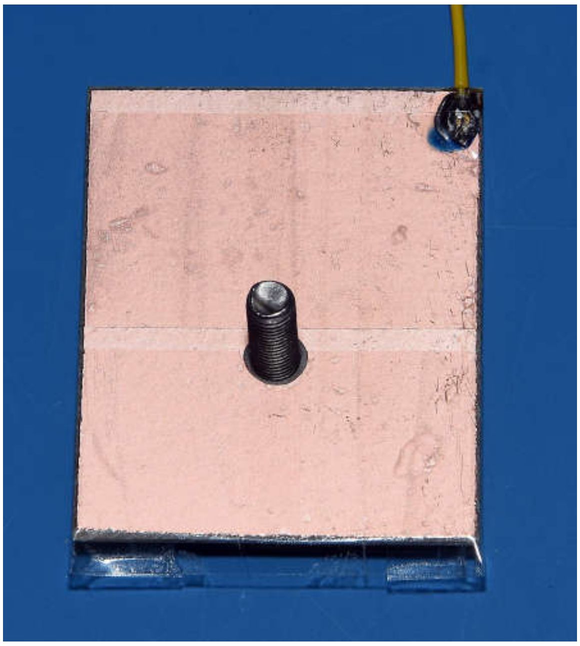


Solder a 6cm long stranded wire to the corner of each pcb if not already done.

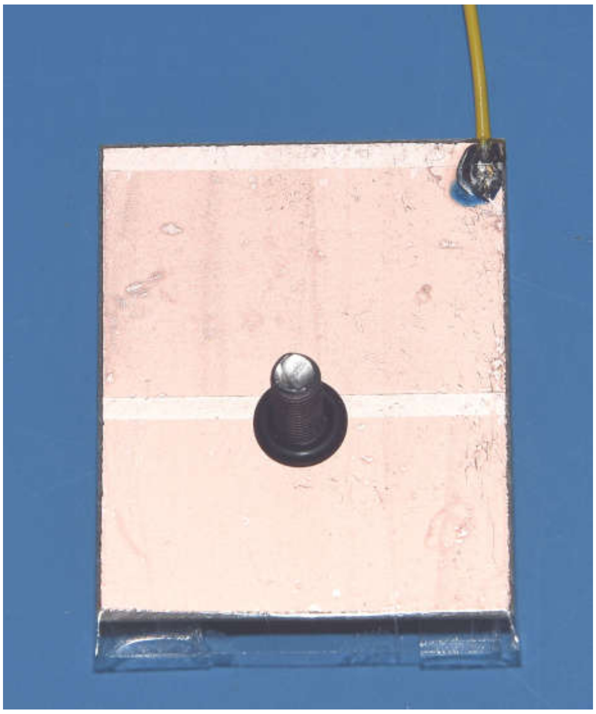
Put two strips of Selotape on the copper side of the board with the small hole.
A small gap in the middle does not matter.
Ensure that there are no creases, overlaps or air bubbles.
Carefully cut away any Selotape from over the hole.



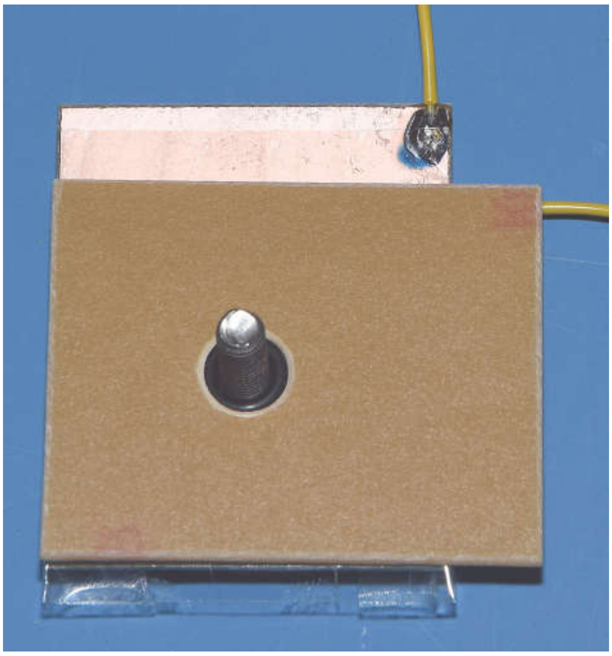
Carefully pass the bolt through the hole in the board.



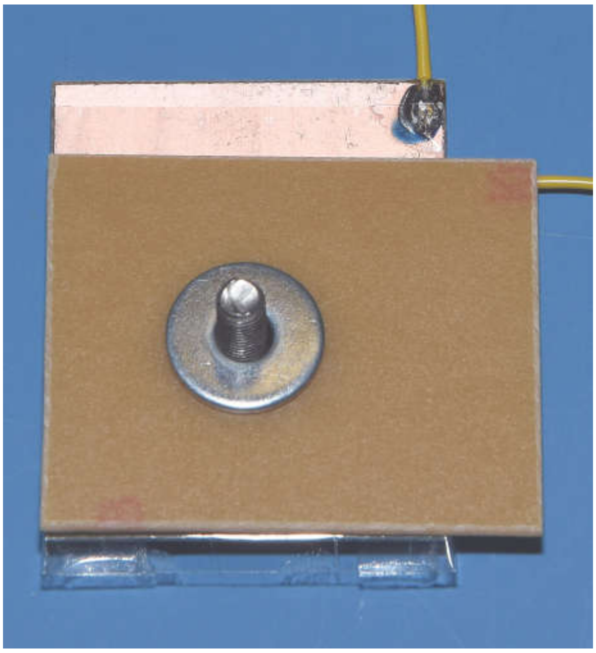
Place the 'O' ring over the bolt.



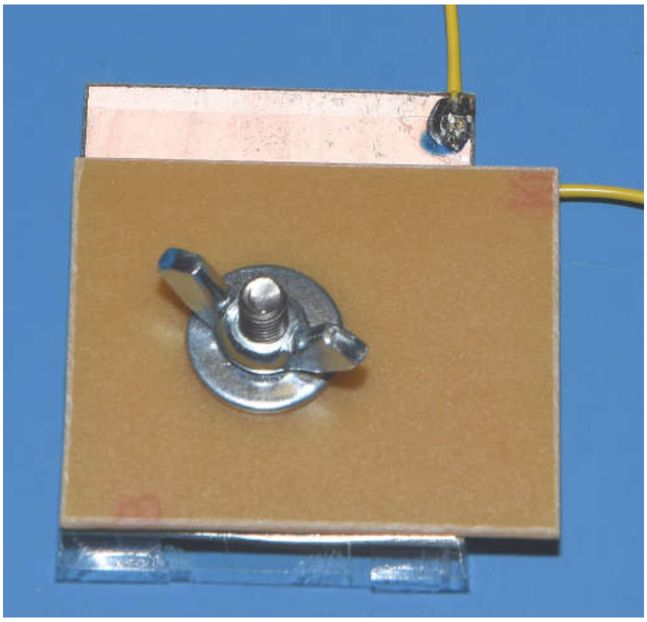
Place the other board over the bolt so that the two copper sides are facing.



Place the large washer over the bolt.

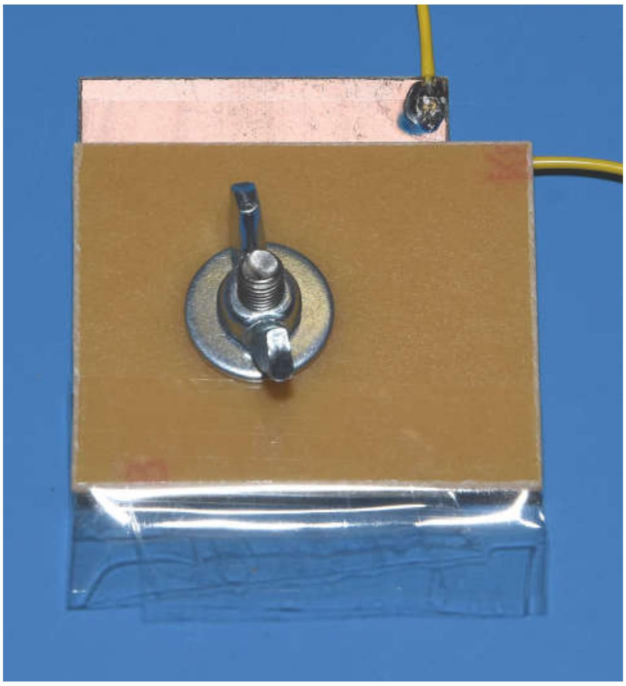


Screw the wing nut onto the bolt.



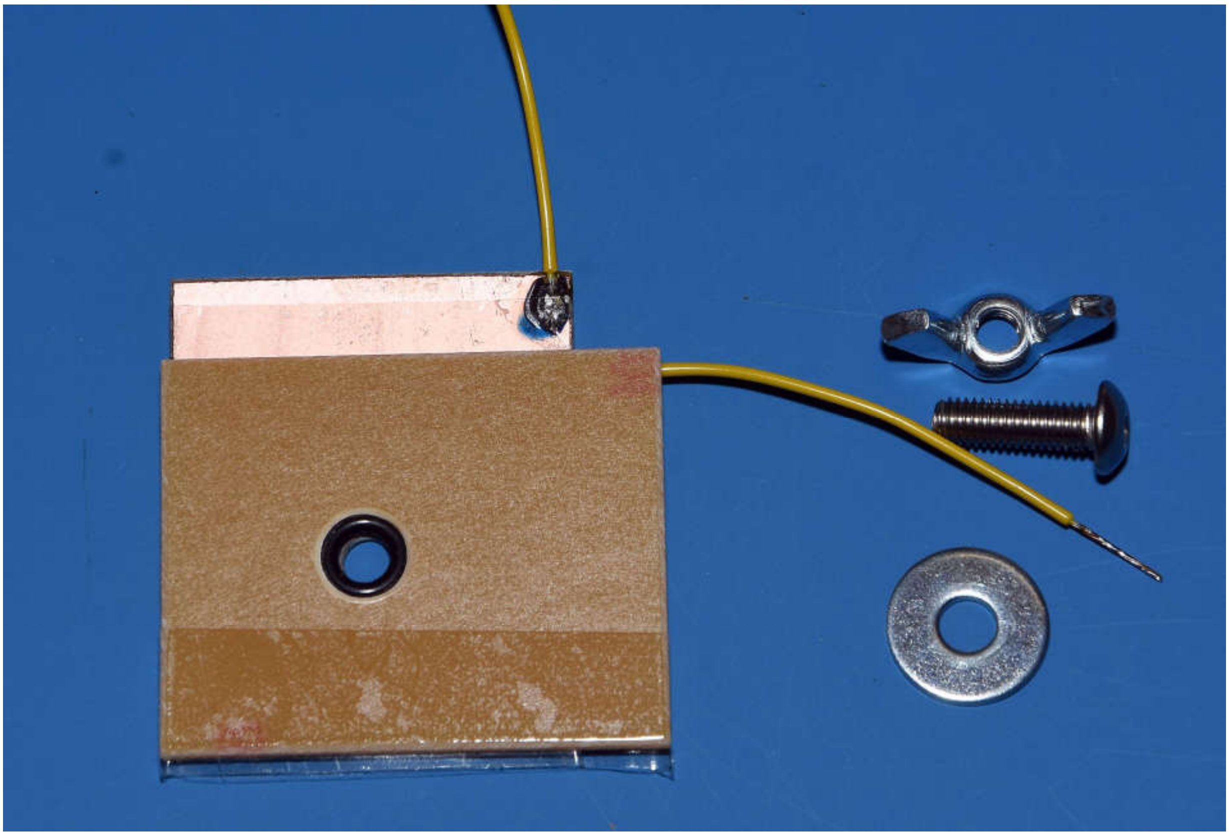
Adjust the wing nut so that the boards are held together loosely.

Put a loop of Selotape loosely around the two boards to hold them together.



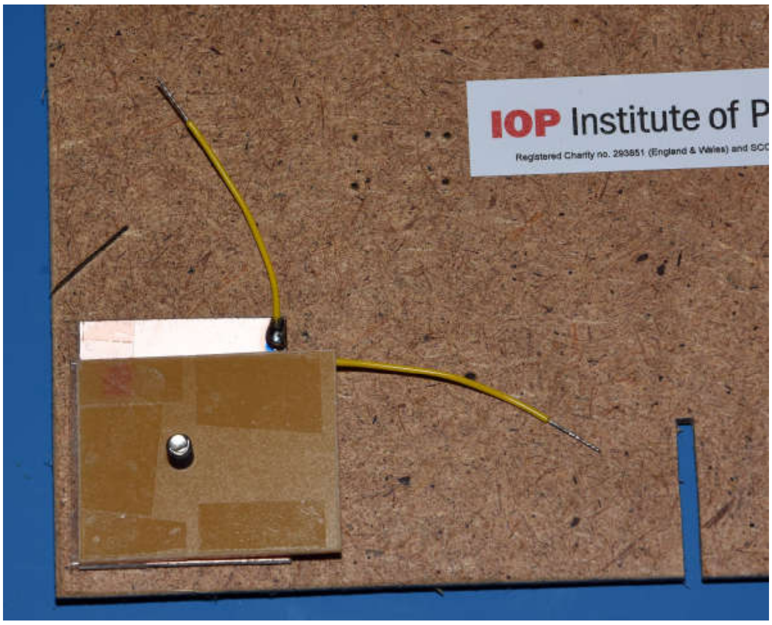
This makes the variable capacitor.
Trim the overhanging Selotape.

Carefully, remove the wing nut, washer and bolt.

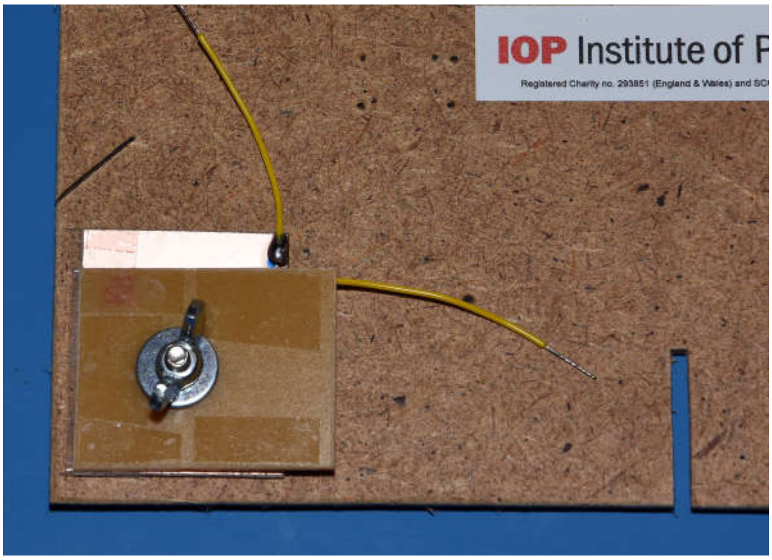


Put the bolt through the hole in the radio board (it will be tight!)

Put glue onto the radio board around the bolt. (Ensure that there is no glue on bolt!)
Carefully put the capacitor onto the bolt.



Finally, put the washer and wing nut onto the bolt.

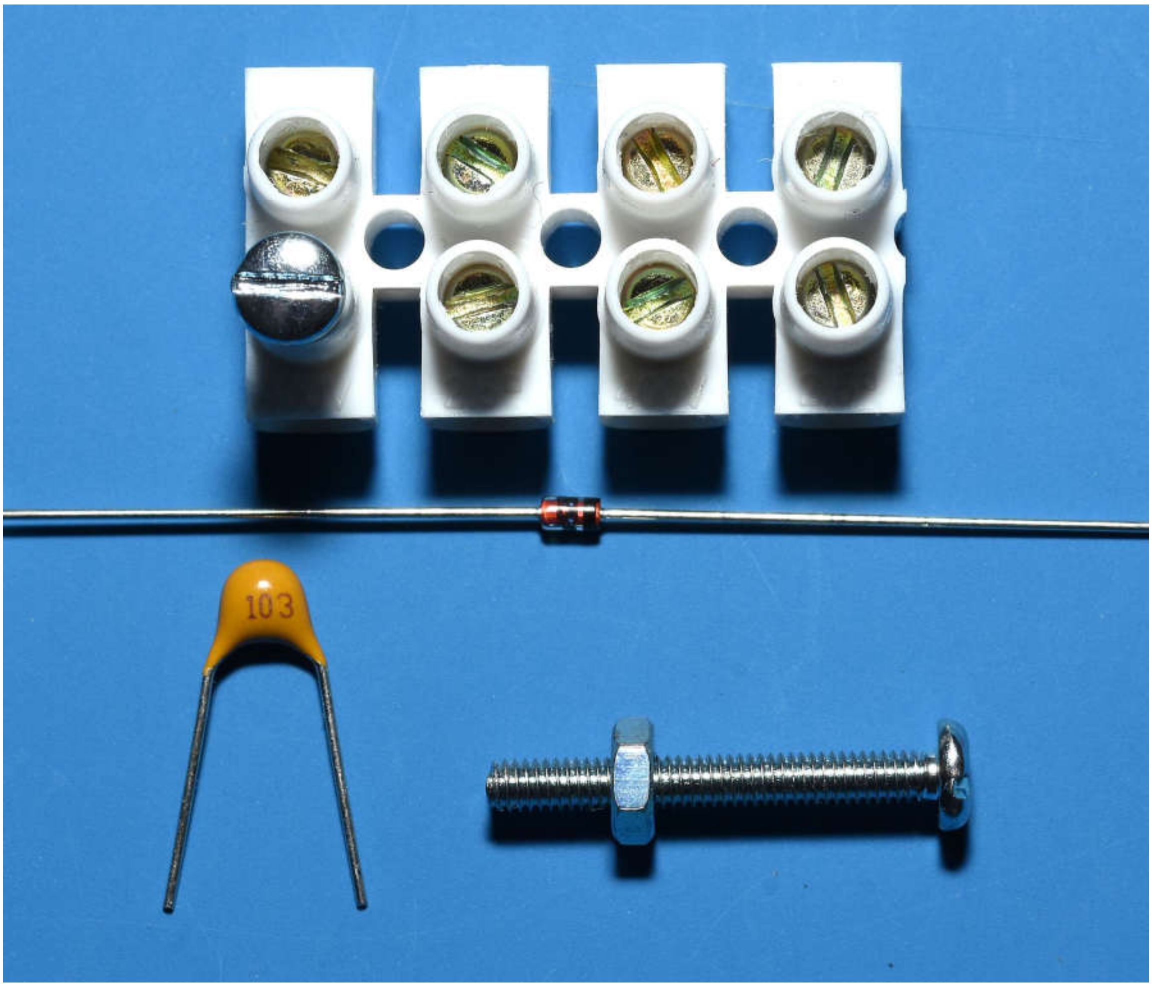


That completes the tuning capacitor.

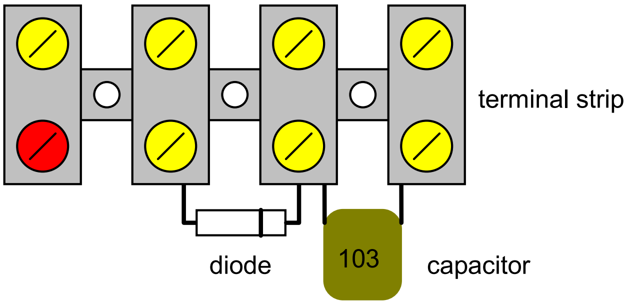
Section 3

You will need:-

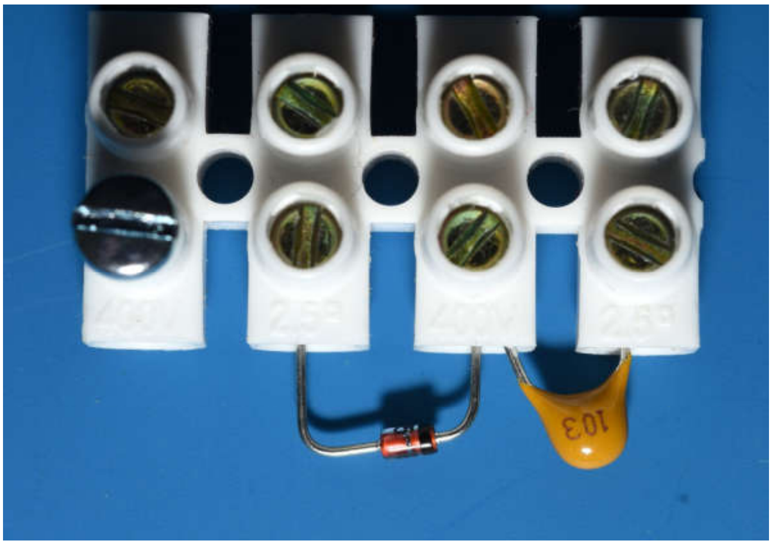
1 x four section terminal strip, with one screw replaced with a 20mm M2.5 bolt.
1 x 25mm M2.5 bolt and nut
1 x BAT 85 diode (or equivalent)
1 x 10nF capacitor.



Put the diode and capacitor into the terminal strip.

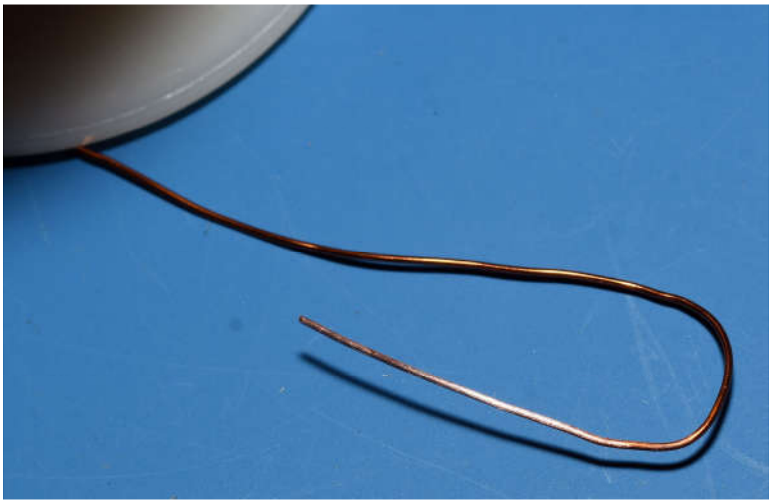


Gently tighten the screws in the terminal strip.



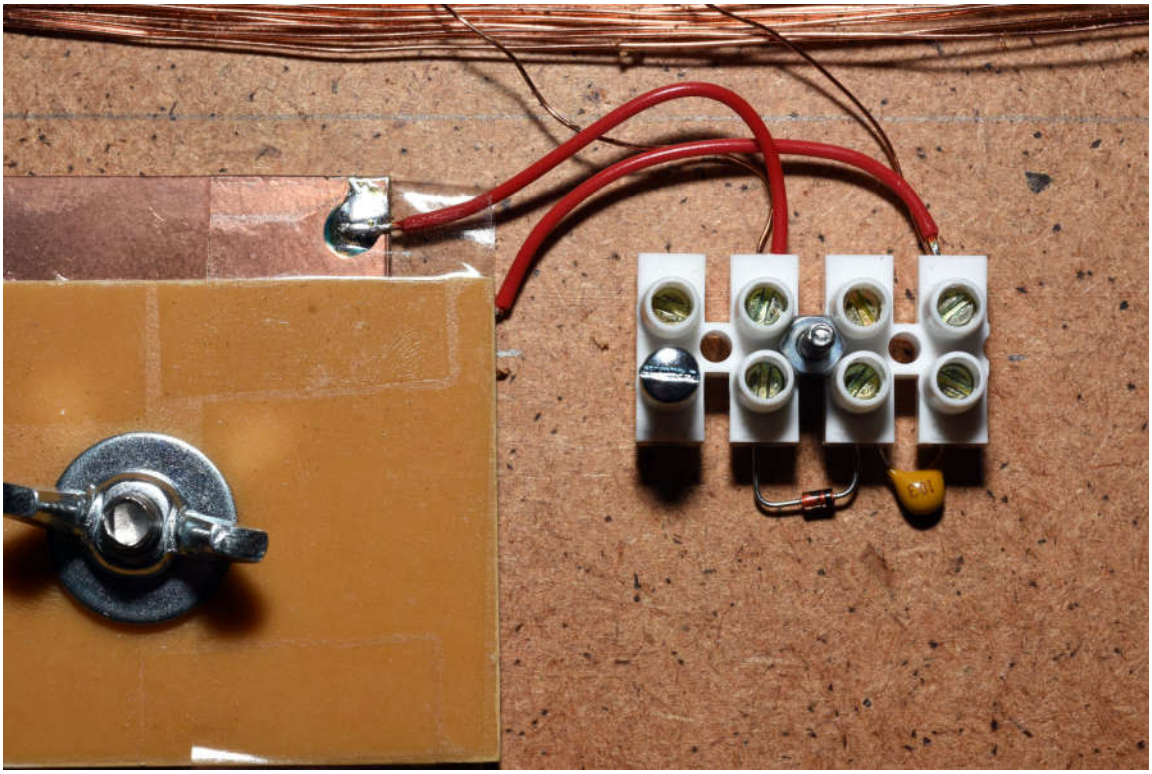
Put the 2.5mm bolt through the hole near the tuning capacitor.
Put the terminal strip onto the bolt and fix with the nut.
Gently tighten the bolt with the screwdriver.

The ends of the coil need to have the enamel removed.
Use sand paper to gently remove the enamel from the end 25mm.



(If time permits - coat the bare wire with solder.)
(Solder melts at 240°C - EXTREME CARE)

Put the wires from the coil into the terminal strip.
Put the wires from the capacitor into the terminal strip.

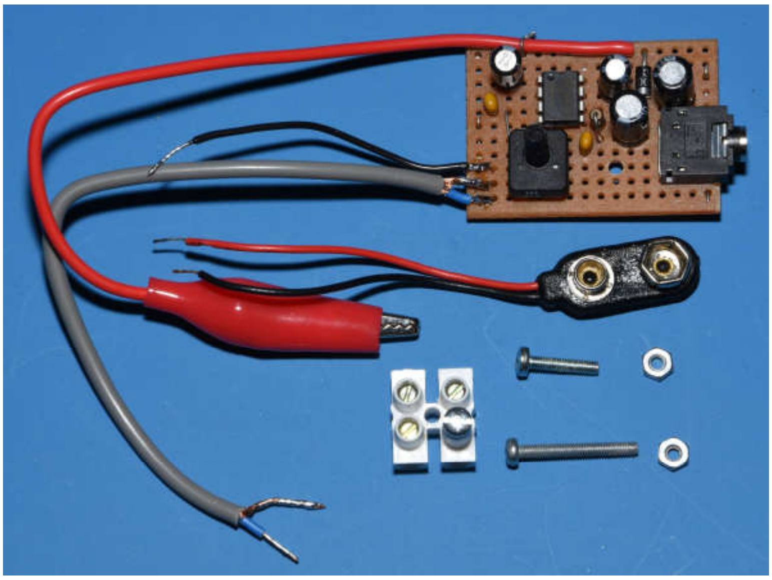


Gently tighten the screws.
This completes the actual radio receiver.
We now need some way to be able to hear the radio!
The output from the radio is very weak (0.01V).
It can be heard with very special earphones - very expensive!
Cheaper to use an amplifier and ordinary earphones.

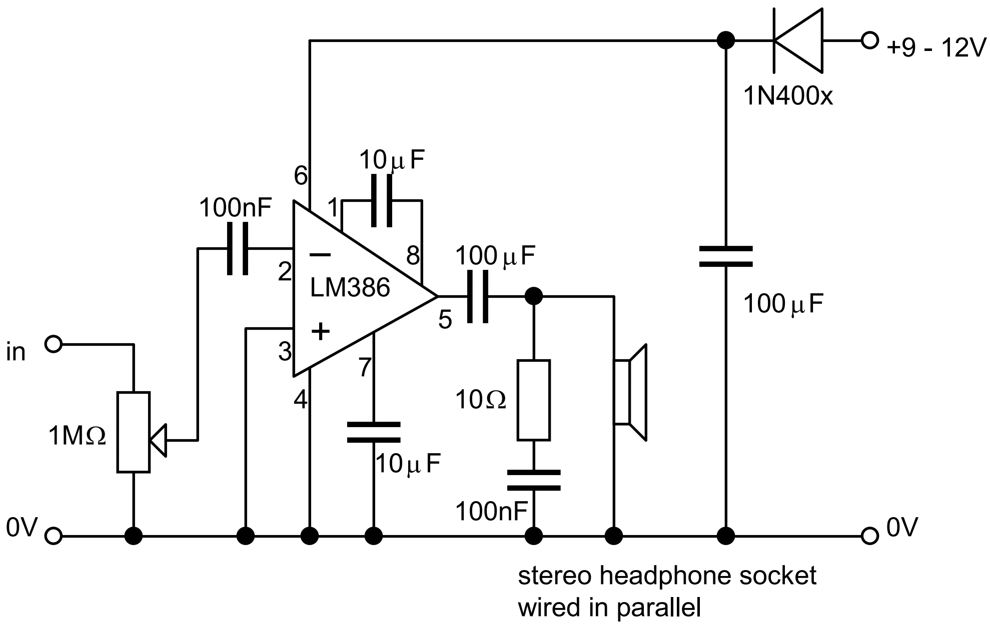
Section 4

You will need:-

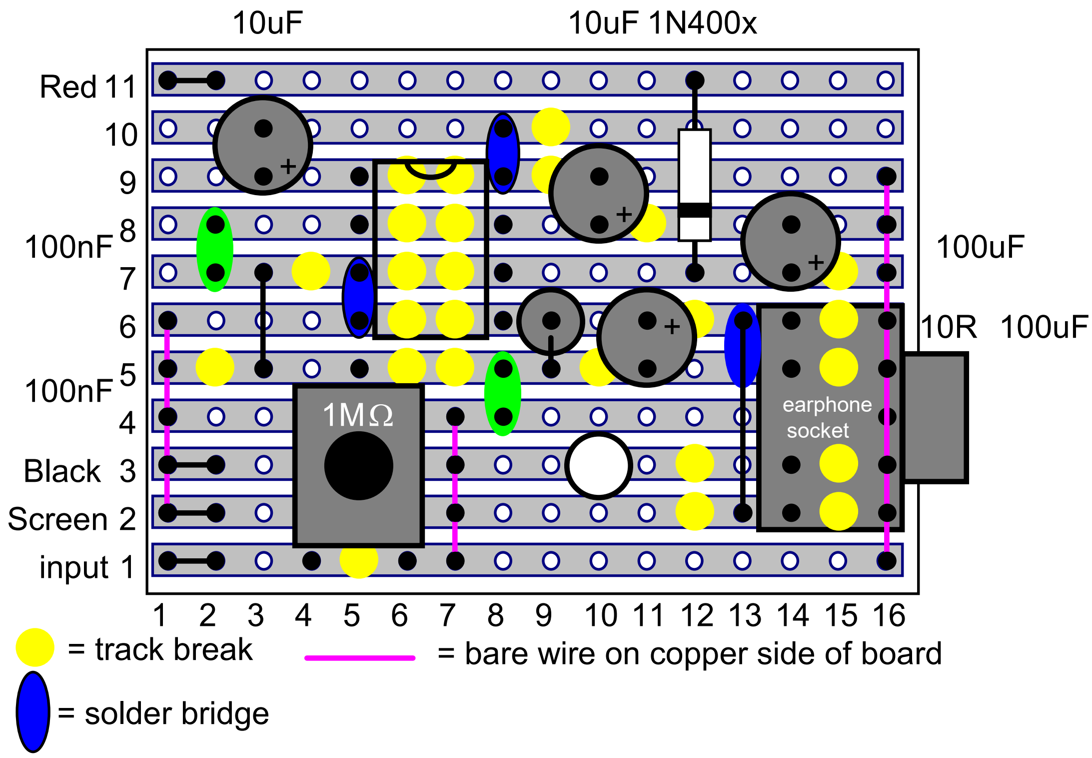
1 x amplifier module
1 x PP3 battery connector
1 x PP3 battery
1 x two section terminal strip, with one screw replaced with a 20mm M2.5 bolt.
1 x 25mm M2.5 bolt and nut
1 x 20mm M2.5 bolt and nut
BluTac or equivalent



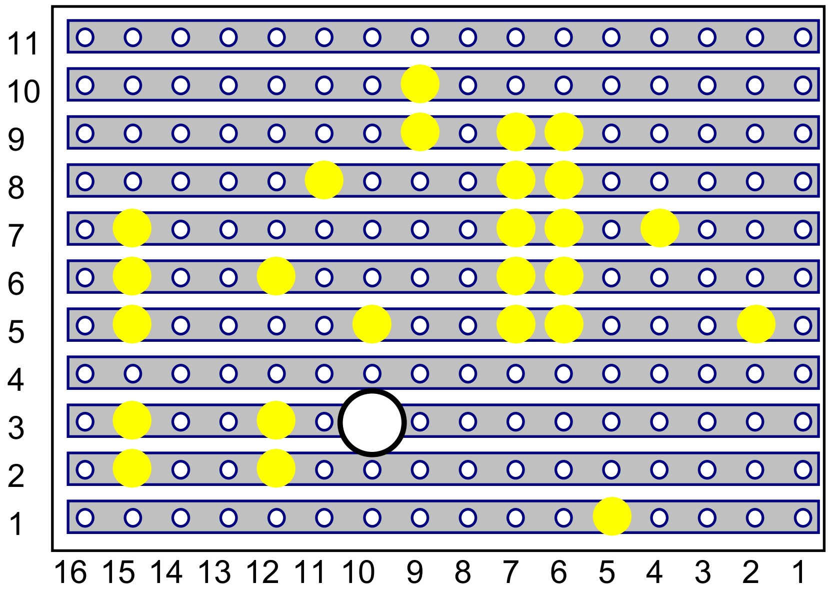
The amplifier module.
This is based on the LM386 amplifier IC.



The originals were assembled on a piece of strip board 11 strips by 16 holes.



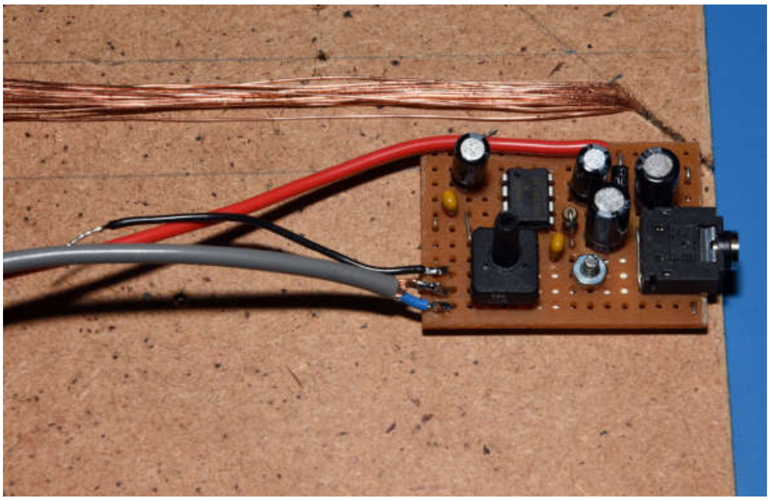
The reverse side of the strip board needs the circuit breaks shown below.



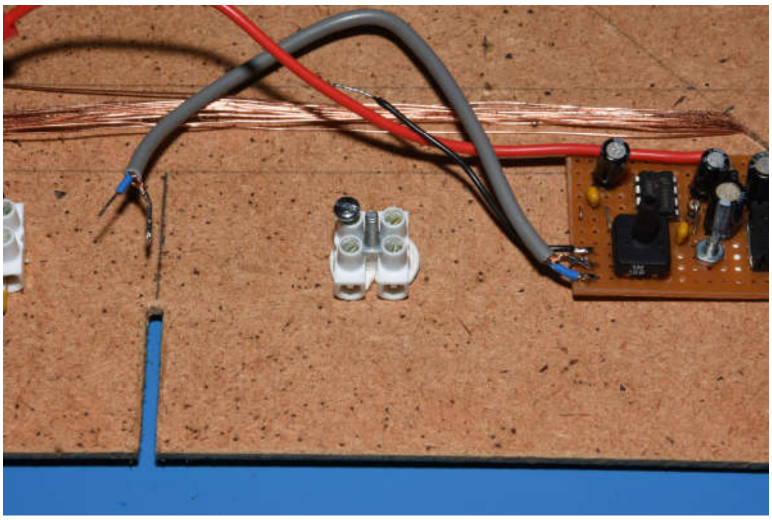
The red crocodile clip lead forms part of the On/Off switch and is 190mm long including the clip.
The black wire is 60mm long.
The battery connector leads are 90mm long including the connector.
The screened wire is 150mm long.

Put a small piece of Bluetac on the solder side of the amplifier.
Push the short 2.5mm bolt through the hole in the radio board.

Put the amplifier onto the bolt and fit the nut to the bolt.
Tighten gently.

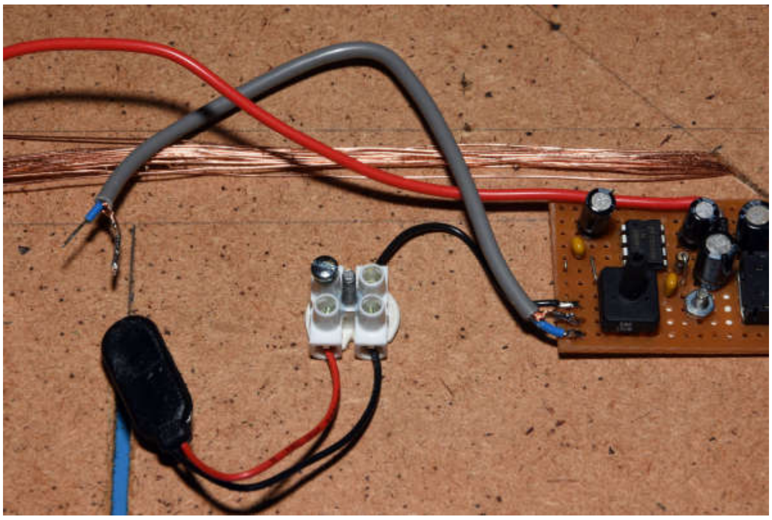


Put the long 2.5mm bolt through the remaining hole.
Put a small piece of Blutac underneath the terminal strip.
Put the terminal strip onto the bolt and fit the nut.

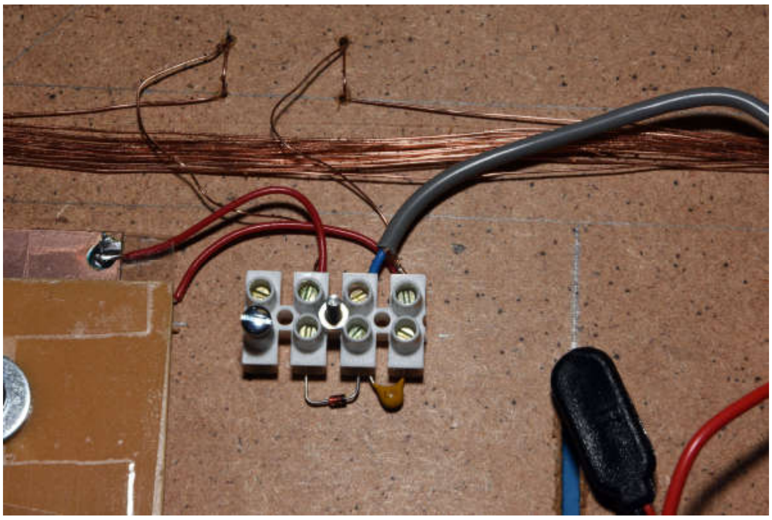


Tighten gently.

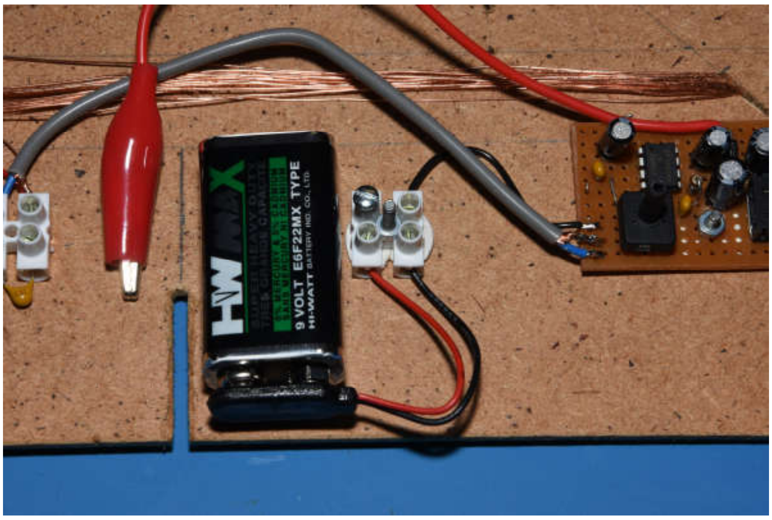
Fit the battery connector wires to the terminal strip.
Connect the black wire from the amplifier to the terminal strip.
Black wire to the battery connector black wire.



Connect the grey wire(s) to the radio terminal strip.
Ensure they are the right way round, screen to the right hand terminal.



Bluetac the battery to the radio board.
Attach the battery connector to the battery.



Plug your earphones into the earphone socket.
Clip the red lead onto the battery connector screw.
Turn the volume control anticlockwise.
Hold the radio vertically.

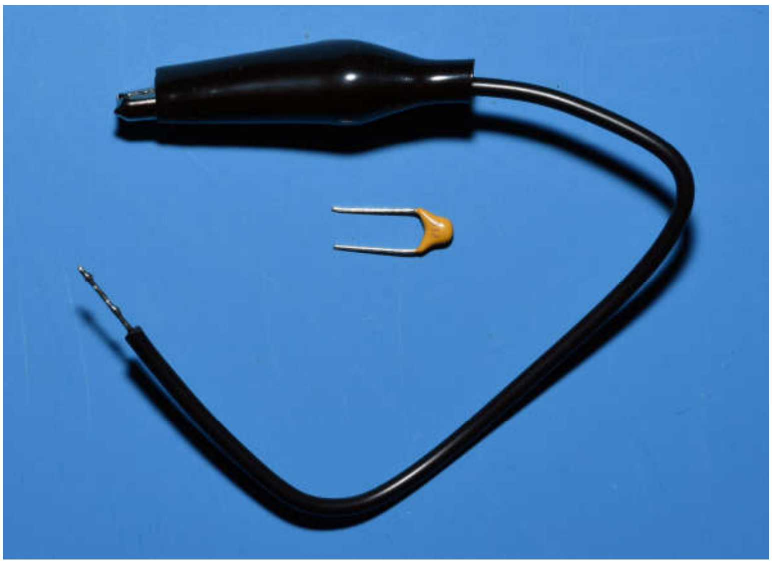
If all is well then something should be heard in the earphones!
Radio stations should now be tuneable using the wing nut on the tuning capacitor.

Fault finding.

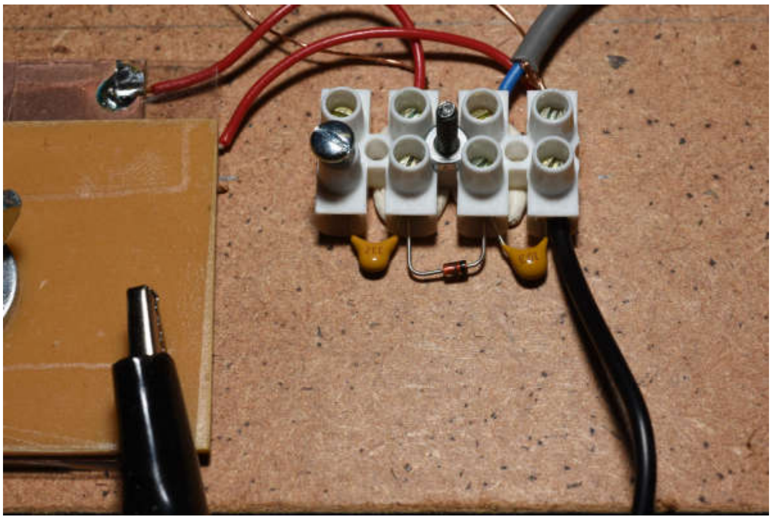
Check for wiring errors.
Ensure that all terminal block screws are tightened.
Check that the enamel is removed from the ends of the coil.
Check that the Selotape and O ring are correctly in place in the capacitor.
If a hiss is heard from the earphones, then the amplifier is working and the fault is in the radio section.

If there is no hiss heard then the fault is in the amplifier section or its wiring.

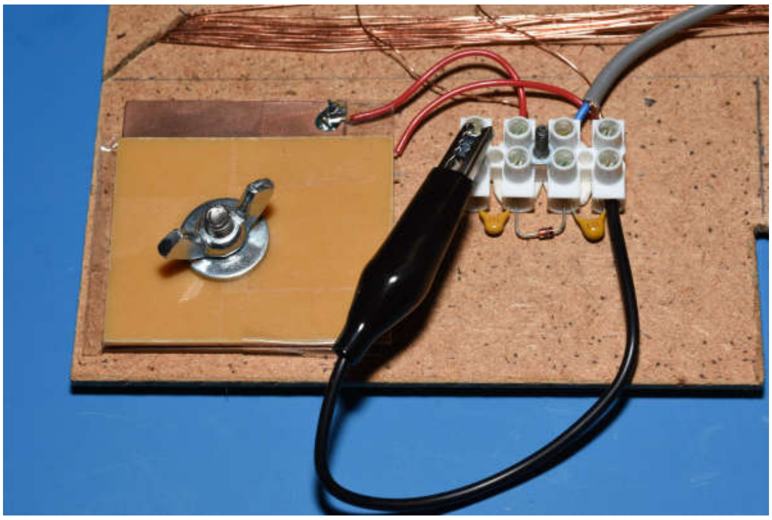
The reception of the radio can be increased to receive Radio 4 (198kHz).
The extra components needed are a 3.3nF capacitor (332) and a crocodile clip lead.



Add the black crocodile clip lead and the capacitor (332) as in the photograph.



To receive Radio 4 clip the black lead onto the screw connector and adjust the tuning capacitor.



To complete the project:-

push the base onto the radio board to make it stand upright,
attach your picture to the radio board to complete the project.

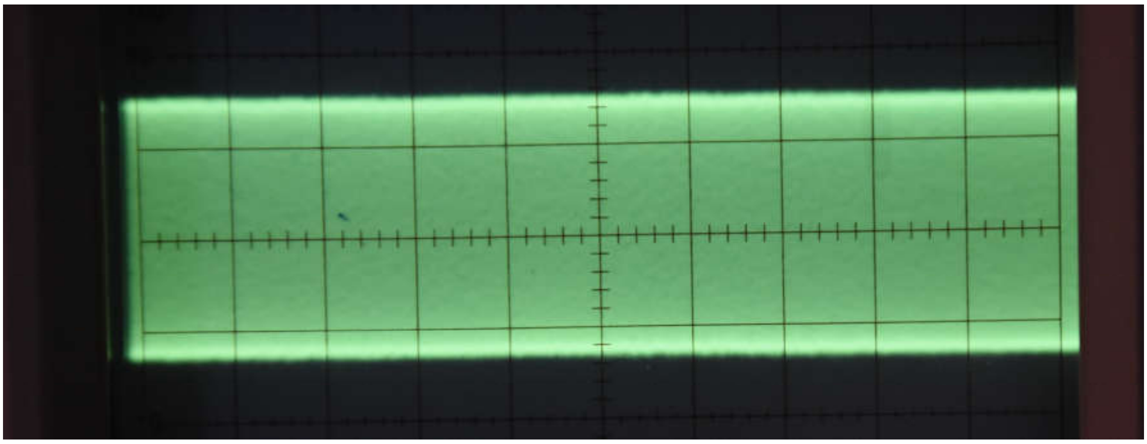
Completed crystal radio project.

How it Works

A radio wave consists of two components - a varying electric field and a varying magnetic field. In most radio systems, it is the electric field that interacts with the aerial and produces a small alternating voltage across the aerial.
In this radio, the varying magnetic field passing through the coil, generates a small alternating voltage across the ends of the coil.

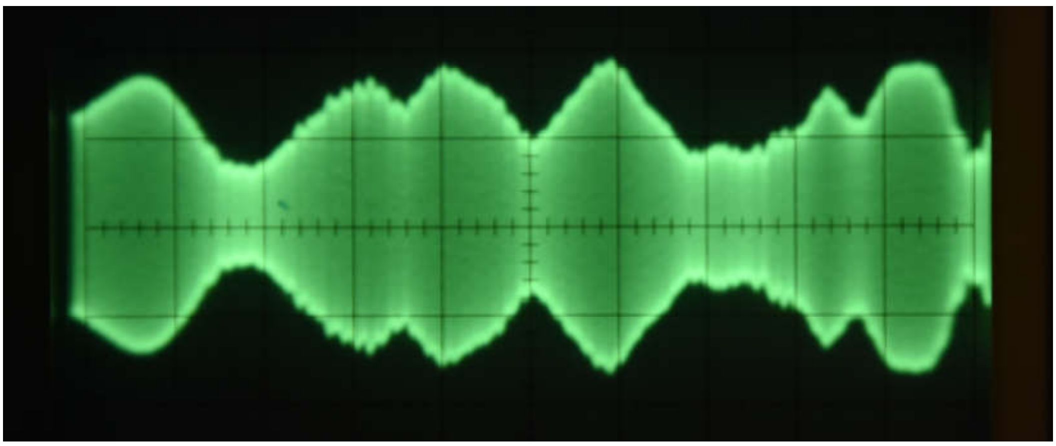
To select a particular station, the coil is made to resonate at the frequency of carrier of the radio station by connecting a capacitor across the ends of the coil.
If the tuning capacitor is variable, then different radio stations can be selected.
The tuning capacitor in this design is made from two thin copper plates (pieces of printed circuit board) separated by a layer of Selotape and air.
As the wing nut is adjusted, the separation of the copper plates changes and the capacitance is varied.
The 'O' ring acts as a spring to push the copper plates apart when the wing nut is undone.

The image below shows the output from the coil and capacitor when tuned to a radio station and displayed on an oscilloscope. The image was taken during a period of silence in the radio program.



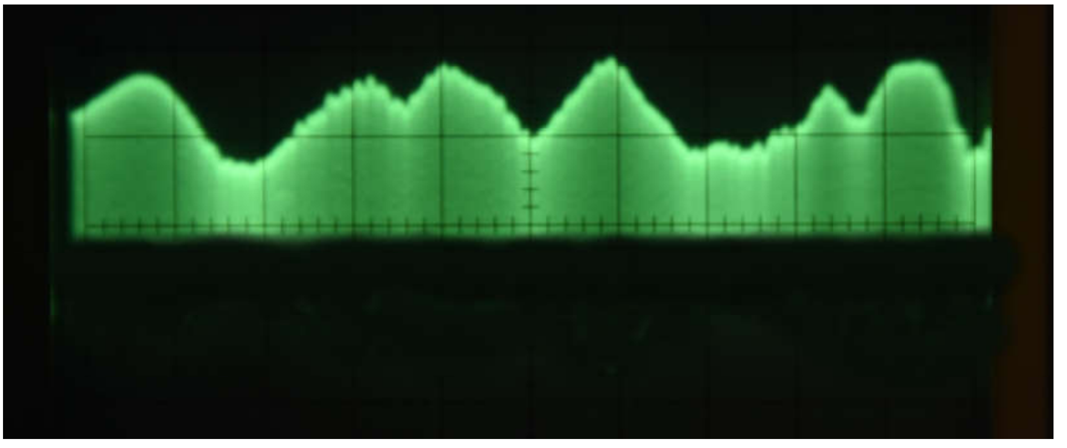
This is the carrier signal and can be thought of as being like an envelope when sending a letter. The output from the coil and capacitor is an alternating voltage, but, because the time taken to produce the oscilloscope trace was long compared to the time period of the carrier, it is shown as above. (The 'waves' are all squashed together).

The image below shows the carrier when information is being transmitted.



In this image, the information is changing (modulating) the amplitude of the carrier. (Amplitude Modulation.)

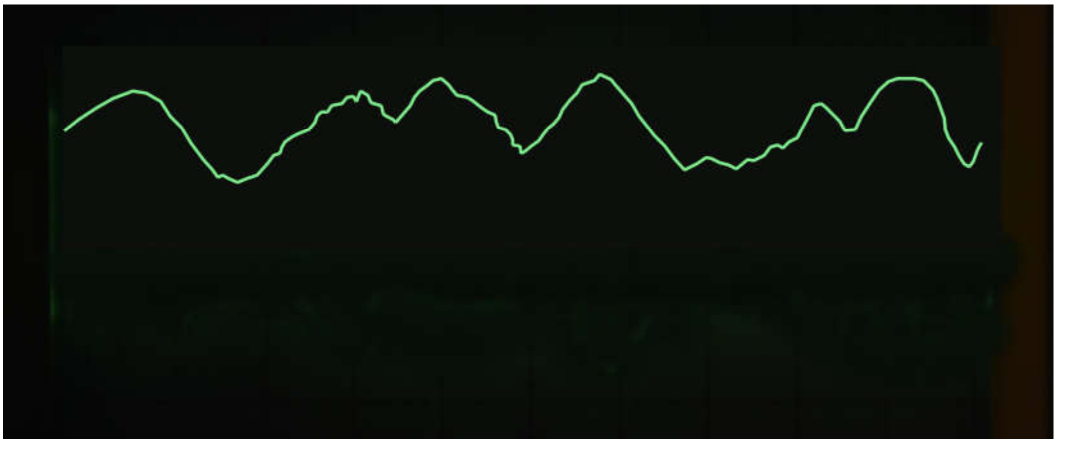
The information is added symmetrically to the top and bottom of the carrier. Just connecting the coil and capacitor to earphones will not produce any information as the top and bottom parts will cancel.
To obtain the information, half of the carrier has to be removed. This is achieved by connecting a diode in series with the coil and capacitor.
The alternating voltage is cut in half as shown in the image below.



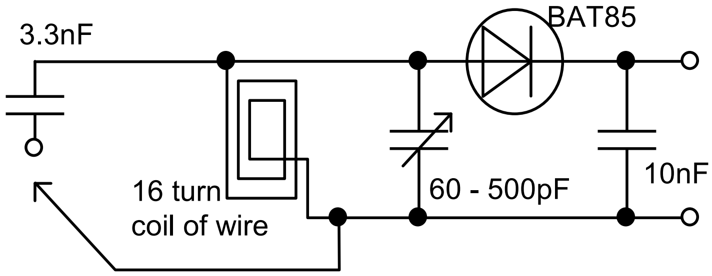
The diode used for this must have a very small 'turn on voltage', since the received voltage is very small. Germanium diodes (OA90) work well but are becoming difficult to obtain.
Shottkey diodes (e.g. BAT85) will also work well and are easier to source.

The signal still has a considerable high frequency signal, which can cause distortion in amplifiers and is removed by connecting a capacitor (10nF) across the output of the radio.

The transmitted information then looks like the image below.



The circuit diagram for the radio section is shown below.



The 3.3nF capacitor enables Radio 4 to be received.
With just 16 turns of wire for the coil, the 3.3nF capacitor does not make the receiver very efficient, but the signal from Radio 4 is very strong and reception is generally good.

The output from the radio receiver is a small voltage and would need very sensitive (and expensive) earphones to directly listen to the radio.
To enable cheaper earphones (or a loudspeaker) to be used, the output of the radio is connected to the input of an amplifier.
The amplifier used in this project has a voltage gain of ~200 and so increases the radio output considerably.

When using the radio it will be found that apart from the volume control, the volume can also be changed by rotating the radio. The minimum volume will be when the plane of the coil is in line with the direction of the transmitter, and maximum volume will be when the coil is at 90° to the direction of the radio station.

When used at night, it may be possible to receive radio stations from the near continent (France, Belgium, Holland etc). The radio will need to be rotated so that the radio board is aligned North - South.