
UKW-Radio-Bausatz
FM Radio Construction Set
English Instructions can be downloaded at
transfer.franzis.de/67226-1_Radio_Instructions.pdf
Wavy
108
100
96
92
88
ON
OFF
FRANZIS

Impressum

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Hereby, FRANZIS Verlag GmbH declares that the radio equipment type FM Radio Construction Set, type number FRANZIS_Radio_015, is in compliance with Directive 2014/53/EU. The full text of the EU declaration of conformity is available at the following internet address: www.franzis.de/conformity

Dear customers!

This product was developed in compliance with the applicable European directives and therefore carries the CE mark. Its authorized use is described in the instructions enclosed with it. In the event of non-conforming use or modification of the product, you will be solely responsible for complying with the applicable regulations. You should therefore take care to assemble the circuits as described in the instructions. The product may only be passed on along with the instruction and this note.

Introduction

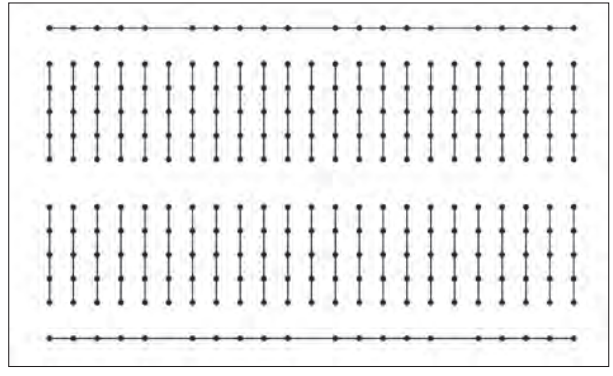
By assembling this radio, you will gain insights into electronics and experience a sense of achievement even early on. Explore the functionality of the individual components and gradually build a complex circuit. Finally, use the completed FM radio to listen to your local FM station in great sound quality!

The FM radio is easy to assemble and yet offers many possibilities. There are numerous versions and options. Feel free to experiment with different circuits and antennae to receive stations near you or far away.

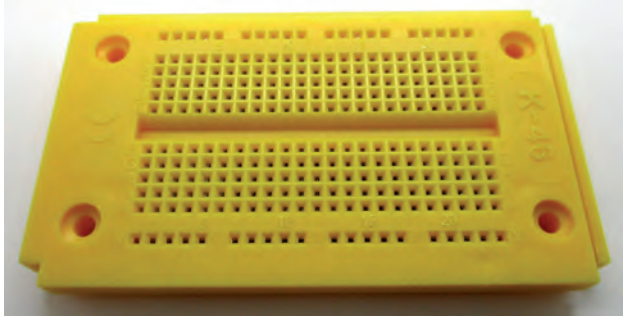
Enjoy your radio kit!

1 The components

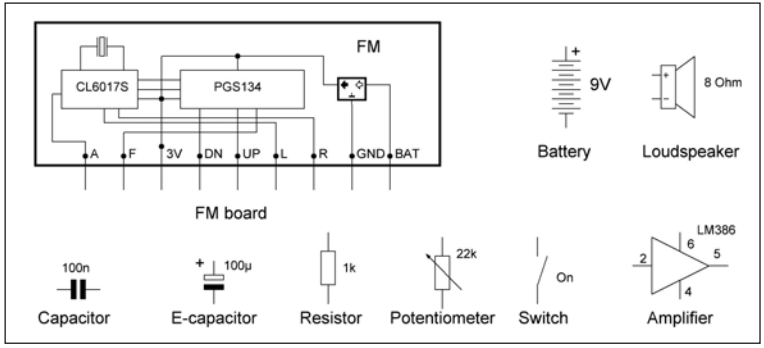
The various circuits are built on a **breadboard**. The centre part contains 46 contact strips with five contacts each. The two long strips with 20 contacts along the edges are typically used to provide the operating voltage.



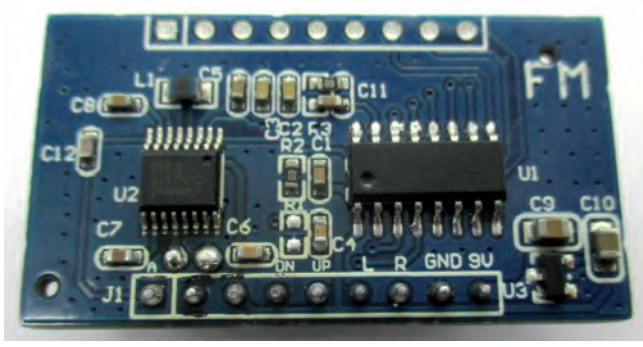
The internal connections of the contacts



All components are placed on the breadboard and connected to it. There is an assembly drawing, a photo and a circuit diagram for each component. The circuit diagrams use the following circuit symbols (see next page).



The **FM board** is the essential component of this radio. It contains three integrated circuits, a quartz crystal, an SMD coil and many small capacitors and resistors that are already soldered on. Nine connections link the board to the other components on the breadboard.



FM board

LM386 amplifier

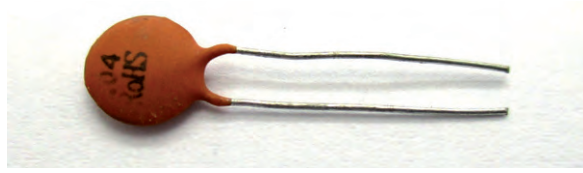
The **LM386 loudspeaker amplifier** is an integrated circuit (IC) in a housing with eight pins, numbered from pin 1 at the bottom left corner to pin 8 at the top left corner. Pin 4 (bottom right) is the negative terminal of the power supply. The amplifier operates at 9 V and provides 0.5 W to the loudspeaker.

Loudspeaker

The **loudspeaker** exhibits a resistance of 8 Ohm and can tolerate up to 0.5 W. The volume depends mainly on how the loudspeaker is mounted. A pleasant sound is only achieved by installing the loudspeaker in the housing.

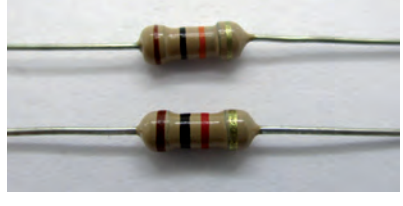
100 µF e-cap

The loudspeaker must not be connected directly to the amplifier but requires a capacitor. Any capacitor consists of two metal sheets insulated against each other. The **electrolytic capacitor (e-cap)** used here contains aluminium sheets in a conductive fluid (electrolyte). You have to pay attention to the mounting direction as the e-cap will be destroyed when the polarity is reversed. The negative terminal is the shorter leg; it is additionally marked by a white bar. The kit contains two identical e-caps with a capacitance of 100 microfarad (100 µF).



100 nF disc capacitor

There is another capacitor with only a 1000th of the capacitance of the e-cap, i.e. 100 nanofarad (100 nF). The imprinted number 104 means 100,000 pF (picofarad). This component is a **ceramic disc capacitor** and can be mounted in any direction.



Resistor with 10 kΩ and with 1 kΩ

The **resistors** in the kit are of the carbon film type and can be mounted in any direction.

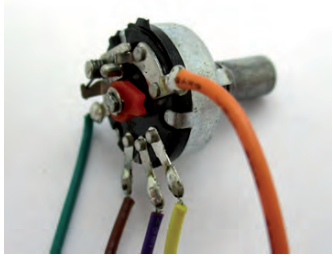
The smallest resistor in this kit has 1 kΩ (kiloohm), the largest have 100 kΩ. They are marked with three colored rings. The fourth, golden ring stands for the tolerance class 5 %. There are four resistors in total:

- - 1 × 1 kΩ: brown, black, red
- - 1 × 10 kΩ: brown, black, orange
- - 2 × 100 kΩ: brown, black, yellow

Tuning potentiometer

Basically, a potentiometer is a resistor; however, it contains a third contact, which is shifted by turning the axis. It will be mounted in the radio housing with a washer and a nut, and a rotary knob will be screwed to the axis.

This three-pin potentiometer is intended for tuning the radio.

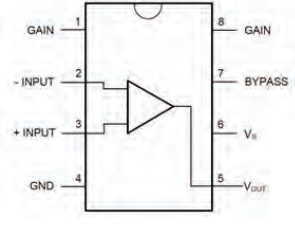


Volume potentiometer

The volume potentiometer contains an additional switch and thus has five connecting wires. By turning the axis to the far left, the radio is turned off. As a special feature of this potentiometer, the resistance curve is not linear but adapted to the human sense of hearing. Hence, the middle setting provides significantly less than half the total resistance.

2 Installation of the amplifier

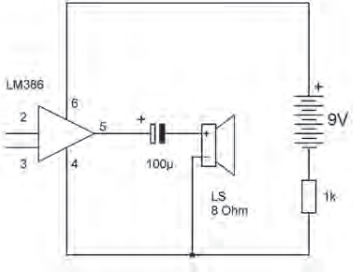
The eight-legged LM386 IC is a loudspeaker amplifier suited for battery operation. Internally, it contains many transistors and resistors. Pin 4 of the IC (GND) connects to the negative terminal of the battery via a 1 kΩ resistor (brown, black, red) in order to limit the current in case of improper assembly. 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. Thus, the positive terminal of the e-cap has to point towards the IC and the negative terminal (marked by a white bar) to the loudspeaker. Pins 2 and 3 are the inputs of the amplifier and remain unattached for the time being.

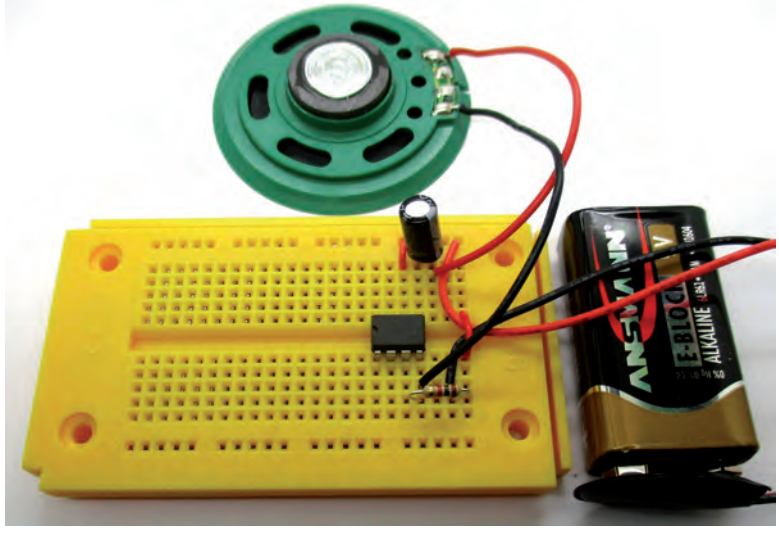


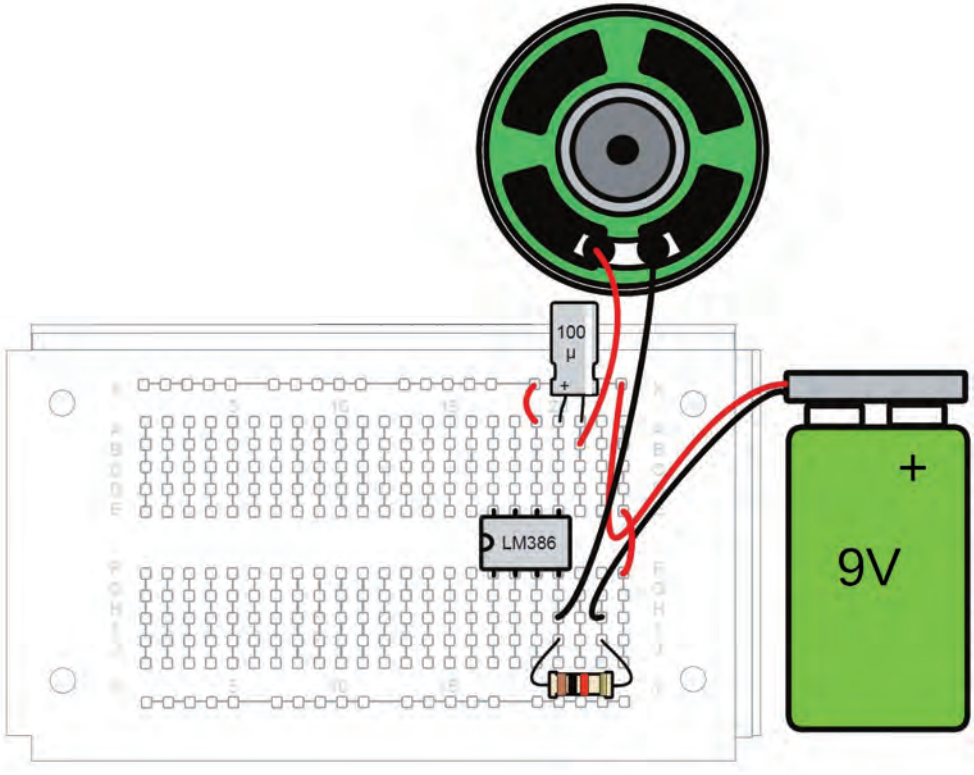
Let's start with the first step and insert the components on the breadboard as shown in the illustration. Inserting components in the breadboard requires some force. The connection wires thus tend to bend. It is important to insert the wires in a straight line from above. Forceps or small pliers may come in handy. Grip the wire a short distance above the breadboard und push it downwards. This way, you can even insert sensitive wires like the tinned tips of the connecting wires of the battery clip or the loudspeaker without bending. If it is hard to insert the wires, use a needle to widen the contacts on the breadboard a little. For the wire connections, you need hook-up wire. Cut appropriate lengths of wire and remove 5 mm of the insulation at the end. You can strip off the insulation with your fingernails or with pliers. Alternatively, you can remove it with the help of a sharp knife. Initially, the eight legs of the IC have a slightly widened stance and must be aligned in parallel rows. This is best done with pliers. Only now it is possible to insert the IC in the breadboard without effort. Be careful to mount the chip in the correct direction. A notch at the left side marks pins 1 and 8.

The assembly drawings show exactly what contacts have to be used. Carefully observe all the drawings. When you adhere to them, everything will work just fine!

As most of the components will remain in the same position, it already makes sense to install a strain relief for the battery wires at this stage to prevent the battery clip from damage. Remove the insulation from the ends of a piece of wire of approx. 2 cm and insert it in the breadboard as shown. Caution: Do not establish a conductive connection with the strain relief!
When you turn on the battery, you will 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. By touching the pins, you apply a small signal voltage to the input.

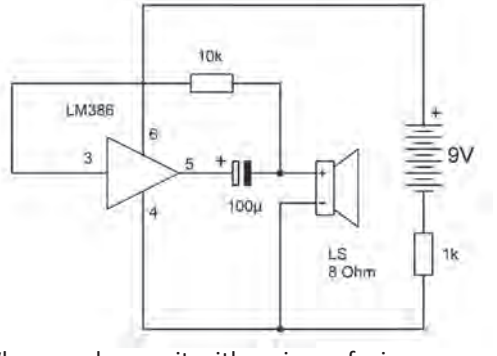




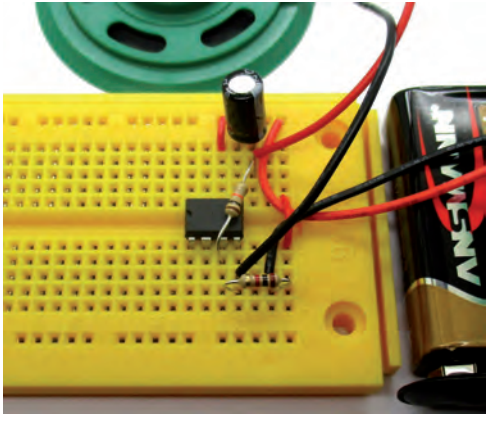

100
µ
+
LM386
+
9V

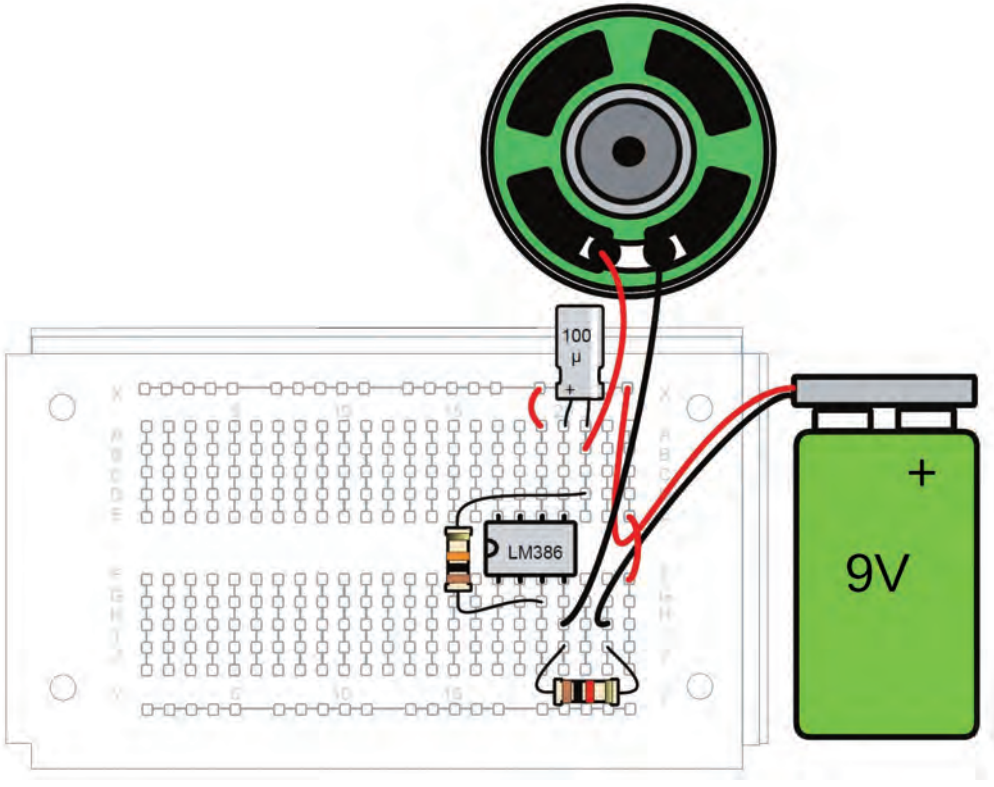
3 Sound generator

This circuit uses the 10 kΩ resistor (brown, black, orange) to turn the amplifier into a sound generator. For natural oscillations to emerge, the non-inverting 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. Pin 2 of the LM386 is an inverting input. When the voltage at this input increases, the amplified voltage at the output decreases. In contrast, pin 3 does not invert the signal: any input signal is amplified at the output but keeps its phase. By the feedback on pin 3, oscillations are generated.
This experiment proves that the amplifier is attached correctly and works properly. The protective 1 kΩ resistor within the negative connection is thus no longer needed.



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

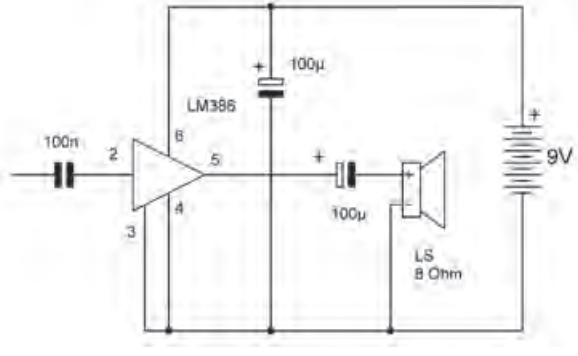


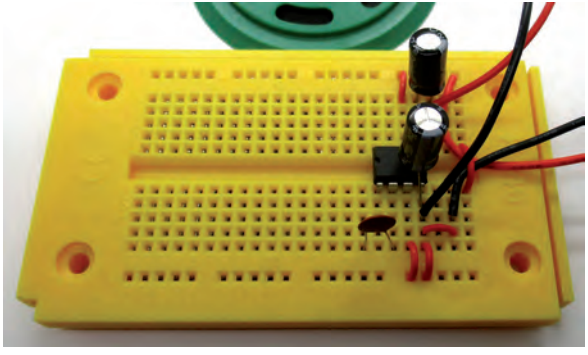

100
µ
+
LM386
+
9V

4 The improved amplifier

Capacitors are often used to transfer sound frequency signals. Here, we use a ceramic 100 nF disc capacitor (labelled 104). This amounts to just a 1000th of the capacitance of the 100 µF e-cap. A 100 nF capacitor is ideally suited as a coupling capacitor at the amplifier input.
The 1 kΩ protective resistor is replaced by a piece of wire because after the successful initial test, there is no longer a risk of a faulty circuit. Later, you will insert the main switch of the radio in this place.
Pin 3 of the amplifier is now additionally 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 wire of the capacitor. Again, you will hear low disturbing sounds from the loudspeaker, e.g. a buzzing or humming.

It originates in the electrical wires and devices in the room, is 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.

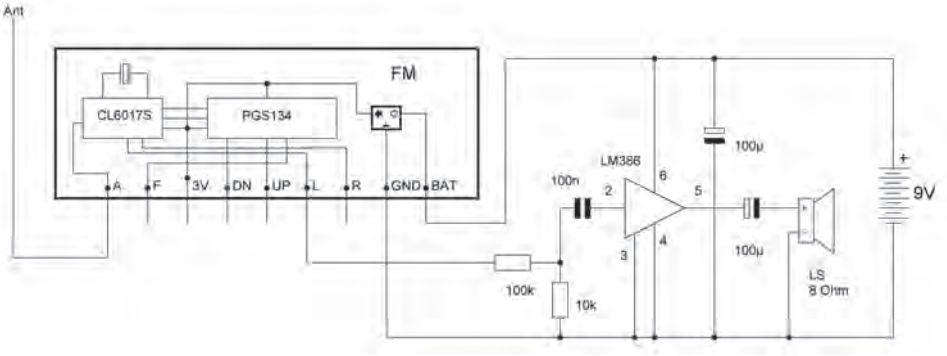


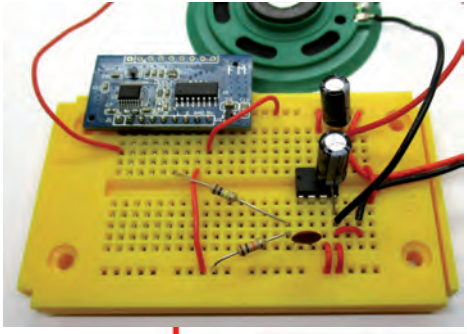


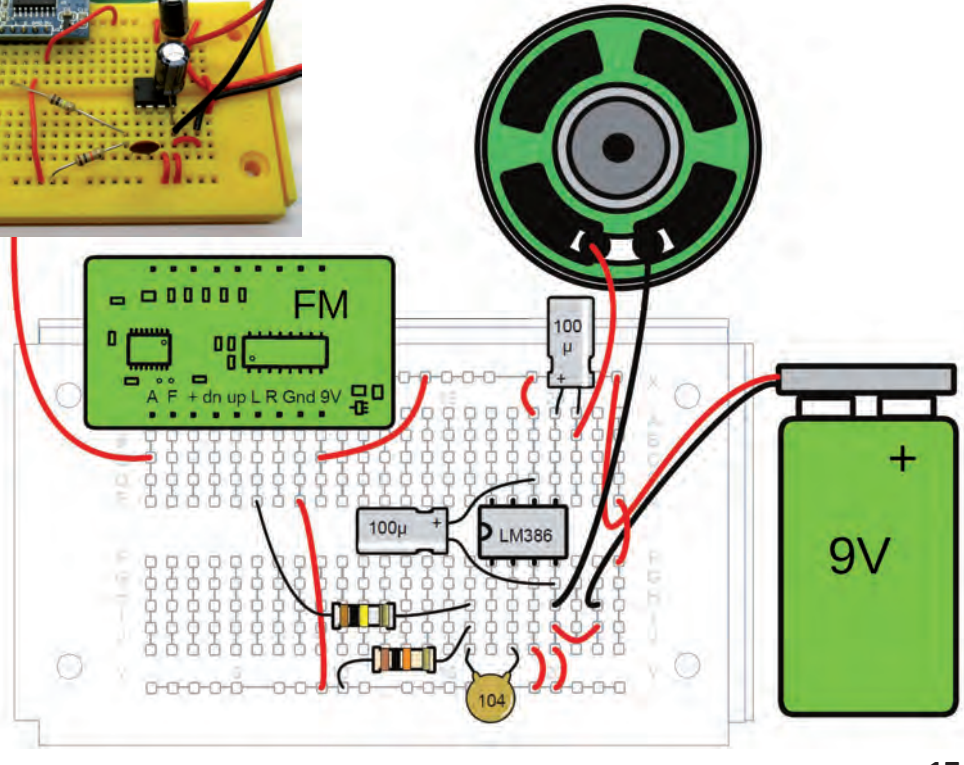
100
µ
+
100µ
+
LM386
104
+
9V

5 The simplest radio

The receiver board with its many small components is the heart of your FM radio. Only four connections are required for the first attempt. The operating voltage of 9 V is supplied via GND (-) and BAT (+).
An antenna wire at least 10 cm long is connected to antenna connection A. The audio signal then appears at the LF output (L). Two resistors of 100 kΩ (brown, black, yellow) and 10 kΩ (brown, black, orange) ensure a sufficiently low input voltage at the power amplifier so that it is not overdriven. Later, the volume control will be connected at this point. Although the radio is far from finished, you can already listen to a radio station. This is the lowest station in the FM range, which was found by an automatic search when the radio was switched on.



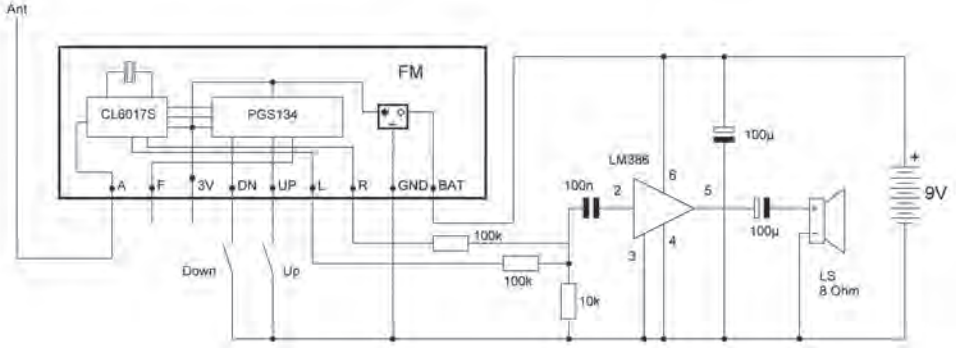


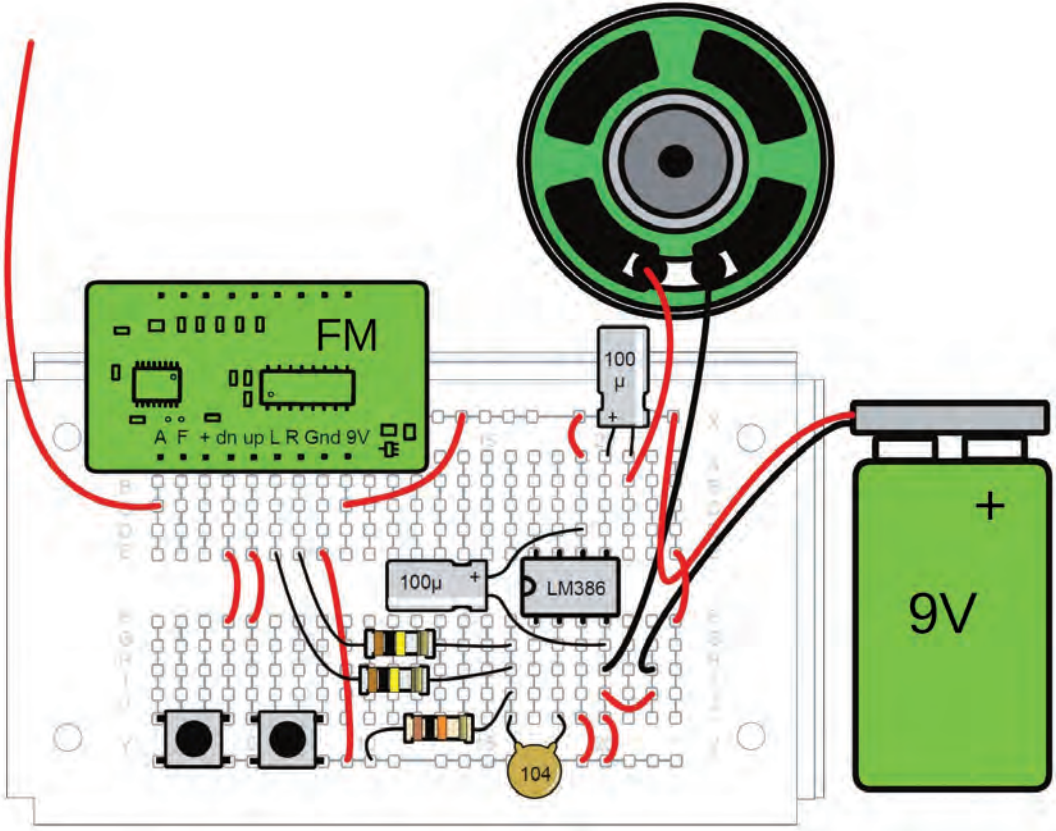

FM
A F + dn up L R Gnd 9V
100
µ
+
100µ
+
LM386
104
+
9V

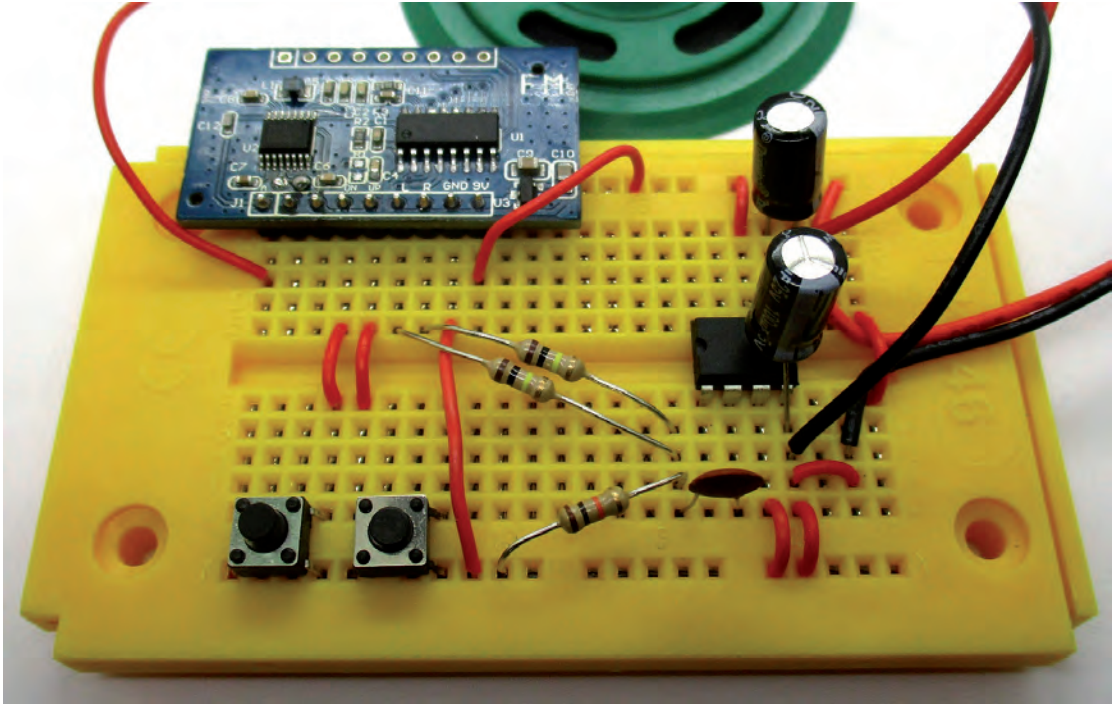
6 Station selection

The radio board has two connections for push-buttons: Up (search upwards) and Dn (down, search downwards). Briefly pressing the Up button causes the station to be searched for on the next frequency. If you have already listened to the last station, the search starts again at the lowest frequency.

A short press on the Dn button starts a search in the opposite direction. Pressing Up and Dn alternates between two stations. The radio board actually provides a stereo signal at the outputs L and R. However, because there is only one loudspeaker, the left and right channels are combinded by two resistors with 100 kΩ each.




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


L R GND 9V

The station memory

In addition to the search function, you also have the option of storing your favorite stations. When you have found a station you like using the Up or Dn button, press and hold the button again. After approx. one second you will hear a beep and this station will be stored. In the same way, you can search for other favorite stations with a short press of the button and store them with a long press. For example, if you have stored three stations and do not want to add any more, switch the radio off and on again. As there is no switch for this, you have to remove the battery clip to switch it off. Alternatively, the short connecting wire on the negative lead can also be pulled out. The main switch will be inserted at this point later.
When switched on again, the two buttons behave differently. They no longer start a search, but only select the stored frequencies. With Up and Dn you can go forwards and backwards through your own list of favorite stations, all other stations in the FM range remain hidden.
The stored frequencies are even more convenient if the radio is later installed in its housing and can then be tuned using the potentiometer. There are then no more empty channels on the dial, so there is no annoying noise between stations as with older FM radios.

Automatic search

If you want to save all available stations, use the automatic search function. Press and hold the Up button when switching on. All stations between 87.5 MHz and 108 MHz are then automatically searched for, made audible and stored in a cycle of four seconds. At the end, the first station remains switched on.

With this complete list, the radio behaves in a similar way after the next start as it did at the very beginning. However, station selection is much faster because you no longer have to start a scan, but instead select the frequencies from the list. However, the main advantage only becomes apparent when the potentiometer is tuned and installed in the housing.

Deleting the station memory

To delete the stored stations and reset the radio to the initial state, press and hold both switches, Up and Dn, and switch the radio on. You will hear a short beep and the memory will be deleted. The radio will then remain silent and you will need to switch it on again. You can then use the Up and Dn buttons again with a short press to search and with a longer press to store your desired stations.

7 Installation in the housing

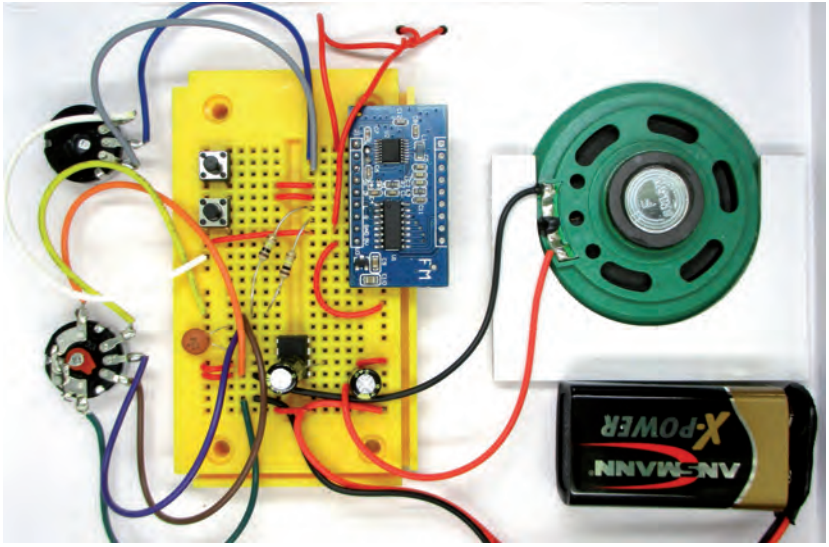
The kit contains two potentiometers. The first one is intended to control the volume and additionally has a switch to turn the radio on and off. The second one will be used for tuning.

Mount both potentiometers with their washers and cap nuts in the radio housing. The small lug of the potentiometer slips into a hole at the side and thus prevents the component from twisting. Slide the loudspeaker into the provided bracket. You can additionally secure it with a little glue.

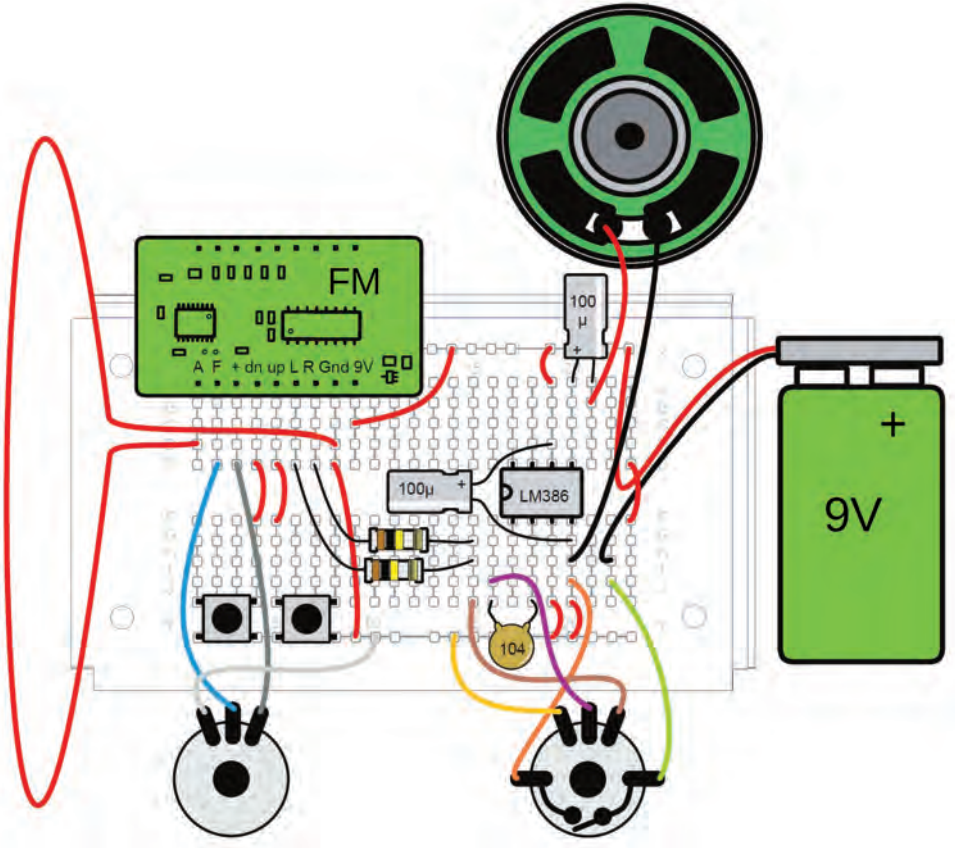
Attach the breadboard between the potentiometers and the loudspeaker. At the bottom side of the breadboard, there is some double-sided adhesive foil covered by a protective sheet. First, find the ideal position for the breadboard,

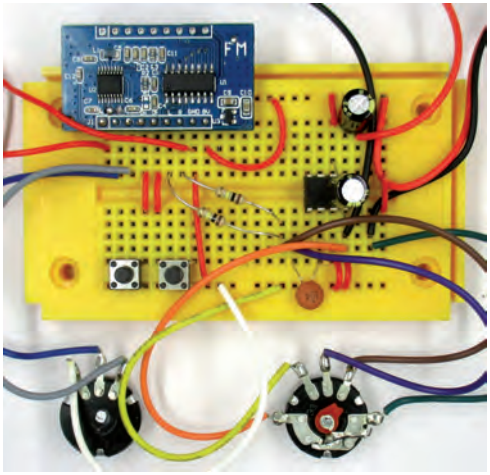
then remove the protective sheet and glue the breadboard in place. Caution: The breadboard must be placed correctly at the first go as it is very difficult to change the position afterwards.

Connect the volume potentiometer as shown in the assembly diagram, paying attention to the colors of the connection cables. Also use the potentiometer switch. It is connected to the negative lead of the battery

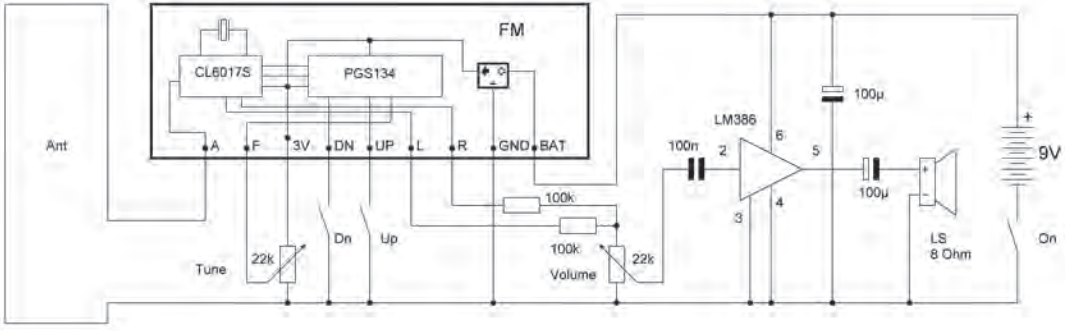


where a resistor was previously installed and later a wire. The other potentiometer is used to select the frequency. Finally, place the two rotary knobs on the axes of the potentiometers. Plug the battery into the clip and test the finished radio.

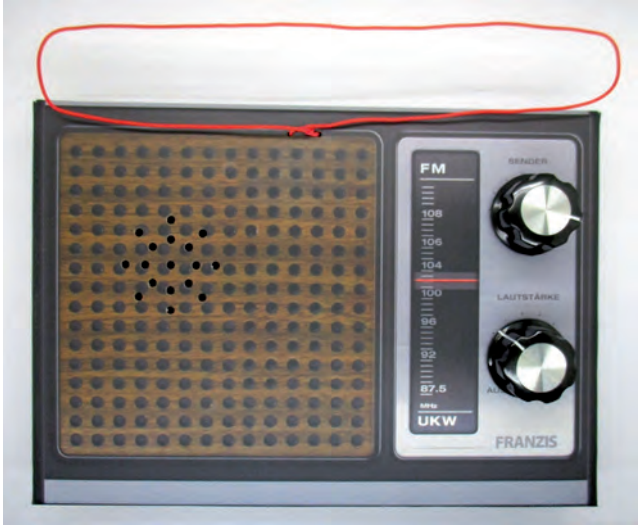

FM
A F + dn up L R Gnd 9V
100
µ
+
100µ
+
LM386
104
+
9V



The antenna now consists of as large a wire loop as possible, which is connected between A and GND. Use a whole meter 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.



The previously stored stations are now evenly distributed across the frequency scale of the upper potentiometer. In contrast to older FM radios, there is no strong noise between the stations. You can also specify which stations you want to listen to. Often there are only two of the three stations that you like to listen to again and again. Tuning is then very convenient and you no longer have to search for the exact setting.



You can still change your channel list. To do this, open the housing to access the push buttons. Delete the old list by holding down Up and Dn when switching on. The next time you switch on the radio, you can search for and save stations using the buttons as before. Alternatively, you can switch on the radio while holding down the Up button and start a complete search and storage of all available stations. If ten stations are found in this way, they will occupy a smaller area on the tuning potentiometer the next time the radio is switched on, but are still easy to tune in.

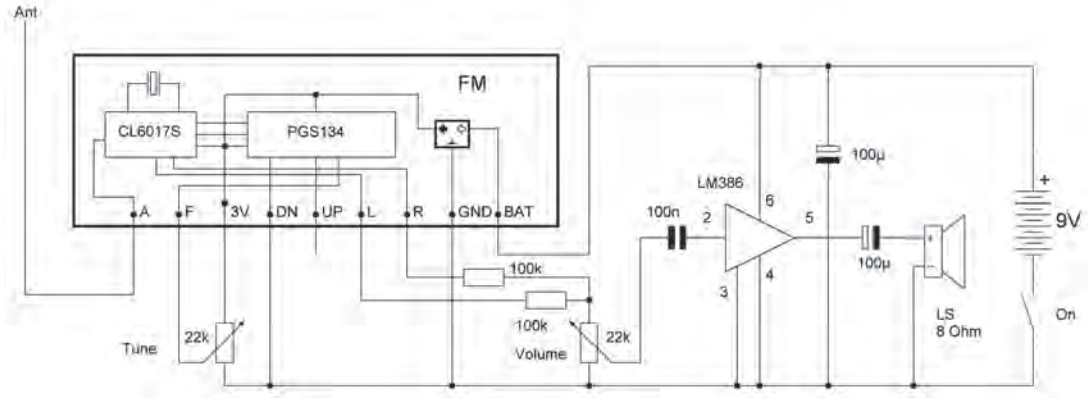
There is now another way to search for desired stations. This time the tuning potentiometer is used for this. Switch the radio on again while holding down the Dn button. You can now tune to any channel in the FM range. As there is a channel grid of 100 kHz, there are over 200 channels between 87.5 MHz and 108 MHz, each of which only occupies a range of just over one degree on the scale. The potentiometer must therefore be operated very slowly and sensitively in order to find the available stations. With stronger stations, a weak signal can also be heard on the neighboring channels. You then have to adjust the frequency very precisely until the signal appears loud and clear. One advantage of this tuning method is that you can also receive distant stations with weak signals that are not audible during an automatic search. It is now also possible to save stations. Once you have found a desired station and left it tuned in for a long time, you will hear a beep after ten seconds and the frequency will be saved.

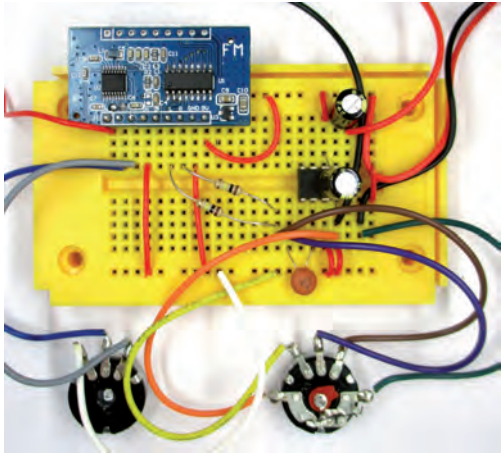
You can also save weak stations using this method. And you can adjust the order of the stations to suit your preferences. If your most important station is in the middle or at the top of the FM range, you can still put it in the first position by storing it first. The next time you switch on the radio, you can then find it by turning the frequency potentiometer all the way to the left. Sometimes weaker stations are only received with audible hiss. In this case, you can try turning the radio or the antenna to improve reception. Also test different locations for the radio. In some buildings, the walls partially shield the FM signals. In this case, a position close to the window may provide better results. Also test the reception outdoors.

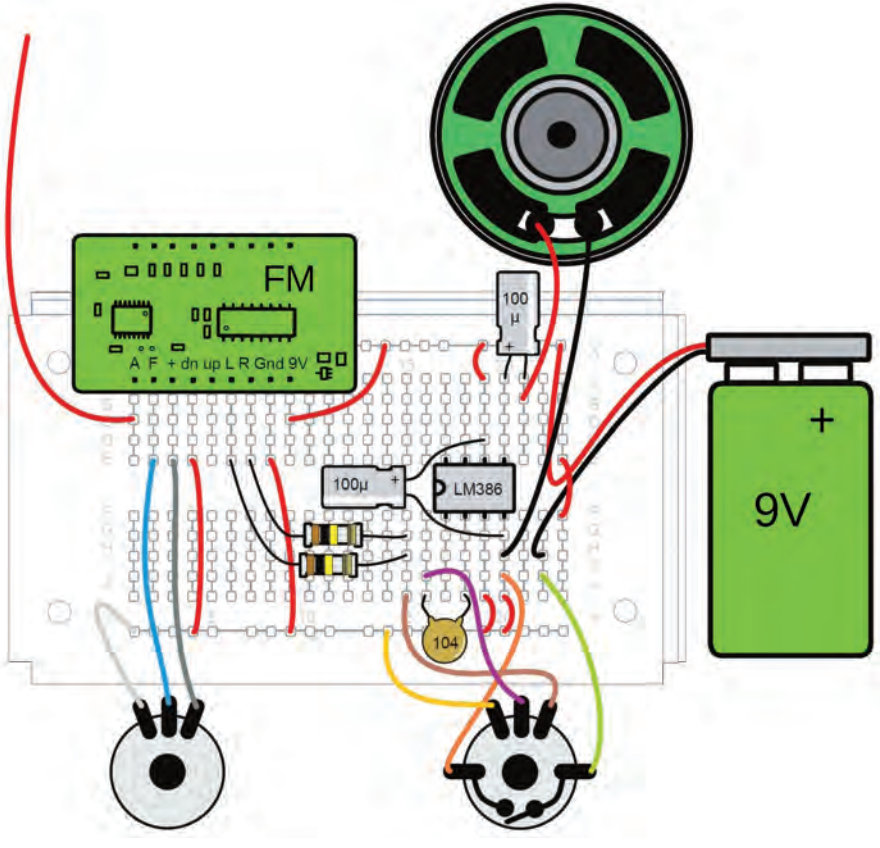
8 The travel radio

If you want to travel with the radio, the pre-programmed stations are no longer helpful because completely different stations with completely different frequencies can be received in other places. Then a traditional radio that receives any channel is better. Today here, tomorrow there, and different frequencies are used everywhere. You can then do without storing the stations.
Connect the Dn connection with a wire to minus. The switches are not needed, the Up connection remains free. This makes the radio behave like a normal analog FM radio.

There will be strong noise on the empty channels and the frequencies of the desired stations must be set very precisely using the frequency potentiometer.
The antenna can be connected as a simple wire, which does not necessarily have to be routed to the outside. For sufficiently strong stations, it is also sufficient to place the antenna wire inside the housing. All local stations can be received clearly and the radio remains compact and portable with the antenna well protected. Many older radios have bent aerials, but this cannot happen here.


Ant
FM
CL6017S
PGS134
A
F
3V
DN
UP
L
R
GND
BAT
100k
100k
Volume
22k
Tune
22k
LM386
100n
2
6
5
4
3
100µ
100µ
+
9V
On
LS
8 Ohm


FM


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

9 Troubleshooting

When setting up the radio, a fault may occur that is not easy to find. In this case, do not give up, but accept the challenge. If the radio does not work, first check all connections. Compare your assembly wire by wire with the assembly drawing and the assembly photo. Check that all wires are in place.
The most common faults are:

- A wire has been inserted in the wrong position.
- The free end of a wire is too short and does not reach the contact of the breadboard.
- A connection of the amplifier is bent over when plugged in and is not in contact.
- Deformation or soiling leads to contact problems on the battery clip or switch.
- The battery is severely depleted and no longer supplies sufficient power.

Make sure that you can hear a click when the switch is switched on. As the rotary switch on the volume control itself makes a noise, it may be useful to leave the switch switched on and hold the battery to the clip. If you do not hear a crackling sound, troubleshooting must first focus on connection or contact problems in the area of the battery, amplifier and loudspeaker. Pay attention to whether the amplifier or any other component becomes hot, which would indicate a connection fault. Move individual wires to detect contact problems. If scratching noises occur when you lightly touch a wire or component, this indicates a poor contact.

If there is no sound coming from the speaker, suspect the speaker, the amplifier and the volume control.

Then repeat the first tests with the loudspeaker amplifier or carry out the following tests:

- Hold a wire or a screwdriver to both connections of the disk capacitor. You should hear a crackling sound, the volume of which depends on the position of the volume control. In this case, everything from the volume potentiometer to the loudspeaker is working.

- If in doubt, pull the disk capacitor out of the circuit and touch pin 2 of the amplifier with a wire. You should hear a soft crackling or humming sound.

If the amplifier has been tested successfully but the radio still does not emit any sound, the FM board and the tuning potentiometer are suspected. The following faults may be present:

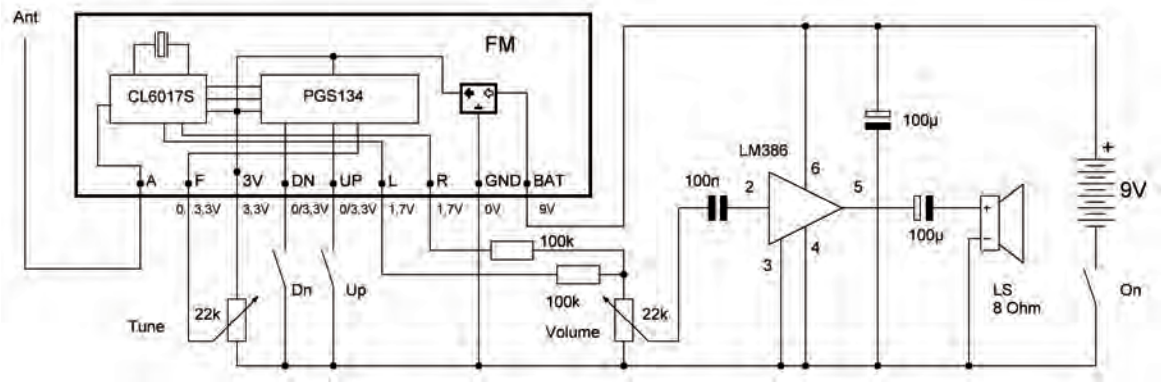
- The circuit board is not receiving its operating voltage of 9 V because the BAT or GND line has been connected incorrectly.

- The tuning voltage at the F connection 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. However, with a little skill, the amplifier can also be used for a simple voltage test. To do this, pull out the brown potentiometer connection and use it as a measuring cable. The volume potentiometer should be in the middle position or even lower. If you then touch a point on the circuit with the brown cable, you will hear a crackling sound, 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). Further tests should show the following:

- BAT connection of the circuit board: 9 V, loud
- GND connection of the circuit board: 0 V, no noise
- LF output L and R of the circuit board: approx. 1.7 V, loud
- Switch connections UP and DN: 3.3 V, loud, or 0 V (pressed), silent
- Gray cable on the tuning potentiometer: 0 V, no noise
- White cable on tuning potentiometer: 3.3 V, loud
- Center pin on tuning potentiometer (blue) and F pin: adjustable 0 V to 3.3 V, quiet to loud



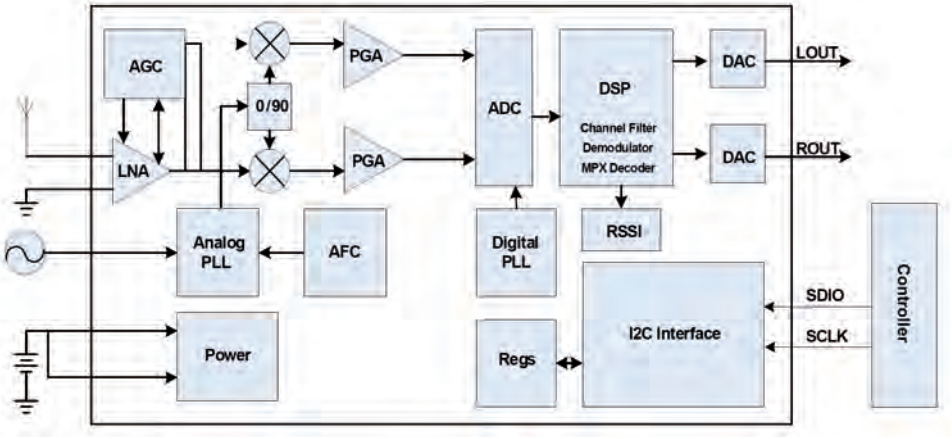
Measured voltages

If you notice a clear deviation at a measuring point, the fault is probably in this area, i.e. usually a contact problem, a mixed-up component or an incorrect connection.

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

10 Technical background

Conventional analog FM radios use an intermediate frequency of 10.7 MHz. The reception frequency is first converted to the intermediate frequency and then filtered, amplified and demodulated in analog form. This radio works digitally. The CL6017S radio module contains a digital signal processor (DSP). The antenna signals are first converted to a lower frequency and then digitized with an analog-to-digital converter. The DSP then takes over the digital filtering, demodulation of the FM signal and decoding of the stereo signal. The block diagram shows the internal structure of the CL6017S.



Digital signal processing takes slightly longer than analog processing in a traditional radio. You can observe this when you tune an analog radio to the same station. The sounds from the DSP radio come a short moment later.
The CL6017S radio module has no connections for operating elements, but is controlled by a microcontroller via the two lines SDIO and SCLK.

This connection is used to set new receive frequencies, start searches and read out frequencies that have been found. The microcontroller is a PGS134 with internal EEPROM and AD converter. The AD converter is used to measure the position of the tune potentiometer and stations are stored in the EEPROM. The operation of the radio is determined by an internal program in the microcontroller.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