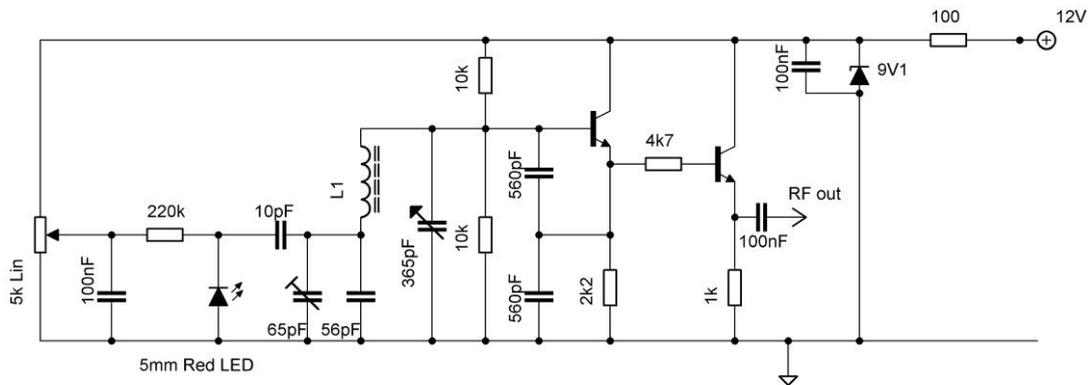


## AN ALTERNATIVE INTERMEDIATE VFO

Some Intermediate tutors have reported difficulties in either obtaining parts for the Intermediate textbook VFO or in getting the VFO going once they have the parts. This alternative design, based on the VFO in Ashar Farhan's BITX transceiver, has been adapted for use on the 80m band. It has been tried and tested and works very well using easy to find parts.

### Circuit



L1 = 60 turns 30 SWG enamelled wire on T50-2 toroid

The circuit is a fairly standard Colpits VFO, although the series tuning is sometimes credited to Gouriet-Clapp. It uses an NPN bipolar transistor in place of the more usual FET to maintain oscillation. I have built several versions with different transistors, including some unmarked surplus transistors of Russian origin and all have worked well; this circuit does not seem to be too fussy about which NPN you use.

Another NPN transistor acts as a buffer amplifier to allow the VFO to be used in a number of radio projects; the prototype is now driving my Walford Electronics 'Brendon' 80m DSB transceiver to extend the coverage beyond that of the original VXO ceramic resonator. It is certainly stable enough to use on air, although frequency critical modes, like PSK31 and QRSS, might be pushing it!

The inductor in the tuned circuit is wound on a T-50-2 toroid. Whilst this does not really allow much variation in the inductance, other than by stretching/squeezing the turns, the toroids are easier to find than the TOKO KANK inductors used in the original design. An alternative inductor, using a plastic 35mm film canister, has been tried in case toroids vanish from the market.

The main tuning variable capacitor should be around 365pF maximum for full band coverage. However, a smaller value capacitor can also be made to work (see later). Useful coverage can be had from the 'common or garden' polycon variables that are available with 160+60pf sections. These can be recovered from scrap transistor radios if no new supplier can be found. However, virtually any surplus variable capacitor for the correct value will do the job but those with built in reduction drives will cause problems in the Intermediate calibration exercise.

The circuit also includes a fine tune circuit, which is extremely useful on the air. The use of a Zener diode acting as a variable capacitance diode may raise some eyebrows, but it works well and Zener diodes are more readily available than vari-caps. In one of my prototypes I did not have a suitable Zener and tried a yellow LED from the junk box and that worked just as well.

The fine tune components (the 10pF capacitor and everything to the left of it in the circuit diagram above) should be omitted if VFO use is going to be limited to Intermediate calibration exercises.

### **Construction Method**

This circuit uses a construction method that will hopefully allow for good repeatability. The technique has a number of names; the Americans call it 'Manhattan-style', whilst Drew Diamond, VK3XU, calls it 'Paddy Board Construction'. Basically, a piece of copper clad board is used copper side up for all ground connections and small 'islands' of copper PCB material are stuck on top to provide soldering points for non-ground connections. This is just a small step from the drawing pin method used for the Intermediate DC Test Circuit and therefore seems appropriate for a 'next-steps' project.

For simplicity's sake, and to aid mechanical stability, the islands for this project are formed by two 6mm wide strips of PCB material with hack-saw cuts to separate the islands. If you want to cut individual islands and stick each one on separately, feel free to do so but there really is no advantage to be had.

The strips are secured using 'Super Glue' or similar quick-setting adhesive. You can use double sided PCB material for the strips and solder them in place if you prefer

but the glue method seems to work well enough and once the components are in place they anchor the islands too.

A front panel, formed from a second piece of PCB material, is used to hold the variable capacitor and the fine-tune pot. This is held secure by a few solder joints and strengthened by a couple of triangles of PCB material (see photos). If the front panel is set back a few millimetres, a false calibration dial can be slipped in behind the variable capacitor tuning knob for the Intermediate practical exercise.

## **Parts List**

### **Resistors**

100 $\Omega$  = 1 (brown, black, brown)

1k $\Omega$  = 1 (brown, black, red)

2.2k $\Omega$  = 1 (red, red, red)

4.7k $\Omega$  = 1 (yellow, violet, red)

10k $\Omega$  = 2 (brown, black, orange)

220k $\Omega$  = 1 (brown, red, yellow)

10k $\Omega$  linear variable = 1

### **Capacitors**

10pF ceramic = 1

56pF polystyrene = 1

270pF polystyrene = 1 (optional)

560pF polystyrene = 2

0.1 $\mu$ F disc ceramic = 3

65pF trimmer = 1

365pF variable capacitor = 1

### **Transistors**

BC547, BC109 (or any similar NPN) = 2

### **Miscellaneous**

T-50-2 Inductor Core = 1 (red toroid)

36V Zener diode (or 5mm LED) = 1

9V2 Zener diode = 1

30swg enamel copper wire = 1200mm

Single-sided copper clad PCB material = 100mm x 120mm

Small self-adhesive rubber feet = 4

Large pointer knob for main tuning capacitor = 1

Smaller pointer knob for fine-tuning pot = 1

Hook up wire = 15cm

## **Construction**

Start by preparing the PCB material. The 'ground base' and the front panel are both 100mm x 50mm. You also need 2 strips 6mm wide and 80mm long and two right-angled triangles about 20mm x 20mm. With care, they will all come out of a 100x120mm board, but dimensions are not critical.

Take one of the 6mm strips and cut through the copper at 10mm, 40mm and 70mm.

Take the second strip and cut that at 10mm, 20mm, 30mm, 50mm and 70mm.

Glue the strip with 5 cuts onto the baseboard centrally, about 12mm in from the back (see photo below). Make sure you have the cuts correctly positioned before placing the strip on the board!

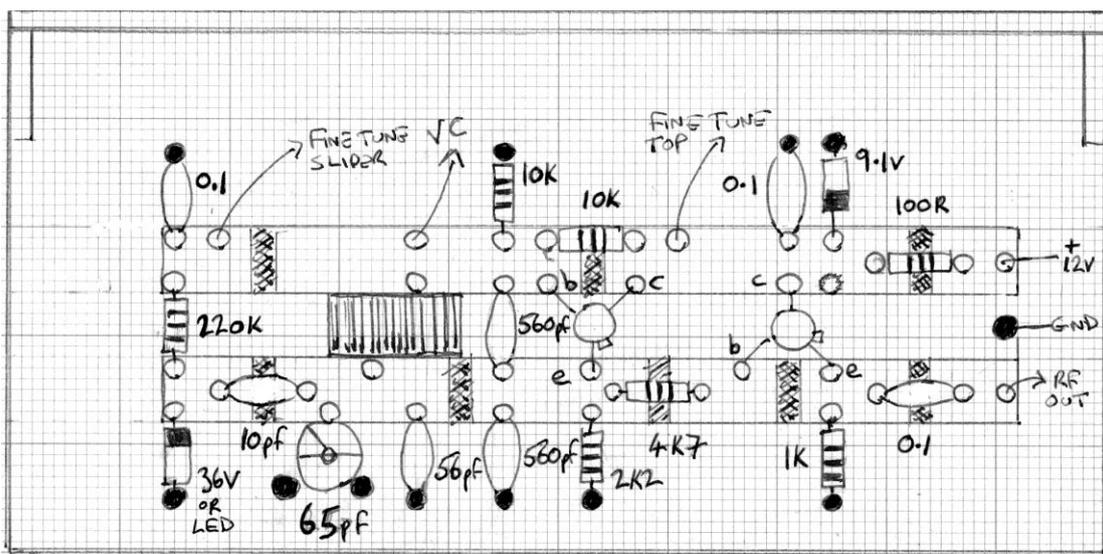
Glue the other strip (3 cuts) parallel to the first leaving a gap of about 6mm between them (see photo below). Again make sure you have the cuts correctly positioned before placing the strip on the board (see photo below).



**Photo 1 - PCB 'Base' with island strips glued in place.**

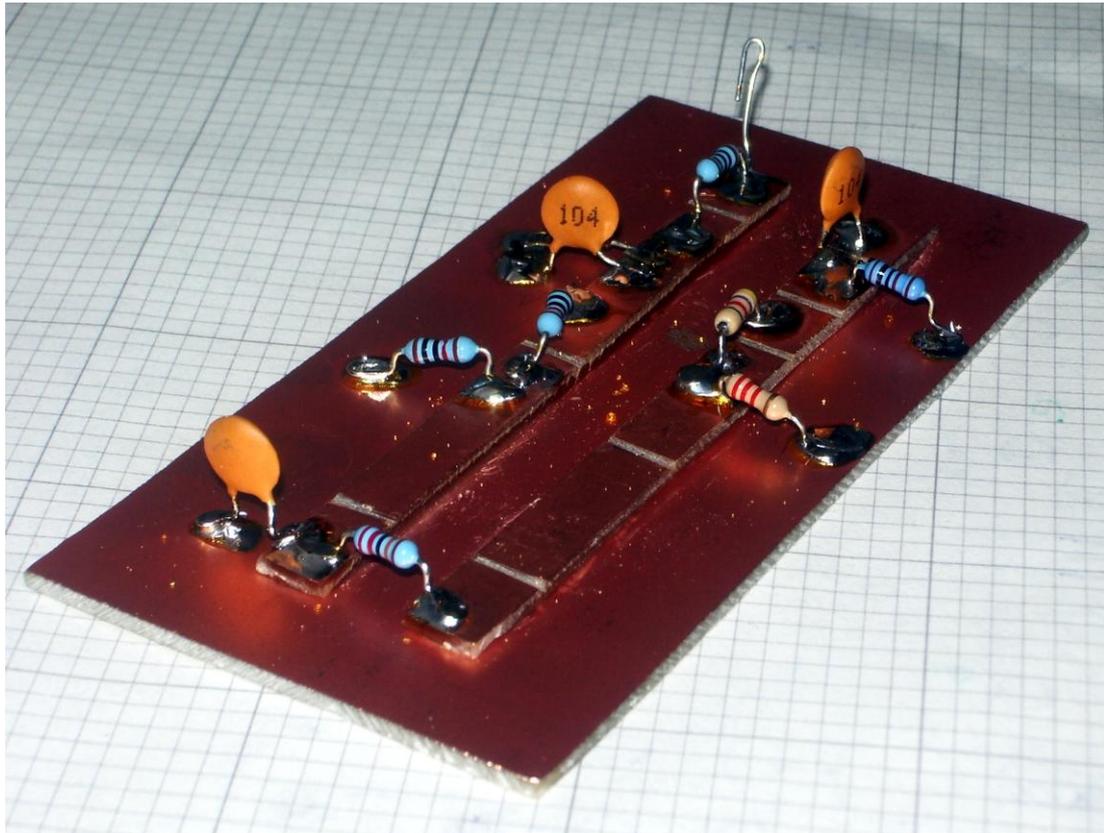
If you should stick the strips down incorrectly, they can be lifted by inserting the blade of a modelling knife between the strip and the baseboard and twisting slightly.

Stick the 4 rubber feet to the underside of the baseboard now to prevent it slipping whilst you are soldering the parts in place.



**Figure 1 - Component layout**

The order of build is really not important for this little project. Some will prefer to fit all resistors, then capacitors, then semi-conductors, others will prefer to start at one end and work across the 2 strips. So long as you get the parts in the right places it really doesn't matter which order you follow. However, it *is* important to keep component leads as short as possible to keep the whole thing fairly rigid – components should not be more than a few millimetres above the PCB material (see photo below).



**Photo 2 – Components soldered to the islands and ground with short leads**

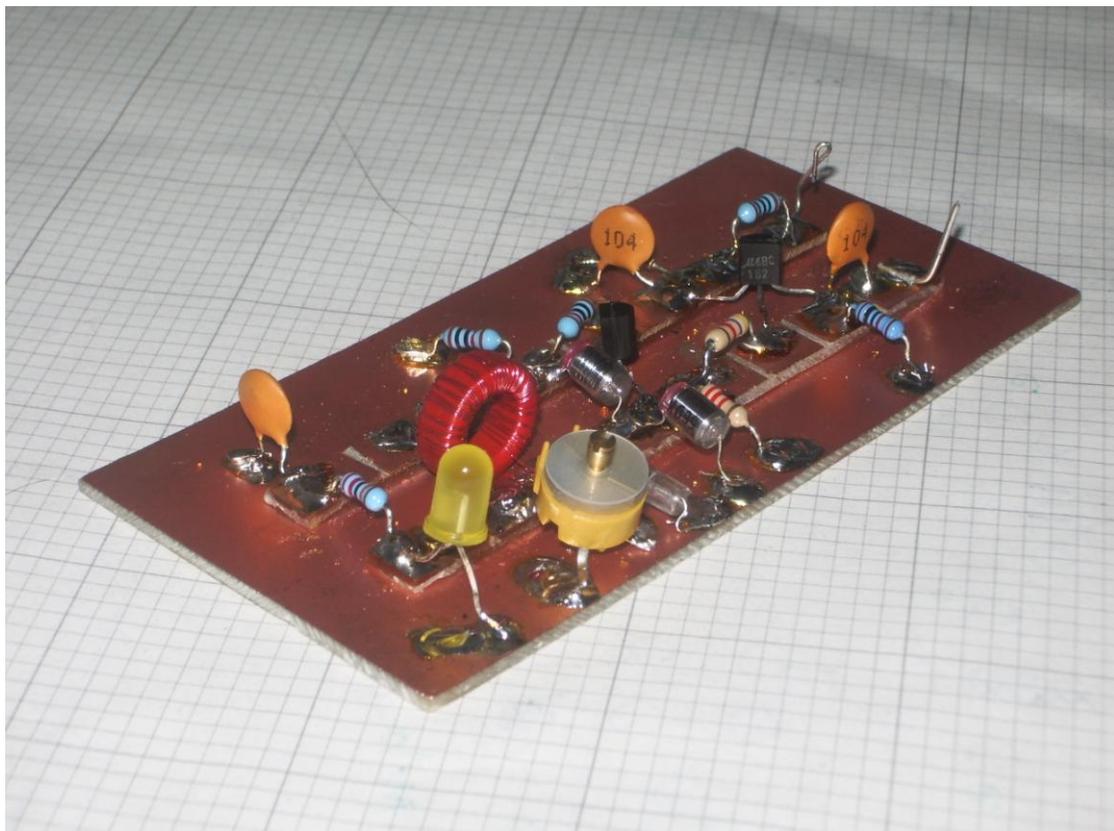
Prepare the inductor (L1) by winding 60 turns of 30swg wire onto the T-50-2. Each time you pass the wire through the core counts as one turn. Because of the length of the wire you might find it easier to do this standing up. Spread the turns evenly around about three-quarters of the toroid leaving 2 'tails' about 20mm long.

If you cannot source a T-50-2 toroid, the inductor can be formed by winding 25 turns of 28swg enamelled copper wire onto a plastic 35mm film canister. This is much larger than the toroid but in tests it proved every bit as reliable.

Using the blade of a modelling knife, or some rough abrasive paper, scrape the enamel off the tails to within a few millimetres of the inductor core. If you are not sure

whether you have got all the copper off, test for continuity using your ohmmeter set to the lowest ohms range. If you are touching bare copper on both tails you will get a very low resistance reading. If you get a high reading you need to scrape off some more enamel.

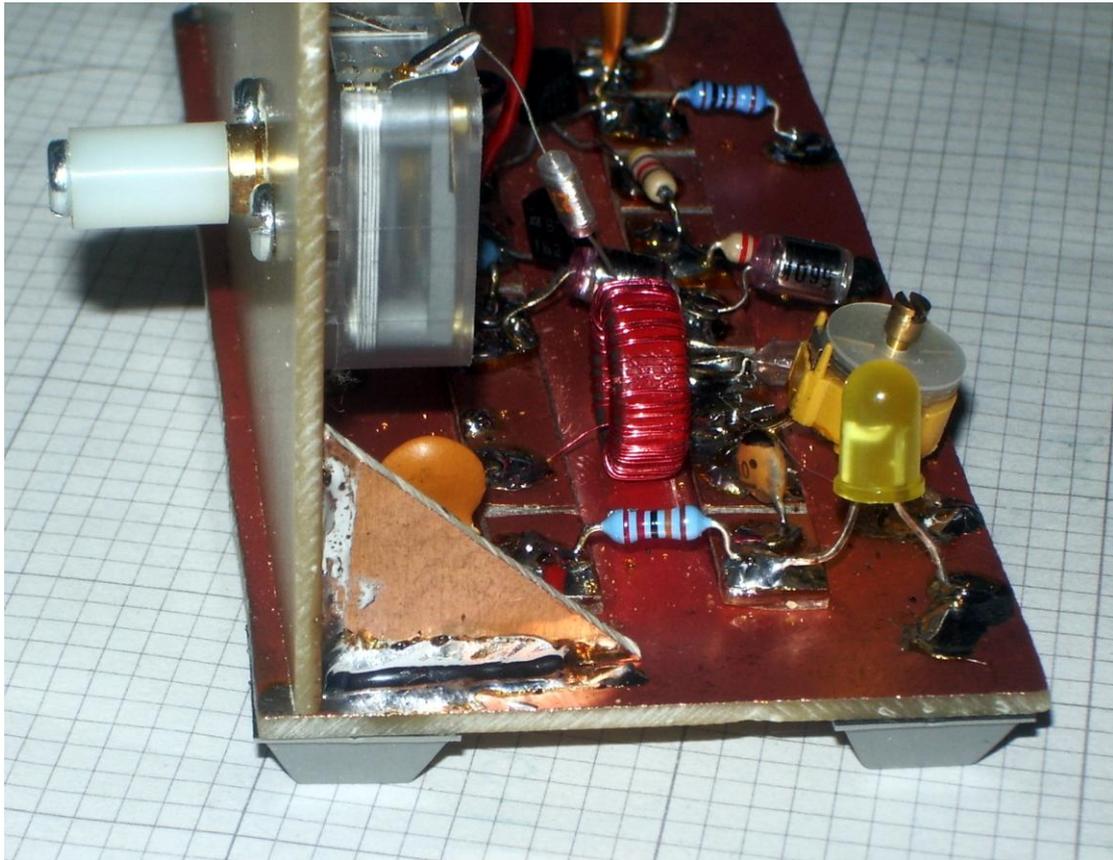
If you are building the VFO for use in a larger project you might like to secure the inductor in place with a blob of 'hot-glue' or melted candle wax. If you want to demonstrate how non-rigid construction can affect frequency stability, then don't secure the inductor!



**Photo 3 – main 'PCB' components fitted**

Now turn your attention to the front panel. Drill the front panel to suit the variable capacitor and the fine-tuning pot (if you are fitting it) making sure to leave enough space for the strengthening triangles (see photos).

Solder the supporting triangles to the front panel. Just 2 solder joints will do the job. It is easier to tin the front panel and the triangle before bringing them together. Make sure the triangles are square with the bottom of the front panel so it stands vertically on the baseboard.



***Photo 4 – supporting triangle soldered in place a few mm back from front***

Now solder the front panel in place, remembering to set it back from the edge by a few millimetres. Three or four solder joints will suffice but if you want to run a complete solder seam it will do no harm. Again, pre-tinning the panel and the board will help.

Now fit the variable capacitor and fine-tuning pot to the front panel. Make sure any fixing screws do not foul the moving parts of the variable capacitor! Short runs of hook-up wire should be used to connect the appropriate islands to the connections on the capacitor and the fine tune potentiometer (if fitted). Note that the capacitor may need to be connected to ground (some ground through the frame, others have a 'common' tab) and one side of the fine tune pot needs to be grounded (if fitted). Set the pot to mid-point of its travel.



**Photo 5 - Rear view of completed VFO with front panel fitted.**

Now comes the moment of truth - does it work? Connect up a 12 volt power supply with the negative lead to the baseboard and connect your multi-meter to measure the current between the positive terminal on the power supply and the positive 12V input 'island'. Remember to check the polarity of the leads (meter red lead to the PSU and black to the circuit under test) and to set the meter to its highest DC current range. This is in case there is a fault in the circuit and it is drawing more current than it should. If all is well drop to a lower range and you should find the current to be around 45mA. If it is a lot more, or no current is flowing at all, check through your parts placement and solder joints.

Assuming all is well with the current, you can connect the power supply properly and check that the VFO is generating an RF signal:

- **Use an RF probe.** An RF probe is one of the most basic, but useful, pieces of test equipment you are ever likely to own. Referring to the layout pattern Figure 2 above, connect the leads of the RF probe between the point marked 'RF out' and

ground (the baseboard) and set the multi-meter to read DC volts. A high range should be used first to get some idea of what you are measuring. In this case, you should expect something like 2 or 3 volts (peak-to-peak).

- **Use an oscilloscope.** If you have a scope then by all means use it. Referring to the layout pattern Figure 2 above, connect the leads of the probe between the point marked 'RF out' and ground (the baseboard) and set the Y-axis to read something like 1V per division. You should expect something like 2 or 3 volts (peak-to-peak).
- Once you have confirmed that the oscillator is working we need to check that it is oscillating on the frequency we want it to – a key requirement for any oscillator! If you have an oscilloscope and it is up to it, you might be able to read off the time period and work out the frequency. If not, read on.
- **Connect a frequency meter across the output.** Do not panic if you do not have one, please read on. A frequency meter displays the frequency of any signal that is applied to its input, so long as it is strong enough to register and not so strong as to overload it. Some multi-meters have this facility built in. If you have access to a frequency meter, or a multi-meter with this facility, then use it now. Referring to the layout pattern, Figure 2 above, connect the meter leads between the point marked 'RF out' and ground (the baseboard). You should find that the oscillator output is somewhere around 3 or 4MHz. If you don't have a frequency meter, try the next test.
- **Listen for the oscillator on a receiver.** If you have a receiver covering the 3.5MHz band tune it to 3.650MHz and set it to receive CW, USB or LSB mode. Now tune the VFO across its range by moving the variable capacitor across its range. You should be able to hear the VFO output at some point. When you find it, just touch part of the circuit and you should hear a slight change in the oscillation. This confirms that you are receiving the oscillator and not some other signal.

Once you have confirmed that your oscillator is working correctly, you need to ensure that its range can be adjusted to include the 80m band.

Use your frequency checking equipment (frequency meter or receiver) to find the frequency at each end of the VFO's range. If you are really lucky the VFO will be oscillating between 3.500 and 3.850MHz. If you are less fortunate, set the VFO to its lowest frequency and adjust the 65pF trimmer until you have 3.500MHz, and check the range again.

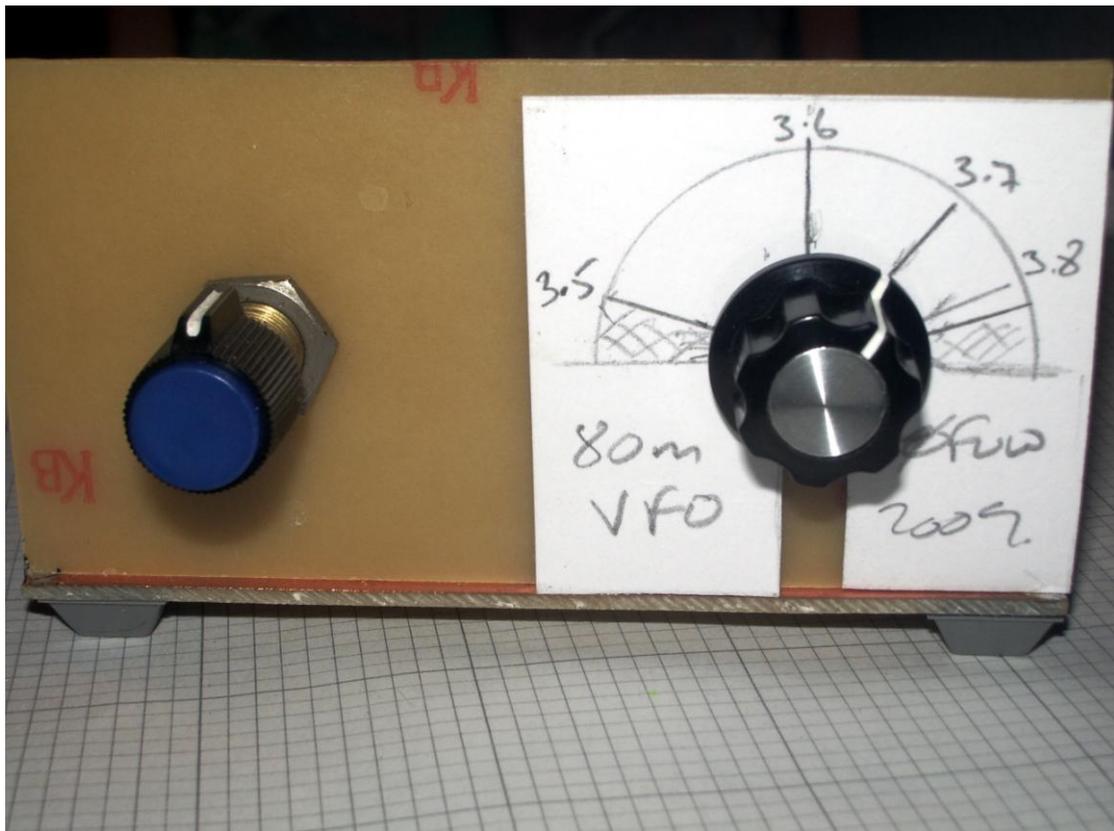
You may also need to stretch, or squeeze together, the turns on the inductor to help shift the VFO's range. If all else fails you can try removing or adding turns – more turns will lower the frequency range but it is easier to take a few off than to rewind and add more! If you need to lower the range it may be better to add another 56pf capacitor across the 65pf trimmer and try again.

This may take several repetitions to get it right – be patient. Once you have the correct range, switch off, and disconnect the power supply leads.

**Advice Note** - If you are using a smaller value variable capacitor it will not give the range required by connecting it as shown in the layout. However, if you connect it to the junction of the inductor and the 65pF trimmer it can be made to do the job. I used a 60pF section of a polycon connected using a 270pF polystyrene capacitor. This worked very well. A 25pF maximum variable would probably not need the series capacitor – experiment with what you have!

**Advice Note** - You may find that you cannot cover the full range of frequencies. This depends on the variable capacitor you are using. For the Intermediate calibration exercise one band edge and a number of calibration points will suffice.

Finally, see what effect the fine-tuning pot has (if fitted). It should shift the VFO a few kHz either side of the set frequency as you move it away from the mid point of its travel. Note that for the calibration exercise it should be set to the mid point and **not** used to calibrate the VFO. As stated above, if the VFO is merely going to be used for Intermediate calibration exercises, the fine-tuning pot is probably best left out.



*Photo 6 - Front view of completed VFO with 'rough & ready' calibration.*