The G-QRP Club

The Limerick Sudden Z-Match Kit

Circuit design – George Dobbs G3RJV

PCB design – Rex Harper W1REX

Kit – Graham Firth G3MFJ

Manual – G3RJV and G3MFJ

Founded in 1974, the G-QRP Club is the largest QRP Club in the world. The club exists to promote interest and growth in low power amateur radio communication (5 watts or less). Membership is open to any licensed radio amateur or short wave listener anywhere in the world.

The club publishes a quarterly journal called SPRAT, which is sent free to members. SPRAT contains many circuits, technical hints and ideas for QRP construction projects, together with club news, contest and award information and other items of interest to QRP operators. SPRAT is an exclusive QRP journal and contains much practical information in each issue. The club operates a club sales department where components are available at special prices to club members. We also publish QRP books which are available to members.

If you are not a member, and would like to find out more, please look at www.gqrp.com. For a sample SPRAT and a membership form, please send your name and address to our membership secretary:

Daphne Newsum G7ENA, 33 Swallow Drive, Louth, LN11 0DN

membership@gqrp.co.uk

Please mention where you saw this information

Z-Match Overview

The Z-Match ATU described here is a version of the SPRAT circuit by G3WQW that has been copied many mes and formed the basis of several kits. It uses one coil and two polyvaricon variable capacitors.

Advantages of the Z-Match

- Matches balanced loads without the use of lossy baluns.
- Being a parallel resonant circuit, the Z-match can provide some band-pass filtering for your receiver and harmonic a*enua on for your transmi*er.
- A well-designed Z-match tuner has a high Q and is more efficient (less lossy) than other types of tuners.
- The fixed inductor simplifies construc on (no switches or rollers needed).

Disadvantage

- Tuning is usually very narrow and can be a bit touchy some mes to tune up

Using a toroid inductor and small variable capacitors, this Z-match can be built into a very compact package. With the components used, it is only suitable for QRP power levels.

The signal from the transmi*er passes through a Resis ve SWR Bridge. Because the bridge will reduce the output from the transmi*er a double pole switch (S1a & S1b) is used to short out the bridge when the transmi*er is in use. The best match between transmi*er and antenna occurs when the bridge indicates a null seen as the dimming of the LED.

The signal is coupled into the Z Match via C1; a variable but high value of capacitance. The Z Match is a parallel tuned circuit with link coupling to the antenna. The two variable capacitors with the tapped tuning coil offers a wide tuning range. It should be possible to use the tuner on all HF bands from 80 metres to 10 metres to match balanced or single ended antennas. The whole link winding, isolated from ground (Balanced Hi-Z) will feed a balanced antenna. Switching S3 to ground and will tune a single ended antenna such as a long wire tuned against ground. A tap in the link coupling coil (S3) at 4 turns offers a low impedance output.. Some antenna configura ons require a higher capacitance value of C1 to obtain a good match and S2 offers an extra 470pF.

Building the Z-Match

You will have no ced that this is a rather unusual kit. It has a printed circuit board without any holes. We call it “Limerick Construc on” because it was designed by Rex Harper, W1REX, of Limerick, Maine. It is a surface mounted board in that the components are mounted on the surface of the board, although the components used are “through-hole” parts. This allows for ease of construc on and easy correc on of any errors. The main board also has the front and back panels for the ATU. They are scored and can be snapped off the main board. We suggest you smooth the snapped off edges with emery paper or an emery board.

The component parts are soldered to the top surface of the board using the leads that would go through the board on a conven onal printed circuit board. The interconnec- ons between the moun ng pads are ready made but hidden by the black screen printed overlay. The designa on of all the parts is printed next to the appropriate pads. Any references to top, boom, le and right assume that the board is held with the printed text the correct way, with the G-QRP Club logo in the top centre. Top is actually the Rear of the finished board, and boom is, of course, the Front.

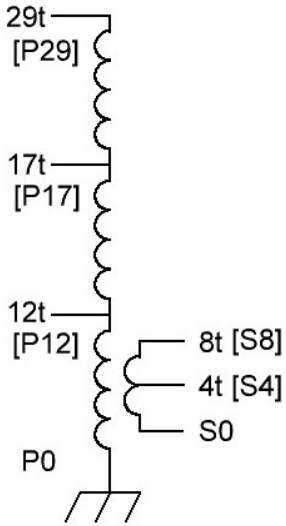
We suggest that you build the kit in the following stages.:

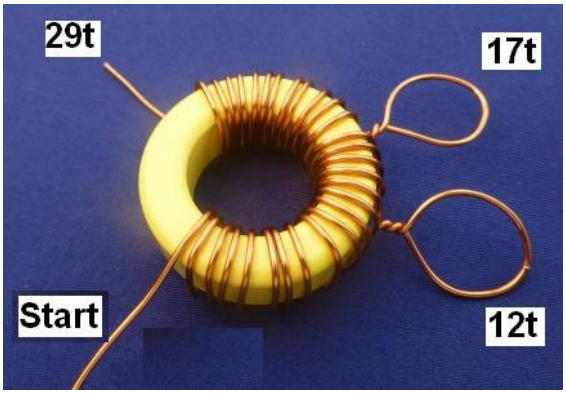
- Wind the toroid & prepare its connec ons
- Solder the toroid on to the main board
- Solder all the rest of the main board parts
- Assemble the parts on the front panel
- Cut and solder wire to the parts on the front panel
- Assemble the parts on the rear panel
- Cut and solder wires to the parts on the rear panel
- Fasten the front panel to the main board and connect the front panel wires
- Solder in place the side cheeks
- Fasten the rear panel to the main board and connect the rear panel wires
- Test the ATU
- Finally - construct the case

We will now describe in detail each of these stages.

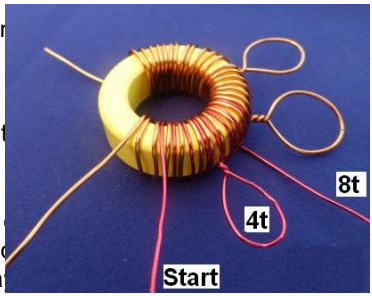
The Coil

Winding toroidal coils is not difficult. It just requires pa ence and care. Using the pictures below should make this easy. The designa ons in brackets are a guide when wiring up the coil, and they are also the labels of the coil connec ons on the board.

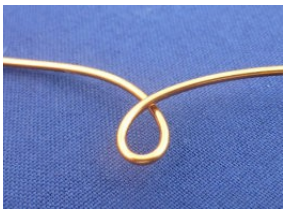




The Primary winding (shown above) has 29 turns of 20swg wire (the thickest wire), tapped at 12 turns and 17 turns. This requires about 50 inches of wire. Each pass of the wire through the hole of the core counts as ONE turn. Leave about an inch of spare wire at the beginning of the coil. Keep the turns close to the core with a ght winding. AKer 12 turns pull out a loop a wire (about an inch long) and lightly twist it to hold the posi on. Con nue to the 17th turn and make another loop. Complete the 29 turns leaving about an inch of wire at the er



The secondary winding has 8 turns of 22swg wire (about 15" of the thinner wire) with a centre tap. This winding should roughly occupy the centre of t first 12 turns on the primary winding so begin the winding 2 turns in from the beginning of the main winding. Interleave these windings with the turns the main winding. (wound in the gaps). Wind the and make the tapping connec ons in the same wa as the main winding.



Be careful if the wire kinks—if it does carefully untwist the kink—to try to pull it out will probably either break the wire, or, at best, weaken it considerably.

Preparing the toroid windings.

The wire supplied is insulated with what is known as “solderable enamel”. You can prepare the connec ons in one of three ways.

The first method is to cut the wire at the end of the loop, then carefully scrape the enamelled coa ng off the two short wires un l bright copper is exposed. Then ghtly twist the two wires together and finally n the wires with a generous coa ng of solder. The ends of the windings are just scraped and then nned.

The second method uses the solderable enamel feature of the wire. This takes quite a bit of heat although most irons are man enough for this. You need to cut the loops as above, then apply the iron and solder to the very end of the wire. This is necessary so that the end of the copper wire ns and then the heat will be applied to the enamel from the inside and outside simultaneously. You will, aKer a short while, see that the enamel will melt and the wire will n. You should then move the iron along the wire slowly - the iron above the wire - with the wire in the blob of solder - to n as much of the wire as you wish. You will probably have to add a li*le more solder as you go. Be careful - don’t do this on the dining table as drops of solder will probably fall off.

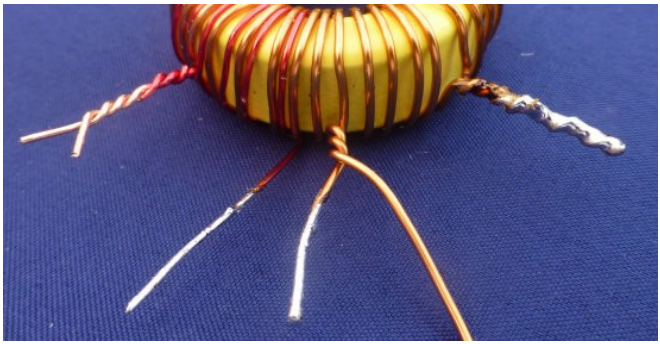
YOU SHOULD TRY TO NOT BREATHE IN THE FUMES DURING THIS PROCESS - PERHAPING IT IN A DRAUGHT. (But you would always try to avoid fumes whilst you are soldering normally - wouldn’t you?).

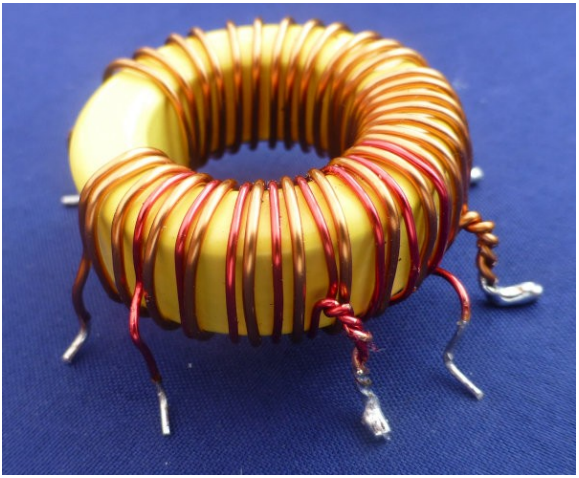
Finally twist the two wires of a tap together and solder them together.

The third method is to twist the insulated wires together, then cut the end, then n a above - star ng at the very end of the wire. This does need a li*le more heat than method two.

Be aware that copper wire - especially thick copper wire, conducts heat very well, and it will not be long before the toroid windings will get very hot. Do not burn your fingers blistered fingers may hold you up when you wish to complete the ATU!

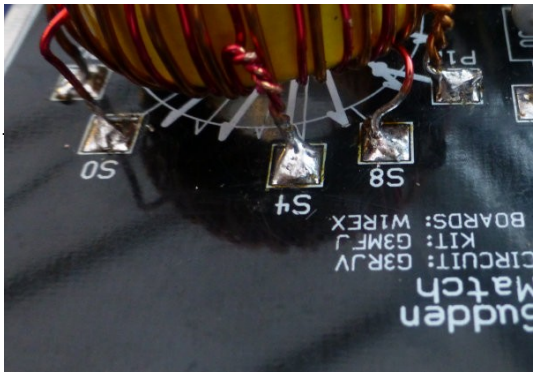
This picture shows the results (from leK to right, of the above three methods.



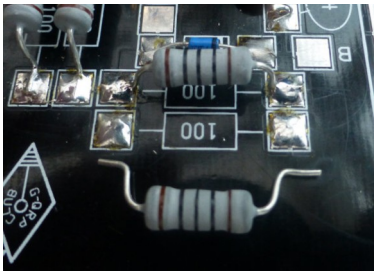


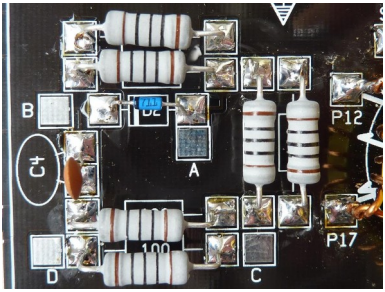
Finally, when you have all the leads fully twisted and nned, the twisted wires of the tappings are bent downwards for soldering to the board and holding the coil a li*le above the board. The 29 turn winding is the Primary and the 8 turn winding is the Secondary. The easiest way to solder the connec ons to the coil to the board is to bend a small “foot” at the end of a wire or tapping that rests on the appropriate pad and is soldered to that pad. The board has designa ons for the placement of the coil.

The Primary wiring is marked as P0 (start of winding), P12 (12 turns), P17 (17 turns) and P29 (29 turns). The Secondary winding has S0 (start of winding), S4 (4 turns) and S8 (8 turns). The placement of the coil above holds it in place and raises the coil a li*le above the board.



Finally for this stage of the construc on, solder in the rest of the parts on the main board. It would be be*er not to overheat the diode and make sure that you get it the right way round - both the diode and the board legend have polarity bars at the end. The resistors should be mounted, like the coil, by making a foot on the end of the wire thus having the resistors some 10mm above the board. This also applies to the ceramic capacitor.



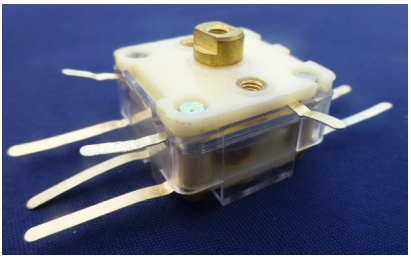


Now put this aside for a while whilst we deal with the front and back panels.

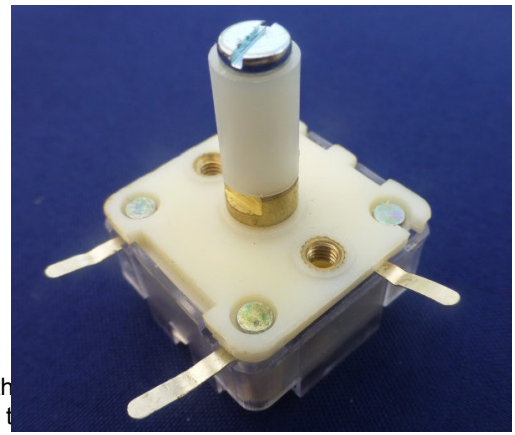
The front panel

Firstly, prepare the two polyvaricons by removing the connec ons to the trimmers—we do not need these. Also, the shaK extension can be fi*ed.

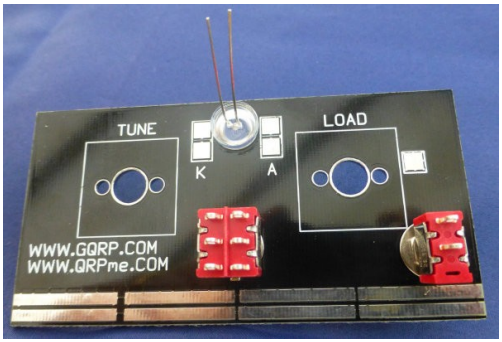
Before



Aer



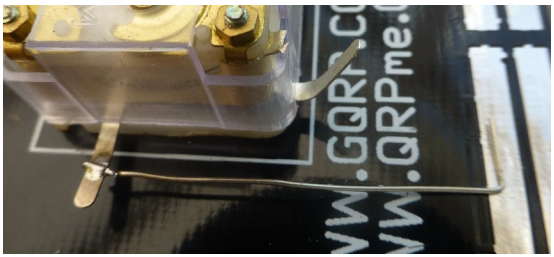
Mount the switches S1 & S2 on th front panel. Push fit the LED into t



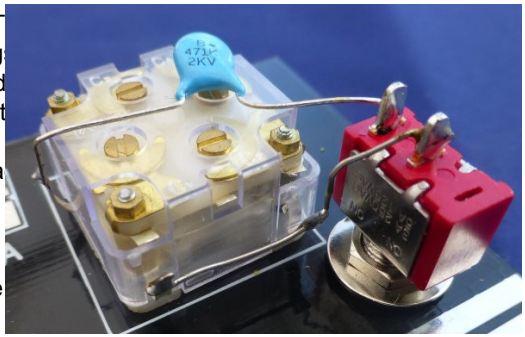
panel, the shorter lead is the kathode and is on the TUNE control side. Note the way up of the switch S2.

Then mount the two modified polyvar-icons. The fixing screws are supplied with the kit. The tags should point downward.

Use a short length of bared nned copper (BTC) wire to connect the side connec on of the TUNE capacitor down to the seam between where the base board will be soldered. It is best to leave the soldering of this end un l the panel is soldered to the main board.



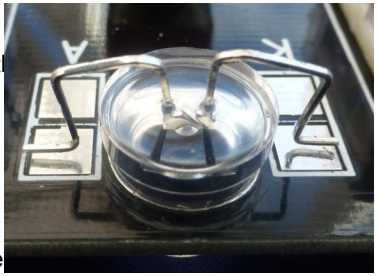
Next, using a short length of BT wire, connect the two bo*om tag of the LOAD capacitor together and to the lower tag of S2, then connect the 470pF capacitor between the upper tag of S2 and the side ta the LOAD capacitor. For all these connec ons to the capacitor, make a small hook at the end of the wire, and squeeze it up to gently grip the capacitor tag.



Then, another very short length between the top two tags of S1

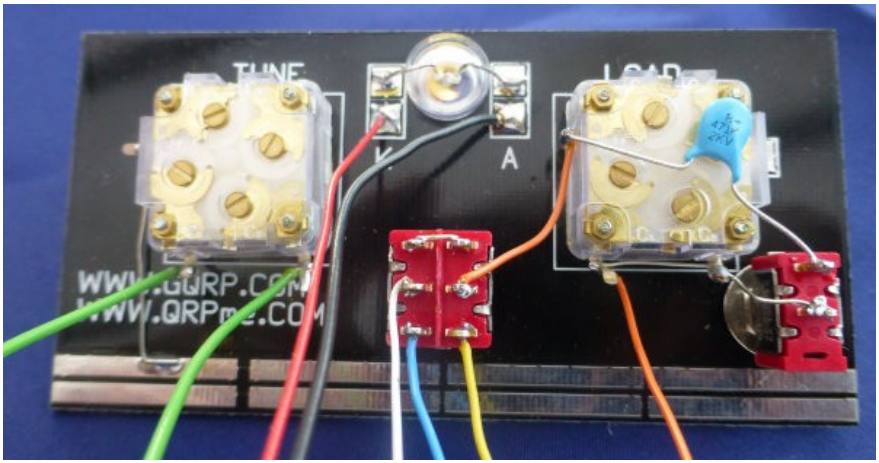
Finally for this stage, bend t LED wires thus:

Then solder the LED leads to the pads.



Cut 3cm of orange wire and connect the side tact of the LOAD capacitor to the middle contact (on the LOAD side) of the switch S1.

Cut 10cm lengths of these wires: black, red, orange, yellow, green (2 pieces of green), blue and white and connect as this picture:

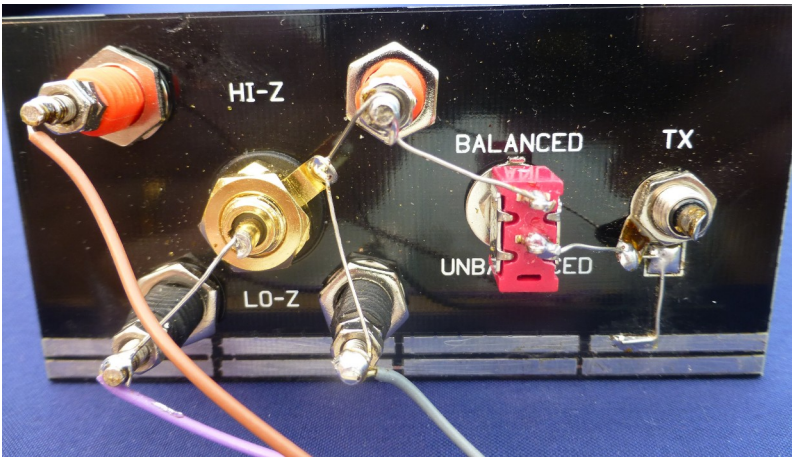


The rear panel

The next job is to assemble the parts onto the rear panel and here is a picture:

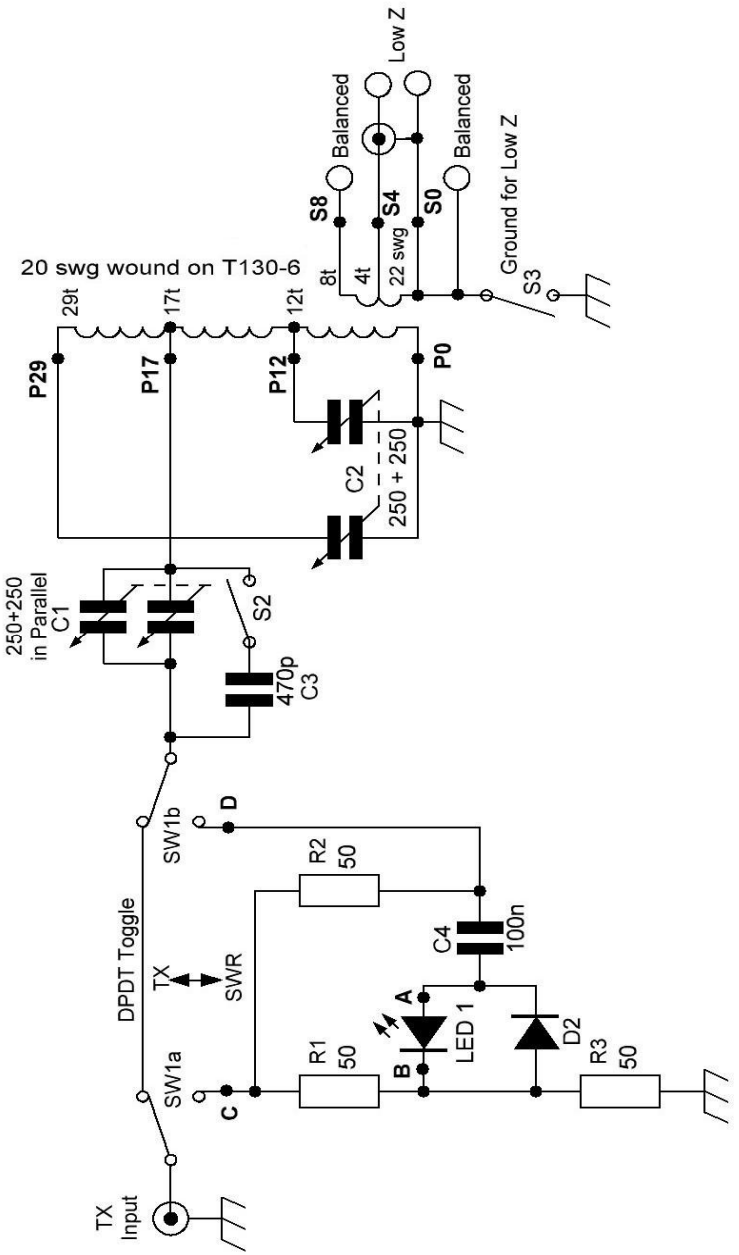
There is nothing awkward about moun ng most of these components - please make sure that the lipped insula ng washer that is part of the gold phono connector is fi*ed into the hole properly from the socket side of the panel. This insulates the outer of the socket from the earthed PCB. You will need to bend the tag on the TX socket outer so it is easier to solder to.

The next stage is to wire the rear panel. Using one piece of BTC wire, join the lower switch connec on, the TX socket outer solder tag, the pad on the panel, then take it to the seam at the bo*om - just as we did for the TUNE capacitor on the front panel. A second piece of BTC wire connects the upper switch tag to the top right hand terminal, the outer connec on of the gold phono socket, and the right hand lower terminal. A third piece of BTC wire connects the inner of the gold phone socket to the bo*om leK black LO-Z tag. These can all be seen on the picture below

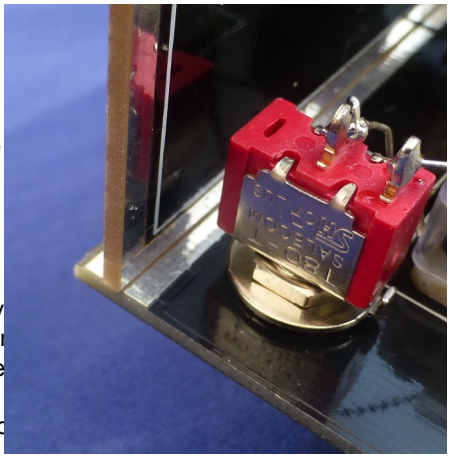


Finally for this panel, take 10cm lengths of each of brown, purple & grey wire and solder one end of each to the tags as pictured above.

Circuit diagram



Fastening the front panel to the main board

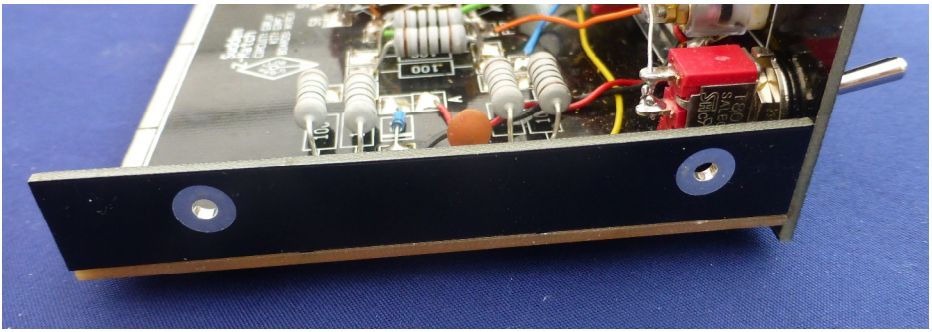


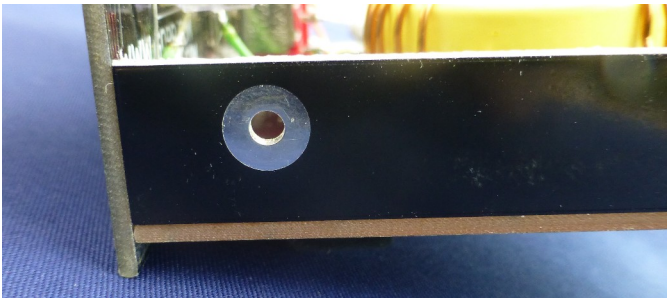
The important thing to remember when soldering the panel to the main board is that it must be at right angles to the base and the base should be between the two solder tracks of the panel thus:

Before you finally solder this, tack it at both ends first so you are sure they are posi oned correctly. When you are happy it is correct, then you can finish it. Rather than run a bead of solder along, it is be*er to put blobs of solder at 4 or 5 places along the top of the board - don't forget to do the same underneath.

Add the side cheeks

This is a good me to solder the "side cheeks" into place either side of the main board. These are designed as fixing plates for the enclosure. As for the front panel, fix the side-pieces with blobs of solder rather than trying to solder the full length. The sides are not iden cal so make sure you have the correct ones at the correct sides – see the pictures below to check.





Now a*ach the 4 feet to the bo*om—place them at each corner — about 1cm from each edge.

Wiring the front panel

Now connect the ends of the front panel wires. We suggest that you do this is the following order, looking at the rear of the front panel:

- LH green wire to pad P29
- Blue wire to pad C
- Yellow wire to pad D
- Orange wire to pad P17
- RH green wire to pad P12
- Lightly twist the red & black wires, thread them behind the two orange wires, under the yellow wire, and under the front 2 x 100 Ohm resistors before connec ng them — red to pad A and black to pad B.

Leave the white wire for the moment - we will connect that to the rear panel on the next step.

Here is a picture of that:

Wiring the rear panel

Now connect the ends of the rear panel wires. We suggest that you do this as follows:

- Purple wire to pad S4
- Grey wire to pad S0
- Brown wire to pad S8
- Finally, connect the white wire from the switch on the front panel to the inner of the TX socket on the rear panel.

That completes the wiring. There is a picture of the completed ATU on the back page of this publica on - you can check this wiring there.

Tes.ng the ATU

Next we need to test the ATU. Connect the rig to the ATU and connect your antenna to the rear panel. If you are using a coax fed, or single wire antenna, use the gold socket between the tags and put the rear switch to the unbalanced posi on. If you are using a balanced feed, then try either pair of terminals with the rear switch in the balanced posi on. There are no fixed rules about this - find the posi on that gives the best results.

Now tune the ATU to match the antenna to the rig. The best way is to use both hands on both knobs and tune, using the receiver, to peak an incoming signal. The switch on the front panel should be in the TRANSMIT posi on, but you may find the peak easier to detect with th switch moved to the SWR posi on. This is much easier to do than to describe. You should find a good peak easily. Then move the LOAD capacitor a li*le to see if you can get a be*er peak. On 40m, there may be 2 peaks - select the best. You may have to switch in the addi onal capacitance using the other front panel switch, par cularly on the lower frequency bands.

When you are happy that you have found the best recep on, switch the front switch to SWR and key the transmi*er. You should find that the sePngs you arrived at using the receiver are very close to the op mum for transmit. Assuming the LED is lit, carefully gently move the controls to try to make the LED dimmer. These are very sensi ve and you may only have to move them a ny amount. As this is s ll a two-handed job, so you may have to rest a book on your key.

Finally, when the LED is at its dimmest, you are tuned, so take the book off the key, move the switch to transmit, and away you go. It is probably a good idea to make a note of the sePngs for each band - this will make it easier next me to get near to the correct sePng.

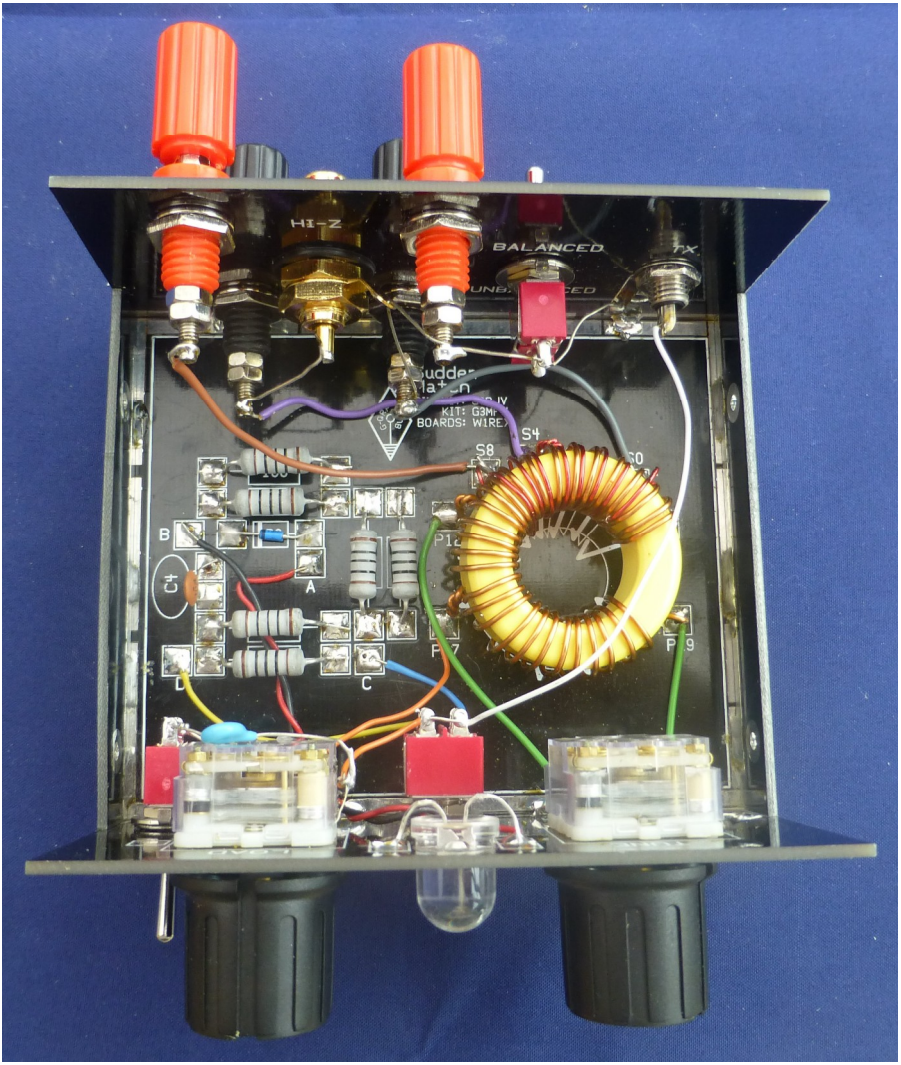
Finally – the case

The case parts should now be soldered together – the important point here is that the sides must be at right-angles to the top. Again, use the single blob technique un l you are sa sfied with the angles – it is be*er if you do not solder right up to the front of the lid as the case overlaps the front to give a hooded effect, and if you solder right up to the front, the case may not fit as well. The ATU will work be*er with the case in posi on.

Limerick Sudden ATU Parts list

	Value	Markings
Resistors		
R1a	100	Brown, black, black, black, brown
R1b	100	Brown, black, black, black, brown
R2a	100	Brown, black, black, black, brown
R2b	100	Brown, black, black, black, brown
R3a	100	Brown, black, black, black, brown
R3b	100	Brown, black, black, black, brown
Note:	R1, R2 & R3 are each made up from	2 off 100 Ohm resistors in parallel
Capacitors		
C1	295 + 295pF polyvaricon	
C2	295 + 295pF polyvaricon	
C3	470pF	471 blue
C4	100nF	104
Inductor		
L1	T130-6 toroid	Primary = 29 turns 20SWG tapped at 12 and 17 turns Secondary = 8 turns 22SWG tapped at 4 turns
Semiconductors		
D1	1N5711 Shottky diode	
LED2	Kingbright 10mm red LED	Ultrabright
Other parts		
SW1	Miniature DPDT toggle switch	C/O switch TX/SWR
SW2	Miniature on/off toggle switch	Add more capacitance to load variable
SW3	Miniature on/off toggle switch	Balance/unbalanced output
J1	Phono/RCA socket	TX input
J2	Insulated Phono/RCA socket	Output Low-Z unbalanced antenna
24mm knobs	2 off	TUNE and LOAD controls
Magnet wire	20SWG	Gold colour
Magnet wire	22SWG	Red colour
PVC wire	20cm of each of 10 colours	
BTC wire	20cm 0.05mm	
Feet	4 off for base	
4mm socket/terminal	red	For balanced H-Z antenna
4mm socket/terminal	Black	For balanced Lo-Z antenna
Manual	Full construction manual	
Main PCB	Front/back/base PCB	
Side panels	Side panels	
Case PCB	Sides/top PCB	

The finished ATU



V1.0 August 2012