EIGHT®
GREAT STUFF TO MAKE
2008

# RETRO RADIO

## Instructions

# Introduction

Electronics can be a very rewarding hobby, especially when building your own radio. You'll gain a real sense of achievement using an FM receiver you've built yourself to tune in to your favourite stations.

Once you've completed this kit, you'll be able to listen to FM stations available locally, and you should be able to hear them clearly, with impressive sound quality.

This project begins by introducing the various components included in the kit and explaining their functions, enabling you to gradually build a complete, working radio circuit.

If you'd rather jump ahead and just construct the final circuit, please read the notes on page 7 and then turn to page 14 and assemble the circuit shown there.

These instructions are also available online at:

**eight-innovation.com/instructions**

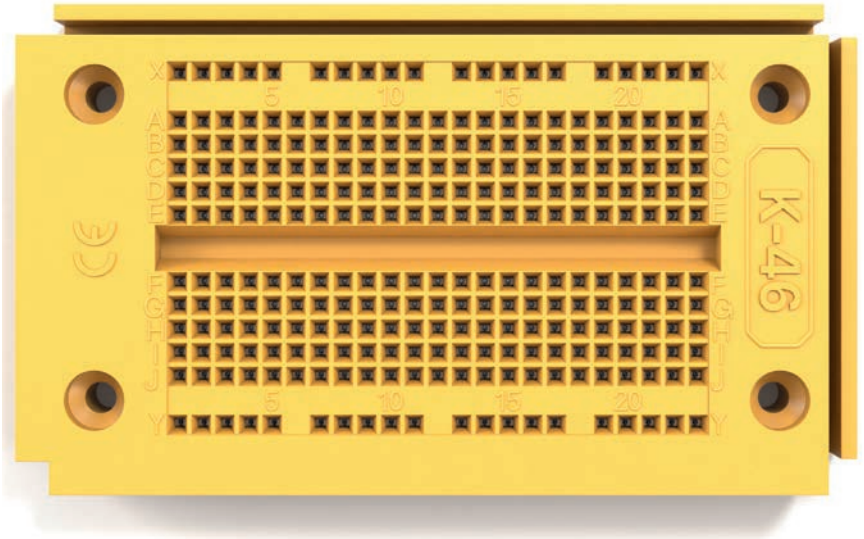
Happy building!

# The Components

## Breadboard

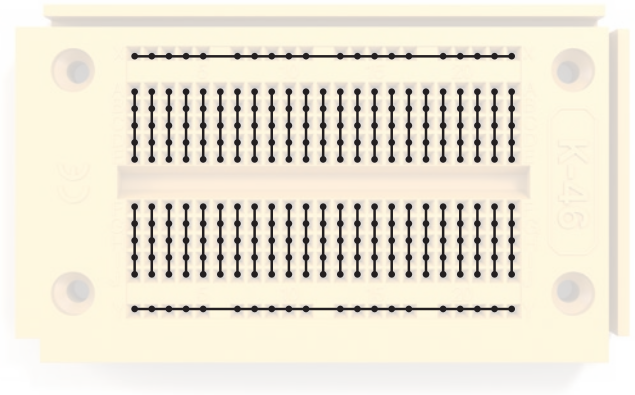
The breadboard allows you to build complicated circuits easily by pushing the component wires into the breadboard's contacts.

The board has a total of 270 contacts, and provides a reliable way of connecting the components without the need to solder wires. The board also allows mistakes to be corrected easily.



In the centre of the board, there are 230 contacts, arranged in vertical groups of 5: 23 upper groups of 5 and 23 lower groups of 5. The upper groups are not connected to the lower groups. Within each group, the 5 contacts are connected together, so to connect components together, push the wires into contacts within the same group of 5. Additionally, along each long side of the circuit board, there is a set of 20 contacts (two sets: 40 contacts in total) to which the battery positive (top set of contacts) and negative (bottom set of contacts) leads can be connected.

To connect the components and wires to the circuit board, push them into the contacts from directly above the contact. To avoid breaking the wires, grip them as close as possible to the breadboard, and try to push them in straight – using a pair of tweezers or small pliers may help. Make sure that the tinned (shiny) ends of the connecting wires, battery connector and loudspeaker are pushed into the board without bending them.



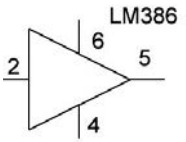
**The internal contact rows**

## Amplifier

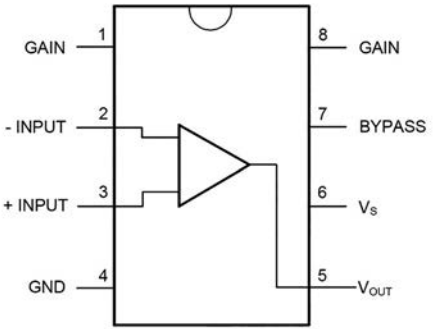

This component is a complete, self-contained loudspeaker amplifier, in the form of an integrated circuit (IC). An integrated circuit contains a complete set of miniature components – including transistors (a component used to amplify or switch electronic signals and electrical power), resistors, capacitors etc – forming a self-contained circuit for a specific purpose. In an IC the various components are 'etched' into a very thin layer of semiconductor material (usually silicon) using a technique similar to a photographic process. ICs revolutionised the world of electronics, and in some cases several million components can be accommodated within an IC the size of a finger nail.

This IC – an LM386 – has eight terminal pins (legs) and is designed as a complete loudspeaker amplifier for a battery-powered circuit.

The IC must be connected in the correct orientation. Note the small semi-circular cut-out on one end.

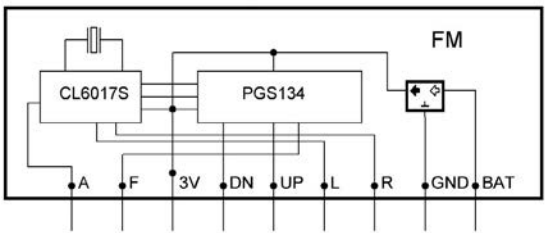



Amplifier



## FM Board

The FM board is the essential component in your radio. It contains three integrated circuits, a crystal, an SMD coil and many small capacitors and resistors that are already soldered on. Nine pins connect the board to the other components on the breadboard.

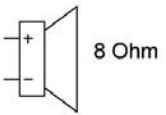



FM board

## Loudspeaker

Take care when handling the loudspeaker – it's a delicate component and one of the most important parts of a radio. At the front of the loudspeaker is the diaphragm. If you tap it very gently with your finger, it will make a noise. This is how the loudspeaker works – any movement of the diaphragm will produce sound.

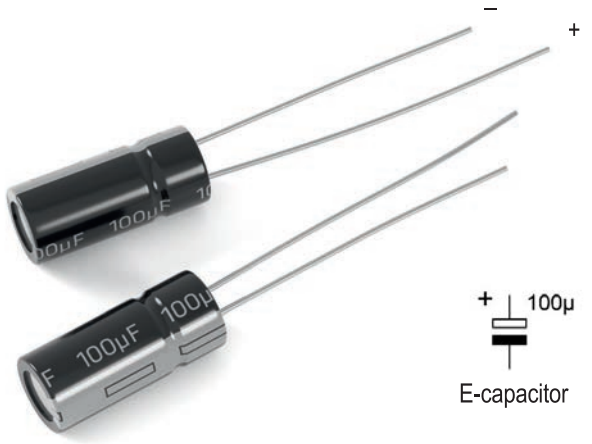
The loudspeaker in this kit has a resistance of 8 Ohm and can tolerate up to 0.5 W. The volume it can achieve depends on how the loudspeaker is mounted. The best sound is only achieved when the loudspeaker is mounted in its housing.




Loudspeaker

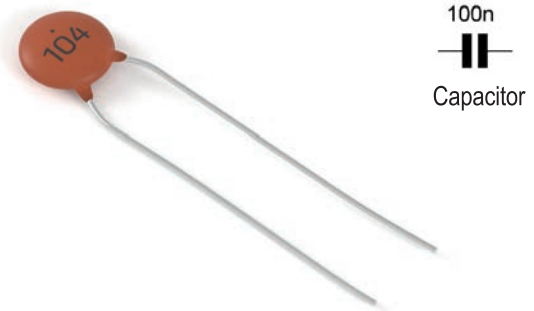
## Electrolytic Capacitor (E-Cap)

A capacitor has two terminals and is used to temporarily store electricity and then release it in a fraction of a second. Inside a capacitor there are two metal plates, insulated from each other, which can be charged with electricity. An electrolytic capacitor is able to store far more energy than a ‘ceramic’ or ‘film’ capacitor of the same size. An electrolytic capacitor must be connected the correct way round in a circuit – it has a positive and a negative connection. The positive connection can be identified by its longer leg. The ability of a capacitor to store electrical energy is called ‘capacitance’ and is measured in ‘farads’.




## Disc Capacitor

A ceramic capacitor is not ‘polarised’ so it doesn’t matter which way round it’s connected. The ceramic capacitor in the kit has a capacitance of 100nF (nanofarads), which is one-thousandth of the capacitance of the 100µF electrolytic capacitor. The ‘104’ marking on the capacitor body signifies ‘10’ followed by four zeros – ie. 100,000pF (picofarads). 1,000pF equals 1nF (nanofarad), and so to simplify things, the 100,000pF capacitor is known as a 100nF capacitor.



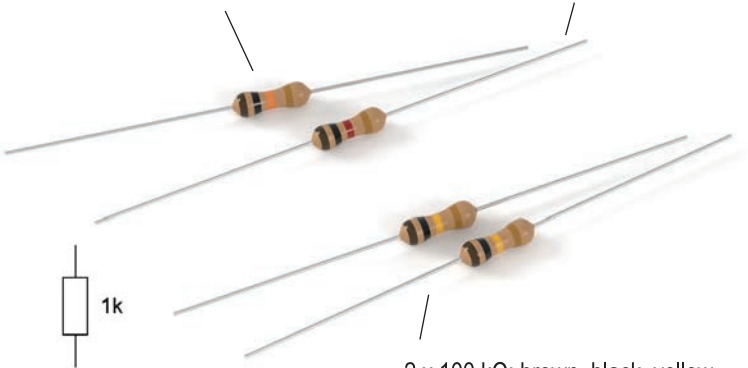
## Resistors

This kit contains 4 resistors. A resistor has two terminals, and 'resists' (limits) the current flow in an electrical circuit. Resistors can also be used to lower the voltage in a circuit. Each resistor has a fixed resistance measured in units called ohms (Ω). Resistors have colour codes on stripes around their bodies, and the colour codes denote the resistance. Resistors may have four, five or six stripes, but the resistors in this kit have four stripes – the first three stripes indicate the resistance, and the fourth band (on its own, at one end of the resistor) indicates the tolerance (the possible variation in resistance from the indicated value).

**These are the 4 resistors included:**

1 x 10 kΩ: brown, black, orange

1 x 1 kΩ: brown, black, red



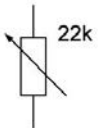

Resistor

2 x 100 kΩ: brown, black, yellow

## Tuning & Volume Potentiometers

In the kit you will find two potentiometers. A potentiometer is a variable resistor, in which the resistance can be changed by turning a knob. One of the potentiometers in the kit is fitted with a switch for turning the radio on and off and controlling the volume (this potentiometer has five wires, and the switch will click when the potentiometer knob is turned fully anticlockwise).

The other potentiometer does not have a switch (and has three wires), and is used for the tuning control.




Potentiometer

## Wire

## Battery clip


Battery

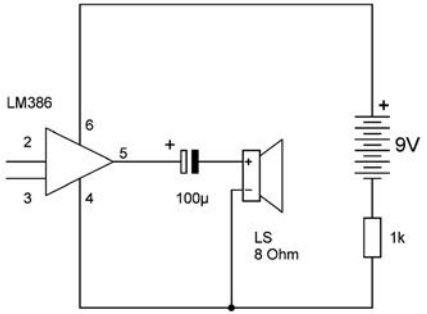
## Before You Start

- Take care to connect the components correctly, as described in the instructions, as some components may be damaged if they are connected incorrectly.
- You will need a 9V PP3-type battery to operate the radio.
- Disconnect the battery before building each new circuit.
- There are 2 bundles of red wire in this kit. Use one of these to cut up to connect the components and save the second to use as the aerial for the final circuit.

## Step 1: Mounting the Amplifier

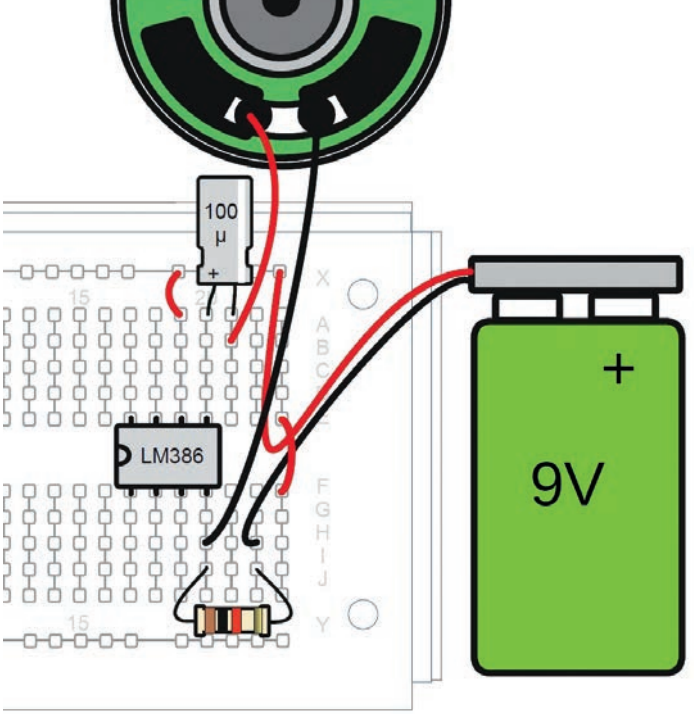
**Required components:**

- Breadboard
- LM386 amplifier IC
- 100 µF e-capacitor,
- 1 kΩ resistor (brown, black, red),
- Wire




The eight-legged LM386 IC is a loudspeaker amplifier designed to be powered by a battery. Internally, it contains many transistors and resistors.

Pin 4 of the IC (GND) connects to the negative terminal of the battery via a 1 kΩ resistor (brown, black, red).




The resistor limits the amount of current that reaches the IC to prevent it being overloaded if a wrong connection is made by mistake.

The positive terminal is attached to pin 6 (Vs). Pin 5 is the output (Vout). Here, the loudspeaker is attached via a 100 µF e-cap. This pin supplies an average output voltage of approx. 4.5 V.

The positive terminal of the e-cap (longer leg) has to point towards the IC and the negative terminal to the loudspeaker.

Pins 2 and 3 are the inputs to the amplifier and remain unconnected for the time being.

Let's get started and insert the components on the breadboard as shown in the diagram.

Inserting components in the breadboard requires a little force. Because of this, the component legs are prone to bending. It's important to insert the wires perpendicular to the breadboard. Tweezers or small pliers can help with this.

Grip the wire a short distance above the breadboard and push downwards. This way, you can even insert thin wires (like the connecting wires of the battery clip or the loudspeaker) successfully. If it's hard to insert a wire, you can use a needle to widen the contacts in the breadboard a little.

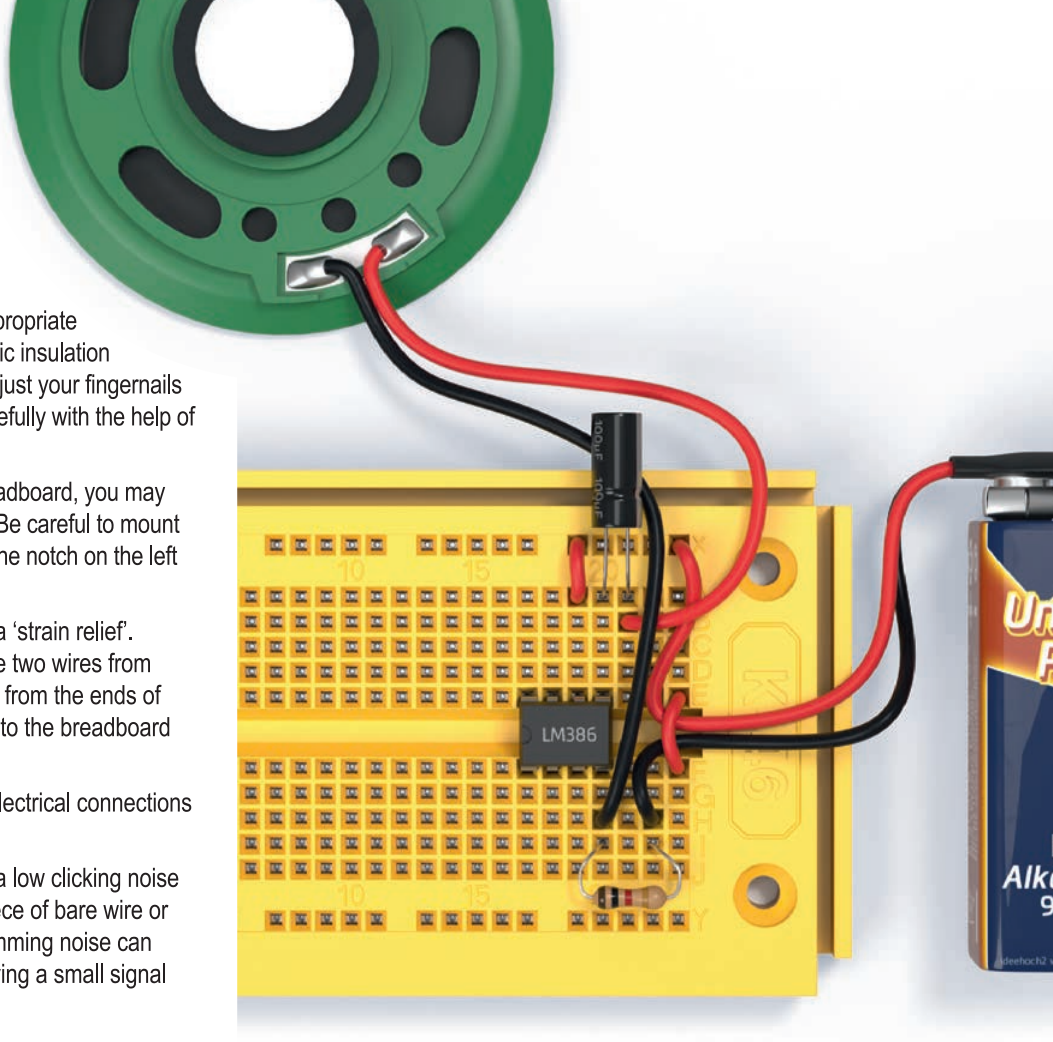
For the red wire connections, you need to cut appropriate lengths of wire and remove 5 mm of the red plastic insulation at the ends. You can strip off the insulation using just your fingernails or with pliers. Alternatively, you can remove it carefully with the help of a sharp knife.

To get the legs of the IC to fit the holes in the breadboard, you may need to gently squeeze the legs together a little. Be careful to mount it in the correct orientation – note the position of the notch on the left hand side.

To prevent damage to the battery clip, we'll add a 'strain relief'. This is a small loop of wire that holds in place the two wires from the battery clip. To do this, remove the insulation from the ends of a piece of wire approx. 2 cm long, and insert it into the breadboard as shown.

**Note:** This is purely a mechanical feature – no electrical connections should be made to this wire loop!

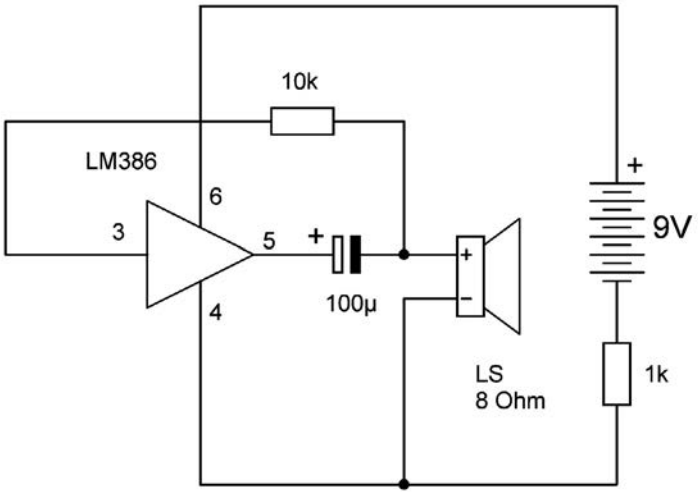
When you connect the battery, you should hear a low clicking noise from the loudspeaker. Touch pin 2 or 3 with a piece of bare wire or another conductive object. Now a clicking or humming noise can be heard. When you touch the pins, you're applying a small signal voltage to the input.



## Step 2: Sound Generator

**Required components:**

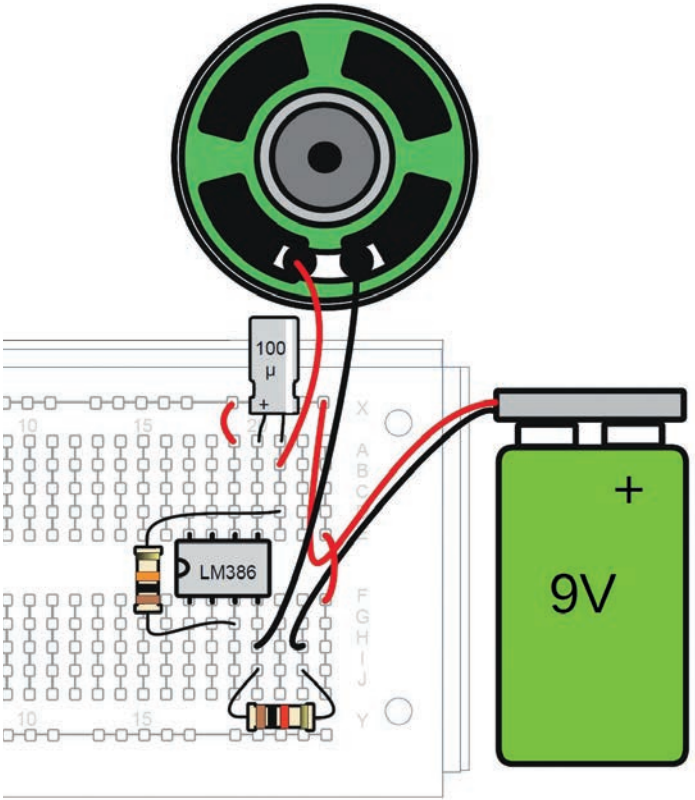
• 10 kΩ resistor (brown, black, orange)




This circuit uses the 10 kΩ resistor (brown, black, orange) to turn the amplifier into a sound generator. To create oscillations, the input at pin 3 of the LM386 has to be connected to the output via a resistor.
This feedback generates oscillations of the amplifier, which become audible in the loudspeaker as humming or clicking.

This experiment proves that the amplifier is mounted correctly and works properly, so the protective 1 kΩ resistor is no longer needed.

When you bypass the resistor with a piece of wire or remove it for a test, the rattling noise becomes very loud.

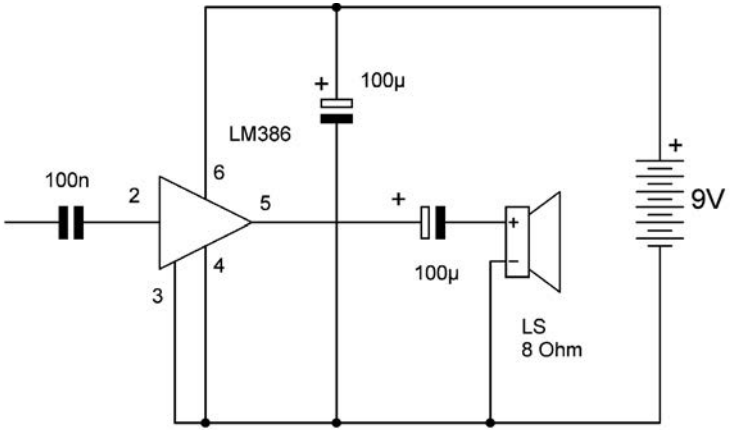


## Step 3: Improved Amplifier

**Required components:**

• 100 nF disc capacitor • 100 µF e-capacitor • Wire

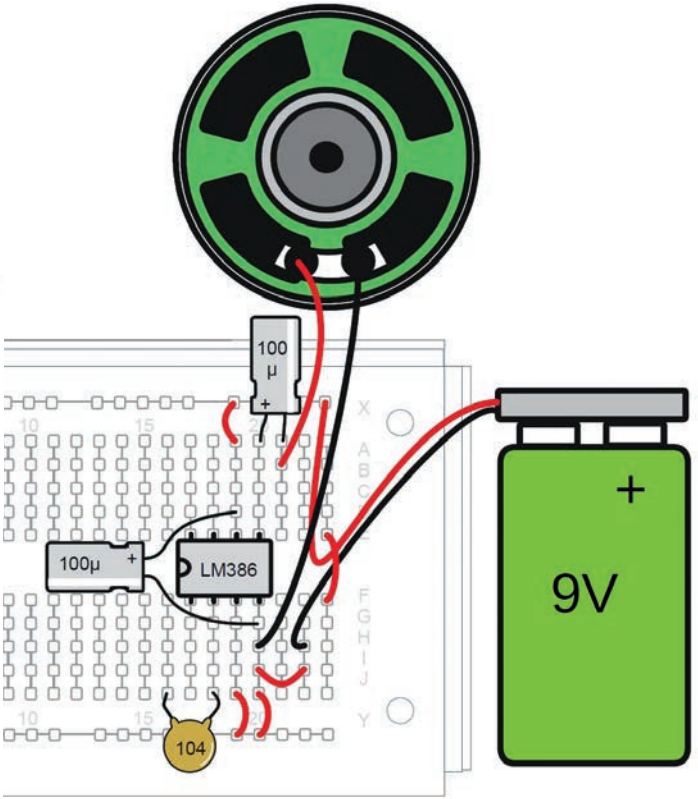
Capacitors are often used to transfer sound frequency signals. Here, we use the ceramic 100 nF disc capacitor (labelled 104).




The 1 kΩ protective resistor is replaced by a piece of wire. This is because after the successful initial test, there is no longer a risk of a faulty circuit. Later, you'll insert the main switch of the radio in this position.

Pin 3 of the amplifier is now connected to GND. This reduces distortions that would otherwise occur by contact resistances on the breadboard.

Pin 2 of the IC is the amplifier input, which will later be connected to the radio module via the capacitor. Touch the leg of the capacitor. Again, you will hear sounds from the loudspeaker, e.g. a buzzing or humming. This comes from the electrical wires and devices around you, received by your body like an antenna and then amplified and made audible. This simple buzz test is helpful to test the amplifier. It can also be used to troubleshoot the completed radio later on.



## Step 4: Simple Radio

**Required components:**

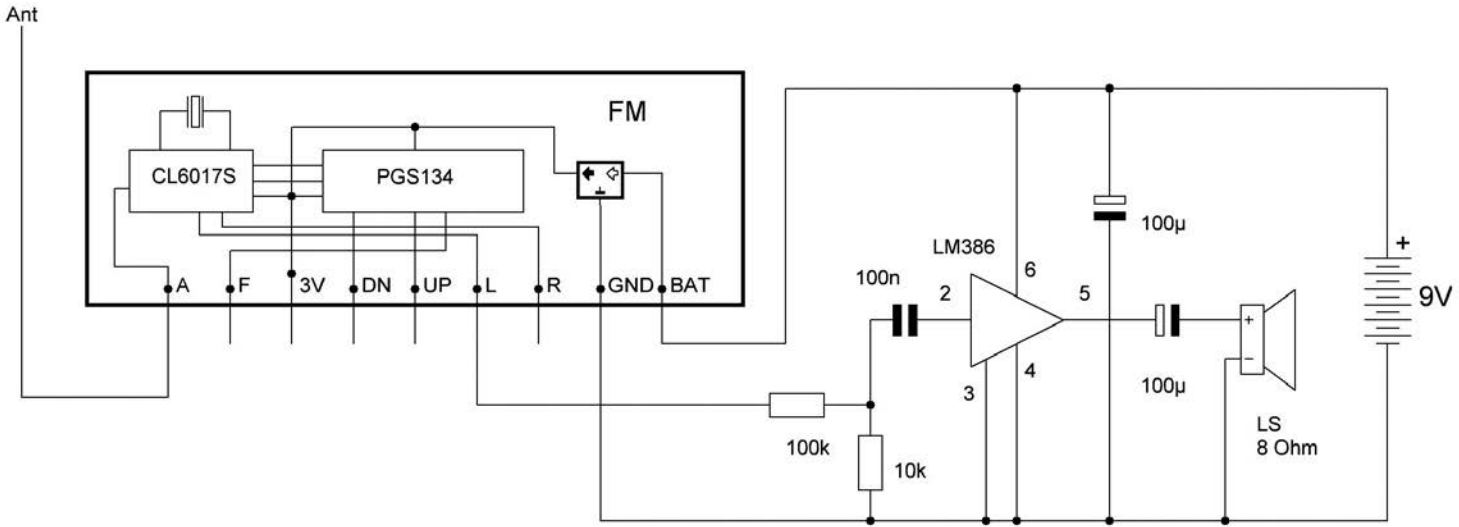
- FM receiver board
- 10 kΩ resistors (brown, black, orange)
- 100 kΩ resistor (brown, black, yellow)
- Wire

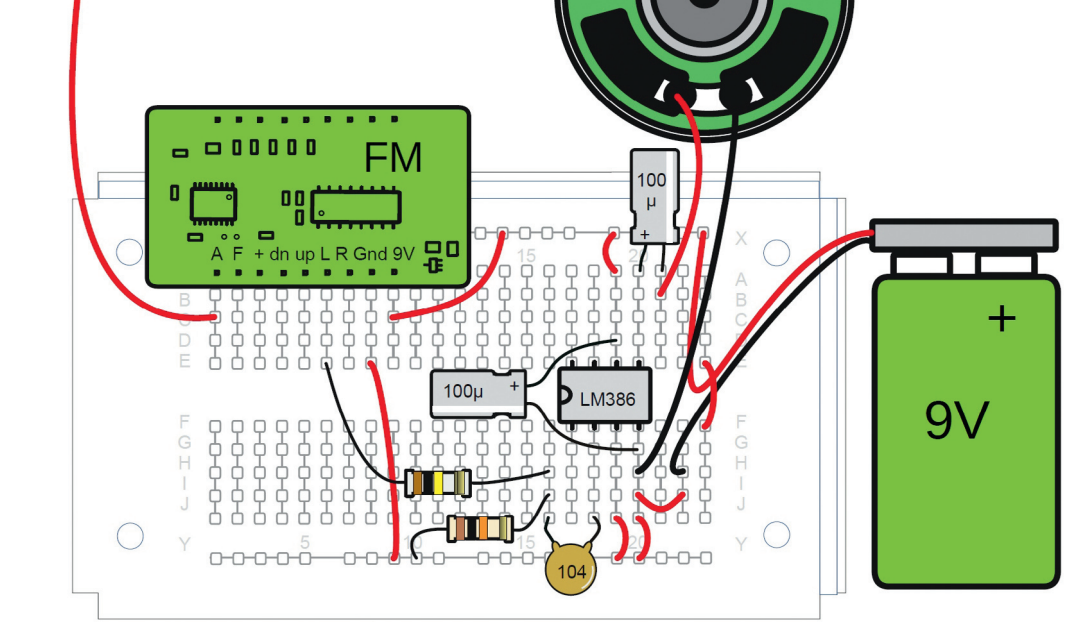
The FM receiver board with its many small components is the heart of your radio. For this stage, only four connections are needed. The operating voltage of 9 V is supplied via GND (-) and BAT (+).

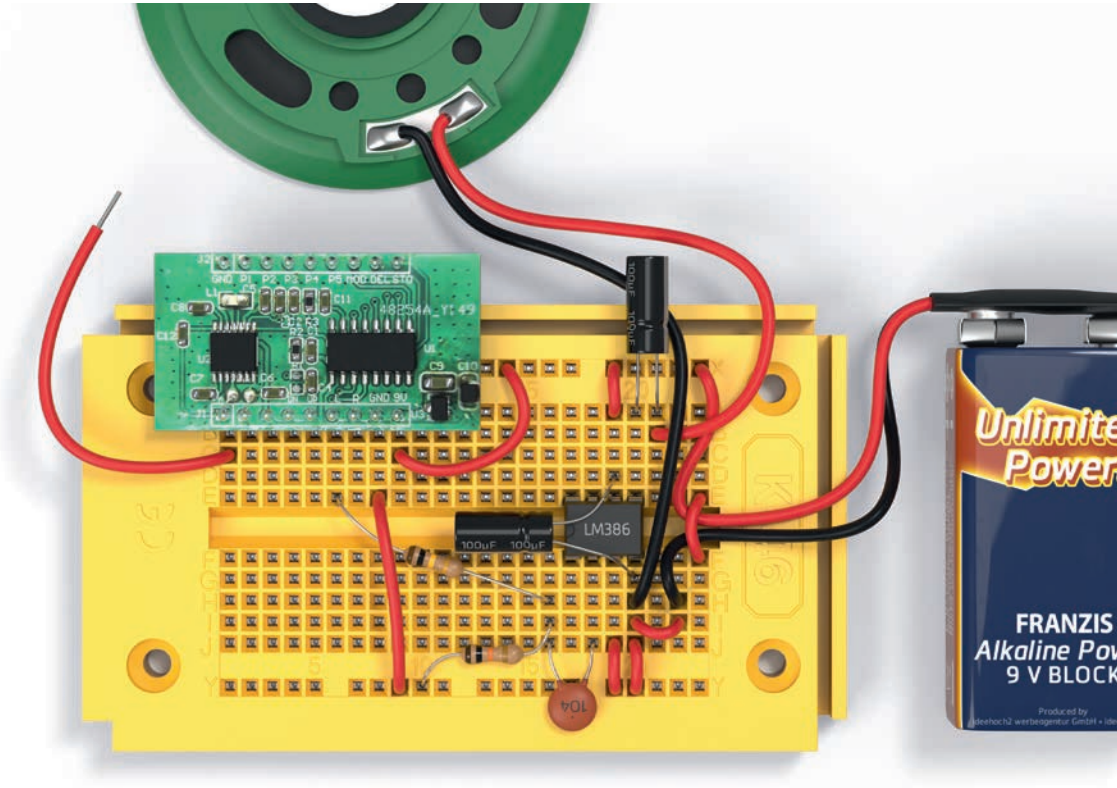
To form the aerial, cut a length of wire at least 10 cm long and connect it to the antenna connection A, as shown in the diagram.

The audio signal then appears at the AF output (L). Two resistors of 100 kΩ (brown, black, yellow) and 10 kΩ (brown, black, orange) ensure a low input voltage at the amplifier so that it is not overpowered. Later, the volume control will be connected at this point.

Although the radio is far from completed, you can already listen to a radio station. It will be the lowest station in the FM range, and is found by the FM board automatically scanning for a signal when the power is turned on.




FM
A F + dn up L R Gnd 9V
100 µ
+
100µ
LM386
104
+
9V


LM386
104
Unlimite
Power
FRANZIS
Alkaline Pow
9 V BLOCK

## Step 5: The Final Radio & Mounting in the Case

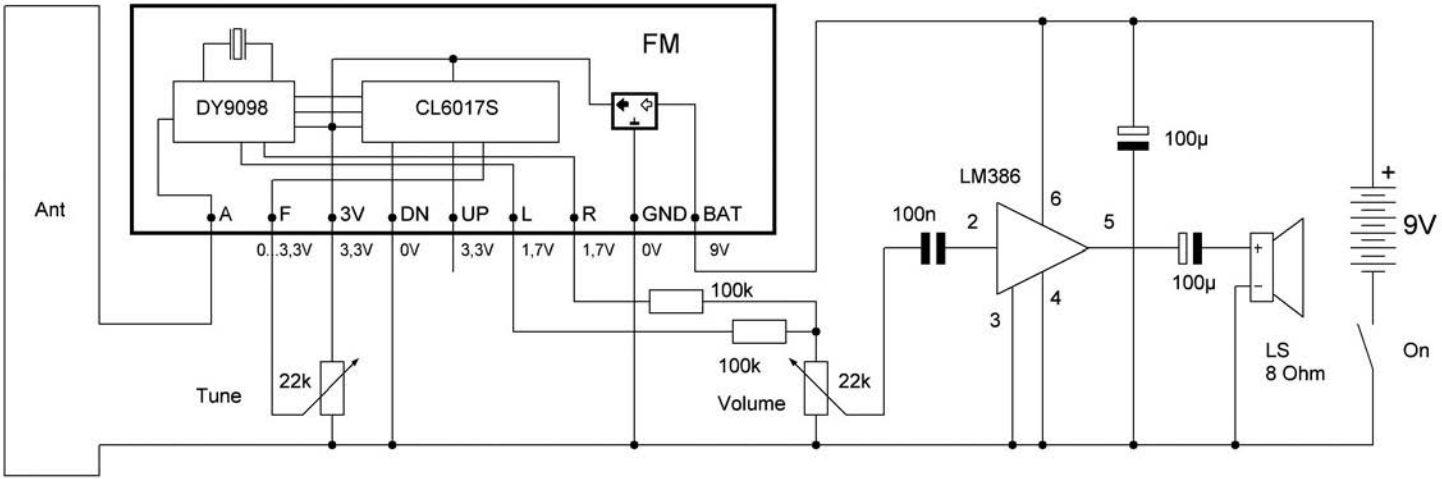
**Required components:**

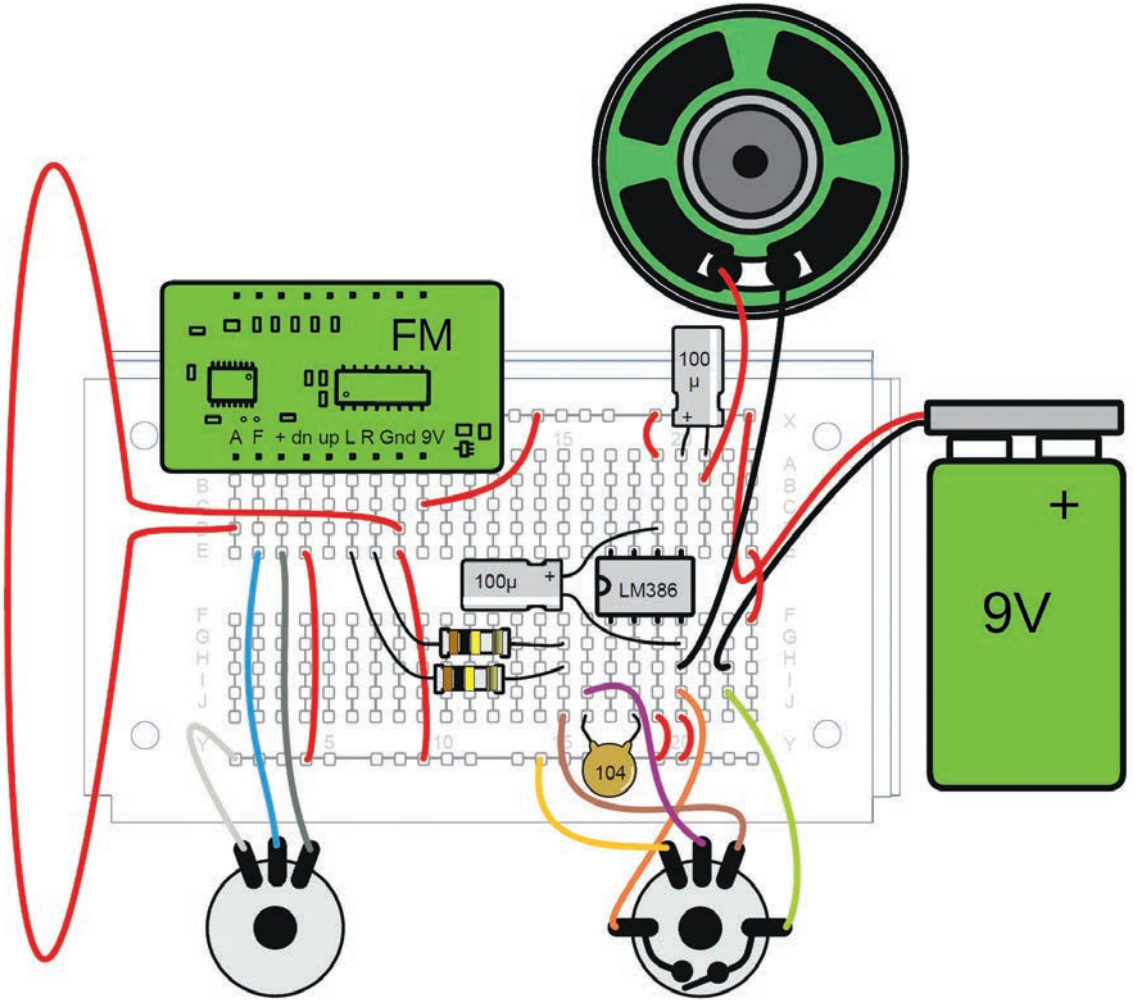
- Volume potentiometer
- Tuning potentiometer
- Cap nuts and washers
- Wire

This kit contains two potentiometers. The first one will control the volume and also has an off/off switch, the second one will be used for tuning.

Mount both potentiometers and the loudspeaker in the case.

Make sure the potentiometers are fitted to the correct holes in the housing – the potentiometer with the switch (and five wires) should be fitted to the 'VOLUME' hole, and the one without the switch (and with three wires) should be fitted to the 'TUNING' hole.




FM
A F + dn up L R Gnd 9V
100
µ
+
100µ
+
LM386
104
+
9V

Push the potentiometers through the holes from inside the housing, making sure that the small metal tabs – one on each potentiometer – engage in the smaller holes in the housing. Then, secure the potentiometers by dropping on the washers and tightening the nuts supplied in the kit. Find the plastic potentiometer knobs, loosen the grub screws (one on the side of each knob) with a small screwdriver, then push the knobs on to the potentiometer shafts. Make sure that the markings on the knobs match up with the markings on the case, then retighten the grub screws to secure them.

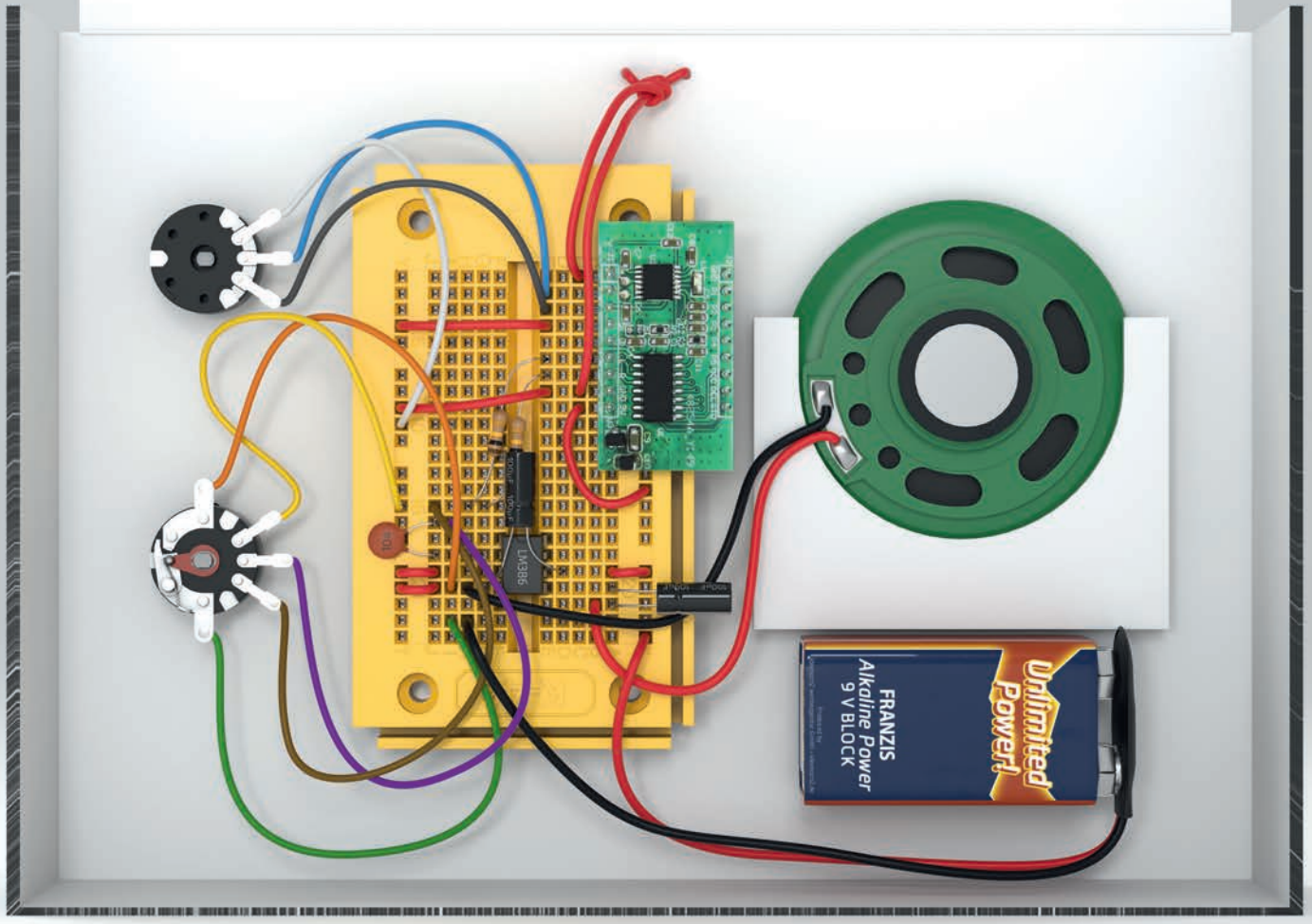
The loudspeaker slides into the cardboard slot provided inside the housing.

Next, mount the circuit board between the potentiometers and the loudspeaker.

The back of the circuit board is covered with an adhesive pad to enable it to be stuck in position. Peel off the protective film, and stick the circuit board in place. Make sure that the board is correctly positioned from the start as, once stuck in position, it will be very difficult to move it!

Connect the wires and resistors as shown in the diagram. Connect the volume potentiometer paying attention to the colours of the connection cables. Finally, connect the battery clip to the battery and test the finished radio.

The antenna now consists of as large a wire loop as possible, which is connected between A and GND. Use a whole metre of wire for this. Feed the antenna wire through the two holes provided so that the antenna loop is outside the housing. The wire should be twisted on both sides so that the antenna is kept stable and cannot slip out of the breadboard.


LM386
Unlimited Power
FRANZIS
Alkaline Power
9 V BLOCK

# Troubleshooting

When building the radio, mistakes can happen that might not be easy to find. In that case, don't give up! Instead, accept the challenge to find the problem. If the radio doesn't work, start by checking all the connections. Wire by wire, and component by component, compare your setup with the circuit diagram and the setup photo. Check to make sure all wires are fully pushed in to the breadboard.

**The most common mistakes are:**

- A wire or component leg was inserted in the wrong position.
- The free end of a wire is too short and does not reach the contact in the breadboard.
- One leg of the amplifier IC is bent when plugged in and is not in contact.
- Contact problems on the battery clip.
- The battery is heavily depleted and no longer provides sufficient power.

Pay attention to whether a power-on crackling sound can be heard. Because the rotary switch on the volume control itself produces a noise, it may be useful to leave the switch on and hold the battery to the clip. If no crackling is heard, troubleshooting must first focus on connection or contact problems in the area of the battery, amplifier and speaker.

Check if the amplifier or any other component becomes hot.
This would indicate a connection error. Move individual wires to detect contact problems. If scratching sounds occur when a wire or component is lightly touched, this indicates a poor contact.

If there is no sound coming from the speaker at all, that suggests that the speaker, the amplifier or the volume control could be at fault. Repeat the first tests with the speaker amplifier or perform the following tests:

- Hold a wire or screwdriver to both terminals of the disk capacitor. You should hear a crackling sound, the volume of which depends on the position of the volume control. In that case, everything from the volume potentiometer to the speaker will work.
- If in doubt, remove the disk capacitor from the circuit and touch pin 2 of the amplifier with a wire. A soft crackling or buzzing sound should be heard.

If the amplifier has been tested successfully, but the radio still does not emit any sound, the suspicion falls on the FM board and the tuning potentiometer.

**The following errors may be present:**

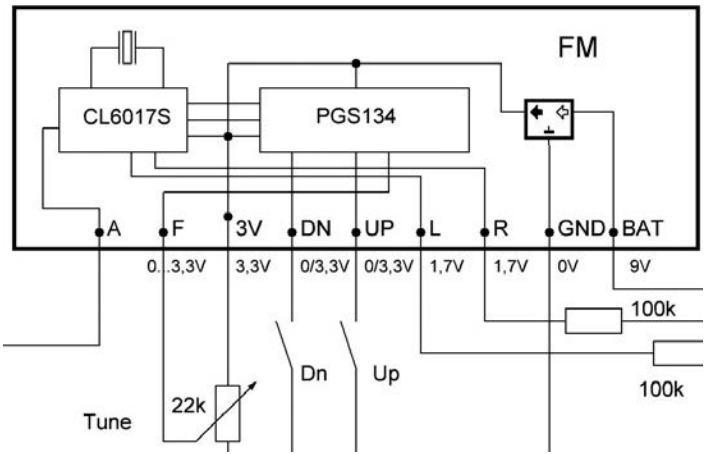
- The board does not get its operating voltage of 9 V because the Bat or the GND line has been connected incorrectly.
- The tuning voltage at the F terminal is missing because the potentiometer is connected incorrectly.
- The AF output is not correctly connected to the volume potentiometer.

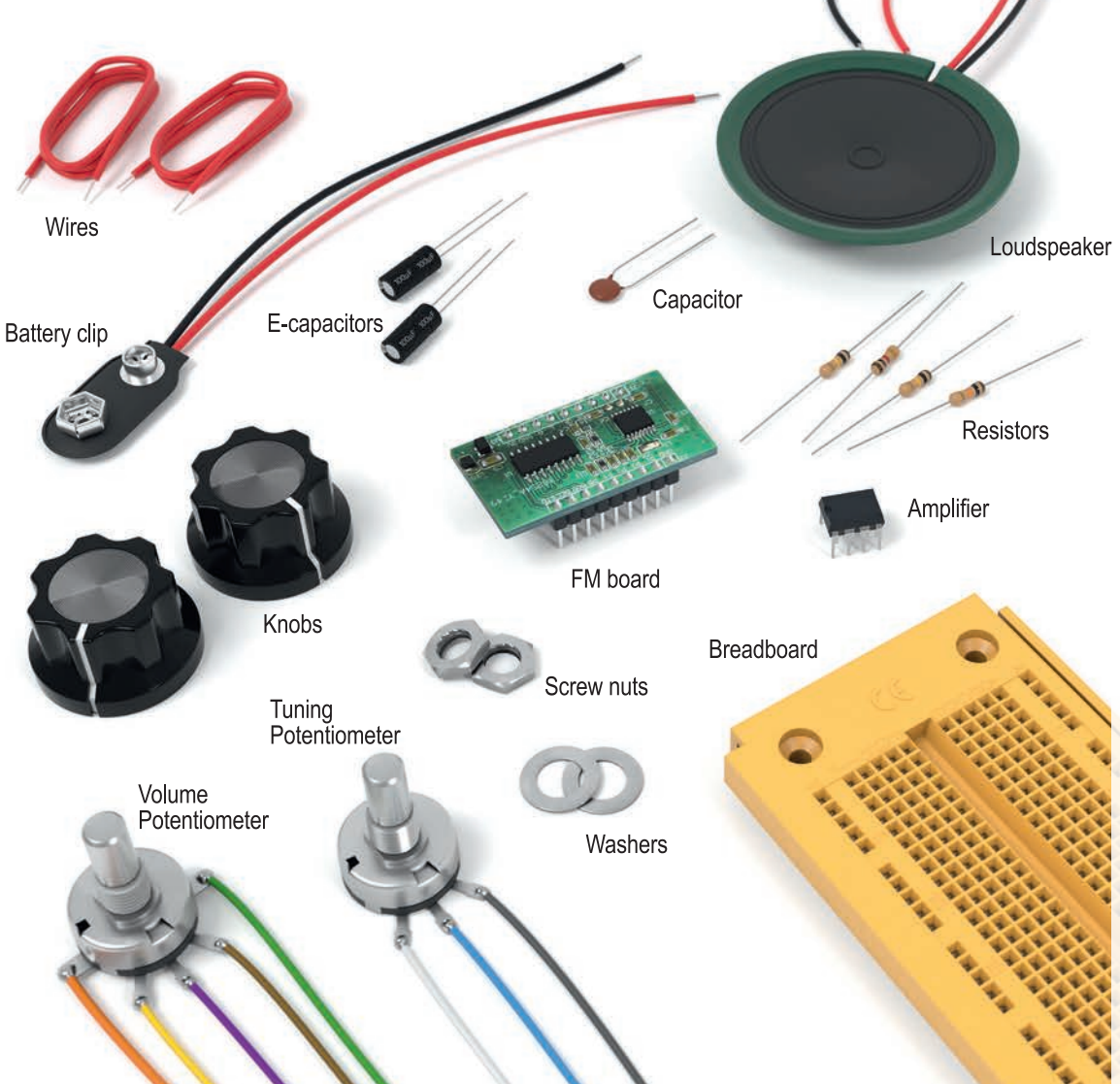
A voltmeter can be useful for further troubleshooting. With a little skill, however, the amplifier can also be used for a rough voltage test.
To do this, pull out the brown potentiometer connector and use it as a measuring cable. The volume potentiometer should be in the middle position or lower. Then, when you touch a point on the circuit with the brown wire, a crackle will occur, the volume of which is a measure of the voltage. Also test the full operating voltage (9 V, very loud) and the negative line (GND, 0 V, no noise). The further tests should show the following:

- Bat connection of the board: 9 V, loud
- GND connection of the board: 0 V, no noise
- NF output L and R of the board: approx. 1.7 V, loud
- Switch connections UP and DN: 3.3 V, loud or 0 V (pressed), silent
- Gray cable at tuning potentiometer: 0 V, no noise
- White cable at tuning potentiometer: 3.3 V, loud
- Centre pin at tuning potentiometer (blue) and F pin: Adjustable 0 V to 3.3 V, quiet to loud

If you notice a significant deviation at a measuring point, the error is probably in this area, i.e. usually a contact problem, a mixed-up component or a wrong connection.

In rare cases, a component may be defective. In particular, the loudspeaker, the amplifier and the FM board can be damaged by incorrect connection or excessive voltage. At the loudspeaker or at the potentiometers the connection contacts can be damaged. Contact problems can occur at the pots and at the switch.






This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

EIGHT Innovation Ltd
MK43 0XT
U.K.
eight-innovation.com

Type Number FRANZIS_RADIO_002

WEEE-Reg.-Nr.: DE21445697

101301-2024/01
Item no. ERR1493



Made in P. R. China