The LARCSet Manual

Ashhar Farhan, VU2ESE

V1.0

Introduction

The BiTX radio developed in 2003 provided an easily built SSB radio that could be built from generic components for ten dollars. However, it needed to be scratch-built, a few test instruments were, though not necessary, very desirable to align it correctly. In retrospect, it was a reasonable success. Hundreds were built from scratch, many thousands were built from kits produced by a number of vendors. From Indonesia to Brazil, different versions of the BITX radios were developed, produced and sold under the permissive

For the last few years, we have been conducting classes for schools around Hyderabad to engage girls (specifically) towards science through ham radio. A workshop project of a direct conversion radio was developed that led the builder through building simple direct conversion receivers. This was a mixed success.

By far, the most successful effort were the direct conversion receivers that Dean Souleles, KK4DAS and Bill Meara, N2CQR designed and evangelized. Over 100 have been built today, completely from scratch. Each radio is beautifully ugly in its own way, using parts that came handy to each builder.

Between 2003 and now (2025), the challenges and advantages of building radios have changed. A few relevant changes are:

- ☐ Surface mounted components are far cheaper than the through hole components ever were.
- ☐ Prototyping services like OshoPark and JLCPCB make even low volume productions cheaper than etching your own PCB and hand soldering radios.
- ☐ People have more modest labs and far less time on their hands than to solder a whole Heathkit HW-101 by themselves.

With that perspective, at Lamakaan Amateur Radio Club, we put the question to ourselves of how inexpensively can an HF radio be built and distributed. The LARCSet is the end result of that

When tasked with this, we are reminded of a few international projects. In 1976, at the ARRL, Jay Rusgrove W1VD, developed a transceiver kit called the “IARU Goodwill Project transceiver kit”. This was covered in the April 1978 and December 1978 issues of the QST. One laptop per child (OLPC) was another such initiative. The Raspberry Pi and Arduino are more successful and recent examples of similar efforts.The question before us was, can we produce a transceiver that can be distributed for less than 30 dollars? If so, what capabilities can we build into such a set?

We considered if we could at all produce a very low cost radio transceiver, that is extremely inexpensive, enough to be gifted for free. Something that is easily understood, extended and played around with. With the Lamakanaa Amateur Radio Convention (LARC) coming up, we set ourselves to be able to gift these surface mounted PCBs to all the delegates

- Transmit at least 5 watts of power on CW and SSB and operate on one band
- It should cost less than 30 dollars (when the kit is produced in quantity)
- A judicious mix of surface mounted components and user assembly can lower the cost
- The radio should be buildable over a single weekend in a few hours
- Fully open sourced with all the circuitry in public domain
- Fully analog design

The LARCSet is a result of this effort. The highlights of the LARCSet are:

- A 5 watt, 7 MHz superhet transceiver kit capable of CW and SBB
- Available at 29 dollars in volumes (of more than one). 39 dollars in singles.
- All analog design with a very clean transmitter and crisp receiver
- Circuit is laid out on a relatively large PCB
- Allows extensions, experimentation and understanding
- Very few components to be installed by the user
- User must provide the power supply, speaker/earphone, mic and/or cw key

Circuit Description

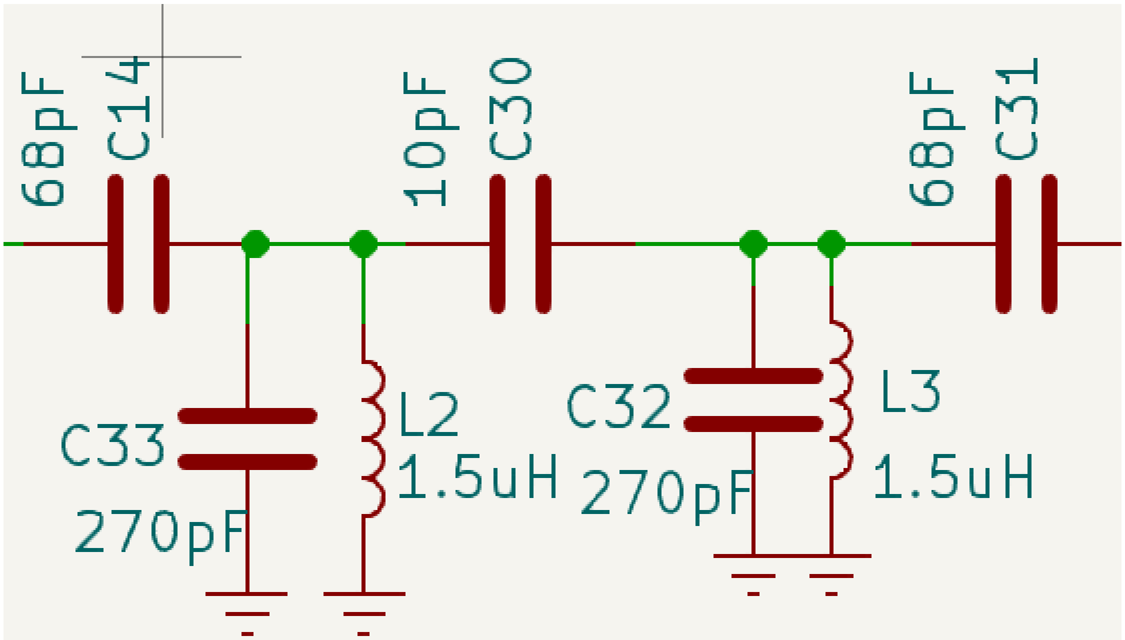
The radio is an updated version of the original BITX40 radio adapted for 40 meters. In the interest of keeping the cost down as well as keeping the assembly simple. The current circuit maximises on low cost SMD components while keeping the through hole assembly to just some large components. Although simple, every effort was made to coax as much performance as was possible given the limitations of keeping the circuit simple and affordable.

The BITX is a family of radios that use bidirectional circuitry. The signal travels through the same stages, reversing the direction signal flow when receiving or transmitting.

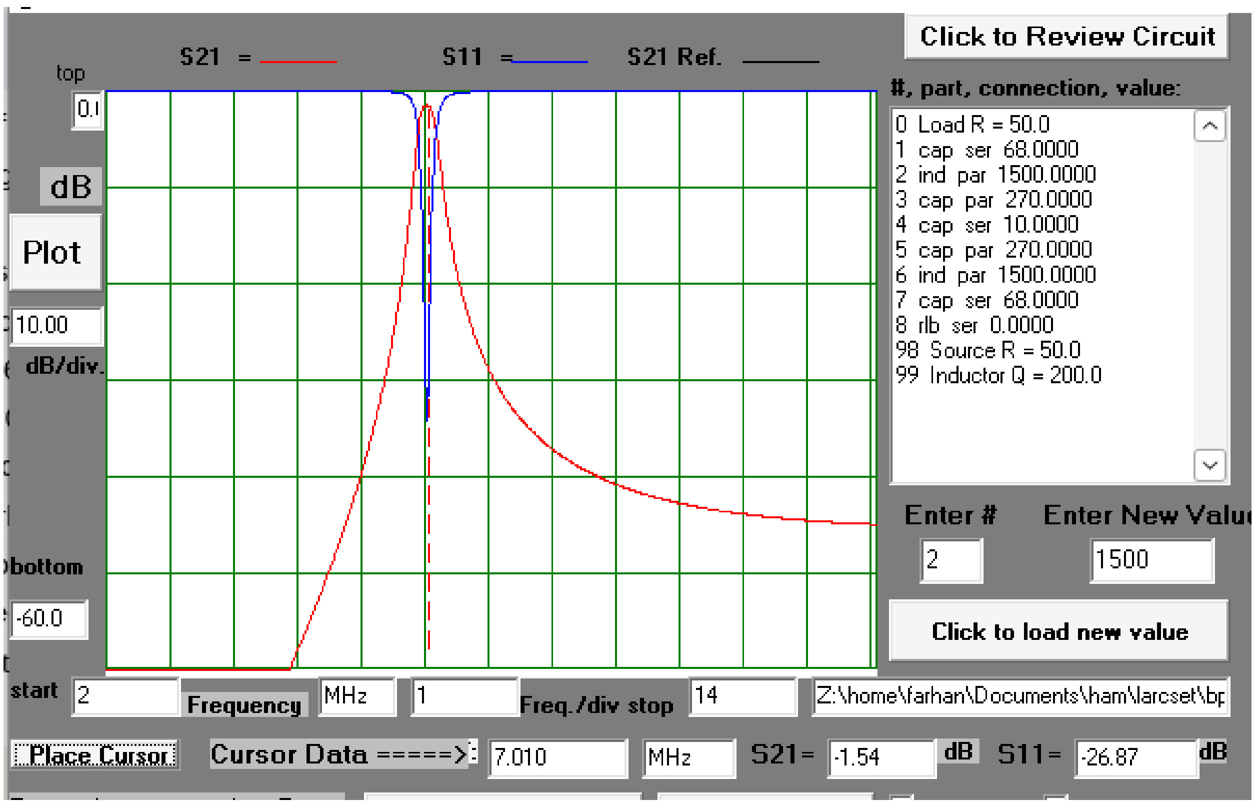
The Bidirectional filters

Let’s examine the bandpass filter of Figure 1. You can see that it is symmetric. There are two coupling capacitors of 68 pf on each side, the nodal capacitance is 270 pf on both sides and the coupling capacitor of 10pf is centered. It’s purpose is to allow signals centered around 7 MHz to flow with minimal reduction and greatly reduce the through flow of other frequencies. This bandpass filter will work equally well if the signal flows from either side to the other side. Interestingly, it will also handle signals flowing in both directions simultaneously!

This filter was simulated in GPL08.exe as well as LTSpice. Interested folks can try this in their favourite circuit simulator.



The simulation of this on GPLA08.exe is below in Figure 2.



There are several interesting features in the Figure 2. You will note that the 'skirt' is steeper on the left (lower frequencies) than on the higher side. This is not an anomaly but a 'feature' of his kind of a bandpass filter that has an overall low pass characteristic. The reader more interested in the mathematics behind this is referred to https://w7zoi.net/filters/mixed_form_n=3_lc_filter.pdf and other excellent resources on https://w7zoi.net/qststuff.html.

Note that we could have chosen an alternative form where the higher frequency response could have been sharper than the lower frequency response. However, in this radio as the local oscillator is on 4 MHz, it was vital to attenuate that when his band pass filter is being used to transmit.

The two sections of this bandpass filter are adequate for our purpose. The image frequency of this superhet is at 11 MHz (IF) + 4 MHz (Local oscillator) = 15 MHz. The image response is attenuated by -45 dB. Not stellar but adequate these days given the sparse usage of higher HF spectrum in non-ham (and ham) bands. A triple tuned circuit would have reduced the image to less than -70dB. However, a triple tuned circuit is not a 'wind and forget' circuit. It will need to be tweaked to peak, something we wanted to avoid from a beginner's project. The weaker bandpass filter has another weakness, it allows for the second harmonic of the 7 MHz generated in the mixer to flow pass at a level incompatible with the FCC rules. A low pass filter at the output of the power amplifier takes care of it as we will see in the following sections.

This filter is a good compromise between ease of construction and performance. It has a relatively low loss and it scales very well.

A note on scaling the filter: You can divide or multiply the component values to get to another frequency. For instance, to generate a bandpass filter for 3.5 Mhz, which is half of 7 MHz, multiply all the values by two (120pf, 560pf, 22pf, 560pf ad 120 pf caps, 3uH inductors). To scale to a higher frequency like 28 MHz (which is four times 7 MHz), divide the values by four (15pF, 68pF, 2.2pF, 68pF, 15 pF ad 0.35uH inductors).

The Crystal Filter

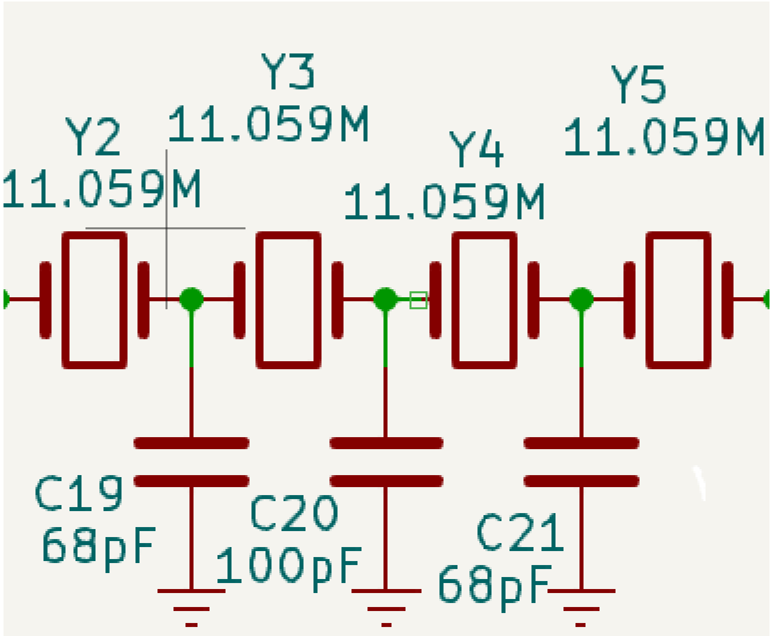
A four element crystal filter was chosen with slight overcoupling (Figure 3) . This leads to better response at the lower (300 Hz to 600 Hz) and higher (1200 to 1800 Hz) audio range. This subtle twin peak response works well for voice as well as CW (at 600 Hz tone). We have chosen the frequency of 11.0592 MHz to steer clear of Radio Frequency Interference generated at the rounded off frequencies like 10 MHz from the clock circuits running inside the digital electronics around us.

Four crystals provide more than 40 dB of opposite sideband suppression. The opposite sideband suppression is adequate for SSB. This is because the transmitters produce distortion around the signal on both sidebands that is usually only about 25 dB below the peak level. Anything above 40 dB is excellent for SSB.

For the operators who might want to use this radio exclusively for CW, they might want to change the filter capacitances to make it a narrow band (say, 300 Hz wide) filter. The paper by Wes, W7ZOI, on narrow filters at https://w7zoi.net/filters/9megxfils.pdf provides an excellent and easy method to design these filters.

The crystal filter too, like the bandpass filter, is symmetrical and allows signal flow in both directions. This filter type is called a ladder filter. It has parallel capacitors and series crystals, as such in not only resembles a traditional low pass filter, it is a low pass filter that has been modified by replacing the series inductors with capacitors. As opposed to the bandpass filter discussed above, this has an overall low pass characteristic, providing a sharp attenuation of the upper sideband - a much desired attribute in our case.

Four crystals are easy to match for the filter, even a deviation of 200 Hz between their central frequency is forgivable. Engineering is the art of compromise between performance and cost and this crystal filter is a good compromise. It is sweet and enough for all but the most demanding CW contests.

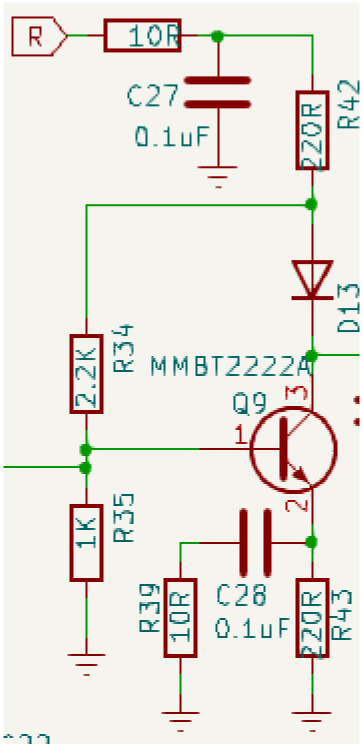


The filter response is in Figure 4, captured on the Rigol DSA-815 spectrum analyzer. Note that the span is reduced to 10 KHz to provide a close up of the ripple and the response will appear to be shallow, but 2 KHz to the right of the second marker is 50 dB down, which is on par with the best of the SDRs.

The Feedback Ampilfiers

Four low power feedback amplifiers are used. Each has a single transistor of MMBT2222 (the 2N2222A's SMD version). The 2N2222s have relatively better signal handling capacity than the 2N3904 and hence, we have used these.

It is useful to intuitively analyze this simple circuit of Figure 5. You are referred to my video on Feedback amplifiers on Youtube (https://youtu.be/j3Xf_SpK7qc?si=jE-tzMaxRncqB8DO0) as well as Wes's paper (https://w7zoi.net/transistor_models_and_the_fba.pdf)



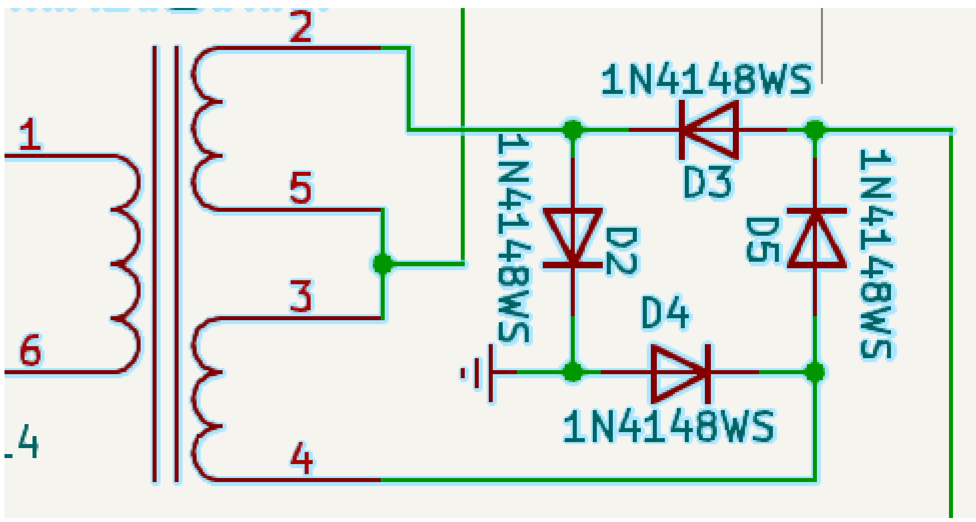
There is an interesting diode in the collector of the amplifier. At the expected signal levels, when the amplifier is powered up by the ‘R’ line, the diode appears almost like a piece of wire connecting the load resistor R42 and R34 to the collector of the transistor. However, when the amplifier is switched off, the diode is reverse biased and it disconnects the 220 ohms as well sa the 2.2K resistor from the collector. This behaviour would have been useless except that in our case there are two amplifiers connected back to back. The 2.2K feedback resistor (R34 in Fig. 5) would have appeared in parallel with R44 of the amplifier working in the opposite direction but for this diode isolating it when switched off.

Using resistive amplifiers simplifies the design, remove the chance of inadvertent inductive coupling between stages and reduces the time spent in building the radio. Replacing the R42 of our circuit with an inductor could have resulted in slightly increased signal handling capability, not a design goal in this radio.

The Diode Mixers

The diode mixers are a three port device. One port is driven by a local oscillator and on either port the output is a multiplication of the signal from the other port and the local oscillator. This is a confusing explanation, but it is easily understood by a simple percept : When you multiply two signals, it results in an output that has two signals, one at the sum of the frequencies of the multiplied signal and one at the difference. For instance, in our case, when we mix and incoming 7 MHz signal at the mixer's PORT A with a 4 MHz local oscillator signal, the mixer will produce outputs at at PORT B at (7+4 =)11 MHz as well as at (7- 4 =) 3 MHz. During the transmission, the mixer can take the 11 MHz signal arriving from the port B at 11 MHz, mixer it with 4 MHz local oscillator and produce outputs at (11-4 =) 7 MHz as well as (11+4 =) 15 MHz.

The diode mixers are not perfect they produce a number of other frequencies as well. Which is why we need to add filters to select the required frequencies and suppress the others. One reason for the these spurious outputs is that what comes out from a port as the mixed output, if not absorbed by the following circuit, goes back into the mixer as an input and arrives at the other port, mixing up the signals once more, this keeps bouncing around in the mixer creating more spurious outputs.



Our diode mixers are singly balanced. That is, the four diodes suppress the local oscillator by around 45 dB on either port. If this was not suppressed, the 4 MHz output would have appeared in the transmitter output. The RF bandpass filter discussed above selects the correct image of 7 MHz, suppressing the 15 Mhz image as well as the local oscillator and its harmonics from getting amplified and transmitted.

The singly balanced mixers if used with proper RF filtering are fine for our purpose as they use just one trifilar wound transformer. The winding of 1 and 6 (in the Figure 6) is driven by the local oscillator, This alternatively switches on the pairs diodes D3+D5 and D4+D2. When the D3+D5 is switched on, it couples the RF input at the junction of leads 5 and 3 to the output. The switching action produces the desired mixing. The diodes pair of D4, D2 grounds the incoming signal alternatively, improving the balance.

Two such diode mixers are used in the radio. One is used to convert between the 7 MHz RF and the 11 MHz IF and the second mixer is used to convert between the audio and the 11 MHz IF.

With these bidirectional circuits understood, now we can proceed to review the receiver.

The Receiver

The RF signal arriving at the antenna is switched to the receiver path relay K1. Two MOSFETS, the Q16 and Q17 act as an additional RF switch that couple the signal directly to the RF bandpass filter. The 7 MHz signal is mixed with the local oscillator at 4 MHz, the mixer outputs in the receive direction are buffered and amplified by Q6 amplifier and fed to the crystal filter. All signals except the precisely tuned signal is filtered through the ladder filter, amplified in Q9 and downconverted by the second diode mixer to audio.

Note that the 0.1uF, C67 suppresses the RF energy at the audio port of the second mixer, now acting as the demodulator.

A simple common emitter audio amplifier of Q10 raises the signal to the level required by the LM386 audio power amplifier. The capacitor of 1 uF between the pins 1 and 8 of the LM386 are required only if the radio is used with a speaker. For earphone operations, remove this capacitor for lower gain and less noisy reception.

SSB Generation

The SSB transmission is just the reverse flow of the signal. A single transistor microphone amplifier Q18 amplifies the 50 mV signal by a factor of 10. The second mixer, now acting as a modulator, just needs about 200mV of signal. Note that the R77 provides the needed bias for the electret microphones that are predominantly produced these days.

The diode modulator produces a double sideband signal which is buffered and amplified by Q8 before being applied to the crystal filter that strips out the upper sideband. The Q7 amplifies and buffers the crystal filter output to the first mixer that converts the 11 MHz signal to 7 MHz.

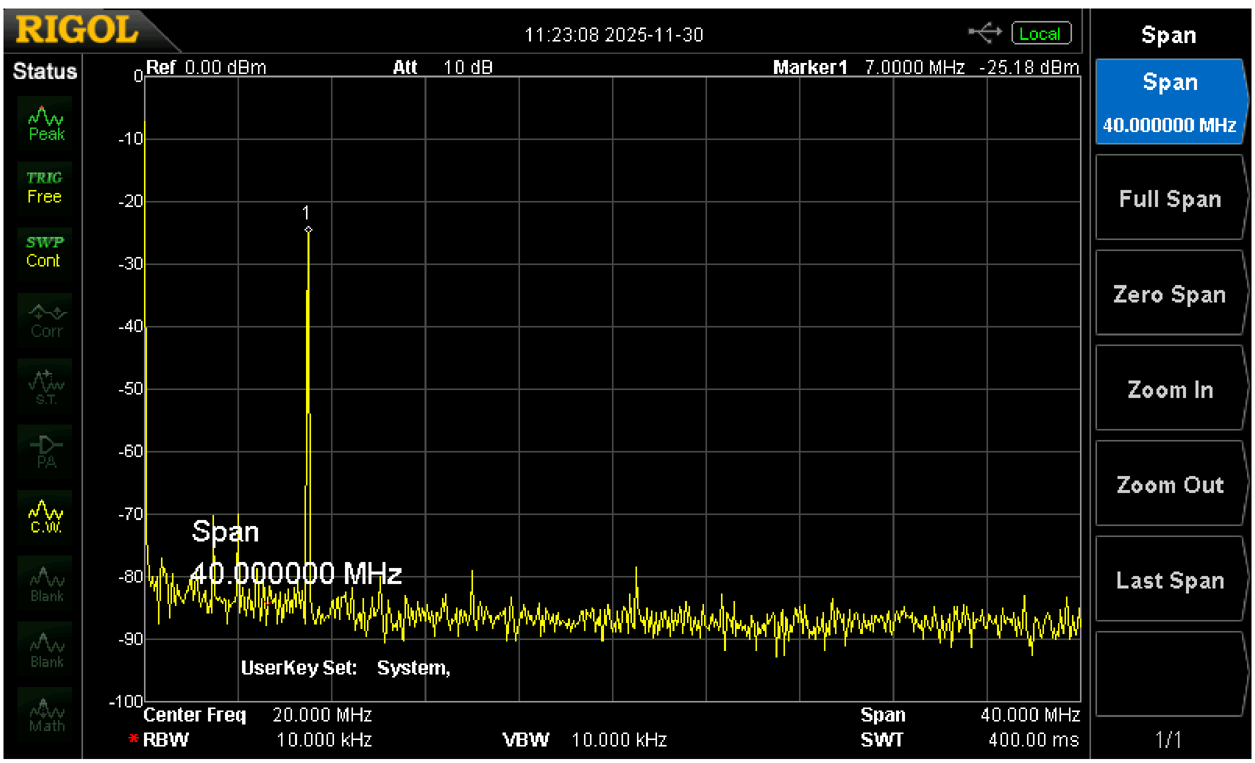
As mentioned above, the mixer outputs include many other spurious frequencies in addition to our desired 7 MHz signal. These are filtered away by the bandpass filter.

Power Amplifier

A clean, broad band power amplifier that can scale from 3.5 MHz to 30 MHz was designed. It uses just one trifilar transformer in the output stage. The predriver and the driver stages use the 2N2222 transistors. As the driver stage needs around 250mW of power (+24 dBm), we have chosen to use through hole transistors for the driver instead of SMD versions.

An IRF510, the workhorse of QRP amplifiers does a great job in the power amplifier, developing 5 watts of power. The second harmonic of 7 MHz at 14 MHz was above the FCC limits with a simple low pass filter. The first section of the low pass filter was modified to provide extra attenuation resulting in a very clean output.

The output spectrum is in Figure 7.



The VFO

For years now, the homebrewers have exclusively focused on dropping in an Si5351 and a digital controller to generate the local oscillators (guilty as charged!. We seem to have lost the art of building and using variable frequency oscillators. This is a pity. A modestly built VFO can provide receiver performance that is rarely matched by any synthesised clocks. It costs cents and it can provide hours of fun.

One of the main challenges of a low-cost radio is the local oscillator. The single most defining factor of a great radio is the VFO performance. A good VFO is marked by:

- Low phase noise
- Stable frequency output with Low drift
- Ease of tuning

Low phase noise and low drift can work against each other. A relatively easy way to get lower phase noise is to increase the energy of the oscillations. This needs high current in the VFO transistor which will heat it up leading to frequency drift from heating of the components.

For a reasonable compromise, we set the idling current Q1 to 4 mA as a compromise between stability.

Good quality variable capacitors have become rare. Slow motion drives are even more difficult to get by. A number of homebrew projects have used permeability tuned oscillators(PTO). A brass screw threads in and out of a cylinder on which the VFO inductor is wound. The PTO provides a multi-turn tuning mechanism and they can achieve less than 50 KHz tuning per turn with zero back-lash.

However such a PTO requires a fully shielded box for the mechanism as the air inductor is susceptible to pulling from hand capacitance unless the inductor was shielded from the tuning knob. A shielding made from copper clad boards was required for proper performance. Possibly a higher performance system can switch back to a variable inductor that uses a brass screw as the tuning element.

At this point, Jitendra, VU3BEO, suggested using a varactor. Our earlier experience with BITX40 prepared me for a drifty VFO. We have selected a reverse biased 1N4007 as the tuning varactor. The 1N4007 in combination with C0G capacitors keep the VFO very stable. It drifts by around 300 Hz in the first five minutes and becomes rock stable. The potentiometer tunes a 150 KHz portion of the band. A large knob is adequate for tuning the radio. Some may find it easier to add a 1K potentiometer in series with the ground terminal of the main tuning potentiometer for fine tuning.

Considerable effort has gone into making the VFO stable enough. The first version had a permeability tuned oscillator that provided amazingly drift-free performance. However, it needed a 3D printed form to hold the inductor and two nuts that allowed a brass screw to slide in and out. It needed strong shielding to prevent the hand capacitance from pulling the VFO frequency while tuning the radio.

The combination of surface mounted C0G capacitors with etched tracks make the VFOs very stable. The reasons need to be investigated. Perhaps the FR4 substratum prevents tracks from changing their dimensions due to the heat.

The VFO drives the front-end mixer with a considerable amount of power. This is required for proper switching action where the diodes in the mixer spend very little time between being fully turned on and being fully turned off.

This VFO demonstrates a fundamental principle: Using high quality inductors and capacitors with adequate power output will keep the VFO clean and stable. You don’t need expensive transistors or even JFETs to build a proper VFO. The inexpensive and common 2N3904s or 2N2222s are good enough for stable, low noise performance. A JFET like the J310 would have provided better phase noise and it can perhaps be directly used in this circuit with the removal of R1 and increasing the R2 to 1M. This has not yet been tested.

The CW Operation

The SSB is a great mode for effortless, rambling ragchews with the local gang and an occasional DX contact. However, for POTA activations, DXing, etc., nothing comes close to CW. It was imperative that CW should be possible on this radio.

A simple one transistor audio tone oscillator of Q18 does the trick. It is a phase shift oscillator, known for clean audio. It is keyed by shorting the R82 to the ground via the morse key. This injects a 700 Hz tone into the mic line, producing CW. A little bit of the side-tone is also leaked into the audio amplifier via R89. You can change the value of the 100K to increase or decrease the CW sidetone. Changing the value of the C74, C75, C76 and C84 and C86 can change the sidetone to suit your preferred tone.

T/R switching of CW is a fun detail. On key down, the C77 quickly charges up via D18, turning off the Q20 which in turn, turns on the Q21. The Q21 shorts the PTT, switching the radio to transmit mode. The key also grounds the R82, generating the modulation from the sidetone.

On key up, the C77 discharges slow through the R85. This delays the return to RX and the next keydown charges back the C77 again. A sufficient amount of time must elapsed since the last key down to discharge the C77 to the point where the Q20 is turned on and, in turn, the Q21 is turned off, releasing the PTT and reverting back to reception.

An important caveat is that the CW is generated as a single tone on LSB. Hence, the LARCSet is capable of cross mode LSB-CW contacts. You must disconnect the microphone when operating the CW.

Conclusion

With the LARCSet, we hope to introduce more hams to understanding electronics by building, experimenting with their own radios. Pete Juliano, N6QW, commented that hams could adapt the LARCSet to different bands by just switching two sets of filters and the VFO. Our hopes are that with the LARCSet we will see many hams come on air with the excitement of a self-made radio. The PCB has been designed with modifications and extensions in mind.

Above all, the clean audio with ‘presence’ on receive and transmit has made this radio a joy to use and listen. We hope others find it rewarding too.

All the files including the schematic, building instructions are available on
https://github.com/afarhan/larcset

Assembling the LARCSet

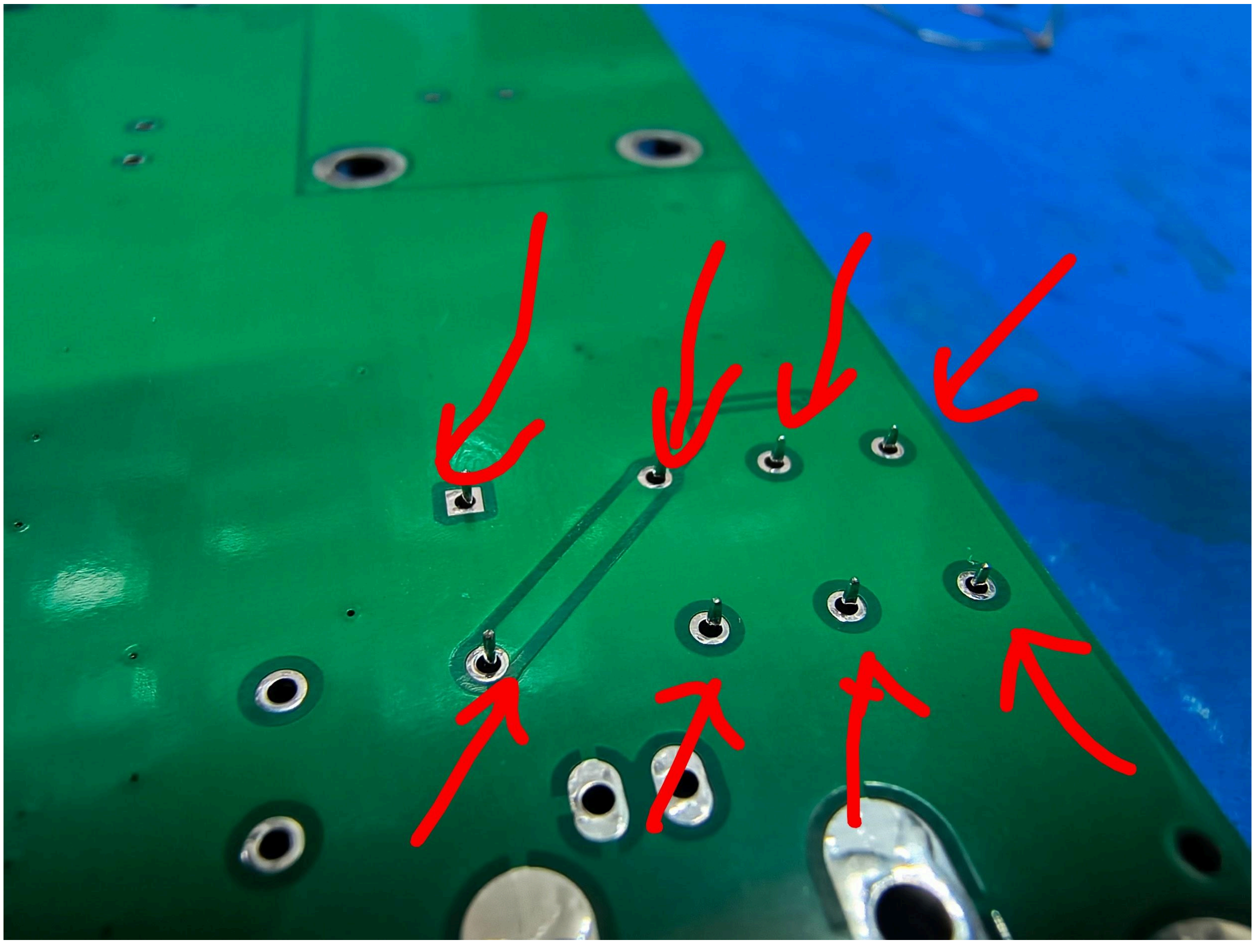
Tools that you will need:

1. An ordinary Volt-Ohm meter with current range.
2. A clean, 12v DC Power supply capable of supplying of at least 1.5A of current capacity.
3. A small long nose pliers
4. A small wire cutter
5. A blade to strip the enamel off
6. A wire stripper
7. A 25 watt soldering iron.

As an overall approach, we will enable the radio in stages.

1. Install the DC components

1.1 **Solder the DC socket onto the PCB**. To do this properly, insert the DC connector into the PCB, turn the PCB upside down and press on it so that all the three leads of the DC jack are fully inside the PCB then solder them. Flow enough solder around these pins as they are going to handle heavy current
1.2 Solder the Relay K1 to the PCB. Inser the relay carefully and check that all the pins of the relay are inserted. It is common to accidentally bend the relay pin such that instead of it slipping into the mounting hole, it bends away. Once soldered, you cannot undo this step. So, please be careful and double check that all the pins of the relay are seen on the other side before soldering the relay.



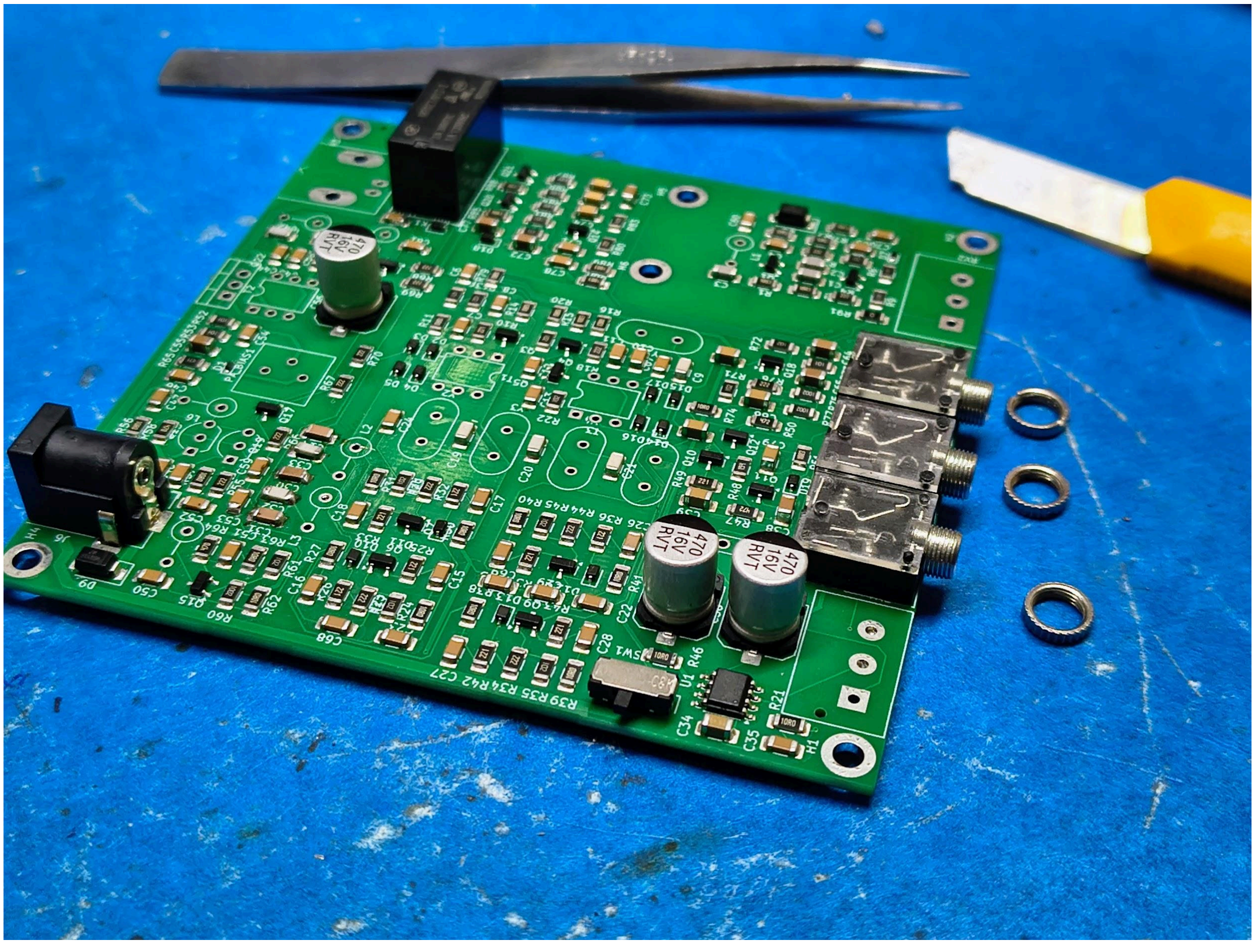
2. Install the front panel

The front panel is held up by the audio jacks.

2.1 Installing the audio jacks.

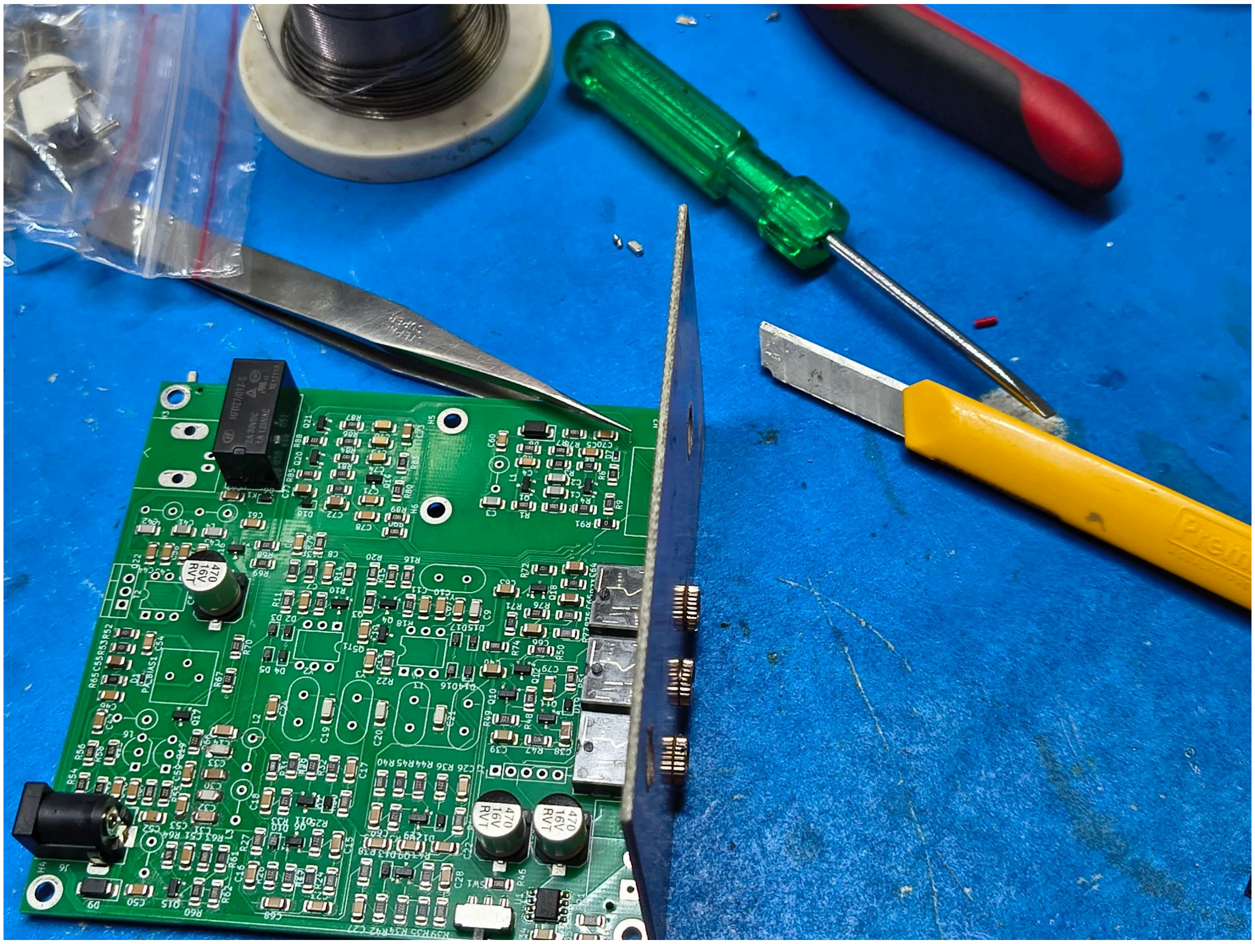
- Remove the mounting nuts (that look like rings) from the audio jacks before attempting to insert them into the PCB. Keep these rings safe as they will be needed later to mount the front panel.
- Insert the three audio jacks. Inspect every lead of each of the three connectors and doubly check that they are inserted properly. It is easy to press the audio connectors onto the PCB and instead of inserting their leads, you might bend them against the PCB. See the picture below to see how they should look before soldering.
- Once, it is confirmed that all the leads of the three audio jacks are properly seated, press down the connectors so that they are properly seated on the pcb.

- Solder the three audio jacks



(Note that the mounting rings of the audio connectors have been removed before they were installed)

2.2 Insert the front panel into the holes of the three audio jacks holding the front panel.Screw in the connector mounting rings so that the front-panel PCB is firmly fixed to the audio connectors. Note that the picture shown below is of the prototype front-panel. The front-panel supplied with the kit will be a regular printed circuit board.



2.3 Insert and secure the Tuning potentiometer onto the front panel and secure it with its accompanying mounting nut.For the time being just hand tighten the nut to firmly hold the potentiometer in place.

2.4 Insert and secure the volume control onto the front panel with its leads point upwards onto the front-panel. For the time being just hand tighten the nut to firmly hold the potentiometer in place.

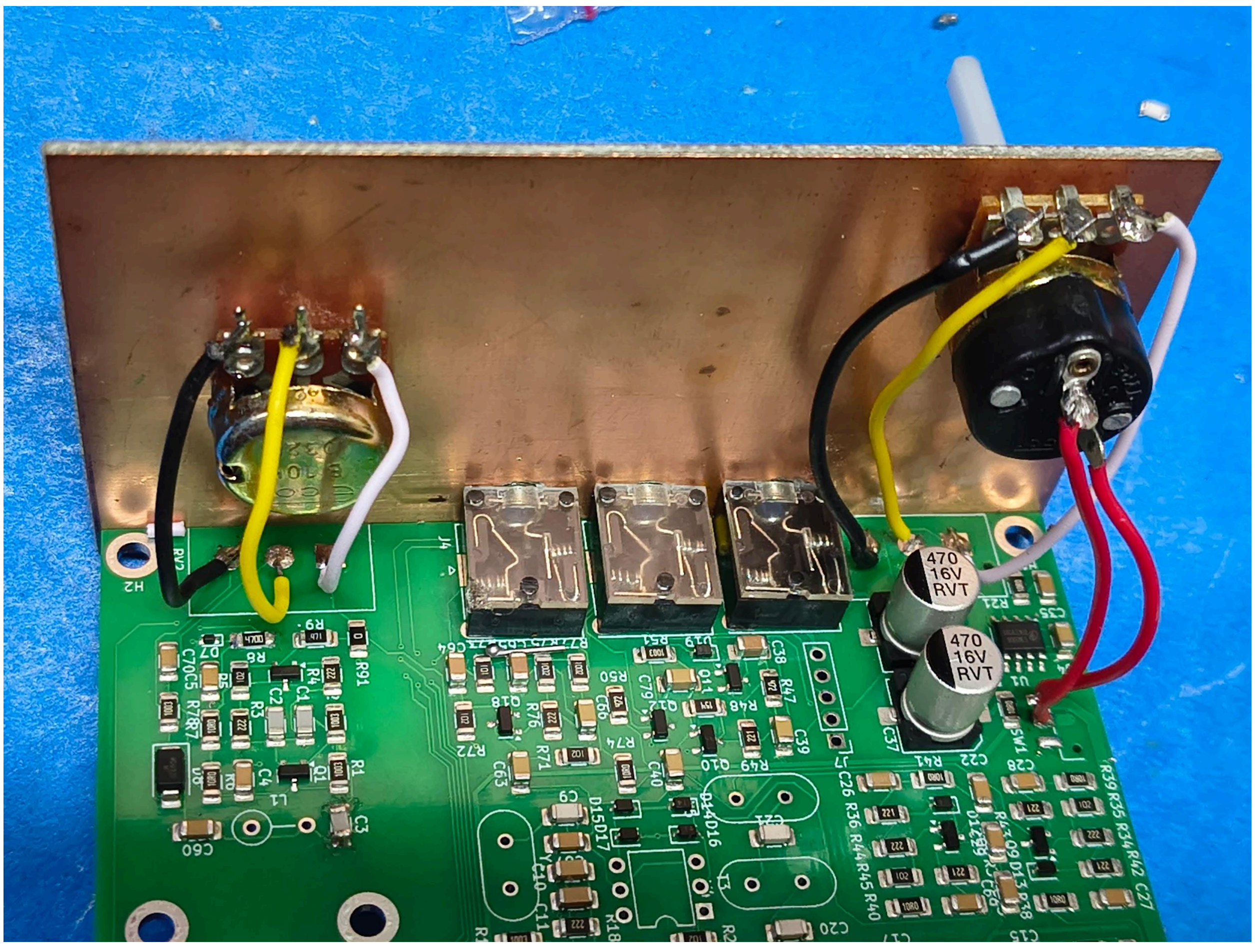
2.6 Use three wires of different colours to solder the controls to their tabs on the PCB. To avoid mistakes note that:

- Pre-tin the wires before attempting to solder them to the control or the pcb
- Keep the wire lengths short, but not too short. They are mostly carrying audio or DC. There is no RF energy in them.
- The middle tab on the PCB goes to the middle tab on the potentiometer. Double check this.

- If you solder the left and right side tabs the wrong way, the tuning will happen in reverse direction or the volume control will give you full volume when held counter-clockwise. You will have to just swap the connections to set it right.

2.6 Add two wires from J8 (power switch) to the on/off switch on the back of the volume control. The polarity here does not matter.

See the picture below so see how the front-panel's back should look. Carefully not where each of the wires go.



(Note: this picture shows the only prototype front panel. The front panel supplied with the kit is a professional printed panel on FR4)

3. Testing the DC and the audio amplifier

3.1 Prepare the DC power supply with +12v on the center pin and the ground on the outer sleeve.

3.2 Turn the power off by turning the volume control fully counter clockwise until it clicks softly.

3.3 Insert the DC power through the jack.

3.4 Switch on the power b turn the potentiometer clockwise. At this point the radio should be drawing between 40mA to 70 mA. If it is drawing more, immediately shutdown the power and check for any short circuits. If the is not drawing any power at all, check the on/off switch and the dc power connector's solder joint.

3.5 Insert telephone handsfree ear buds into the left most audio jack. The noise floor of the radio should smoothly increase and decrease as the volume control is turned. If the volume control is behaving in the opposite direction, reverse the wires connecting the two side lugs of the volume control.

By now, you have completed the most important part of your radio.

4. Tuning the VFO

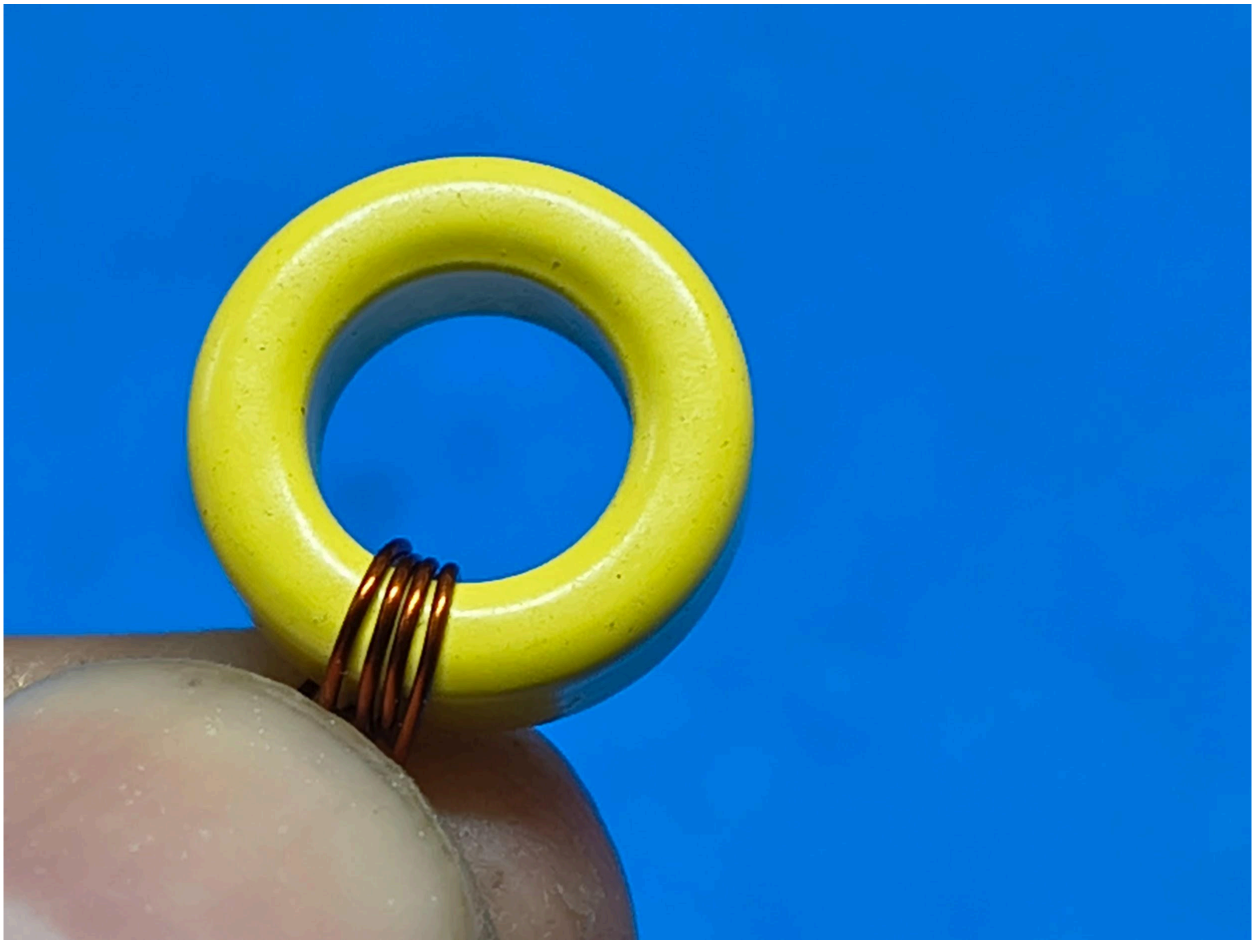
Traditionally, radios have used VFOs for tuning. They provide the best-in-class phase noise performance. To start the VFO,

4.1 First, turn off the radio. Always do your soldering with the power jack disconnected.

4.2 Locate the larger yellow toroid. This is a Micrometal's T50-6 toroid. We have to wind 33 turns of the enamalled wire on this.

4.3 Cut off two feet of enamelled wire and thread the toroid through it so that it is midway between the two ends of the wire.

4.4 Each pass through the toroid counts as one turn. Keep the wire tensed while you wind from one side. Take care that turns don't overlap each other.



(The VFO toroid with 4 turns. Note that the turns are close to each other, they don’t overlap and they are wound tightly).

4.5 Finish 35 turns through the core of the T50-6. Cut the ends of the wire so you have only 1/2 inch wire on both sides. Scrap the enamel off the wire pigtails until the white metal shows from all sides of the wire. See the picture below.

4.6 Solder the two ends of the toroid across the L1

4.7 Attach a small loop to a nearby receiver.

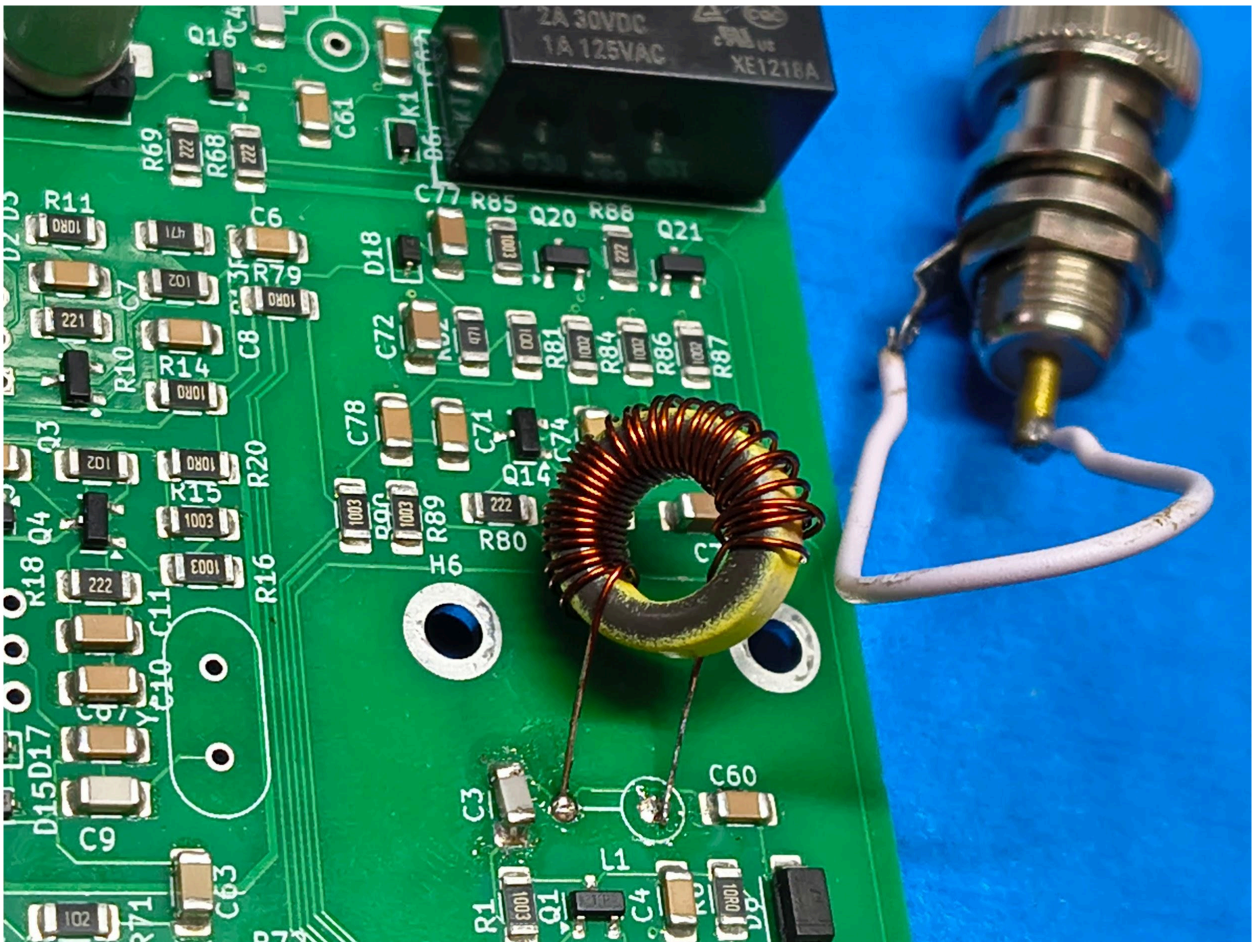
4.8 Switch on the LARCSet, setting the tuning potentiometer all fully clockwise and tune the receiver across the 80 meter band. You should be able to locate the strong VFO carrier. Note the frequency of the VFO.

4.9 Note that as you turn the tuning potentiometer clock-wise, the frequency of the vFO should decrease.

4.9 We want the frequency lower end frequency (tuning control fully clockwise) to be within 3.85 MHz and 3.9 MHz. If the frequency is below 3.65 MHz, you may have to remove a turn from the

VFO toroid. Spread the turns to increase the frequency and push them closer to decrease the frequency.

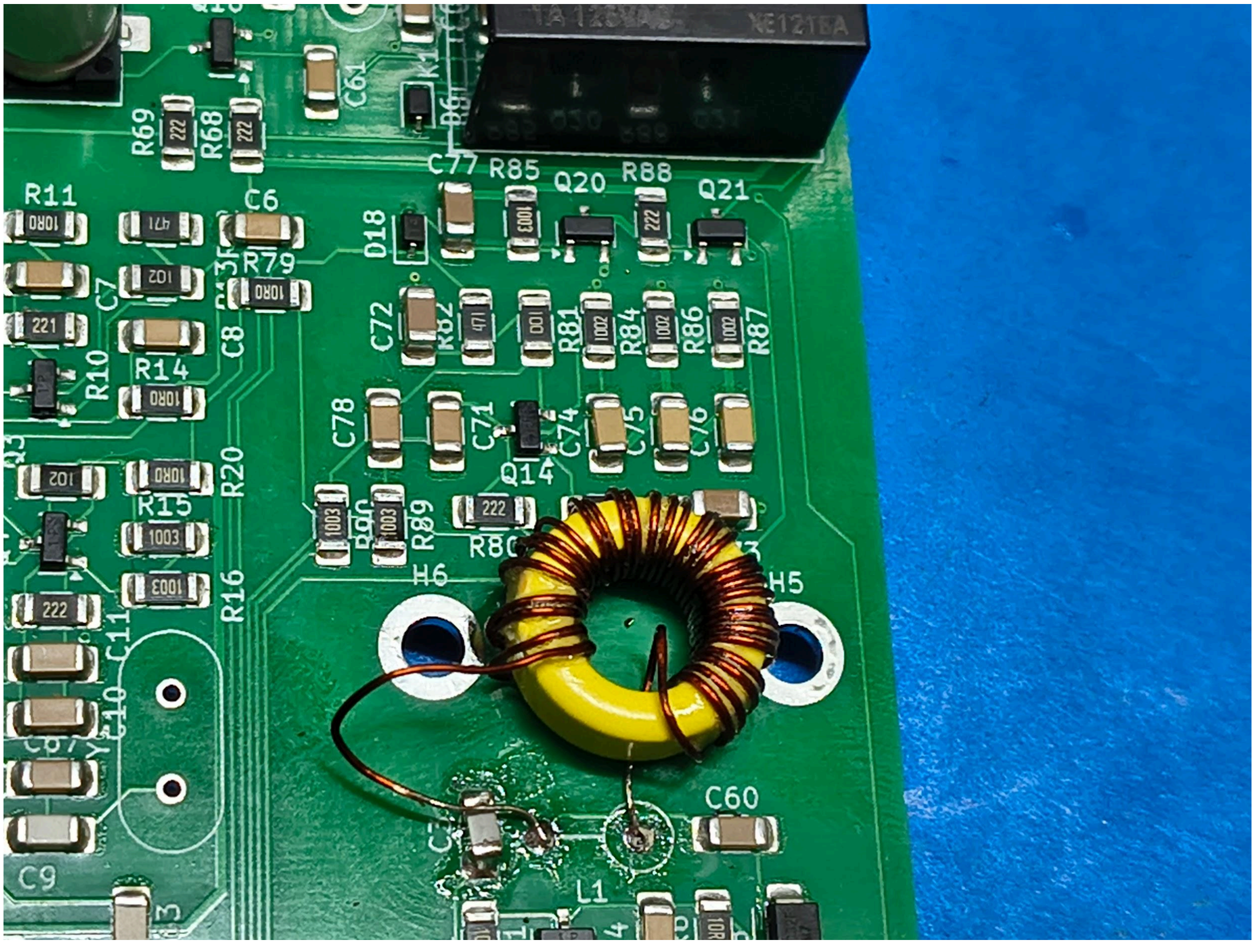
4.10 At this point, the VFO will appear to drift a bit. This is expected as the toroid is hanging in the air with all the soldering happening around it. See below how the VFO is soldered during the tune-up. Note the coupling loop connected to nearby receiver tuned to 3.8 MHz.



4.11 When the VFO is within the range you should be able to tune it from 4,059 to at least 3.9 MHz.

4.12 At this point, when you are satisfied with the VFO range, add a few drops of superglue to the toroid so that it flows all around it and gently press it down to the pcb and hold it there for a minute to allow it to set.

Here is the picture of the VFO toroid glued to the board:

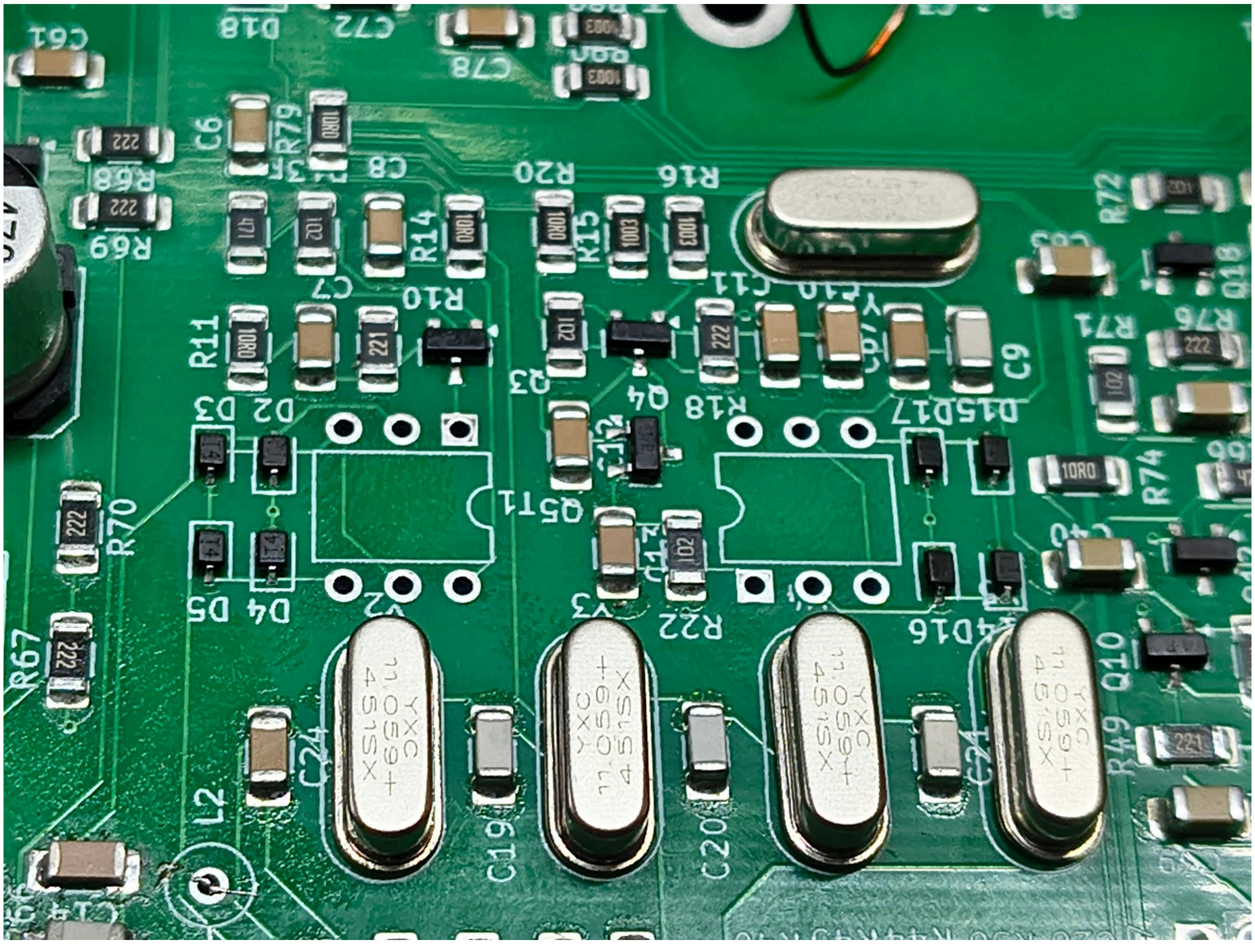


This completes the VFO setup.

5. The Crystal filter and the BFO

You have to simply insert and solder the five crystals supplied.

It is advisable that you solder them, one at a time, snipping the remaining leads of each before proceeding to the next crystal.



6. Soldering the Trifilar transformer

The trifiar transformer soldering needs very careful work. It is best done when are fresh. Do not triy this late at night!

The reason is simple. The ‘tri’ in the trifilar transformer refers to the presence of three windings in the transformer, Each winding’s wire has two ends. Hence, there are six leads coming out of the trifilar transformer.

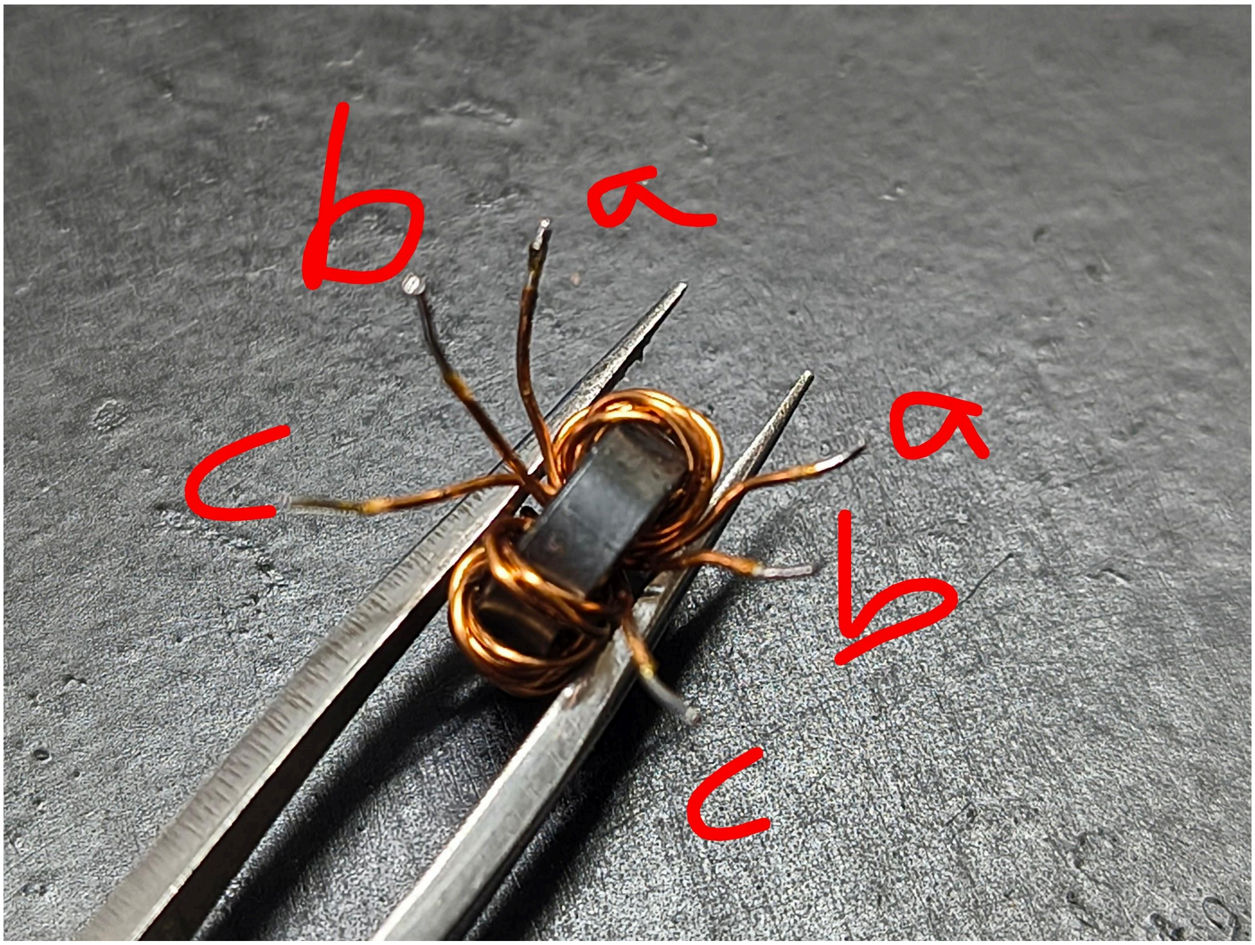
You have to carefully separate out each end, test them with the VOM meter for continuity before inserting and soldering them. Do this when you are fresh, preferably with a friend overseeing your work.

6.1 The transformer is a set of three wires tightly twisted together and wrapped into the toroid.

6.2 Identify the two ends ot the twisted wires and separate out each of the wires on either side.

6.3 The trifilar transformer wires are already have tinned ends.

6.4 Using the continuity setting of your VOM meter, separate out the three windings of the transformer like in the picture below:



Note that you must separate out the wires such that:

- There is continuity between a-a, b-b and c-c
- There is no continuity between a-b, b-c, c-a.

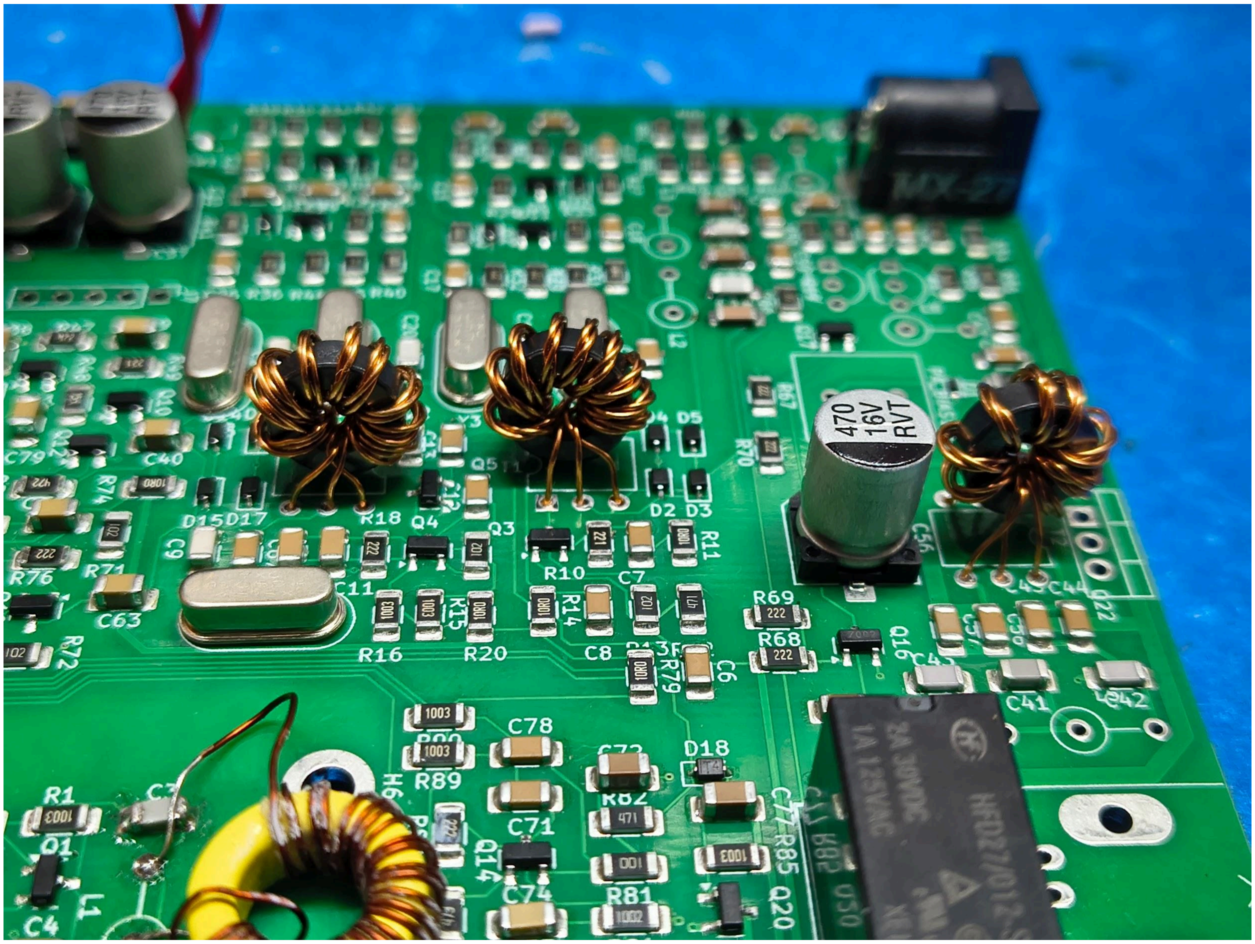
6.5 The transformer has to be inserted keeping a, b, c wires on the pins across each other. It is easier if the leads are clipped to 1/4 inch each.
See the picture below:

6.6 Carefully insert the a-a, b-b and c-c windings into the holes as shown in the picture above. You may want to use tweezers to nudge each wire into it's hole.

6.7 Check that only the tinned part of the leads sticks to the other side. Soldering over the enamelled (insulated, copper colored part of the wire) is a common mistake. It looks like it is soldered but in reality the enamel keeps the PCB insulated from the transformer leads.

6.6 Finish solder T1, T2 and T3 transformers.

Now, the board must look like this:



This completes the trifilar transformers

7. RF Bandpass filters

We have to wind two L2 and L3 on the smaller yellow T30-6 toroids. Each inductor needs 19 turns.

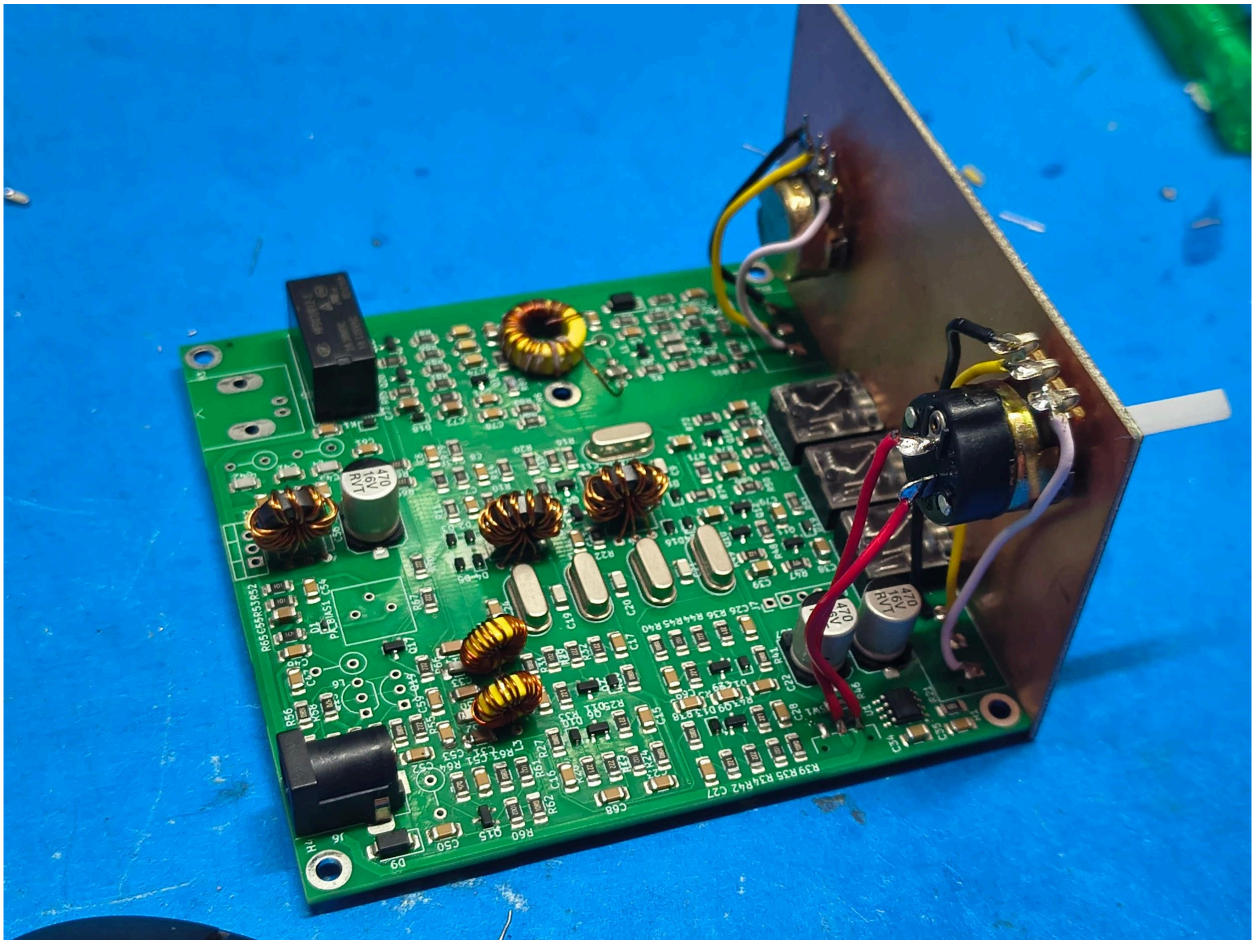
7.1 For each (L2 and L3), cut a 12 inch long enameled wire. Wind it similar to how you wound the L1. These are much easier to wind as the wire length is smaller.

7.2 Take care to not overlap the windings and keep them tight and packed next to each other. The windings, when completed, will take up almost the whole of the toroid’s surface.

7.3 Once you have tinned the leads, check for proper continuity between the leads with a VOM meter.

This is how both the inductors will look once they are ready to be installed:

Once they are installed at L2, L3 positions, the radio will look like this:



8. Install the BNC Connector

Our receiver portion is almost done. We just need to solder the BNC connector before we can switch on the radio!

The BNC connector is easy to install. As usual, take care that the RF pins are not bent away from the PCB.

9. Testing the receiver.

Now we are ready to test the receiver. Attach an antenna to the BNC connector and switch on the radio. You should be drawing around 80mA of current. When you tune around, you may pick up the band activity if there are any active stations!

If the receiver appears dead: Carefully reheat and resolder the through hole components. More often than not it is a bad solder around the enamelled part of the inductor or transformer wires. You can tap around the circuit to see if anything is lose.

10. Transmitter driver

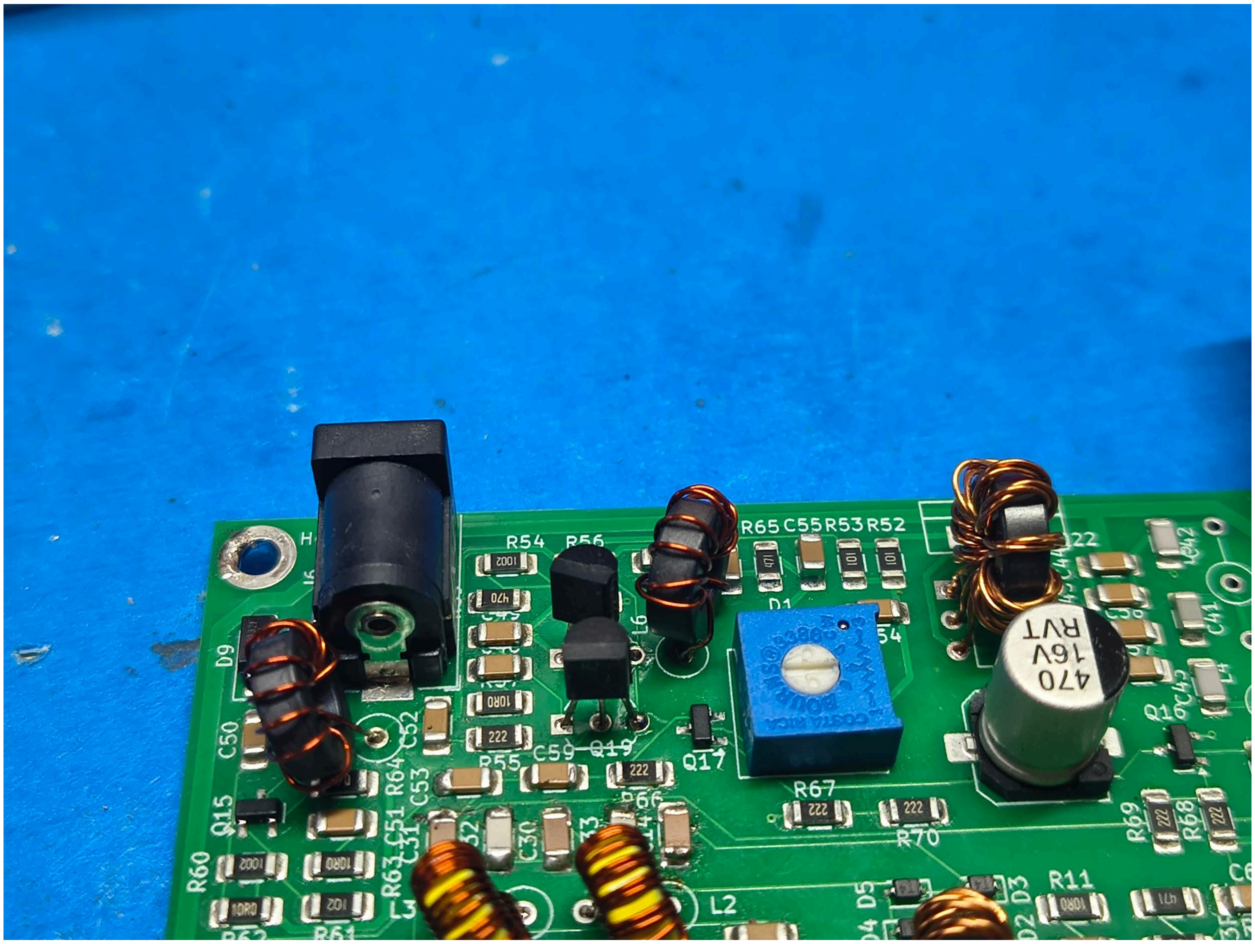
10.1 Cut two 7 inch lengths of the enamelled wire and wind the L6 and L7 as 10 turns each on the black FT37-43 toroid. Scrap off the enamel from the pigtails and tin the pigtails.

10.2 Solder the L6 and L7.

10.3 Solder the Q19, Q13, the PN2222A (alternatively, 2N3905 might have been supplied along with your kit) through hole transistors. Their flat side faces away from the rear edge of the board.

10.4 Solder the blue PA BIAS trimmer. Turn it fully clockwise.

After installing these components, the board's driver portion will look like this:



11. Power Amplifier

In the power amplifier stage, you have to install the IRF510 with the heatsink and the transmitter output filter’s inductors.

11.1 Bolt the IRF510 down to the heatsink with the supplied A3 screw. The screw should be firmly tight for proper heat conduction. If it is tightened too much, the IRF510’s case could crack, so be careful!

11.2 Solder the IRF510 with its heatsink installed onto the PCB. The heatsink should be installed on the IRF510 before it is soldered in.

11.3 The L4 and L5 are both with slightly different values. So, instead of winding both of them and trying to solder them together, it is best to wind and solder the L4 first and then the L5.

11.4 Cut a 12” enamelled wire piece and wind 17 turns on one of the two T30-6, yellow toroids. Scrap the enamel off and tin the leads. Insert the inductor into the L5. This is the inductor footprint towards the edge of the board.

11.5 Cut another 12” enamelled piece and wind 19 turns on the last remaining T30-6 , yellow toroid. Scrap the enamel, tin the leads and solder it in the only remaining inductor footprint at L4. (the position away from the edge of the board).

This completes the assembly of the radio.

12. Setting the PA bias.

12.1 Attach a dummy load or a well matched 7 MHz antenna to the radio,

12.2 Attach a microphone to the radio’s middle audio jack. The tip is the mic, the ring is the PTT and the sleeve is the common ground.

12.3 Turn the PA_BIAS trimpot to fully clockwise direction.

12.4 Press the PTT on the mic. Do not modulate. The current draw should be around 170mA.

12.5 Turn the PA BIAS trimpot slowly in the anti-clockwise direction until the standing current increases to 350 mA.

12.6 Speak clearly into the mike, elongating the vowels to increase the average power of the transmitter.The DC current draw should increase to 0.6A on peaks

12.7 Plug in a morse key into the right most jack. On key down, a carrier of 45 volts peak-to-peak should be measured if you have an oscilloscope connected across the antenna socket. It should be drawing between 0.8 and 1 A on the key down.

13. Calibrating the dial

LARCSet is an analog radio. Though it is easy to add a frequency counter to read the tuned frequency, it is much simpler to just mark the frequencies on the dial with a sharpie. Here is our favourite way of doing this.

You will need access to another radio transceiver that can transmit CW on 7 MHz.

13.1 Set the **other radio** so that:

- It is connected to an antenna or preferably a dummy load
- Tune it to exactly 7.000 MHz, set the mode to CW

13.2 Insert a small piece of wire, a couple of inches long into the antenna socket of the LARCSet. This will pick up reduce the strength of the calibrating signal from the other radio.

13.3 Press the CW key on the other radio. Tune the signal on the LARCSet. Draw a line onn the front panel where the LARCSet's tuning knob's pointer is as "00".

13.4 Move the **other radio** by 10 KHz to 7.010 MHz, Press the CW key on the other radio and tune the signal in on LARCSet, Mark the dial again as "10".

13.5 Repeat the step for every 10 KHz on the band.

13.6 There will be many other ways of calibrating the LARCSet. The really important thing is to be sure that you are within the ham bands all the time.

Using the LARCSet

The LARCSet is really easy to use and simple. For best reception either use earphones or an external 8 ohms speaker:

- Use a well matched antenna. Though the LARCSet will not blow up with mismatch, given its low power every bit of RF that gets out will help.
- SSB: Plug in a microphone into the middle socket on the front-panel. It takes a 3.5 mm stereo jack (one is provided in the kit) with the mic connected between the TIP and the sleeve and the PTT button connected between the ring and the ground.
- CW: Disconnect the mic if it is already attached to the middle socket, Attach a morse key to the right most socket with the key connected between the tip and the sleeve of the jack. Press to transmit!