

# *Magwitch Modular*

## *Mutota*

### *Eurorack Module*

*Build Guide*



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# Specification

<b>Width</b>	10 HP
<b>Depth</b>	25 mm
<b>Power</b>	+12V 19 mA, -12V 12 mA, +5V 0 mA
<b>Channels</b>	4
<b>Inputs per channel</b>	1 CV, 1 Signal
<b>Outputs per channel</b>	1
<b>Channel muting</b>	Toggle or momentary by switch, or by CV
<b>Input Signal</b>	-5V to +5V
<b>CV Signal</b>	0V muted, 5V un-muted

## Components

### Suggested Suppliers

- [uk.farnell.com](http://uk.farnell.com)
- [www.mouser.com](http://www.mouser.com)
- [www.bitsbox.co.uk](http://www.bitsbox.co.uk) – for toggle switches and wire
- [www.thonk.co.uk](http://www.thonk.co.uk) – for toggle switches and jack sockets
- [www.toby.co.uk](http://www.toby.co.uk) – for shrouded power sockets (J1)

### Component Notes

Over the page is the complete bill of materials, listing all components, values, packages and recommended parts.

Other variants of the given op-amps and voltage regulators will likely work. Googling the supplied part numbers should produce results with more information and links to suppliers.

It is important to use OPA4196 for U2 and U3, as it has the required rail-to-rail input and output characteristics to operate as a slew limiter. Others that can work are OPA4191, OPA4192, OPA4197, OPA4990 – but these are typically more expensive, and some are more power hungry.

TLV2172 are recommended for U4 and U7, but TL072 should work just as well.

Before assembly, it is recommended to adjust each of the trimmers so that the resistance between the outer pins and the middle pin is the same for each pair – i.e. in the middle of the range. This can make calibration quicker, or if you don't have an oscilloscope will suffice as basic calibration.

Not present: R3, R4, R8, R9, R18, R23, R24, R33, R38, R39, R48, R53, R54, R63.

## Bill of Materials

Parts	Description	Count	Package	Recommended
R16, R31, R46, R61, R65, R66, R67, R68	470 ohm resistor, 1%	8	0805	ERJ-6ENF
R15, R30, R45, R60	1K resistor, 1%	4	0805	ERJ-6ENF
R2	3K resistor, 1%	1	0805	ERJ-6ENF
R13, R28, R43, R58	3K3 resistor, 1%	4	0805	ERJ-6ENF
R1	4K7 resistor, 1%	1	0805	ERJ-6ENF
R6, R10, R21, R25, R36, R40, R51, R55	10K resistor, 1%	8	0805	ERJ-6ENF
R7, R22, R37, R52	27K resistor, 1%	4	0805	ERJ-6ENF
R19, R34, R49, R64	30K resistor, 1%	4	0805	ERJ-6ENF
R12, R27, R42, R57	36K resistor, 1%	4	0805	ERJ-6ENF
R5, R14, R20, R29, R35, R44, R50, R59	47K resistor, 1%	8	0805	ERJ-6ENF
R17, R32, R47, R62	82K resistor, 1%	4	0805	ERJ-6ENF
R11, R26, R41, R56	100K resistor, 1%	4	0805	ERJ-6ENF
C21, C22, C23, C24	220p ceramic, C0G	4	0805	16V or higher
C2, C3, C4, C5, C6, C7, C9, C10, C11, C12, C13, C14, C19, C20	100n ceramic, X7R	14	0805	16V or higher
C15, C16, C17, C18	470n ceramic, X7R	4	0805	16V or higher
C1, C8	10uF electrolytic	2	4mm can	EEEF1E100AR, 25V+
D1, D2	Schottky diode	2	SMD	STPS1L30U
D3	5V reference	1	SOT-23	LM4040DBZ-5
D4	2.5V reference	1	SOT-23	LM4040DB -2.5
D5, D6, D9, D10, D13, D14, D17, D18	1N4148	8	SOD-123	
D7, D11, D15, D19	5V1 Zener diode	4	SOD-123	BZT52C5V1
D8, D12, D16, D20	3mm blue LED	4		C4SMF-BJF-CR24Q4T2
RV1-4	5K trimmer	4	Thru-hole	3296W or PV36W
RV5-8	1K trimmer	4	Thru-hole	3296W or PV36W
J1	Power pin header	1	Shrouded	302-S-10-D1R1
J2-13	Thonkiconn jack	12		PJ398SM or PJ301M-12
L1, L2	Ferrite bead	2	0805	BL01RN1A1F1J
U1	LM339	1	SOIC-14	LM339DRG4
U2, U3	OPA4196	2	SOIC-14	OPA4196IDR
U5, U6	LM13700	2	SOIC-16	LM13700MX/NOPB
U4, U7	TLV2172 or TL072	2	SOIC-8	TLV2172IDR
SW1-4	SPDT on-off-(on)	4	Panel	Miniature size
Single core wire with insulation				1/06mm or 22 to 23 AWG

# Assembly

This module requires both surface mount and through-hole soldering. You can use various methods for the surface mount soldering, such as hand soldering, heat gun or the hotplate method. If you haven't attempted these before, it is highly recommended to study them and practice first.

- [Hotplate method by Hobbytronics](#) – this shows the basics
- [Surface Mount Soldering](#) – this shows the heat gun method, both with and without a stencil.

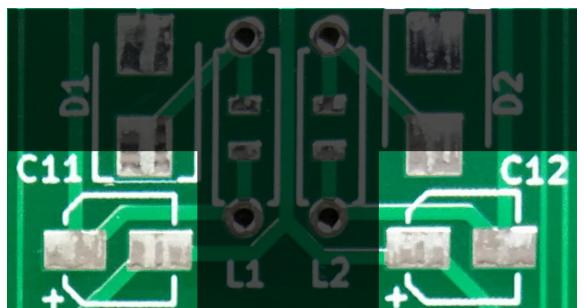
The steps to follow for this module using the heat gun method are as below; the order is similar if hand soldering is used. It is recommended to build up the board step by step, checking the joints and connectivity after each step.

Some hints for the hot plate method are provided at the end.

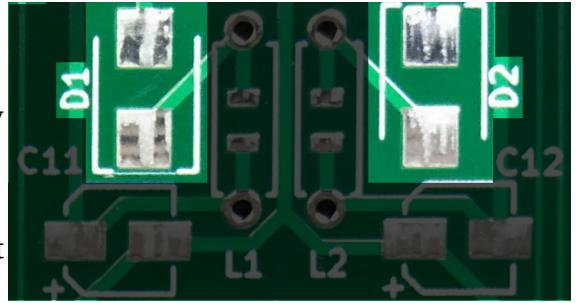
## Orienting Components

Pay attention to the silkscreen printing around component footprints; this gives an indication of how certain polarised components (capacitors, diodes) and ICs should be placed.

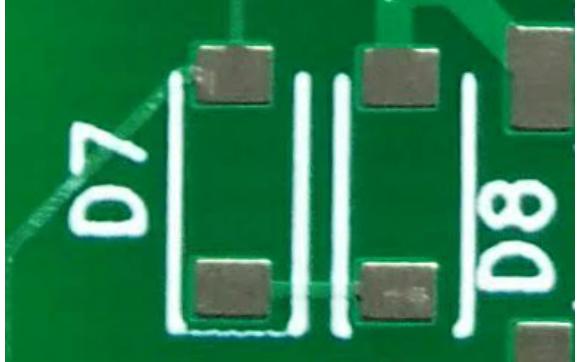
Orient electrolytic cap bases with the outline on the PCB, as highlighted here:



Orient all diodes correctly; the cathode is the closed end of any diode outline on the PCB, and should line up with the cathode marking on the diode itself, usually a line). The closing line may not be fully present on the silk screen – in that case, place the diode with the cathode on the pad where the silk screen lines outside it extend furthest.



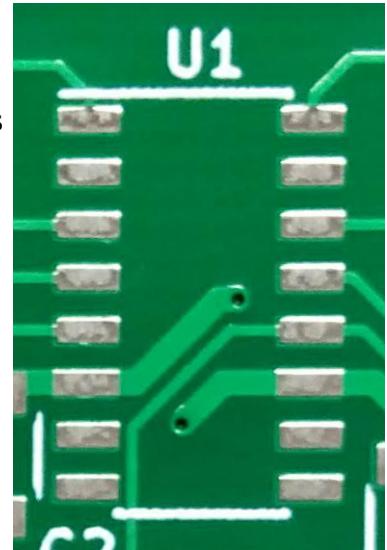
This applies to all types and sizes of diodes – the large rectifier diodes on the power inputs (D1, D2) and the various signal diodes (e.g. D5, D6, etc.).



Orient all ICs properly – pin one should be on the pad with the adjacent extended line on the silkscreen.

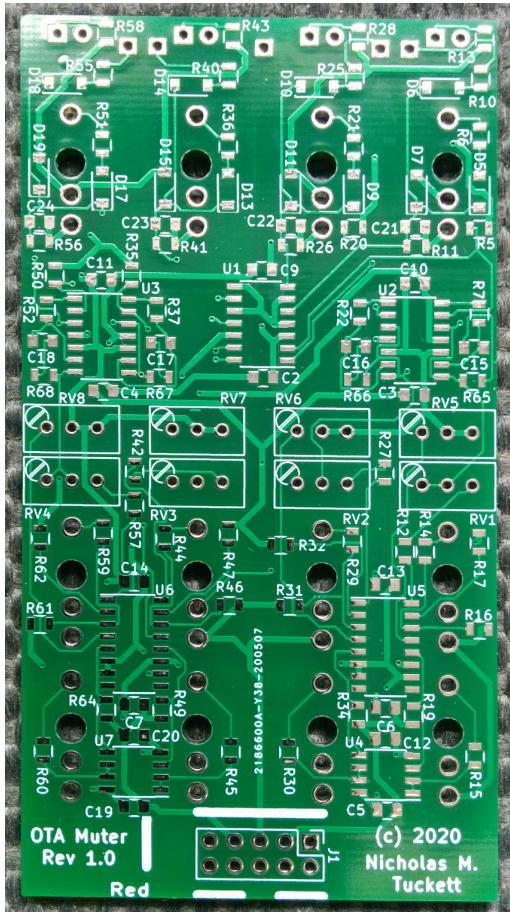
The ICs in this circuit will have pin one marked by one or more of the following:

- A short line across the IC body indicating its top, where pin 1 is located.
  - A circle, dot or dimple at the corner where pin 1 is located.
  - A chamfer on the body (sloped edge) which marks the side on which pin 1 is located.

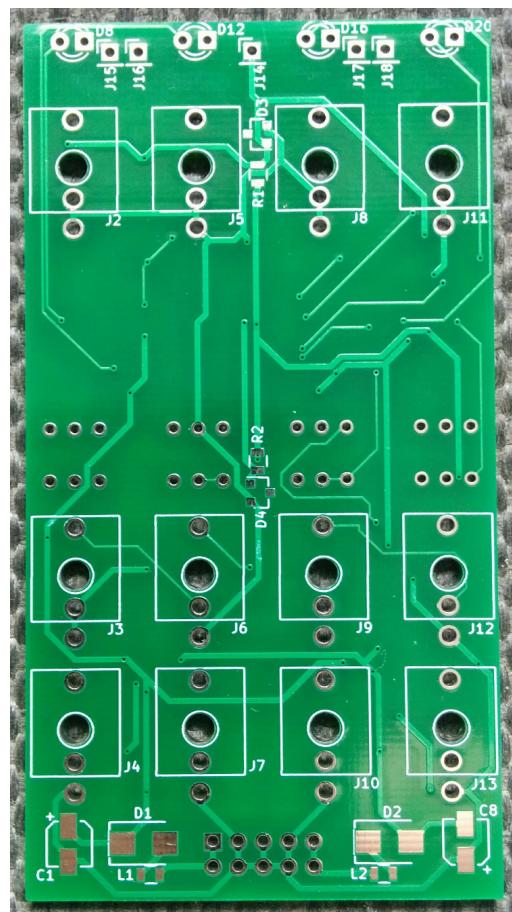


# Orienting the PCB

The PCB is taller than is wide, and should be oriented so the text is readable horizontally. The Eurorack power connector should be at the bottom of the board.



*Rear of PCB*



*Front of PCB*

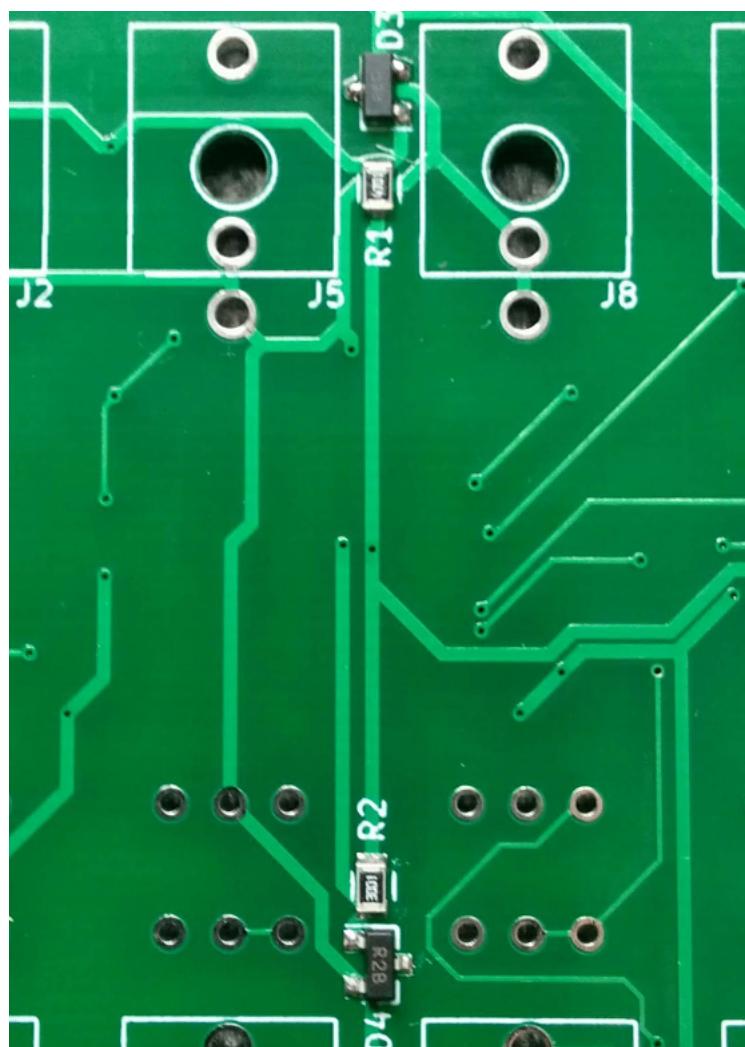
# Heat gun/Hand Soldering Step-by-Step Assembly

The overall direction of assembly is as follows:

1. Surface mount non-power components on PCB front.
2. Surface mount components on PCB rear, top to bottom.
3. Surface mount power components on PCB front.
4. Eurorack power header
5. Trimmers
6. Jacks and LEDs
7. Switches

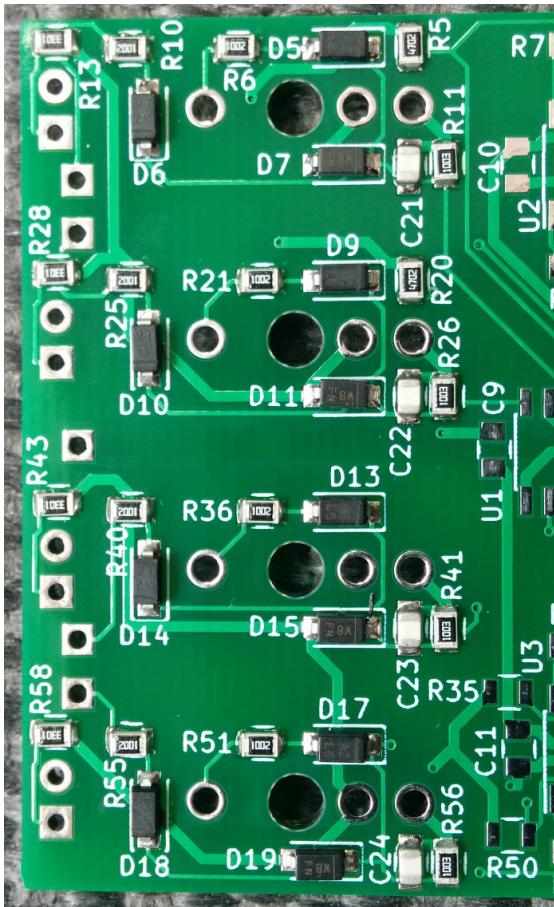
## Non-power Components on PCB Front

On the front side of the PCB, solder the two voltage regulators (D3, D4) and their associated resistors (R1, R2):



## Components on PCB Rear

Begin with the components around the top row of jacks, as in the picture below. For hand soldering, a good way to do this is in groups of components around each jack – four/five resistors, three diodes and one capacitor. For heat gun soldering, you can paste and place all the components around all the jacks.



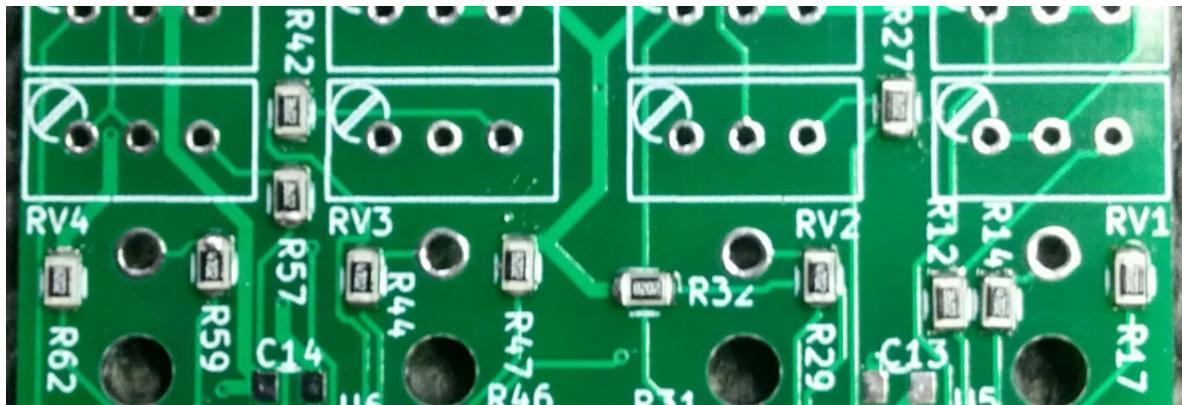
- Diodes:
  - D5, D6, D7
  - D9, D10, D11
  - D13, D14, D15
  - D17, D18, D19
- Resistors:
  - R5, R6, R10, R11, R13
  - R20, R21, R25, R26, R28
  - R36, R40, R41, R43
  - R51, R55, R56, R58
- Capacitors:
  - C21, C22, C23, C24

Now proceed with the three ICs U1, U2 and U3 and their surrounding components. For hand soldering, place and solder the ICs first, then the 100nF capacitors, then the remaining capacitors and resistors. For heat gun, paste pads and place all components (easiest to put the ICs on first before the passives) then apply the heat to solder each IC and its nearby components in turn:



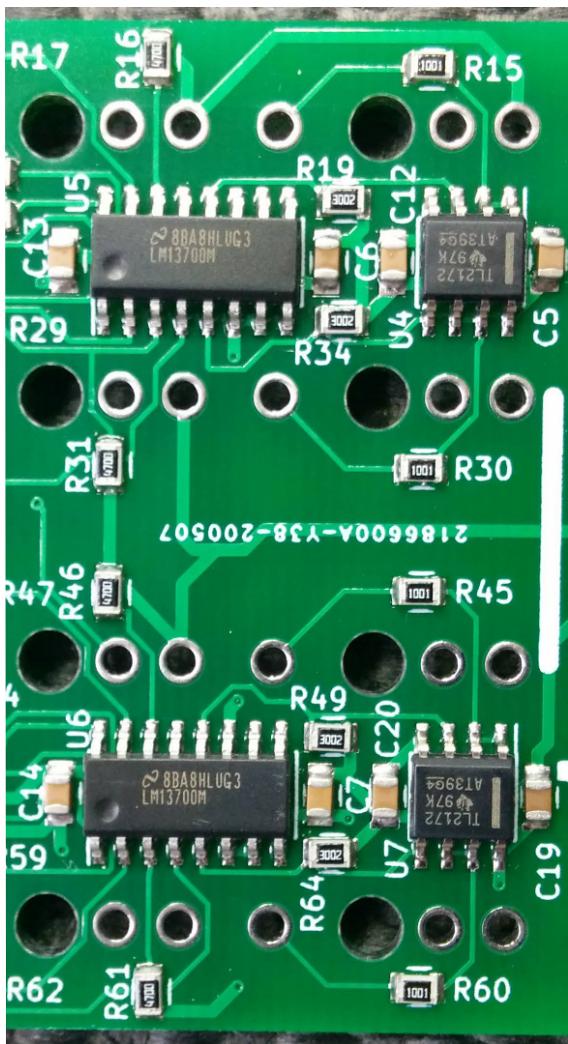
- ICs: U1, U2, U3
- Resistors: R7, R22, R35, R37, R50, R52, R65, R66, R67, R68
- Capacitors: C2, C3, C4, C9, C10, C11, C15, C16, C17, C18

Next place and solder the resistors around and below the trimmers:



- R12, R14, R17, R27, R29, R32, R42, R44, R47, R57, R59, R62

And finally solder the remaining ICs and associated passives:



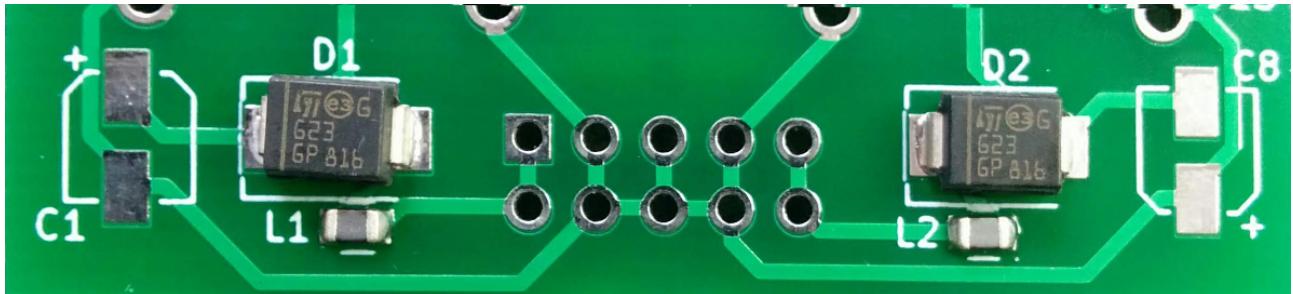
- ICs: U4, U5, U6, U7
- Resistors:
  - R15, R16, R19, R30, R31, R34
  - R45, R46, R49, R60, R61, R64
- Capacitors:
  - C5, C6, C7, C12, C13, C14, C19, C20

For hand soldering, place and solder the ICs first, then the capacitors, then the resistors.

For heat gun soldering, paste all the pads, then place components in the order ICs, capacitors, resistors. Apply heat to each IC and neighbouring passives in turn to solder them.

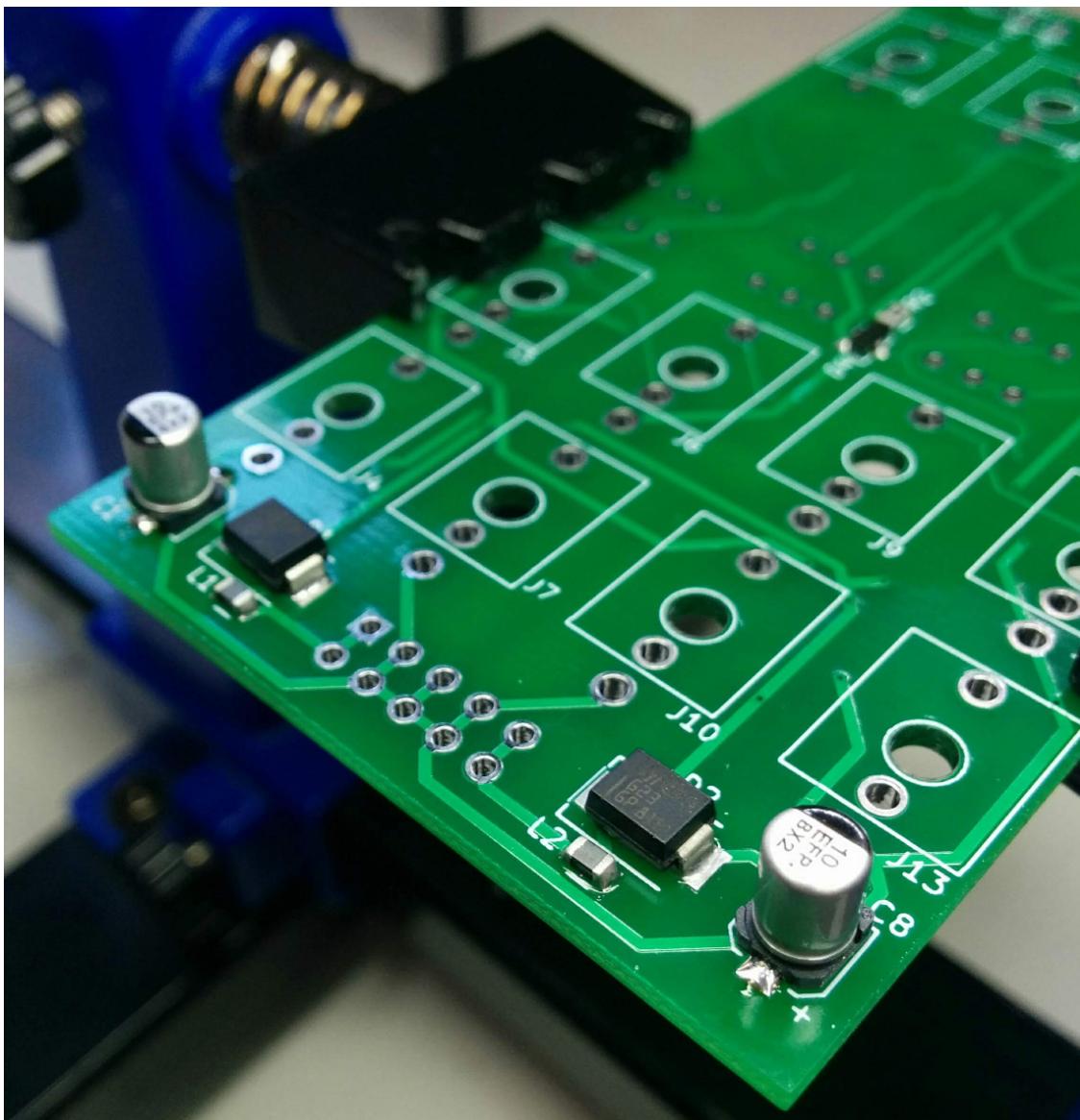
## Power Components on PCB Front

Turn the PCB to its front, and solder the surface mount power components: D1, D2, L1, and L2:



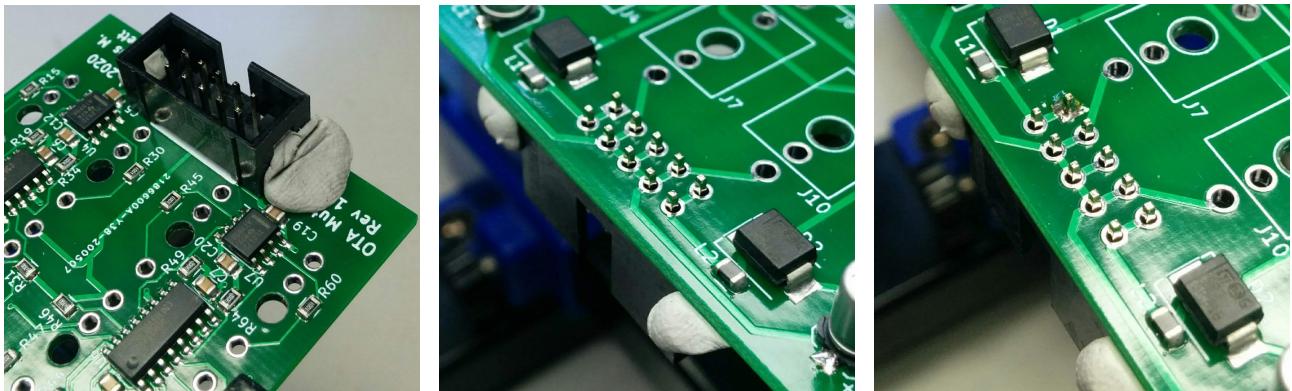
This can be easily done in that order either by hand soldering or by heat gun.

Next, solder the two electrolytic capacitors C1 and C8. It is recommended to do this via hand soldering instead of a heat gun, as that will be quicker and reduce the likelihood of overheating the capacitor:



## Eurorack Power Header

Now place the power header on the rear of the PCB and solder it from the front. You can use some sort of temporary adhesive to hold it in place (e.g. kapton tape or blu-tak). It is recommended to solder one pin first, then re-flow that pin while pushing the connector up onto the board to ensure it sits correctly on the board. If it does not, re-flow and adjust the connector position again. Be careful not to overheat the pin and melt the plastic of the header! Then follow through soldering the remaining pins.



## Trimmers

Place the 5K trimmers RV1 through RV4 on the rear of the PCB and hold them in place with tape or tak. As for the power header above, solder just one pin on each on the other side, then re-heat each and press/hold the trimmer into the correct place. Then solder each remaining pin on each trimmer in turn; i.e. do all pin 2s, then all pin 3s. This helps minimise the heat applied to each trimmer.

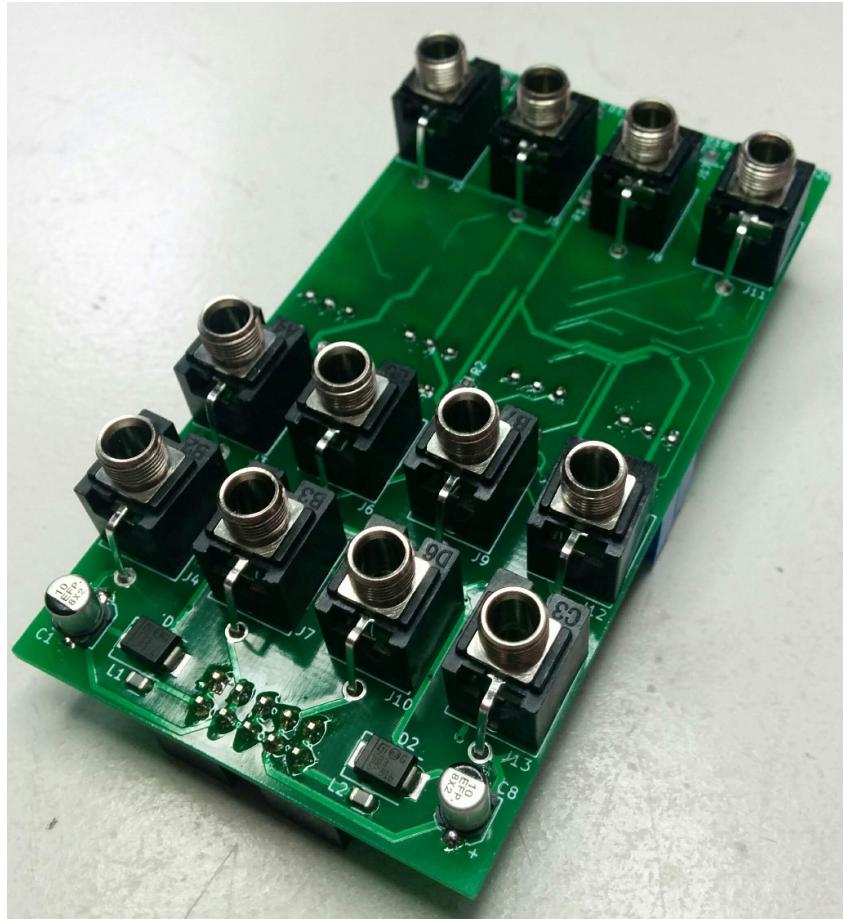


Clip off the leads of each trimmer. Now repeat for the four 1K trimmers RV5 through RV8.

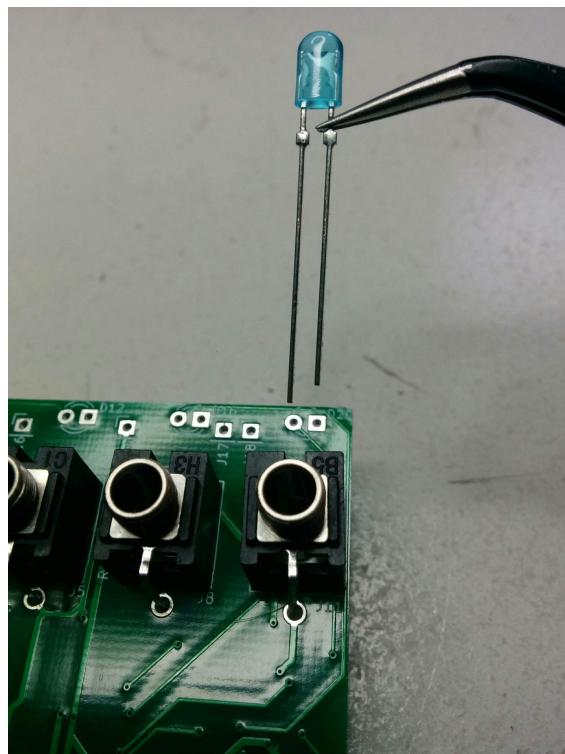


## Jack Sockets and LEDs

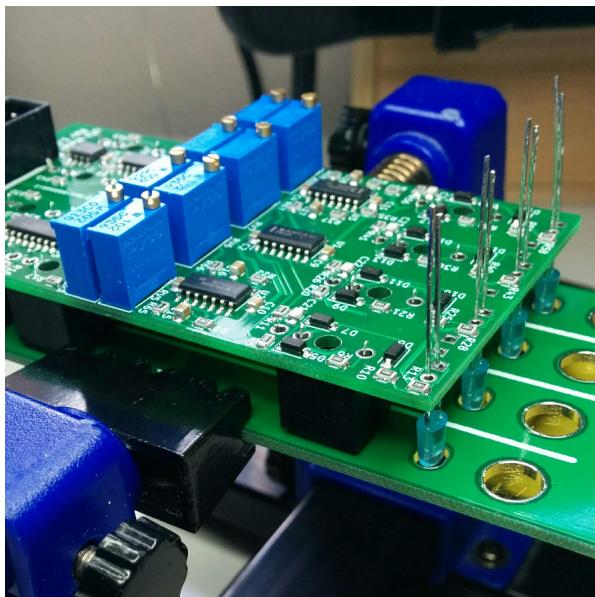
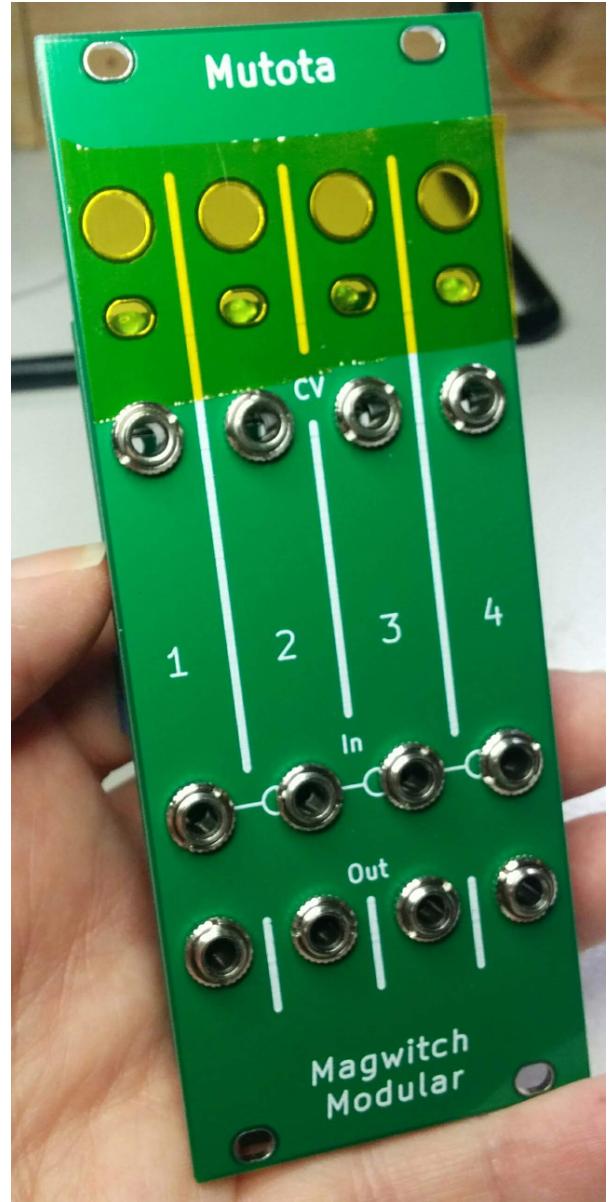
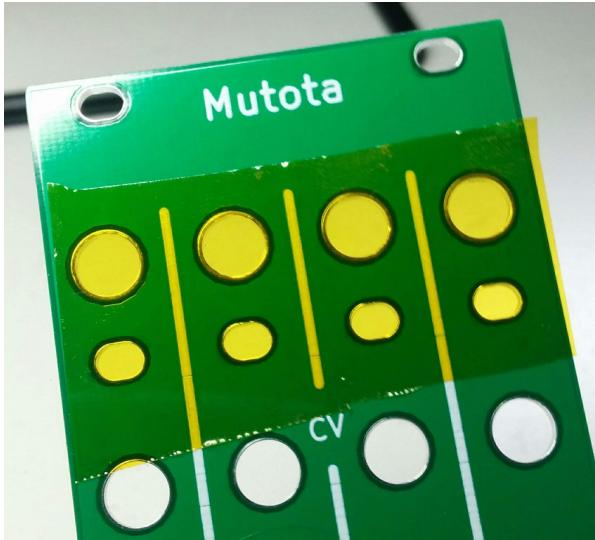
Place all the jacks (J2 to J13) into their holes, but do not yet solder them!



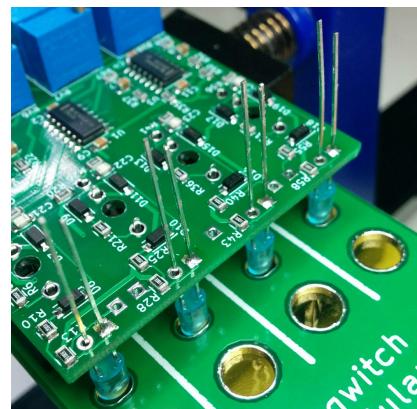
Next place the LEDs (D8, D12, D16, D20) into their holes. The long leg of the LED (anode) should go into the hole with the **ROUND PAD**.



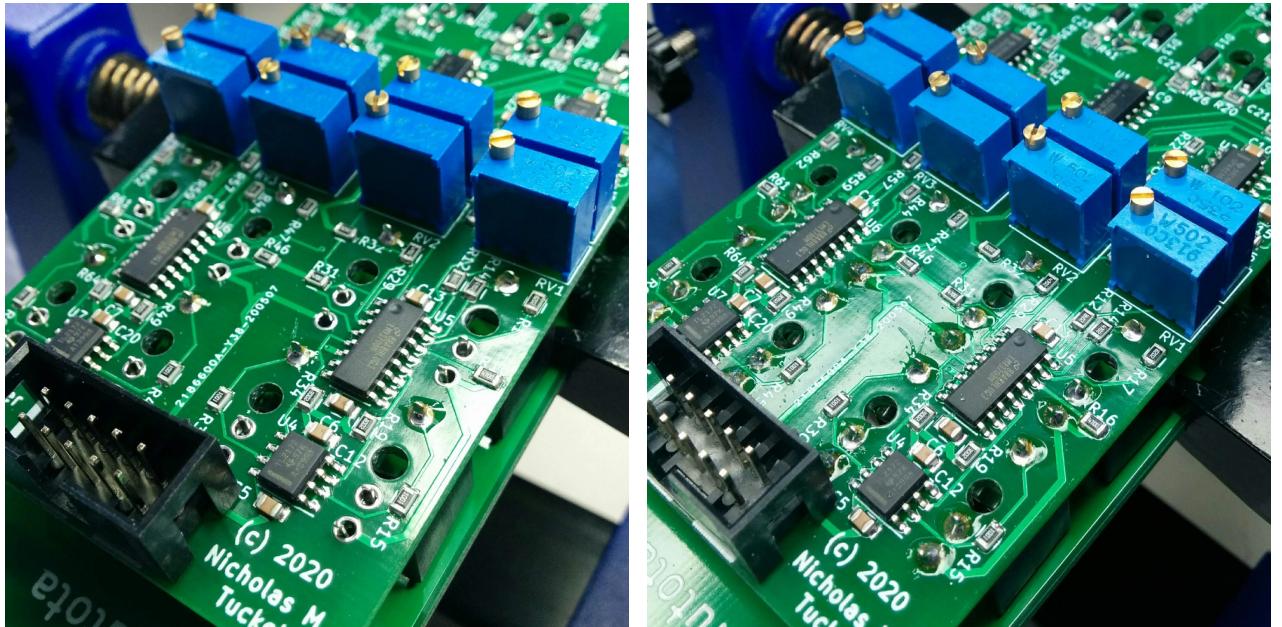
Take the panel, and place some tape over the LED holes. Put the panel onto the jacks and screw on the jack nuts to hold it in place. Clamp the PCB and panel into your PCB holder, and adjust the LEDs to be central in their holes and just being held in place by the stickiness of the tape.



Solder the square pins of each LED next – check their placing, re-heating and adjusting as required. Then solder the round pins of each LED.

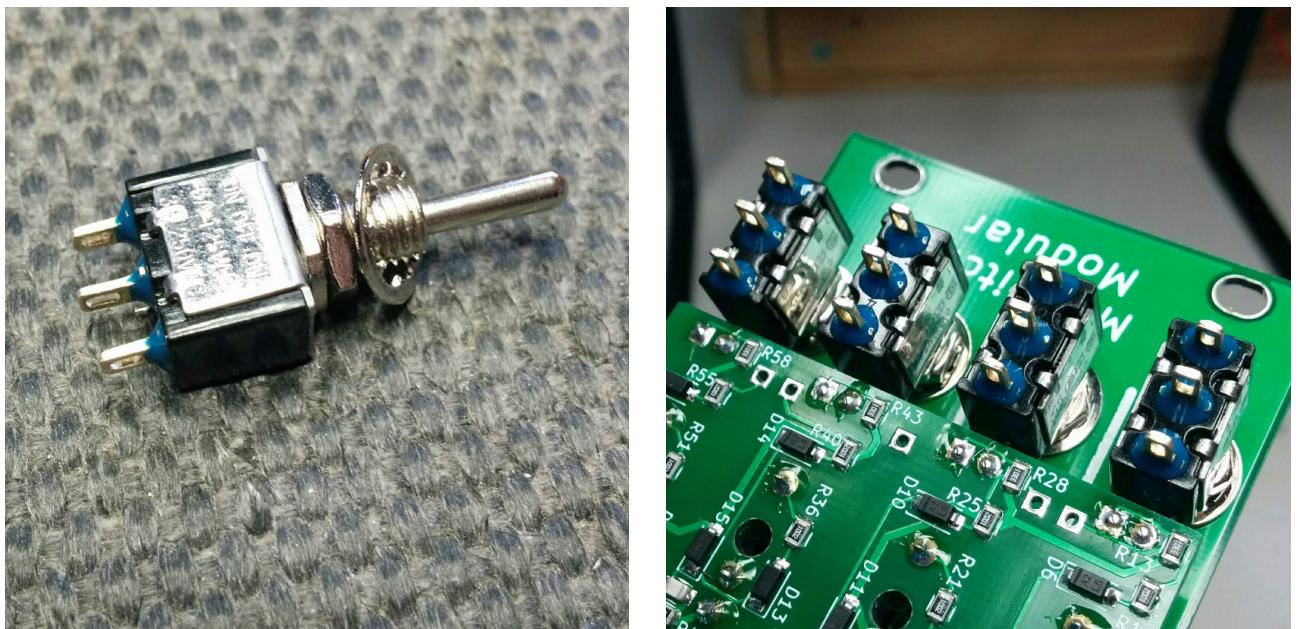


Move onto soldering the jacks. Solder the top pin of each jack first, then check that they are properly located and flush with the PCB – re-heat and adjust if required. Once you're happy with all the jacks, go around and solder the rest of the jack pins.

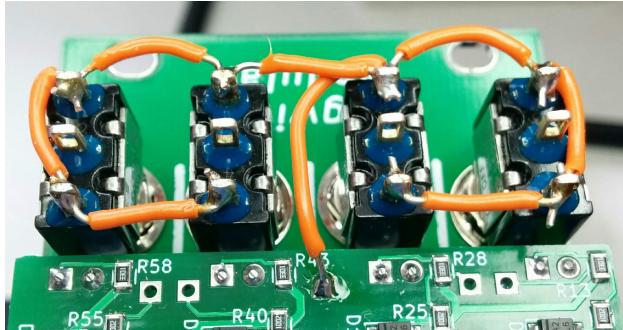


## Switches

On each switch (SW1 to 4), ensure there is one nut screwed down onto the body of the nut. Place the locking washer above that on the thread, insert the switches into their holes on the panel and secure with the other nuts on the front of the panel. Ensure that the switches are aligned as in the picture, with the momentary position of the switch at the top.



Using single core wire, cut eight short lengths and use them to connect the central jumper connector J14 to all the outer pins of the switches (see below left). Then cut four lengths with a different coloured insulator and use those to connect J15, J16, J17 and J18 to the center pins of each switch in turn (see below right).



Congratulations, you have now assembled your Mutota!

## Hot-plate Soldering

The suggested way to approach hot-plate soldering is as follows:

1. Apply paste to all pads on rear of PCB.
2. Place all components on PCB rear, and use hot-plate to solder.
3. Hand-solder the non power SMD components on the front of the PCB (D3, D4, R1, R2)
4. Hand-solder the power SMD components on the PCB front (D1, D2, L1, L2, C1, C8).
5. Proceed with the remaining hand soldering as above: power connector, trimmers, jacks & LEDs, switches.

# Calibration

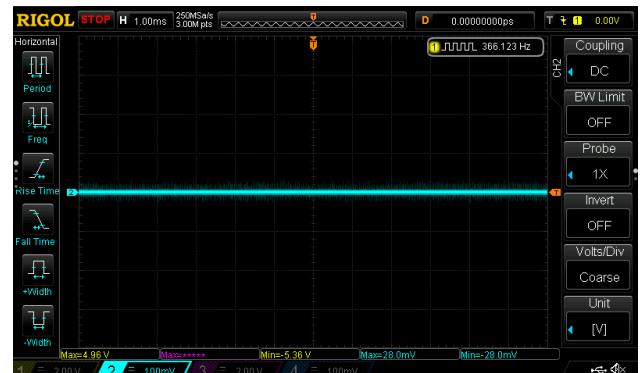
Each channel has two calibrations – one for output offset, one for gain. You will need an oscilloscope and an oscillator to perform the calibration.

## Offset Calibration

1. Leave all the inputs of the Mutota unconnected.
2. Connect the output of Mutota channel 1 to your oscilloscope.
3. Set the voltage range on your oscilloscope to 100mV or as close as possible.
4. Toggle the switch on Mutota channel 1 to un-muted – i.e. press it down. The LED for the channel should light.
5. Adjust the 1K trimmer for that channel (RV5) until the output is 0V
6. Repeat 2 to 5 for the other three channels and trimmers (RV6, RV7, RV8).



Output with offset



Calibrated output

## Gain Calibration

1. Connect a square wave from your oscillator to input 1 of the Mutota, and also to one channel of your oscilloscope.
2. Connect the output of channel 1 on Mutota to another oscilloscope channel.
3. Switch Mutota channel 1 to be un-muted (switch down).
4. Observe the waveforms – if they do not match in amplitude, adjust the 5K trimmer RV1 until they do.
5. Repeat 2 to 4 for the further three Mutota channels and trimmers RV2, RV3 and RV4. Note that you can leave the oscillator connected to channel 1, as that input is normalled to the other channels.



Input (yellow) with uncalibrated output (blue)



Calibrated output (blue) over input (yellow)