

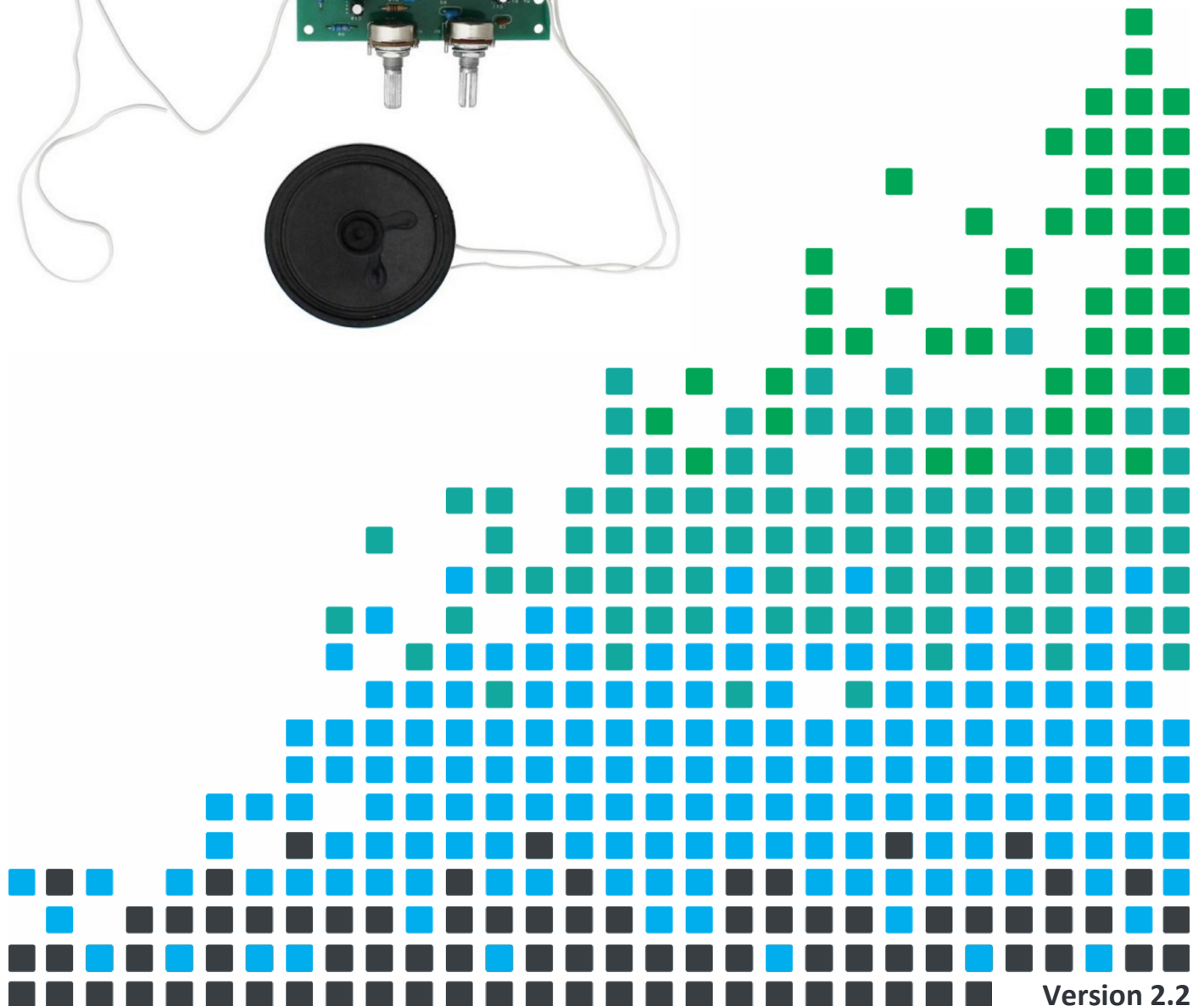
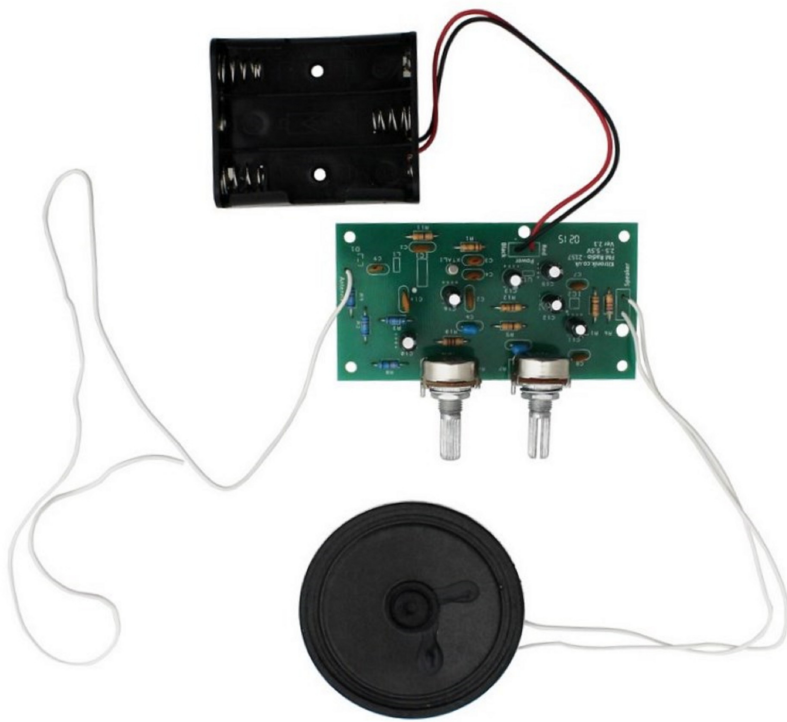


## ESSENTIAL INFORMATION

BUILD INSTRUCTIONS  
CHECKING YOUR PCB & FAULT-FINDING  
MECHANICAL DETAILS  
HOW THE KIT WORKS

GET IN TUNE WITH THIS

# FM RADIO KIT



Version 2.2

## Build Instructions

Before you start, take a look at the Printed Circuit Board (PCB). The components go in the side with the writing on and the solder goes on the side with the tracks and silver pads.

### 1 PLACE RESISTORS

Start with the eleven resistors:  
The text on the PCB shows where R1, R2 etc go.  
Ensure that you put the resistors in the right place.

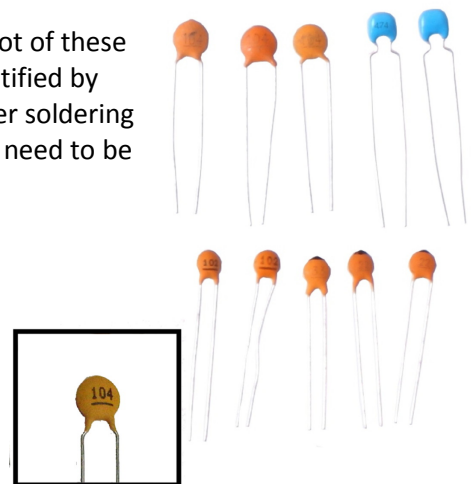
PCB Ref	Value	Colour Bands
R1	100k	Brown, black, yellow
R2 & R9	220k	Red, red, yellow
R3	56k	Green, blue, orange
R5 & R11	0Ω	Black
R6	6.8k	Blue, grey, red
R8	3.3k	Orange, orange, red
R10	100Ω	Brown, black, brown
R12	470Ω	Yellow, purple, brown
R13	10k	Brown, black, orange



### 2 SOLDER THE CERAMIC DISC CAPACITORS

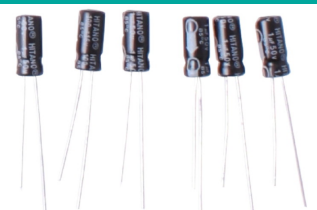
The ceramic disc capacitors should be soldered into the board. There are a lot of these so be careful to put them all in the correct place. The capacitors can be identified by the text printed on them (see close up image below right). To allow for easier soldering wide footprints have been used on the board, the smaller capacitors do not need to be pushed firmly in to the PCB.

PCB Ref	Value	Text
C1, C2, C14	100nF	104
C3, C4	22pF	22
C5, C6	470nF	474
C7	470pF	471
C8	1nF	102
C9	33pF	33



### 3 SOLDER THE ELECTROLYTIC CAPACITORS

The other six capacitors are electrolytic capacitors. The capacitor C10 is marked 100μF, place this one first. Make sure that the device is the correct way around. The capacitors have a '-' sign marked on them, which should match the same sign on the PCB. The other 5 are all marked 1μF and should go in the spaces marked C11, C12, C13, C15 and C16.



## 4

### SOLDER THE TIMING CRYSTAL

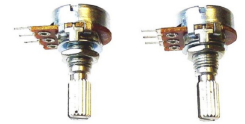
This is a very small metal cylinder with two very thin legs protruding from one end. Gently place this component into the holes in the PCB where it is marked 'XTAL1'. The legs are fragile so care should be taken when putting them through the holes in the PCB.



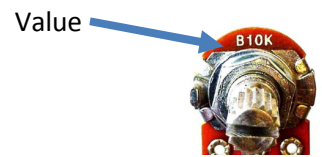
## 5

### SOLDER THE POTENTIOMETERS

The two potentiometers are different so make sure that you check which is which before soldering them into position. When placing the potentiometer into the board make sure the knob is pointing outwards from the PCB.



PCB Ref	Value
R4	100k
R7	10k



## 6

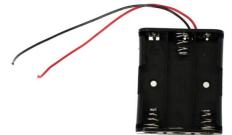
### SOLDER THE ANTENNA

Strip one end of the thin white wire and solder it into the hole on the PCB labelled 'Antenna'. The longer the antenna wire is up to 56cm the better it will perform. It is not a problem to have an antenna longer than 56cm as it won't degrade the reception. Keep the off cut for the speaker.

## 7

### SOLDER THE BATTERY CAGE

Next look for the two holes labelled 'Power'. Thread the wires from battery cage through the strain relief hole near these holes then solder the red wire into the hole marked 'red' and the black wire into the hole marked 'black'.

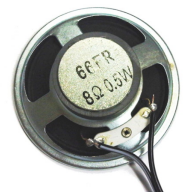


## 8

### SOLDER THE SPEAKER

Finally, cut the wire left over from the antenna connection in half and strip the ends. Thread both lengths of wire through the strain relief hole marked 'Speaker' and solder one of the wires to each of the two holes, it doesn't matter which one goes in either hole.

Solder the other end of the speaker wires to the terminals on the speaker. Again it doesn't matter which way around these go.



## Checking Your FM Radio PCB

Check the following before you connect any batteries to your radio.

### Check the bottom of the board to ensure that:

- All holes (except the four large mounting holes) are filled with the lead of a component.
- All these leads are soldered.
- Pins next to each other are not soldered together.

### Check the top of the board to ensure that:

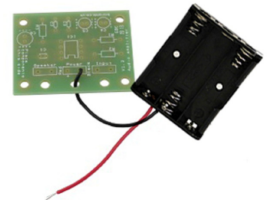
- The negative markings on the electrolytic capacitors line up with the same markings on the PCB.
- The red wire on the PP3 lead is connected to the power connector labelled 'Red' and the black wire on the PP3 lead is connected to the power connector labelled 'Black'.
- Additionally check that the resistors and capacitors are in the correct place if your board does not work.

## Adding an On / Off Switch

If you wish to add a power switch, don't solder both ends of the battery clip directly into the board, instead:

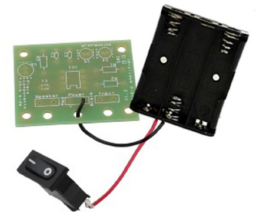
1

Solder one wire from the battery cage to the PCB, either black to '-' or red to '+'.



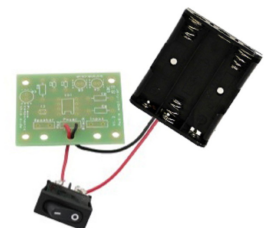
2

Solder the other wire from the battery cage to the on / off switch.

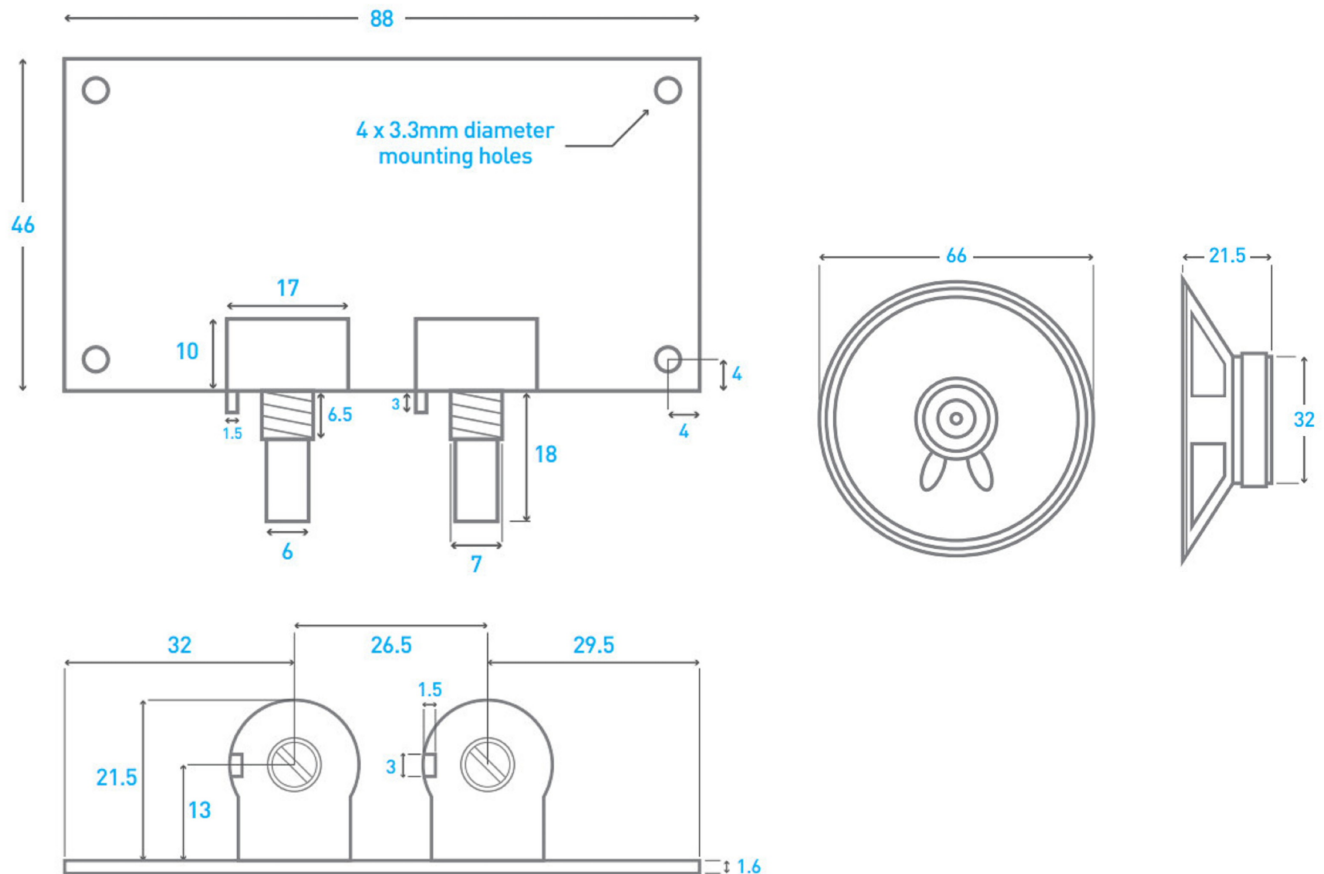


3

Using a piece of wire, solder the remaining terminal on the on / off switch to the remaining power connection on the PCB.



## Designing the Enclosure



(All measurements are in mm)

<p>P.C.B</p> <p>SPACER</p> <p>ENCLOSURE</p> <p>2 X M3 BOLTS</p>	<p><b>Mounting the PCB to the enclosure</b></p> <p>The drawing to the left shows how a hex spacer can be used with two bolts to fix the PCB to the enclosure.</p> <p><i>Your PCB has four mounting holes designed to take M3 bolts.</i></p>
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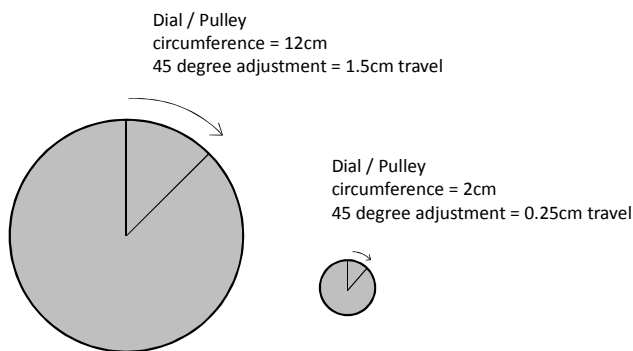


## Improving the Radio Tuning

Tuning the radio using the potentiometer can be a tricky task. This is because one turn of the potentiometer covers the whole frequency range. This means that only very small adjustments of the potentiometer are required to tune into the different stations.

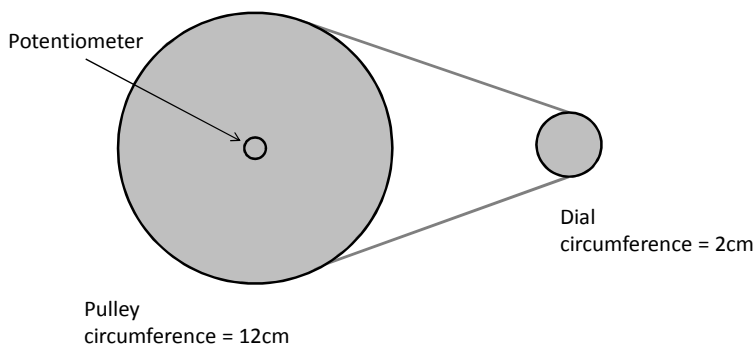
### Large Dial

One way to improve the tuning mechanism is to attach a large dial to the end of the potentiometer. Look at the two dials below. As the smaller dial has a circumference six times smaller than the large dial, it would take six times the travel on the larger dial to achieve the same degree of change than if you used the smaller dial. This would therefore make fine tuning the radio six times easier.



### Using a Pulley to give Mechanical Gearing

Another solution is to use a pulley system to improve the tuning mechanism. Take the system shown below. In this arrangement the larger pulley would be attached to the tuning potentiometer and the smaller dial would be used to make the tuning adjustments. As the smaller dial (pulley) has a circumference six times smaller than the large pulley, it would take six full rotations of the smaller dial to give one full rotation of the larger pulley. This would therefore make fine tuning the radio six times easier than if the small pulley had been connected directly to the tuning potentiometer.



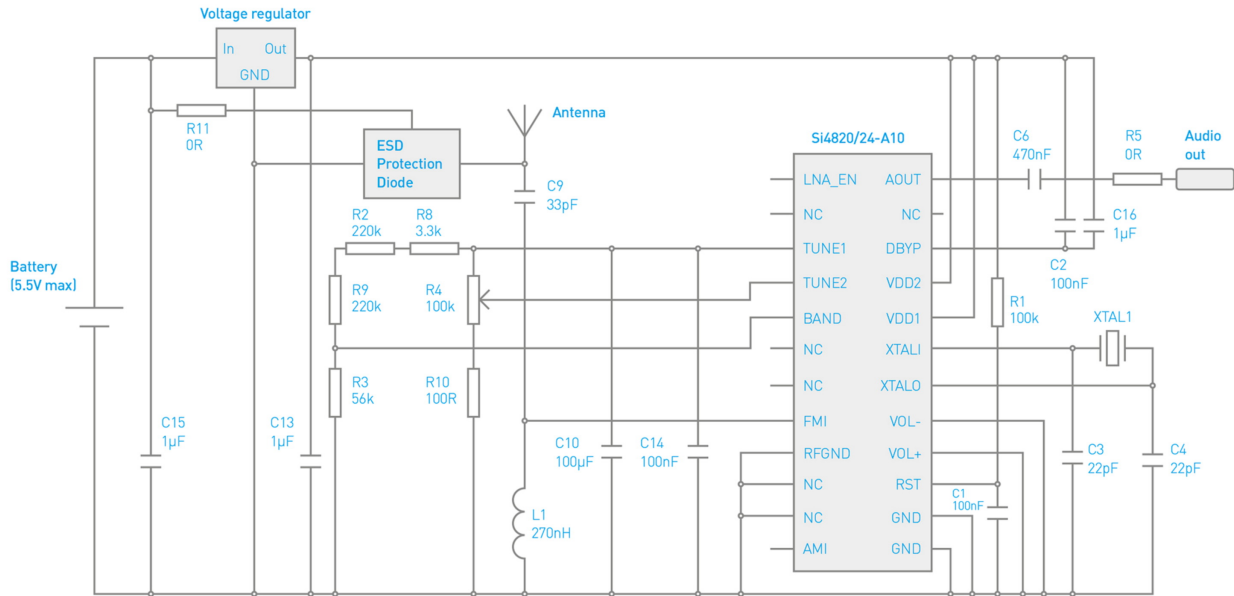
### Using both a Pulley System and a Large Dial

Of course an even better solution would be to add a large dial in front of, but on the same shaft that the small pulley/dial in the above diagram is attached to. That way you would get the benefit of both systems this would give thirty six times better adjustment.



## How the FM Radio Kit Works

To aid the description of the circuit we have split it into two parts. The first deals with the decoding of the FM radio signal and the second deals with the audio amplification.



### Radio decoding

For the radio circuit to work it needs a stable power supply. To provide the stable power supply a voltage regulator is used. This provides a 3.3V output for the circuit to run from. Capacitors C15 and C13 help the regulator to output a steady voltage by removing noise from its input and output.

The key component of the radio circuit is the Si4820/24-A10 chip. This chip is used to receive radio signals via an 'antenna' and then decodes this signal to recover the audio signal it carries. To recover the radio signal the chip needs to generate a timing signal to match the radio signal to. This is achieved using the timing crystal XTAL1 and the two capacitors C3 and C4.

The resistor network composed of R2, R3, R4, R8, R9 and R10 controls the range or 'band' of frequencies that the IC is able to tune into. Different countries use different bands for FM radio and these values have been chosen for best performance in the UK and Europe. R4 is a potentiometer which can be turned to swap from station to station.

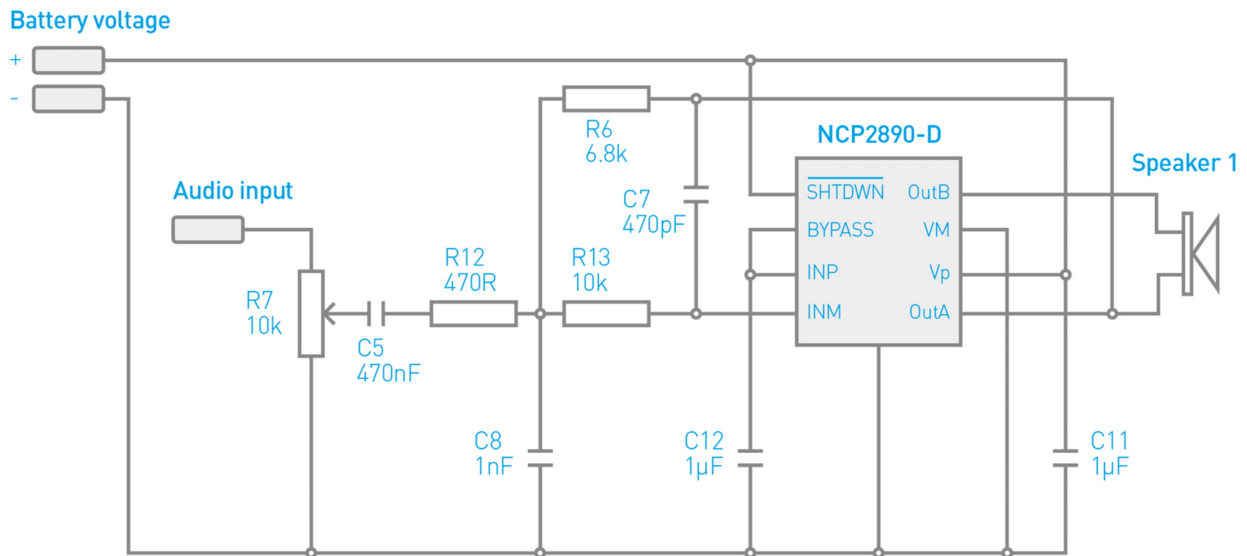
L1 and C9 help to filter out unwanted signals received by the antenna. C10 and C14 help to keep the tuning signal to the IC steady to prevent fluctuations in power from causing the IC to lose the station it has been tuned to.

The ESD protection diode protects the IC in the event of a static shock being delivered to the antenna. Static shocks are harmless to people but can damage the silicon inside the IC. The ESD protection diode redirects any such shock harmlessly to the ground rail.

C1 controls the reset timing of the IC which in this case only applies when switching on the device as this pin is held low by R1. C6 takes any DC bias out of the output signal from the radio IC and R5 and R11 just acts as a wire links to "jump" over tracks on the PCB.



## Audio amplification

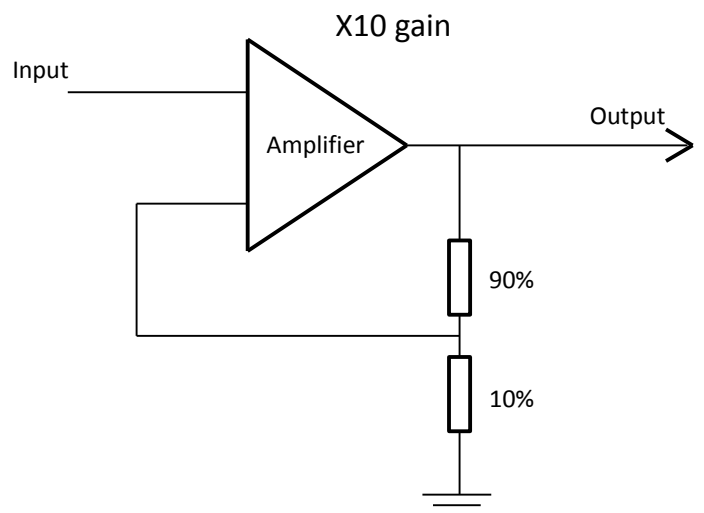


The audio amplification is performed by another Integrated Circuit or IC called an NCP2890-D. Inside the NCP2890-D are lots of transistors, which are connected together to allow the small input signal to be amplified into a more powerful output that can drive a speaker.

All amplifiers need to use feedback to ensure the amount of gain stays the same. This allows the output to be an exact copy of the input just bigger. The gain is the number of times bigger the output is compared to the input, so if an amplifier has a gain of 10 and there is 1 volt on the input there will be 10 volts on the output. Before looking at how the feedback works, we first need to understand how a standard amplifier works. An operational amplifier has two inputs, these are called the inverting (-) and non-inverting (+) inputs. The output of the operational amplifier is the voltage on the non-inverting input less the voltage on the inverting input multiplied by the amplifiers gain. In theory an operational amplifier has unlimited gain so if the non-inverting input is a fraction higher than the inverting input (there is more + than -) the output will go up to the supply voltage. Change the inputs around and the output will go to zero volts. In this format the operational amplifier is acting as a comparator, it compares the two inputs and changes the output accordingly.

With an infinite gain the amplifier is no good to amplify audio, which is where the feedback comes in. By making one of the input a percentage of the output the gain can be fixed, which allows the output to be a copy of the input but bigger. Now when the two inputs are compared and the output is adjusted, instead of it going up or down until it reaches 0 volts or V+, it stops at the point when the two inputs match and the output is at the required voltage.

Looking at the circuit diagram for the audio amplifier you can see R6 connecting the pin 'OutA' back into the input pin 'INM'. This is the feedback for the amplifier.





## ***Audio amplification continued***

The output of the NCP2890-D uses two op-amps that are connected in a differential configuration. The second amplifier produced a 'mirror' (or reverse) of what the first op-amp produces. The output of one feeds OutA and the other feeds OutB. This configuration allows twice the power to be generated compared to amplifiers using a single op-amp configuration.

The rest of the components are needed as follows:

R7 is the volume control potentiometer. C5 and R12 filter the input signal. C7 increases bass response by allowing it to bypass R13. C11 and 12 keep the power supply to the IC smooth.



## Online Information

Two sets of information can be downloaded from the product page where the kit can also be reordered from. The 'Essential Information' contains all of the information that you need to get started with the kit and the 'Teaching Resources' contains more information on soldering, components used in the kit, educational schemes of work and so on and also includes the essentials. Download from:

[www.kitronik.co.uk/2157](http://www.kitronik.co.uk/2157)



This kit is designed and manufactured in the UK by Kitronik

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