Our preferred way to assemble the VLF-3 receiver
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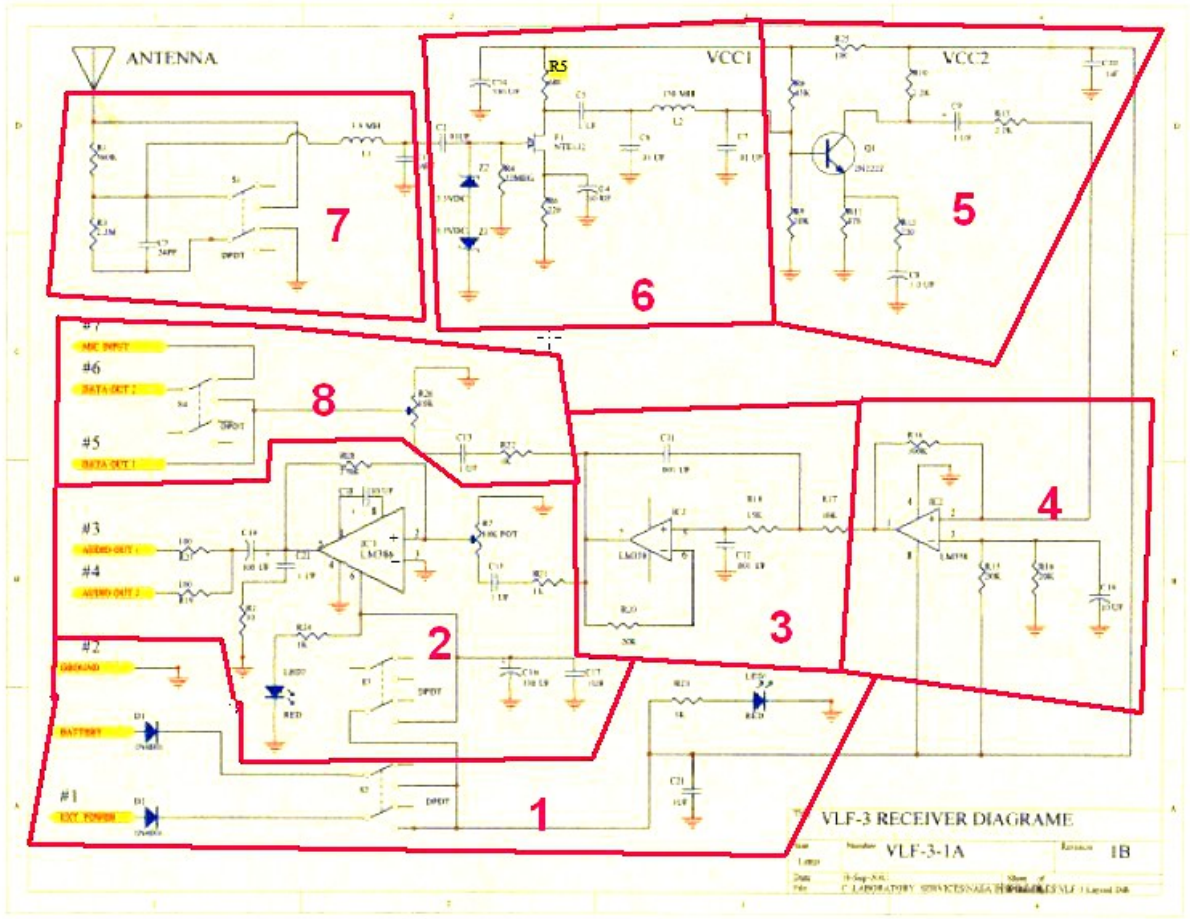
We shall do the assembly in a somewhat different sequence than described in the instructions, because it will make testing and an eventual fault-finding much easier:

What do we do?

- We assemble each section and test it before proceeding to the next section: thus we can better locate any malfunction.
- We start building from the output end: testing is done by listening to the output; as we add the other sections, the receiver becomes progressively more sensitive, and this we can also verify.
- Execute your assembly carefully, and at your own pace, please! This workshop is NOT a speed contest!

The different sections are shown in the circuit schematic:



Section 1:

This is the first activity, and it is best done by all of us together, under the guidance and explanations by the workshop helpers. Let's follow it in single steps:

- Find among the parts the black plastic holder for the battery
- Locate on the circuit board where this holder would go to. Be careful to identify on which side it would go to, by observing the appropriate markings.
- Place the battery holder on the proper side – we do not yet need to fix it with any screws. Push the two terminal pins through the holes in the board, and solder them from the other side. Make sure that the solder connections are done nicely, with the solder covering the pad area and having a shiny surface.
- Looking at the circuit board, you'll see that one terminal is connected to a larger area: this is the ground to which the negative pole of the battery goes. The positive terminal follows a short trace ending at the location where the diode D1 is to be inserted
- Locate the diodes – the 1N4001 are the black cylinders – and place one of them into the position. Observe that the band marking on the diode should correspond to the marking of the symbol on the circuit board's silk printing: diodes work only in one sense, so their orientation matters.
- It may be that the diode's leads turn out to be a bit too thick for the holes: In that case, we'll give you smaller diodes with thinner leads which will do the same job
- Following the board track from the diode, you'll see that it ends in an area with six solder pads, which is marked on the other side as switch 2.
- Locate such a switch – there are four of them, all the same – and put it in the proper position. Again, make sure that you insert it from the correct side. Refer to the illustrations of the Assembly Instructions or have a look at the finished INSPIRE receiver somewhere on your tables. Push the terminals into the holes, until the switch sits flush on the board.
- Solder the switch terminals from the other side. You may have noticed from the board or the circuit diagrams that not all six terminals are connected to a track. So you do really not need to solder these.
- The track leading away from the switch ends at resistor R23. This is a 1kOhm which you find on the sheet with the resistors. Its coloured bands should have the sequence brown-black-red-silver (or gold). Insert it so that it sits flush on the board, make the solder connections, and then cut off the excess wires.
- Using a 1kOhm resistor makes the LED shine bright enough to be seen in sunlight, but this also consumes a fair amount of power. During night-time observations, one does not need such a bright indication … so, if you want to enjoy a longer operation with a single battery, it is wise to use about 3 kOhm resistors (for R23 and R24), from our box of spare parts.
- The other end of the resistor leads to the LED 2 – note that in some plans it may be labelled as LED 1, but it is always better to follow the tracks on the circuit board!
- Since the LED will be oriented to the face-plate, make sure that you put it not only on the proper side, but also at a proper height above the board, so that it can stick its head out of the face plate! Thirdly, this is a component whose polarity we have to obey: Its plastic case has one side flattened, and the lead of that side is shorter than the other. This is the lead that should go to the ground side. So the longer lead should be on the solder pad connected to the resistor R23. The silk screening on the board also indicates the proper orientation.

When all this is done, we'll test the circuit:

- Put in a 9V block battery
- If you slide the Receiver Power switch to its ON position, the LED should light up: Well done!

Section 2:

This is the final audio amplifier together with the Audio Level control, the Audio Power switch. The amplifier raises the received signal to such a level that it can easily be heard in low impedance ear phones.

- It is best to first locate the small 8-pin integrated circuit IC1, labelled LM386, and one of the sockets. Observe the orientation of the IC on the circuit board: one side has a small indentation. Do not put in the IC itself, but the socket. Since the socket's pins are quite close together, avoid making a solder connection between neighbouring pads. So you should not use too much solder!
- Identify all the other components, place them accordingly, make the solder connections, and clip off excess wires.
- **General advice**: The tracks on the circuit board are on the same side as most of the components, but the solder pads are on the other side. Therefore it is important that the two sides get a good electrical connection. This you can ensure by heating each pad sufficiently long, so that the tin can nicely flow into the hole. Do not just leave a lump of solder on the wire and the pad! If you want to make really sure, you could solder the resistors also from the components' side!
- The electrolytic capacitors – the black cylindrical things with two wires sticking out from one end – require orientation: On the board, the positive side is marked with +, while on the component the **negative** lead is marked with a stripe and minus-signs.
- The volume control (R7 POT) is one of the larger components with three broad leads that match the three holes in the board. Check for its correct placement, as it will be accessed from the face plate.
- Before finishing this section, we make a provisional connection from the Audio Output to one of the audio output sockets. This will make it easy to connect a test loudspeaker or earphone and executing all further tests:
- Locate the two audio socket – usually small black plastic boxes with 3 leads and the socket itself. Connect pad #3 (or #4) to the leads that stick out behind the socket, and connect pad #2 (ground) to the socket lead going off at right angles. For this purpose, use two wires, but leave them at their full length … we shall need them later.

When all is done, install the IC in its socket with the correct orientation, put in the battery, connect the test loudspeaker – or an earphone – to the audio socket, and switch both Receiver and Audio Power switches. Turn up fully the Audio Level control, and touch the "hot" solder lug of the potentiometer with a screw driver or a key: you should hear a faint humming noise (the 50 Hz noise from our mains supply), or at least some slight crackling when the terminal is touched. Turning down the Level control should make the hum less loud. Also, touching pin 2 of the LM 386 IC with the finger should also bring up the hum. How much you may hear, depends strongly on the room and its electrical wiring.

Sections 3 and 4:

These are a two-stage audio amplifier which serves as a low-pass filter. Here the signal is amplified but also all frequencies above about 10 kHz are attenuated, because they do not contribute much to the quality of the signal. Both amplifier stages come in one IC: the LM 358. As before, be careful about the orientation of the IC and its socket.

- The electrolytic capacitor C10 must be put in while observing the correct polarity: the negative lead should go to the ground side. You identify this on the board as the one which has direct connection to the large copper-plated area that forms most of the soldering side, and in which the solder pads are placed like island. The ground side pad has bridges to the surrounding ground area!

When testing, touch pin 5 of this IC or the free end of R17 with your finger. Or simply touch various pads in this area with your finger. You should hear again the hum, but slightly louder. When touching pin 2 of the IC, the hum should be much louder.

Usually, by the time participants reached successfully this stage, their have acquired sufficient knowledge and confidence that they are able to deal with the following sections without great problems.

Section 5:

This is a low-noise audio preamplifier, with a single transistor Q1 which is already in place. Here the received signal is substantially boosted in level, so this stage is quite crucial to the overall performance of the receiver. Simply put in all the other components.

- On the circuit board, R11 and R12 are erroneously marked. The proper operation is with these resistors swapped, so that the 220Ohm resistor is connected to the positive end of C8 – as shown in the circuit diagram. There may not be much of a difference, though.

The test is to touch the centre pin of the transistor – or the point where R8 and R9 meet, and the hum should be even louder. Probably it will be sufficient to come close to this point, in order to hear a weak hum. Often it sounds a bit like music of another world, because the hum is also rich in harmonics of 50 Hz…

Section 6:

This is the high-impedance front end amplifier with a FET (F1, already in place). Since any useable antenna (of 1 to 2 m length, say) will me very much shorter than the wavelength (of 300 km for 1kHz), it is important that the antenna sees a very high impedance load by the receiver's input. This is the job of the FET. It amplifies the signal which then is passed through a low-pass filter composed of C6, L2, and C7. The input of the FET is protected against potential voltage overload by the zener diodes Z1 and Z2.

Since the two inductors (the large blue cylinders) are soldered on the bottom side, while the conducting tracks are on the top side of the board, it is a good idea to heat these solder pads sufficiently long, so that the solder has time to flow freely into the hole in the board and to make a safe connection with the other side of the board! If during final testing you hear some hissing noise, but connecting the antenna does not make a big difference, it often is simply a poor connection at this point that prevents the signal to pass through!

TEST: at full audio level, it should be sufficient for your hand to come close to this section, especially the "hot" end of the back-to-back zener diodes, to hear the hum of the mains. If you place a watch with hands driven by quartz in the vicinity of the FET F1, you should hear the second ticks! This should also work later when the receiver is in its enclosure: Merely place your watch below the receiver!

Section 7:

This is the switch S1 close to the antenna terminal. A low-pass filter (L1, C1) protects the FET input against signals from low and medium wave radio stations. However, in the presence of strong local radio stations, this may not suffice, and hence the switch S1 allows adding C3 to make that filter more effective.

TEST: after the board is attached to the front panel, and all connections are done, the antenna terminal should be sensitive against a hand in its vicinity.

Section 8:

We put finishing touches to the board by adding the Data Level control and the Mic./Data switch. A dedicated testing is probably not necessary, but if you want to make recordings, it is best to verify that everything is OK.

Finally:

Follow the Assembly Instructions for placing the circuit board to the front panel and making all the connections. This requires some attention and care! It is not necessary to follow these instructions to the last letter as far as the lengths and the colours of the connecting wires are concerned. Rather keep them as long as you need them. If you run out of wire, use bits from our box of spare material! The mechanical integration may be a bit tricky, and you'll need to push a little bit, but don't push too hard if things do not slide in place easily.

Before mating to the front panel, you will need to cut off at the two potentiometers a small metal tab that would protrude and would make it impossible that the front panel lies flat on the potentiometers!

The FINAL TEST would be:

- Placing a quartz watch (with 'analogue' hands) below the bottom of the receiver should make the ticking audible
- Touching the antenna terminal with the finger should make some hum noise from the mains supply audible. This depends of course on the electricity system of the room where one does this test, but usually some awful humming and whining should be heard
- Attach an antenna or even a short (15cm) wire to the antenna terminal: you should hear hum and whine noises, while without an antenna only the receiver's hiss should be audible. Approaching a mains socket or a lighting switch on the wall or a fluorescent light should give an enhanced level of hum, sometimes sounding really "dirty". As the antenna comes close to a computer screen or a LCD screen from a mobile phone or personal organizer, one should be able to hear the high pitched whine from the electrical pulses that update the display.
- Going outside of the building, one should be able to notice that the mains hum noise becomes weaker as one gets more distant from the building.
- In the free area of a car park, one would be able to hear apart from any mains hum, also some crackling noise: these are spherics!
- But under a tree, all the crackling (and most of the humming) will die down, and all one hears is the rushing hiss by the receiver itself … because trees contain water and therefore they represent a conducting structure which shields against radio waves like a Faraday's cage.
- When you have progressed that far in the tests, you are already doing observations …

In case of problems:

There is no general way of giving advice what to check, measure, and do in case of improper functioning, because problems may occur in a great variety, and each may require a different approach to locate its origin. Some steps may be envisioned:

- Check carefully that each component is at its proper place, and in the proper orientation (such as electrolytic capacitors). For instance, it is easy to mistake a 100kOhm resistor for a 10kOhm one, as the yellow third band might be mistaken for orange.
- Because we assemble the various sections one after the other, the occurrence of a fault may thus be limited to the components added for the last finished section.
- As the conductive tracks are on the components' side, but the solder pads are on the other side, a lack of electrical connection might be a reason. Thus, it is useful to reheat the solder pads of the faulty section, and if necessary, solder the components also on the components side.
- Measurement of voltages can be helpful to locate a fault. It will be obvious that the tracks that connect directly to the positive battery terminal, and which supply the circuit with that voltage, should give voltages readings close to that of the battery, when measured with respect to the ground or minus terminal. One first check would be to see that the ICs have their proper supply voltage, and that the tracks marked VCC1 and VCC2 in the circuit diagram carry indeed the battery voltage. However, for any more detailed measurements, an understanding of the circuit will be necessary to interpret these readings correctly.