UKW-Radio Bausatz

FM Radio Construction Set

Imprint

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Author: Burkhard Kainka

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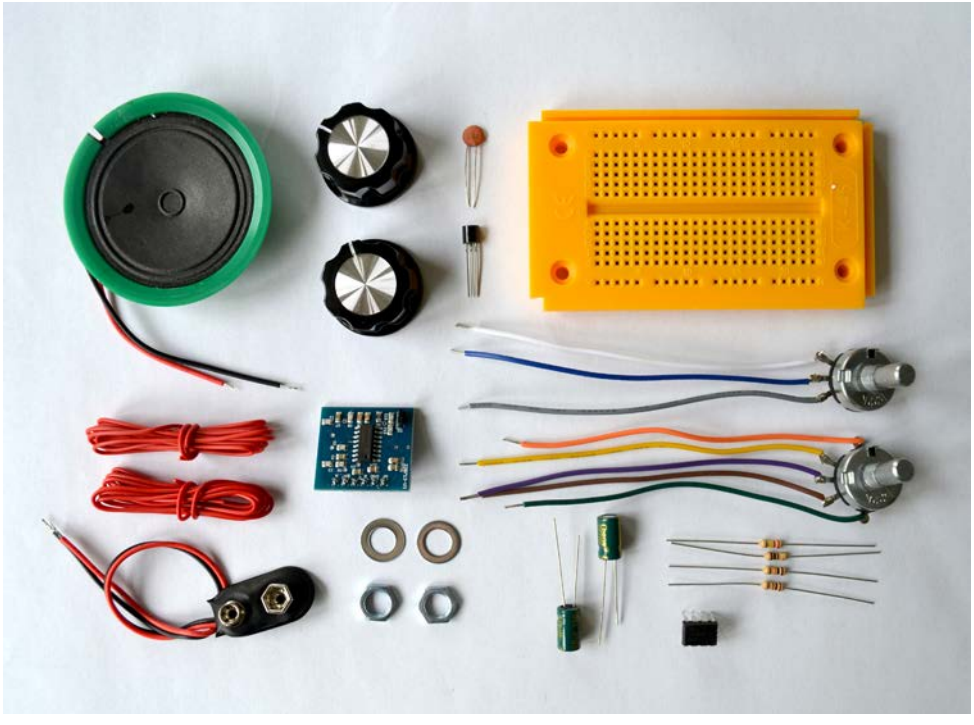
Dear customers!

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!



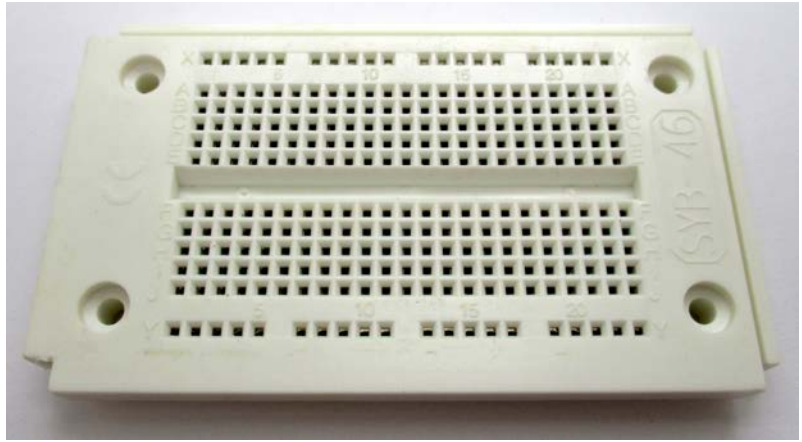
The FM radio is easy to assemble and yet offers many possibilities. There are numerous versions and options. Feel free to experiment with different circuits and antennae to receive stations near you or far away.

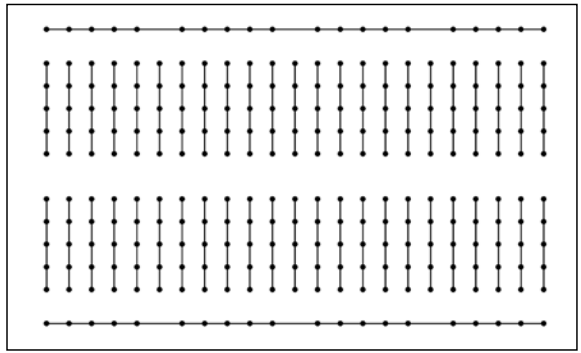
Enjoy your radio kit!

Contents

The Components

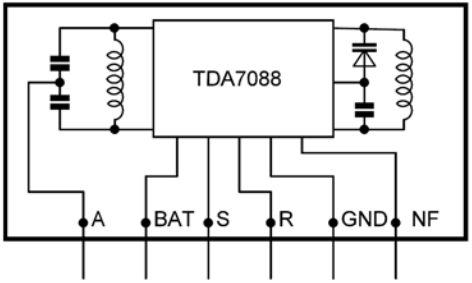
The various circuits are built on a **bread-board**. The centre part contains 46 contact strips with five contacts each. The two long strips with 20 contacts along the edges are typically used to provide the operating voltage.



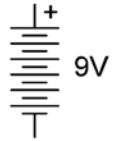


Internal connection of the contacts

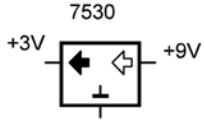
All components are inserted in the breadboard and thus connected to each other. The individual steps are illustrated with assembly drawings, photos or circuit diagrams. The symbols in the circuit diagrams are as follows:



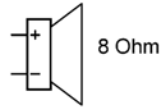
FM board



Battery



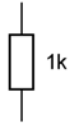
Voltage regulator



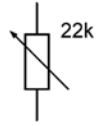
Loudspeaker

Capacitor

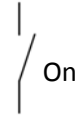
E-capacitor



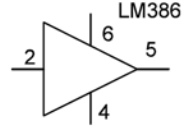
Resistor



Potentiometer



Switch

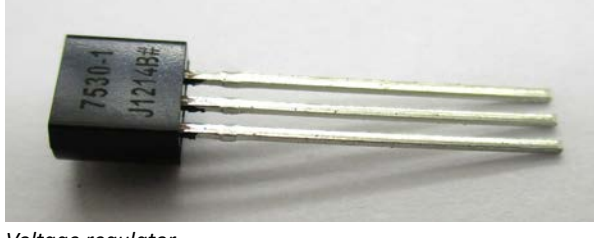


Amplifier

The **FM board** is the essential component of this radio. It contains an integrated circuit and many tiny pre-soldered capacitors and resistors. You can easily recognise two printed coils and the upright variable capacitance diode. There are six pins to connect the board with the breadboard and thus the other components. It is important to supply the radio board with an operating voltage of only 3 V. It must never be connected directly to a 9 V battery. Instead, a voltage regulator is required.

The **HT7530 voltage regulator** provides a stable voltage of 3 V. Its three legs are not interchangeable. The middle leg is the input. It connects to the positive terminal of the 9 V battery. The output, i.e. the right pin, then provides a stable voltage of +3 V. The third pin connects to a shared negative terminal.

FM board



Voltage regulator

LM386 amplifier

Loudspeaker

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.

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.

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 µF e-cap

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.

100 nF disc capacitor

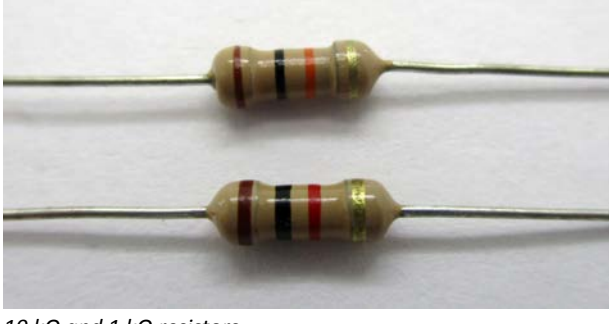
The **resistors** in the kit are of the carbon film type and can be mounted in any direction. The smallest one has a resistance of 100 ohm (100 Ω), the biggest one has 220 kiloohm (220 kΩ). The resistance values are shown by three coloured rings. The fourth, gold ring represents a tolerance of 5%. The kit contains four resistors in total.

100 Ω: brown, black, brown

1 kΩ: brown, black, red

10 kΩ: brown, black, orange

220 kΩ: red, red, yellow

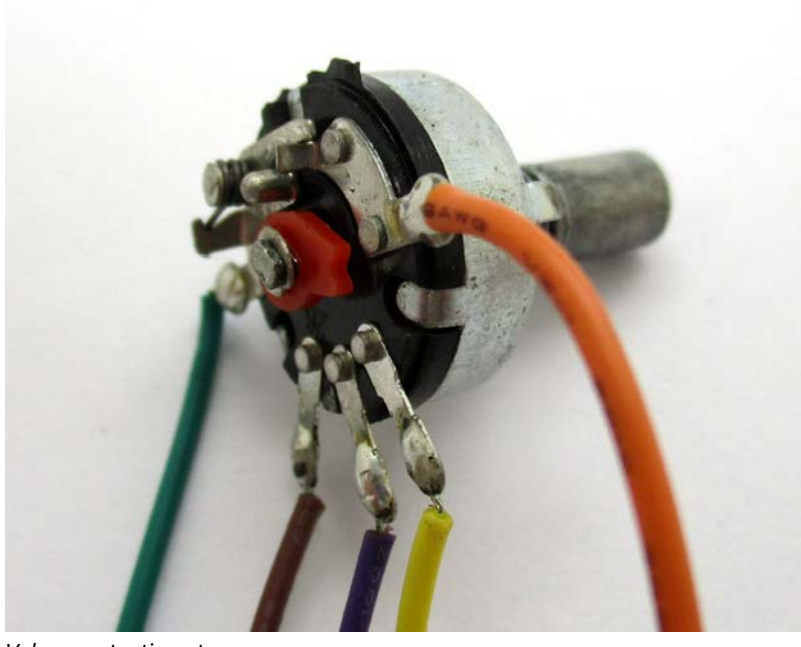


10 kΩ and 1 kΩ resistors

Basically, a **potentiometer** is a resistor; however, it contains a third contact, which is shifted by turning the axis. The potentiometer 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.

Tuning 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 more than half the total resistance.

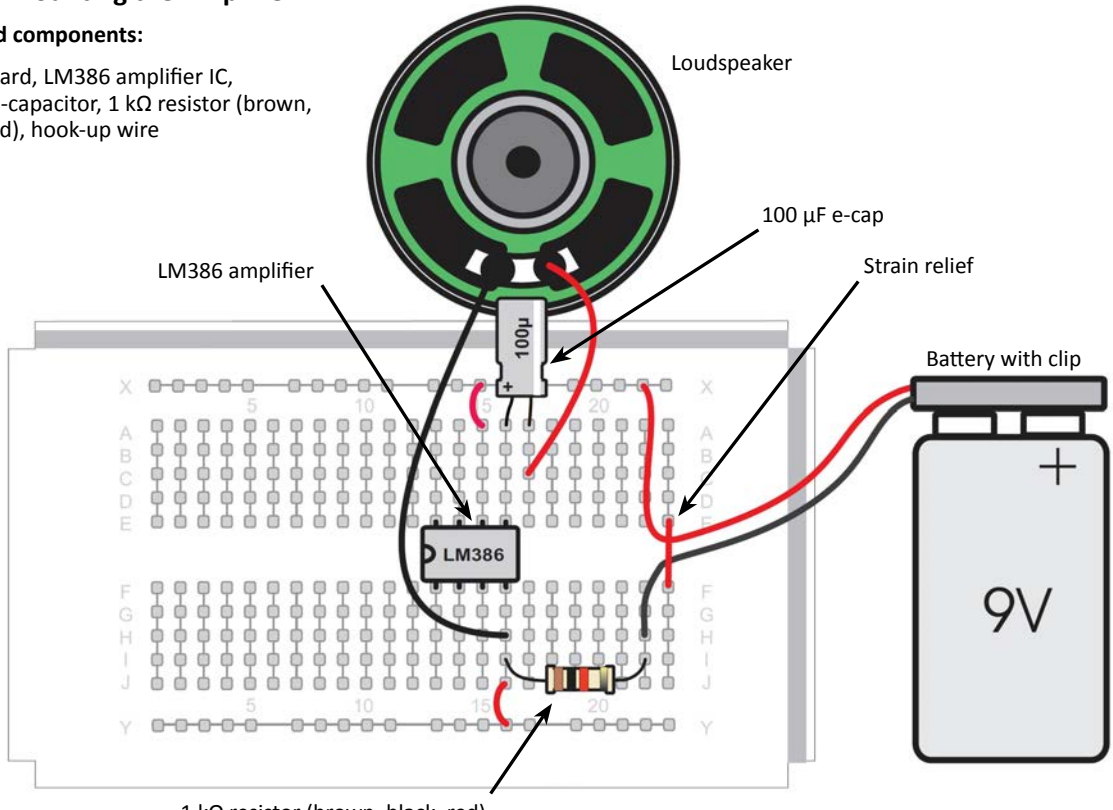


Volume potentiometer

Step 1: Mounting the Amplifier

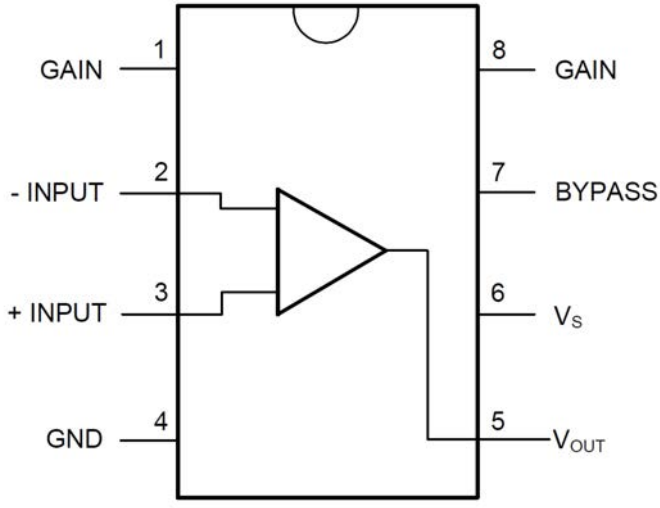
Required components:

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



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.

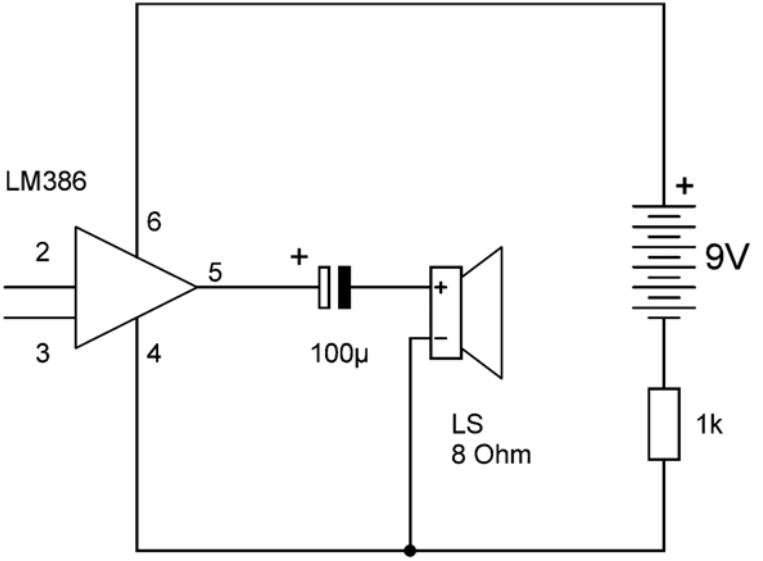
For the wire connections, you need hook-up wire. Cut appropriate lengths of wire and remove 5 mm of the insulation at the end. You can strip off the insulation with your fingernails or with pliers. Alternatively, you can remove it with the help of a sharp knife.

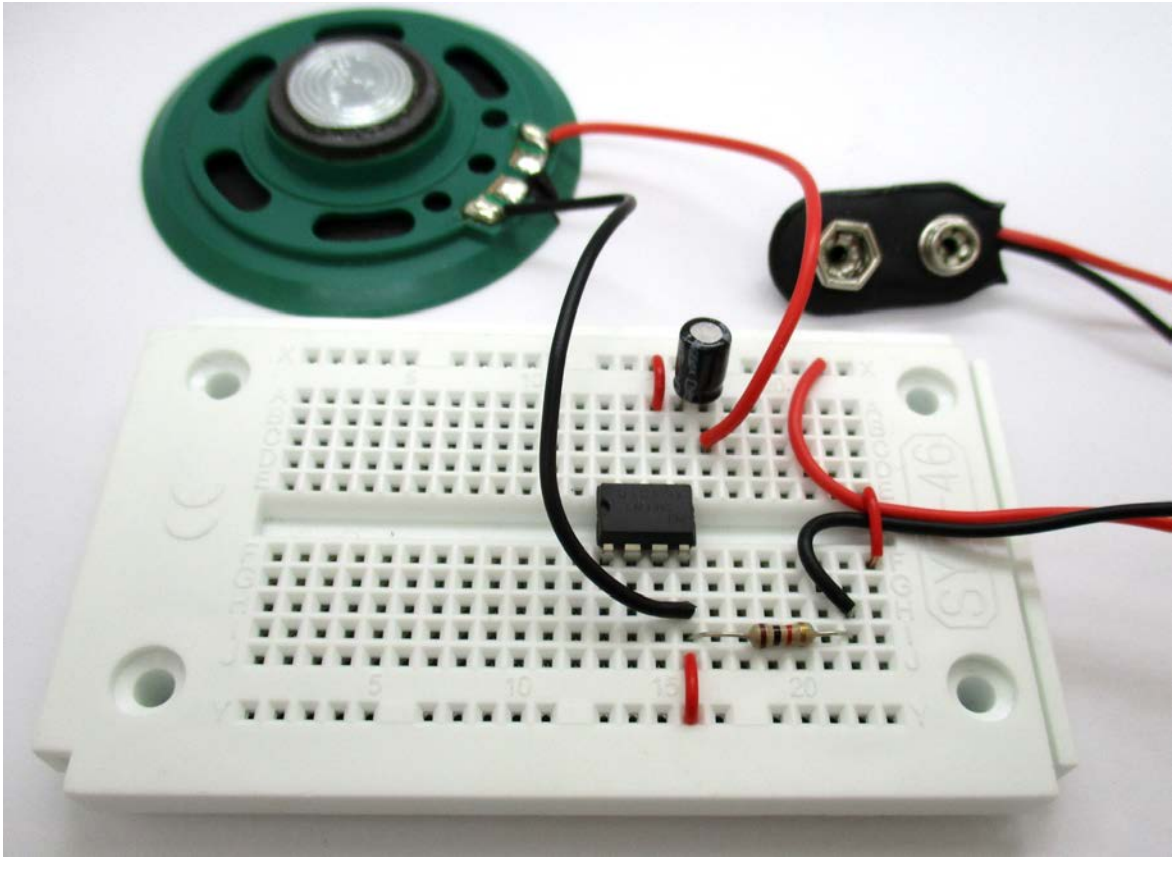
Initially, the eight legs of the IC have a slightly widened stance and must be aligned in parallel rows. This is best done with pliers. Only now it is possible to insert the IC in the breadboard without effort. Be careful to mount the chip in the correct direction. A notch at the left side marks pins 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.

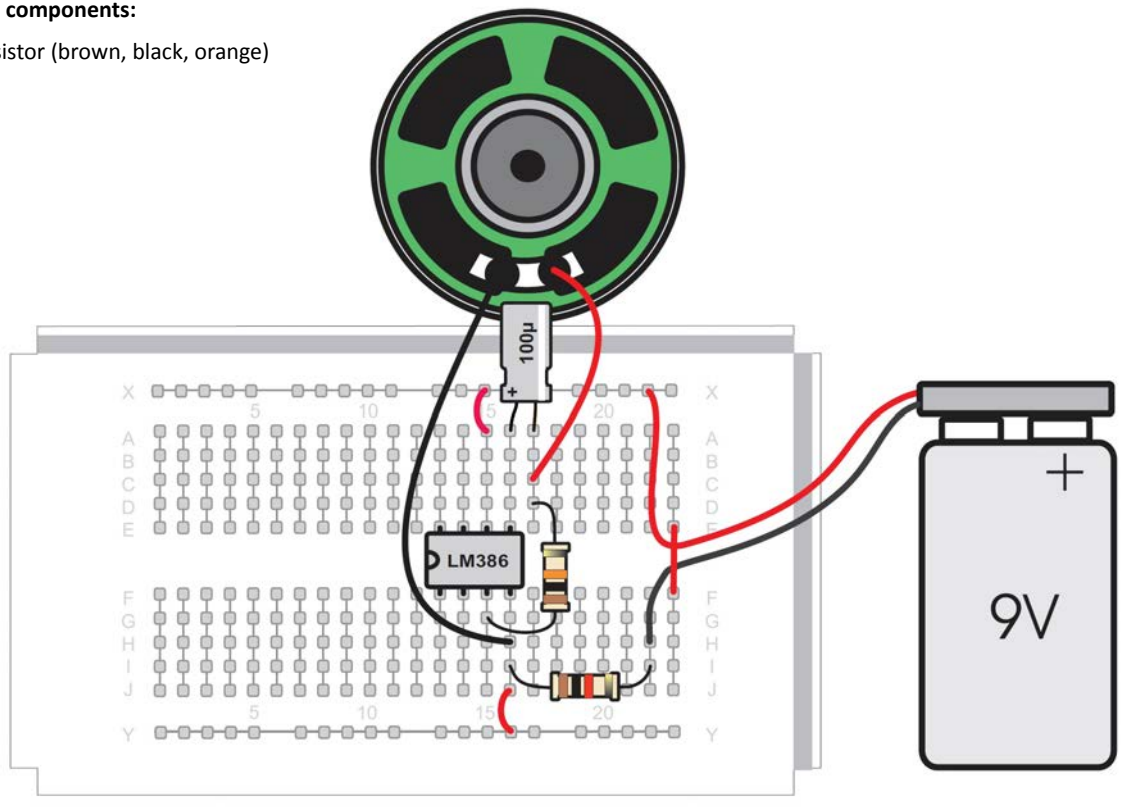




Step 2: Sound Generator

Required components:

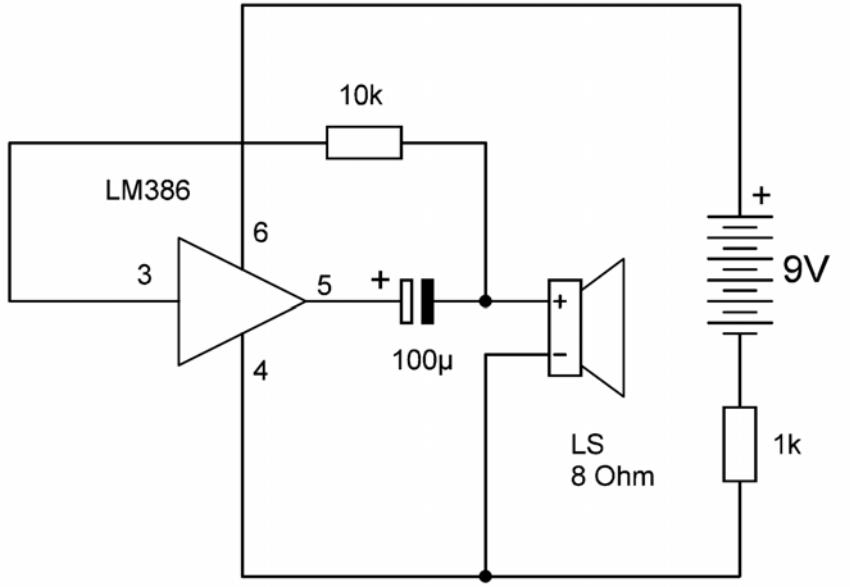
10 kΩ resistor (brown, black, orange)

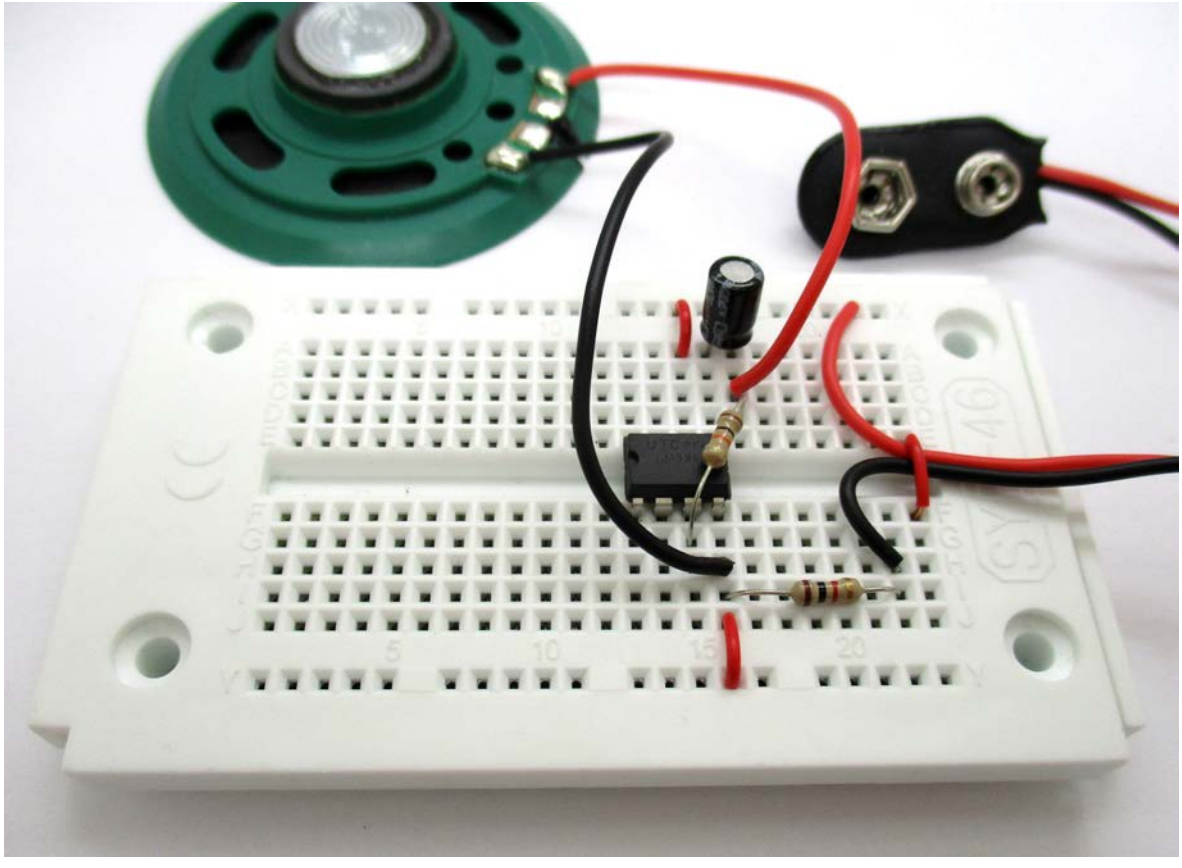


This circuit uses the 10 kΩ resistor (brown, black, orange) to turn the amplifier into a sound generator. For natural oscillations to emerge, the non-inverting input at pin 3 of the LM386 has to be connected to the output via a resistor. This feedback generates oscillations of the amplifier, which become 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.

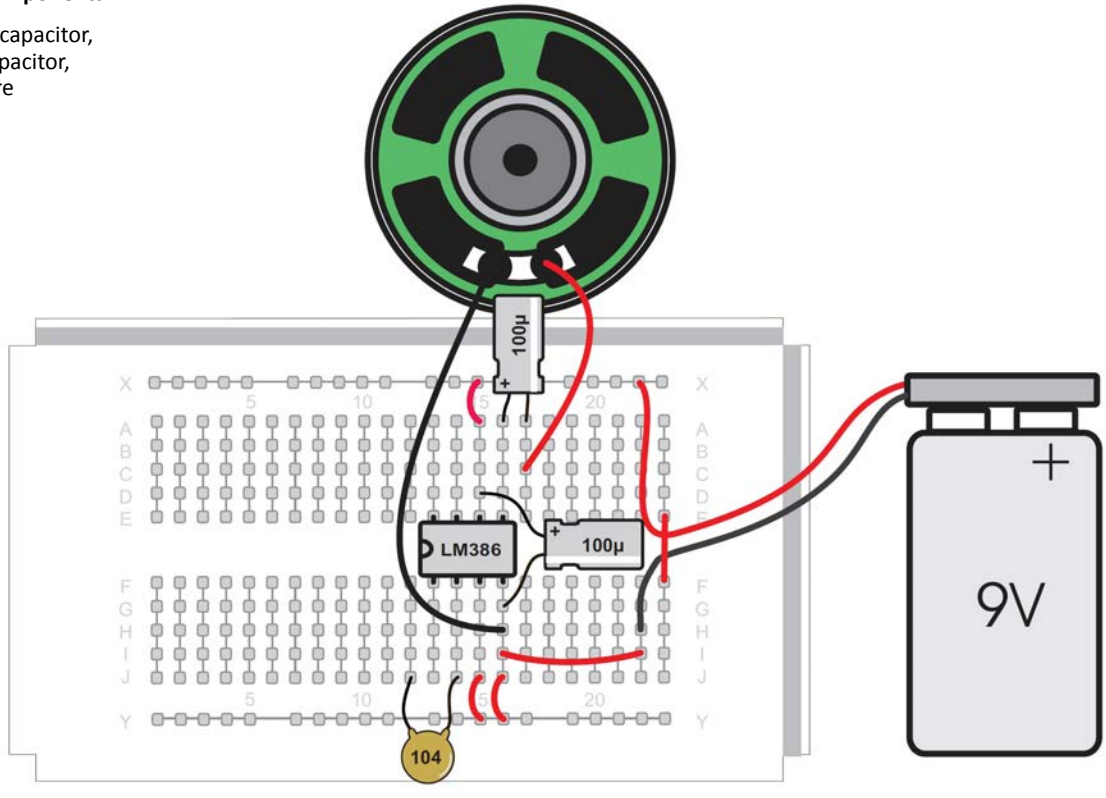




Step 3: Improved Amplifier

Required components:

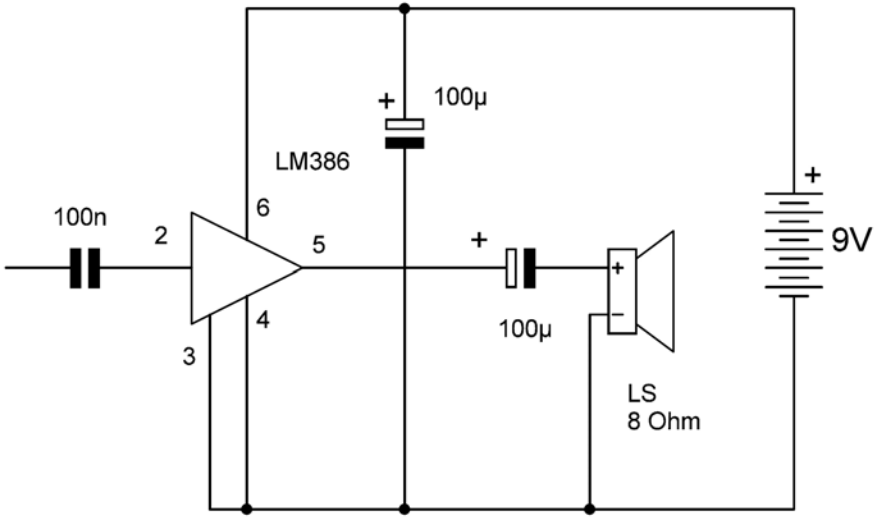
100 nF disc capacitor,
100 µF e-capacitor,
hook-up wire



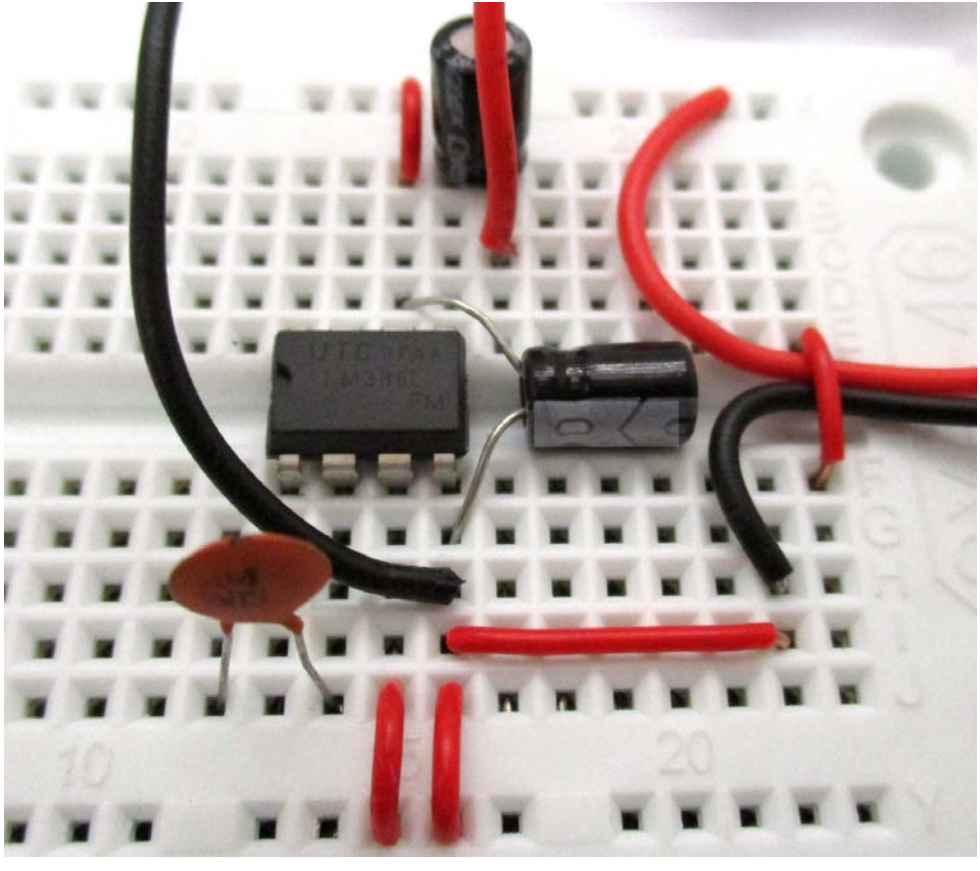
Capacitors are often used to transfer sound frequency signals. Here, we use a ceramic 100 nF disc capacitor (labelled 104). This amounts to just a 1000th of the capacitance of the 100 µF e-cap. A 100 nF capacitor is ideally suited as a coupling capacitor at the amplifier input.

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.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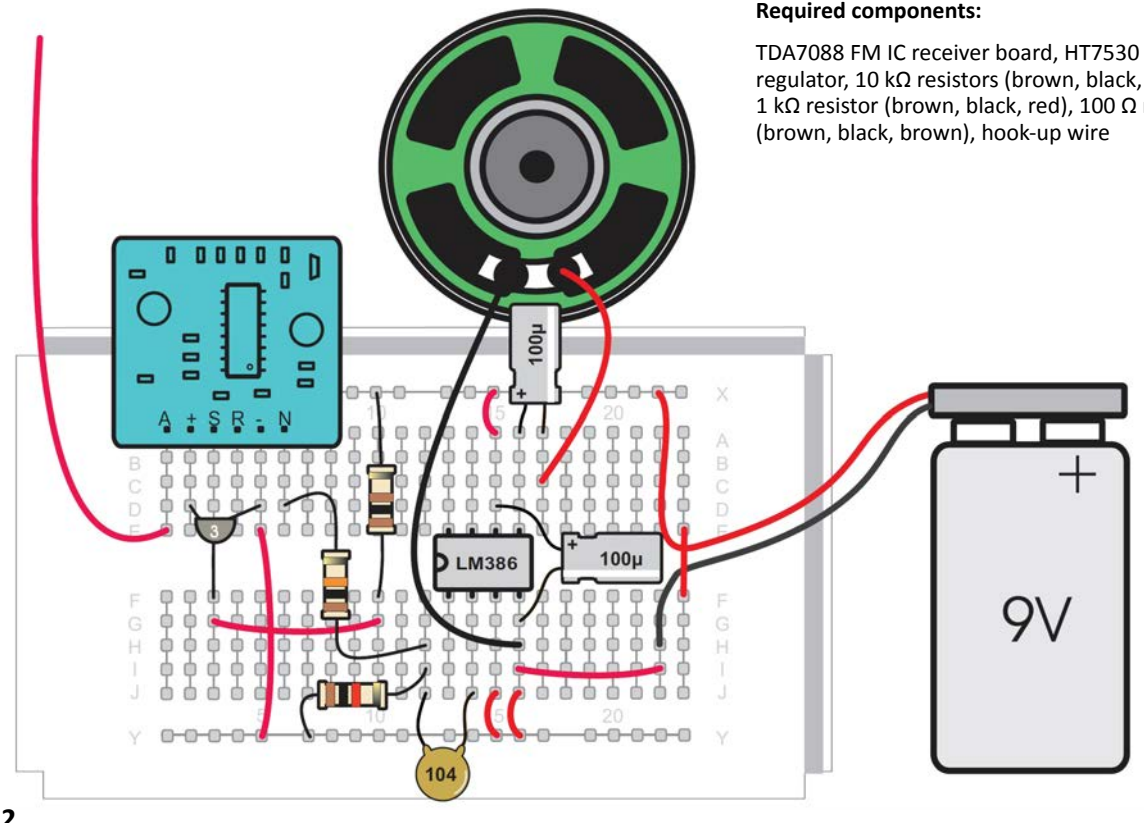
Step 4: Simple Radio



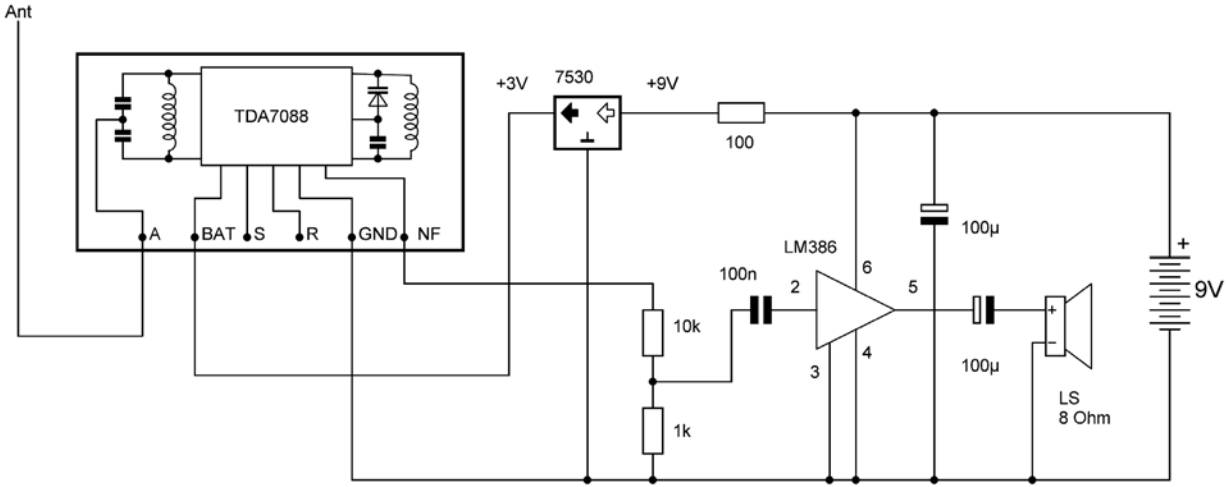
Required components:

TDA7088 FM IC receiver board, HT7530 voltage regulator, 10 kΩ resistors (brown, black, orange), 1 kΩ resistor (brown, black, red), 100 Ω resistor (brown, black, brown), hook-up wire

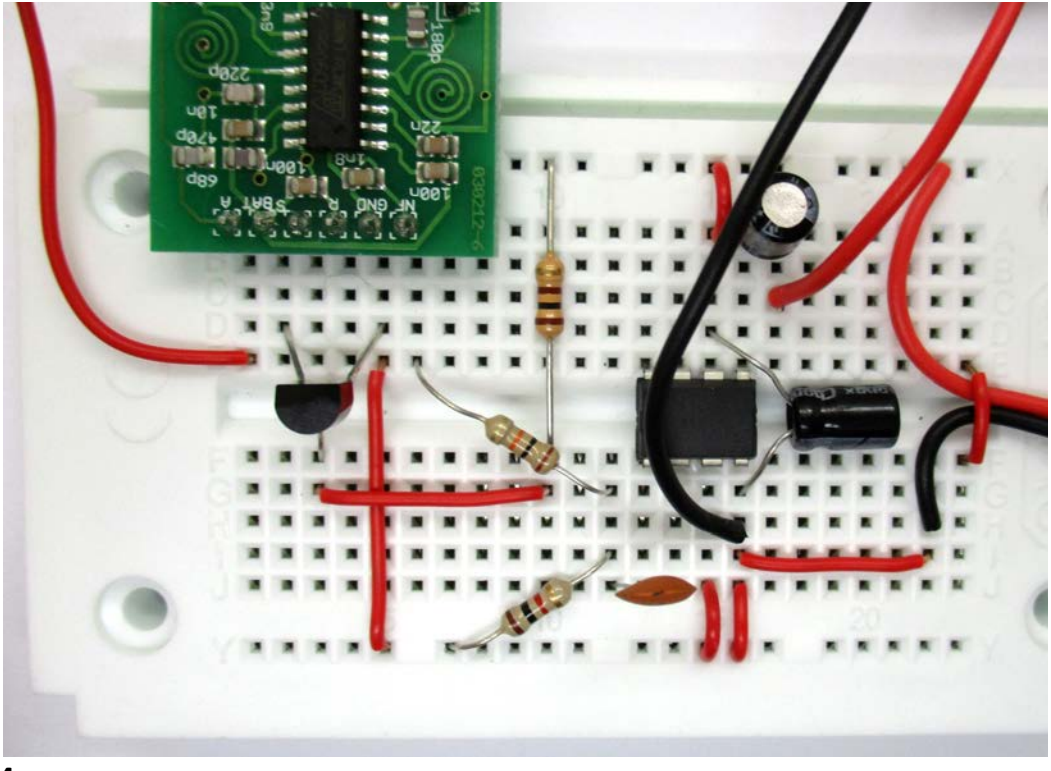
The receiver board with the TDA7088 FM IC is the heart of your FM radio. Apart from the IC, the board contains many tiny capacitors, a variable capacitance (varcap) diode and two printed coils. For the first experiment, only four pins are used. The stabilised 3 V operating voltage is supplied via GND (-) and BAT (+).

Caution: The radio board must not be attached to 9 V but requires an operating voltage of 3 V. For this reason, the type 7530 voltage regulator is used. Its three legs are not interchangeable. The input (middle pin) is attached to the positive terminal of the battery and the ground pin (right) to the negative terminal. The output (left) now provides a stable voltage of 3 V. Pay attention to the mounting direction! The flat, unlabelled side has to point towards the FM board. The plus connection behind +9V contains a 100 Ω protective resistor (brown, black, brown), which prevents damages to the components in case of an incorrect setup of the circuit.

An antenna wire of 10 cm is attached to the antenna pin A. The NF output provides the sound signal. Two resistors of 10 kΩ (brown, black, orange) and 1 kΩ (brown, black, red), respectively, provide for a moderate input voltage at the end amplifier. Later, you will attach the volume control at this point.



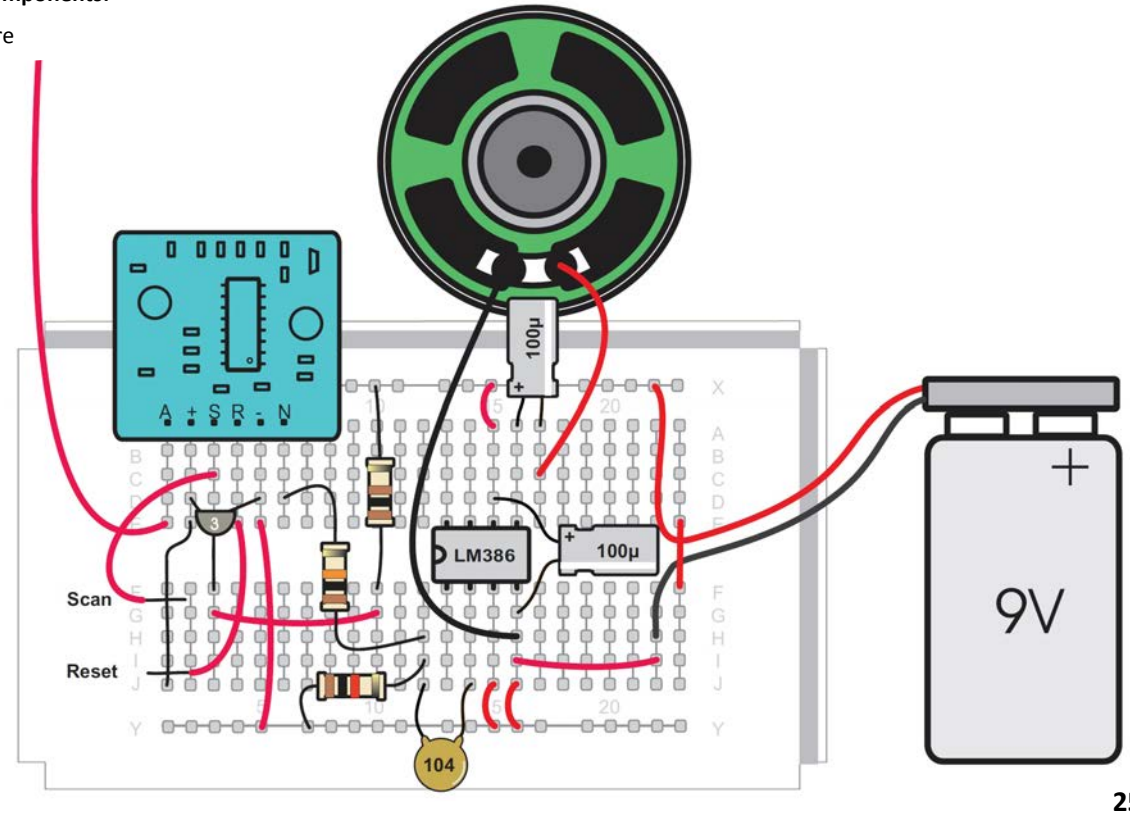
While there is still much to do to complete the radio, you may already be lucky and be able to receive a radio station. As the tuning contacts are not yet attached, you will receive a random frequency. However, by momentarily touching the +, S, R, and - contacts on the receiver board, you can switch to a different station.



Step 5: Tuning

Required components:

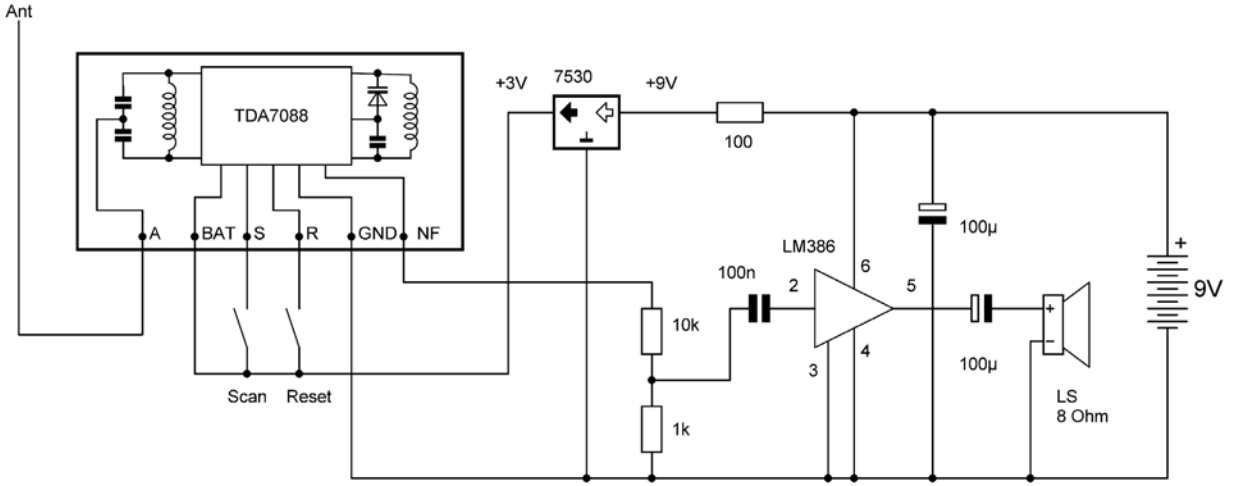
Hook-up wire



The radio IC has a scan input (S) to start the station scan. The corresponding push-button is placed between the positive operating voltage and the S input. To build the push-button, you use hook-up wires that will connect the BAT terminal to the S input when they touch each other. Bend the wires so that they make contact when you push them slightly.

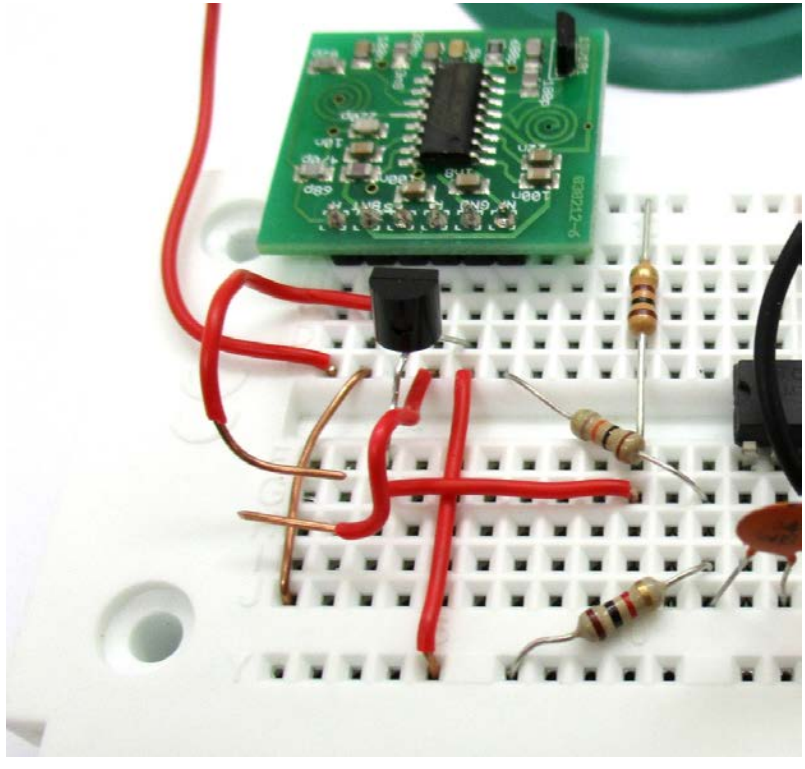
Momentarily touching the push-button causes the radio to search for the station of the next higher frequency. After reaching the last station, the scan ends.

Another push-button is attached to the reset input (R) of the receiver board. A touch of this button resets the receiving frequency to the lower end of the FM range. Now you can restart the scan by touching the scan button.

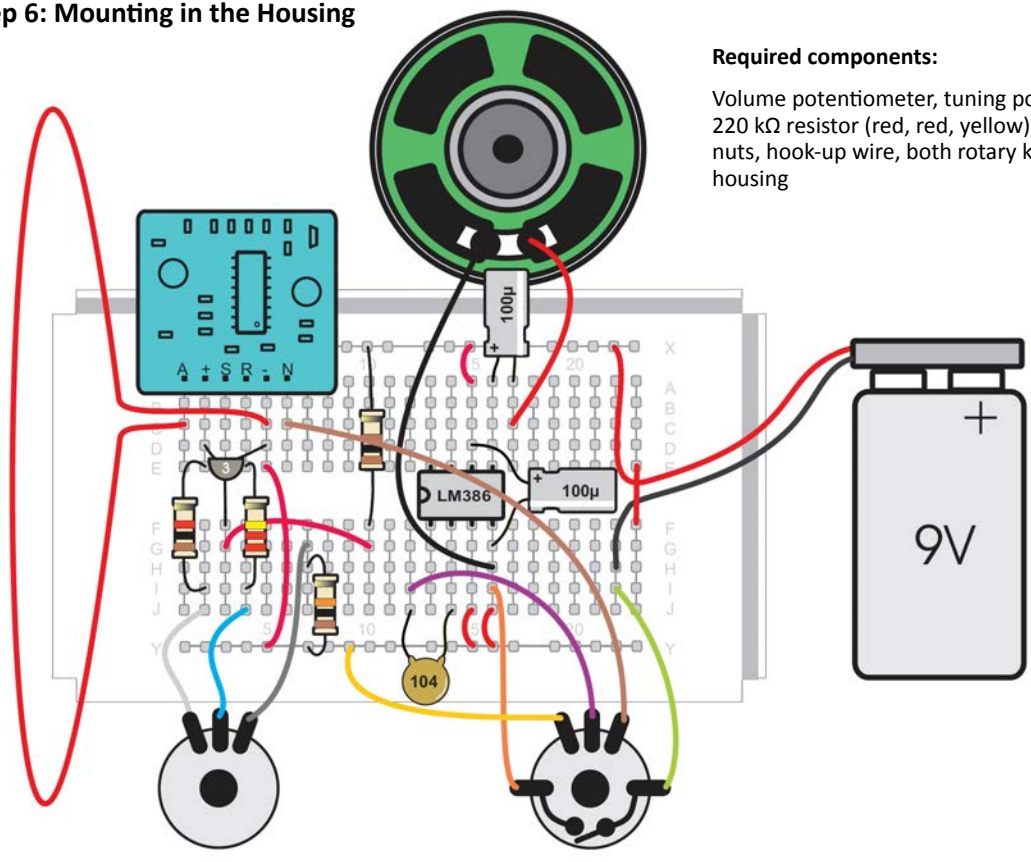


The receiver board also contains a variable capacitance diode (varcap) whose capacitance changes depending on the applied DC voltage. The smaller the capacitance, the higher the frequency. The R pin of the radio board is connected to the varcap diode. By its connection to the BAT pin, the reset button causes the voltage at the diode to be cut off. In this way, the minimum frequency of a little lower than 87.5 MHz is set. The board contains an additional integrated capacitor to hold the current tuning voltage. By touching the reset push-button, this capacitor gets discharged.

With every press of the scan button, a new scan starts. A higher DC current between the positive terminal (BAT) and the R input increases the frequency. The tuning voltage is increased until a new station is found. The automatic frequency control (AFC) fine-tunes the frequency in case of deviations.



Step 6: Mounting in the Housing

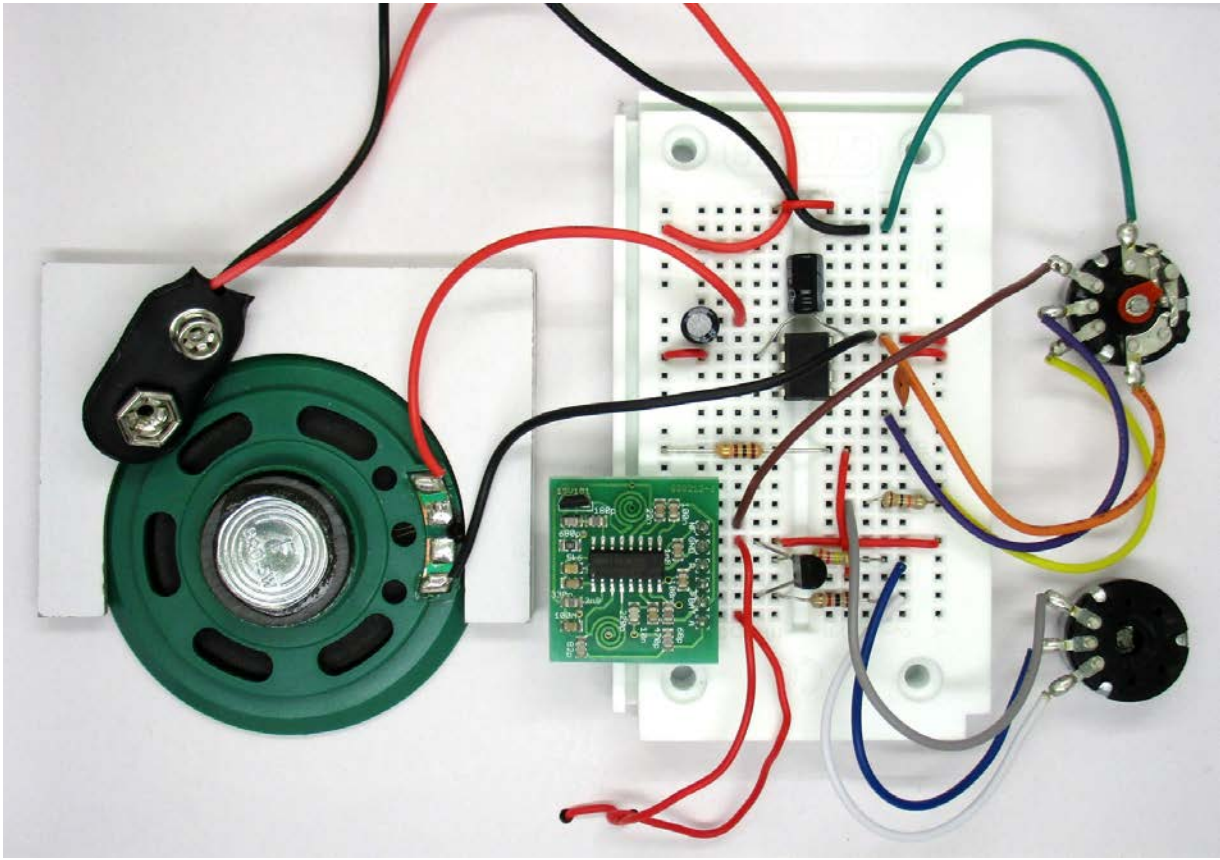


Required components:

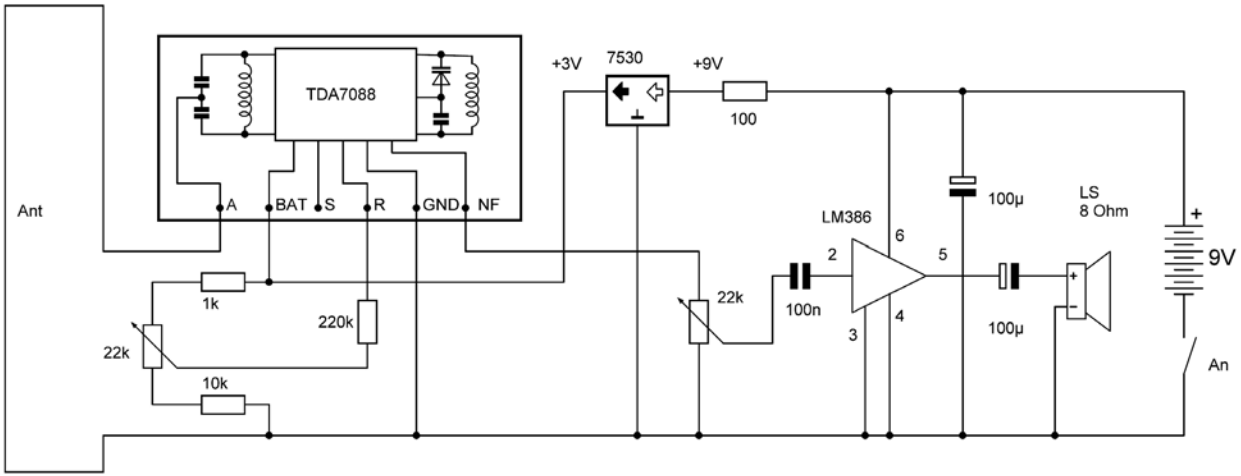
Volume potentiometer, tuning potentiometer, 220 kΩ resistor (red, red, yellow), washers, cap nuts, hook-up wire, both rotary knobs, radio housing

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.

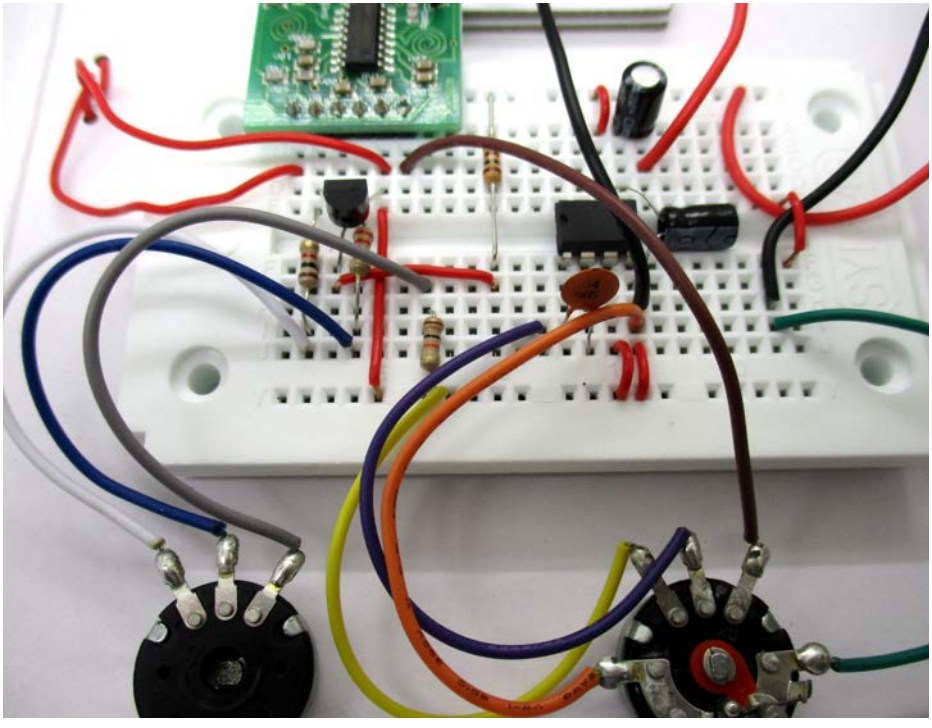
Attach the breadboard between the potentiometers and the loudspeaker. At the bottom side of the breadboard, there is some double-sided adhesive foil covered by a protective sheet. First, find the ideal position for the breadboard, then remove the protective sheet and glue the breadboard in place. Caution: The breadboard must be placed correctly at the first go as it is very difficult to change the position afterwards.



Connect the volume potentiometer instead of the previously used voltage divider made of two resistors. Also integrate the switch of the potentiometer with the negative battery connection, where previously a resistor or a wire had been attached. The second potentiometer will be used for scanning the frequencies.



When the potentiometers are attached, you can close the housing and control the radio from the outside. Compared to the two-button tuning method, the rotary knobs provide the additional advantage that you can search for another station in both directions. Furthermore, when you turn on the radio, the previously chosen station will reappear.



The tuning voltage set at the left potentiometer is applied via a 220 kΩ resistor (red, red, yellow) to the reset pin and thus to the varcap diode. When the wiper of the potentiometer is placed near +3 V, the resulting frequency is low. Accordingly, a maximum frequency will result from a setting of 0 V.

The 220 kΩ resistor increases the influence of the automatic frequency control (AFC) on the tuning process. An improperly adjusted station will automatically be tuned more precisely. While slowly scanning the FM range, you will register a certain lock-in range where the radio clings to a chosen station. This simplifies selecting a station.

However, with only one potentiometer, the tuning range would be too large and the FM range would only take up part of the whole scale. Two resistors are used to limit the range to values from 87.5 MHz to 108 MHz. Now the FM range takes up the whole scale. The 1 kΩ resistor sets the lower frequency limit; the 10 kΩ sets the upper one.

The antenna consists of a wire loop as big as possible and is attached between A and GND. Use a wire with a length of 1 m. Thread it through the designated holes so that the antenna loop remains outside the housing. Twist the wire at both ends so that the antenna remains stable and does not slip out of the breadboard.

Finally, screw the rotary knobs on the potentiometer axes. Put in the battery and test the completed radio.

You should be able to receive the more powerful stations clearly. First, test the radio at low or medium volume. At full volume, clipping at the amplifier might already occur and cause audible distortions. Depending on the battery state, the volume has to be slightly reduced in such a case.

Sometimes, fainter stations can only be received with audible noise. In such a case you can try and turn the radio or the antenna in order to improve reception. You should also test various locations of the radio. Sometimes, the walls of a building attenuate the FM signals. Locating the radio near a window can produce better results. Also, test the reception outside.

Troubleshooting

While assembling the radio, you might make a mistake that is not so easy to spot. If this happens, do not give up but accept the challenge! When the radio doesn't work, you should first check all connections. Compare your setup with the diagrams and photos wire by wire. Make sure that all wires are firmly attached. The most common problems are:

- A wire is attached at the wrong position.
- The end of a wire is too short and does not reach the contact point inside the breadboard.
- A pin of the amplifier IC is bent and not properly connected.
- Deformation or contamination causes connection problems at the battery clip or the switch.
- The battery is exhausted and does not provide sufficient current.

Make sure that a clicking noise is audible when you turn on the radio. As the volume control knob itself produces a noise, it may be sensible to keep the radio switched on, remove the battery and then touch the battery with the clip. When you don't hear the clicking, you have to concentrate your troubleshooting efforts on connection problems in the area of the battery, the amplifier and the loudspeaker.

Find out if the amplifier or the voltage regulator heats up, as this would point to an improper connection. Jiggle the individual wires to track down connection problems. Scratching sounds that appear while you lightly touch a wire or a component are caused by improper contacts.

On the other hand, when the loudspeaker does not emit any sounds, the usual suspects are the loudspeaker itself, the amplifier and the volume control. Repeat the initial amplifier test or try the following tests:

- Touch both terminals of the disc capacitor with a wire or a screwdriver. This should result in a clicking noise with a volume depending on the setting of the volume control. In this case, the part of the circuit from the volume potentiometer to the loudspeaker works correctly.
- If in doubt, remove the disc capacitor and touch pin 2 of the amplifier with a wire. You should hear a low clicking or humming sound.

If the radio does not emit any sound although the amplifier has passed the test, check the FM board, the voltage regulator and the tuning potentiometer. The following problems may be present:

- The board is not supplied with the required 3 V operating voltage because the voltage regulator or the negative connection is attached improperly.
- The tuning voltage is always either 0 V or 3 V because the potentiometer or one of the associated resistors is connected in the wrong way.
- The NF output is not properly connected to the volume potentiometer.

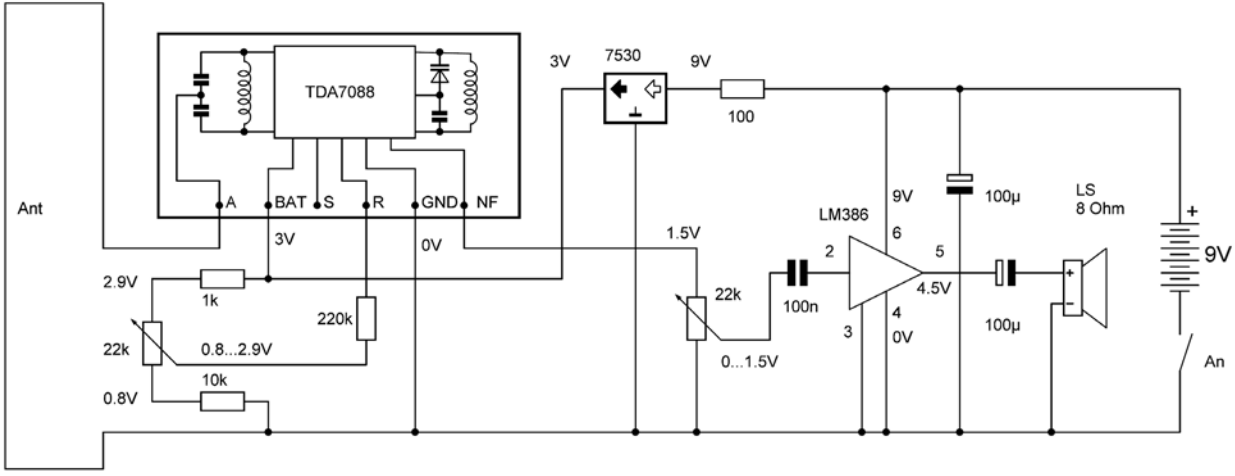
Repeat the first radio experiment without a particular tuning. It is sufficient to remove the middle connection of the potentiometer (blue). When you turn on the radio, it should find a station, except when there is a problem with the voltage supply. Reattach the potentiometer. If it is now impossible to find a station by means of the potentiometer, the problem resides in the area of the potentiometers and the attached resistors.

For further troubleshooting, a voltmeter can be useful. However, with some skill you can also use the amplifier for a rough voltage check. To do so, pull out the brown potentiometer connection and use it as measuring wire. Set the volume potentiometer to the middle position or lower. When you now touch a point of the circuit with the brown wire, a clicking noise occurs. Its volume indicates the voltage. Also test the full operating voltage (9 V, very loud) and the negative connection (GND, 0 V, no sound). Further tests should yield the following results:

- BAT pin of the board: 3 V, loud
- GND pin of the board: 0 V, no sound
- NF output of the board: 1.5 V or more, loud
- Grey wire at the tuning potentiometer: 0.8 V, low noise
- White wire at the tuning potentiometer: 2.9 V, loud
- Middle pin of the tuning potentiometer (blue): adjustable from 0.8 V to 2.9 V, low to loud noise

When you get a significantly different result at one of the measuring points, the problem probably resides in the respective area. In most cases, it is a contact problem, a wrong component or an incorrect connection.

In rare cases, one of the components may be faulty. In particular the loudspeaker, the amplifier IC and the FM board can be damaged by applying excessive voltage. Also, the pins of the loudspeaker and the potentiometers can be damaged. Contact problems can occur at the potentiometers and the switch.



Measured voltages