136 / 475kHz Broadband 5 Watt Linear Amplifier

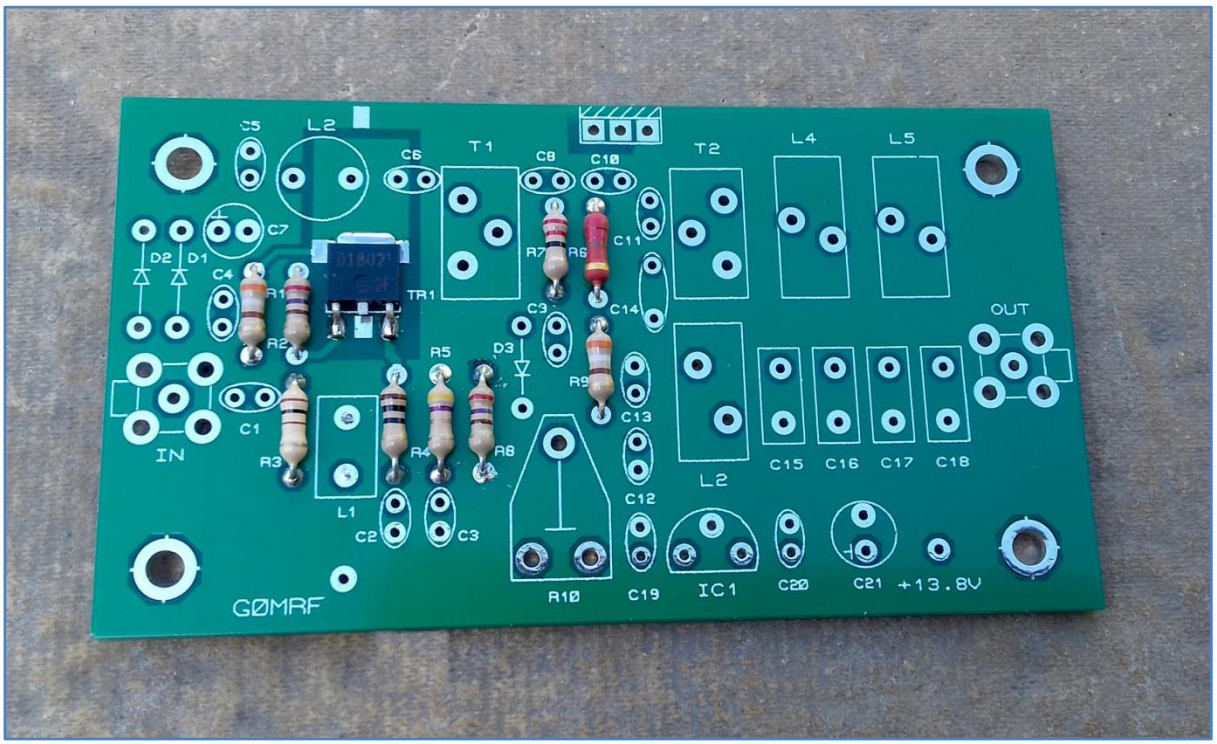
Assembly guide

This kit can be assembled in a couple of evenings by constructors with a medium level of experience. While it is possible to build the circuit in almost any order, this guide provides a proven sequence of assembly. To avoid mis-identifying components, the kit is divided into 3 separate bags. The contents of the bags are listed on the packing list. As some components are visually very similar, you should not simply empty the bags and hope to find the correct parts from a big pile of bits. Instead, keep the contents of the bags separate and refer to the packing list as you progress your way through the assembly process. There is one surface mount part which is soldered directly to the top of the PCB, all other parts are soldered from the underside. Excess component wire should be cut off about 2mm from the PCB

1) **TR1** and **R1 – R9**

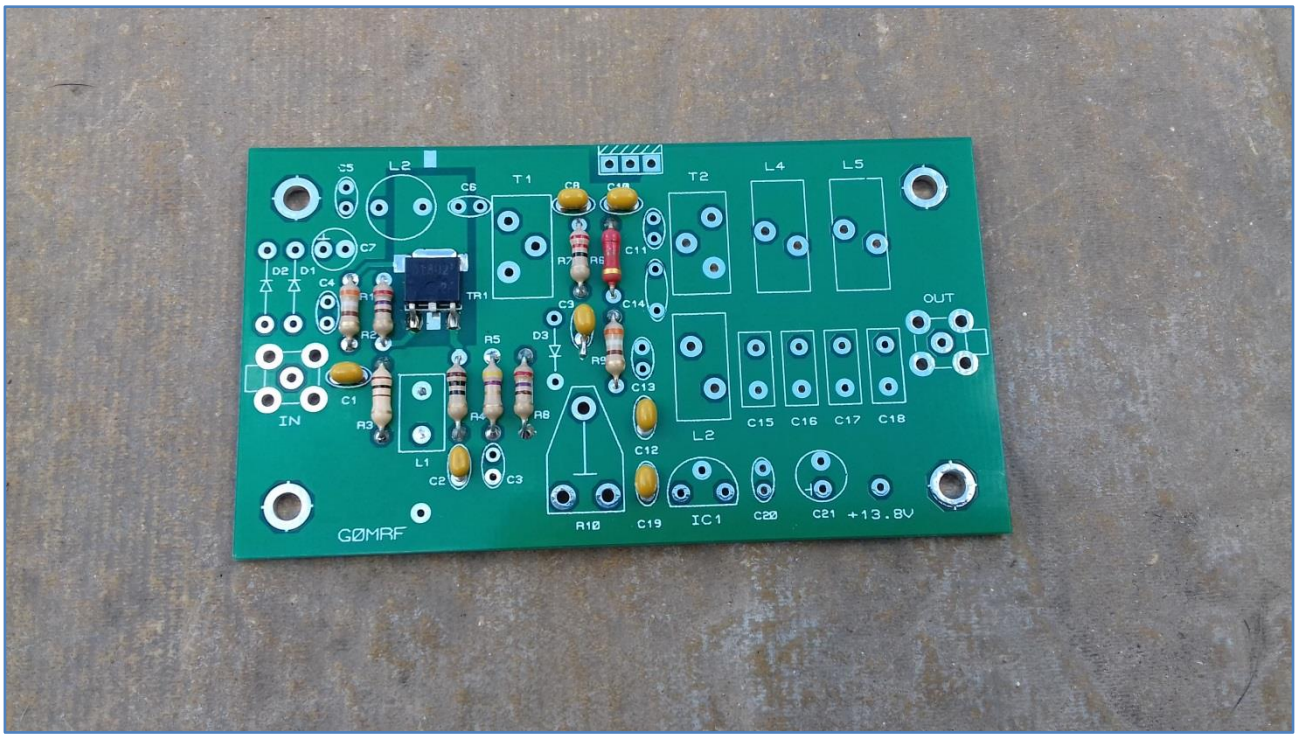
Find transistor TR1 (2SD1802) from bag 3 and place it onto the appropriate pads on top of the PCB. The tab is the collector and this is soldered to the tinned area on a large rectangle etched on the board. This area of copper dissipates heat from the device. Make sure solder flows across the full width of the tab. Finally solder the base and emitter connections as shown.

From bag 2, locate the 9 fixed resistors R1 to R9. Place the resistors into the locations indicated on the silk screen and spread the leads out by a small amount so the resistors will not fall out when the board is turned over. Turn the PCB over and place on a flat surface so the resistors are pressed against the PCB, then solder the resistors to their pads.



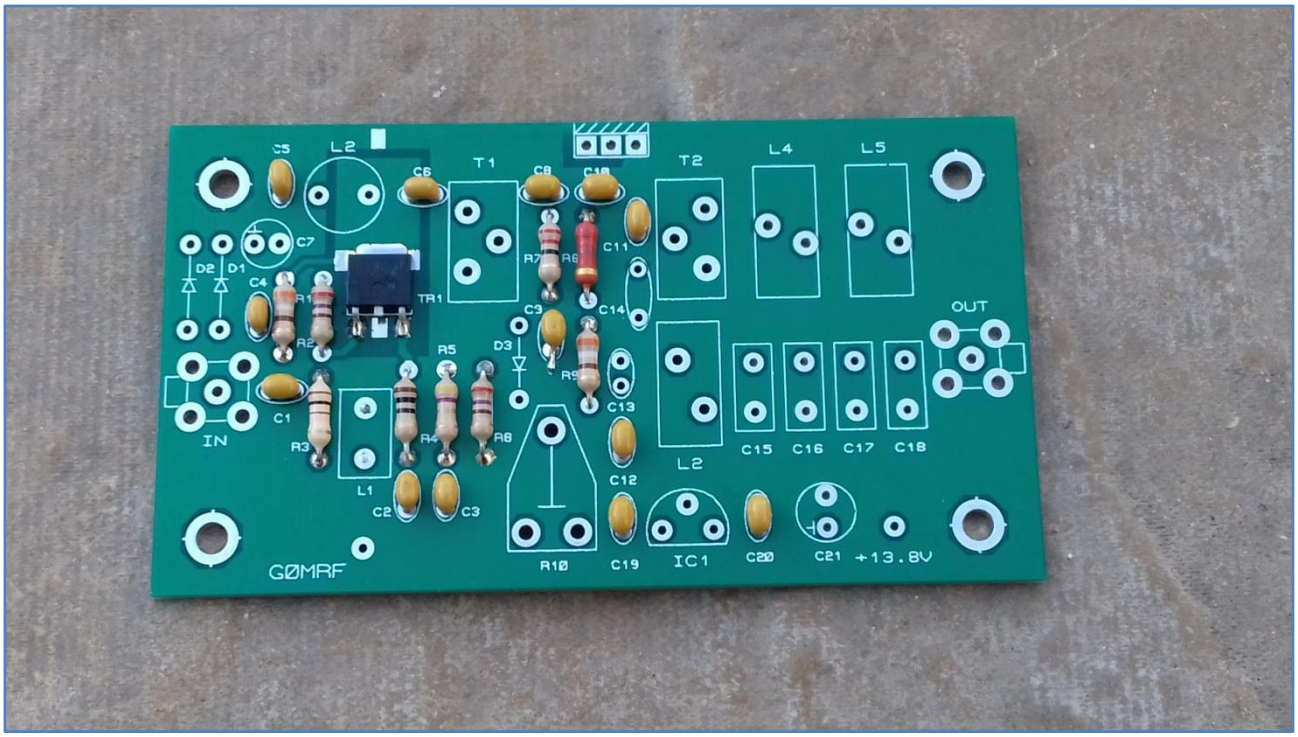
2) Capacitors **C1 C2 C8 C9 C10 C12 C19** (470nF)

Remove the 7 yellow 470nF capacitors from bag 3. Note that these capacitors look almost identical to the 220nF components in bag 2. It is important not to accidentally mix the 2 values. Doing so will change the gain and frequency response of the amplifier. Solder each capacitor in turn leaving C9 until last. Before fitting C9 a small modification is required due to a minor error on the PCB. Unfortunately the lower of the 2 pads for C9, closest to R10, is isolated from the groundplane rather than being connected to it. Before fitting C9 take a small knife or small screwdriver and carefully scrape away a small amount of the green protective layer just under the lower of the 2 pads exposing the copper underneath. Just a couple of millimetres will be plenty. Take the capacitor and bend one of the leads 90 degrees away from the body of the device. Fit the capacitor into the pcb so that the bent lead comes down where R10 is shown on the board. Cut that lead about 3mm from the body of C9 so that it can be soldered neatly to the exposed copper. Solder in place. The board should now look like the picture below. If you look at C9 on my board, you can see how neat this small modification can look. This error will be corrected on the next batch of PCBs.



3) Capacitors **C3 C4 C5 C6 C11 C20** (220nF)

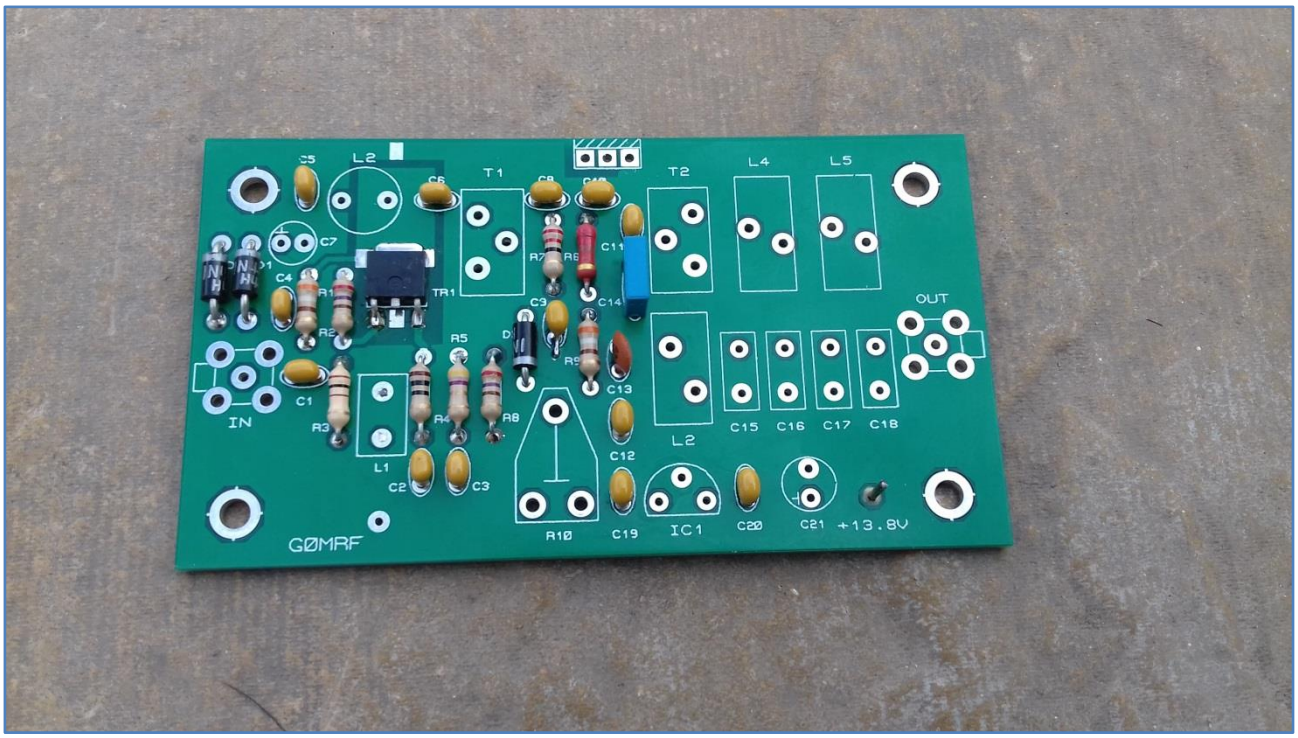
Take the 6 yellow 220n capacitors from bag 2 and fit / solder them into their correct locations. When soldering keeping lead lengths short as shown in the photos, this ensures the performance of each amplifier will be repeatable. Your board should now look like the picture below. Congratulations…you have half the components fitted already !



4) Capacitors **C13 + C14** and diodes **D1 D2 D3**

Take C13, the small 10nF ceramic capacitor from bag 3. Fit into place and solder to the pads. Then also from bag 3, find the 4n7 film capacitor and solder in the space for C14.

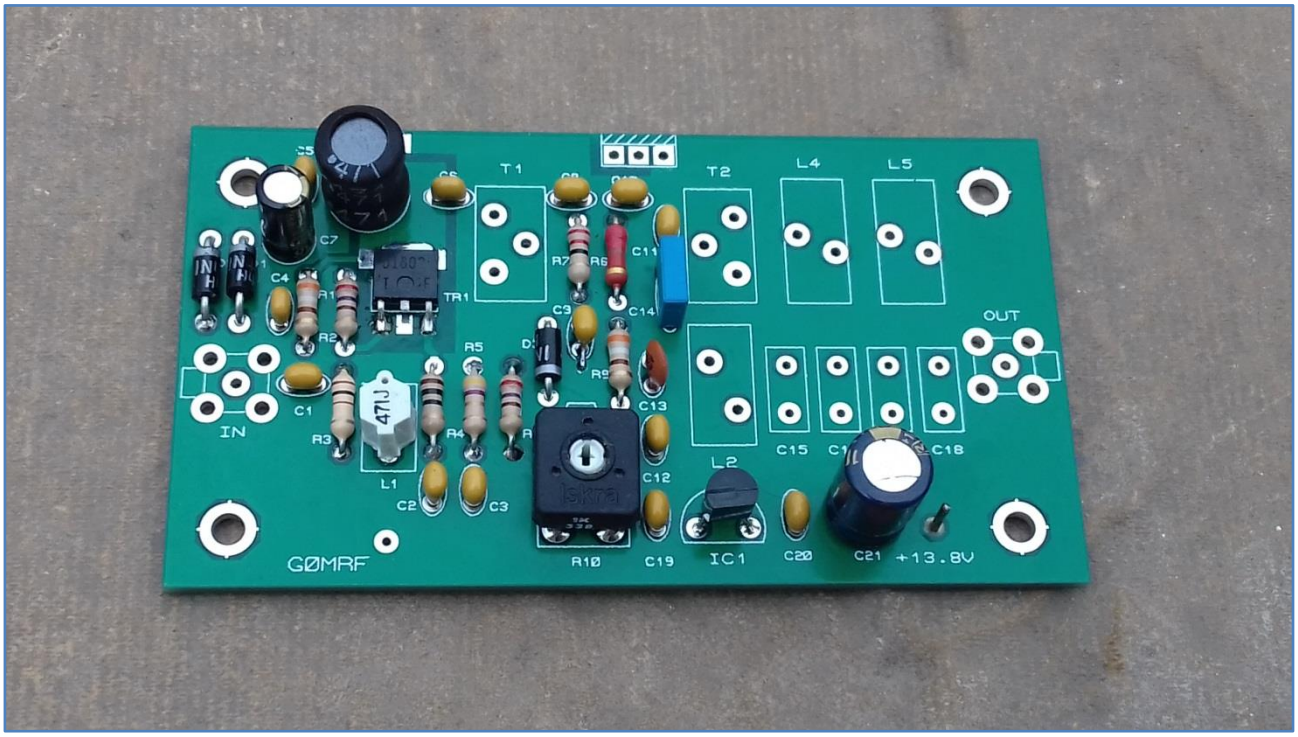
Finally for this step, take one of the 1N4002 diodes and position it over the space for D2 near the edge of the board. Look carefully at where the pads are relative to the body of the diode. As the leads of the diodes are a larger diameter than the leads on the resistors, it is necessary to be precise when you bend the leads down at 90 degrees. The spacing needs to be just right for the diode to fit snugly against the PCB. Fit D1 taking care to make sure the white band on body of the component lines up with the cathode symbol on the silk screen. Repeat the process for D2 and D3.



In the picture above you may spot that I have fitted a 1mm terminal pin for the supply connection. After trying a couple of different techniques I have concluded that a stranded wire is probably the best method of getting power to the board. So, leave this pad until it's time to test the board, then solder on a length of wire.

5) **R10 C21 C7 IC1 L1 and L2**

Place variable resistor R10 into the PCB and ensuring it is flat against the PCB and solder the 3 connections. Next, fit voltage regulator IC1 making sure the flat on the device faces the edge of the board. Then fit and solder the 2 electrolytic capacitors C21 and C7. These must be soldered in the correct way round. The PCB pad for the positive lead is marked with a small + symbol. Double check the markings on the body of the capacitors to correctly identify the positive and negative leads. Usually the longest lead on the capacitor is the positive connection. It's important to get this right as incorrectly fitted electrolytic capacitors can explode when power is applied. Finally fit 470uH inductors L1 and L2 as shown. The small 'dots' mark the phasing of the windings. The orientation probably will not make any difference….But why take a chance. Fit as shown.



In the picture above, the only components remaining to be fitted are L3, the 2 transformers and a low pass filter for the band of choice. Winding and fitting the transformers T1 and T2 needs concentration while winding L4 and L5 needs patience. If you want a break from soldering, this is a good time !

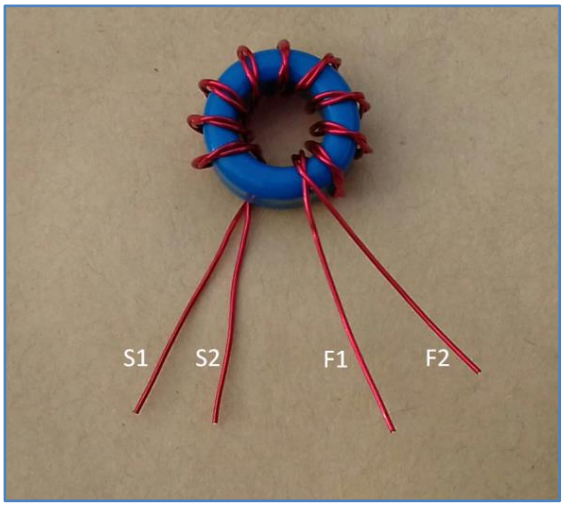
6) **L3 + Transformers T1 T2**

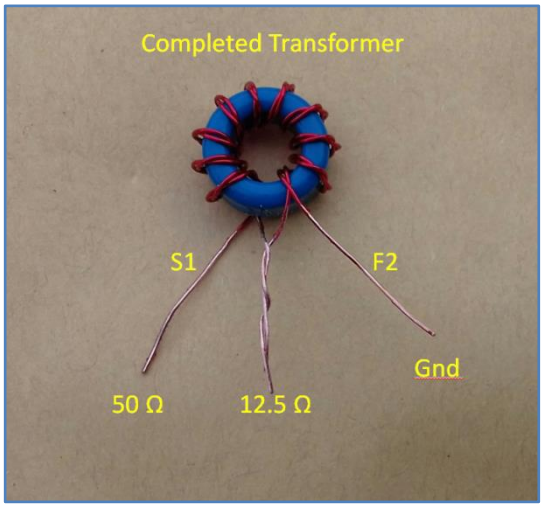
This is the part of construction that requires some concentration. On the card packed with the kit you will find 3 lengths of enamelled copper wire. For the kit with the 475kHz Low pass filter you have:

a) 35cm of 0.5mm for the RF choke L3
b) 60cm of twisted pair for the transformers T1 and T2. Cut this into 2 equal lengths
c) 2.6m of 0.4mm dia for the low pass filter inductors L4 and L5. Cut this into 2 lengths

L3. Note: On the first PCBs there is a silk screen error in which L3 is incorrectly labelled 'L2'. Take one of the 3 Epcos N87 blue ferrite cores and position it on the PCB over the space for L3. Look at the positions of the pads. They are not inline, but are slight off-set so the core can sit neatly on the board without having wire underneath it. Work out how to wind the wire for best fit. Wind 16 turns tightly and evenly onto the core. Push the wires through the holes in the pcb and check it is a good fit. The inductor is then removed and the enamel scrapped away from the wire where it needs to be soldered. Put the inductor back into the PCB and while pulling the wire gently from beneath solder the wires to the pads.

Broadband transformers. Both transformers have identical construction but are connected as 4:1 step down on the input to TR2 or 1:4 step up to match the output of the PA to the low pass filter. Start by taking one of the pieces of twisted pair and wind 10 turns onto a blue ferrite core. Cut any excess wire so that around 25mm or 1 inch remains. Then, as shown in the picture below, untwist and straighten the excess wires on each side of the core. Separate the wires so that you have one pair as the start of the windings and the other pair as the finish of the windings. Strip some of the enamel from the ends of each wire and use a multimeter to identify the start and finish. Place the core on a flat surface and arrange the windings as shown below. (left)

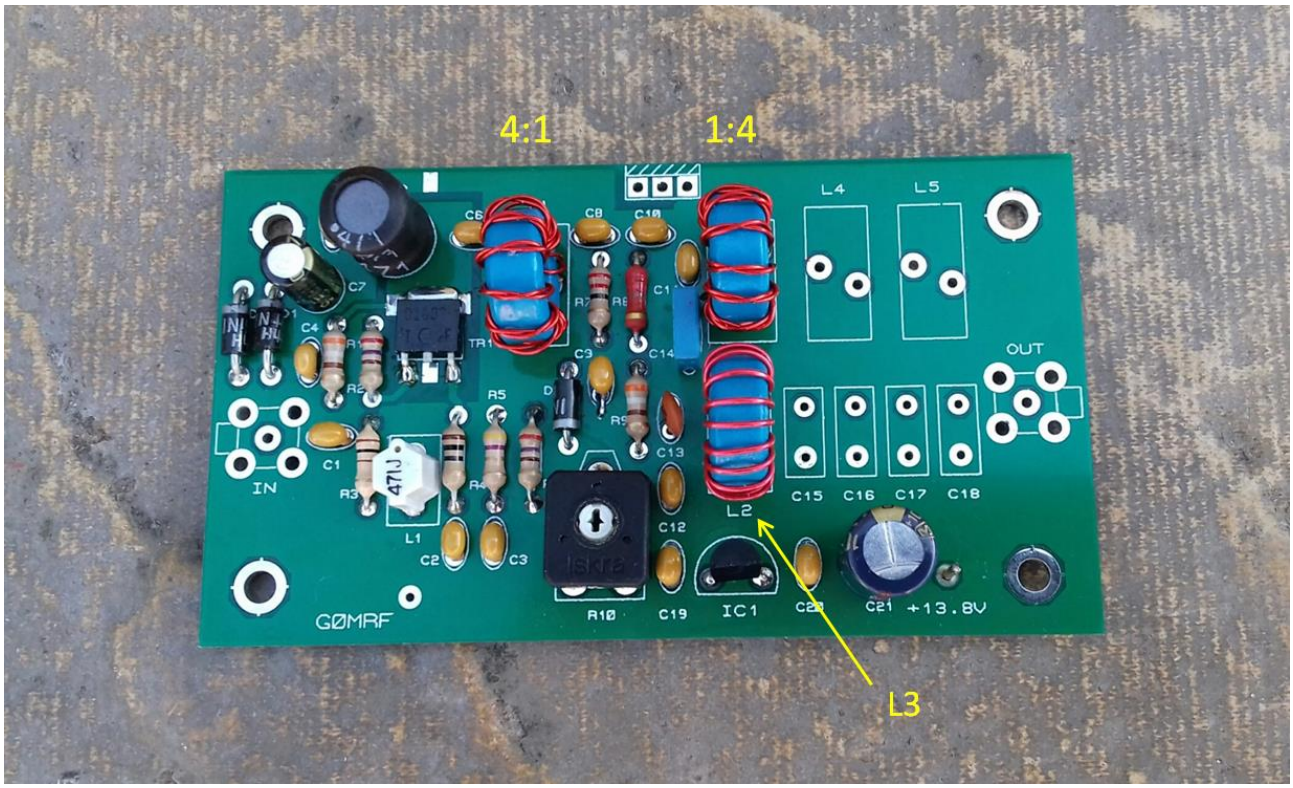




Next, strip the enamel from S2 and F1, taking care not to damage the wire if you use a knife. Then loosely twist S2 and F1 together. This is the low impedance (12.5 ohm) side of our broadband RF transformer. The connections are shown above (right). - Don't mix them up !!!

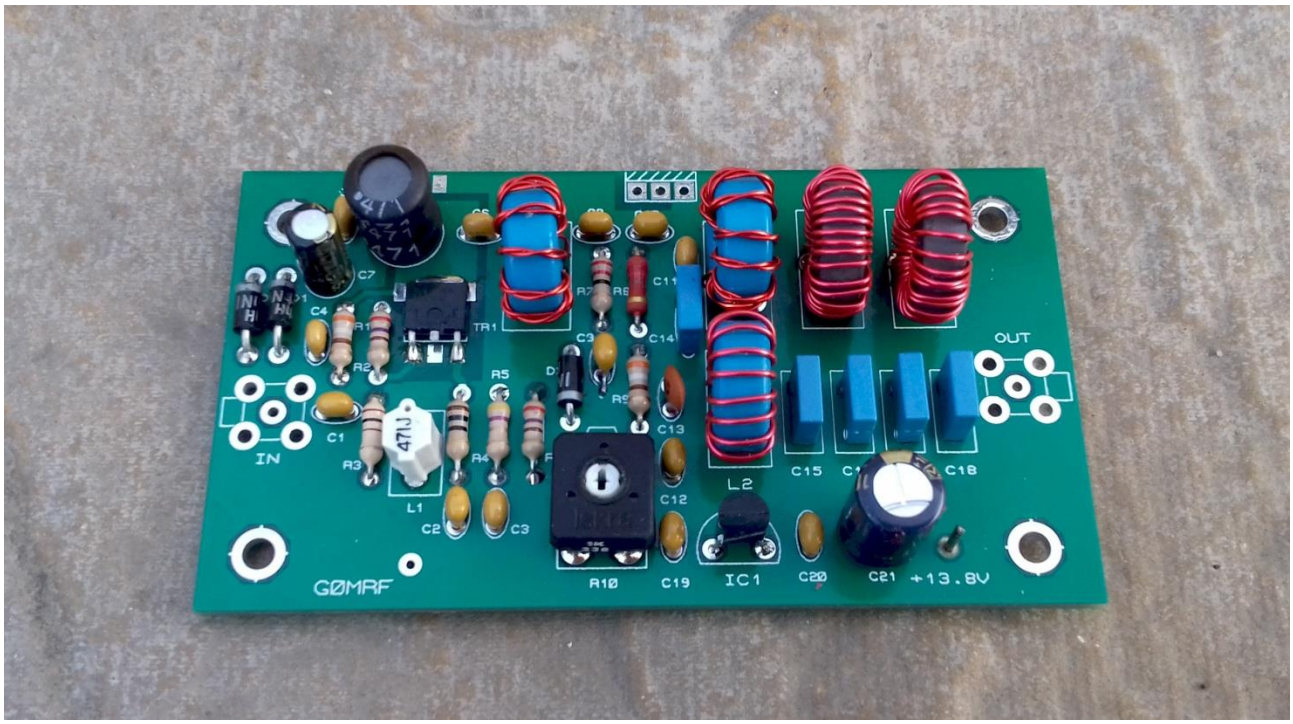
To fit T1 correctly, look closely at the PCB. The ground connection is the pad on the lower left close to the silk screen legend for TR1. The 50 ohm connection is top left near C6 and the 12.5 ohm connection with the two wires twisted together goes to the centre pad on the right which connects to C8. Insert the wires from the transformer into the correct holes and adjust the wires so the core fits neatly on the board. Strip enamel from the wires and solder the transformer in place.

T2 has identical construction to T1 but is connected as a 1:4 step up transformer. When fitting to the PCB, the low impedance side of the transformer (2 wires twisted) is connected to the centre pad near C11. The ground connection is the lower pad near L3 and the 50 ohm side is soldered to the pad that connects by a track to the low pass filter at L4.



7) **Low pass filter.** Now your board is nearly finished, you need to decide which low pass filter you want to install. The initial batch of kits contain components for a 630m LPF. Locate and solder into their correct positions the 8n2 capacitors C15 and C18, followed by C16 (10n) and C17 (3n3). Next, take one of the lengths of 0.4mm wire and wind 56 turns onto a T68-2 iron dust core. When I wind these toroids, I pass the core along the wire so that I only have 0.65m to thread through the core. Try to keep the windings tight onto the core and close together. Avoid any kinks in the wire. 56 turns will fit onto the core in a single layer but only if each turn is touching the one adjacent to it. i.e. – No gaps. Solder to the PCB and repeat the process for the other inductor.

Low pass filter for 136kHz.
As I have already built a few boards for 630m, I thought I would build this demo version for 136kHz, The low pass filter for this band uses 22nF capacitors for C15 to C18 while the 2 inductors are made using 0.5mm diameter wire on FT50-61 cores. The ones I purchased were from e-bay and I expected, if online calculators are to be believed, to get 67uH from around 31 turns. Actually, e-bay did a good job. 31 turns measured as 72uH but unwinding just one turn to leave 30 turns came out spot on 67uH. The second inductor produced the same reading.



Testing the Completed Amplifier
The broadband linear amplifier now needs the bias to TR2 to be set. In most cases amateurs use non linear modes like CW JT9 FT8 or other similar FSK modulation schemes. For this type of operation my suggestion is to set the bias in TR2 to 50mA. The first step is to set the value of R10 mid-way or about 500 ohms. The screwdriver slot in the middle of R10 should look as shown above. Next we need to measure the supply current to the board before we fit TR2. Connect a wire to the supply pin and connect a milliammeter in series between it a 12V – 13.8V supply. A current limited supply is ideal, if you don't have one use a 1A fuse to provide some protection in the event of a fault. The ground lead can be clipped onto the small area of exposed ground near 470uH choke L2, or onto one of the 4 mounting holes.
Switch on the supply and chances are you will see 90mA of current. This current is mainly going to TR1 with a few milliamps being used by D3 and the bias network. Make a note of the current and switch off the supply.

8) **TR2 the PA transistor**. Consider how this is going to be mounted before soldering it to the pads. TR2 can be vertically mounted, or can be bolted to the same surface that that PCB is going to be mounted on. Keep the leads short, but check that the transistor can be bolted securely onto its heatsink or the enclosure without causing mechanical stress to the transistor or the PCB. Sometimes bolting the transistor into position then soldering the leads is the better option.

With TR2 mounted onto a heat conducting surface, connect up the supply line with the multimeter in series. It is probably a good idea to connect the RF output to a 50 Ohm dummy load. Switch on the supply and look at the current. Now you need to adjust R10. If you had previously measured 90mA you need to adjust R10 so that the total current increases by 50mA. So in this case adjust until you see 140mA. The amplifier is now set up and ready for some RF.
Typically the amplifier will need +6dBm or 4mW to give 5 Watts output. If you have a higher level of drive then you can use a fixed attenuator to get the input signal to the correct level. If you are using the amplifier as part of a transverter or larger project then power to the board can be switched on during TX periods only. This gives both transistors chance to cool between transmit periods.

Below is a picture of my amplifier for the 136kHz band. BNC sockets are used for RF connections and the enclosure is used as a heatsink, this is fine for moderate duty cycle modes but probably not for high duty cycle modes like WSPR15, in which case a conventional heatsink needs to be added on the case. -
Have fun. Any questions please email me at g0mrf@aol.com 73 David