BARTON MUSICAL CIRCUITS

Voltage To Rhythm Converter Rev 2

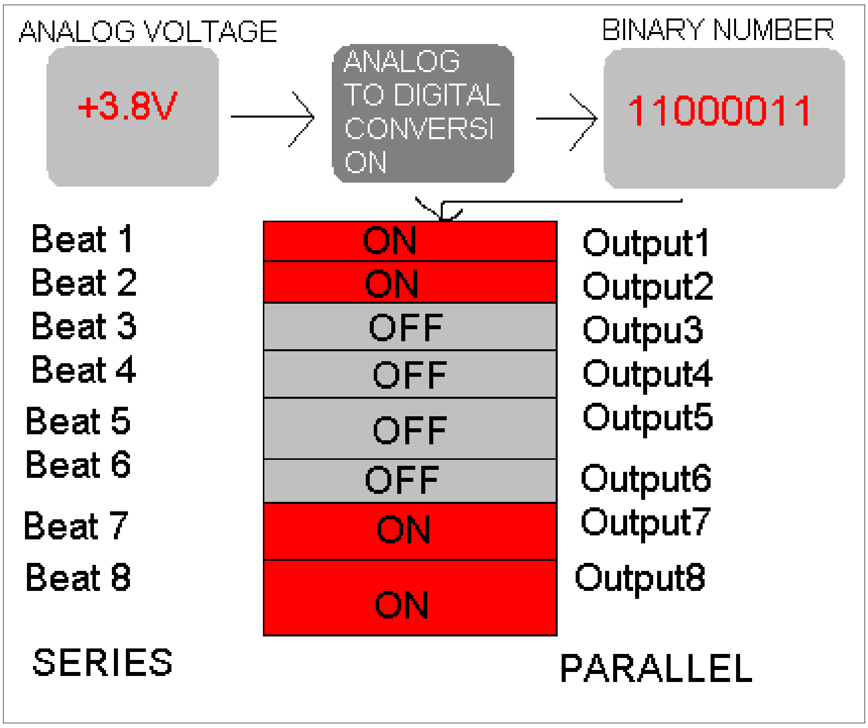
For Rev 1 documentation, click here.

Written October 28, 2022

PCB ERROR NOTICE!

On the Rev 2 top board, the labeling of "V+" and "V-" is reversed on the MOTM style header. Ignore these labels and just look at the outlines of the connectors and you should be fine.

I. What is A Voltage To Rhythm Converter?



A.Voltage->Binary Number-> Rhythm.

This module turns voltages into binary numbers in a two different modes series, and parallel. Both modes utilize analog-to-digital conversion in creating rhythms from beats. In either mode, an input voltage is sampled and converted to an 8-bit binary number. A clock is then applied and on each tick of the clock, the output should change.

In series mode, the input voltage is sampled, converted to binary and then the numbers are cycled through on each clock tick with the 1's represent beats that should be played upon, and 0's represent beats that should be rested upon. An input voltage of 0v will result in all rests. An input voltage of 5v will result in all on-beats. All voltages between 0 and 5v will result in a rhythm that has both rests and on beats. Each output has it's own button and trigger input telling it when to sample the input voltage.

In parallel mode, the binary number is outputted directly to the outputs, and each clock tick triggers a resample of the input voltage. So if the input voltag is at 5v when the clock ticks, all outputs will turn on. If the input is at 0v when the clock ticks, all outputs will turn off.

B. Inputs/Outputs/Controls

INPUTS

1.Sample input - This is the voltage that will be converted into a binary number. This is a DC-coupled input that has it's own attenuater and manual offset, so any input voltage can be used.
2.Clock input - When using an external clock signal, input it here. This can accept trigger, gate or oscillator signals as it's input.
3.Speed cv - When using the internal clock, this is an input for speed control voltage. This voltage will be summed with the manual speed control. When inputting external CV, higher voltages will lower the speed which is counter to how most frequency controls work.
4.Sample Triggers - There are 8 of these inputs, 1 for each output. Only a gate or trigger signal (a signal alternating between 0 and 5V) should be used for this input. When a rising gate or trigger is detected on this input, it will cause the module to resample the input voltage for that output.

OUTPUTS

1.Trigger/Gate outputs - There are 8 of these, one for each channel. These outputs will output either a gate or trigger corresponding to the current input voltage or sampled voltage depending on the mode of operation you are in. Each has an LED corresponding with it's output.
2.Clock output - This outputs a trigger on each new clock. It is active whether using the internal or external clock.

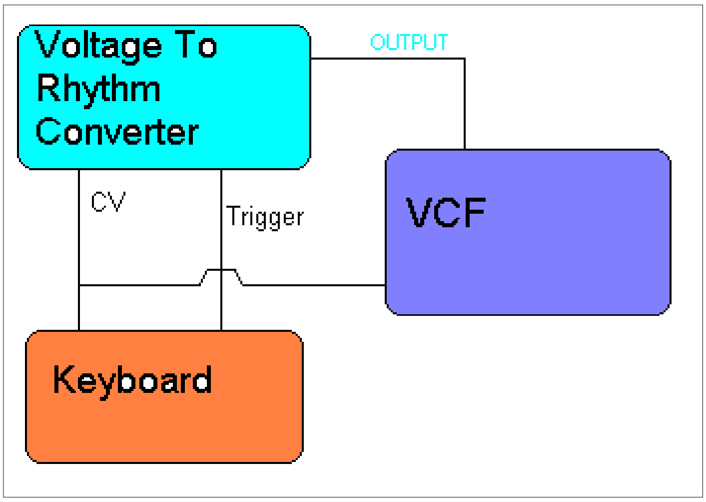
CONTROLS

1.Sample Attenuator and offsetter - These two control knobs condition the external sample voltage. When no external sample voltage is used, the offsetter can be used to manually select the sample voltage. To get the full range of inputs from an input in the 0 to 5v range, like a seqeuncer, turn the offset knob fully counter clockwise and the attenuater fully clockwise. To get the full range of inputs from an input in the -5V to +5v range, like an LFO, turn both knobs to be halfway up.
2.Speed - When using the internal clock, this controls it's speed.
3.Sample buttons - There are 8 of these, one for each output. Pushing one of these while in series mode will cause that output to resample the input voltage.
4.Parallel/Series switch - This switches between series and parallel modes of operation.
5.Trigger/Gate switch - This switch determines whether outputs will be triggers or gates. Gates remain on until an off-beat is presented, triggers turn on for 5ms at the start of each on-beat.
6.Divide switches - These switches cause division on the clock signal. One divides by 4 and the other divides by 16. When both are used, this causes a division of 64.

C. Sample Patches

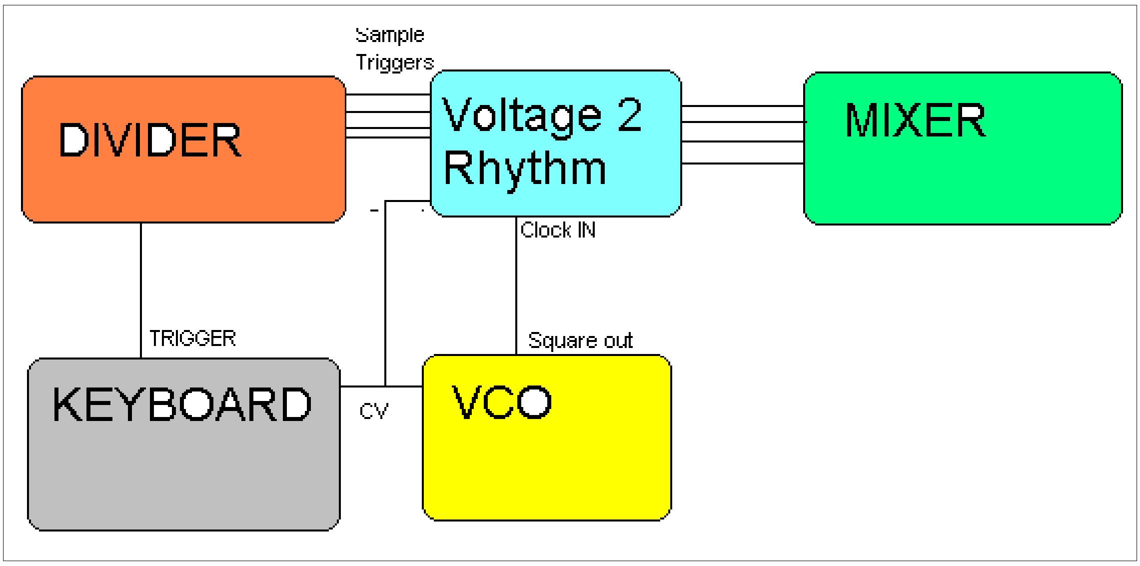
These are just a couple of ideas for patches using the Voltage To Rhythm converter. There are plenty of other uses.

PATCH1



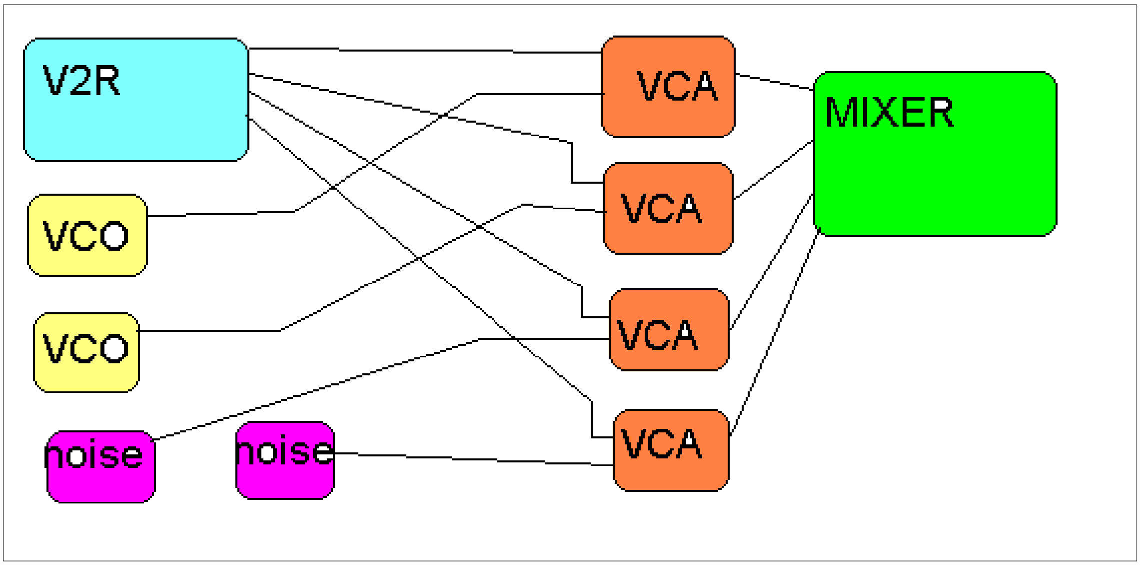
This is the first patch I ever did, when testing the original prototype. The VCF's Q should be cranked so that when the V2R's output is put into it's input, it produces a short, percussive sound. The V2R should be in trigger/series mode. With this patch, each note played will have it's own corresponding rhythm.

PATCH2



This patch gives a constantly shifting timbre. The keyboard's trigger output is sent to a divider's input, and it's outputs are sent to the V2R's sample trigger inputs. The keyboard's CV output is sent to the V2R's sample input, and a VCO's 1v/oct input. The square output of the VCO is sent to the clock input of the V2R. 4 of the outputs of the V2R are sent to a mixer. Each time a note is played on the keyboard, the V2R will resample one of it's outputs, and the clock's frequency will change.

PATCH3



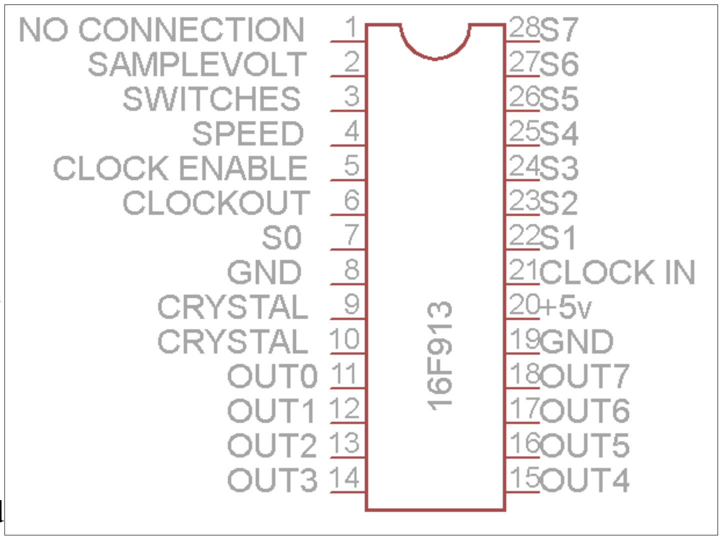
In this patch, the V2R is used as a standalone rhythm sequencer, controlling the on/offs of two VCOs and two noise sources. Very simple, but very satisfying to play with.

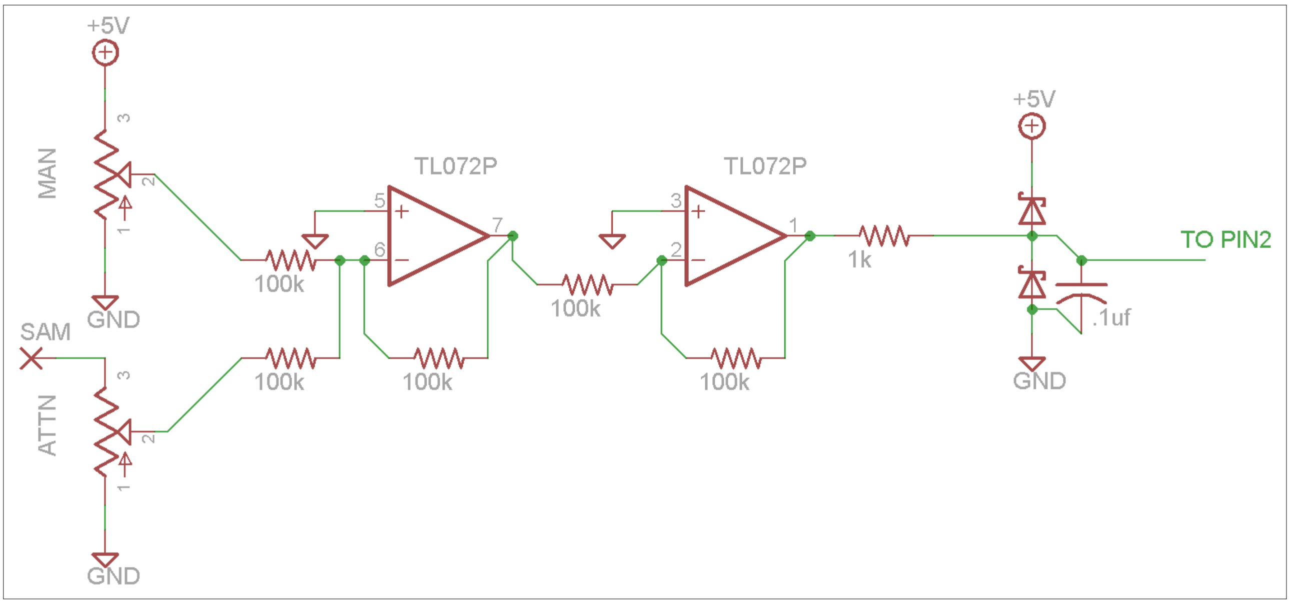
II. Circuit Description/Schematics

A. The Chip

The heart of this design is the 16F913 microcontroller. All other circuits in this section interact directly with this chip, we will look at these sub-circuits one at a time.

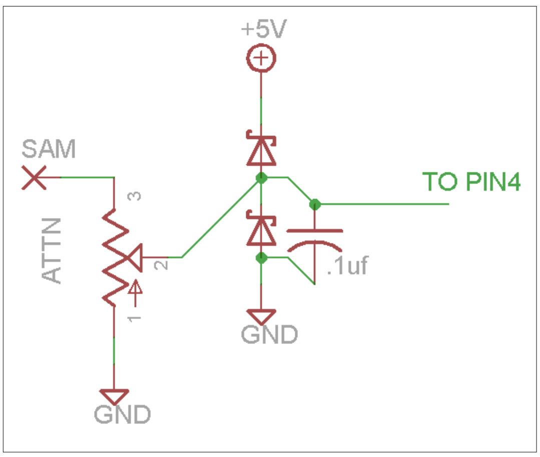
Here is the pinout for the chip. Pins 2-4 are analog inputs which read a variable voltage. Pins 5, 7 and 21-28 are all digital inputs which read either 0 or +5V signals. Pins 11 - 18 and pin 6 are all digital outputs which put out either 0v or +5V. Pins 9 and 10 are connected to a crystal oscillator which maintains the processing clock for the chip. Pins 8, 19 and 20 are all part of the power supply.





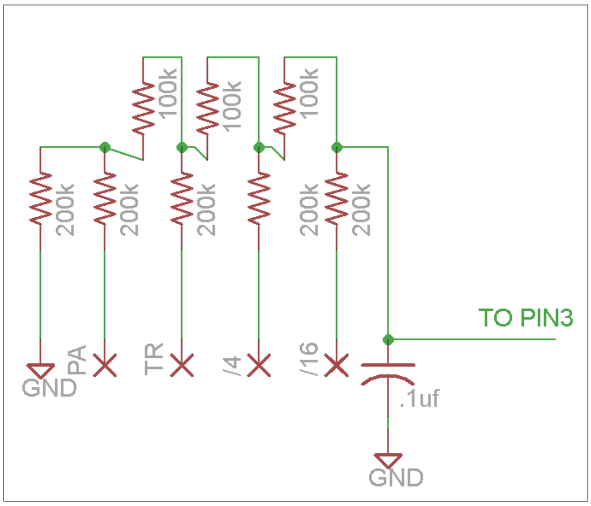
B. Analog Inputs

1. Sample Voltage Input. This subcircuit consists of two potentiometers wired as voltage dividers. The top one, creates the offset voltage for the sample voltage. The bottom one attenuates the input voltage. The 100k resistors and pair of amps form a pair of zero gain inverting op-amp gain stages. The first one is used to mix the two voltages and the second inverts it back to a positive voltage. The 1k resistor and pair of Schottky diodes protect the pin of the microcontroller from negative voltages and voltages above 5v which could damage the chip or cause erratic behavior. The .1uf cap filters high frequency noise out of the input of the chip.



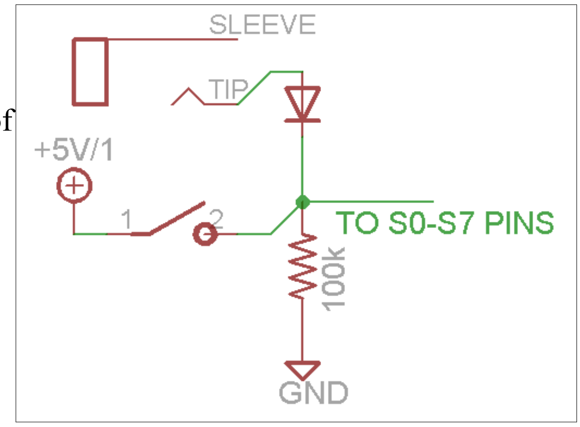
2.Speed. This circuit consists of just an attenuator and voltage protection. The speed input jack should be a switching type normalled to +5V.

3.Switches. This circuit is a text book R/2R Digital to Analog conversion circuit. At first it might seem extremely odd to convert digital inputs to an analog voltage and then send it to an analog to digital converter on the microcontroller, but it is done as an easy way to use one pin on the chip to read several switches at once. This is connected to the Parallel/Series switch, the Trigger/Gate switch and the two divider switches. Each switch should be switching between +5V and Gnd, as you'll see in the wiring diagram section.

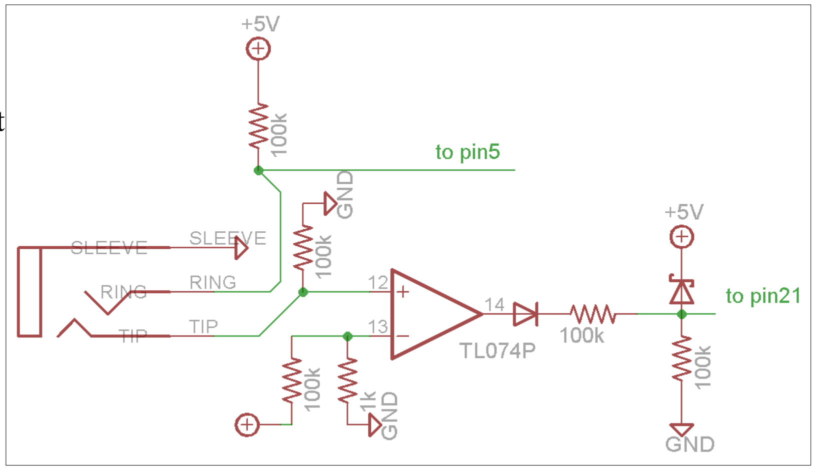


C.Digital Inputs

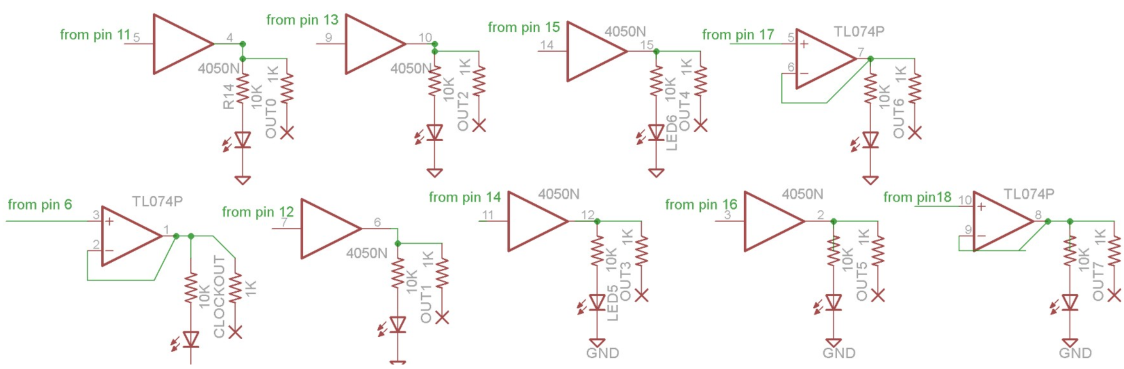
1.Sample Switches This circuit is repeated 8 times, once for each output. The 100k resistor is either part of a single-in-line bussed array or it's a standalone. The 100k resistors keep the input pins of the chip at ground until a gate or trigger is applied to the input jack or the button is pressed. The diode is there to keep the button from interacting with a module connected to the input jack.



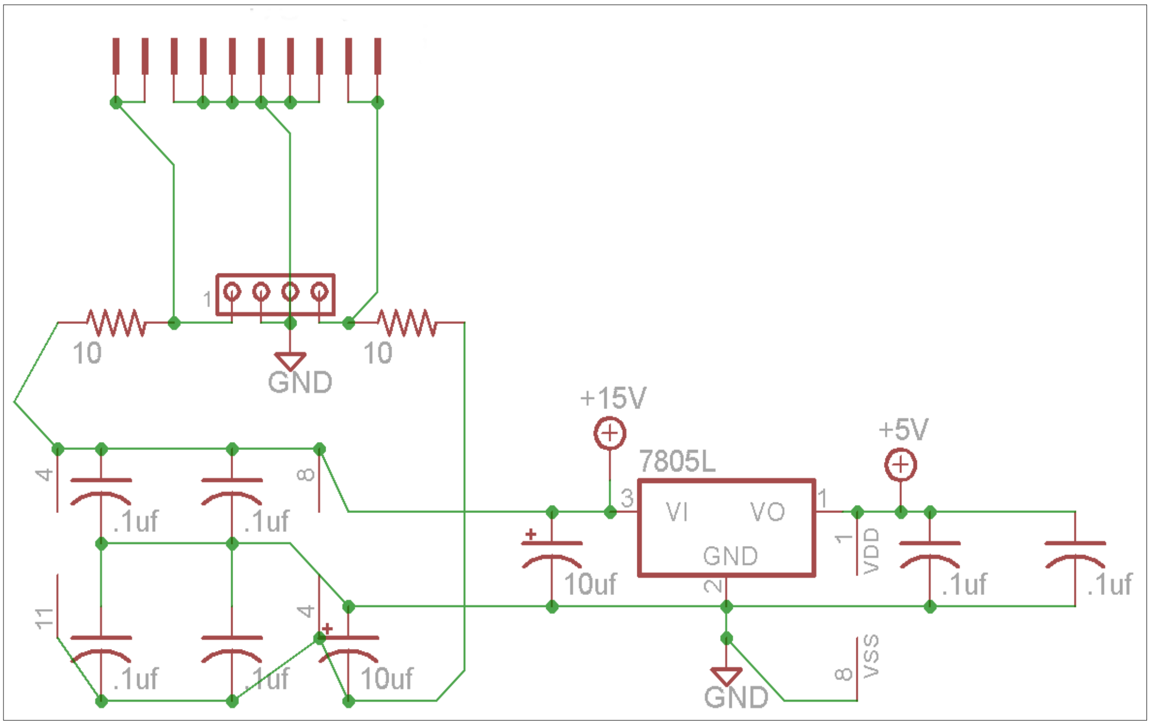
2.Clock Input. Pin5, the clock enable pin, is connected to +5V through a 100k resistor, keeping the clock enabled when no external clock jack is plugged in. When one is plugged in, the sleeve of the jack will connect Pin5 directly to ground. The tip of the jack is connected to a standard 1k and Schottky diode voltage protection arrangement and then sent to Pin21.



D. Digital Output A CD4050 is used to buffer 6 of the 9 outputs, and the final 3 are buffered by some extra op-amps.



E. Power Supply. Here we see two connecters, one for Eurorack and one for MOTM format synthesizer modules. The two 10 ohm resistors and a pair of 10uf electrolytics filter the positive and negative rails of the power supply, and a 7805 provides a +5V supply, which is then filtered with another 10uf. There are additional .1uf caps for the power supply pins of each IC.



F. Board Connection
The new layout uses two PCBs sandwhiched togehter, below is the pinout for the connector to aid in troubleshooting. On the PCB only the first pin is marked with a "1"
1 T0 – T0 through T7 are the trigger inputs, both the pushbutton and external triggers flow through these
2 T1
3 T2
4 T3
5 T4
6 T5
7 T6
8 T7
9 Clock Enable
10 Clock Input
11 Voltage Pot Wipers
12 Toggles out
13 Tempo CV
14 Clock Out
15 Out 0
16 OUT 1
17 OUT 2
18 OUT 3
19 OUT 4
20 OUT 5
21 OUT 6
22 Out 7
23 Ground
24 +5V

III. Construction

A. Parts List

1.Semiconductors

Value	Quantity	Notes
16F913	1	Should come with your PCB
TL072	1	DIP package
TL074	1	DIP package
7805L	1	In To-92 packaging
CD4050	1	DIP package
1n4148	9	Or any other small signal diode
SD101C	3	Or any other schottky
3mm LED	9	

2.Capacitors

Value	Quantity	Notes
.01uf	11	Cheap ceramics, value not critical.
10uf electrolytic	2	
22pf	2	2.5mm lead spacing. Cheap ceramics should work fine.

3.Resistors

Value	Quantity	Notes
10 ohm	2	1/4W metal film for all resistors unless otherwise noted
1Kohm	12	
10Kohm	9	Controls LED brightness, increase value to reduce brightness
100Kohm	12	
200Kohm	5	
B100Kohm Potentiometer	3	9mm PC mount with shaft perpinduclar to PCB, like these.
100K 9 pin bussed resistor array	1	Or use 8x 100K resistors to make your own array

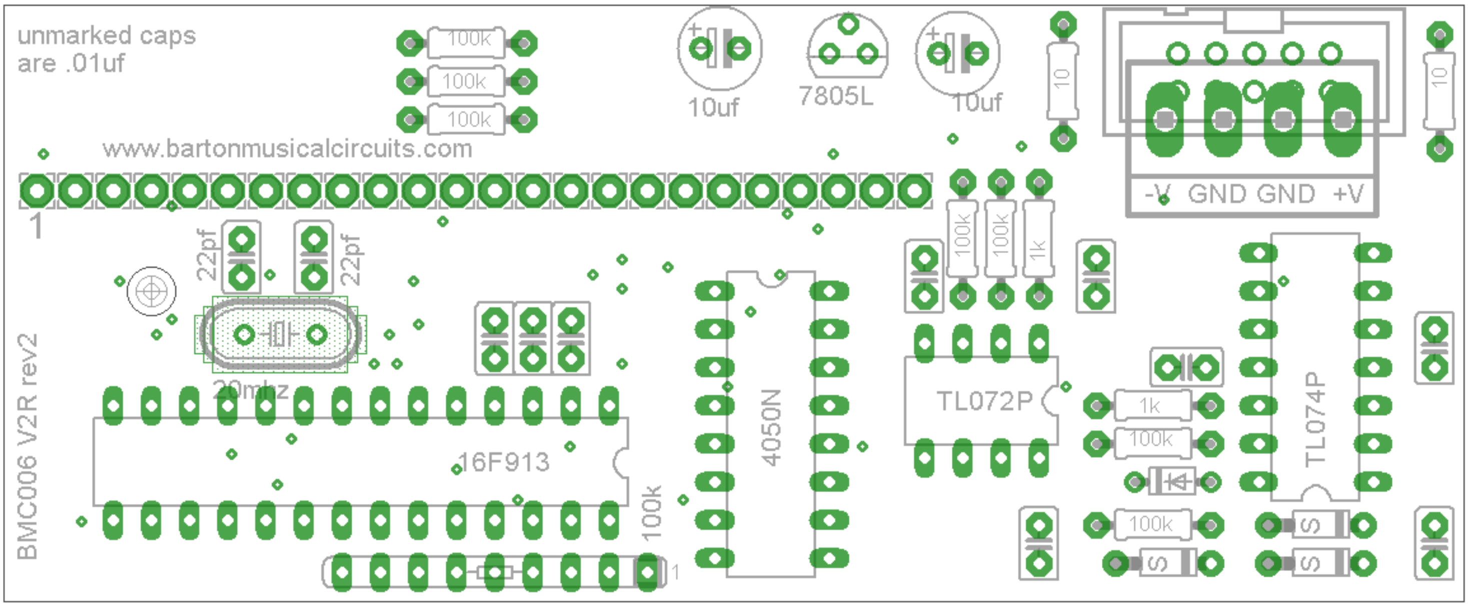
4. Other

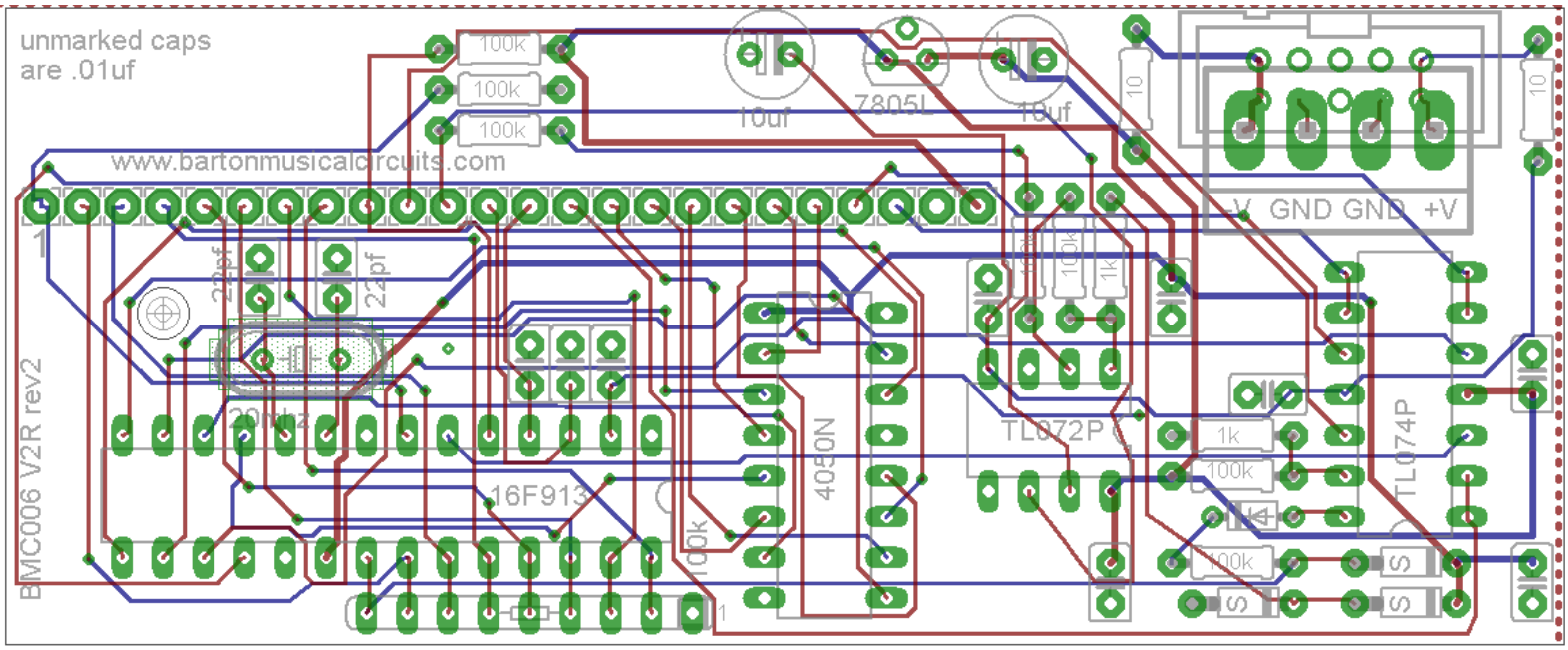
value	Quantity	Notes
20mhz Crystal	1	5mm lead spacing
28 pin Dip socket	1	
8 pin Dip socket	1	
14 pin DIP socket	1	
16 pin DIP socket	1	
Singe row PCB connectors	1	2.54 spacing, one set of male and one set of female, like these and these.

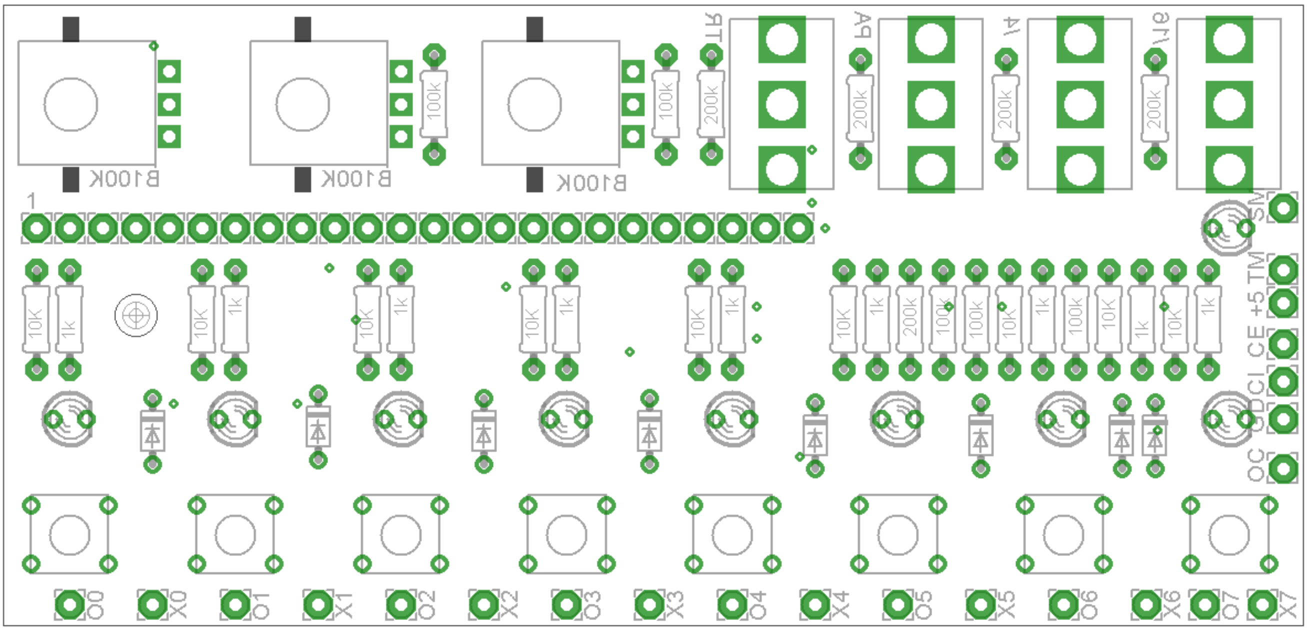
Power connecter	1	either 4 pin MOTM or 10 pin Eurorack
Tactile Switches	8	6x6mm with 13mm shaft NO
Toggle Switches	4	SPDT, mini toggle size
Stereo Jack	1	For Clock Input
Switching Jack	1	For Speed CV input
Mono Jack	18	Stereo or switching jacks can be used as mono jacks.
Knobs	3	For the potentiometers.
Spacer	1	Optional, secures boards together

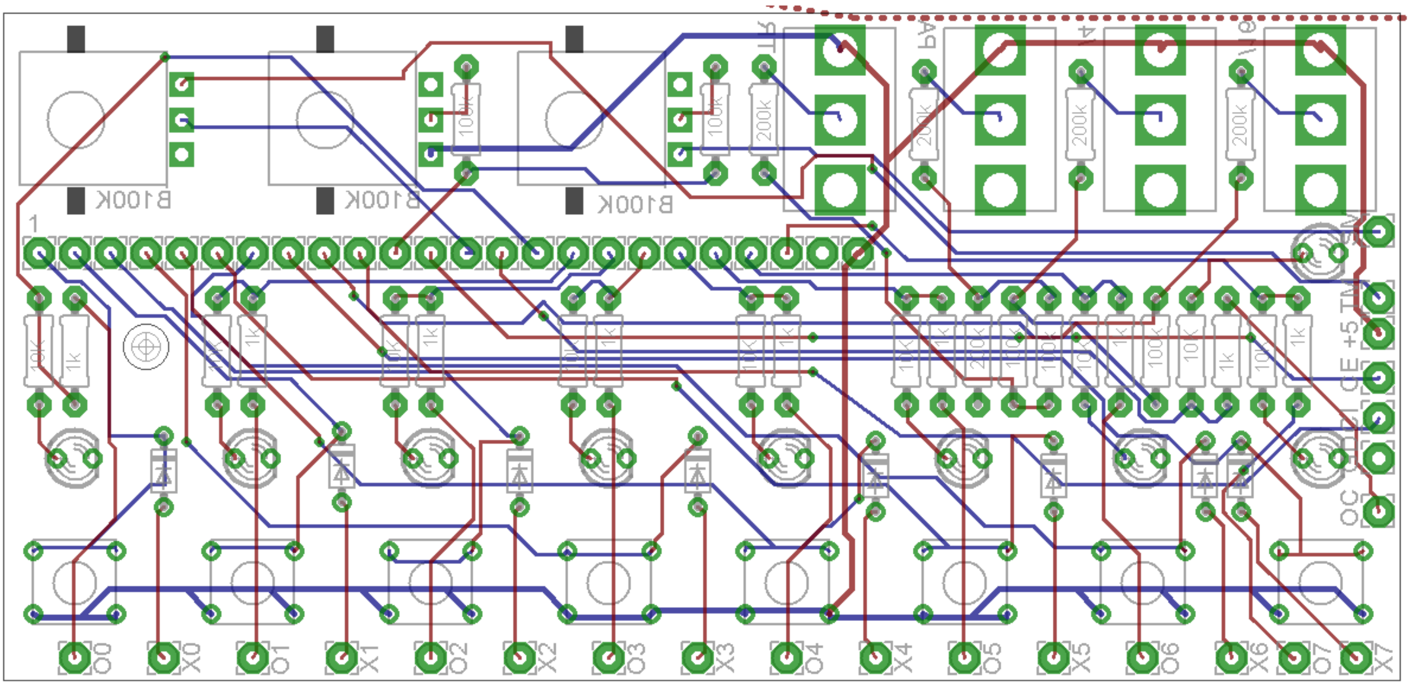
B. The Board

Below, and on the next page. are renderings of the circuit boards. On the renderings with the traces, the ground fill plane is not pictured. This image of the top PCB includes the erroneous markings on the MOTM style power connector. The V+ and V- labels should be reversed.









C. ASSEMBLY ORDER / WIRING INSTRUCTION

When assembling the PCBs, I suggest stuffing/soldering components in the following order:

Top PCB

1. Resistors and diodes
2. Sockets for Ics
3. 20mhz crystal
4. Ceramic Capacitors
5. 7805 regulator
6. Power connector
7. Electrolytic capacitor
8. Connector pins on the bottom of the PCB. I find it easier to use the male pins on the top PCB, but it doesn't matter.

Bottom PCB

1. Resistors and diodes (not the LEDs)
2. Connector pins on top of PCB.

3. LEDs. The bottom of the LED should be ~9mm from the PCB. I usually just solder one of the holes and leave the leads long when initially installing them and then adjust to the final height once I've attached the PCB to the panel.
4. Tactile switches
5. Potentiometers. For potentiometers and toggles, I will just solder one connection initially and then solder the rest after attaching the panel. This puts less strain on the part/PCB if the holes on the panel are a little bit off.
6. Toggles.

Final Assembly, Wiring.

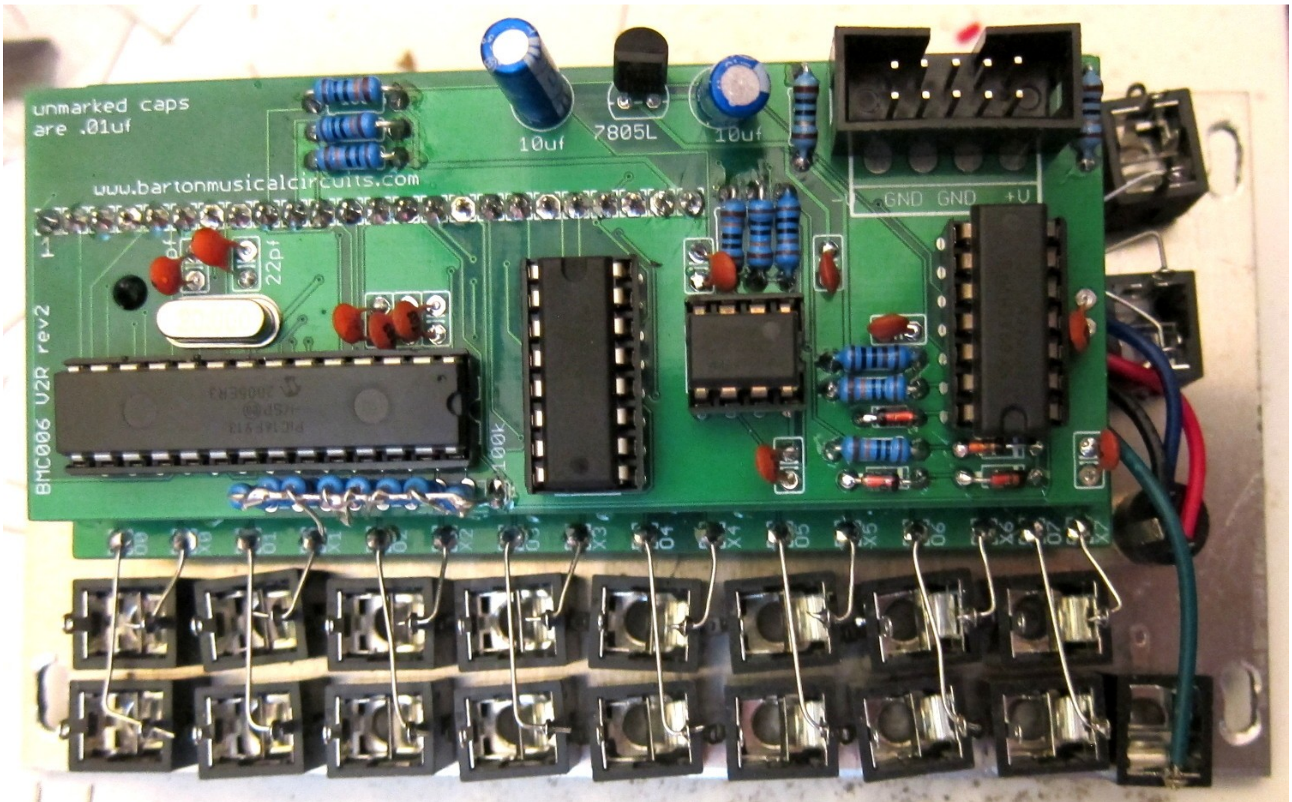
1. Attach the bottom PCB to the panel. Unscrew the nuts on the pots/toggles and place them through the panel. When doing this, flip all your toggles the same way. Then reattach the nuts.

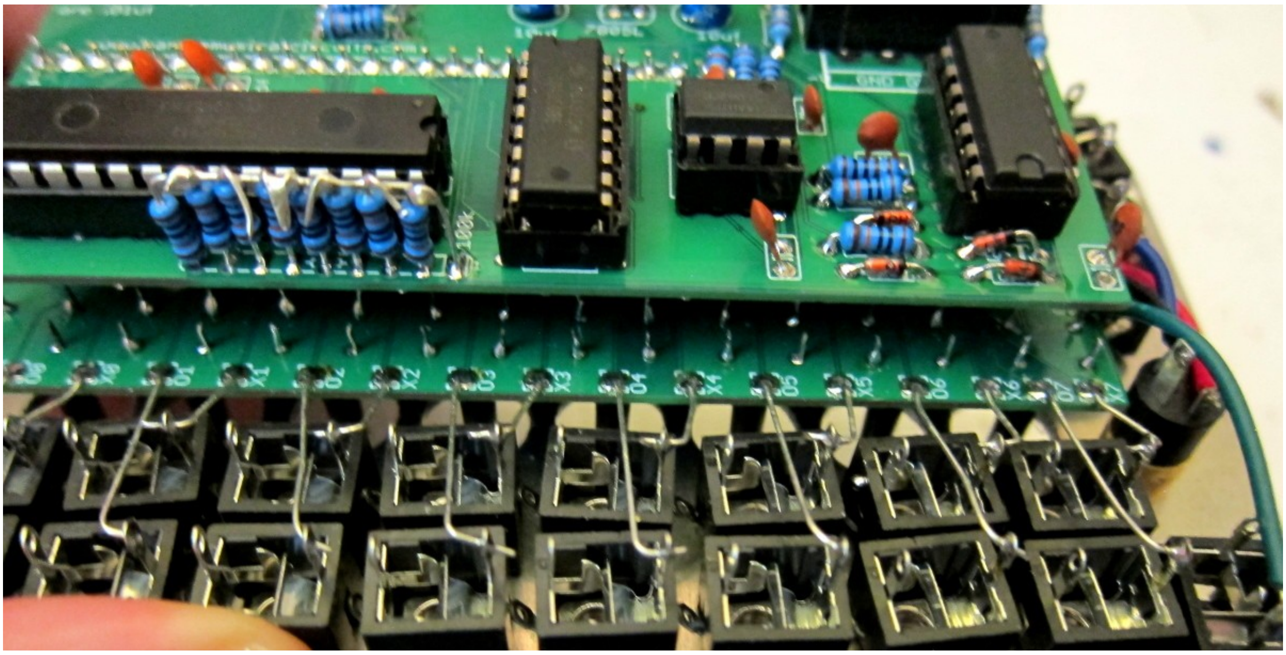
2. After attaching the bottom board to panel, I'll retouch the soldering for toggles/pots, and then adjust the height on the LEDs. I adjust it by heating the solder joint while gently pushing down on the lead to push the LED in place, then I solder both holes and trim the leads.

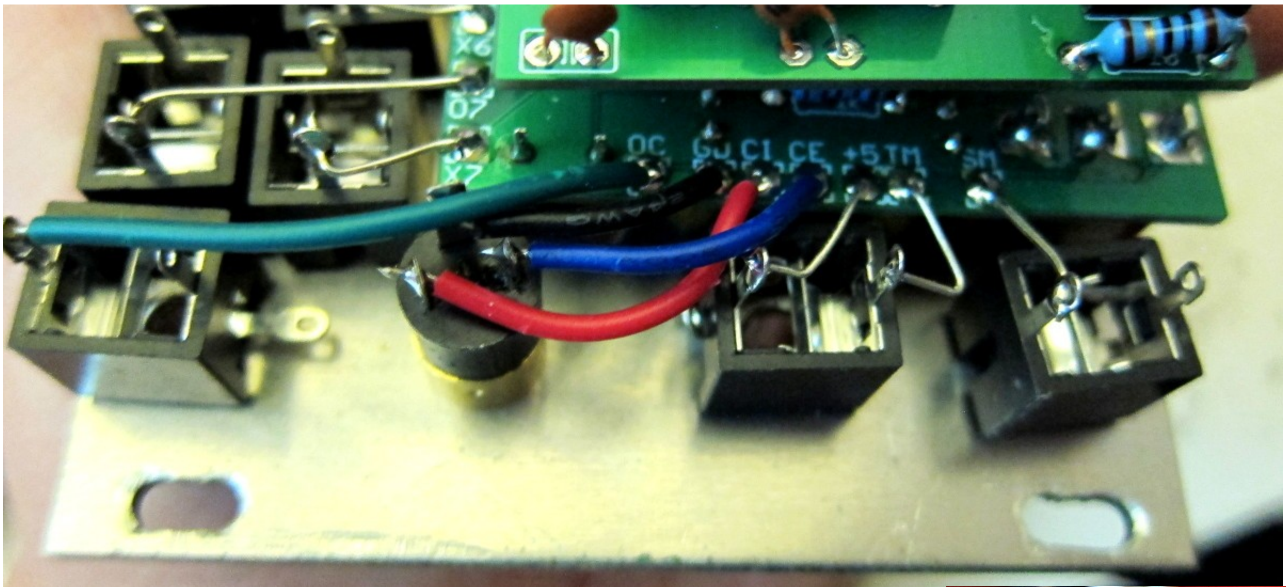
3. Attach all the jacks to the PCB.

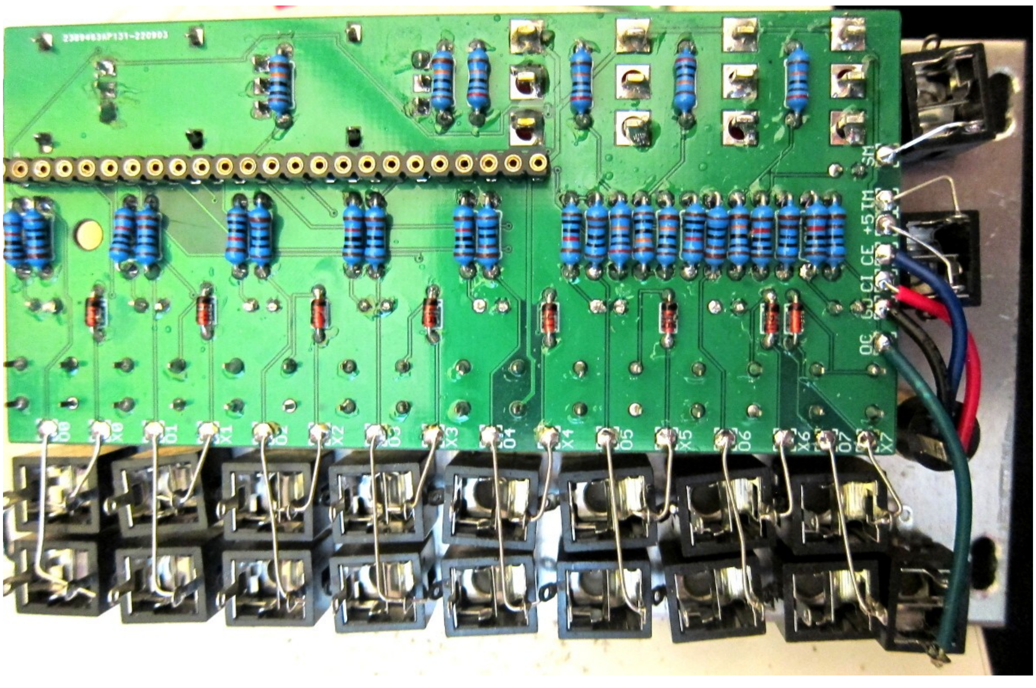
4. Wire the jacks to the PCB. The wirepads should be connected as follows:
X0-X7 - External trigger inputs, they go to the tips of the sample trigger inputs jacks.
O0-O7 – Outputs, these pads connect to the tips of the output jacks.
OC – Clock output, this connecst to the tip of the clock out Jack
GD – Ground, this connects to the sleeve of the clock input jack. If you're using a non-conductive panel, you may want to first connect the sleeves of all jacks to ground everything.
CI – Clock input, wire this to the tip of the clock input jack.
CE – Clock enable, wire this to the ring connector of the clock input jack.
+5 - +5V supply, wire this to the switch of the speed/tempo jack.
TM – Tempo CV, wire this to the tip of the speed/tempo jack.
SM – Sample CV input, wire this to the tip of the CV Input jack.

Below and on the next page are some pictures of a completed module for reference:






X6
O7
X7
OC
CI
CE
+5TM
SM



D. Calibration

Calibration is unnecesary for the V2R, but if you want to adjust the length of triggers when in trigger mode, this can be done by doing the following steps.

1.With the unit powered off, adjust the Speed knob to set length. The further counterclockwise, the longer the trigger.
2.Hold down S0 (usually the bottom pushbutton) while you turn the unit on.
3.The PIC will read the position of the knob, record it and save this as the new value for trigger length. You do not need to repeat this process on power up.