Build Your Own Tube Radio

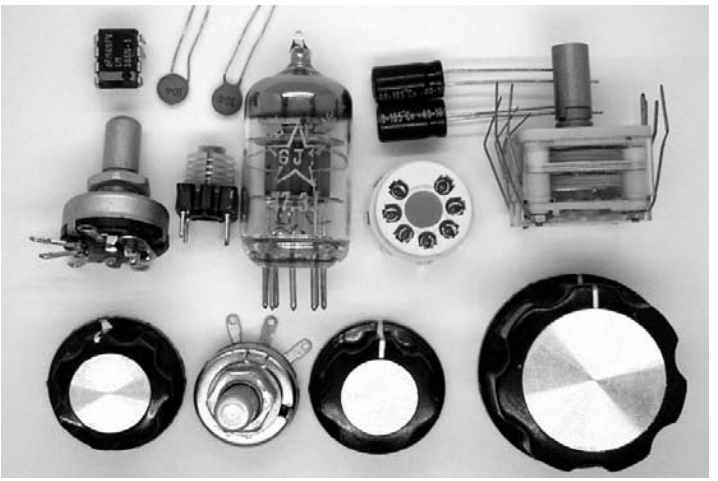
This nostalgic short-wave radio is a real tube audion as they were built in the early days of radio technology. A high-frequency tube in the receiver ensures outstanding reception, while a modern amplifier IC provides the required volume. Tubes were usually operated with dangerously high anode voltages in excess of 100 V. This radio will, however, not need any more than 15 V.

An audion is a straight receiver that, in contrast to the superhet as they were common later, does not require any interim frequencies. The adjustable feedback is the reason for the good reception of an audion. Fine adjustment of the feedback changes the amplification and selectivity of the radio and permits making the best of any reception situation. The receiver therefore is not all that easy to operate, but it often achieves the reception performance of modern world receivers and can even exceed it in some cases.

Take lots of time and leisure to take long trips into the short-wave area. Enjoy the mysterious glow of the tube cathode and the special sound. Listen to stations from many countries, particularly in the evening. Set frequency and feedback precisely and listen even to very distant stations.

The tube 6J1 used was long used in military communication. This is a special high-frequency tube with a particularly low heat output. The radio works with a heating battery of 6 V and an additional anode battery of 9 V with an anode voltage up to 15 V. The 6J1 corresponds to the European EF95, also used in commercial and military technology but never in radios or TVs for household use. Only after semi-conductors had mostly replaced the tube was it possible to use stock from the heyday of tube technology for experiments

as well.

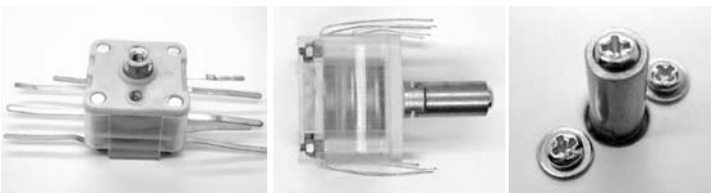


Components

Tube 6J1 Time fitting PCB Variable capacitor 265 pF Short-wave coil with ferrite screw core Speaker 8 f, 0.5 W Feedback controller 22 kf Volume controller 22 kf log with switch four 4 mm sockets two 4 mm sockets 2 m wire strand battery holder four AA Battery clip 9 V IC1 Audio amplifier LM386 T1 NPN-transistor BC547 T2 NPN-transistor BC547 R1 100 kf (brown, black, yellow) R2 1 kf (brown, black, red) R3 1 kf (brown, black, red) R4 100 kf (brown, black, yellow) R5 470 kf (yellow, violet, yellow) R6 10 kf (brown, black, orange) R7 10 kf (brown, black, orange) C1 10 pF ceramic (10) C2 100 pF ceramic (101) C3 10 nF ceramic (103) C4 100 nF ceramic (104) C5 Elko 10 µF C6 100 nF ceramic (104) C7 Elko 100 µF C8 Elko 100 µF C9 Elko 100 µF

Assembly of the Operating Elements

The variable capacitor is used to set the desired reception frequency. Place the extension axis onto the variable capacitor and screw it on with the long 2.5mm-screw. Do not turn the axis



against the stop too hard and use pliers to maintain the axis. The variable capacitor is only installed in the casing later using two small screws.

The variable capacitor

Install the speaker by pushing it into the matching slot. The connections should point down so that short connections lead to the board later. The speaker is placed sufficiently firmly in its slot, but you can add a drop of glue or hot glue as well.

Speakers

The volume controller with three connections additionally also carries the on/off switch. If you turn the axis all the way to the left, the switch will open. Place the volume controller into the left assembly hole. A small tab prevents twisted insertion. Attach the controller with the ring nut and do not forget the washer. Install the feedback coupling controller in the middle position in the same manner.

Volume controller with switch and feedback controller (potis)

Aerial sockets and plugs

Insert the four connection sockets. The red earth connection should be installed at the outer edge, and next to it the three brown sockets as aerial connections.

Placement of the operating elements

Soldering

13 cables are needed to set up the radio. Cut the following lengths from the wire pieces:

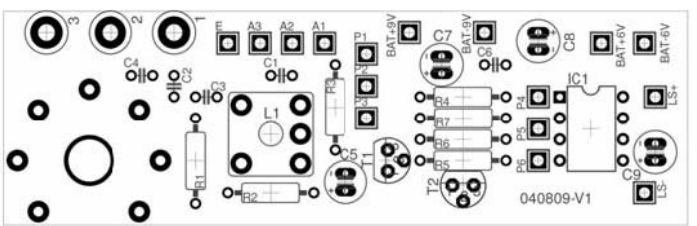
2 x 4 cm / 3 x 6 cm / 4 x 8 cm / 4 x 9 cm

Remove the insulation at the end for a length of 5 mm. The plastic insulation is relatively soft and can be removed with the fingernails applying a little force. Twist the fine strands with your fingers. Tin the stripped cable ends carefully to prevent the fine strands from spreading. Hold the hot tip of the solder gun to the cable ends at the same time as the soldering wire for this. The solder must flow all the way around the wire.

Prepared cables

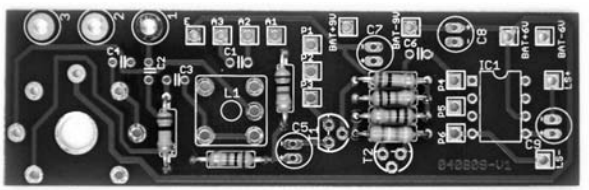
Now the PCB is to be soldered together. The circuit diagram for the complete receiver is enclosed on the last page of the manual for orientation.

Components on the PCB



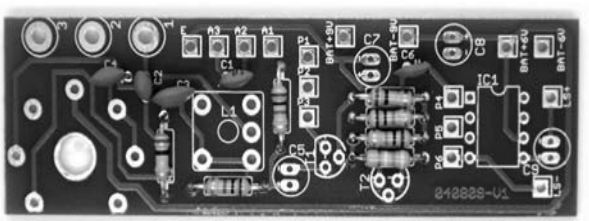
Equip the OCB with the electronic parts according to the equipment plan. Start with the resistors: R1, 100 kf (brown, black, yellow), R2, 1 kf (brown, black, red), R3, 1 kf (brown, black, red), R4, 100 kf (brown, black, yellow), R5, 470 kf (yellow, violet, yellow), R6, 10 kf (brown, black, orange), and R7, 10 kf (brown, black, orange). Bend the connection wires to match and push them into the corresponding holes of the PCB. Solder the two wires onto the bottom. Then cut off the protruding wires with sharp pliers about 2 mm above the PCB.

Caution: Do not cut off the wires too close to the PCB; this may cause mechanical strain that



disconnects the copper lanes.

Installing the resistors



Insert the ceramics capacitors: C1, 10 pF (10), C2, 100 pF (101), C3, 10 nF (103), C4, 100 nF (104), and C6, 100 nF (104).

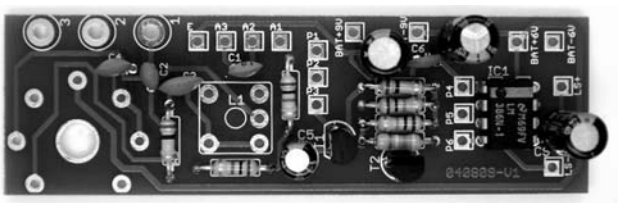
Insert IC1, T1 and capacitors

Equip the four variable capacitors with 10 µF (C5) and 100 µF (C7, C8, C9). The installation direction must be observed. Plus and minus for each variable capacitor is indicated on the PCB. The plus pole is at the longer connection wire. The minus pole is additionally marked with a white bar on the plastic insulation. For verification: In C8, the minus pole points down, in the other

three variable capacitors, it points up.

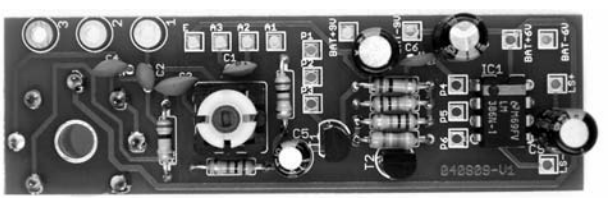
Inserting variable capacitors

Install the semi-conductors. Observe the flat housing side in the transistors BC547 (T1, T2); the installation direction is indicated by the label on the PCB. The integrated amplifier LM386 bears a groove that is visible on the PCB label as well. Pin 1 is marked by a dot in addition to this and must be close to connection P4.



Installing transistors

Equip the coil and tube fitting. The coil can only be installed in one direction, since one side has three connections and the other one only two. The tube fitting must be equipped from the back.



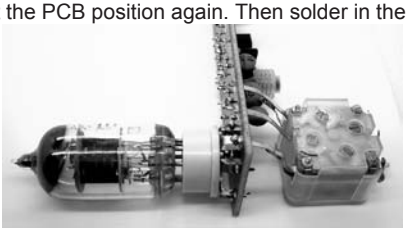
Soldering on the coil and tube fitting

Now push the tube into the fitting. Check for precise fit of the seven connections. In some cases, slightly bent pins must be adjusted so that the individual contacts are hit precisely. Make sure that the tube is inserted straight. Push the PCB with the tube into the correct position so that the tube is placed centrally behind the sight window and in the cover. The variable capacity is the actual holder for the PCB; its connections must be aligned precisely for this.

Next, solder the variable capacitor to the PCB. It has more connections than are needed. Use the AM side with five connections in total while the FM side with four connections remains free. The middle connections are conductively connected to the axis and from the counter-connection for all parts of the variable capacitor. Additionally, there are trimmer capacitors with dedicated connection vanes on the AM-side (265 pF, large plate packages). Solder the variable capacitor and the trimmer connection together each.

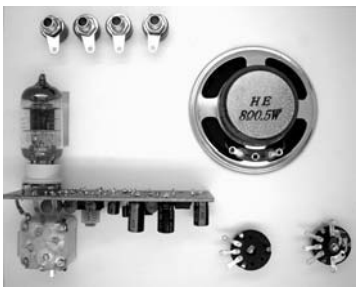
Connecting PCB and variable capacitor

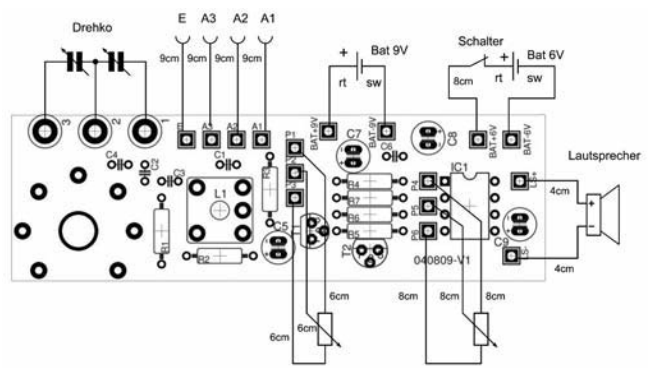
The variable capacitor forms the mechanical holder for the PCB at the same time. The long connections must be carefully adjusted. Solder on only the middle connection at first and then adjust the PCB position again. Then solder in the outer long connections. Only then solder the shorter connections C1 and C2 to the long connection vanes. This fastens the position of the PCB additionally. The double connection vanes are required for correct function of the variable capacitor while also ensuring higher stiffness of the PCB attachment.



Installation position of the PCB

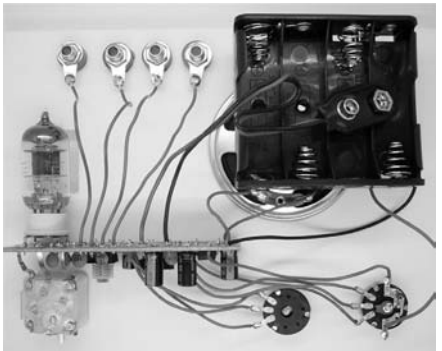
Next, solder in the matching cable pieces. The lengths are indicated in the wiring plan. You can push the tin-plated wire ends though the holes from both sides and solder them on again like the other components. The black wire of the battery compartment must be soldered to the connection "Bat-6V". The red connection leads to the switch of the volume controller. The 9-V battery clip is connected directly to the PCB. The two short wires to the speaker can be replaced by hard switching wire to additionally stabilise





the PCB.

The wiring plan The complete wiring



Connect the PCB to the aerial sockets, the speaker, the feedback controller, the volume controller and the battery according to the setup plan. Now the radio has been set up completely and can be tested. Draw the setup into the circuit diagram on the last page of the instruction manual with your name and date. Copy or tear out that page and glue it into the radio housing so that you'll know what you did even years later. This is the case in old tube radios as well. Repairs are possible even after a long time because the circuit diagram is always inside the radio.

Prepare earth connection and wire aerial. There should be about one metre left of your wire strand. Divide the section and screw on the 4 mm plugs. The earth cable (red plug) should be stripped on a length of a few centimetres at the end. Use this to produce a conductive connection to an earth connection. Water pipes or radiators are good earth conductors.

The First Test

The radio requires four 1.5-V alkaline batteries and a 9-V-block battery. Switch it on and turn the volume controller to the medium volume. After a few seconds, you will see the red glow of the tube cathode. Connect the earthing wire to E and the aerial wire to A1.

Turn the feedback coupling controller to the middle position and find a station with the dial switch. Open the feedback controller more and more.

The volume will increase and you will have to turn back the volume controller. Find the setting with the best reception at the feedback controller. This may change with the frequency as well, so that you will have to adjust the feedback controller for each. If the feedback is set too strongly, there will be a loud whistling sound.

Observe the tube from different angles in operation. You can see the hot cathode glowing red. The light is partially reflected in the other parts of the tube. Brightness and colour temperature of the cathode indicate the condition of the heating battery. The tube heating requires about 175 mA. Together with the end amplifier, the receiver requires 200 mA. Alkaline batteries with a capacity of 2000 mAh will thus last for about ten hours. If the cathode glow clearly reduces, the batteries need to be replaced.

Reception Practice

When tuning the frequency, you will find several stations in individual short-wave bands. Short-wave will have a high range even during the day, but many stations aren't switched on before evening. Below 4 MHz, there is the 75 m-band that is missing in many short-wave radios. Here, there are some few interesting stations in the evening. The 49 m band at 6 MHz is densely occupied with many European stations. Some frequencies are used by different stations in sequence. The 41 m band above 7 MHz doesn't see any strong use before evening. In the 31 m band around 10 MHz and in the 25 m band around 12 MHz, far-distant stations can often be heard. Often, even stations outside of Europe can be received. Between the radio bands, there are many stations in CW (morse telegraphy), SSB (single-side-band radio), RTTY (radio teletype) and weather fax (facsimile transmission). All of these stations can only be heard with the feedback engaged.

Setting the feedback controller requires some skill and lots of practice. Quick tuning across the individual radio bands can be performed with the feedback engaged first, which will lead to a loud whistling in individual stations. Turn back the feedback until the stations can be heard clearly. If the feedback setting is perfect and the aerial coupling not too strong, the audion has a very high selectivity and a low reception bandwidth of less than 10 kHz. Therefore, the variable capacitors must be tuned very precisely as well. For strong stations, the feedback will reduce on its own a little and the bandwidth will increase. Test the receiver with different aerial connections and different aerial lengths. A long outdoor aerial can be used at the connection A3 with the smallest coupling. If the aerial coupling is too strong, you will notice the receiver not reaching the oscillation start even with the feedback opened all the way, reducing volume and selectivity.

Calibrating the Scale

The printed-on frequency scale goes from 3.5 MHz to 12 MHz. For the displayed frequencies to be as accurate as possible, you have to calibrate the receiver. For this, you need two radio stations with a known frequency at the upper and lower edge of the area or a second radio for comparison.

Set the higher station first. Then adjust the trimmer capacitor above C2 on the variable capacitor with a screwdriver until the transmitter is in the right position on the scale. Generally, the trimmer has to be set to middle capacity. Then find the station at the lower end. Now adjust the ferrite screw core of the coil until the scale fits perfectly. The frequency will be lower the farther the core dips into the coil. The upper setting may also change again a little. Therefore, you will need to repeat the setting at the upper end again.

CW and SSB

Receive morse stations at the lower end of the 80 m amateur radio band from starting at 3.5 MHz. The feedback should be set just above the oscillation start. The frequency heard corresponds to the distance of the station frequency from the oscillator frequency of the audion. For clear reception, the frequency must be set very precisely. Other CW transmitters are found in the 40 m amateur radio band as of 7 MHz.

The common radio operating mode in amateur radio is SSB (Single Side Band). To receive these stations, a dedicated carrier must be added with the feedback engaged. Reception requires highly precise setting of the frequency. Since the receiver is not shielded, you can achieve fine adjustment by manual approximation. If you hear a Mickey-Mouse-like voice, the frequency has to be corrected a little. With a little exercise, you will be able to perform the right settings. SSB stations are found in the 80 m band between 3.6 MHz and 3.8 MHz, as well as in the 40 m band between 7 MHz and 7.2 MHz, particularly in the evening. Commercial SSB stations can be found between the radio bands, e.g. the flight weather service at 5.5 MHz.

With the feedback engaged, you can discover much more even. Machine telegraphs can be recognised by warbled sound. The German Weather Service regularly sends weather fax images at 3855 kHz at 120 lines per minute. You can hear a regular signal at two passes per second. There are special devices and PC software options for decoding such stations.

DRM

In the radio bands, you will also find stations with the new digital broadcasting method DRM (Digital Radio Mondiale). The Audion will only give you loud noise. Decoding requires a very stable receiver, a PC and the matching decoder software. The stations send their programme at UVHF-like quality, with additional text messages and partially in stereo. The receiver alone is not sufficiently stable, but in combination with an external oscillator it can be used for DRM reception.

Explanations on the Circuit Diagram

The tube has three tasks: Amplification, de-dampening of the resonant circuit and demodulation of the HF signal. The pentode 6J1 is operated with a connection between the screen grid and anode in a triode circuit. The grid resistance R1 is connected to the anode and thus increases the grid bias. At a low anode voltage, a sufficiently high anode current can be achieved in this manner. The cathode at the centre tapping of the resonant circuit feeds the amplified HF energy back into the circuit. The tube works in a Hartley oscillator circuit. The reception signal is amplified by this. At the same time, the grid diode rectifies the HR signal and thus causes demodulation.

Correct setting of the anode voltage permits choosing the amplification with the feedback coupler P1 so that the oscillator just doesn't oscillate. At this working point, the tube balances out all loss occurring in the resonant circuit. The quality factor can be increased from approx. 50 to more than 1000. At a reception frequency of 6 MHz, the bandwidth is at about 6 kHz, i.e. it is also possible to separate stations that are close together.

De-dampening leads to an increase of the signal amplitude at the same time. At the control grid of the tube, there may thus be HF voltages of several 100 mV. The AM signals are demodulated at the grid diode since the grid current increases at a larger HF amplitude and the grid voltage drops. The demodulated NF signal is pending at the grid at the same time, modulating the anode current. The NF signal thus appears at the anode resistance R2. T2 forms an NF pre-amplifier for the integrated amplifier IC1.

The radio uses two batteries. Four mignon cells with a total of 6 V supply the tube heating and the NF amplifier. An additional anode battery with 9 V is switched in series with the heating battery. The anode voltage is thus up to 15 V. Since the operating switch at the volume poti only has a single contact, the transistor T1 switches off the anode battery. In fact, a voltage of 9 V is pending at the anode, the screen grid and the control grid when deactivated. Since the tube cathode is cold, no current is glowing in this condition. Switching on the operating voltage will cause T1 to become conductive and the lower end of P2 will be connected to ground. The operating current of the anode battery is less than 1 mA so that it will usually last longer than the heating battery.

Dear customers!

This product was produced in alignment with the applicable European directives and therefore bears the CE sign. Intended use is described in the included instructions.

For any other use or modification of the product, you alone are responsible for compliance with the applicable rules. Therefore, build the circuit just as described in the instructions. The product must only be passed on together with these instructions.

The icon with the crossed-out waste bin means that this product must be recycled as electronic waste separately from domestic waste. Your community administration will inform you of the next free-of-charge collection site.

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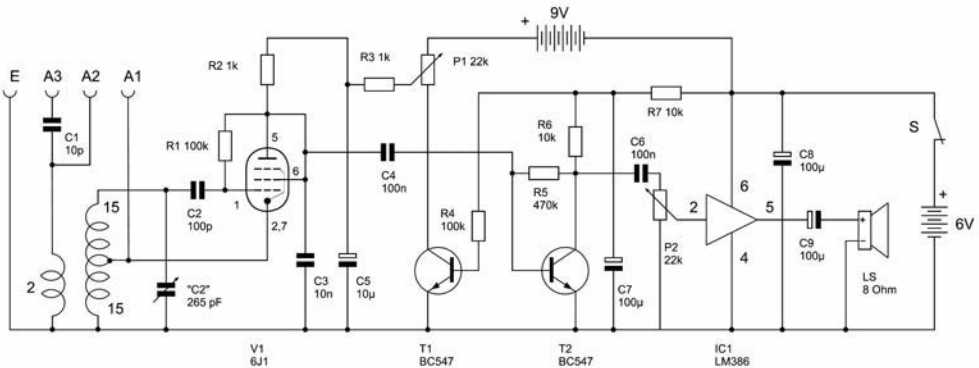

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