



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:

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Z-Match Overview

The Z-Match ATU described here is a version of the SPRAT circuit by G3WQW that has been copied many times 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 attenuation for your transmitter.
- 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 construction (no switches or rollers needed).

Disadvantage

- Tuning is usually very narrow and can be a bit touchy sometimes 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 transmitter passes through a Resistive SWR Bridge. Because the bridge will reduce the output from the transmitter a double pole switch (S1a & S1b) is used to short out the bridge when the transmitter is in use. The best match between transmitter 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 configurations 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 noticed that this is a rather unusual kit. It has a printed circuit board without any holes. We call it “Limerick Construction” 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 construction and easy correction 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 conventional printed circuit board. The interconnections between the mounting pads are ready made but hidden by the black screen printed overlay. The designation of all the parts is printed next to the appropriate pads. Any references to **top**, **bottom**, **left** 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 **bottom** is, of course, the **Front**.

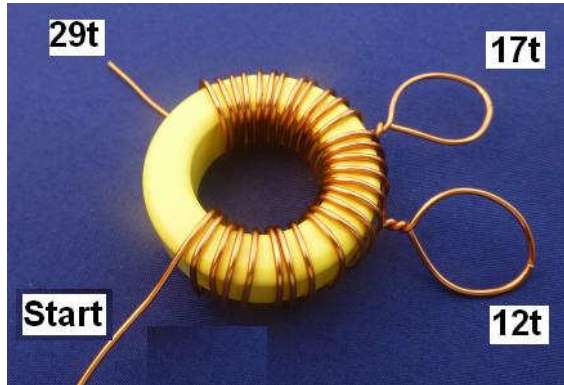
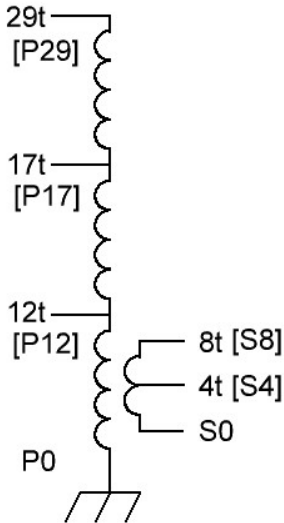
We suggest that you build the kit in the following stages.:

- Wind the toroid & prepare its connections
- 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 the wire to the parts on the front panel
- Assemble the parts on the rear panel
- Cut and solder the 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

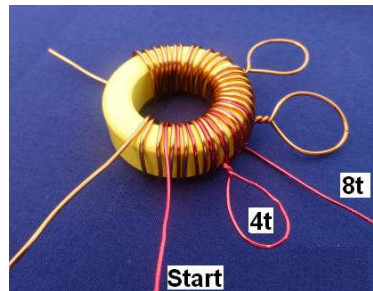
Winding toroidal coils is not difficult. It just requires patience and care. Using the pictures below should make this easy. The designations in brackets are a guide when wiring up the coil, and they are also the labels of the coil connections on the board.



The Primary winding (shown above) has 29 turns of 20swg wire (the thicker 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 tight winding. After 12 turns pull out a loop a wire (about an inch long) and lightly twist it to hold the position. Continue to the 17th turn and make another loop. Complete the 29 turns leaving about an inch of wire at the end.

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 the 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 on the main winding. (wound in the gaps). Wind the coil and make the tapping connections in the same way 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 connections in one of three ways.

The first method is to cut the wire at the end of the loop, then carefully scrape the enamelled coating off the two short wires until bright copper is exposed. Then tightly twist the two wires together and finally tin the wires with a generous coating of solder. The ends of the windings are just scraped and then tinned.

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 tins and then the heat will be applied to the enamel from the inside and outside simultaneously. You will, after a short while, see that the enamel will melt and the wire will tin. You should then move the iron along the wire slowly - the iron above the wire - with the wire in the blob of solder - to tin as much of the wire as you wish. You will probably have to add a little more solder as you go. Be careful - don't do this on the dining table as drops of solder will probably fall off.

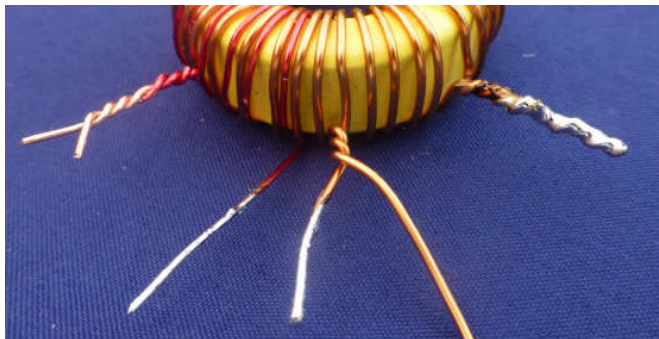
YOU SHOULD TRY TO NOT BREATHE IN THE FUMES DURING THIS PROCESS - PERHAPS DOING IT IN A DRAUGHT. (But you would always try to avoid fumes whilst you are soldering normally - wouldn't you?).

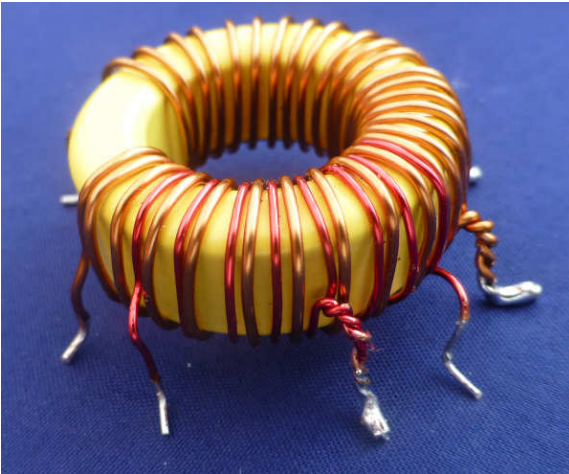
Finally twist the two wires of a tap together and solder them together.

The third method is to twist the insulated wires together, then cut the end, then tin as above - starting at the very end of the twisted wires. This does need a little more heat than method two. **Again - do not breath in the fumes.**

Be aware that whatever method you use to tin the wire, 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 left to right, of the above three methods.



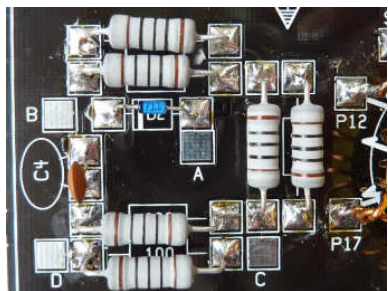


Finally, when you have all the leads fully twisted and tinned, the twisted wires of the windings are bent downwards for soldering to the board and holding the coil a little above the board. The 29 turn winding is the Primary and the 8 turn winding is the Secondary. The easiest way to solder the connections 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 designations for the placement of the coil.

The Primary wiring is marked as **P0** (start of the winding), **P12** (tap at 12 turns), **P17** (tap at 17 turns) and **P29** (29 turns - the end of the winding). The Secondary winding has **S0** (start of winding), **S4** (tap at 4 turns) and **S8** (the end of the winding). Place the coil above the appropriate pads, and then solder them as seen here. This holds it in place and raises the coil a little above the board.



Finally for this stage of the construction, solder in the rest of the parts on the main board. It would be better 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.

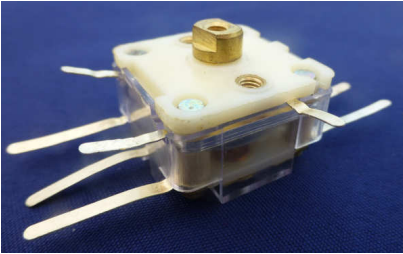


Now put this aside for a while whilst we deal with the front and back panels.

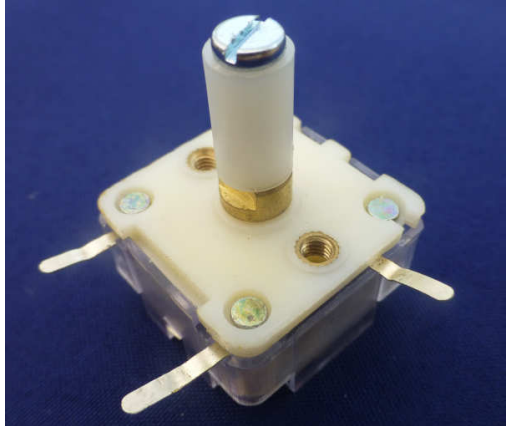
The front panel

Firstly, prepare the two polyvaricon capacitors by removing the connections to the trimmers - we do not need these. Also, the shaft extension can be fitted.

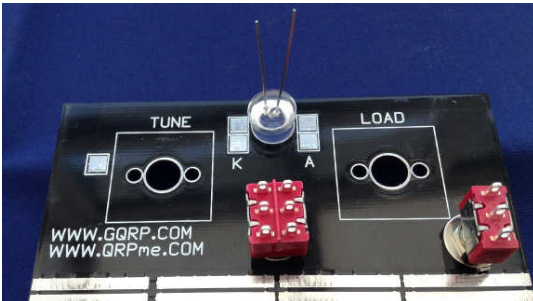
Before



After



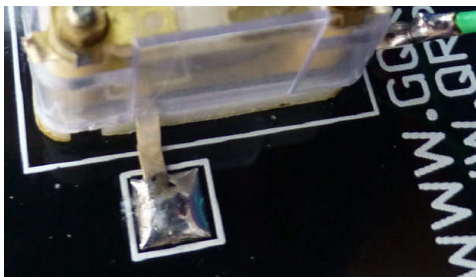
Mount the switches S1 & S2 on the front panel. Push fit the LED into the panel, the shorter lead is the c(k)athode and is on the TUNE control side.



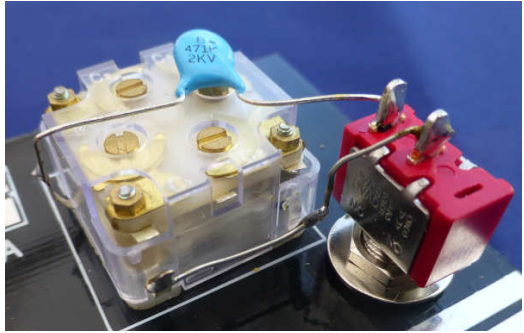
The switch S2 (RHS) may have 2 or 3 tags. We only use the top 2 tags, so if your kit has a 2 tag switch, mount it so that the 2 tags are towards the top of the panel. If you have a 3 tag switch, just ignore the bottom one.

Now mount the two modified polyvaricon capacitors. The fixing screws are supplied with the kit. The tags should point downward.

The side connection of the TUNE capacitor is soldered to the pad underneath it - see below.



Next, using a short length of BTC wire, connect the two bottom tags 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 tag of the LOAD capacitor. For all these connections 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.

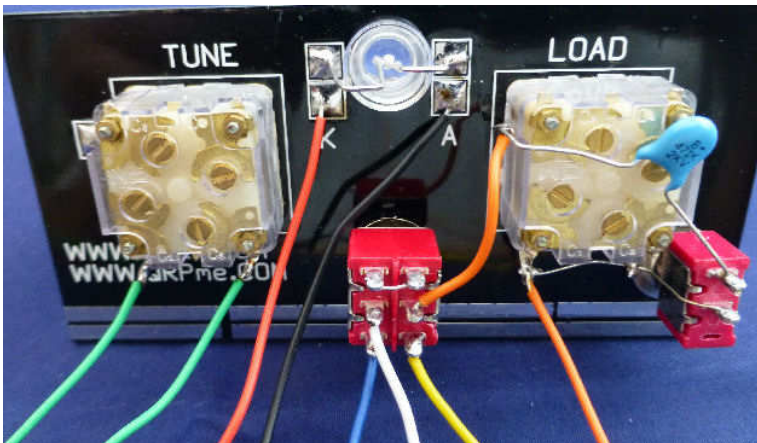
Finally for this stage, bend the LED wires thus:

Then solder the LED leads to the pads.



Cut 3cm of orange wire and connect the side contact 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 mounting most of these components - please make sure that the lipped insulating washers that are part of the gold phono connector are fitted into the hole properly from both sides of

the panel. These insulate 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. We supply a solder tag for each terminal, so fit these before wiring the back panel. The comments regarding 2 or 3 tags on switch S2 (page 8) also apply to S3 here - we do not use the bottom tag on a 3 tag switch

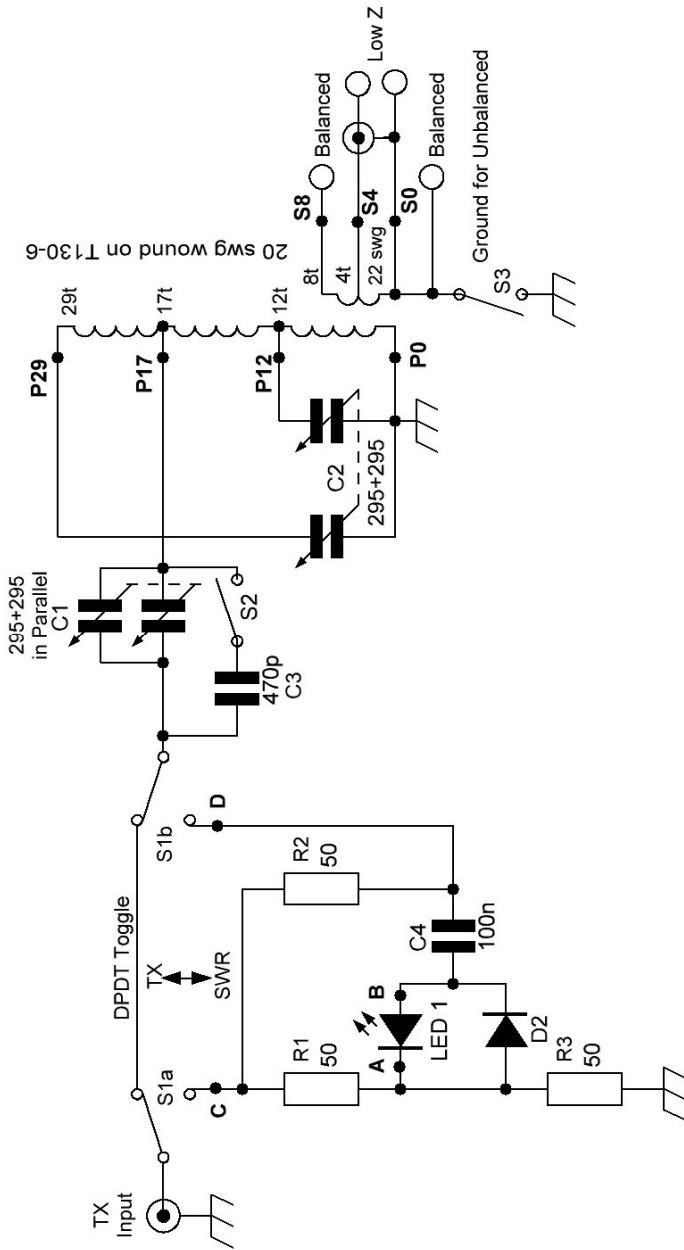


The next stage is to wire the rear panel. Using one piece of BTC wire, join the lower switch connection, the TX socket outer solder tag, and the pad on the panel under the TX socket. A second piece of BTC wire connects the upper switch tag to the top right hand terminal, the outer connection of the gold phono socket, and the right hand lower terminal. Finally, a third piece of BTC wire connects the inner of the gold phone socket to the bottom left black LO-Z tag. These can all be seen on the picture below



Now we add the wires to the panel components that connect them to the baseboard. Take 10cm lengths of each of brown, purple & grey wire and solder one end of each to the tags as pictured above.

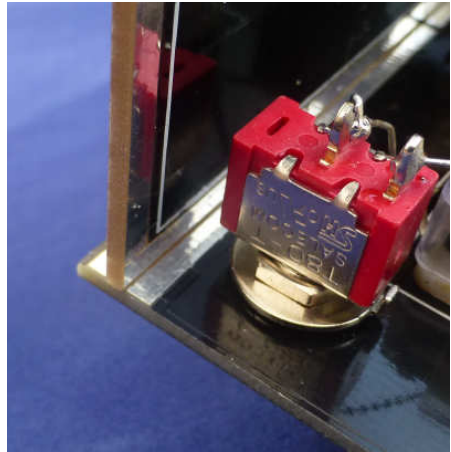
Circuit diagram



Fastening the front panel to the main board

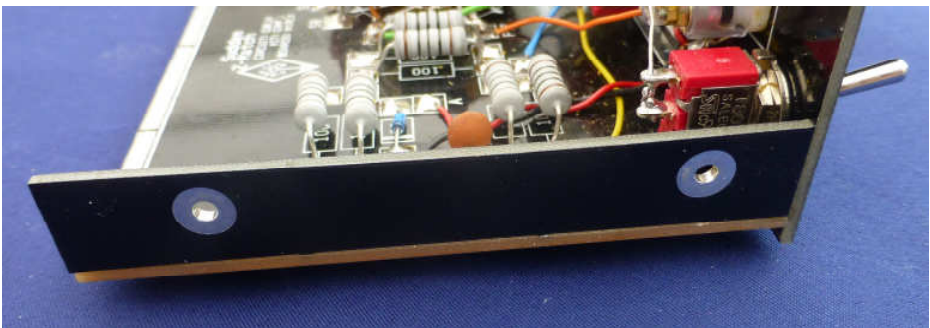
The important thing to remember when soldering the panel to the main board is that it must be at right angles to the base and the base should be between the two solder tracks of the panel thus:

Before you finally solder this, tack it at both ends first - we suggest tacking it underneath the base first - so you are sure it is positioned correctly - then add a couple of blobs of solder on the top side. When you are happy it is correct, finish it by adding a few blobs above and below, rather than run a bead of solder along.



Add the side cheeks

This is a good time 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 identical so make sure you have the correct ones at the correct sides – see the pictures below to check.



Now attach the 4 feet to the bottom—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 in 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 connecting 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
- Now 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 publication - you can check this wiring there. Finally, fix the rear panel to the base by soldering it using the method described for the front panel.

Testing 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 a single wire antenna, use the gold socket between the tags and put the rear switch to the unbalanced position. If you are using a balanced feed, then try either pair of terminals with the rear switch in the balanced position. There are no fixed rules about this - find the position 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 position, but you may find the peak easier to detect with the switch moved to the SWR position. This is much easier to do than to describe. You should find a good peak easily. Then move the LOAD capacitor a little to see if you can get a better peak. On 40m, there may be 2 peaks - select the best. You may have to switch in the additional capacitance using the other front panel switch, particularly on the lower frequency bands.

When you are happy that you have found the best reception, switch the front switch to SWR and key the transmitter. You should find that the settings you arrived at using the receiver are very close to the optimum for transmit. Assuming the LED is lit, carefully gently move the controls to try to make the LED dimmer. These are very sensitive and you may only have to move them a tiny amount. As this is still 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 settings for each band - this will make it easier next time to get near to the correct setting - until you try another aerial of course—but even then it will be a good start!

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 until you are satisfied with the angles – it is better 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 better with the case in position.

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 Schottky 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	
Solder tags	For rear terminalks	4 off
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	
Screws	4 off self tapping screws	To fasten case on

The finished ATU



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