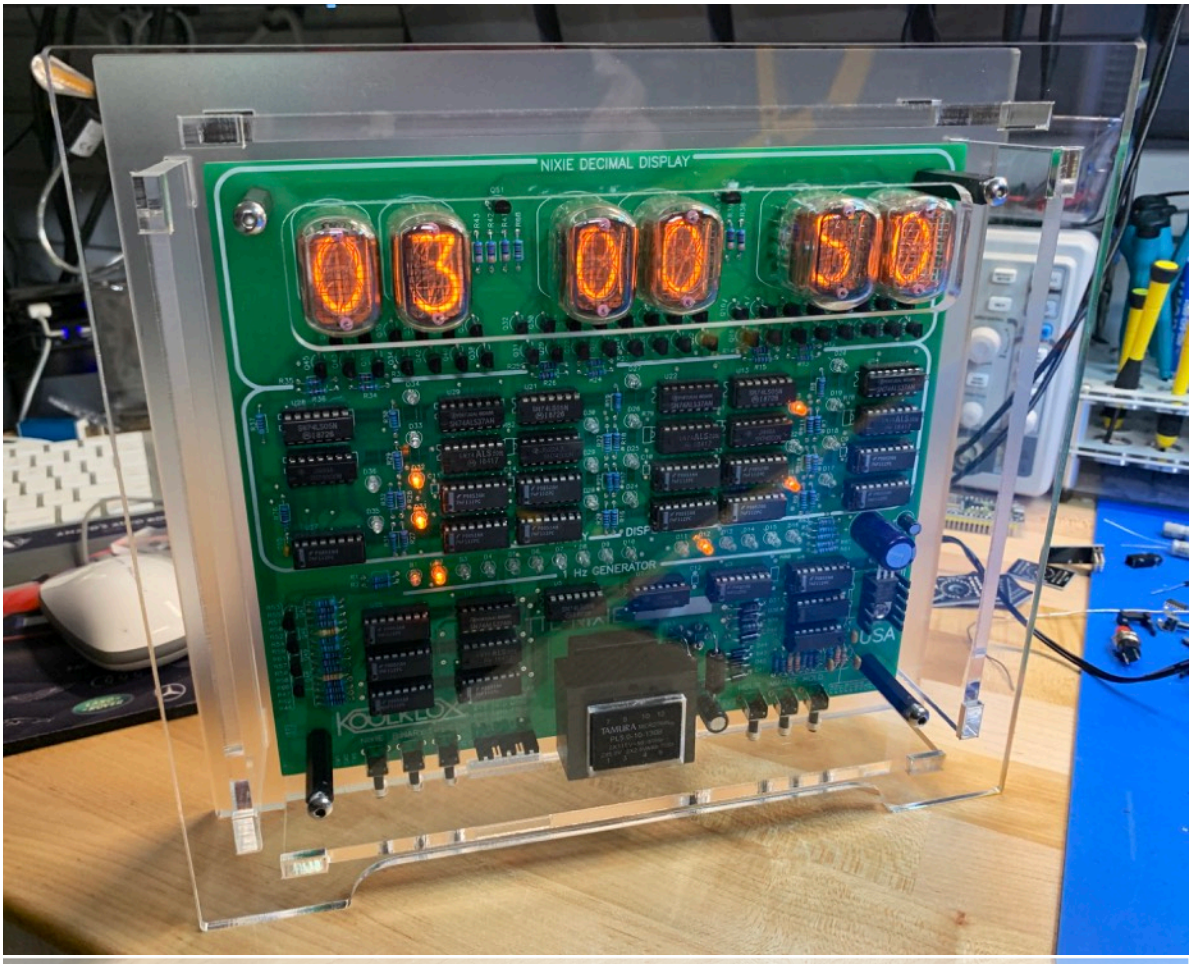
# KOOLKLOX

*A Unique TTL[1] Nixie Digital TimePiece*




## Assembly and Operation Manual

Jan 2024

[1] https://en.wikipedia.org/wiki/Transistor-transistor_logic

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## INTRODUCTION

Congratulations on your purchase of the Koolklox TTL NIXIE clock kit. This digital clock is capable of displaying the time in decimal and/or binary. With simple jumper settings this clock displays the time in 12 or 24 hour modes with operation on 50 or 60Hz power grids. The circuit design is based on the 7400 series TTL (Transistor to Transistor Logic) chips that have been used in digital devices over the last 40 years. TTL chips have survived for so many years primarily due to their electrically rugged design, high reliability and good performance. Given the conservative design approach, this clock has been designed to provide many years of reliable operation. As it derives timekeeping from the mains frequency, its accuracy is actually pretty reliable over the long term.

## DESIGN OBJECTIVE

- To design a digital clock using technology from the 1950's to 1970's era with a simple but attractive case, allowing all internal parts to be viewable
- Provide an education on binary (digital) counting.
- Straight-forward design, micro-processor free only using basic logic gates.
- All parts and manufacturing as local as possible. IC's are made by Motorola, National Semiconductor, Texas Instruments, Fairchild (all American Companies).

## THEORY OF OPERATION

Time keeping is derived from the AC mains line frequency (50/60Hz selectable) which is divided down using a divide by 10 and a divide by 5 or 6 counter to obtain a 1Hz signal to count seconds. The seconds and minutes each contain divide by 10 and divide by 6 counters and lastly the hours use a preset-able divide by 10 and 3 or 4 reset-able counter for 12 or 24 Hr operation.

The counters are comprised of flip-flops (F-F's) configured in a series or "ripple" configuration generating a binary count displayable by turning on the "BINARY DISPLAY" LED's. The binary count is then converted to decimal using a handful of basic NAND and NOT logic gates and displayable by turning on the NIXIE tubes.

Power is supplied by a standard 9V AC/1A wall transformer (wall-wart), full wave rectified, filtered and linear regulated to 5VDC for powering all the IC's. The high voltage required by the NIXIE tubes is derived from a dual primary 10V transformer wired "backwards" with its primary winding in series to produce ~200-250 volts, rectified and filtered.

Display dimming is performed using a total of six F-F's (two F-F's per counter) to make three 2-bit counters offering four levels of brightness. The two bits are combined resistively creating a stepped analog signal fed to a common collector voltage source for the two LED displays, the last counter is fed to a pulse width modulator (PWM[2]) to drive the NIXIE tubes. Utilizing PWM topology permits the NIXIE tubes to dim while maintaining even lighting of their segments.

[2] https://en.wikipedia.org/wiki/Pulse-width_modulation

## ASSEMBLY TIPS

This kit has been designed with the "intermediate" kit builder in mind, and if at any point, this kit appears to be getting "too involved", PLEASE, do not hesitate to call/contact me. There are roughly 300 components and 1,000 connections that have to be soldered, so please take your time and check off each step using the "(  )" parenthesis provided. DO NOT RUSH!! This kit will take at least 8-12 hours for the experienced kit builder to complete. The clock generates ***HAZARDOUS*** *voltages* to drive the nixie tubes. If you are not comfortable with this, please do not attempt to build it. I am more than happy to supply fully built clocks for a fair price.

## REQUIRED TOOLS/GENERAL GOOD PRACTICES

You will need a few basic assembly tools:

- Small wire cutters
- Sharp-nosed pliers (optional)
- A good quality soldering iron and solder (e.g. 60/40 Pb/Sn with rosin flux)
- A digital multimeter
- A hex key/Allen wrench

Soldering skills: If you feel uncomfortable or are unfamiliar with electronic soldering we highly recommend having a professional or qualified person build this kit. ***This kit is not designed for beginners***.

## INSPECTION

Upon receiving your new kit, it is important that you identify and verify all parts have arrived (see next page), and are in good condition and not damaged during shipping. Included in this kit are one (1) PCB, all PCB components, one (1) 120VAC AC adaptor[3], one (1) complete case and hardware kit. Most of the electronic components come on cut tape (leads stuck to tape), it is highly recommended to keep them stored this way until installing them, this way there will be less chance of loss or damage to the components and it is also a good way to determine if you have installed all of the required parts (each component type is supplied in the exact quantity needed to construct the clock).

## BEFORE STARTING

After inspection and verification that all parts are present and in good condition they should be placed back in the box or kept together so as not to get lost. There are nearly 300 parts, many of which are small and easily lost. Clear a workspace to work at that is comfortable and clutter-free. The assembly instructions are written such that one type of part will be installed and then the next type (e.g. all 1.5k resistors will be installed, then all 1.8k resistors and so forth until all the resistors have been installed). Assembly in this fashion keeps the clutter down, and only one part type needs to be out of the box at a time.[4]

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[3] Only for USA delivered orders.

[4] For best results, familiarize yourself with this manual and follow these instructions in order, there are preliminary tests that must be performed ***BEFORE*** all the parts have been installed in the circuit board.

## PARTS LIST

| Part # | Qty. | Location | Description |
|---|---|---|---|
| *Resistors (all ¼ watt)* | | | *(note - some resistors may be 5 band versions and hence the color code may look different - **always use a multimeter to double check -** do not rely on the color code as it can be easy to mistake the correct values)* |
| 01-2700-2-05 | 2 | Bag #1 | 270Ω (**red-violet-brown-gold**) |
| 01-1501-2-05 | 25 | Bag #1 | 1.5kΩ (**brown-green-red-gold**) |
| 01-1801-2-05 | 4 | Bag #1 | 1.8kΩ (**brown-grey-red-gold**) |
| 01-3901-2-05 | 1 | Bag #1 | 6.8kΩ (**blue-grey-red-gold**) |
| 01-4701-2-05 | 4 | Bag #1 | 4.7kΩ (**yellow-violet-red-gold**) |
| 01-1002-2-05 | 8 | Bag #1 | 10kΩ (**brown-black-orange-gold**) |
| 01-2202-2-05 | 5 | Bag #1 | 22kΩ (**red-red-orange-gold**) |
| 01-3302-2-05 | 6 | Bag #1 | 33kΩ (**orange-orange-orange-gold**) |
| 01-4702-2-05 | 15 | Bag #1 | 47kΩ (**yellow-violet-orange-gold**) |
| 01-5602-2-05 | 1 | Bag #1 | 56kΩ (**green-blue-orange-gold**) |
| 01-1003-2-05 | 3 | Bag #1 | 100kΩ (**brown-black-yellow-gold**) |
| 01-2003-2-05 | 1 | Bag #1 | 200kΩ (**red-black-yellow-gold**) |
| 01-2703-2-05 | 1 | Bag #1 | 270kΩ (**red-violet-yellow-gold**) |
| *Capacitors and Inductors* | | | |
| 10-221-050-10 | 1 | Bag #2 | 220pF capacitor |
| 10-104-050-10 | 4 | Bag #2 | 0.1µF capacitor |
| 15-225-350-20 | 1 | Bag #2 | 2.2µF/350 volt electrolytic |
| 15-476-016-20 | 1 | Bag #2 | 47µF/16 volt electrolytic |
| 15-228-016-20 | 1 | Bag #2 | 2200µF/16 volt electrolytic |
| 22-226-102-10 | 2 | Bag #2 | 22µH RF choke |
| *Diodes and LED's* | | | |
| 30-1N5392 | 4 | Bag #3 | 100 volt/1.5 amp rectifier |
| 32-1N4005 | 4 | Bag #3 | 600 volt/1 amp rectifier (sub STTA106 or MUR160) |
| 36-3LED | 36 | Bag #3 | LED, 3mm, orange/blue/other |
| *Transistors and IC's* | | | |
| 42-MPSA42 | 50 | Bag #4 | MPS-A42, 300 volt, NPN, transistor |
| 42-MPSA92 | 1 | Bag #4 | MPS-A92, 300 volt, PNP, transistor |
| 50-LM324 | 1 | Bag #10 | IC, Quad OP amp |
| 51-74LS00 | 4 | Bag #10 | IC, Quad, NAND gate (or 74LS37) |
| 51-74LS05 | 4 | Bag #10 | IC, Hex INVERTER |
| 51-74F14 | 1 | Bag #10 | IC, Hex Schmidt trigger |
| 51-74LS37 | 4 | Bag #10 | IC, Quad, NAND buffer (or 74LS00) |
| 51-74LS40 | 4 | Bag #10 | IC, Dual, quad input NAND (or 74LS20) |
| 51-74F112 | 16 | Bag #10 | IC, Dual J-K Flip Flop |
| 51-74LS112 | 1 | Bag #10 | IC, Dual J-K Flip Flop |
| 59-LM7805T | 1 | Bag #7 | IC, +5 volt regulator |

## PARTS LIST (CONTINUED)

| Part # | Qty. | Location | Description |
|---|---|---|---|
| *Tubes, Transformers, Connectors, Switches* | | | |
| 41-IN12A | 72 | Bag #5 | Socket Pins for Nixies |
| 23-PL5010 | 1 | | Power transformer, 10 volt, 5VA |
| 23-41A9 | 1 | Bag #6 | Wall transformer, 9VAC, 1amp (US Orders only) |
| 64-A100205 | 18 | Bag #9 | IC socket, 14 pin |
| 64-A100206 | 17 | Bag #9 | IC socket, 16 pin |
| 64-8RA100 | 1 | Bag #7 | Connector, 8 position right angle header |
| 64-JMP100 | 3 | Bag #7 | Connector, Jumper |
| 64-PJ047A | 1 | Bag #7 | Connector, Power |
| 60-B3F3150 | 6 | Bag #7 | Switch, pushbutton |
| *Hardware* | | | |
| 89-HS1041 | 1 | Bag #7 | Heatsink, TO-220, voltage regulator |
| 82-6-32-5/16 | 1 | Bag #7 | Screw, M3 x 10mm, pan head |
| 83-6-32 | 1 | Bag #7 | Nut, M3 |
| 84-6-LOCK | 1 | Bag #7 | Washer |
| *Case and Case Hardware* | | | |
| 79-TTLNIX-R2 | 1 | | Printed circuit board (PCB) |
| | 4 | Bag #8 | Standoff, Black nylon x 15mm |
| | 4 | Bag #8 | Spacer, Black nylon x 30mm |
| | 8 | Bag #8 | Screw, M4 x 12mm |
| PLEX-1 | 1 | | Laser cut acrylic front plate |
| PLEX-2 | 1 | | Laser cut frosted acrylic back plate |
| PLEX-3 | 1 | | Laser cut acrylic top plate |
| PLEX-4 | 1 | | Laser cut acrylic bottom plate |
| PLEX-5 | 2 | | Laser cut acrylic sides |

## STEP 1. IC SOCKETS

All **35** IC (chip) sockets will be installed in the next pages. Hint: solder pin 1 and pin 9 first, make sure socket is flush with PCB. Re-heat pin 1 or 9 as required while lightly pressing on top of socket to confirm flushness. After soldering Pins 1 and 9 solder the remaining 12 or 14 pins.

*NOTE: THESE PARTS HAVE POLARITY*, make sure "U" notch on the end of the socket matches "U" notch on the silkscreen of the PCB (all notches will point to the left). DO NOT install the IC's in the sockets at this time, IC's will be installed later during testing.

Locate Bag #9 containing (**17**) 16-pin IC sockets. These will be installed in locations U1, U2, U3, U4, U9, U10, U11, U12, U17, U18, U19, U20, U25, U26, U27, U32, U35. See figure 1 and 4.

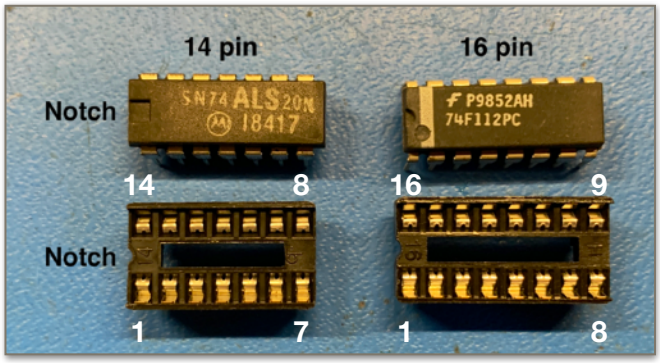
( ) Install U1, U2, U3 and U4

( ) Install U9, U10, U11 and U12

( ) Install U17, U18, U19 and U20

( ) Install U25, U26, U27 and U32

( ) Install U35




Note notches on IC sockets and IC's themselves, including the pin numbers for reference

Locate Tube #9 containing (**18**) 14-pin IC sockets. These will be installed in locations U5, U6, U7, U8, U13, U14, U15, U16, U21, U22, U23, U24, U28, U29, U30, U31, U34, U36.

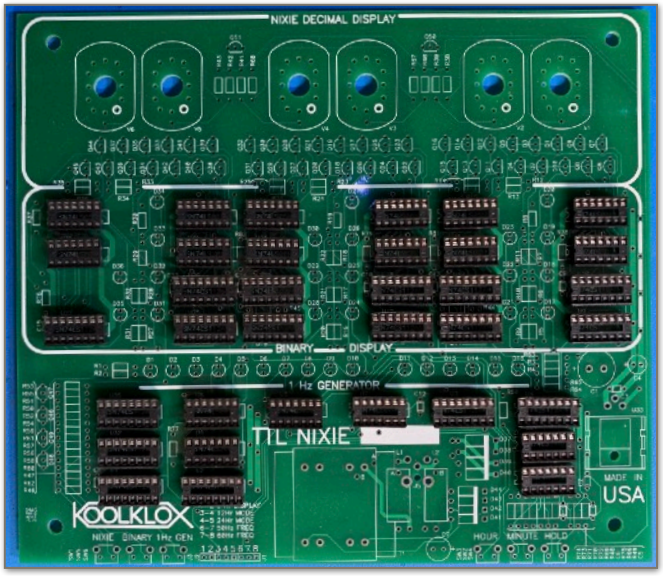
( ) Install U5, U6, U7 and U8

( ) Install U13, U14, U15 and U16

( ) Install U21, U22, U23 and U24

( ) Install U28, U29, U30 and U31

( ) Install U34 and U36




All of the IC sockets installed

## STEP 2. RESISTORS

It is a good idea to use a multimeter to measure the resistance of each batch of resistors *before* installing them. Locating a wrongly placed resistor can be a ***time-consuming process***.[5] The colors provided are for convenience, but some resistors may be a 5 color type and so a **multimeter should always be used to check the correct resistance.** Not all the supplied resistors will adhere to the color codes detailed.

Locate bag #1 containing (**25**) 1.5kΩ (**brown-green-red-gold**) resistors. Using a pair of side cutters, cut the resistors from the tape (do not pull the tape off the resistor lead, glue residue may remain on the resistor lead potentially leading to a bad solder joint). These parts do not have any polarity so they can be installed in either direction.[6]

( ) Install R1, R2, R3 and R4.

( ) Install R5, R6, R7 and R8.

( ) Install R9, R10, R11 and R16.

( ) Install R17, R18, R19 and R20.

( ) Install R21, R22, R27 and R28.

( ) Install R29, R30, R31, R32 and R74.

Locate bag #1 containing (**4**) 1.8kΩ (**brown-grey-red-gold**) resistors. Using a pair of side cutters, cut the resistors from the tape. These parts do not have any polarity so they can be installed in either direction.

( ) Install R54, R55, R60 and R61.

Locate bag #1 containing (**1**) 6.8kΩ (**blue-grey-red-gold**) resistor.

( ) Install R49.

Locate bag #1 containing (**4**) 4.7kΩ (**yellow-violet-red-gold**) resistors.

( ) Install R37, R53, R59 and R72.

Locate bag #1 containing (**8**) 10kΩ (**brown-black-orange-gold**) resistors.

( ) Install R46, R47, R62 and R65.

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[5] Ask me how I know… :)

[6] Hint: Installing all the resistors in one direction makes for a neater, more professional looking PCB.

( ) Install R68, R73, R75 and R76.

Locate bag #1 containing (**5**) 22kΩ (**red**-**red**-**orange**-gold) resistors.

( ) Install R52, R58, R66, R70 and R71.

Locate bag #1 containing (**6**) 33kΩ (**orange**-**orange**-**orange**-gold) resistors.

( ) Install R38, R39, R40 and R41.

( ) Install R42 and R43.

Locate bag #1 containing (**15**) 47kΩ (yellow-**violet**-**orange**-gold) resistors.

( ) Install R12, R13, R14 and R15.

( ) Install R23, R24, R25 and R26.

( ) Install R33, R34, R35 and R36.

( ) Install R51, R57 and R63.

Locate bag #1 containing (**1**) 56kΩ (**green**-**blue**-**orange**-gold) resistor.

( ) Install R48.

Locate bag #1 containing (**3**) 100kΩ (**brown**-**black**-yellow-gold) resistors.

( ) Install R50, R56 and R64.

Locate bag #1 containing (**1**) 200kΩ (**red**-**black**-yellow-gold) resistor.

( ) Install R69.

Locate bag #1 containing (**1**) 270kΩ (**red**-**violet**-yellow-gold) resistor.

( ) Install R67.

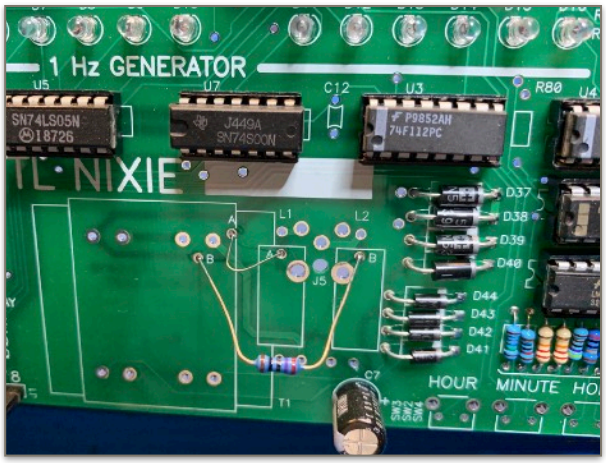
**There will be some resistor positions that are not filled at the end, so don't worry if some are still empty.**

This next step is temporary and will be removed prior to final assembly, do not be concerned with neatness.

Locate bag #1 containing (**2**) 270Ω (**red**-**violet**-**brown**-**gold**) resistors.

( ) Install a 270Ω resistor between points "B" and "B" as shown.

( ) Install a jumper (a discarded resistor lead from any of the previous steps works well) between points "A" and "A" as shown.



Link between 'A's and 270Ω resistor between 'B's

## STEP 3. SMALL CAPACITORS

Locate bag #2 containing (**4**) 0.1µF/100nF capacitors (small yellow or blue in color). Using a pair of cutters cut the capacitors from the tape (do not pull the tape off the capacitor lead, glue residue may remain on the capacitor lead potentially leading to a bad solder joint). These parts normally have pre-bent leads and should install without any lead bending. These parts do not have any polarity so they can be installed in either direction.

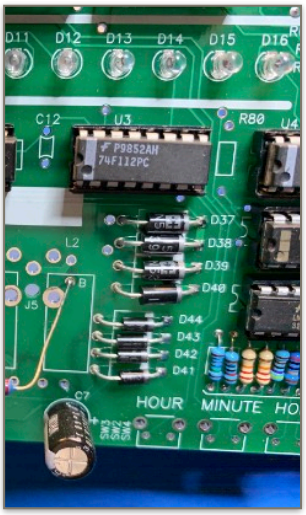
( ) Install C2, C3, C5 and C6. (marking will show 104)

Locate bag #2 containing (**1**) 220pF capacitor. This part does not have any polarity so it can be installed in either direction.

( ) Install C15.

## STEP 4. DIODES

Locate bag #2 containing (**4**) 1N5392 diodes. Using a pair of cutters cut the diodes from the tape (do not pull the tape off the diode lead, glue residue may remain on the diode lead potentially leading to a bad solder joint). These parts DO HAVE polarity and MUST be installed as shown (white band to the right to match the silkscreen on the PCB). Note: All diodes, LED's, transistors and nixie tubes are sensitive to heat, when soldering do not apply excessive heat or anymore heat than necessary to make a good solder joint.



Diodes in place

( ) Install D37, D38, D39 and D40.

Locate bag #2 containing (**4**) 1N4005[7] diodes.

( ) Install D41, D42, D43 and D44.

[7] These can be substituted with MUR160/STTA106 type diodes and the kit may sometimes be supplied with these.

## STEP 5. TRANSISTORS

Locate bag #4 containing (**50**) MPS-A42 transistors. Using a pair of cutters cut the transistors from the tape, (do not pull the tape off the transistor leads, glue residue may remain on the transistor leads potentially leading to a bad solder joint). These parts may have pre-bent leads and do not require any lead bending if so.[8] These parts DO HAVE a specific orientation and MUST be installed as shown with flat side to the right. *Take your time* to make them all straight and even, as once they're installed they will be visible for as long as the clock is in operation. A quick tip here is to solder just one leg of all the transistors, then adjust them to be the same height and in-line with each other *before* soldering the rest of the legs.

( ) Install Q1, Q2, Q3 and Q4.

( ) Install Q5, Q6, Q7 and Q8.

( ) Install Q9, Q10, Q11 and Q12.

( ) Install Q13, Q14, Q15 and Q16

( ) Install Q17, Q18, Q19 and Q20.

( ) Install Q21, Q22, Q23 and Q24.

( ) Install Q25, Q26, Q27 and Q28.

( ) Install Q29, Q30, Q31 and Q32

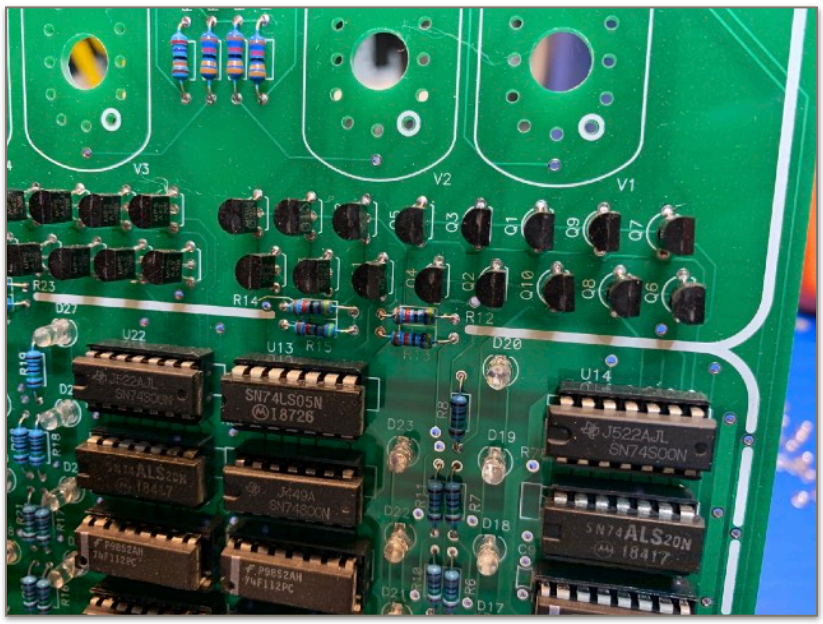
( ) Install Q33, Q34, Q35 and Q36.

( ) Install Q37, Q38, Q39 and Q40.

( ) Install Q41, Q42, Q43 and Q44.

( ) Install Q45, Q46, Q47 and Q48.

( ) Install Q49 and Q50.



Note transistors installed in the same orientation as silkscreen

Locate bag #4 containing (**1**) MPS-A92 transistor.

( ) Install Q51.

[8] Depending on the style supplied with the kit, some come with pre-bent leads others have straight leads. Both work just as well… 😀

## STEP 6. LED's

Locate bag #3 containing (**36**) LED's. These parts are VERY SENSITIVE TO HEAT, so when soldering try to minimize soldering time as much as possible. This part DOES HAVE polarity and MUST be installed as shown on the PCB with the flat side facing towards the top/long leg through the bottom. Take time to make sure they're all seated flush to the PCB and aligned.

( ) Install D1, D2, D3 and D4.

( ) Install D5. D6, D7 and D8.

( ) Install D9, D10, D11 and D12.

( ) Install D13, D14, D15 and D16.

( ) Install D17, D18, D19 and D20.

( ) Install D21, D22, D23 and D24.

( ) Install D25, D26, D27 and D28.

( ) Install D29, D30, D31 and D32.

( ) Install D33, D34, D35 and D36.

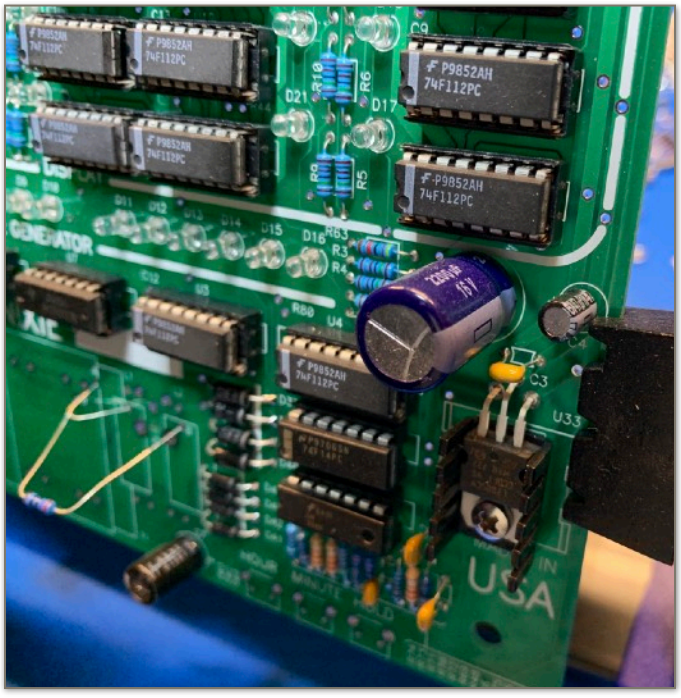
## STEP 7. LARGE CAPACITORS

Locate bag #2 containing (**1**) 47µF electrolytic, (**1**) 2200µF electrolytic and (**1**) 2.2µF electrolytic capacitor. Using a pair of side-cutters, cut the tape from their leads (do not pull the tape off, glue residue may remain on their leads potentially leading to a bad solder joint). These parts do not require lead bending but they DO HAVE polarity and MUST be installed as shown.

( ) Install C4, 47µF (smallest) electrolytic as shown, noting polarity orientation.

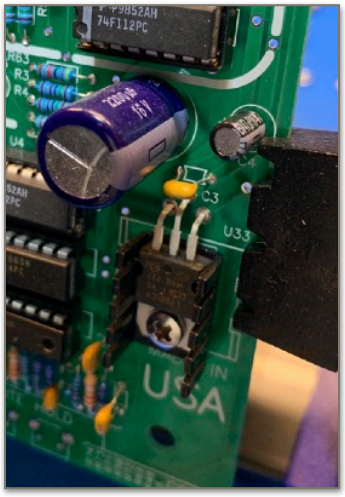
( ) Install C7, 2.2µF (mid size) electrolytic as shown, noting polarity orientation.

( ) Install C1, 2200µF (largest) electrolytic as shown, noting polarity orientation.




Electrolytic capacitors have polarity, installed as shown.

## STEP 8. VOLTAGE REGULATOR




Locate bag #7 containing (**1**) LM7805 voltage regulator, associated heatsink and hardware. Using your fingers or sharp nosed pliers bend leads as shown, place in PCB (DO NOT SOLDER!), make sure LM7805 mounting hole lines up with PCB mounting hole. Next, slide heatsink between LM7805 and PCB and secure with #6-32 screw, nut and washer as shown making sure heatsink lines up with outline on PCB, then tighten the screw. After heatsink and LM7805 are lined up and tightened, then solder LM7805 leads to PCB.

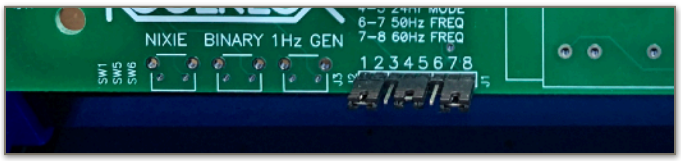
(  ) Install U33, LM7805 voltage regulator as shown.

## STEP 9. CONNECTORS

Locate bag #7 containing (**1**) 8-pin header, (**3**) jumpers and (**1**) power connector.

(  ) Install J1-3, 8-pin header as shown, making sure the header is flush to PCB and pins are parallel to PCB as this is necessary for accurate case alignment (the picture shows a prototype, the kit will have right angled headers).

(  ) Install (**3**) jumpers on header pins between 1-2, 4-5, and 7-8 as shown.




Note - Right angled headers are supplied with the kit

This next part, J5 power connector, is mounted on the BACK side of the PCB as shown, soldering will be required from the front side of PCB.

(  ) Install J5, power connector on back side of PCB as shown, making sure connector is flush to PCB, this is necessary for accurate case alignment.

## STEP 10. SWITCHES

Locate bag #7 containing (**6**) pushbutton switches. It is recommended to solder these in one at a time making sure they are soldered flush to the PCB this is necessary for accurate case alignment.

(  ) Install SW1, SW2, SW3, SW4, SW5 and SW6

At this point the PCB should have all the aforementioned parts installed EXCEPT for V1-V6 NIXIE tubes and socket pins, T1 transformer, L1 and L2 chokes and all the IC sockets should be empty (**no IC's installed**).

This completes the first and main part of the assembly, before final finishing steps we need to do some *testing*.

## PRELIMINARY TESTS

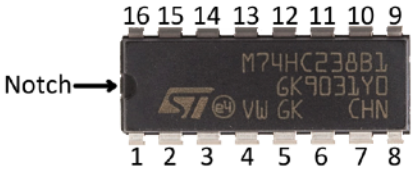
NOTE: During these tests we will be applying 9 VAC power to the PCB. There will only be low voltages present, nothing more hazardous than a 9 volt battery.

## STEP 11. VERIFY +5 VOLT SUPPLY

( ) Plug AC adaptor into power connector on PCB.

( ) Plug AC adaptor into wall outlet.

( ) Using a DC voltmeter (DMM, multi-meter, etc.), verify 5 volts DC between pins 8 and 16 on U1 IC socket. (See TROUBLESHOOTING if 5 volts is not present)




( ) Unplug AC adaptor from the wall and PCB.

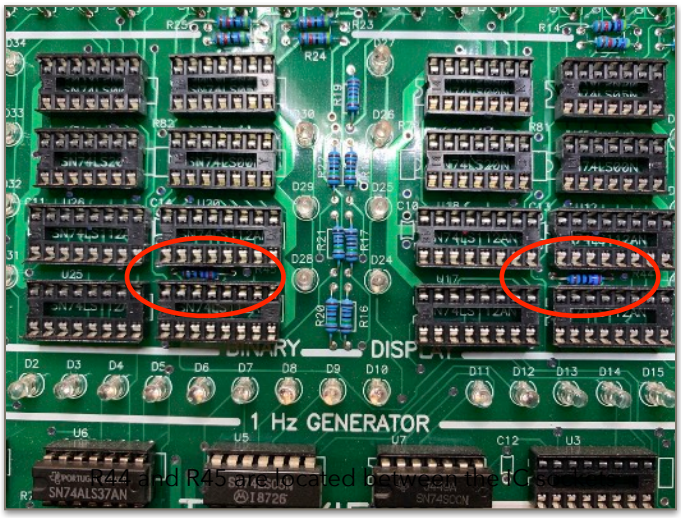
*NOTE: 4.85-5.10 volts MUST BE PRESENT to continue with preliminary tests. Proceeding without passing this test will result in component failure(s) !*

( ) Unsolder jumper wire between points "A" and "A".

( ) Unsolder 270Ω resistor between points "B" and "B" and install in location R44.

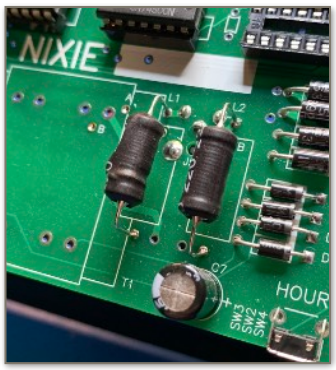
Locate bag #1 containing the remaining 270Ω (**red**-**violet**-**brown**-gold) resistor. Using a pair of cutters cut the resistor from the tape (do not pull the tape off the resistor lead, glue residue may remain on the resistor lead potentially leading to a bad solder joint).

( ) Install R45.



R44 and R45 are located between the ICs

Locate bag #2 containing (**2**) 22µH RF chokes (black in color). Using your fingers or sharp nosed pliers bend leads and solder into PCB as shown in figure 8 noting slight body elevation (1/8" - 3/16" clearance between choke body and PCB) on the top side of the PCB. These parts do not have any polarity so they can be installed in either direction. If you install them too high, you may need to bend the left hand one a little to the right to clear the transformer.




( ) Install L1 and L2

NOTE: During the next (6) steps you will be installing the IC's into their appropriate sockets. If there could be any presence of static electricity we highly recommend placing the clock PCB on an ESD[9] work-mat along with the IC's. If an ESD mat is not available, a damp (not wet) towel will work just as well (similar to the dampness after drying your hands).

## STEP 12. VERIFY 1Hz GENERATOR COUNTER

(  ) Locate the IC's, remove tape from tube ends (if present) and place IC's onto ESD mat. **Note these components are polarity sensitive and need to be inserted with the 'notch' on the IC matching the silkscreen 'notch'. All IC's have the 'notch' installed to the left and the markings on the IC's will be right side up.**

(  ) Install U1 and U2, 74F112.

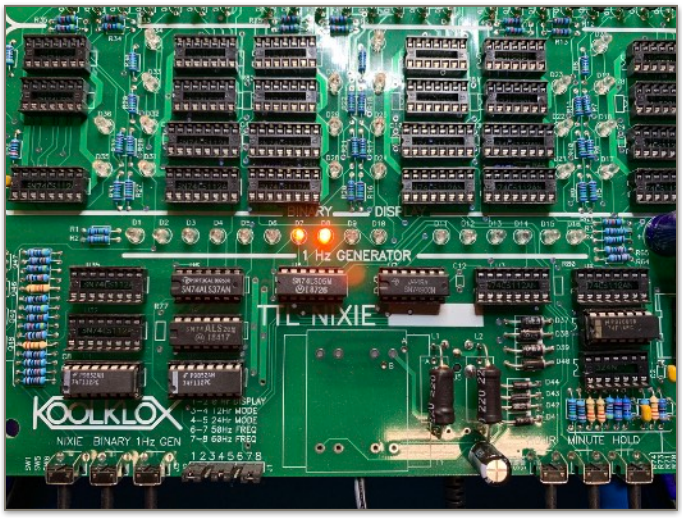
(  ) Install U5, SN74LS05N.

(  ) Install U6, SN74ALS37AN.

(  ) Install U7, SN74S00N.

(  ) Install U8, DM74LS40N (or SN74LS20N).

(  ) Install U34, 74F14PC.



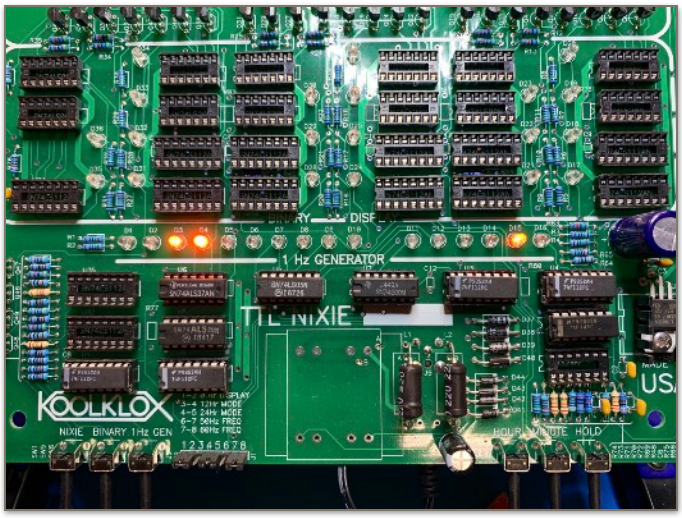

(  ) Power clock on and verify D1-D10 LED's sequence left to right.

(  ) Disconnect power to clock (See TROUBLESHOOTING if this did not take place).

(  ) Install U3 and U4, 74F112.

(  ) Power clock on and verify D1-D10 LED's flash rapidly and D11-D16 LED's flash slow. **Note, if you're in 50Hz land then only D11-D15 will count and D16 will remain unlit.**

(  ) Disconnect power to clock (See TROUBLESHOOTING if this did not take place).




[9] https://en.wikipedia.org/wiki/Electrostatic_discharge

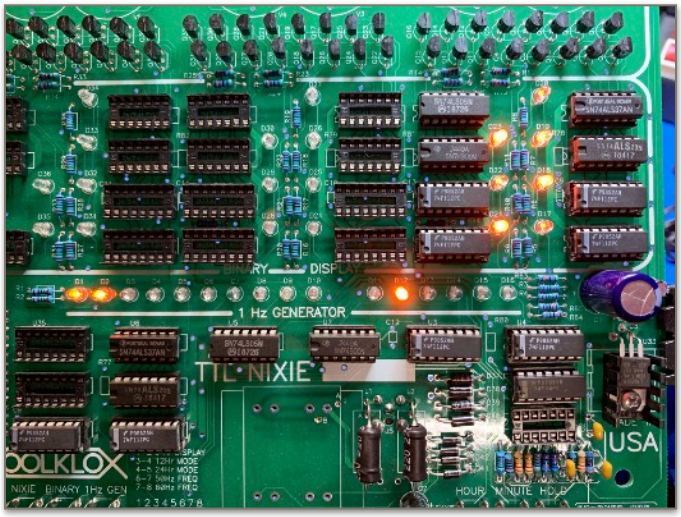
## STEP 13. DECODING BINARY

Reading time or any numbers in binary is not difficult. It is the method most computers continue to use today. There are only two "states" or conditions for any input or output to be in, either a "1" or "0" hence "bi"-nary.

Looking at the "BINARY DISPLAY" LED's, there are white numbers 1, 2, 4 and 8 superimposed next to the LED's. These indicate the significance or value for each specific digit. If we add up the white numbers next to the lit LED's in any given row they will equal what is displayed on the nixie tube directly above it.

| Decimal | Binary |
|---|---|
| 0 | 0000 |
| 1 | 0001 |
| 2 | 0010 |
| 3 | 0011 |
| 4 | 0100 |
| 5 | 0101 |
| 6 | 0110 |
| 7 | 0111 |
| 8 | 1000 |
| 9 | 1001 |
| | (8421) |

## STEP 14. VERIFY SECONDS COUNTER




( ) Install U9, U10, U11 and U12, 74F112.

( ) Install U13, SN74LS05N.

( ) Install U14, SN74ALS37AN.

( ) Install U15, SN74S00N.

( ) Install U16, DM74LS40N (or SN74LS20N).

At this point when the clock is powered up LED's D17-D20 should count seconds in binary and D21-D23 should count 10's of seconds in binary. NOTE: All LED's may be lit, watch the bright LED's count.

( ) Power clock on and verify D17-D20 and D21-D23 binary counting.

( ) Disconnect power to clock (See TROUBLESHOOTING if this did not take place).

## STEP 15. VERIFY MINUTES COUNTER

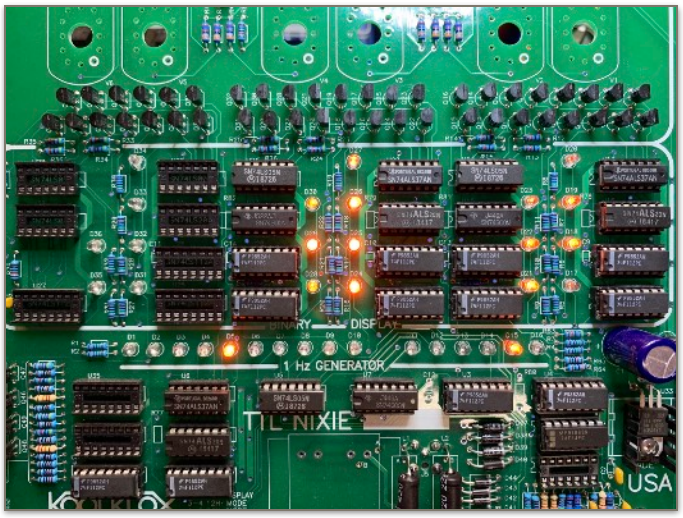
( ) Install U17, U18, U19 and U20, 74F112.

( ) Install U21, SN74LS05N.

( ) Install U22, SN74ALS37AN.

( ) Install U23, SN74S00N.

( ) Install U24, DM74LS40N (or SN74LS20N).




At this point when the clock is powered up LED's D24-D27 should count minutes in binary and 28-D30 should count 10's of minutes in binary (to "speed" this test up press and hold the "MINUTE" set button on the bottom of clock and minutes should count at the rate of seconds. NOTE: All LED's may be lit, count the bright LED's.

( ) Power clock on and verify D24-D27 and D28-D30 binary counting.

( ) Disconnect power to clock (See TROUBLESHOOTING if this did not take place).

## STEP 16. VERIFY HOURS COUNTER

( ) Install U25, 74LS112

( ) Install U26 and U27, 74F112.

( ) Install U28, SN74LS05N.

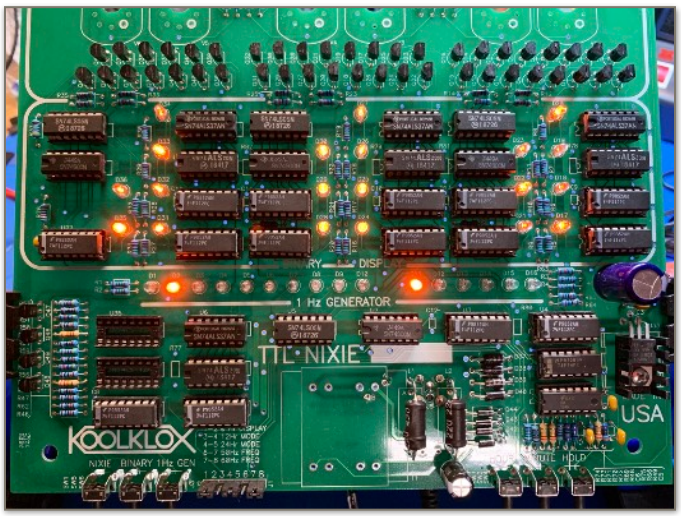
( ) Install U29, SN74ALS37AN.

( ) Install U30, SN74S00N.

( ) Install U31, DM74LS40N (or SN74LS20N).

( ) Install U32, and U35, 74F112.

( ) Install U36, LM324N.

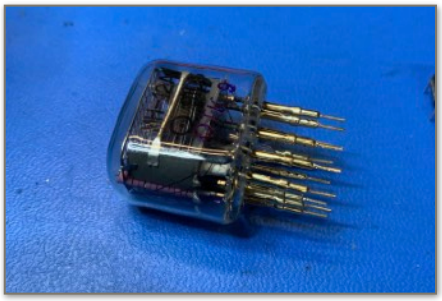



At this point when the clock is powered up LED's D31-D34 should count hours in binary and D35-D36 should count 10's of hours in binary (to "speed" this test up press and hold the "HOUR" set button on the bottom of clock and hours should count at the rate of seconds. NOTE: All LED's may be lit, count the bright LED's.

( ) Power clock on and verify D31-D34 and D35, D36 binary counting.

( ) Disconnect power to clock (See TROUBLESHOOTING if this did not take place).

## STEP 17. NIXIE TUBES

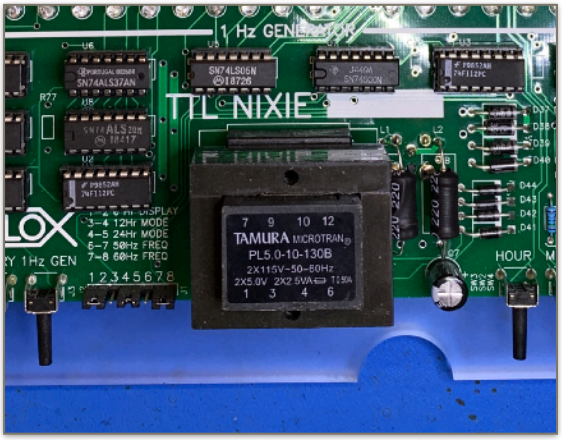


Locate the (**6**) Nixie tubes and (~**72**) socket receptacle pins. Take one Nixie tube at a time and place the socket receptacles on each pin. When complete, insert into the PCB, with the digits the right way up and solder one of the pins in place. Check that the rest of the pins are flush with the PCB and solder the remainder. Repeat this process for all 6 nixies. Take your time, you want them to all be level with each other and *neat*.

(  ) Install V1 - V6, IN12A Nixie tube with socket pins. Make sure that the tube is the correct way up after soldering all the socket pins. You'll note that inside the tube one of the pins has a white coating - this marks the anode of the tube and should line up with the white mark on the PCB.

## STEP 18. HIGH VOLTAGE TRANSFORMER

Locate the high voltage power transformer (you can't miss it…).




NOTE: This part DOES HAVE polarity and MUST be installed as shown.

(  ) Install T1 into PCB as shown (writing on transformer top is right-side up).

This completes the final assembly of the clocks PCB.

WARNING: From this point onwards applying power to the clock will produce potentially DANGEROUS VOLTAGES on the circuit board!!!

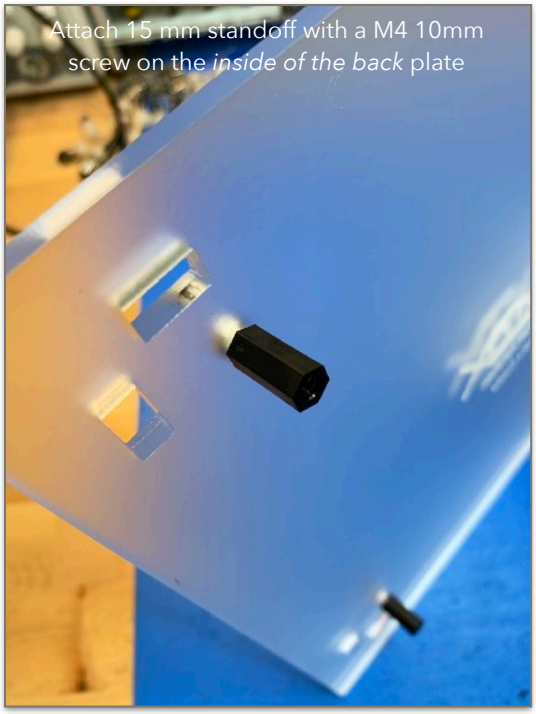
**DO NOT APPLY POWER UNTIL FULLY ASSEMBLED IN THE CASE!!**

For safety purposes final assembly must be performed before power is re-applied to the clock PCB.

## STEP 19. FINAL ASSEMBLY

NOTE: Prepare a clean work area and place a clean towel or soft material on work area surface to prevent scratching the Plexiglas case pieces. It's easy to get fingerprints on clear acrylic, so either wear some gloves or just be aware of where your fingers are… :). You'll need to peel the paper of each piece as you go. Locate Bag #8 which contains the case hardware.

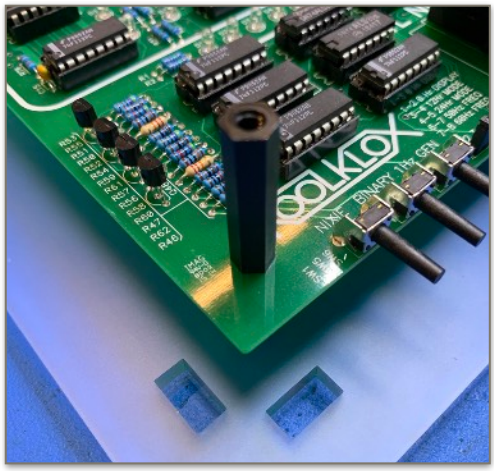
i) Attach 4 x M15 standoffs on the frosted back plate with the laser engraving *on the inside face* (so it faces outwards from the back).



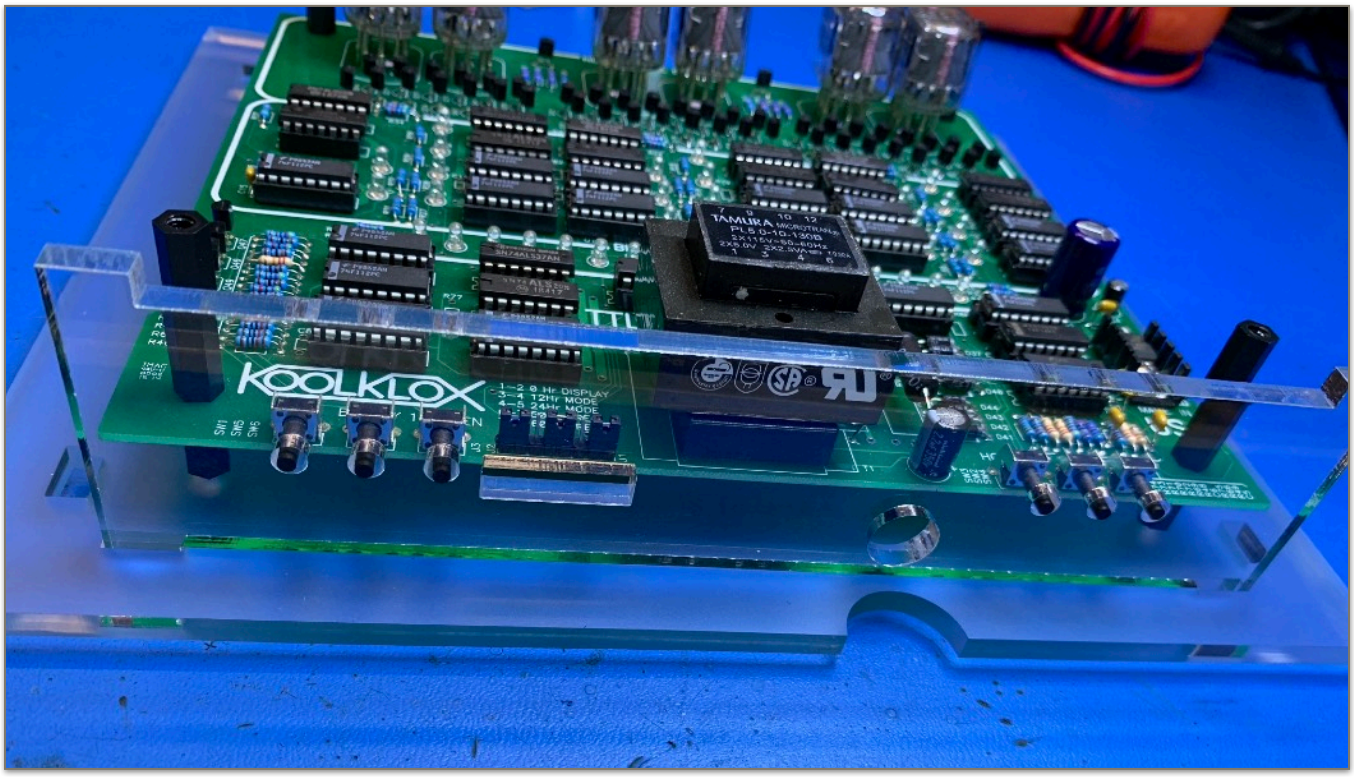


When all four standoffs are in place, lay the part flat on the bench ready for the PCB assembly.

ii) Lay the PCB over the 4 standoffs and insert the threaded M4 x 30 mm black nylon standoffs to attach the PCB. Hand tighten.

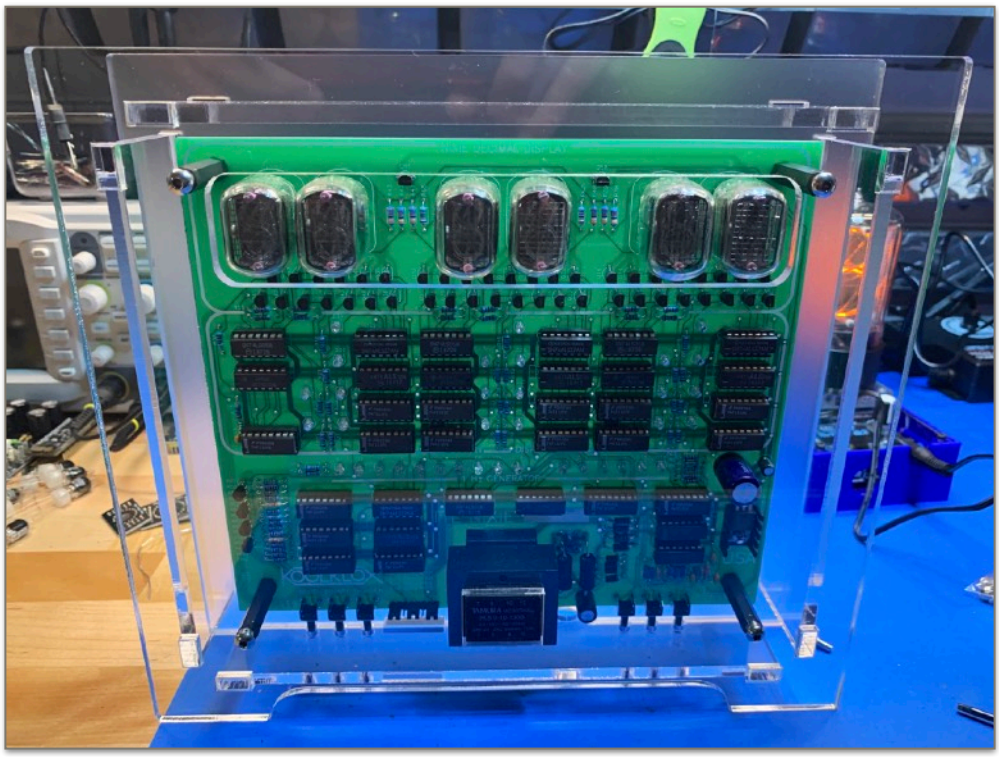



iii) Take the bottom piece of acrylic and install in in the slots making sure the switches etc clear the holes. It will only fit one way around…now would be a good time to decide how you want the jumper switches set….(see page 22). You may have to loosen the bottom two standoffs to lift the PCB a little.



iv) Repeat this process with the top and side pieces.


v) Take the front plate and line it up with the tabs of the top piece and gently coax the top tabs into place, then the two tabs at the top of the side pieces, then the bottom piece tabs and the face plate should lay flush against the standoffs, with the hole for the transformer lines up and the nixie tubes protruding ever so slightly. Attach with 4 x M4 10 mm screws but don't fully tighten them yet.

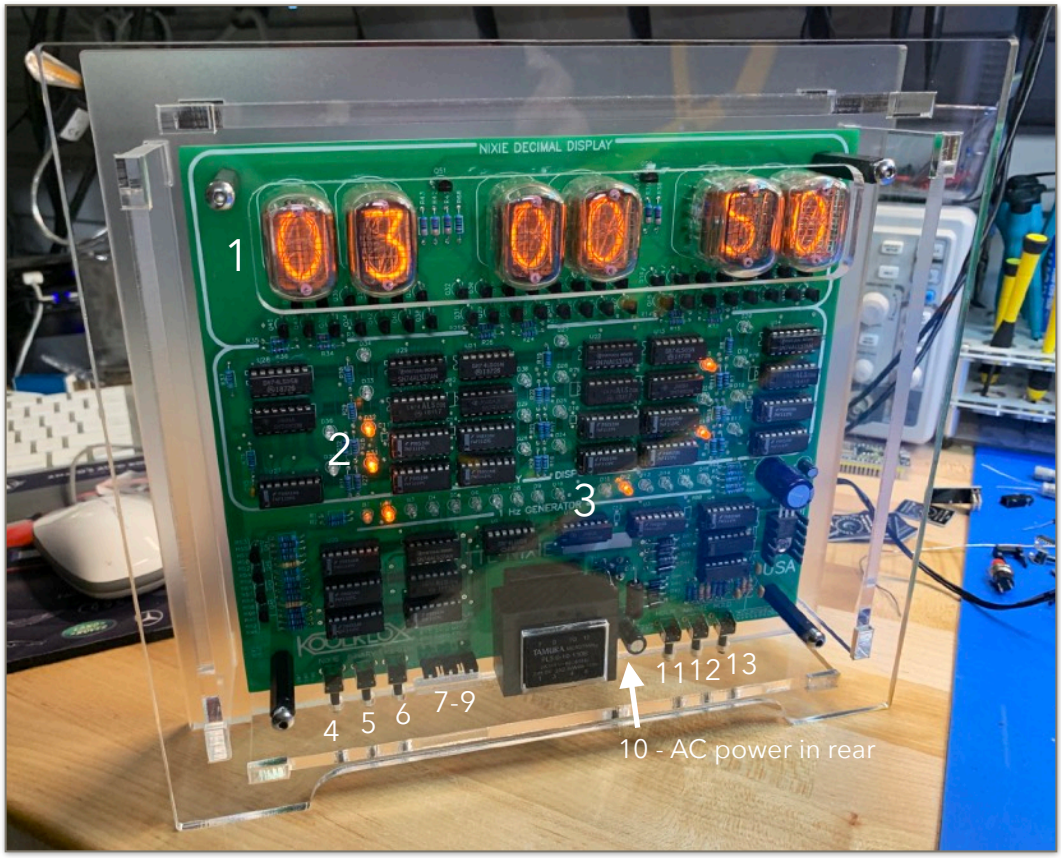


With the clock standing on its 'feet' make sure it doesn't rock and then tighten the front M4 screws in place. You're done!

This completes the final assembly and now it's time to plug it in and test all functions.

## SWITCHES AND FUNCTIONS

1. *NIXIE DECIMAL DISPLAY* - Utilizes Russian made IN12A neon NIXIE tubes to display time in conventional decimal format.
2. *BINARY DISPLAY* - Contains six vertical rows of soft glowing purple LED's used to display the time in binary format or "base 2" which is explained HERE. This section also contains the logic IC's to count seconds, minutes and hours.
3. *1Hz INPUT PRE-SCALER* - This is a selectable divide by 50 or divide by 60 counter used to scale the line input frequency down to 1Hz (one cycle per second) to drive the main clock circuit. The output of this two stage counter is displayed as a moving "dot" on these soft glowing purple LED's.
4. *NIXIE* - This button sets the brightness level of the NIXIE tubes.
5. *BINARY* - This button sets the brightness level of the BINARY DISPLAY LED's.
6. *1Hz GEN* - This button sets the brightness level of the 1Hz INPUT PRE-SCALER LED's.
7. *"0" Hr DISP* - This jumper is used to display or blank the "0" in the 10's Hours digit.
   Example: Jumper can be set to display "09:23:45" or "9:23:45".
8. *12/24 Hr MODE* - This jumper sets the clock to display in 12 Hour or 24 Hour modes.
9. *50/60Hz FREQ* - This jumper is used to select the incoming line frequency.
   Example: For operation in USA set to 60Hz, for Europe set to 50Hz.
10. *AC POWER INPUT* - Plug **AC** power plug in here.
11. *HOUR* - This button is used to set the Hours time.
12. *MINUTE* - This button is used to set the Minutes time.
13. *HOLD* - This button "freezes" the Seconds time for precise time setting.



## TROUBLESHOOTING

Most problems are related to the following:

- Solder bridges (shorts) between connections.
- Unsoldered pins on IC's or any other component.
- Parts left out, make sure you have installed ALL the components. The *exact* number of parts for each step are supplied, so if you're left with spares then you've missed something.
- Parts installed backwards or incorrectly (note electrolytic capacitors, diodes and transistors must all be installed in the correct orientation/polarity).

| STEP | SYMPTOM | DIAGNOSIS |
|---|---|---|
| #11. (5 volt supply) | 0 volts or voltage too high. | Verify 120 VAC mains voltage is present<br><br>With AC adaptor plugged into AC mains supply, verify 9-12 Volts AC on adaptor output connector.<br><br>Verify jumper between points "A"-"A" is installed.<br><br>Verify 270Ω resistor between points "B"-"B" is installed.<br><br>Verify D37-40 and U33 are installed properly.<br><br>Check for solder bridges (shorts) on PCB and unsoldered connections |
| #12. (1Hz Generator) | LED's not flashing/ Constantly on | Are LED's D1-16 installed correctly?<br>Confirm U1,2,5,6,7,8,34 are installed correctly<br>Verify R1-4 are installed.<br>Verify R49 (6.8kΩ) is installed.<br>Check for solder bridges (shorts) on PCB and unsoldered connections.<br>Confirm temporary jumper (A-A) is removed.<br>Confirm temporary 270Ω (B-B) is removed.<br>Confirm L1,L2 installed |
| #14. (Seconds) | LED's not flashing/ Constantly on | Are LED's D17-23 installed correctly?<br>Confirm U9-16 are installed correctly.<br>Verify R5-15 are installed.<br>Check for solder bridges (shorts) on PCB and unsoldered connections. |

| | | |
|---|---|---|
| #15. (Minutes) | LED's not flashing/ Constantly on | Are LED's 24-30 installed correctly?<br>Confirm U17-24 are installed correctly.<br>Verify R16-R26 are installed.<br>Check for solder bridges (shorts) on PCB and unsoldered connections. |
| #16. (Hours) | LED's not flashing/ Constantly on | Are LED's D31-D36 installed correctly?<br>Confirm U25-32,U35-36 are installed correctly.<br>Verify R16-26, R48-49, R50-62 are installed.<br>Check for solder bridges (shorts) on PCB and unsoldered connections.<br>Make sure a Fairchild version of the 74F112 is in position U27. |
| NIXIES | Do not light/dim | Are NIXIE V1-6 tubes installed correctly?<br>Confirm C5, 6 are installed.<br>Confirm Q1-50 are installed correctly.<br>Confirm Q51 is a MPSA92 transistor.<br>Verify R38-43, R63-76 are installed.<br>Check for solder bridges (shorts) on PCB and unsoldered connections. |
| LED's | Do not dim | Confirm Q46-49 are installed correctly.<br>Verify U32,35 are installed correctly.<br>Confirm R50-62 are installed. |

If you are stuck somewhere and need help, then please email me at stocksclocks@gmail.com and I'll try and help you with any issues. If the clock needs to be returned for troubleshooting, then you will need to pay for shipping if the fault is determined to be user/kit building error.

## APPENDIX A - FIGURES 1,2 and 3

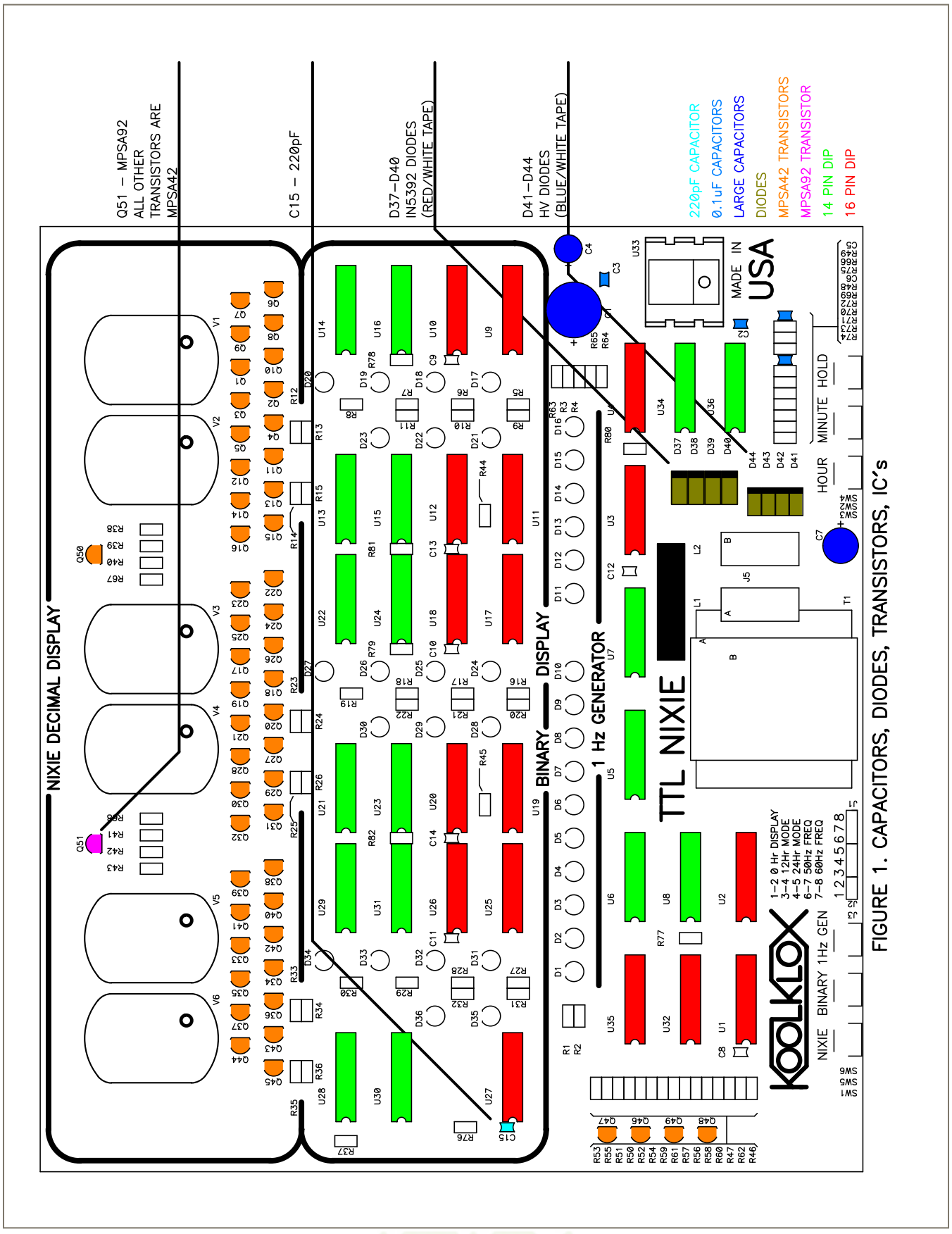



FIGURE 1. CAPACITORS, DIODES, TRANSISTORS, IC's

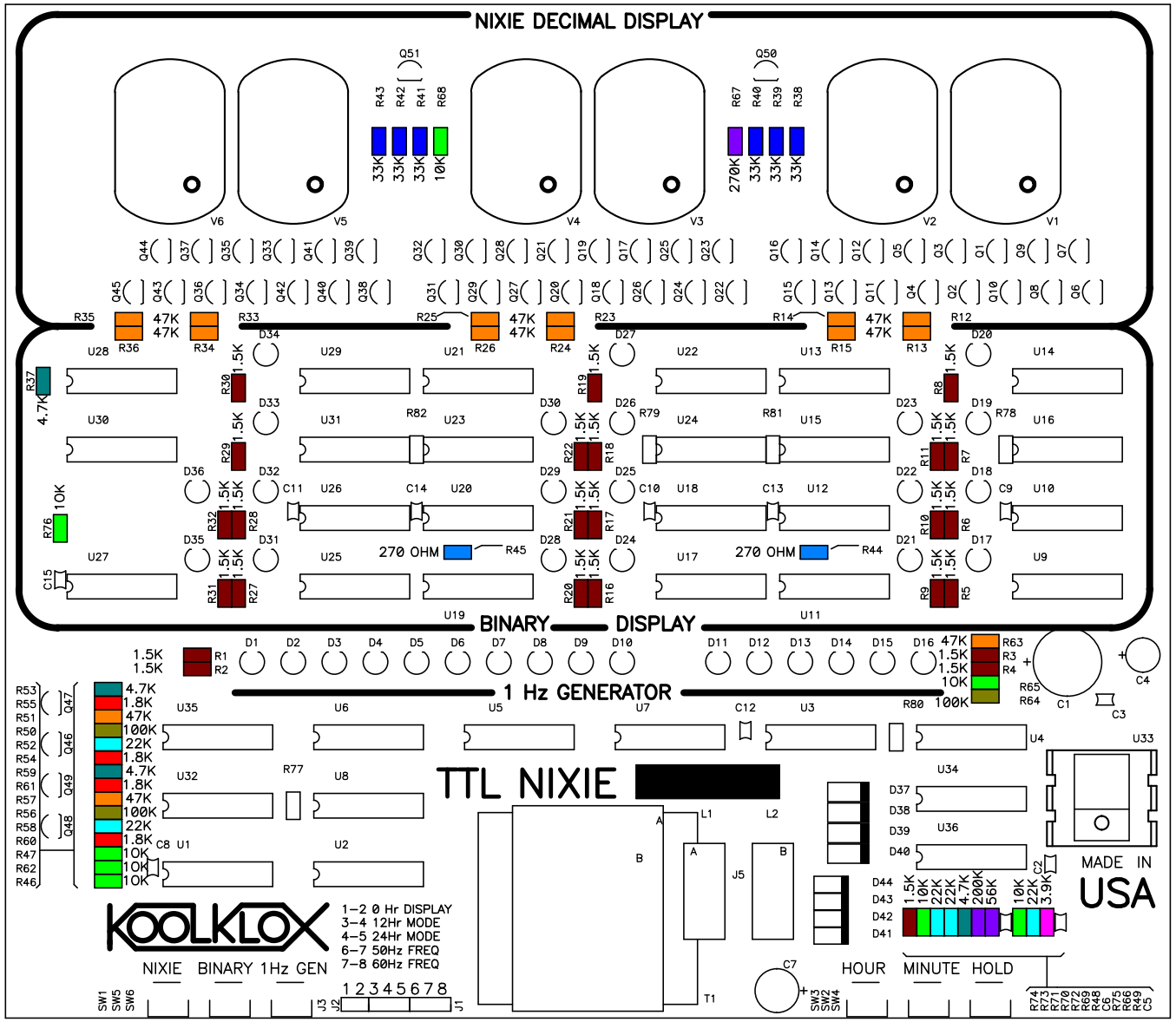



FIGURE 2. RESISTORS

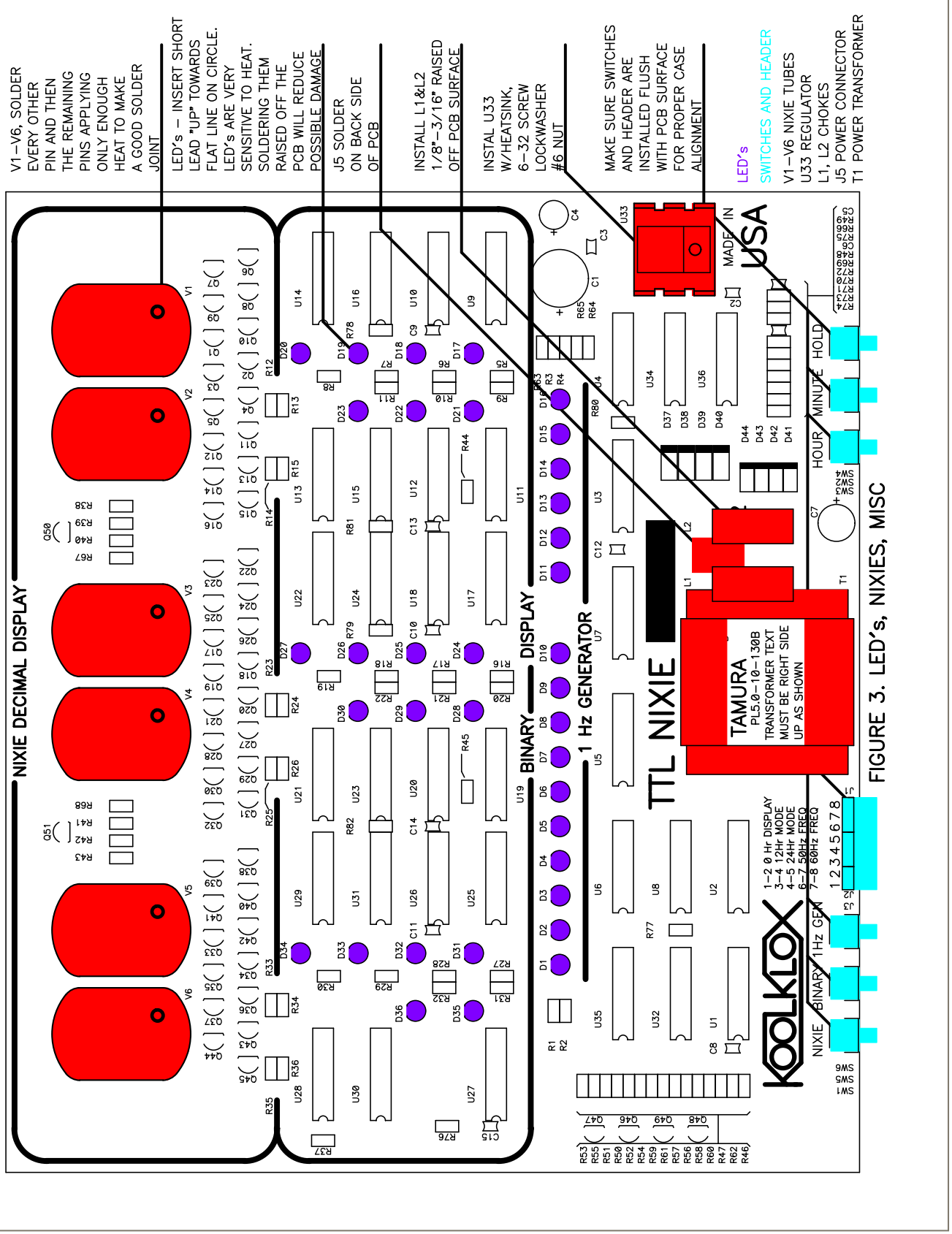



FIGURE 3. LED's, NIXIES, MISC

# APPENDIX B - SCHEMATICS