Ammeter Clock

Information

and

Assembly Guide

Sleepy Pony Labs

sleepyponylabs.com

Document Revision **1** for Board Revision **1 & 2**

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https://sleepyponylabs.com/

Introduction

Welcome and thank you for purchasing the Ammeter Clock soldering kit from Sleepy Pony Labs! The Ammeter Clock is a controller board that can be connected to a set of ammeters (analog or digital) to turn them into a clock.

This kit is a fun weekend project that contains both through-hole and SMD parts to solder, and you can learn how logic chips could be used to build a clock, as well as how we use MOSFETs to control the current flows.

This kit also has an optional front panel for analog ammeters made from aluminum PCB available for order as well. Please check on the store page or contact me for more info.

Specifications

- **PCB board:** Blue FR4 board of size 100x100mm
- **Parts count:** 158 pieces
- **Power supply:** 5v DC adapter, 5.5x2.1 mm, center positive (not included)

- **Soldering Difficulty:** 6/10
- **Soldering Type:** THT and SMD, smallest pitch 0.8 mm

- **Firmware parts:** None

Unpacking List / Bill of Materials (BOM)

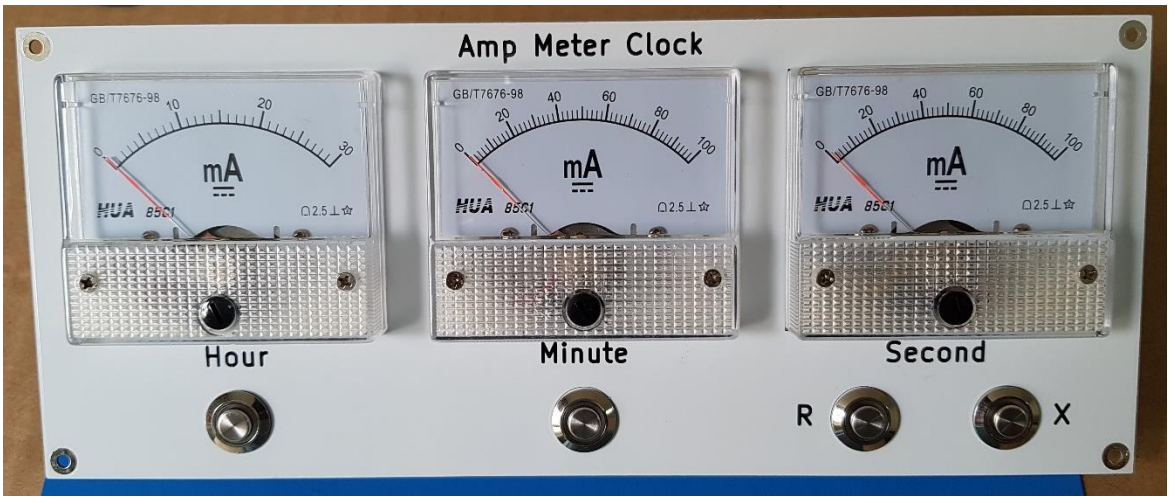
References	Description	Quantity
C1 – C11	100nF Ceramic Capacitor	11
C12, C13	22pF Ceramic Capacitor	2
C14 – C16	1uF Ceramic Capacitor	3
C17	470uF Electrolytic Capacitor	1
R5 – R7, R13 – R15, R21 – R23, R26 – R28, R31 – R37	100 Ω Resistor	19
R1 – R3, R8, R16, R20, R24, R25, R29, R30	4.7 kΩ Resistor	10
R10 – R12	2.2 kΩ Resistor	3
R17 – R19	1 kΩ Resistor	3
R4	470 kΩ Resistor	1
R38	100 kΩ Resistor	1
R9	10 MΩ Resistor	1
RN1 – RN6	4.7 kΩ Resistor Arrays	6
RV1 – RV19	1 kΩ 3362P Trimpot	19
D1	ZMM6V2 Zener Diode	1
D2 – D7	LL4148 Diode	6
D8 – D27	White LED	20
U1	CD4027 Logic IC	1
U2, U3	CD40106 Logic IC	2
U4, U5	CD4081 Logic IC	2
U6	CD4060 Logic IC	1
U7, U9	CD4510 Logic IC	2
U8, U10, U11	CD4516 Logic IC	3
Y1	32.768 kHz Crystal	1
Q1 – Q19	2N7002 N-Ch MOSFET	19
Q20	NCE30P12S P-Ch MOSFET	1
SW1 – SW4	SMD Tactile Switch	4
MES1 – MES3	2P Screw Terminal	3
J1	THT DC Jack (5.5x2.1mm barrel)	1
-	14-Pin IC Socket	4
-	16-Pin IC Socket	7
	Total	158

Note: High-Resolution image of the PCB is on page 20.

Note: We strongly recommended that you use the interactive BOM during unpacking and assembling. It will make your life much easier. It is available here:

https://www.sleepyponylabs.com/ibom/html/ibom_ampmeter_clock_rev_1.html

Optional Aluminum Front Panel



If you bought an aluminum front panel from us, you will need additional hardware parts to buy that is not included with the front panel. You can buy them from AliExpress or Amazon.

Description	Example Products Link	Quantity
9.8"X 7.5" X 4.3" Enclosure Box	aliexpress.com/item/1005002824192439.html	1
85C1 Ammeter (30mA)	aliexpress.com/item/32964135859.html	1
85C1 Ammeter (100mA)	aliexpress.com/item/32964135859.html	2
12mm Push Button	aliexpress.com/item/1005002416736155.html	4
Panel Mounted DC Jack	aliexpress.com/item/32259883750.html	1

Assembly Guide

The general guide in soldering anything is to solder components with the lowest profile (least in height) first before soldering other taller components.

This guide sums up my experience in soldering the board during the testing. Follow the steps here to reduce possible problems.

Note: Before we proceed, since this kit contains SMD parts, I would like to give some recommendations first.

- Be careful while unpacking. Remove parts from their tubes/tapes ONLY when you need it and be careful while doing so. SMD parts are very hard to identify and easy to lose after they leave their packaging.
- Conical tip that comes with most soldering iron will not work well with SMD (or anything really). I recommended you get a horse hoof tip (Hakko type C) or a chisel tip (Hakko type D) because these will transfer heat better, act as a reservoir for solder which you can use to both add and remove solder from a joint and allow you to perform neat tricks such as drag soldering.
- Make sure you have all the tools needed. At the minimum, I suggest you have a temperature-controlled soldering-iron, a tweezer, good brand of solder, flux, and solder wick. Do NOT use eBay junk please.
- SMD pads are small and easier to break than through-hole counterparts. Use temperature between 350-400 Deg Celsius while soldering and do not hold your iron on the pads too long because that is how you lift them off. If the solder bridge between pads, a lot of flux and solder wick helps. You might find a soldering pump easier for you, but from my own experience it has a higher chance of damaging the board.
- While tacking one side down first then solder the other side is a standard practice for parts with two pads, you might find putting a part on the board, applying flux, then use already melted solder on your iron to tack both sides in one go easier. Try and see which way works best for you.
- **Do not afraid to try. We all start somewhere.**

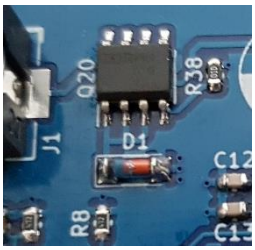
1. MOSFET (SOIC-8)

Align the MOSFET with the pads. The Pin-1 Mark on the chip should match the longer white line on the board. Hold the chip with tape then solder diagonal pins first so it will not move around (pin 4 and 8, or pin 1 and 5). Then solder the rest of the pins.

You might want to check out SOIC/SOP soldering tutorial online first. For example: https://youtu.be/-l5D2em4PBI from Androkavo.

2. MOSFET (SOT-23)

Remove the parts from its packaging onto the board. Flip them so that the right side is up. Solder one pin first to hold in place, then solder the rest of the pins.



3. SMD Tactile Switch

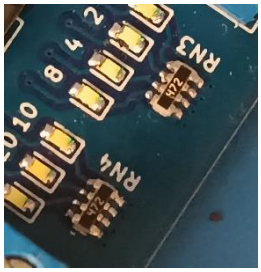
Remove the parts from its packaging onto the board. Flip them so that the right side is up. Align the switch with the pads. Solder one pin first to hold in place, then solder another pin.

Note: If you have a front panel, skip this part.

4. Resistor Arrays (HARD)

Remove the parts from its packaging onto the board. Flip them so that the side with numbers is up. First, put small amount of solder on one corner pad, then use your tweezer to hold the resistor to the pad. Solder that pin and its diagonal pin first so it will not move around. Then solder all remaining pads.

It is very likely that solder bridges will form on these resistor arrays. Just put a lot of flux on the bridge, clean your iron tip, then use it to wipe the legs outward. Any excess solder will be sucked out. Androkavo also made a tutorial video for this: https://youtu.be/omR7QE8H82w



5. Resistor

Remove the parts from its packaging onto the board. Flip them so that the side with numbers is up. First, put small amount of solder on one pad, then use your tweezer to hold the resistor to the pad. Heat the pad up again until the solder flows to the resistor. Finally, solder the remaining pad.

Note: You can touch up with an iron and flux if you have cold joints.

6. Ceramic Capacitor

Remove the parts from its packaging onto the board. Flip them so that they lay flat to the board. First, put small amount of solder on one pad, then use your tweezer to hold the resistor to the pad. Heat the pad up again until the solder flows to the capacitor. Finally, solder the remaining pad.

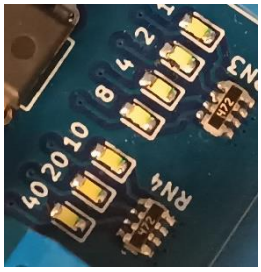
Note: You can touch up with an iron and flux if you have cold joints.

7. LED

Remove the parts from its packaging onto the board. Check the polarity of the LED before you flip it. First, put small amount of solder on one pad, then use your tweezer to hold the resistor to the pad. Heat the pad up again until the solder flows to the part. Finally, solder the remaining pad.

Note: You can touch up with an iron and flux if you have cold joints.

Note: SMD LEDs are fragile. Do not touch the lenses of the LED with your iron or tweezers. Also do not add too much solder.



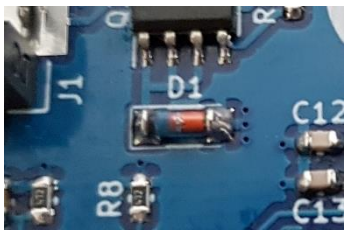
8. Diode (MiniMELF)

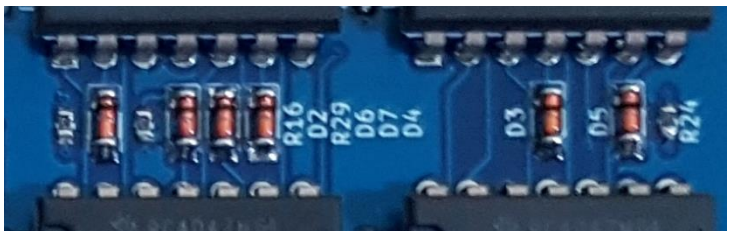
Remove the parts from its packaging onto the board. Check the polarity of the diode first. The side with black or blue line on the glass is the cathode. Align the diode with the pads. The cathode pad is the one with a solid white line.

First, put small amount of solder on one pad, then use your tweezer to hold the diode to the pad. Heat the pad up again until the solder flows to the part. Finally, solder the remaining pad.

Note: You can touch up with an iron and flux if you have cold joints.

Note: MiniMELF diode could easily rolls off the board. Be careful with that.

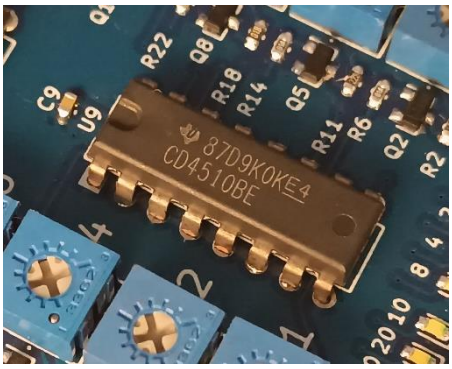




9. IC

First, find the pin 1 mark. It will be a dimple or indent on one side of the chip. Align it with the notch marking on the board. Insert the chip into the holes. Be careful not to break any pin. Hold it in and solder two diagonal pins (for example, pin 1 and 8, or pin 7 and 14), then solder the rest of the pins.

You might also want to add IC sockets so you could easily remove the chips later. Solder the sockets first before installing the chips.



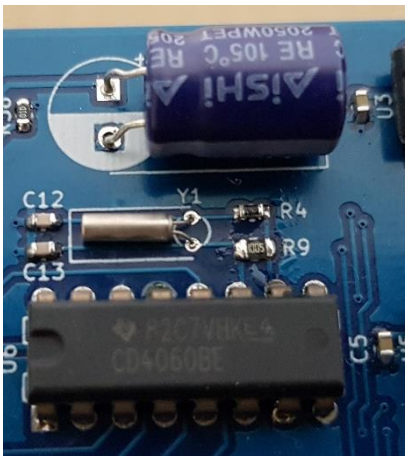
10. Crystal

Insert it through the hole and bend it down according to the silkscreen. Hold it with tape the solder it. There is no polarity.

11. Electrolytic Capacitors

Insert it through the hole and be careful of the polarity. Hold it with tape then solder them.

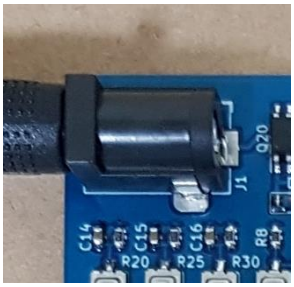
Note: The white stripe on electrolytic capacitors denotes the <u>negative</u> pin.



12. Barrel Jack

Insert it through the hole. Hold it with tape then solder it.

Note: If you have a front panel, skip this part.



13. Screw Terminal

Insert it through the hole. Hold it with tape then solder it.

How to Use

First Power Up

On the first power up, the LED indicators will light up randomly due to the POR (Power-On Reset) condition of the logic chips. Pressing the R button (Reset) should clear the counters and turn all of the LEDs off.

If one or more buttons doesn't work, check U3 (CD40106).

Now we will move onto testing the clock signal. Without pressing any buttons, the CLK LED should blink once a second. Holding the X button (Clock Halt) should turn off the CLK LED until the button is released.

If the clock does not work, check U6 (CD4060) and crystal circuits.

If the clock is working correctly, we will test the counters next.

- Without pressing any buttons, the LEDs in the seconds group should count from 0 to 59 then overflows to minutes group.
- Hold the M (Minute) button, the LEDs in the minute group should count from 0 to 59 then overflows to hours group.
- Hold the H (Hour) button, the LEDs in the hours group should count from 0 to 23 then overflows to zero again.

If the counting sequence or overflow are incorrect, refer to the schematics and check the chips in that section.

Now, if your ammeters are analog, adjust the needle on the meter to zero first by turning the screws in the front. Connect the output ammeters for the hour, minute, and second groups to the respective screw terminals on the board. The ammeter should move when the counter value (the LEDs) change.

If the ammeter does not work, check the output MOSFETs.

Setting the Output Current Levels

To make sure the ammeters are driven to the correct levels, the potentiometers need to be set up first. The setup is a repetitive process for all 19 potentiometers, and are as follows:

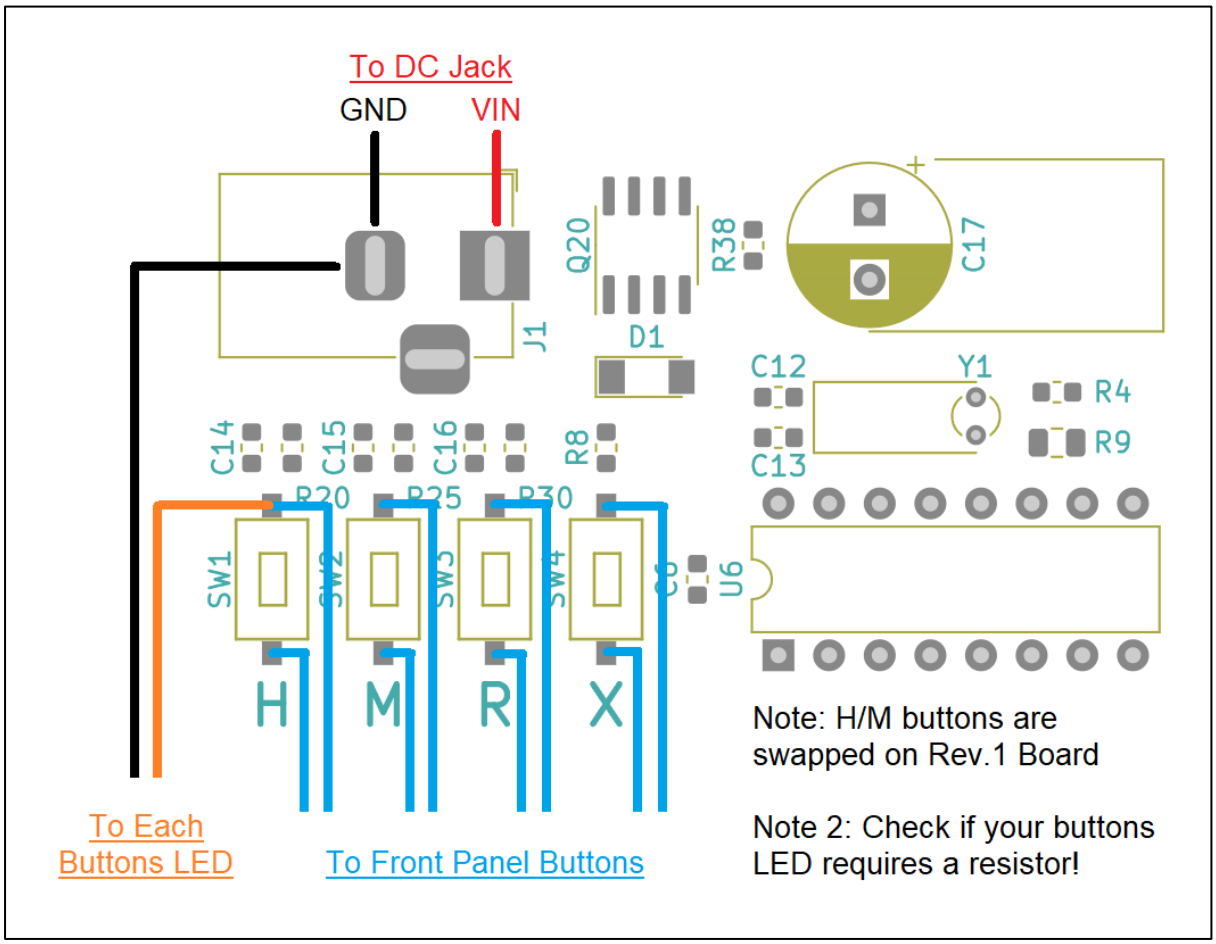
1. Identify the LED that matches the potentiometer to adjust. They will be in the same group and has the same number next to them.
2. Make sure that LED is the only one lit in the group, then hold the X button to halt the clock signal, which will stop the counting.
    a. Hour group: 1, 2, 4, 8, 16
    b. Minute and Second groups: 1, 2, 4, 8, 10, 20, 40
3. For hour and minute groups, you can use the H and M buttons to jump to each position needed.
4. Use a screwdriver to adjust the potentiometer until the ammeter for that group shows the current equal to the number next to the pot (for example 20 mA for the 20 position).

Setting Time & Normal Operation

Use the H and M buttons to set the current time. Then observe if the output ammeter shows correct levels on the hour, minute, and second groups.

Additional Instructions for Aluminum Front Panel and Enclosure

1. Secure the ammeters and the push buttons to the front panel using the hardware included with the ammeters and buttons.
2. Drill a hole in the back of the enclosure box. Install the DC jack with the hardware included with the jack.
3. Mount the board on the bottom of the enclosure.
4. Connect the ammeter inputs to the screw terminals using wires.
5. Connect the front panel buttons to the pads on the board where the SMD buttons are omitted.
6. If your buttons have a built-in LED, connect anode to each top button contacts, and cathode to ground. Don't forget resistors if your buttons require one.
7. Connect the DC jack to the pads on the board where the on-board DC jack are omitted.



Troubleshooting

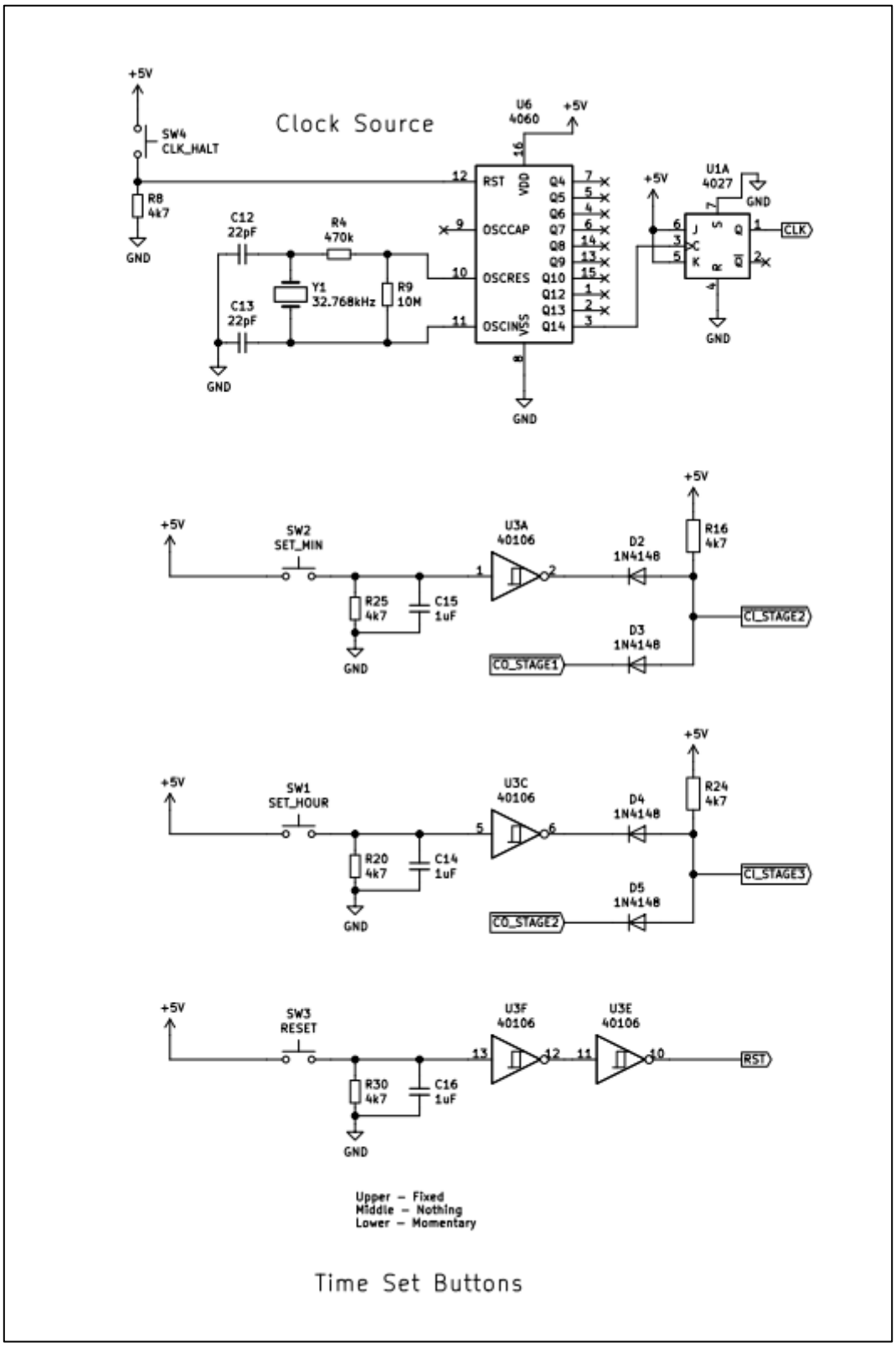
In case your circuit does not work, the list below contains some possible causes of the issue from most likely to least likely:

- Bad solder joints (Cold joints, Short between joints, Unconnected joints)
- Incorrectly installed components (Wrong location or orientation)
- Bad power supply (Battery dry, Wrong type, Wrong polarity)
- Components damaged by soldering heat.
- Components damaged by static electricity or broken from the factory.
- PCB damaged by soldering heat or impact (Broken pads or traces).

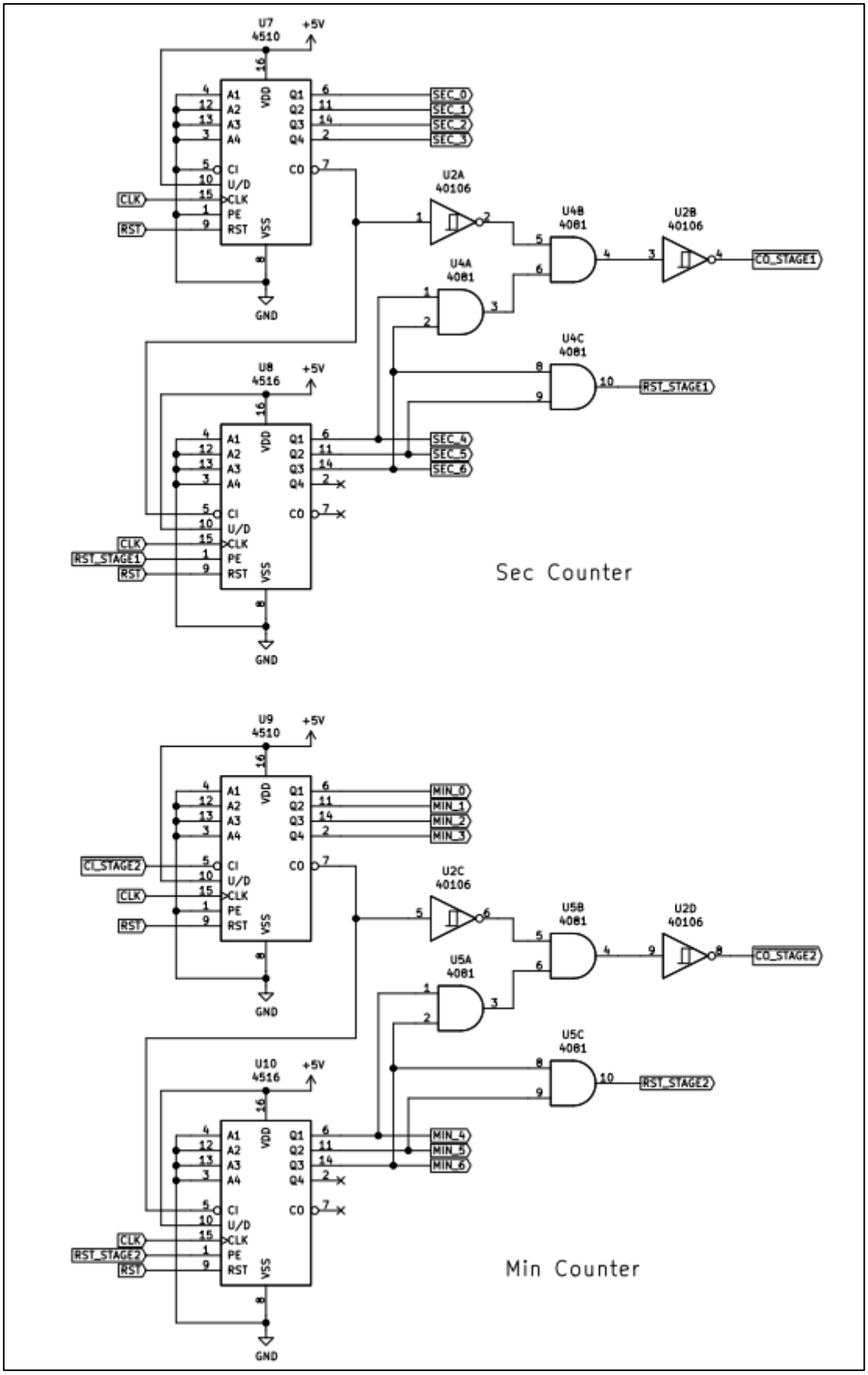
And these are possible causes specific to this kit:

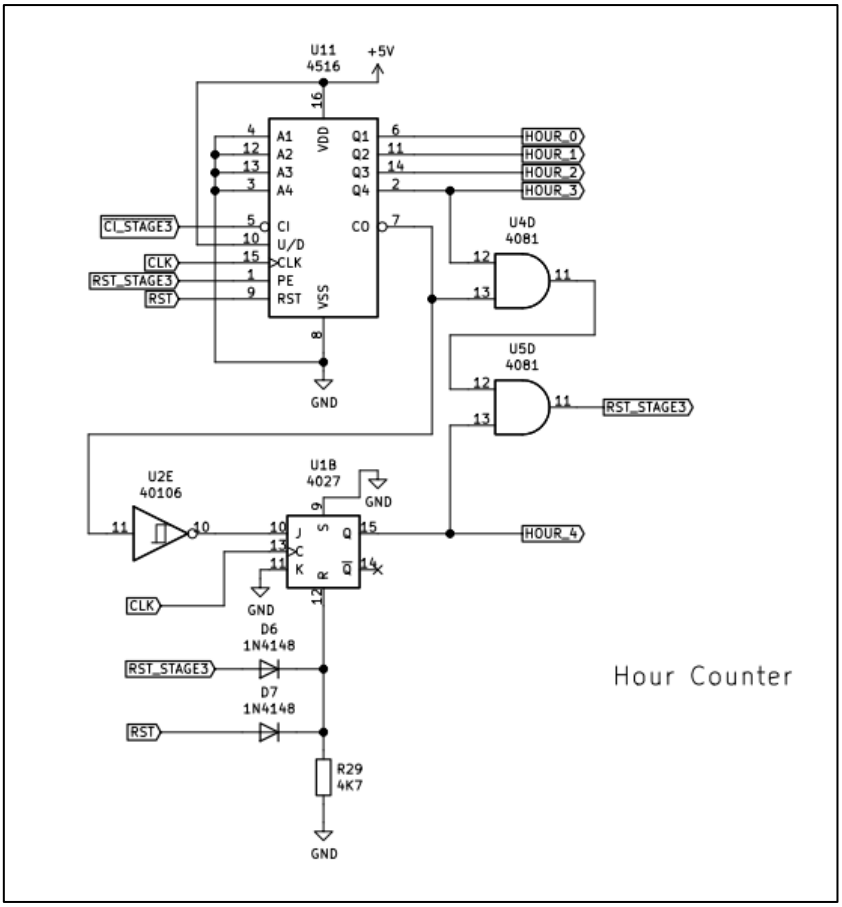
- For board revision 1, there is a mix up between H and M button labels. This does not affect the board's functionality, just keep in mind while connecting the front panel buttons or setting the time.

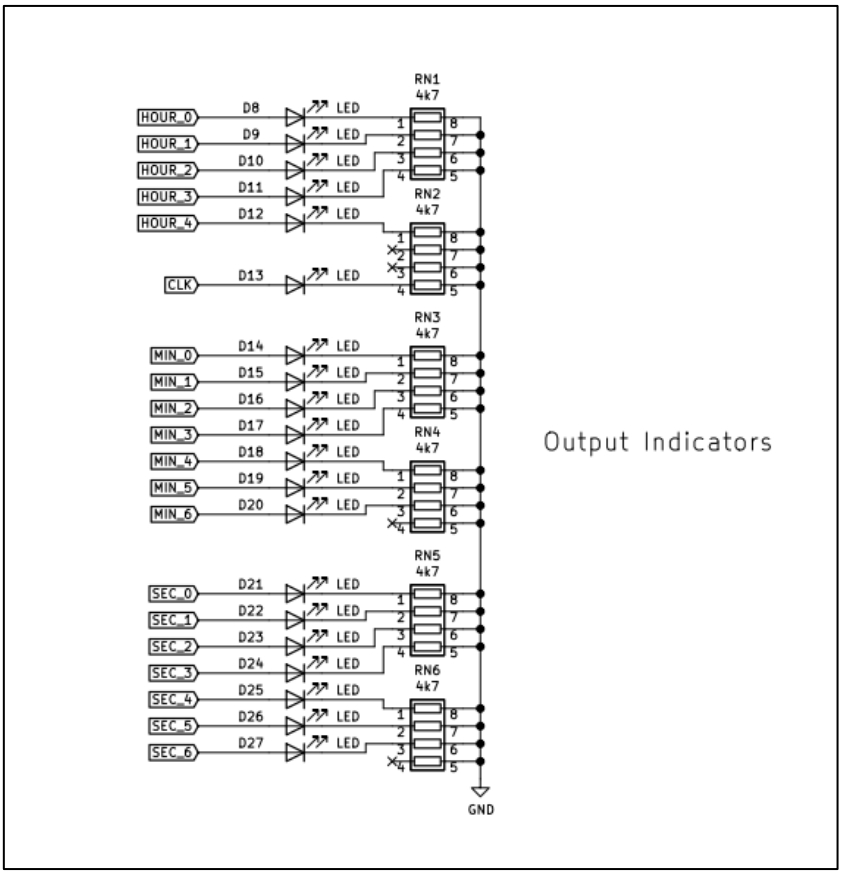
Schematics

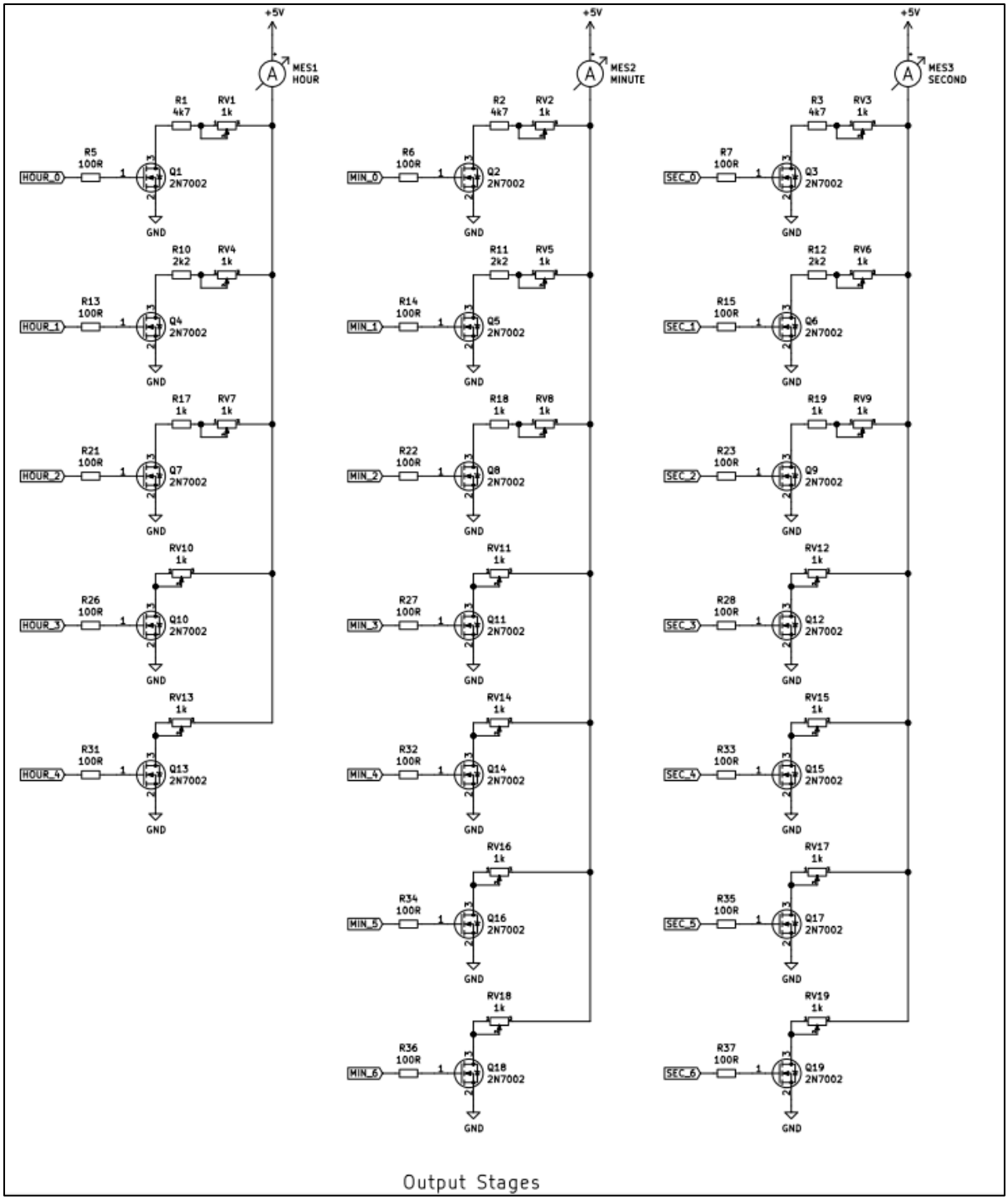


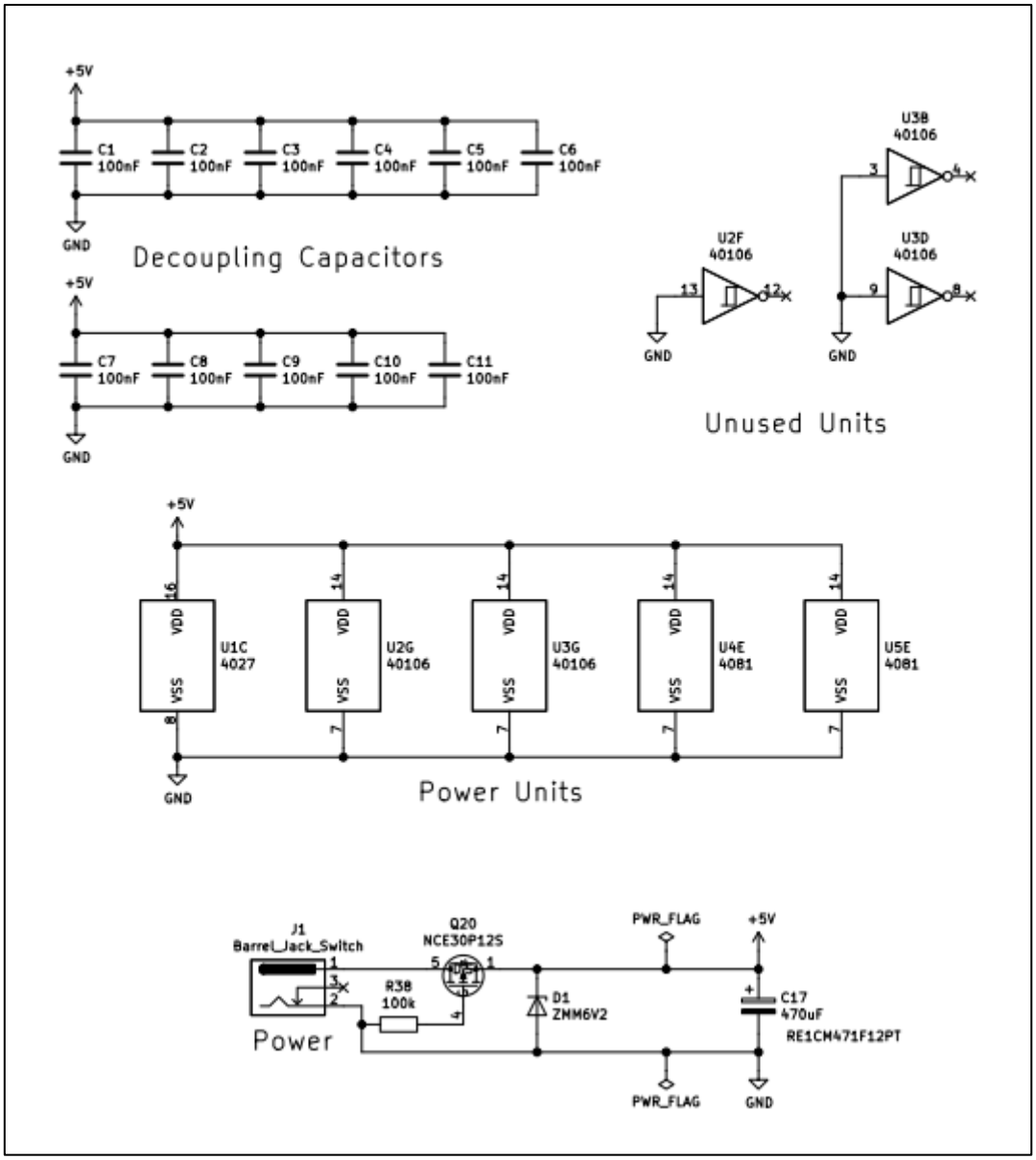
Note: On Rev.1 board, SW1 and SW2 are swapped.


U7
4510
+5V
SEC_0
SEC_1
SEC_2
SEC_3
CLK
RST
U2A
40106
U4B
4081
U2B
40106
CO_STAGE1
U4A
4081
U4C
4081
RST_STAGE1
U8
4516
SEC_4
SEC_5
SEC_6
RST_STAGE1
GND
Sec Counter
U9
4510
MIN_0
MIN_1
MIN_2
MIN_3
CI_STAGE2
U2C
40106
U5B
4081
U2D
40106
CO_STAGE2
U5A
4081
U5C
4081
RST_STAGE2
U10
4516
MIN_4
MIN_5
MIN_6
Min Counter


U11
4516
+5V
HOUR_0
HOUR_1
HOUR_2
HOUR_3
CI_STAGE3
CLK
RST_STAGE3
RST
U4D
4081
U5D
4081
RST_STAGE3
U2E
40106
U1B
4027
HOUR_4
D6
1N4148
D7
1N4148
R29
4K7
GND
Hour Counter


RN1
4k7
RN2
4k7
RN3
4k7
RN4
4k7
RN5
4k7
RN6
4k7
HOUR_0
HOUR_1
HOUR_2
HOUR_3
HOUR_4
CLK
MIN_0
MIN_1
MIN_2
MIN_3
MIN_4
MIN_5
MIN_6
SEC_0
SEC_1
SEC_2
SEC_3
SEC_4
SEC_5
SEC_6
LED
GND
Output Indicators


+5V
MES1
HOUR
R1
4k7
RV1
1k
R5
100R
HOUR_0
Q1
2N7002
GND
R10
2k2
RV4
1k
R13
100R
HOUR_1
Q4
2N7002
GND
R17
1k
RV7
1k
R21
100R
HOUR_2
Q7
2N7002
GND
RV10
1k
R26
100R
HOUR_3
Q10
2N7002
GND
RV13
1k
R31
100R
HOUR_4
Q13
2N7002
GND
+5V
MES2
MINUTE
R2
4k7
RV2
1k
R6
100R
MIN_0
Q2
2N7002
GND
R11
2k2
RV5
1k
R14
100R
MIN_1
Q5
2N7002
GND
R18
1k
RV8
1k
R22
100R
MIN_2
Q8
2N7002
GND
RV11
1k
R27
100R
MIN_3
Q11
2N7002
GND
RV14
1k
R32
100R
MIN_4
Q14
2N7002
GND
RV16
1k
R34
100R
MIN_5
Q16
2N7002
GND
RV18
1k
R36
100R
MIN_6
Q18
2N7002
GND
+5V
MES3
SECOND
R3
4k7
RV3
1k
R7
100R
SEC_0
Q3
2N7002
GND
R12
2k2
RV6
1k
R15
100R
SEC_1
Q6
2N7002
GND
R19
1k
RV9
1k
R23
100R
SEC_2
Q9
2N7002
GND
RV12
1k
R28
100R
SEC_3
Q12
2N7002
GND
RV15
1k
R33
100R
SEC_4
Q15
2N7002
GND
RV17
1k
R35
100R
SEC_5
Q17
2N7002
GND
RV19
1k
R37
100R
SEC_6
Q19
2N7002
GND
Output Stages


+5V
C1 100nF
C2 100nF
C3 100nF
C4 100nF
C5 100nF
C6 100nF
GND
Decoupling Capacitors
+5V
C7 100nF
C8 100nF
C9 100nF
C10 100nF
C11 100nF
GND
U3B 40106
U2F 40106
U3D 40106
GND
GND
Unused Units
+5V
U1C 4027
U2G 40106
U3G 40106
U4E 4081
U5E 4081
VDD
VSS
GND
Power Units
J1 Barrel_Jack_Switch
Q20 NCE30P12S
R38 100k
D1 ZMM6V2
PWR_FLAG
+5V
C17 470uF RE1CM471F12PT
PWR_FLAG
GND
Power

PCB Layout

Front