The Valve Radio Kit

The complete kit with valve, case and all the other needed parts

Hear radio stations as in the pre-transistor days of 50 years or more ago

This nostalgic looking radio is a relatively simple "straight-through" valve shortwave receiver using manual feedback. The principle by which the receiver works is similar to the Audion valve system from the dawn of radio reception history (See http://en.wikipedia.org/wiki/Audion_tube) originally patented by Lee De Forest in 1906.

80 years ago the Audion design could be found in many homes, also it could be found in many amateur rigs, military equipment and telecommunication units, as well as many „ship to shore“ radio units.

An Audion (See: http://en.wikipedia.org/wiki/Audion) is a simple type of radio receiver where no mixing is required of intermediate frequencies (as in superhet radio) (http://en.wikipedia.org/wiki/Regenerative_circuit) is required to help improve reception and selectivity.

The adjustable feedback as used here is the main reason for the good to excellent receiving qualities of this Audion style radio. Through fine adjustment of the amount of feedback it is possible to change both the amount of amplification (volume) and the selectivity of the radio and it can therefore be finely and correctly "tuned" for each and every station received, e.g. you can achieve the optimum/best signal quality possible. Because of this, the receiver is not quite so simple to operate as many later superhet designs are, but it can achieve from a far more simple (and cheaper!) design, a similar performance to most modern good quality „world“ receivers, and in some cases to actually beat them (no pun intended!) at their own game!

Please take plenty of time to make sure that you fully understand all the details of short wave receiving with this radio, you can start with it to enjoy the world of "glowing" electronic valves (tubes) and their special audio tone that they give to received stations. You will be able to hear the transmitters of many foreign countries, especially in the evenings and after careful & fine adjustment of the Tuning frequency and the feedback pot, it will allow many even more distant stations to be clearly heard.

The valve used here is a 6J1 which was for many years only seen in military telecommunication equipment. It is a special high frequency valve, with particularly low cathode heating power requirement. The radio functions using both a "low tension“ heater 6 volt battery and a "high tension“ battery of just 9 volts, with an actual anode voltage of around 15 volts.

The 6J1 is basically the same as the European EF95 valve, that was also extensively used in both commercial and military telecommunication equipment, but never in radio or TV equipment intended for domestic usage.

Only since valves have been mainly replaced by semiconductors has it been possible to actually get hold of such units from the "Days of Glory“ of glass valves for personal experimental usage.

You can find out more about this on the internet under:http://www.elo-web.de/elo/radio-r-hrentechnik/franzis-r-hrenradio
but only provided you are able to read the German language!

The internet based "ELO Magazine" of the Franzis publishing house is full of projects, tips and information with regard to electronics, both valve and semiconductor based. This online magazine also has a particular page supporting this valve radio for users. This may prove useful for when you run into problems or you want to try some further development with this valve radio. But as I have mentioned before, the information on their homepage is ONLY in the German language.

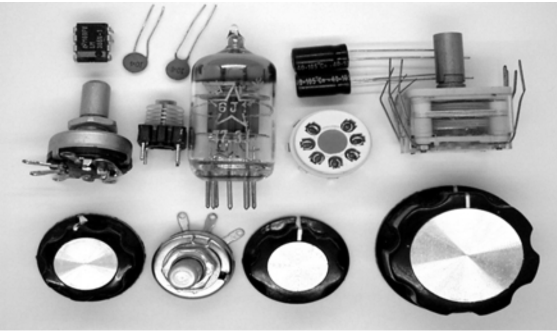

Fig.1. Components.

Component list	
1x valve 6J1 + socket/holder	1x T1 NPN transistor BC547
1x printed circuit board	1x T2 NPN transistor BC547
1x variable capacitor 265pF	2x R1, R4 100 k (brown, black, yellow)
1x short-wave coil on an adjustable ferrite core	2x R2, R3 1 k (brown, black, red)
1x L1 loudspeaker 8 ohm, 0.5 W	1x R5 470 k (yellow, violet, yellow)
1x P1 feedback pot 22K	2x R6, R7 10 k (brown, black, orange)
1x P2 volume control pot 22K log with switch	1x C1 10 pF ceramic (10)
4x 4 mm "banana" sockets.	1x C2 100 pF ceramic (101)
2x 4 mm "banana" plugs	1x C3 10 nF ceramic (103)
2x 1 meter Insulated connecting wire, flexible	1x C4 100 nF ceramic (104)
1x B1 battery holder for 4 x AA cells	1x C5 electrolytic 10 µF
axle extension for the tuning capacitor, case	1x C6 100 nF ceramic (104)
assorted control knobs for the various controls	3x C7, C8, C9 electrolytic 100 µF

Mounting the components

The variable tuning capacitor is used to set up the required receiving frequency. Place the axle extension on the variable capacitor's axle and fix it securely using the 2.5 mm grub-screw provided. See the middle and RH pictures below.
Make sure that while screwing the grub-screw down tight, that you do not run into one of the capacitor end stops and accidentally damage it. Before fixing the screw, ONLY hold the axle firmly with pliers or grips, but without causing any damage. The variable capacitor will be later held securely in the case with two small screws (supplied).

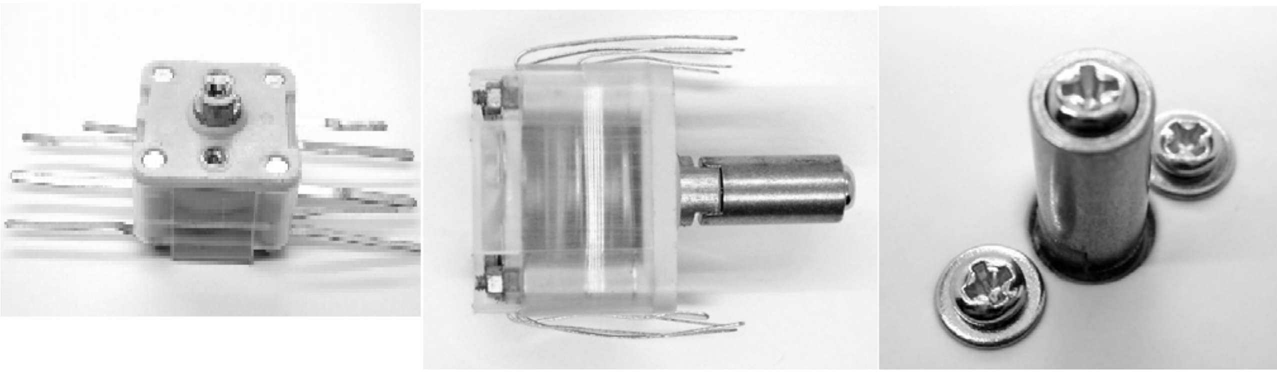

Fig.2. The variable capacitor (3 views)

Mount the loudspeaker in the case by pushing it gently into the slits provided. The solder connections should be orientated towards the bottom of the case, so shortening the required connections to the PCB, which they also support a little.
The loudspeaker should sit firmly in the slits provided, but a small drop of (hot!) glue or similar can be used to make certain of this.
See photo of the fitted loudspeaker below.

Fig.3. Loudspeaker

The volume control (22k P2 log) with it's three connections, also contains an integrated on/off switch.
When turning the volume control from right to left (anticlockwise), the switch will be opened (off).
Place the volume control pot in the left-hand case hole (viewing from fron of case). A small tongue on the pot stops the body from turning while in use. The tongue is shown in all of the next 3 pictures, in the middle one its in the hole mentioned.
Secure the pot with the ring nut supplied, do not forget to install the special washer while doing this to stop it turning when in use.
Install the feedback pot (22k P1) in the same manner as the volume control, but in the middle case hole.

Fig.4. Volume control with on/off switch P2 (pot) "Anti-twist" tongue in hole Feedback control P1 (pot)

Fig.5. Aerial sockets and plugs

Mount the four sockets in the case. The socket next to the case edge should be the red earth connection, the other three should be the three brown aerial connections. Orientate the solder tags as shown in the photo below.

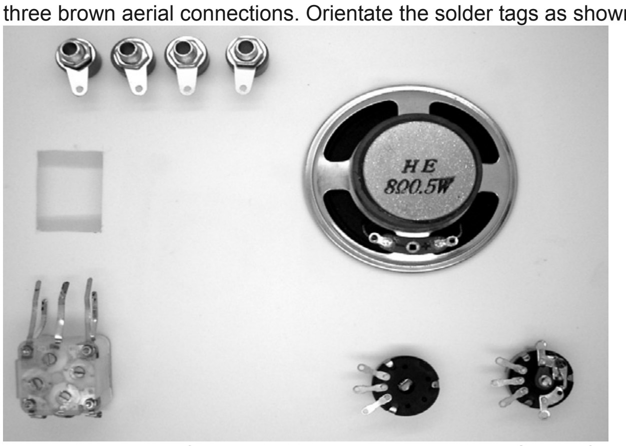

Fig.6. Positioning of the various elements in the case. Shown from inside the case.

Soldering

To complete the radio, 13 insulated stranded wire connections are required. Cut them to the following lengths:
2 x 4 cm / 3 x 6 cm / 4 x 8 cm / 4 x 9 cm.

Remove the insulation at each end for about 5 mm. The plastic insulation is very soft and can usually be removed using your fingernails. If using cutters, try not to damage the strands. A proper "stripping" tool is best. Twist the strands together and tin the ends carefully to stop them splaying out when soldering. Hold the hot tip of the soldering iron and the solder together on the cable ends. The solder must completely fill the end of each wire.

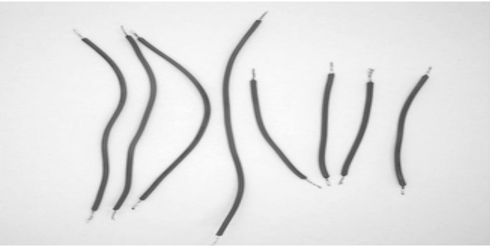

Fig.7. Finished wires

In the case where you have little or no experience of soldering techniques, use the tinning of the wire ends as a way to become more familiar with the method. For those who can read German, there is a short tutorial on soldering at www.elo-web.de in German.
Here is one in English: http://www.aaroncake.net/electronics/solder.htm

Now you can start soldering the components onto the supplied PCB, the schematic on the last page will help with regards to orientation of each component if you have polarity questions, but the PCB is very clearly marked. Do not solder in anything till you are 100% sure how & where!

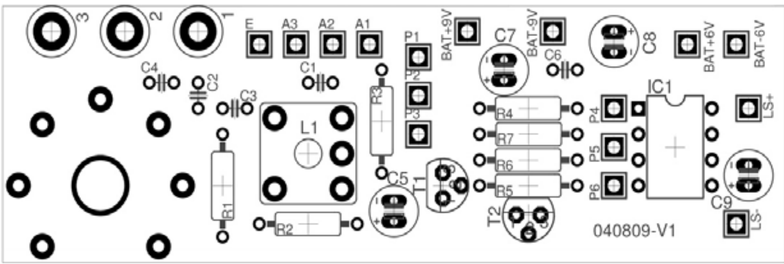

Fig.8. Component positioning on the PCB.

Resistors have usually 4 bands of colour, one usually being silver or gold, start reading the colours from the non silver or gold end only to get the correct value. See resistor colour code chart on the last page before the schematic.

Only electrolytic caps are polarised (that means that they must be correctly orientated), the other caps here are not polarised and can be placed either way round in the PCB.

Place all the components in/on the PCB, feeding the wires through the correct holes. Make sure that you put the components on the correct side of the PCB at all times. The valve base, for example, is mounted on the opposite side to all the other components. Check the photos carefully! (Details in the brackets are to help identify THAT particular component! Do please use those infos to identify each component before starting)

Start with the resistors R1, 100K (brown, black, yellow), R2, 1K (brown, black, red), R3, 1K (brown, black, red), R4, 100K (brown, black, yellow), R5, 470K (yellow, violet, yellow), R6, 10K (brown, black, orange), R7, 10K (brown, black, orange).

Bend the connecting wires to fit them in the relevant PCB holes. Use fine nosed pliers or a resistor bending form, to make sure that you do not bend a resistor wire next to the component body, or it might break off.

Bend neatly! Mount carefully, do not strain the component body. Splay the wires out behind to hold it in the PCB. till soldered

Solder both of the wires on the bottom of the PCB and cut any extra off with sharp side cutters leaving approximately 2 mm protruding.

Warning: do not cut off the wires too short as this could eventually mechanically damage the PCB lands.

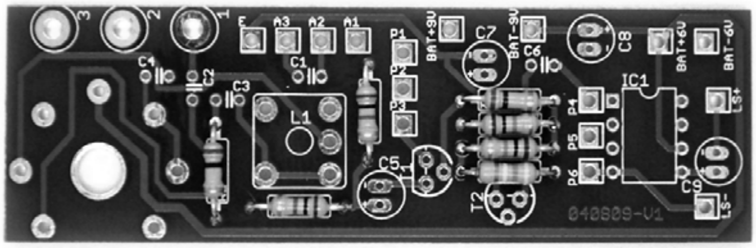

Fig.9. Mounting the resistors

Now fit the ceramic capacitors in place: C1, 10 pF (10), C2, 100 pF (101), C3, 10 nF(103), C4, 100 nF (104), and C6, 100 nF (104).

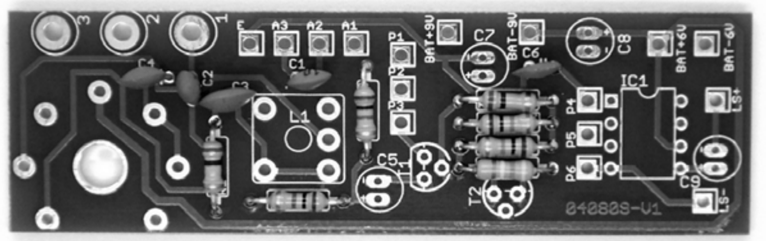

Fig.10. Fit IC1, T1 and the capacitors

Place the four electrolytics 10 µF (C5) and the 100 µF (C7, C8, C9). Make sure that these are correctly orientated with the "+" and "-" in the correctly marked holes. DOUBLE CHECK, ITS VERY IMPORTANT!!
On the capacitors, the plus pole is next to the longer wire and the minus pole has an extra white minus sign marking on the plastic insulation. As a check, C8 has the minus pole downwards, the other three. has it pointing upwards.

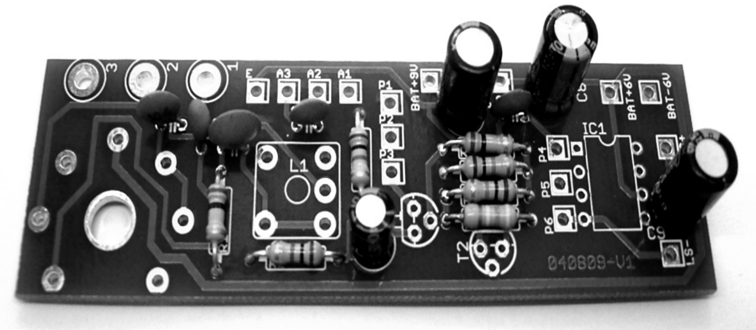

Fig.11. Electrolytic capacitor placement

Now you need to insert the semiconductors in the correct positions. Note that the BC547 transistors (T1, T2) have a flat on the side of the plastic case for orientation purposes. Make sure that this lines up with the similar markings on the PCB.

The audio amp LM386 chip has a small indentation by pin 1, this is also shown on the component plan on the PCB,

Orientate the chip in the same way so that pin 1 on the LM386 is near to connector P4. See next photo.

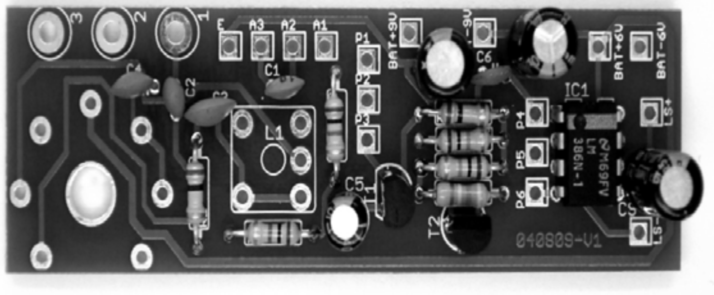

Fig.12. Placing of the transistors

Now orientate and fit the coil (L1) and the valve socket. luckily the coil can only fit one way due to it having three connections on one side and two on the other.

The valve base must be mounted on the opposite side of the PCB to the other components. See here:-

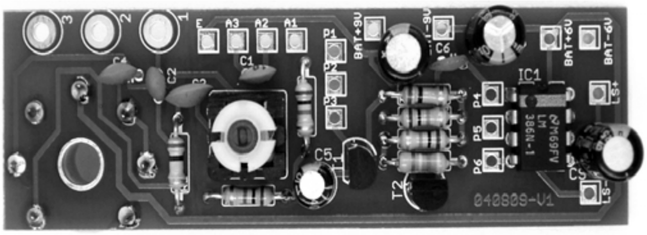

Fig.13. Solder in the coil and valve base

Place the valve in the base and check that the valve and base together fit correctly in the PCB. Sometimes the base pins need to be gently bent to fit properly to make sure that proper contact is made. Do make sure that the valve is sitting vertically while doing this. Recheck. Push the PCB and the valve on its base into the final position, checking carefully that the valve sits exactly behind the window in the case front and inside the cover.

The first actual fixing for the PCB is the variable capacitor wire connections to the PCB, so do not forget to orientate it correctly.

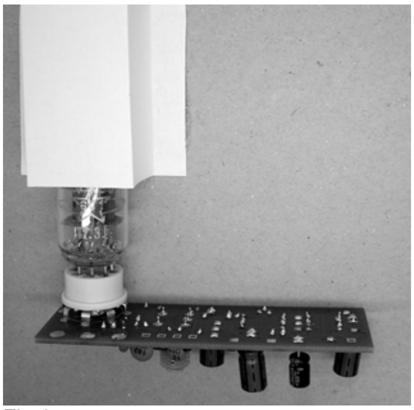

Fig.14.

Solder the variable capacitor connections next, it has several, on the case of the variable capacitor are markings of C1, C2, C3, C4. The segments C1 and C2 have each 265pF. Only C2 will actually be used in practise though. The middle connections are also connected to the axle of the variable capacitor and make together the earth connection for it.

Also there is an extra trim capacitor that lies above C1 and C2. It has its own connections.

Solder the wires first onto the PCB before soldering to the tuning capacitor.

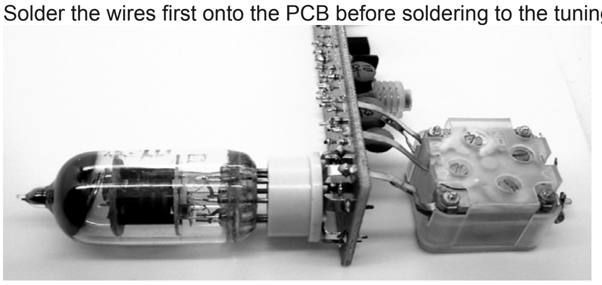

Fig.15. Connecting the PCB and variable capacitor

As previously mentioned, the variable capacitor is also the mechanical fixing for the PCB via its connecting wires.

These must be carefully adjusted for position and length before soldering. Solder only the middle variable capacitor connection first in place, then carefully adjust the position of the PCB to get it both flat and horizontal. Once that has been done, place the outer connections carefully in place and solder them to the variable capacitor, one by one. Checking each step carefully. Then carefully solder the shorter connections C1 and C2 to the longer connections. That way you hold the PCB mechanically better in its position.

The doubled connections have two jobs, one is the correct functionality of the variable capacitor, the other is they add needed extra stiffness to the PCB fixing. See photo above.

Also, the connections to the loudspeaker serve in a similar manner, adding further mechanical stiffness to the PCB's position.

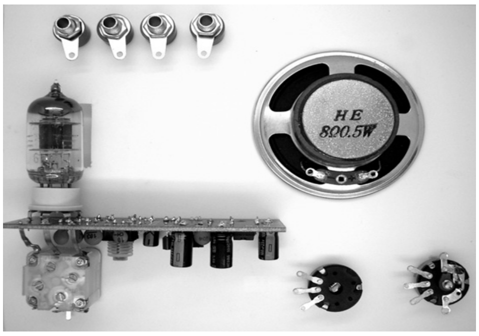

Fig.16. Fitting of the PCB.

Next, solder the rest of the precut wires onto the PCB. They can easily be pushed through the relevant holes in the PCB and soldered securely on both sides.

The connection marked „Bat -6 V“ must be soldered to the black wire (-) of the 4 x AA battery Holder. The red wire (+) must be carefully and quickly soldered to one side of the volume control switch contacts, to prevent melting of the plastic switch.

Both of the short wires connecting to the loudspeaker can be replaced with solid insulated wire to further improve the mechanical support of the PCB, if it is felt that extra strength/stability is required.

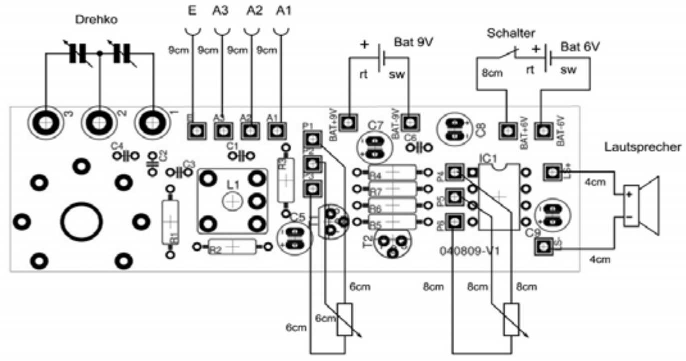

Fig.17. The connection plan

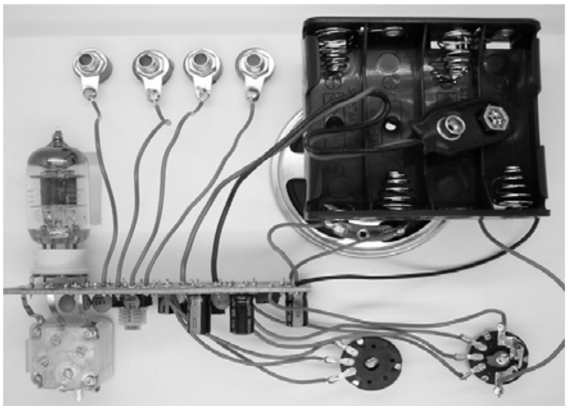

Fig.18. The finished wiring

Using the plan of the PCB, connect the aerial sockets to the PCB, the loudspeaker, the feedback pot P1 and the volume control pot P2 and the PP3 battery clip, observing polarity carefully - red to positive (Bat +9V).

Now you have completed the main part of the building of this shortwave radio.

Complete the building by filling in the boxes on the schematic with your name and build date and either photocopy or cut out the schematic and paste it in the back of the radio case. In this way, you will still be in a position to understand and possibly repair the radio if ever needed at any time in the future.

This is the way it was done in the days of valve radios, no searching for the schematic, its always right where you need it!
Get the earth and aerial cables ready for usage. From the rest of the stranded insulated wire you should still have around 1 meter left. Cut this into two approximately similar lengths and remove the insulation from each end and attach a single 4 mm plug to each wire.

The earth cable should have several centimetres of insulation removed as this will make it easier to attach the radio to an earth source inside your house, a metal water pipe or even a metal radiator for example. Make sure that a good stable connection is made each and every time. A big (battery charger) crocodile clip will make this even easier.

The first test

The radio needs 4 alkaline AA cells and a 9 volt PP3 battery or similar. Switch the receiver on and turn the volume control to the mid range of adjustment. After a few seconds, you will see the cathode of the valve starting to glow red hot. Connect the earth to the "E" socket and the aerial cable to the A1 socket.

Rotate the feedback control to approximately the mid position, then carefully rotate the variable capacitor to try and receive a signal from a transmitter. When you have a signal, turn the feedback pot so that the loudspeaker increases in volume, you may need to turn the volume slightly down at the same time.

Try to find the position of the feedback control that gives the strongest reception, note, this position changes in relation to the frequency selected by the tuning capacitor! Therefore you must try a new setting if and when you change the receiving frequency. If you turn the feedback up too high, you will cause oscillation and loud peeping/whistle tones, turn it back a little till this just stops.

Always keep the colour of the red hot cathode in the valve under observation. The colour and strength of the glow will keep you informed of the state of charge left in the 4 x AA Alkaline batteries. The cathode takes about 175 mA, together with the audio amp, the receiver needs around 200 ma. when switched on. Alkaline batteries with a capacity of 2000 mA will therefore last about 10 hours of continuous usage. When the valve's cathode colour/temperature cools down, this indicates that you must change out the 4 AA Batteries for new.

Practice in operating the short wave receiver

When turning the tuning capacitor, you will probably find several short-wave bands/stations receivable. Even during the day, you will be able to receive stations from many miles away, but do remember that many stations are only switched on at night.

Under 4 MHz, you will find the 75 meter band, that is actually missing from many commercial radios. Here you will find a few very interesting stations.

The 49 meter band at 6 MHz is also full of many interesting European stations. Some frequencies are used, one after the other, by different stations at different times of the day. The 41 meter band above 7 MHz, is more heavily frequented with stations in the evenings. The heavily used bands of 31 m at 10 MHz and 25 m around 12 MHz where you can hear stations from a very great distance away. Often stations outside of Europe can be clearly received.

Between the various short-wave bands, there are many transmissions in CW (Morse telegraphy), SSB (**S**ingle **S**ide **B**and), RTTY (**R**adio **T**ele**TY**pe) and weather-fax (weather Pictures)

All of these stations can only be received when using the feedback pot correctly. For the best settings of the feedback pot, you need a certain deftness and a lot of practice.

To find stations over the different bands quickly, start by turning up the feedback pot, when the individual stations will be signalled by a loud whistling from the receiver, then start by slowly turning the feedback pot back till the station can be heard clearly.

With an optimal adjustment of the feedback pot and a not over driven aerial coupling, the Audion system can easily separate different stations, having a receiving bandwidth of 10 kHz or less. To achieve this though, the variable capacitor must be adjusted exactly on the station each time.

With very strong stations, it is recommended to reduce the feedback even further than usual, doing this properly actually increases the bandwidth.

Test the receiver with the different aerial connections and different lengths of aerial for different transmitters.

A long aerial should be used on aerial socket A3 which has the least coupling, first.

A too strong signal/coupling of the aerial will be signalled by the fact that even with the feedback pot turned back,the radio has both a low volume and low selectivity. The aerial sockets exhibit the least coupling starting with the A3 and the most coupling in socket A1. Less is usually better in such cases. Experiment.

Scale calibration

The printed frequency scale is marked from 3.5 MHz to 12 MHz. So that the scale is fully accurate, you must calibrate the receiver to it. To achieve this you need two stations that you know the exact frequency of, one at the top of the scale and one at the bottom, or look at another calibrated radio to compare frequencies with.

First go to the higher frequency station and adjust the trim condenser at the top of C2 with a small screwdriver till the sender is found at the correct frequency. Generally speaking, the trimmer must be set to approximately the middle position for this.

Then tune the receiver to the station in the lower frequency area. This time you must adjust the ferrite core in the coil (L1) till the scale is correct. Tip: the frequency will lower as you screw the core further into the coil. A plastic tuning tool will a) not affect the tuning and b) is less dangerous to the ferrite.

Do remember that when adjusting the ferrite core for the lower frequency, you also maladjust the upper frequency scale slightly. This means that you must go back and readjust the set-up at the upper scale again. Go back and forth till the frequency scale is correct in all positions.

CW and SSB

When receiving Morse stations at the bottom end of the 80 m amateur bands from 3.5 MHz, the feedback pot should be adjusted just above the point where oscillation occurs, do remember that the frequency of the Morse heard is actually the difference in frequency between the senders transmitter's frequency and the oscillator frequency of the Audion. Readjust if the frequency is thought NOT to be easy to hear.

For clear reception, the frequency MUST always be carefully and accurately set-up. You will find further CW stations in the 40 m amateur band from 7 MHz upwards. The usual method of amateur voice transmission is SSB (Single Side Band). To receive such a transmission, the station needs very careful adjustment of the feedback pot to define your carrier frequency. Also the tuning capacitor needs a very accurate set-up of the reception frequency as well.

Due to the fact that this radio is not shielded in any way, it is possible with careful positioning of your hand near to the radio to make an even finer adjustment to your reception, a good tip is if you hear a sort of "Mickey Mouse" voice, the frequency setting is not quite as accurate as it needs to be, first, finely adjust the tuning capacitor, before proceeding further.

The correct set-up needs some practice. SSB transmitters you will mostly find in the evenings on the 80 m band between 3.6 MHz and 3.8 MHz, as well as on the 40 m band between 7 and 7.2 MHz You can also receive commercial SSB stations between the bands, e.g. Weather forecasts for planes/airlines and the like.

With active feedback in use, there are many more "things" that can be found to listen to, telegraphy machines for example which can be identified by the "warbling" tone developed. The "Deutsche Wetterdienst" the German weather Service for example, sends faxes of weather pictures at 3855 kHz with 120 lines a minute. You will hear a regular signal with two sequences per second. To decode such signals there is special equipment and PC software needed to decode them.

Note

Do please remember, that with your Audion short wave valve radio, there is still far more to discover on the airwaves than we have described here.

"Tips and Tricks" and other options for this receiver are also published in the ELO-Onlinemagazine for readers of the German language at:
http://www.elo-web.de/elo/radio-r-hrentechnik/franzis-r-hrenradio
Also further explanations with regard to the schematic of the short wave receiver, but in the German Language only at this time.

Mode of Operation

The valve used actually has 3 separate jobs in this schematic - amplification, Q-multiplying and demodulation of the HF-signal. The 6J1 pentode valve is used with a connection between the grid and the anode in "triode" mode. The grid resistor R1 connects the anode and the screen grid and therefore increases the voltage on the screen grid. So in spite of a lower anode voltage, a higher anode current is achieved. With the cathode connected to the middle of the oscillator it greatly increases the amount of HF-energy that is fed back due to the fact that the valve operates as a Hartley oscillator. The received signal is thereby amplified. At the same time the grid diode rectifies the HF Signal, therefore it also simultaneously demodulates the signal.

Through careful adjustment of the amount of feedback with P1, its possible to get the oscillator to just stop oscillating. When working at this point, the valve equals out any losses that appear in the oscillator. This "quality factor" can be improved from around 50 to over 1000 with careful adjustment. At a receiving frequency of 6 MHz, the bandwidth is about 6 kHz, so that it is also possible to separate stations that are very close to each other with this radio. The changed Q-multiplying brings with it an increase in signal amplitude. On the control grid of the valve can appear HF voltages of several hundred millivolts. The AM signal will therefore be demodulated by the grid diode and for greater HF amplitudes, the grid current rises and grid voltage drops.

On the grid therefore lies the demodulated LF signal which modulates the anode current. The LF Signal appears therefore on the anode resistor R2. T2 is the LF amplifier for IC1 the LM386.

The radio uses two Batteries, 4 x AA's which produce about 6 volts for the valve heater and the LF amplification. An extra anode battery with 9 volts, works in series with the 6 volt battery, so that the anode voltage will be up to around 15 volts with fresh batteries.

Due to the fact that the on/off switch on the volume control has only one pair of contacts, it cannot switch both battery supplies simultaneously, therefore transistor T1 is used to switch the 9 volt battery. This does mean that in a switched off state, there is actually still 9 volts on the anode, the screen grid and the control grid. But due to the fact that the cathode is unheated at this time, no current actually flows. So the battery will not be discharged.

When the on/off switched is placed in the on position, T1 conducts and connects the lower leg of P1 to ground. The actual current drained from the anode battery in use is less than 1 ma, so that it normally lasts far longer than the 6 volt heater battery.

Company information

Author: Burkhard Kainka · Art & Design, Satz: www.ideehoch2.de · ISBN 978-3-7723-4670-5

4 band resistor colour code chart

Colour	Black	Brown	Red	Orange	Yellow	Green	Blue	Violet	Grey	White	Gold+	Silver+
Band 1	*	1	2	3	4	5	6	7	8	9	N/A	N/A
Band 2	0	1	2	3	4	5	6	7	8	9	N/A	N/A
Band 3	x1	x10	x100	x1,000	x10,000	x100,000	x1,000,000	x10,000,000	x100,000,000	x1,000,000,000	N/A	N/A
Band 4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	5.00%	10.00%

* = Bridge is a 0 Ohm resistor. Generally a bridge will have black, black, black bands and no 4th band, or no marking at all.
\+ = 5% or 10% are the allowed maximum tolerances for the resistor type
N/A = Not Applicable.

Diagram - Schematic