Build Guide:
Macro Oscillator for 5U modular synthesizer

Format: MOTM

Version: v2a

Introduction

This module is an 5U adaption based on the famous Eurorack module "Plaits" invented by Émilie Gillet, the successor to the popular "Braids" module:
https://www.martinjankoehler.com/synthesizers/synth-macro-oscillator-in-5u/

This document describes the assembly of the ported module.

License information

- PCB, Panel & Build Guide:
  CC-by-SA-3.0 Martin Köhler

- Schematics & Firmware:
  CC-by-SA-3.0 Émilie Gillet

https://mutable-instruments.net/modules/plaits/open_source/

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Macro Oscillator / 5U edition by martinjankoehler.com			**Format: MOTM**	**PCB v2**		**BOM v2b**	*CC-by-SA-3.0 Martin Jan Köhler CC-by-SA-3.0 Émilie Gillet*
Index	**Qty**	**Description**	**Specs**	**Value**		**Package**	**References**
C6 C8 C10 C11 C12 C17 C18 C23 C27 C28 C32 C34 C36 C37 C44 C45 C51 C52 C53	19	Capacitor, ceramic	>= 25V, X5R	100n	SMT	0805	Kemet C0805C104J5RACTU
C29, C31	2	Capacitor, ceramic	>= 25V, X5R	2.2u	SMT	0805	Kemet CC0805KKX7R8225
D3	1	BAT54S diode			SMT	SOT23	NEXPERIA BAT54S.215
U2	1	TLC59281DBQ 16ch LED driver			SMT	TSSOP24	Texas Instruments TLC59281DBQR
U3	1	LD2981ABU33 LDO regulator	3.3V		SMT	SOT89-3	ST LD2981ABU33TR
U5	1	PCM5100APW Audio DAC			SMT	SSOP20	Texas Instruments PCM5100APWR
Rled1 (green, left button)	1	Resistor	<= 1%, >= 200mW	68R	THT		TE Connectivity / Neohm LR1F68R
Rled2 (red, right button)	1	Resistor	<= 1%, >= 200mW	75R	THT		TE Connectivity / Neohm LR1F75R
R46, R47	2	Resistor	<= 1%, >= 200mW	1.0k	THT		Welwyn Components / TT Electronics MFR4-1K0FI
R11, R12	2	Resistor	<=1%, 100mW	2.2k	THT		TE Connectivity / Neohm LR1F2K2
R37	1	Resistor	<= 1%, >= 200mW	5.6k	THT		Welwyn Components / TT Electronics MFR4-5K6FI
R3, R16, R21, R45, R48, R49, R50, R51	8	Resistor	<=1%, 100mW	10k	THT		Welwyn Components / TT Electronics MFR4-10KFI
R19, R32, R35	3	Resistor	<=1%, 100mW	20k	THT		TE Connectivity / Neohm LR1F20K
R18, R20, R22, R28, R31, R34	6	Resistor	<=1%, 100mW	33k	THT		TE Connectivity / Neohm LR1F33K
R17	1	Resistor	<=1%, 100mW	56k	THT		Welwyn Components / TT Electronics MFR4-56KFI
R13, R14, R15, R24, R38, R39, R40, R41	8	Resistor	<=1%, 100mW	100k	THT		Welwyn Components / TT Electronics MFR4-100KFI
R26	1	Resistor	<=1%, 100mW	110k	THT		TE Connectivity / Neohm LR1F110K
R23, R33, R36	3	Resistor	<=1%, 100mW	120k	THT		TE Connectivity / Neohm LR1F120K
R29	1	Resistor	<=1%, 100mW	140k	THT		Yageo MF0207FTE52-140K
R25, R27, R30	3	Resistor	<=1%, 100mW	200k	THT		TE Connectivity / Neohm LR1F200K
L1, L2, L3, L4, L5	5	EMI Filter Bead	>= 1k ohm, 300mA		THT		MURATA BL01RN1A1F1J
C50	1	Capacitor, ceramic	>= 25V, X6S	1u	THT 5mm	5mm radial	KEMET C333C105K5R5TA
C1, C2, C13	3	Capacitor, ceramic	>= 25V, X5R	22u	THT 5mm	5mm radial	TDK FG24X5R1E226MRT6
C38, C42, C43, C46	4	Capacitor, ceramic	>= 25V, C0G, <= 5%	100p	THT 5mm	5mm radial	TDK FG28C0G1H101JNT06
C33, C35, C39, C40, C41, C47, C48, C49	8	Capacitor, ceramic	>= 25V, C0G, <= 5%	1n	THT 5mm	5mm radial	TDK FG28C0G1H102JNT06
U8	1	IC Socket DIP-8			THT	DIP-8	AliExpress
U6, U7	2	IC Socket DIP-14			THT	DIP-14	AliExpress
U4	1	IC Socket DIP-40			THT	DIP-40	AliExpress
Power MOTM	1	MTA-156 4-way Header			THT	MTA-156	MOLEX MX-26-60-4040
Audio Outputs	2	MTA-156 4-way Header			THT	MTA-100	Molex 538-22-23-2041
LED/Switches	1	MTA-100 7-way header			THT	MTA-100	
Normalization	1	MTA-100 5-way header			THT	MTA-100	Molex 538-22-23-2051
Control Voltages	1	MTA-100 8-way header			THT	MTA-100	MOLEX 022232081 A-6373-08A222
CP3, CP7, CP16, CP22, CP30	5	Capacitor, electrolytic	>= 16V	10u	THT 5mm	5mm radial	Panasonic EEUFR1H100
CP4, CP5	2	Capacitor, electrolytic	>= 35V	22u	THT 5mm	5mm radial	Panasonic EEUFR1H220
D1, D2	2	1N5819 diode			THT	DO41	DIODES INCORPORATED 1N5819-T
D4	1	LM4040 Shunt Vref	C grade (0.5%, 100ppm)	10V	THT	TO92	Texas Instruments LM4040BIZ-10.0/NOPB

Bill of Materials (2 / 2)

Macro Oscillator / 5U edition by martinjankoehler.com			**Format:**	**PCB v2**	**BOM v2b**	*CC-by-SA-3.0 Martin Jan Köhler CC-by-SA-3.0 Émilie Gillet*
Index	**Qty**	**Description**	**Specs**		**Package**	**References**
LED1, LED2, LED3, LED4, LED5, LED6, LED7, LED8	8	LED 3mm red/green common anode		THT	T-1 (3 mm)	Lumex SSL-LX3059IGW-CA
Jgate1, Jtrig1, Jharmonics1, Jmodel1, Jfm1 Jmorph1 Jtimbre1, JoutL1 JoutR1, Jvoct1	10	Mono 1/4“ jack PCB Mounted, Switched		THT		AMPHENOL ACJM-MV-2S
Audio Outputs	2	MTA-100 4-way Connector (KK for Coax)		-	MTA-100	Molex 22-01-2047
Crimp Terminals	8	KK Crimp Terminals		-	MTA-100	Molex 08-50-0114
LED/Switches	1	MTA-100 7-way Connector (IDC or KK)		-	MTA-100	
Normalization	1	MTA-100 5-way Connector (IDC or KK)		-	MTA-100	
Control Voltages	1	MTA-100 8-way Connector (IDC or KK)		-	MTA-100	
U1	1	DC-DC converter R-78E3.3-0.5	3.3V, 500mA	THT		Recom R-78E3.3-0.5
U6, U7	2	MCP6004 quad op-amp R2R IO		THT	DIP-14	Microchip MCP6004-I/P
U8	1	TL072 dual op-amp		THT	DIP-8	Texas Instruments TL072ACP
RVfreq1 RVfreqatt1 RVharmonics1 RVmorph1 RVmorphatt1 RVtimbre1 RVtimbreatt1	7	10k linear pot, 16mm Alpha, angled		THT		Alpha 16mm 10k linear
SW1	1	Illuminated Tactile Switch, Red		THT		Highly PB61303BL-1
SW2	1	Illuminated Tactile Switch, Green		THT		Highly PB61303BL-3
AWG 22 wire different colors (for all signal cables except audio)						
RG174AU coax wire for audio						
Panel	1					
PCB	1					
MCU Daughterboard	1					
M3 x 11mm hex nuts	5					
M3 x 8mm screws, Black, ISO 7380	5					
M3 Washers, Black, DIN 125 3,2	9					
M3 x 8mm screws, ISO 7380F, black	4					

An XLS version of the BOM is available over at:
https://www.martinjankoehler.com/synthesizers/synth-macro-oscillator-in-5u/

PCB overview and recommendations

The PCB contains 3 parts that will be interconnected using MTA-100:

1. main board
2. push button and LED board
3. jack board

I recommend not to break out the three parts of the PCB at this point, that's nicer to solder IMHO.

Using 2 kinds of soldering wire is recommended:

1. 0,4 mm solder wire with Kester 331 water soluable flux core.
   This is corrosive, which is a good thing as it will eat through any component oxide layer. After washing drying you should get a perfect looking shiny solder joints.
   VERIFY: Make sure to thoroughly wash the PCB with warm/hot tap water after every couple of hours.
2. 0,6mm solder wire with no clean flux core for the parts that should not better not be washed (like potentiometers, etc…)

Soldering the Main Board

1. Part A – Water Washable Flux

Start with the back side (opposed to the front side which is oriented towards front panel).

1.1. SMT parts (back side)

Start with soldering the SMT ICs U2 and U5.

NOTE: PLEASE use extreme care!
Should this goes wrong, there is no point in continuing.
It's important to take care not to destroy the PCB pads. It's a 4-layer PCB and mistakes can not always be MacGyver'ed in every case. Correct only using hot air or if you use solder wick, use very narrow ones suited for SMT.

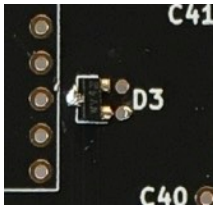
Recommended steps:

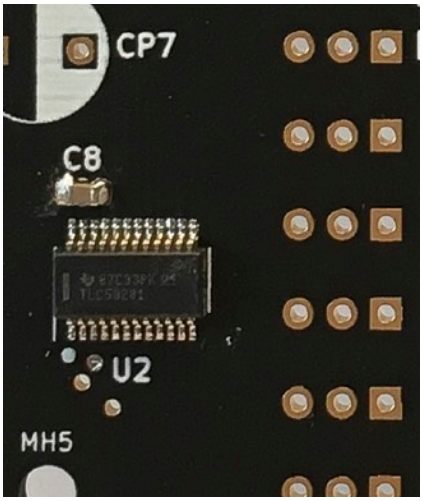
1. Place IC and align with an ESD pin
2. **VERIFY:** silkscreen dot marking pin 1 is aligned with the chip and all pads are aligned correctly
3. Solder the pin 1 at the dot
4. **VERIFY:** alignment of pads/pins
5. Solder the pin diagonally on the other side
6. **VERIFY:** alignment of pads/pins
7. Apply flux
8. Add tiny amounts of solder (if you use too much, you risk bridging pins)
9. Apply flux
10. Use hot air gun to reflow
11. **VERIFY:** there are no shorts between using the continuity testing function of your multimeter

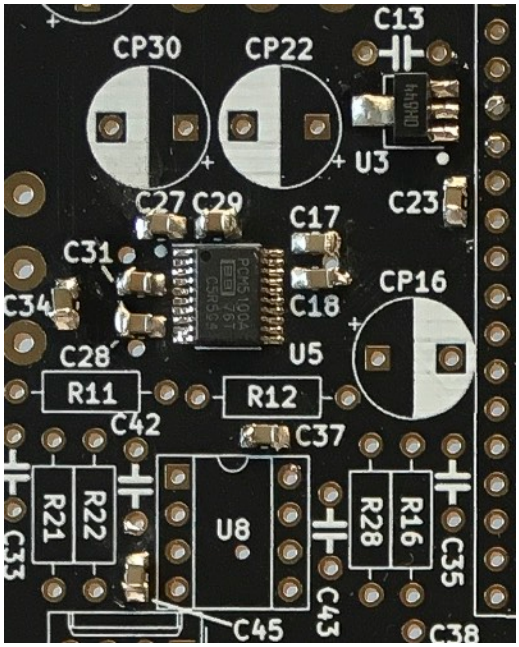
OK! You did it! Awesome!
From now on, it's a piece of cake.

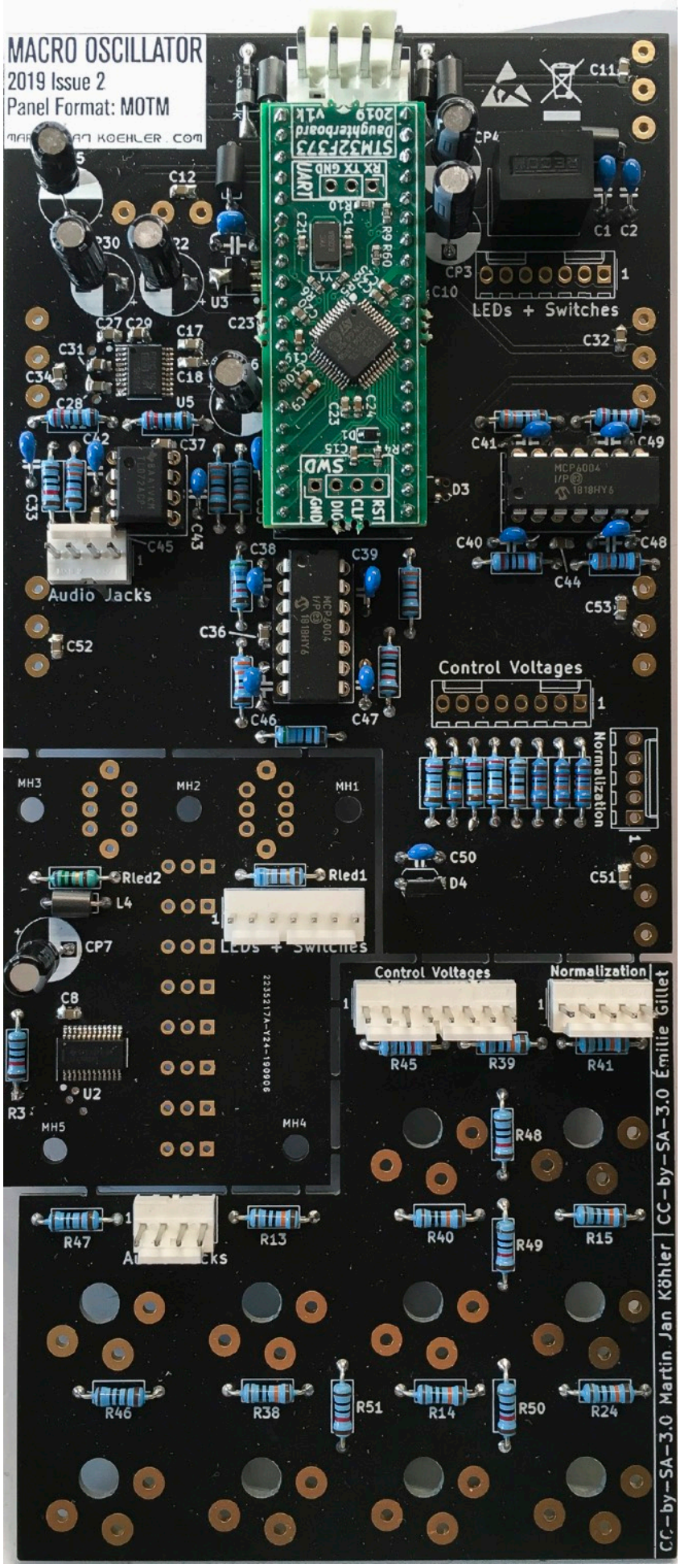
Continue with the remaining back side SMT parts :

1. D3, U3, 0805 SMT Caps).
2. **VERIFY:** there are no undesired shorts against the schematics using the continuity testing function of your multimeter








MACRO OSCILLATOR
2019 Issue 2
Panel Format: MOTM
LEDs + Switches
Audio Jacks
Control Voltages
Normalization
Control Voltages
Normalization
LEDs + Switches
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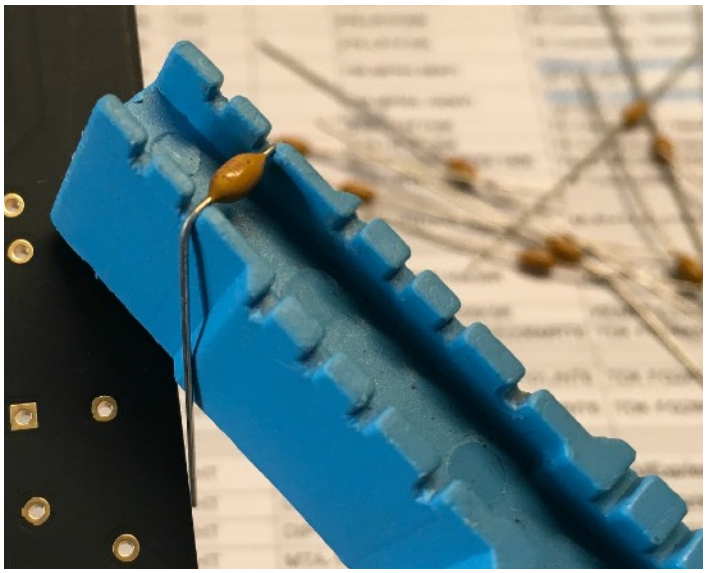
1.3. Front side

We'll leave the front side as-is until later when the user interface elements (potentiometers, LEDs, push buttons) will be fitted.

1.4. Back side



Populate the PCB according to the large photograph on the next page.

For axial parts (resistors, diodes, ferrite beads) a wire bending utiilty can come in handy.

Recommended order:

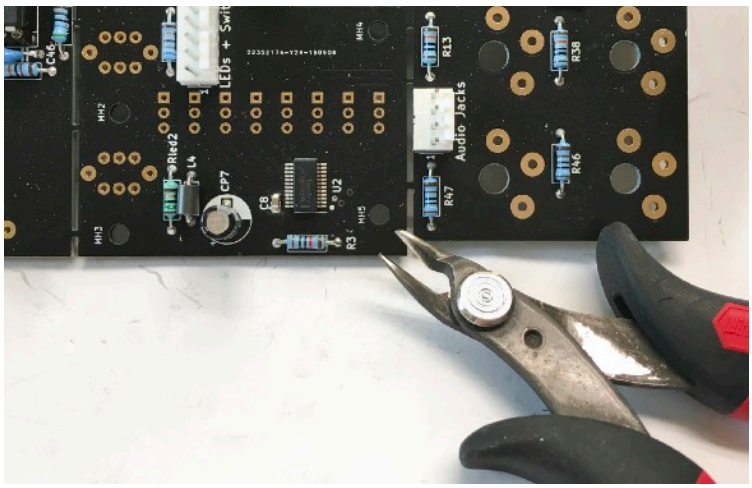
1. Resistors
2. THT diodes
3. Ferrite beads
4. Radial MLCCs (be sure to use C0G according where specified)
5. IC sockets
6. MTA sockets
7. Pin Headers
8. Voltage reference (D4)
9. DC-DC converter (U1)
10. Electrolytics

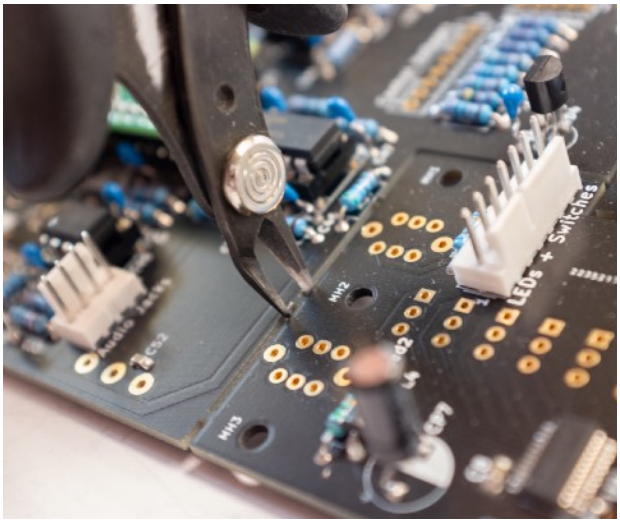
NOTES:

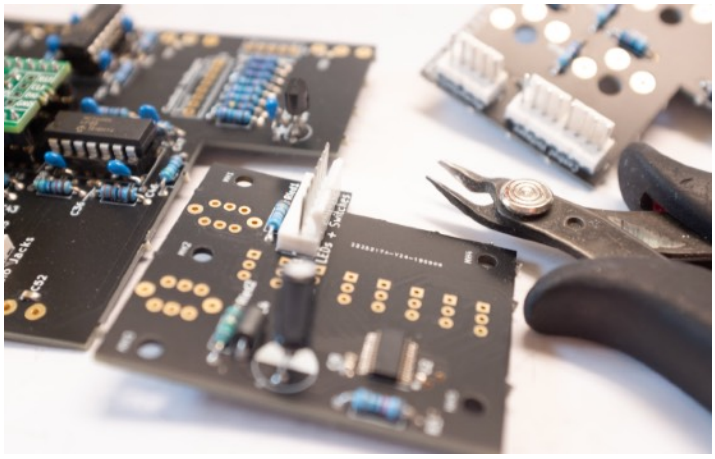
- I recommend leaving out the main board MTA headers (Switches, Normalization, Control Voltages), and directly soldering the wires on the main board side.
- The distance between resistors and screws on the push button board is too tight. Therefore make sure to bend Rled1, Rled2 away to prevent contact with the screws.

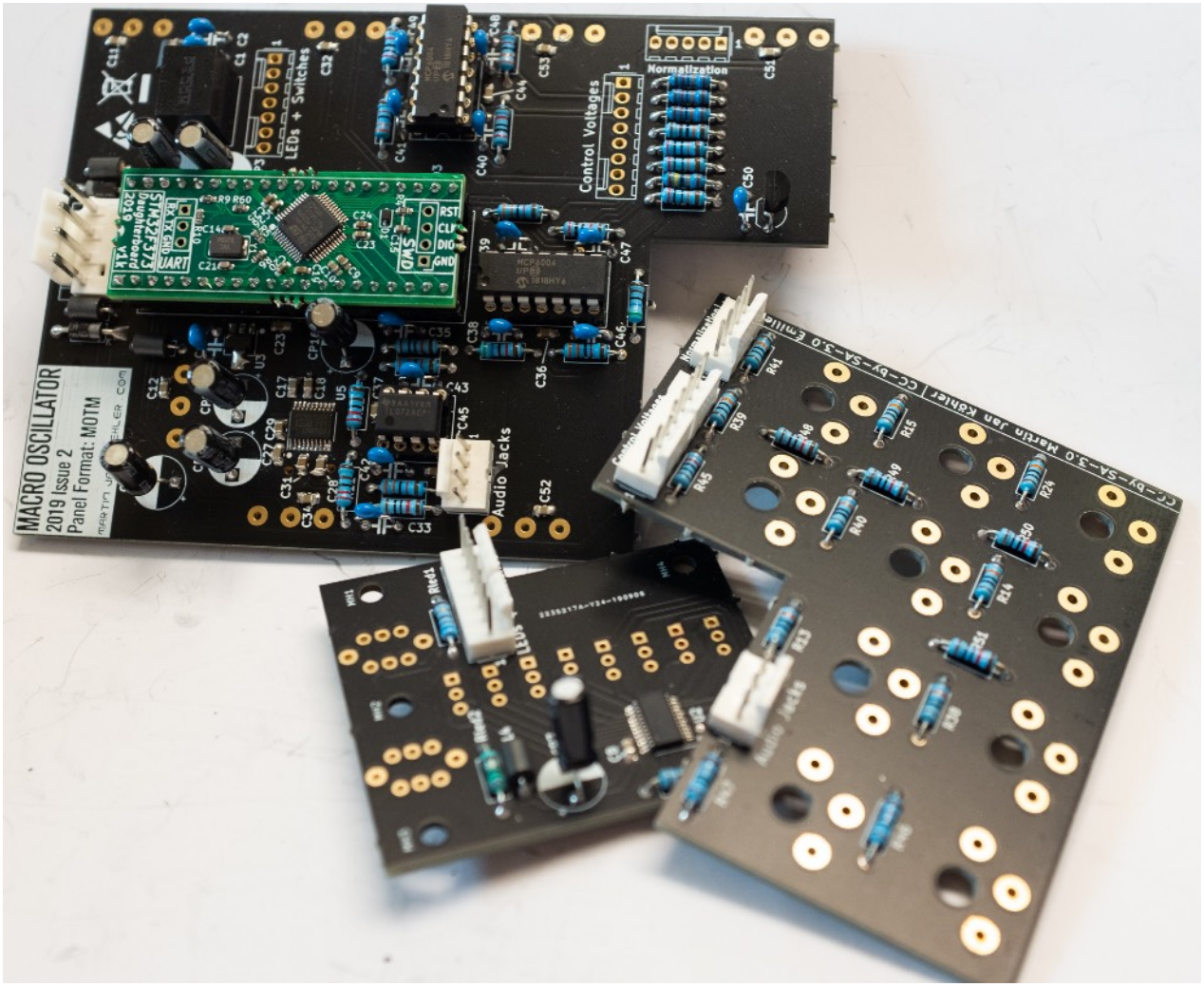
2. Separate PCB parts

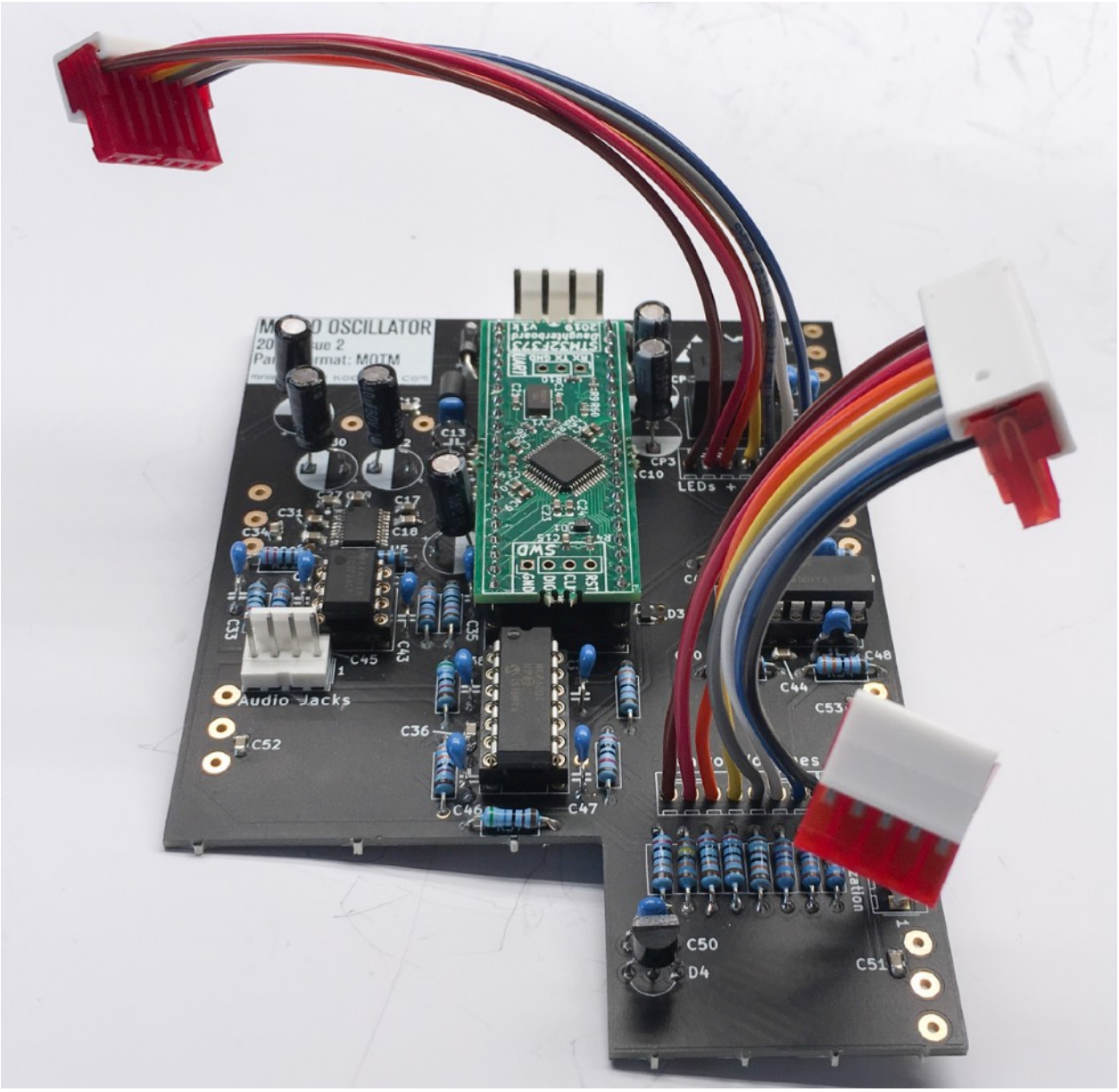
Use a fine side cutter to separate PCB into the 3 parts / boards by cutting the little bridges between the mouse bites.

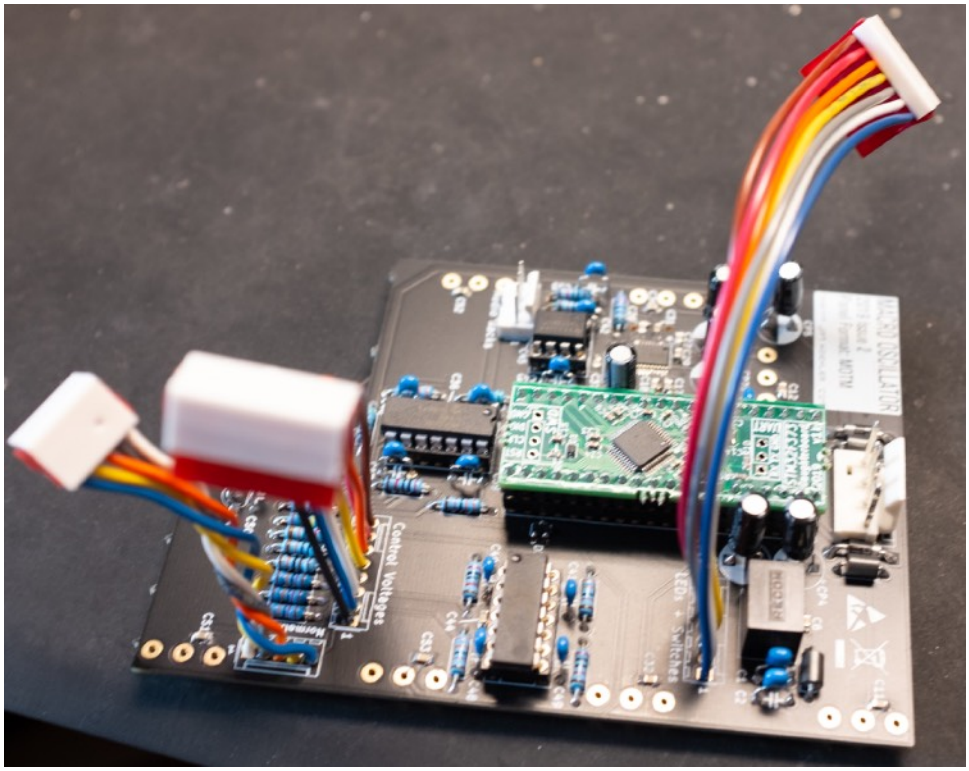






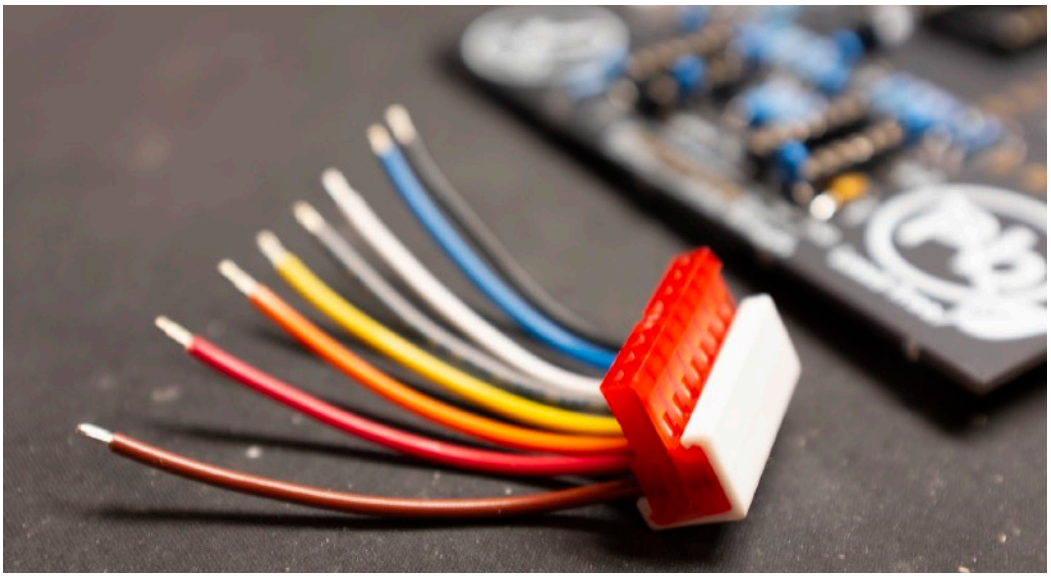



Audio Jacks
C52
C36
C46
C47
C50
D4
C51
C44
C48
LEDs +
SWD



3. Prepare and Solder Cables

	Type	Qty	Pins	Length	Mother Board Connection	Daughter Board Connection
Normalization	AWG 22 multi strand drilled	5	5P	6 cm	Directly soldered according to PIN 1 alignment	MTA-100 (KK or IDC)
Control Voltage	AWG 22 multi strand non-drilled	8	8P	8 cm	Directly soldered according to PIN 1 alignment	MTA-100 (KK or IDC)
Switches/ LEDs	AWG 22 multi strand non-drilled	7	7P	13 cm	Directly soldered according to PIN 1 alignment	MTA-100 (KK or IDC)
Audio	Coax RG174U	2	4P	4 cm	MTA-100 (KK)	MTA-100 (KK)

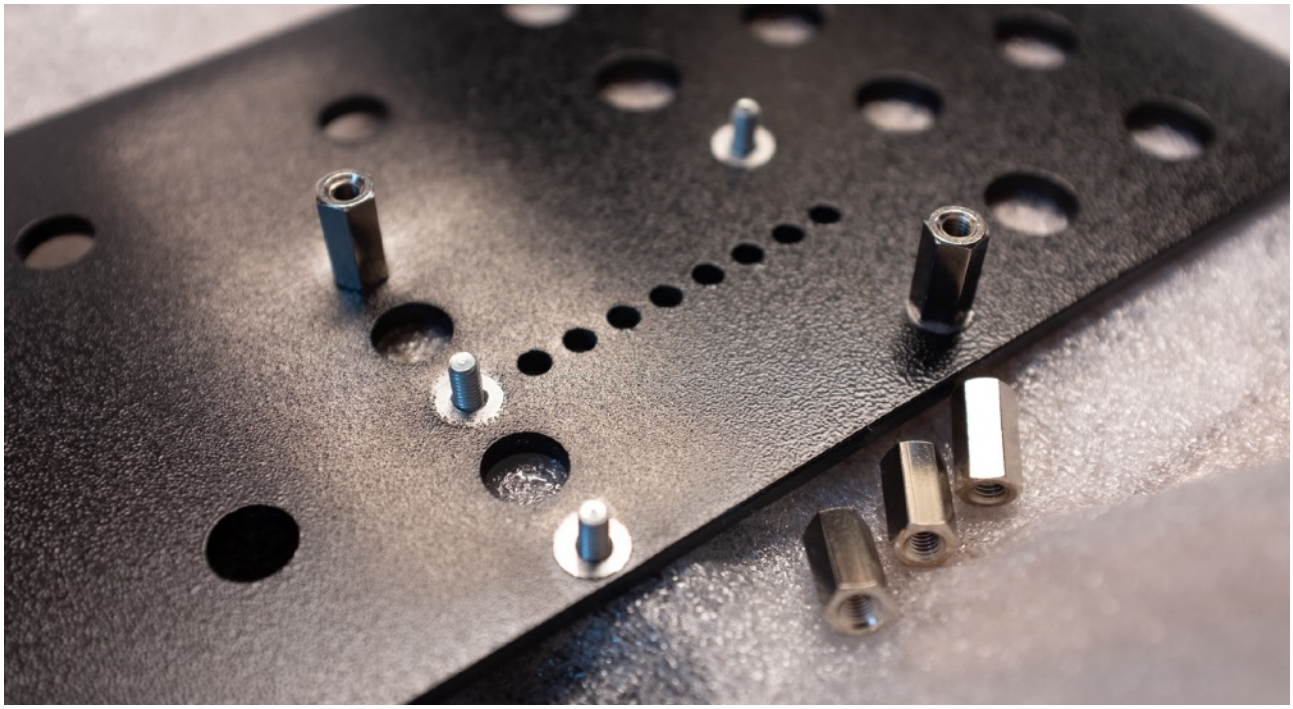


From now on, no clean solder is used.

Solder according to the motherboard to photos on the next page.
VERIFY: use pin number next to the MTA footprint to match the pinout on both sides of the cables.

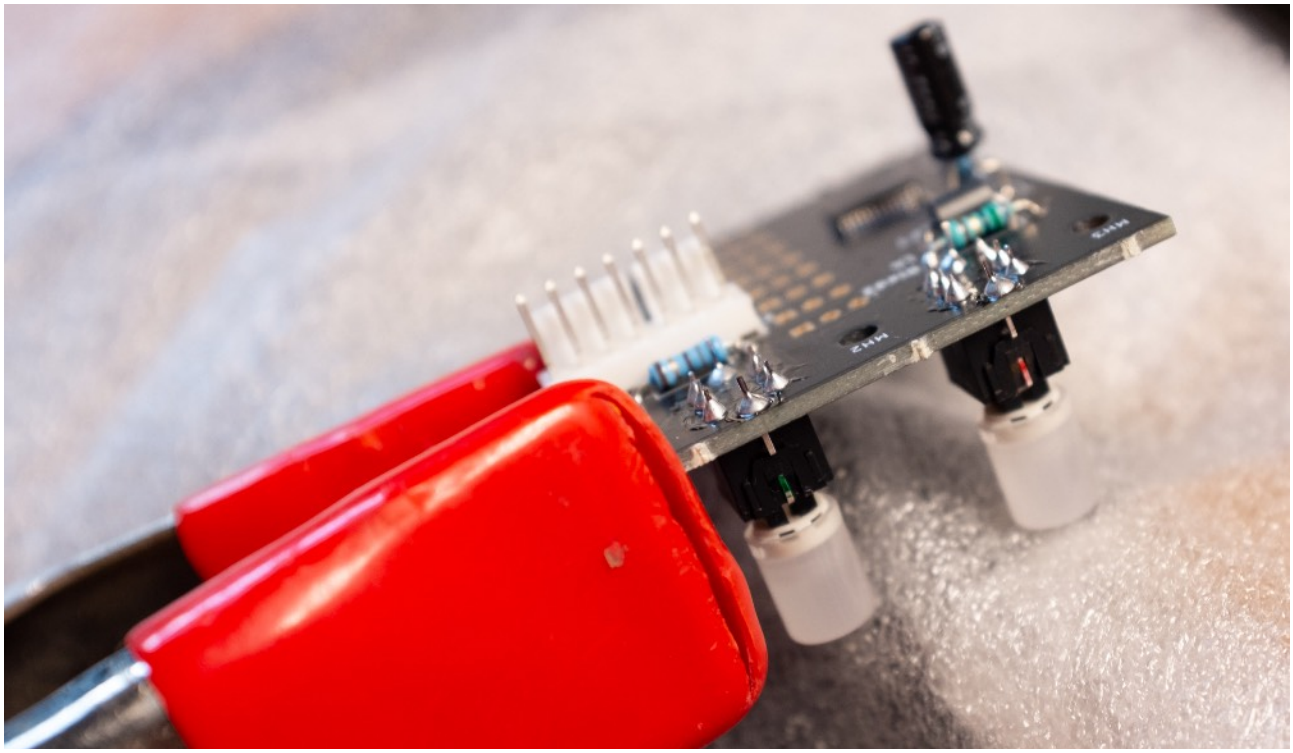
4. Front panel: hex nuts

Fit the five hex nuts to the back side front panel to secure the button/LED board.

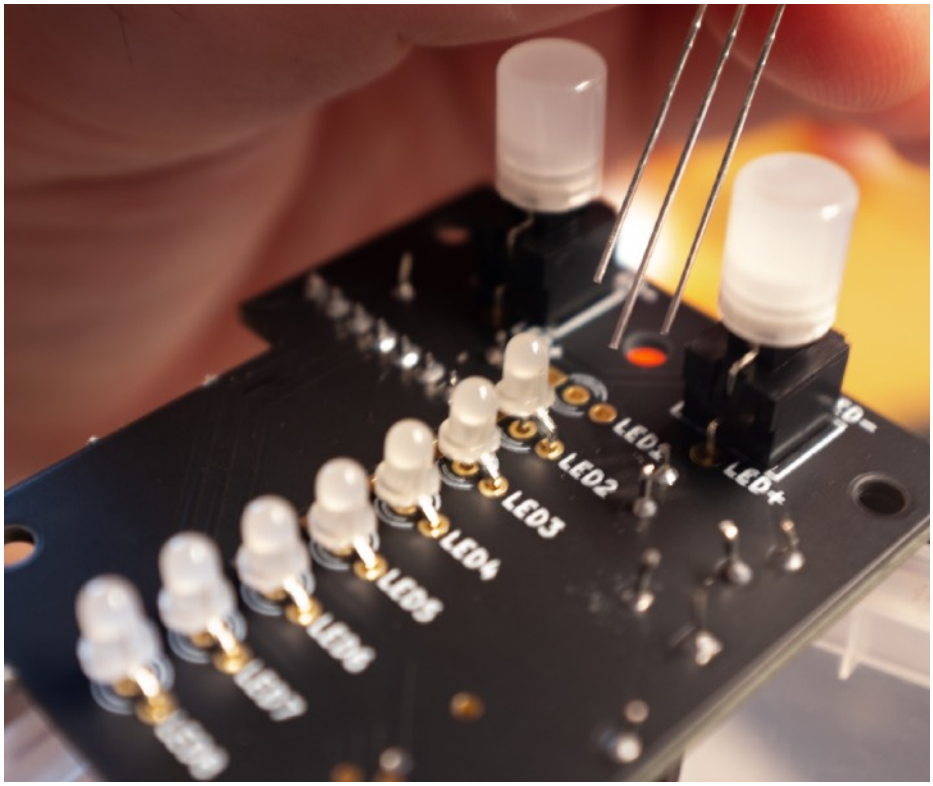


5. Buttons

Solder the push buttons to the LED/button PCB.



6. LEDs and screws

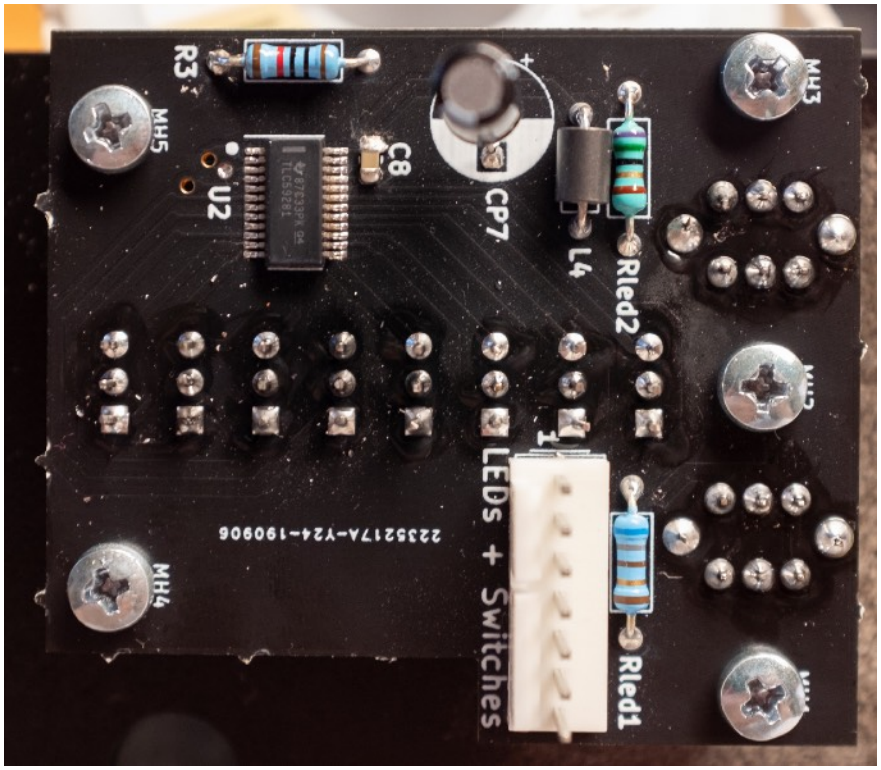


Fit the LEDs through the footprints on the front side of the PCB.
VERIFY: Match the orientation according to the picture (shorted lead goes through the left-most hole).

Put the front panel on top and turn over the sandwich.

Skrew down the two of the screws (MH2 and MH5), then check that the knobs do not touch the holes in the front panel, but can be pressed smoothly before you screw down the rest and re-check.

VERIFY: The knobs do not touch the holes in the front panel, but can be pressed smoothly.



Use your fingers to align the LEDs so that they all fit equally into the LED holes.
Solder one leg each, then double check they're all in their holes, else reflow and correct. Then clip and solder all the remaining legs.

VERIFY: All LEDs are equally and fully through their holes

7. Potentiometers

Using the pliers, break off the little tabs of the potentiometers.

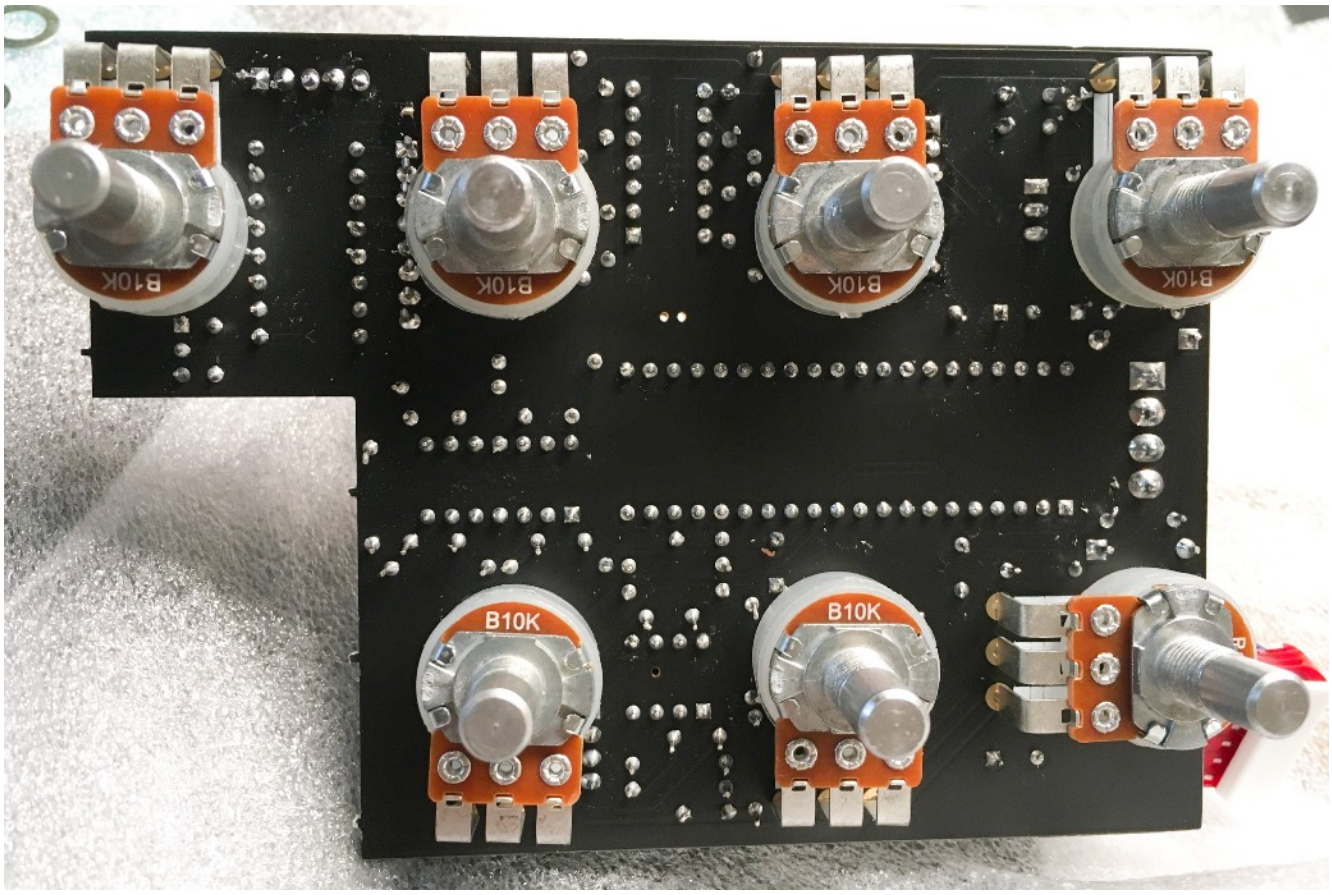
For securing the potentiometer nuts, a tool is recommended that does not scratch the front panel. So do not use a regular wrench, but a hex key tool as in the picture.
10mm is needed for the Alpha potentiometers.

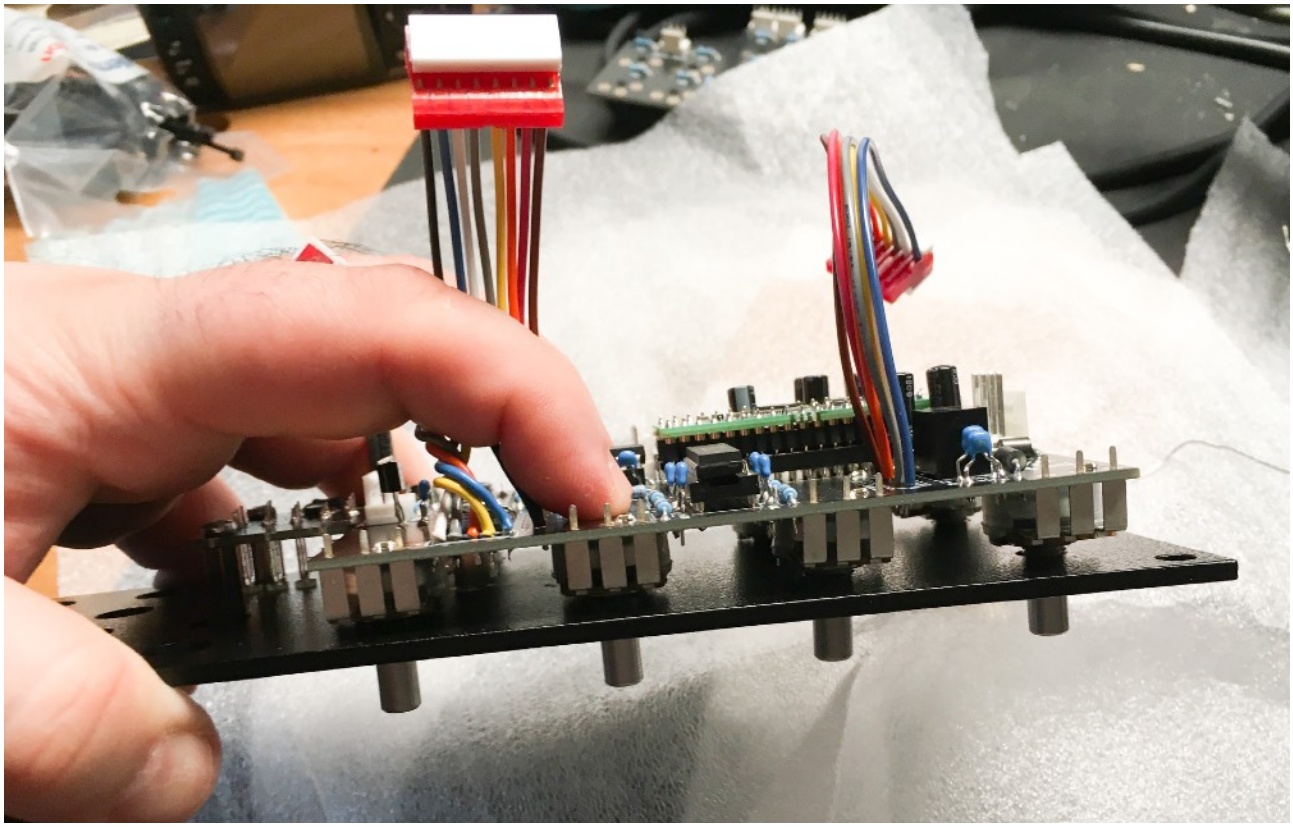
Now flip the PCB again so you can see the potentiometers on the silk screen on top.
Place the PCB on an open cubic box somewhat smaller than the PCB. This will make it easy to lift it up.

Place the 7 potentiometers according to the silk screen image and slide the Panel on top of the potentiometers.

Carefully lift up the sandwich, without allowing the potentiometers to fall out of position,
and press your finger against the middle of the PCB to ensure this.

Place the smooth side of the Alpha washers towards the panel and lock the potentiometers with the nuts first by finger, than with the hex key.
VERIFY that they are centered before tightening them down.



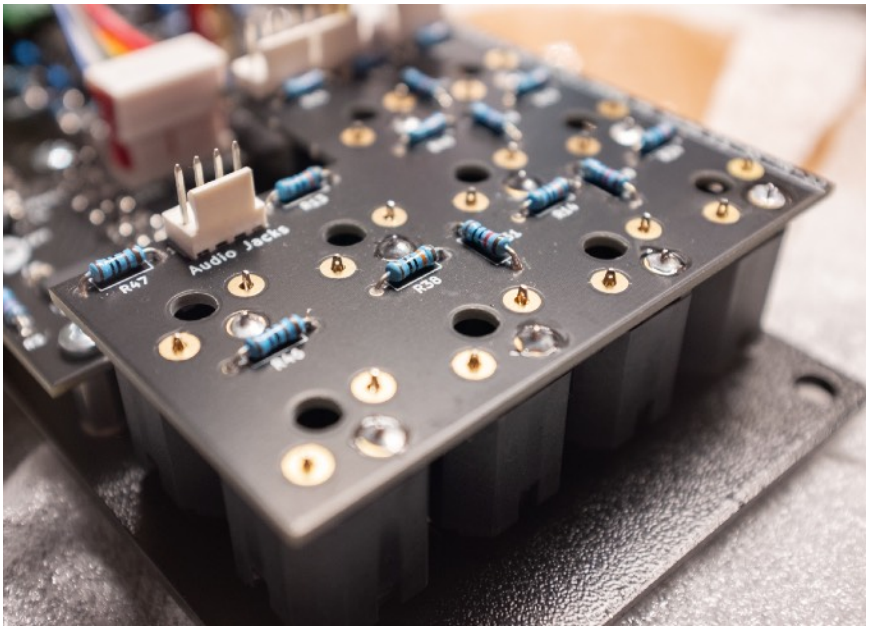



FREQUENCY
0
10
TIMBRE
0
10
HARMONICS
0
10
MORPH
0
10
TIMBRE ATTENUATION
MORPH ATTENU

8. Jack board

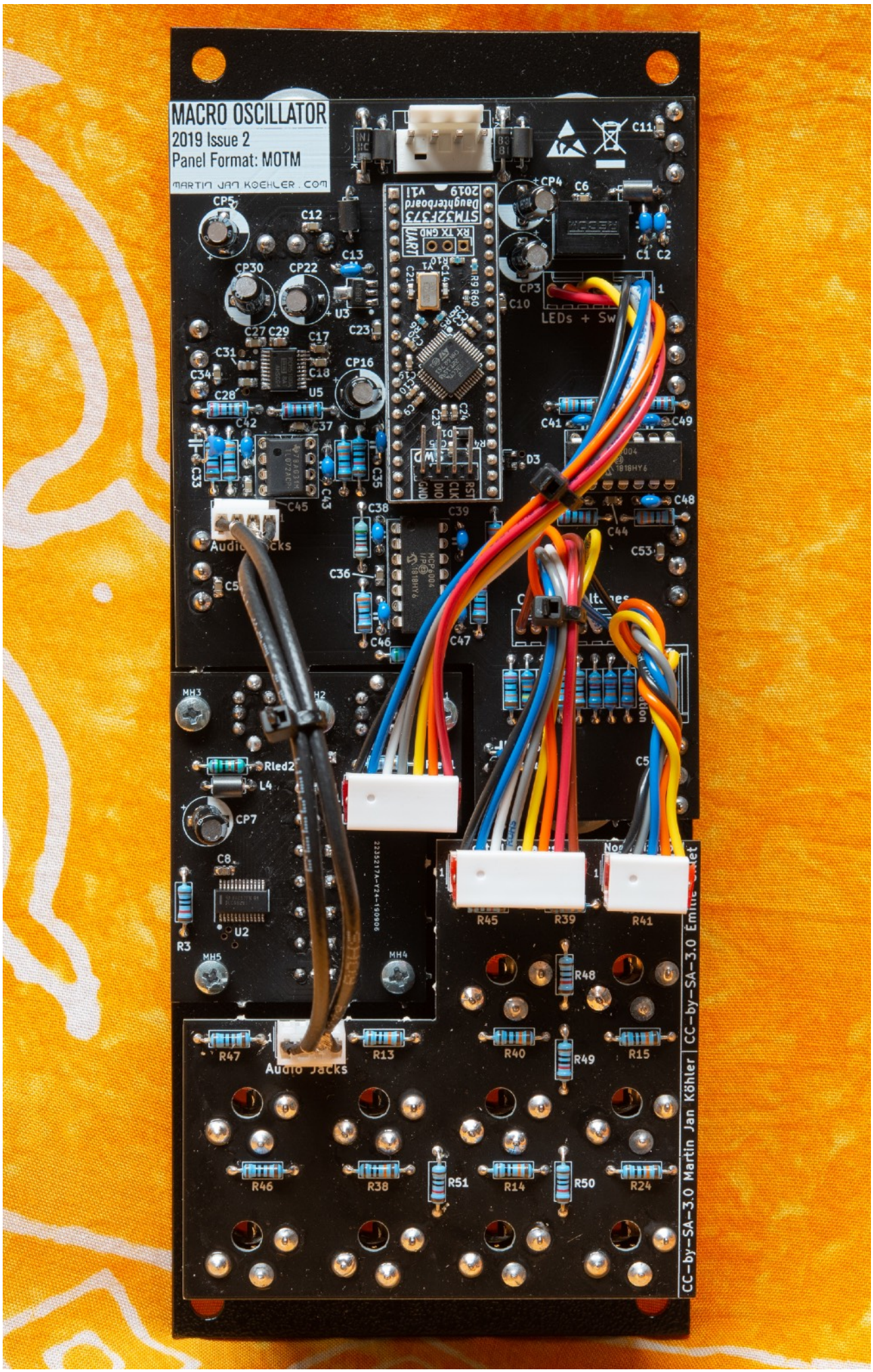
Place the jacks through the jack board.
Then slide the front panel over and carefully use pliers to align them to fit through the mounting holes.

Hold the sandwich in place and flip it around.
Then pin the jacks down in place with a dab of solder on just one pin.
Place the washers (smooth side towards the panel) and tighten down the nuts with a 12mm hex tool.
Start with the middle (FM, V/OCT), then work your way towards the edges.



VERIFY: to conform to MJK's OCD, make sure to align the hex nuts with one corner facing top ;-)

The backside of the finished modules should look somewhat like the photo on the next page.


MACRO OSCILLATOR
2019 Issue 2
Panel Format: MOTM
MARTIN JAN KOEHLER.COM
LEDs + Sw
Audio Jacks
Audio Jacks
R45
R39
R41
R48
R40
R49
R15
R47
R13
R46
R38
R51
R14
R50
R24
CC-by-SA-3.0 Martin Jan Köhler | CC-by-SA-3.0 Emilie Gillet

Tests and Calibration

Set your lab power supply to +15V (current limit 70mA) and -15V (current limit 15mA)
and turn it on and verify that the current limit is not reached (which could mean that there are shorts), and that no parts are getting hot or magic smoke escapes.

After programming the push buttons should cycle through the LEDs, it's normal that the LEDs do strange things at this point before calibration.

Follow the „Calibration Procedure“ from the official manual:
https://mutable-instruments.net/modules/plaits/manual/

1. *Disconnect all CV inputs.*
2. *Connect the note CV output of a well-calibrated keyboard interface or MIDI-CV converter to the V/OCT input. Leave all the other CV inputs unpatched.*
3. *Press both buttons (A). The first LED slowly blinks in green.*
4. *Send a voltage of 1.000V to the V/OCT input.*
5. *Press any button. The first LED now blinks in orange.*
6. *Send a voltage of 3.000V to the V/OCT input.*
7. *Press any button.*

The module should work by now.

In case of issues there's a thread on muffwiggler:
https://www.muffwiggler.com/forum/viewtopic.php?t=216177