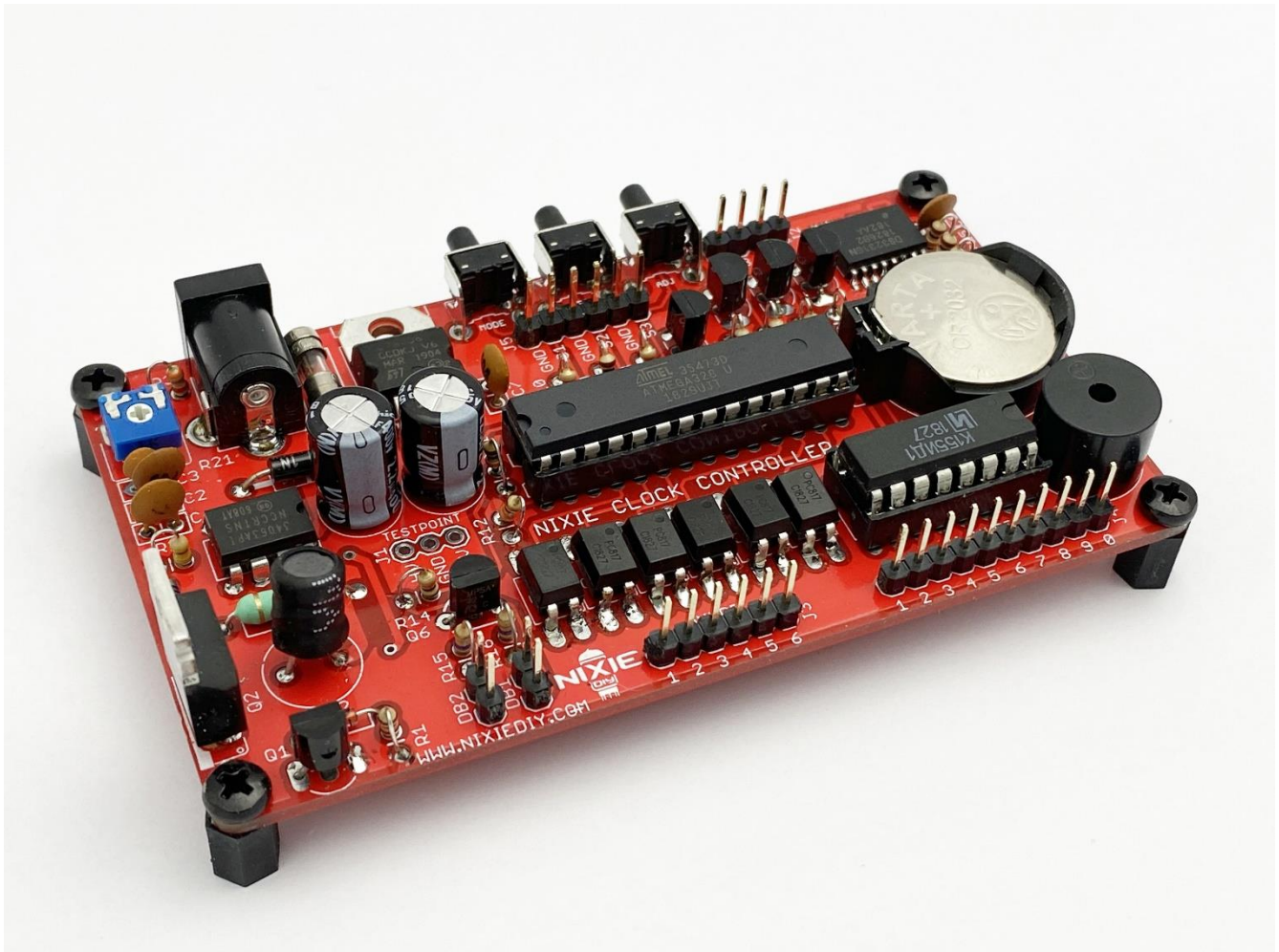


UNIVERSAL NIXIE TUBE CLOCK KIT

Assembly instruction and user manual



Bring to your home a piece of history with The Vintage Nixie Clock and its Cold War era components. The clock will give a cosiness and a uniqueness for your house.

Introduction

This parts kit intended for an electronics hobbyists that want to make a Nixie clock and do not want go deep to complicated clock control electronics and software. This instruction step-by-step assists you to assemble the clock.

The kit consists all necessary electronics parts (excluding Nixie tubes and power adapter) and a microcontroller with pre-programmed an application software.

The main features of the clock

- Hours, Minutes and Seconds display
- 12 or 24 hour operation modes
- Time accuracy is provided by built-in RTC (Real Time Clock) based on extremely precise DS3231 module with temperature compensation and backup with CR2032 battery
- Programmable leading zero blanking
- Date display in either DD/MM/YY or MM/DD/YY format
- Alarm
- Simple time setting using three buttons
- Standard, crossfade and scrollback display modes
- "Slot Machine" Cathode poisoning prevention routine
- Programmable Blue LED tube lighting
- Not AC frequency dependent – works in all countries
- Auto increase of adjusting value for quick time setting
- Neon colon indicators blinking at 1 Hz
- Tubes are driven in high frequency dynamical indication and provide service for many years

Safety precautions

The clock printed circuit board (PCB) includes a High Voltage source that powers the Nixie tubes. Its output voltage can reach 180 Volts DC. The voltage generated by this source can give a potentially LETHAL ELECTRIC SHOCK. When PCB is powered its contacts shall be not touched by hands or non-isolated tools (non-isolated tweezers for example).

Required experience

This product is supplied as a kit of parts, intended only for suitably qualified electronic hobbyists, who are suitably qualified and experienced in electronics assembly and electronics components proper soldering, and are familiar with safe procedures for working with high voltage and its potentially danger.

Assembly and testing of the clock from this kit should be attempted by competent persons only, or under supervision of someone fully experienced in this field.

Correct component placement is critical. A few minutes spent checking placement and orientation prior to soldering will save hours of mistakes search and rework later.

REMEMBER: A properly placed components and carefully soldered PC board will perform well for years, a hastily assembled board will cause ongoing clock problems and failures.

The most important skill for our kit assembly is an electronic components soldering. If you have not an experience enough, next site with Basic Soldering Guide will be useful for you:

<https://learn.sparkfun.com/tutorials/how-to-solder-through-hole-soldering>

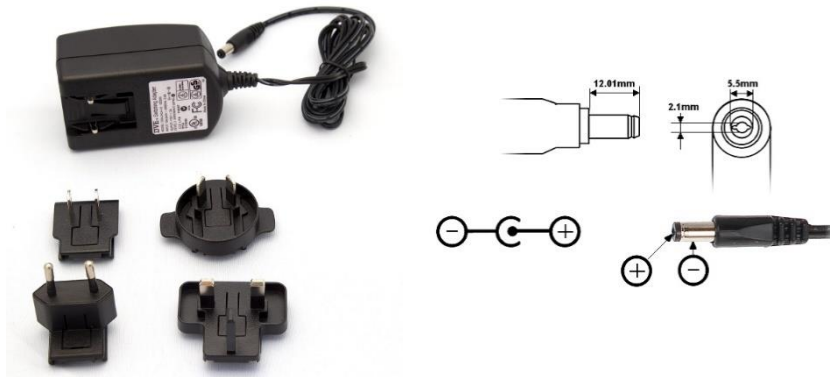
Tools and materials required for assembly

- Screwdriver
- Angled tweezers with thin noses
- Long nose pliers for tube leads bonding
- Side cutting pliers to trim the excess component leads after soldering
- Electronics grade solder 0.5-1mm thickness that contains cores of "flux" which helps the molten solder to flow more easily over the joint
- De-soldering wick or pump may be useful if you accidentally create solder bridges between adjacent solder joints or improper solder any component
- Soldering iron with small a "tinned" tip
- Multi-meter for voltage measurements and for identifying the resistors
- Magnifying glass.



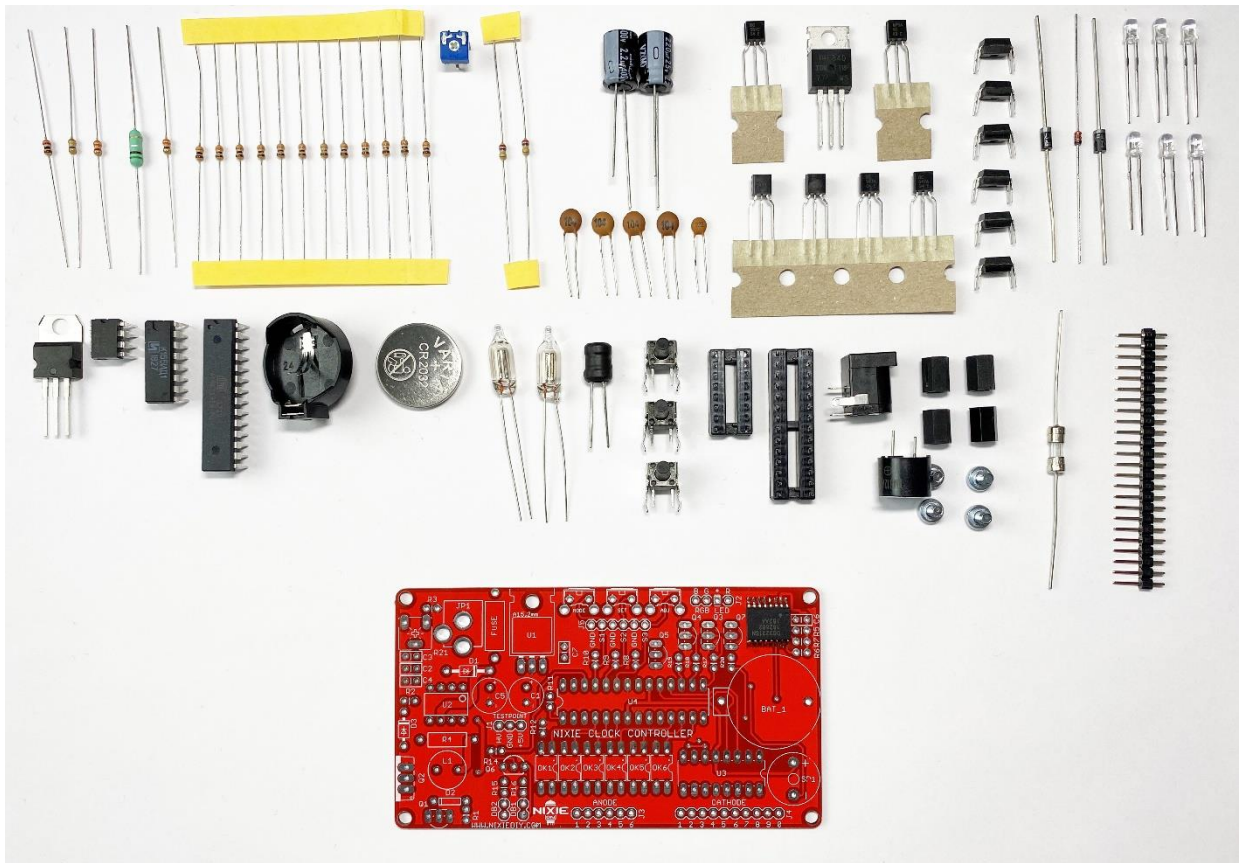
The clock kit does not include next components

- A power adapter. Output voltage 12V DC, output current ~1A. Output end plug – 5.5 x 2.1mm, centre positive. It is cheaper to buy such power adapter in your local electronics shop because it will be equipped by necessary grid plug. You may have similar power adapter in your house also because such type power adapters are popular and widely use.



- The KIT consists electronics components necessary for a clock assembly only. Nixie tubes need to purchase separately. This KIT can work with many nixie tube models. Tested with In-8, In-8-2, In-18, In-12, In-14, In-16, In-1, z573m. Controller does not support biquinary type nixie tubes.
- The KIT does not consist the case of the clock also.
- Wires and nixie tubes sockets are not included.

Parts list



Component designation	Component description
RESISTORS	
R1	1k Ω , 0.25W
R2	470k Ω , 0.25W
R3	3.3k Ω , 0.25W
R4	0.5 Ω , 0.5W
R5, R6, R7, R8, R9, R10, R11, R14, R17, R18 R19, R20	10k Ω , 0.25W
R12	330 Ω , 0.25W
R15, R16	270k Ω , 0.25W
R21	1K, 0.1W (Potentiometer)
CAPACITORS	
C5	2.2 μ F, 250V, Electrolytic
C2, C4, C6, C7	0.1 μ F, Ceramic
C3	2.2nF, Ceramic
C1	220 μ F, 25V, Electrolytic
TRANSISTORS	

Q1	BC557
Q2	IRF840, MOSFET
Q3, Q4, Q5, Q7	BC547
Q6	MPSA42
OK1-OK6	EL817, Optocoupler
DIODES	
D1	1N4004
D2	1N914
D3	UF4004
LED1-LED6	LED, 3mm
INTEGRATED CIRCUITS	
U1	LM7805
U2	MC34063
U3	K1551D1
U4	ATMEGA328P-PU
U5	DS3231
MISCELLANEOUS	
PCB	Nixie Clock PCB
BAT_1	CR2032 Battery socket
Battery	3V CR2032
DB1, DB2	Neon bulb
FUSE	0.5A
L1	330uH, 1A Inductor
S1 - S3	Buttons
U3 Socket	16pin socket
U4 Socket	28pin socket
Power socket (JP1)	5.5mm x 2.1mm
Speaker (SP1)	Active alarm buzzer
PCB Spacers	4 PCB spacers
Screws	4 Screws 3mm
J2, J3, J4, J5, DB1, DB2	Pin strips

Components review

NOTES:

- Components actual view can differ due to different manufacturers.
- If an inscription or color bar coding of the component is small, it is necessary to use the magnifying glass.

Resistors

1k Ω (R1)



10k Ω (R5, R6, R7, R8, R9,
R10, R11, R14, R17, R18, R19, R20)



470k Ω (R2)



0.5 Ω (R4)



3.3k Ω (R3)



330 Ω (R12)



270k Ω (R16, R17)

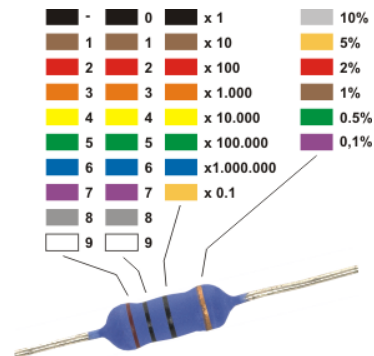


1k (R21)



The resistors used in the kit are marked with four coloured bands to identify the value. Bands 1 and 2 identify the first two digits, band 3 is the Multiplier and band 4 is the tolerance. The first, second and third coloured bands on the resistors indicate the resistance using a colour code. This table indicates how to convert each colour to its numerical equivalent. Gold band means 5% tolerance.

Band colour	Numerical equivalent	Band colour	Numerical equivalent
black	0	green	5
brown	1	blue	6
red	2	violet	7
orange	3	grey	8
yellow	4	white	9



To read a resistor code, first locate the gold band and read the colours in order from the other end. (All resistors in this kit have a gold band indicating 5% tolerance.) The first two bands indicate digits in the resistance; the third band (called the multiplier) indicates the number of zeroes to be added to the digits to obtain the resistance. However, it is sometimes unclear in which direction the bands should be read. Therefore, we recommend that the resistors will be identified with a multimeter. Use the resistor code to identify and sort all of the resistors. One good way to keep them sorted is to tape one end to a piece of paper and write the resistance and component number (R1, R2, etc.). Once you have identified and sorted all of the resistors, you are ready to solder them to the PCB. To prepare a resistor for insertion into the board, bend the two leads so that they form a right angle to the resistor body.

Capacitors

0.1uF (Code 104), (C2, C4, C6, C7)



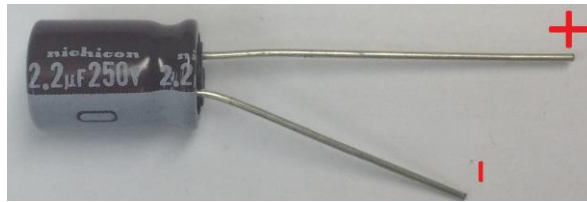
2.2nF (Code 222), (C3)



220uF 25V, (C1)

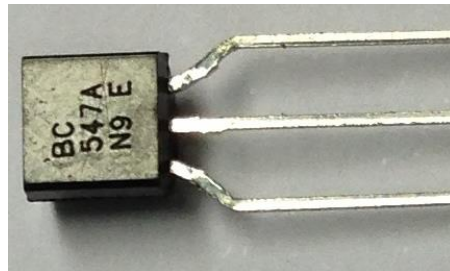


2.2uF 250V, (C5)

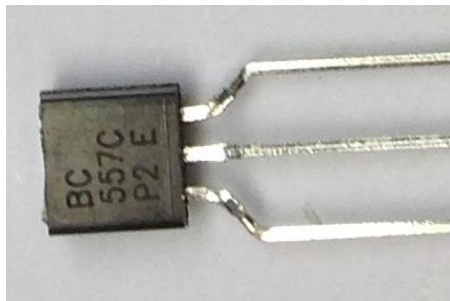


Transistors

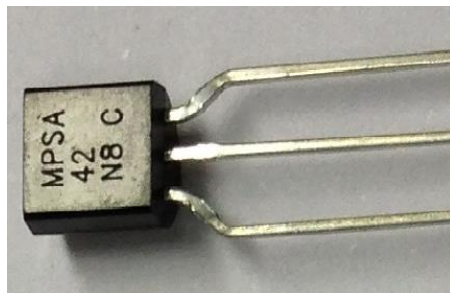
BC547, (Q3, Q4, Q5, Q7)



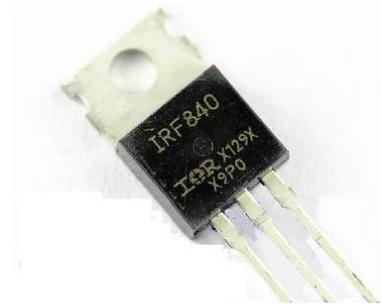
BC557, (Q1)



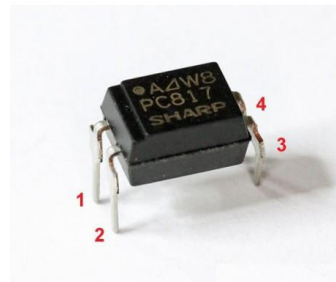
MPSA42, (Q6)



IRF840, MOSFET, (Q2)



EL817, (OK1-OK6)

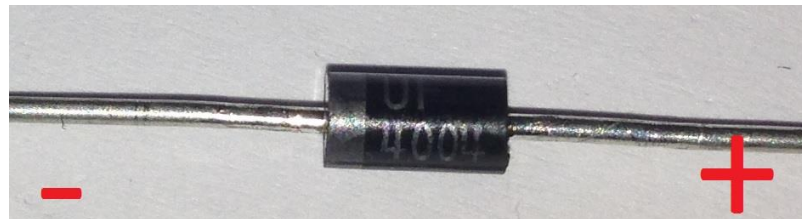


Diodes

1N4004 (D1)



UF4004 (D3)



1N914 (D2)

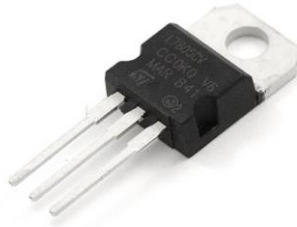


LED, 3mm



Integrated Circuits

LM7805 (U1)



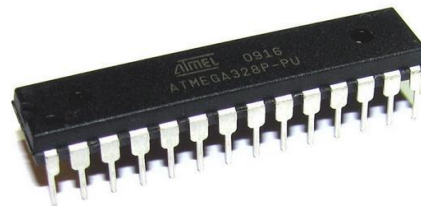
MC34063 (U2)



K155ИД1 (U3)



ATMEGA328P-PU (U4)



DS3231 (U5)



Miscellaneous

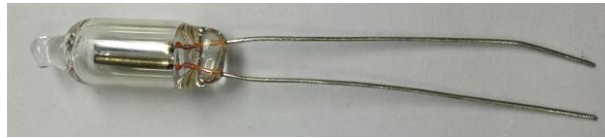
CR2032 Battery socket (BAT_1)



Battery



Neon bulb (DB1, DB2)



Fuse



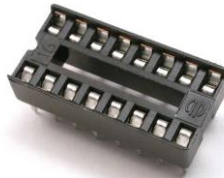
330uH, 1A Inductor (L1)



Button (S1-S3)



16 pin socket



28 pin socket



Power socket (5.5mm x 2.1mm)



Speaker



PCB Spacers



3mm screw



Packing Sheet

Component description	Quantity, pcs
RESISTORS	
1kΩ, 0.25W	1
470kΩ, 0.25W	1
3.3kΩ, 0.25W	1
0.5Ω, 0.5W	1
10kΩ, 0.25W	12
330Ω, 0.25W	1
270kΩ, 0.25W	2
1k (Potentiometer)	1
CAPACITORS	
2.2uF, 250V, Electrolytic	1
220uF, 25V, Electrolytic	1
0.1uF, Ceramic	4
2.2nF, Ceramic	1
TRANSISTORS	
BC557	1
IRF840, MOSFET	1
BC547	4
MPSA42	1
EL817, Optocoupler	6
DIODES	
1N4004	1
1N914	1
UF4004	1
LED 3mm	6
INTEGRATED CIRCUITS	
LM7805	1
MC34063	1
K155ID1	1
ATMEGA328P-PU	1
DS3231	1
MISCELLANEOUS	
Nixie Clock PCB	1
CR2032 Battery socket	1
CR2032 Battery	1
Neon bulb	2
330uH, 1A Inductor	1
Buttons	3
16 pin socket	1
28 pin socket	1
Power socket (5.5mm x 2.1mm)	1
Speaker	1
PCB spacers	4
Screws	4
Fuse	1
Pin Strips (Male)	30
Pin Strips (Female)	30

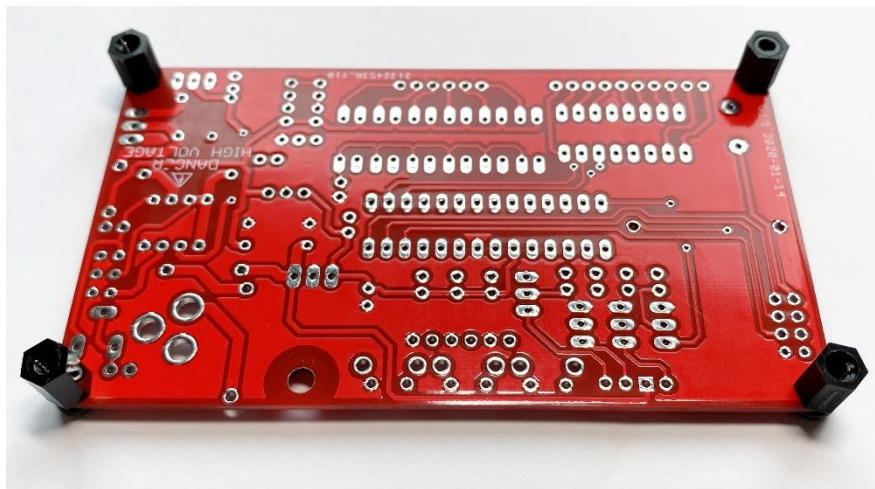
PCB assembly sequence

NOTES:

- This instruction contains high definition pictures. If anywhere is uncertainty, PCB view can magnify and an interested component may view in details.
- The side of the board that has printed component marking is the “component side”. This means that components must mount by inserting them down from the printed side. Make sure that the components mount on the proper side of the PCB!
- Prior to beginning an assembly, make sure to have a well-lighted, well-ventilated workplace. Make sure that all of the electronic assembly tools are available.

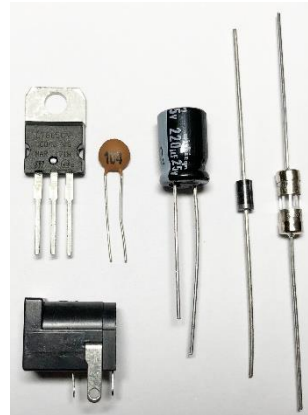
1. Screwing PCB spacers to PCB by screws

Spacers lift the PCB over table surface. It will be more convenient to install and to solder components to the PCB. These spacers can use for fixing an assembled clock in applicable casing also.



2. Low Voltage Power source components preparation for insertion into the board and soldering order

U1	LM7805
C1	220uF, 25V, Electrolytic
C7	0.1uF, Ceramic
D1	1N4004
FUSE	FUSE 0.5A
Power socket	5.5mm x 2.1mm PCB DC Jack



2.1. Bend U1 integrated circuit leads.

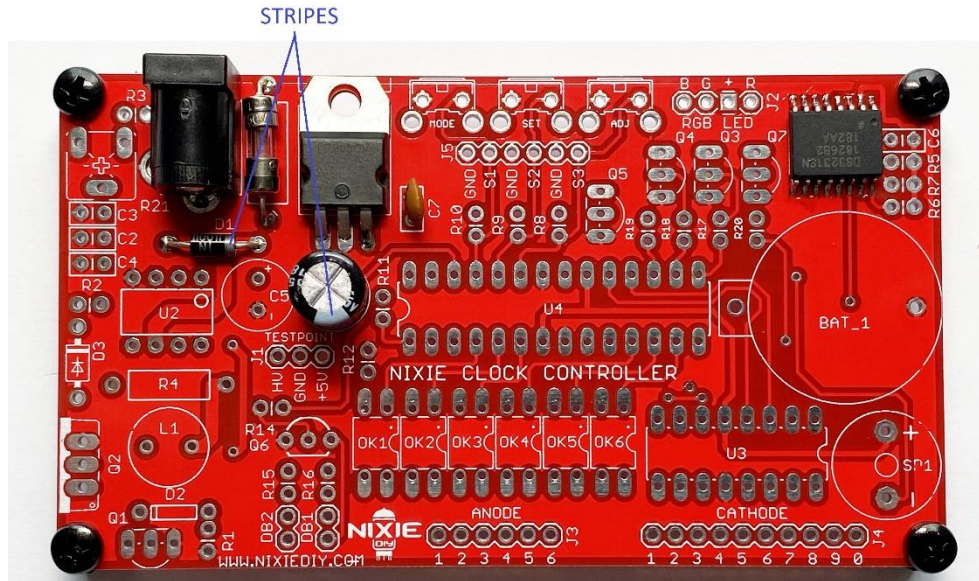


2.2. Bend the two leads of the fuse and diode D1 so that they form a right angle to the component body.

2.3. To install, place the leads of the component through the appropriate holes and press the component down against the component side of the PCB.

2.3.1. The small-value ceramic capacitor (C7) may be installed in either orientation, but the larger-value cylindrical capacitor (C1) must be installed with the proper polarity. The polarity is indicated on the PCB by a "+" sign near one end of the capacitor location. The polarity is indicated on the body of the capacitor with a stripe with a minus (-) sign located on the negative side of the capacitor. In addition, the shorter lead is the negative lead.

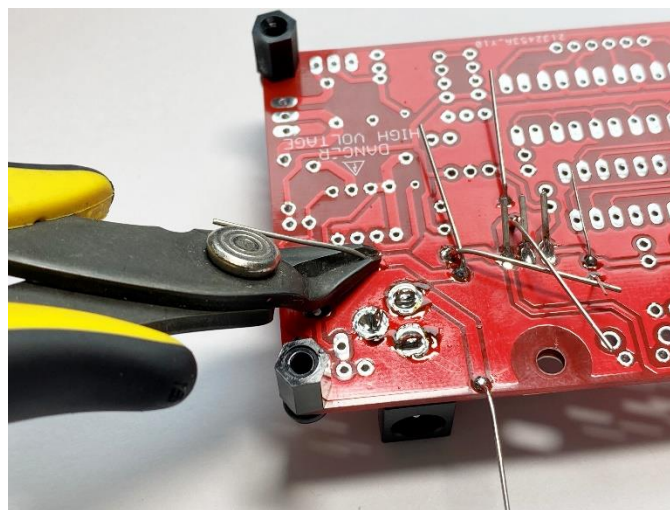
2.3.2. Either lead of the fuse may be inserted in either hole its location.



NOTES:

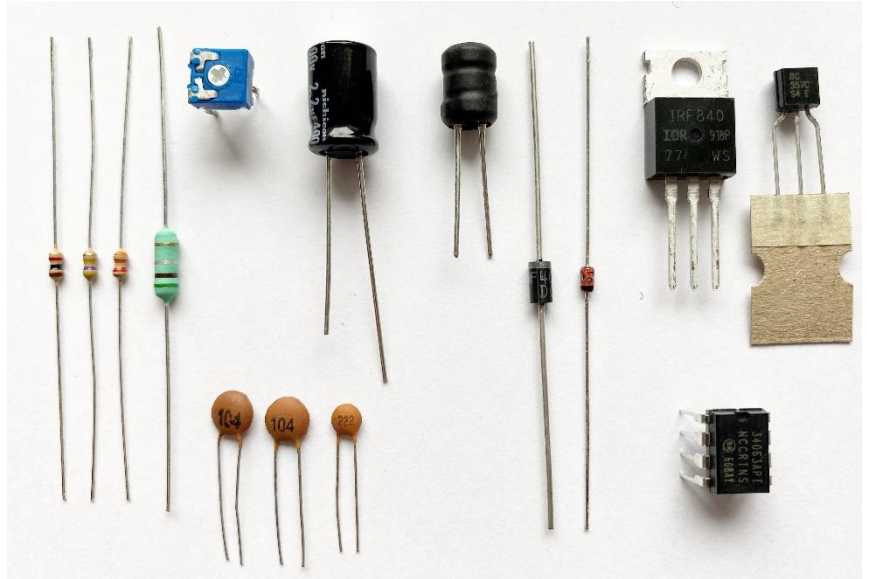
- To make sure that capacitor C1 and diode D1 polarity is not mistaken.
- To make sure that integrated circuit U1 (LM7805) is not mistaken with transistor Q2 (IRF840) and diode D1 (1N4004) is not mistaken with diode D3 (UF4004) because they look like similar.

2.3.3. Turn the board over while holding the relevant component in position and bend the leads slightly outward to hold the component in place. Solder the leads to the contact and trim the excess lead wire above the solder joint.



3. High voltage generator components preparation for insertion into the board and soldering order

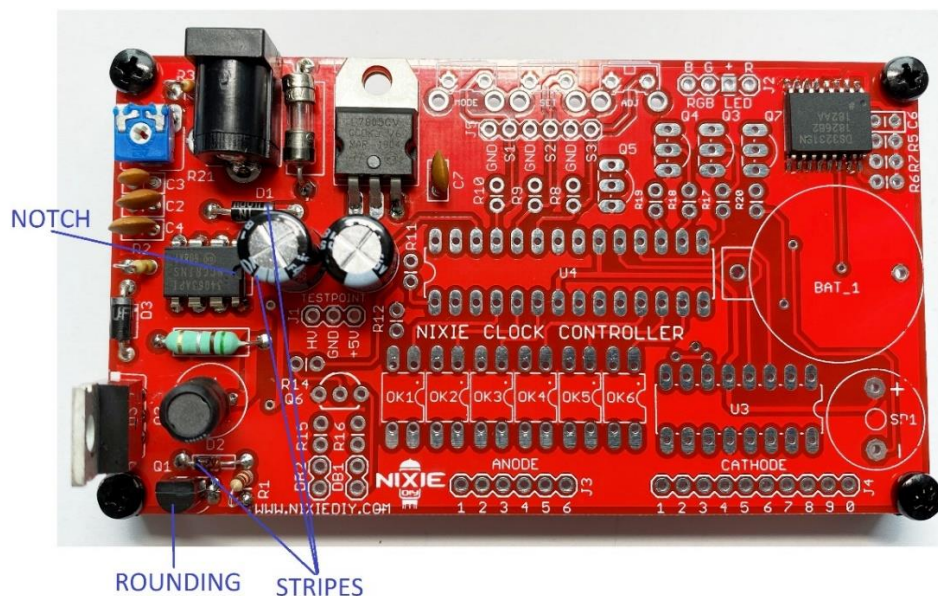
U2	MC34063
Q1	BC557
Q2	IRF840
D3	UF4004
D2	1N914
L1	Inductor 330uH
C5	2.2uF, 250V
C2, C4	0.1uF
C3	2.2nF
R4	0.5Ω 0.5W
R1	1k
R3	3.3k
R2	470k
R21	1k (Potentiometer)



3.1. All resistors (except R4) leads bend in accordance with this picture that each resistor place on board surface will be minimal.



3.2. Repeat actions pointed in items 2.3, 2.3.1 and 2.3.3 for proper components insertion into the PCB and soldering.



4. Low and High Voltage sources operability test

After Low and High Voltage sources components assembly it is necessary to check relevant source proper operability.

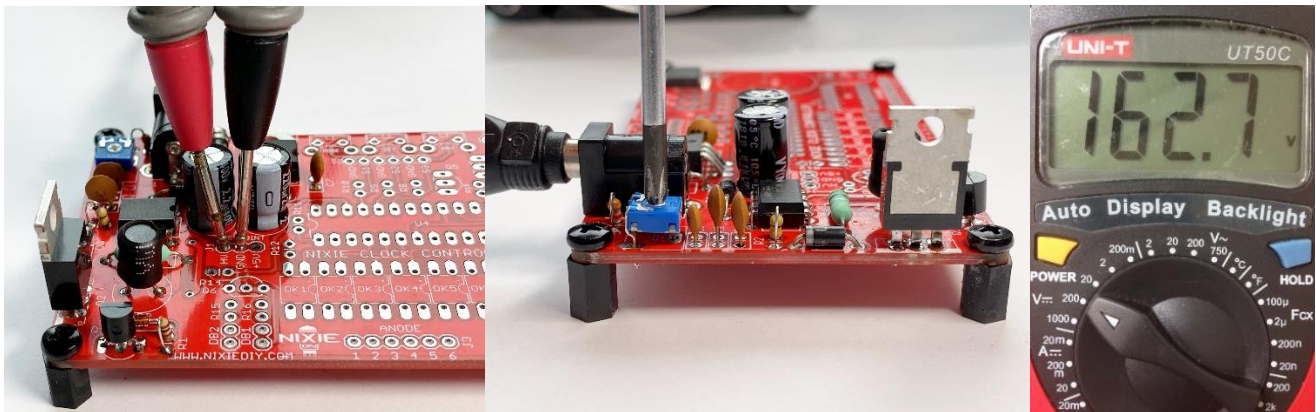
4.1. Select multi-meter DC 200 V measuring range.



4.2. Identify the test ground (GND), 5V and HV test points as shown below.

4.3. Plug in the power supply, and then test HV source operability using a multi-meter in DC voltmeter mode. Touch the black probe on the GND test point and the red probe on the HV test point. The voltage should measure between 140 and 180 Volts. When PCB is powered its HV source contacts shall be not touched by hands or non-isolated tools (non-isolated tweezers for example). If not, disconnect power and remember that the HV source output could still hold charge at 165-175 V. Check all relevant joints quality and polarity.

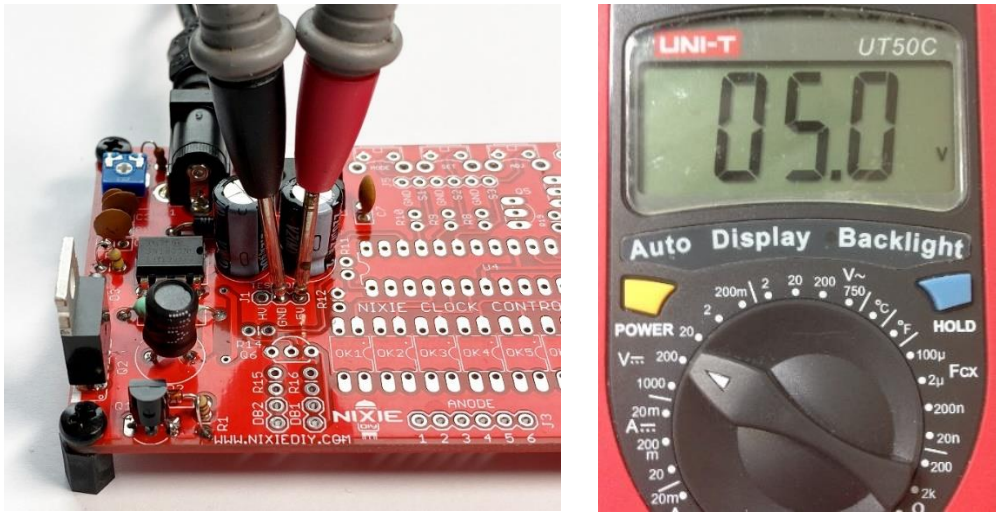
Do not continue with the next test until the error in HV source exists.



NOTES:

Turn the potentiometer to adjust the voltage to approximately 165V. A potentiometer is needed to change the brightness of the nixie tube.

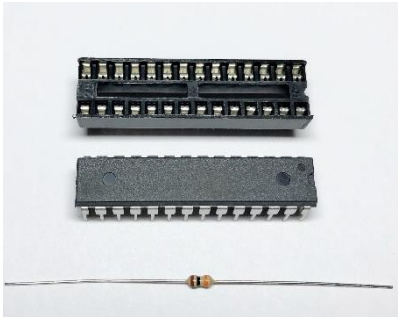
4.4. Test low voltage (LV) source operability. Touch the black probe on the GND test point and the red probe on the 5V test point. The voltage should measure between 4.8 and 5.2 Volts. If not, disconnect power and check all relevant joints quality and polarity.
Do not continue with the assembly until the error will be corrected.



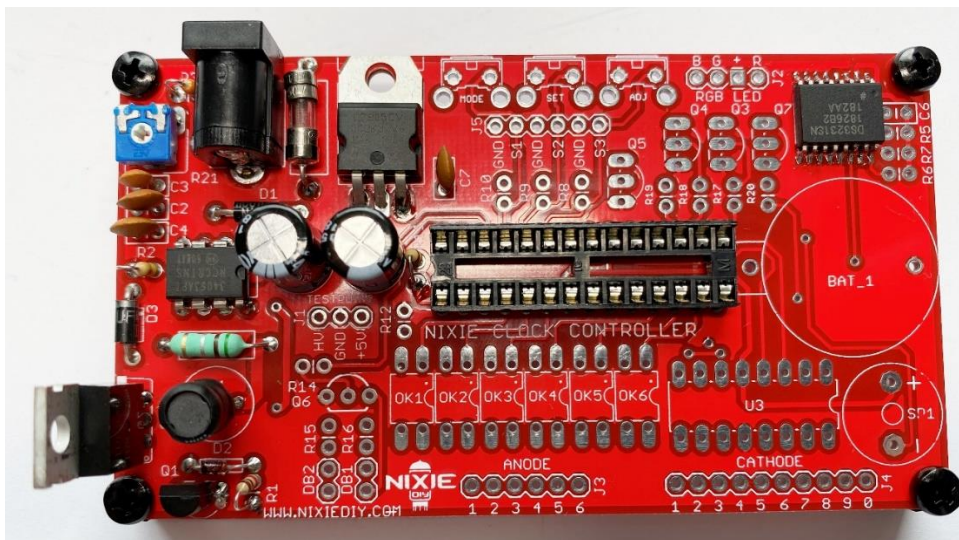
4.5. Once the last test of LV source is completed, disconnect the power.

5. Microcontroller circuit components assembly

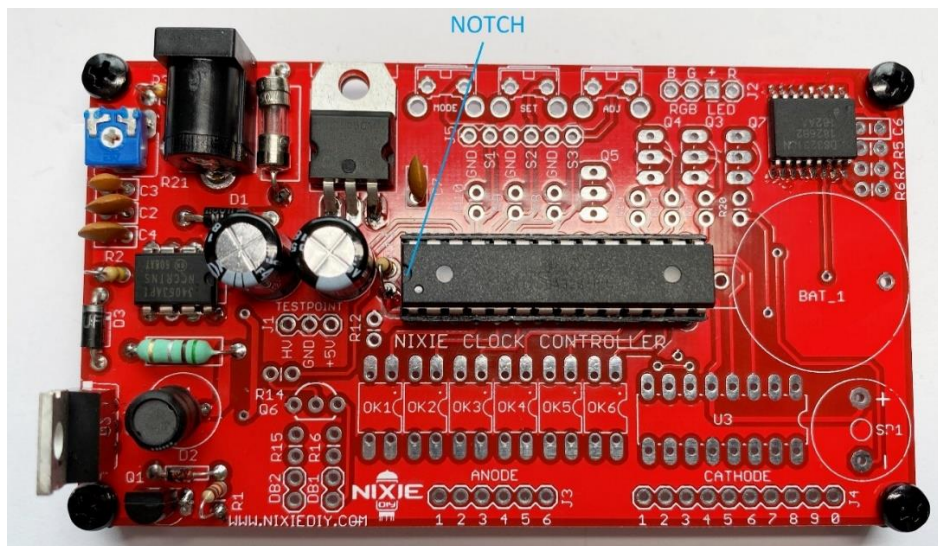
U4	Atmega328P-PU
R11	10kΩ
U4 Socket	28 pin socket



- 5.1. Take the resistor R11 and bend it, like pointed in item 3.1. Insert resistor into the board holes marked as R11 and solder it leads.
- 5.2. Insert U4 socket and solder it leads.



5.3. Insert the microcontroller into the socket

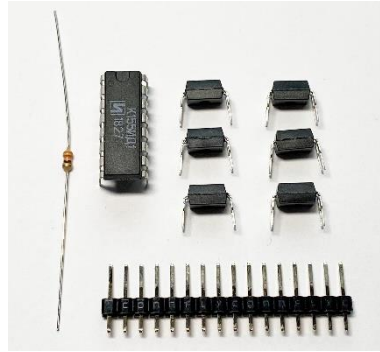


NOTES:

- Do not place the microcontroller U4 into the socket before you mount the socket onto the board.
- Mount the socket such that the notch in the socket lines up with the notch marking in rectangular outline printed on the board.
- After inserting a socket into the board, solder its two opposite-corners pins first. This will hold the socket in place. Look at it carefully to check its proper orientation. If not, it is easy to heat one or both pins and adjust the socket. Only if everything is correct, solder the rest of the pins. Remember: to keep the soldering time per pin brief. The pins do not need to be clipped.
- The microcontroller notch indicates how the IC should be mounted into the socket after the socket has been soldered into the PCB.

6. Tube driver circuit components

U3	K155ИД1
OK1-OK6	EL817
R12	330Ω
U3 socket	16 pin socket
J3, J4	Pin strips

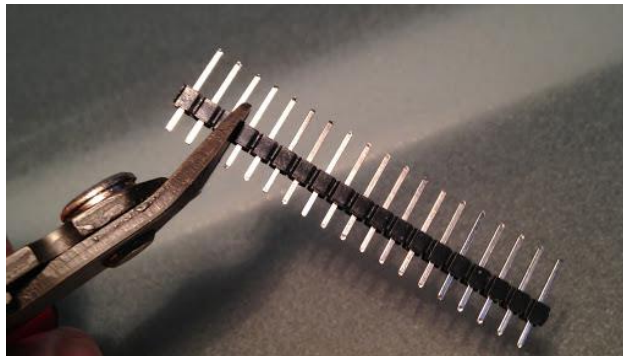


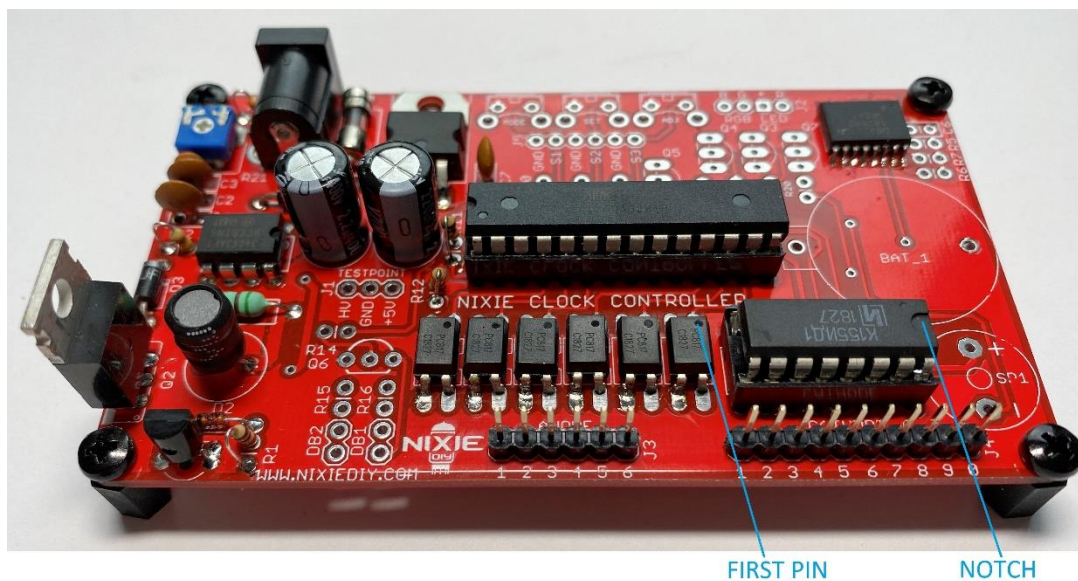
6.1. Take the resistor R12 and bend it, like pointed in item 3.1. Insert resistor into the board holes marked as R12 and solder it leads.

6.2. Actions for tube driver IC and its socket mounting are similar as pointed in item 5. Check your work results with picture below.

6.3. One end of the OK1 ... OK6 symbol on the PCB has a half-hole at one end of the symbol. In optocouplers OK1 ... OK6 first pin of the case marked by small dot. Install the optocouplers so that the end with the dot is at the end of the half-hole symbol on the PCB. Press the IC firmly into the holes into the PCB and solder the pins taking care not to create any solder “bridges” between the pins.

6.4. Cut the desired number of male pins and solder them into position J3, J4.





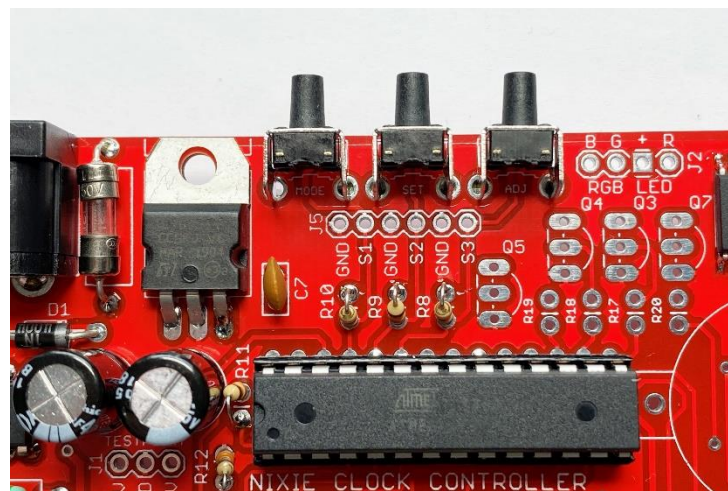
7. Buttons circuit components assembly

S1-S3	Buttons
R8, R9, R10	10kΩ

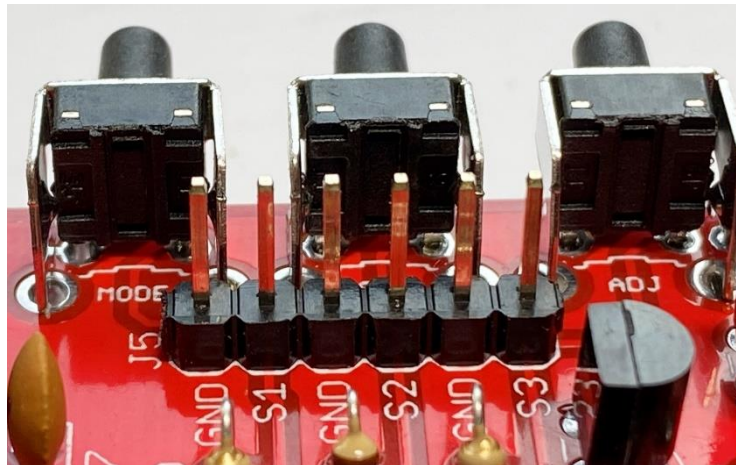


7.1. Parts S1-S3 are right-angle tactile button switches. Insert them into locations and make sure that they sit flat on the board. Solder all four pins of each switch.

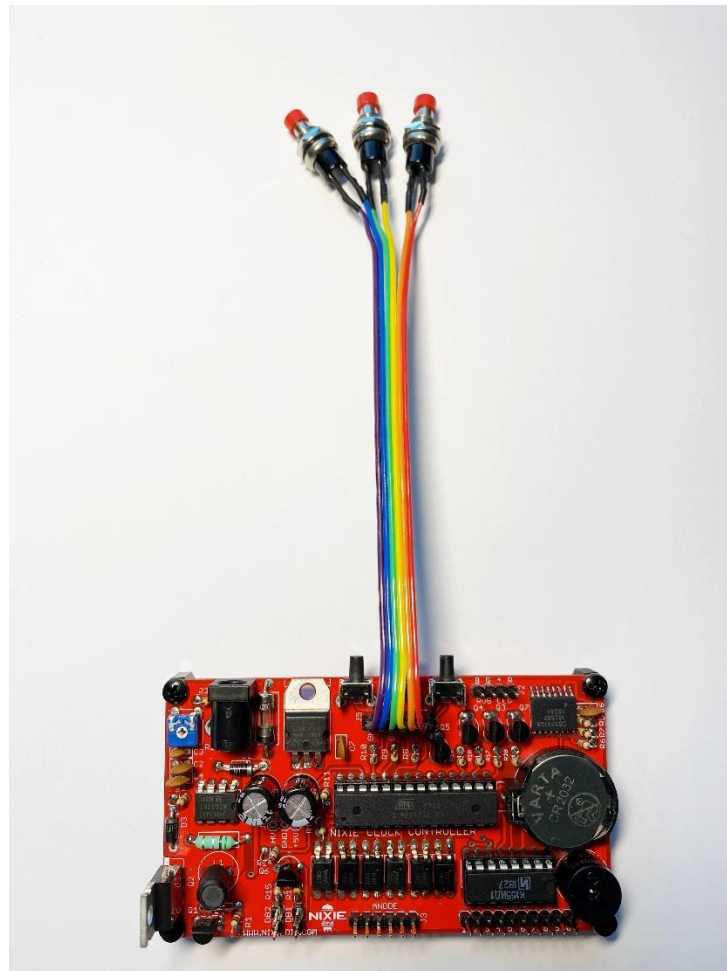
7.2. All resistors R8, R9 and R10 leads bend in accordance with item 3.1. Insert them into locations R8, R9, R10 and solder their leads as pointed on the picture.



7.3. Cut the desired number of pins and solder them into position J5

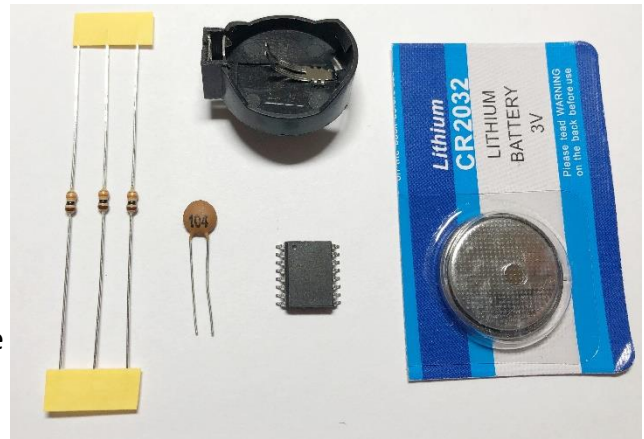


An example of connecting remote buttons is shown in the photo below.



8. RTC (real time clock) circuit components assembly

U5	DS3231
C6	0.1uF
R5, R6, R7	10kΩ
BAT_1	CR2032 Battery socket
Battery	3V CR2032

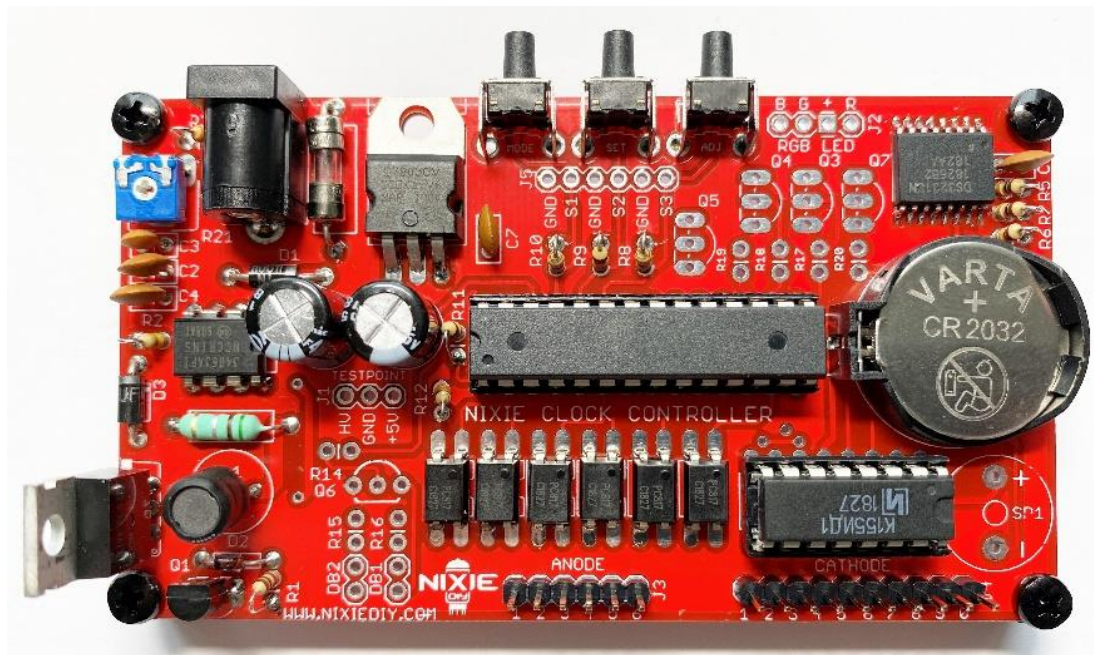


7.1. Take the resistors R5, R6, R7 and bend them, like pointed in item 3.1. Insert each resistor into the board holes marked as R5, R6 and R7 respectively and solder its leads.

7.2. Solder capacitor C6 on the board at location C6.

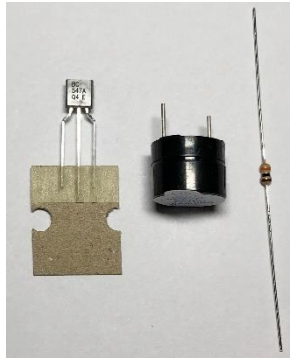
7.3. Battery has polarity (+/-) and requires special attention when mounting. Its socket BAT_1 solder as pointed on the picture. Insert the battery into the socket.

NOTE: An integrated circuit U5 DS3231 is in SMD (surface mount device) case, which is very difficult for soldering. Due to it soldered in advance.

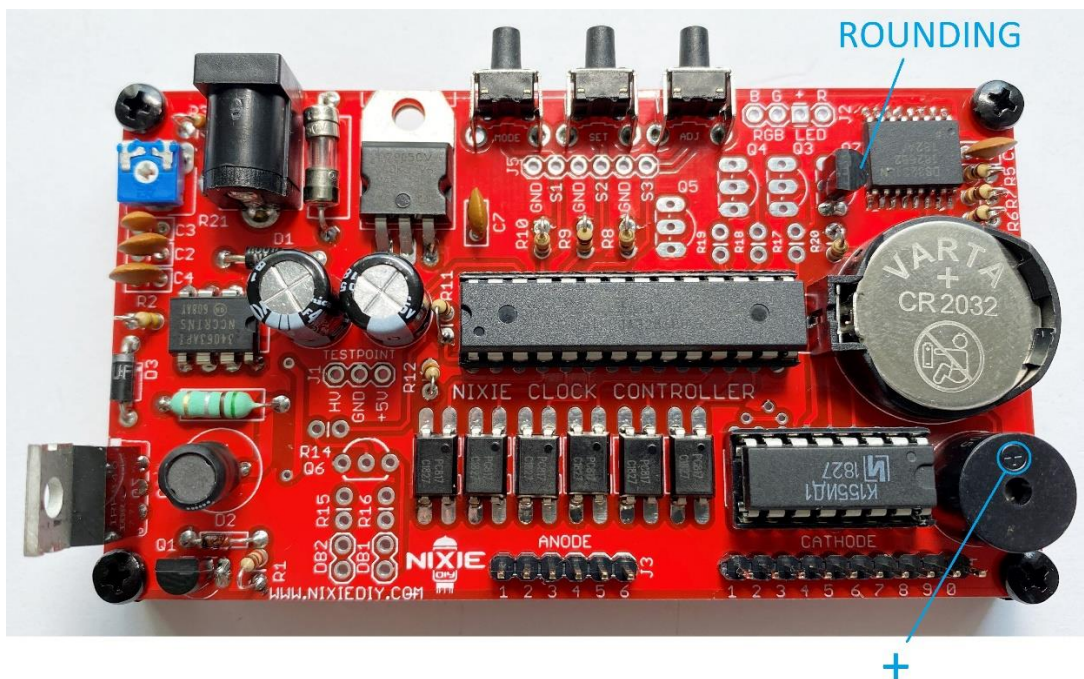


9. Speaker circuit components assembly

Q7	BC547
R20	10k Ω
Speaker	

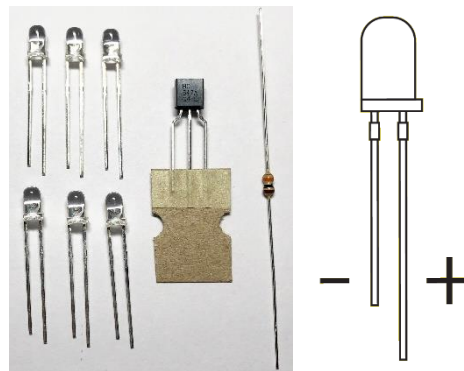


- 9.1. Take the resistor R20 and bend it, like pointed in item 3.1. Insert resistor into the board holes marked as R20 and solder it leads.
- 9.2. Install the transistor Q7 legs into the board holes marked as Q7 that its case flat edge is above the flat edge of the placement marking. Solder it leads.
- 9.3. Speaker is polarized device and requires special attention when mounting. Install the lead marked (+) in the hole marked (+) and opposite lead in the hole marked (-). Solder leads.
- 9.4. Remove speaker seal after soldering.

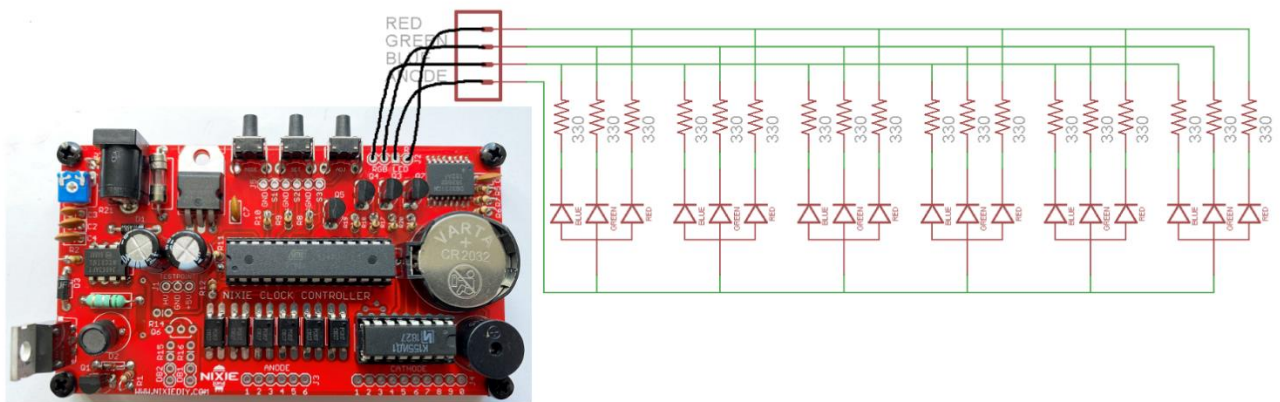


10. LED backlight circuit components

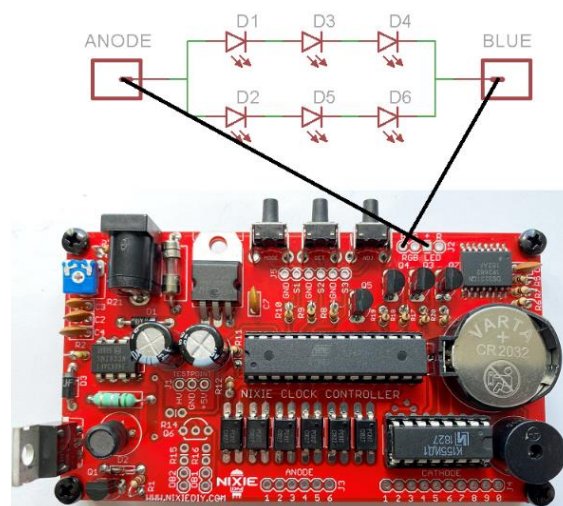
R17, R18, R19	10k Ω
Q3, Q4, Q5	BC547
LED1-LED6	LED, 3mm
J2	Pin strips



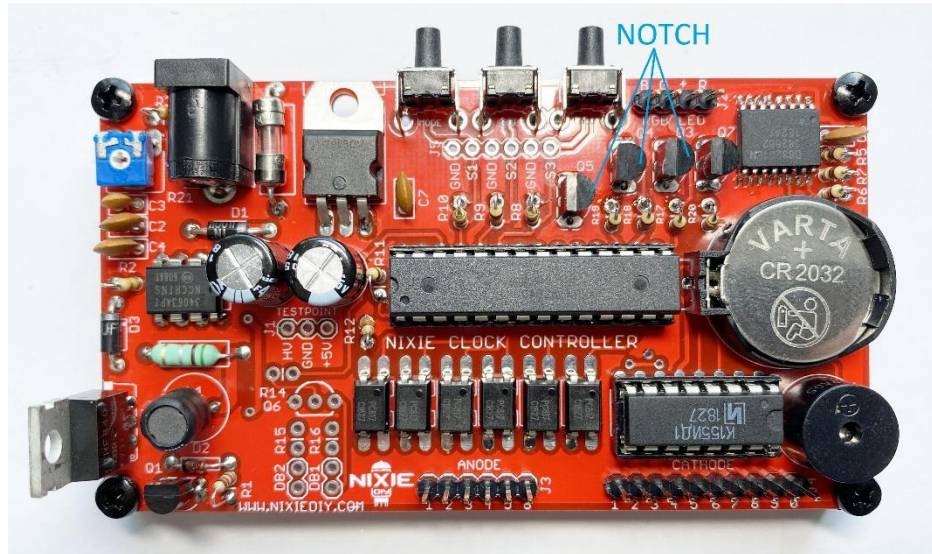
If necessary, RGB LED backlight can be connected to the controller. The controller supports common anode RGB LEDs and single color LED's (6pcs of blue color LEDs are included).
Connection diagram of RGB LEDs with a common anode:



Connection diagram of single color (blue) LED's:

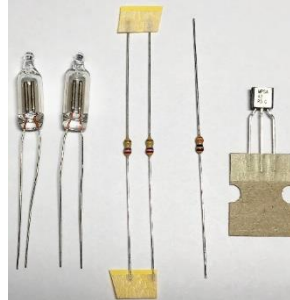


- 10.1. Resistor R17, R18, R19 leads bend in accordance with item 3.1. Insert them into location R17, R18, R19 and solder it's leads as pointed on the picture.
- 10.2. Install the transistor Q3, Q4, Q5 legs into the board holes marked as Q3, Q4, Q5 that its case flat edge is above the flat edge of the placement marking. Solder it leads.
- 10.3. Cut the desired number of pins and solder them into position J2.



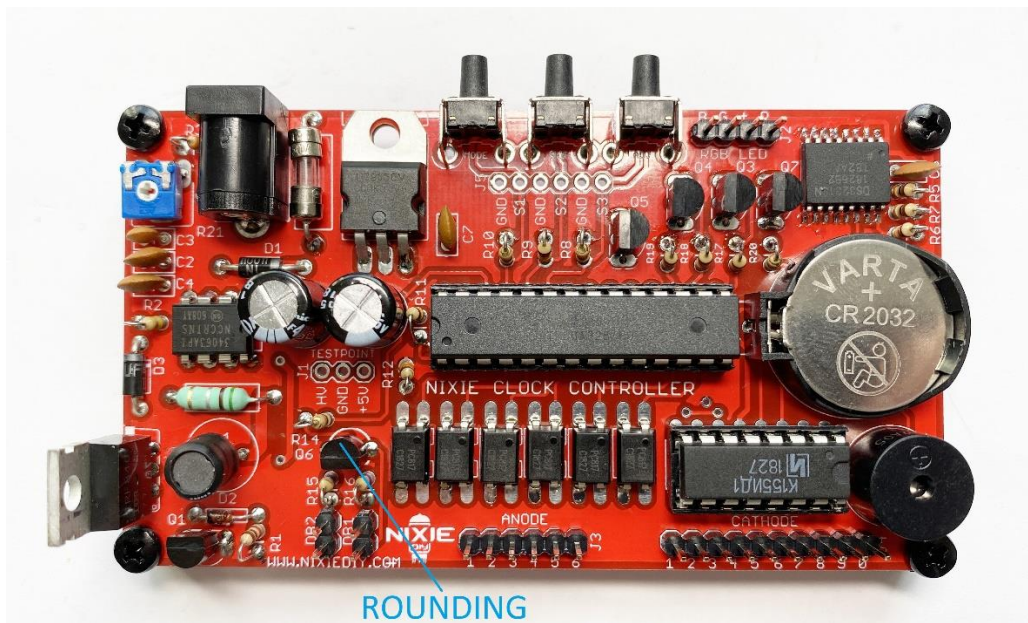
11. Neon dot circuit components

DB1, DB2	Neon Bulb
R15, R16	270k Ω
R14	10k Ω
Q6	MPSA42

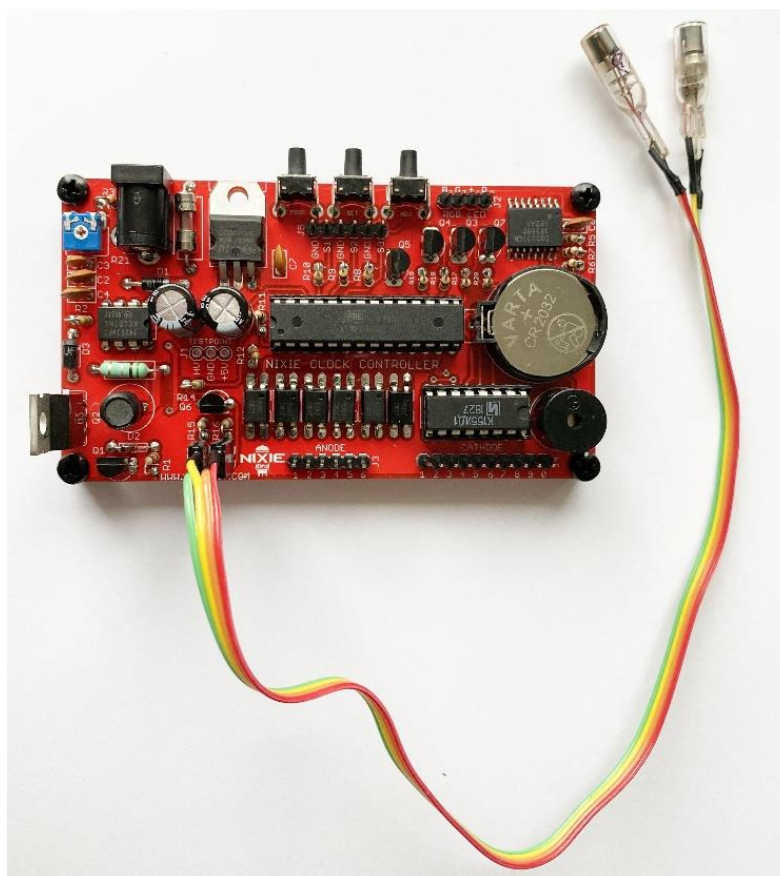


NOTE: Resistors R15, R16 are selected for standard neon bulbs that are included in the KIT. If necessary, connect other neon bulbs, select the appropriate resistors.

- 11.1. Resistors R14, R15 and R16 leads bend in accordance with item 3.1. Insert them into locations R14, R15, R16 and solder their leads as pointed on the picture.
- 11.2. Install the transistor Q6 legs into the board holes marked as Q6 that its case flat edge is above the flat edge of the placement marking. Solder it each leg in accordance with sub-item 10.2 directions.
- 11.3. Cut the desired number of pins and solder them into position DB1, DB2.

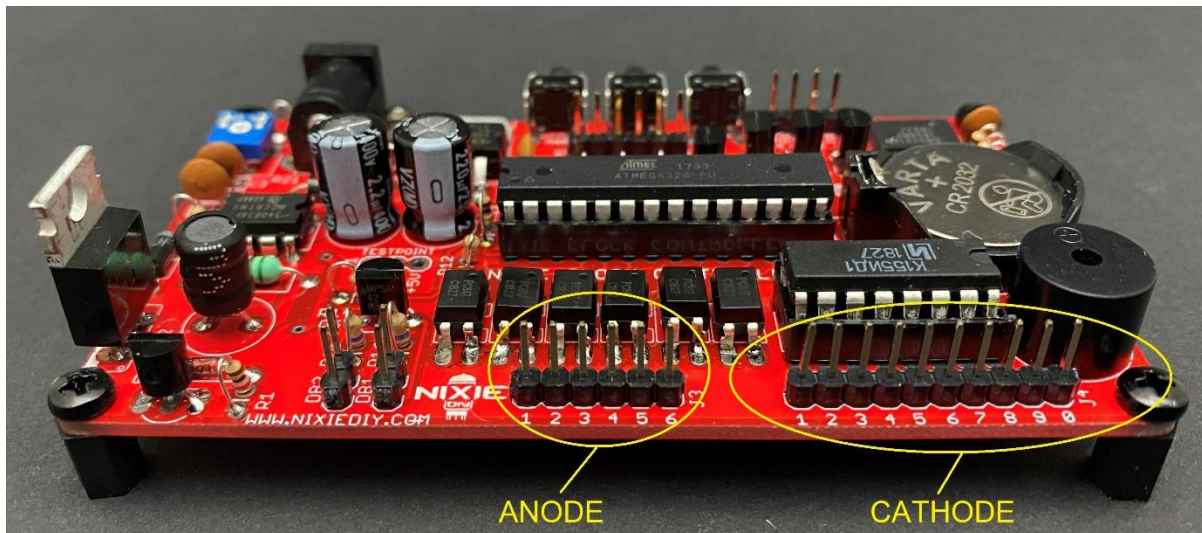
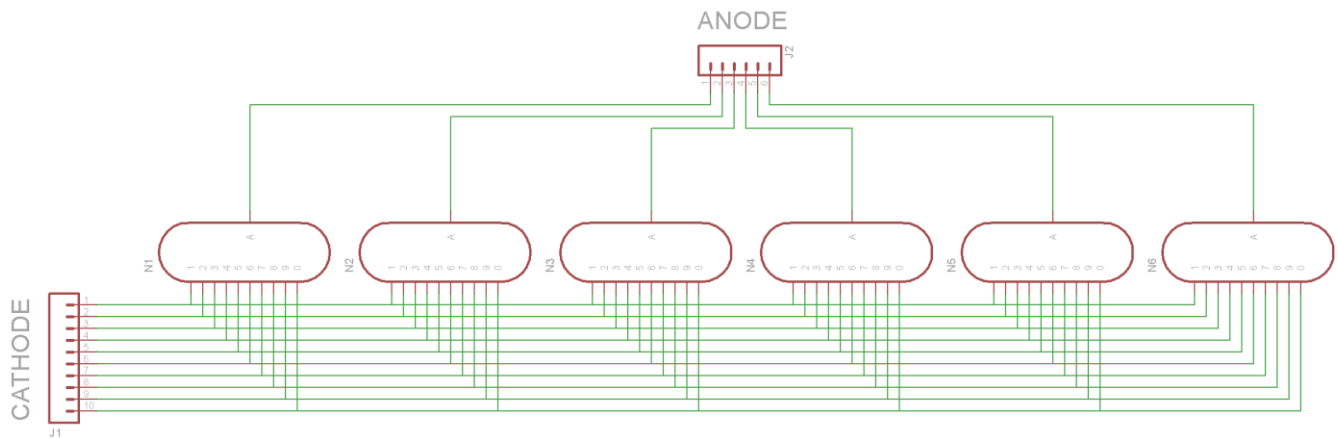


An example of connecting neon bulb INS-1 is shown in the photo below.



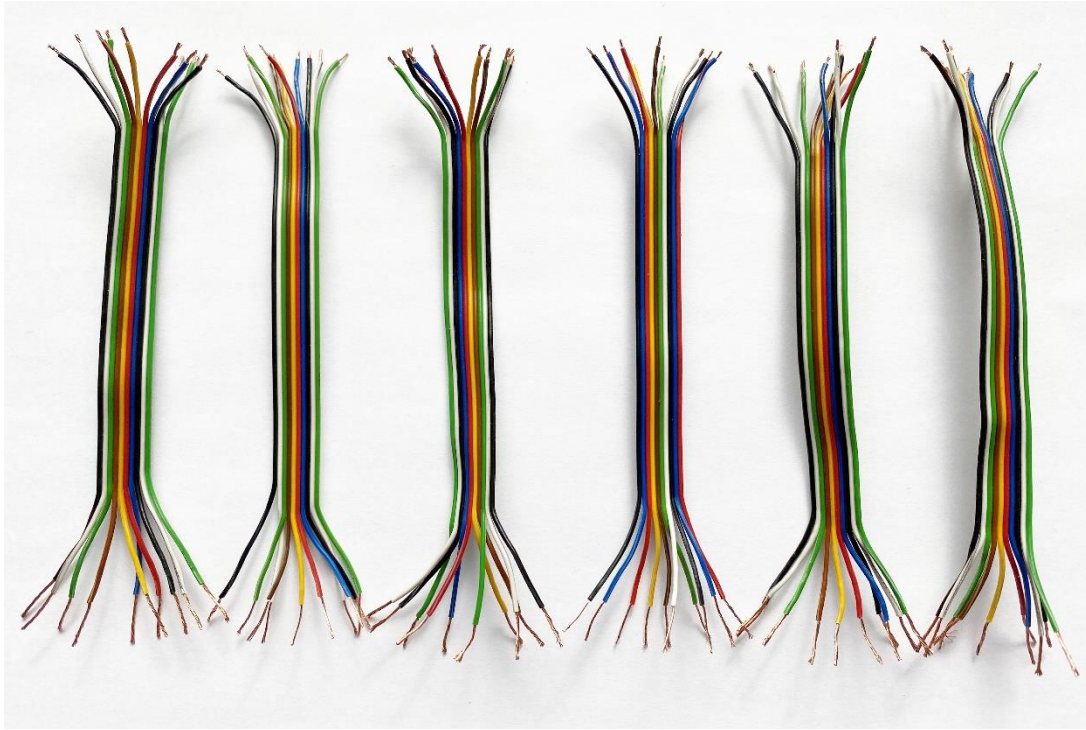
12. Nixie tube connecting

All tube cathodes must be connected in parallel. Anodes must be connected separately for each tube.

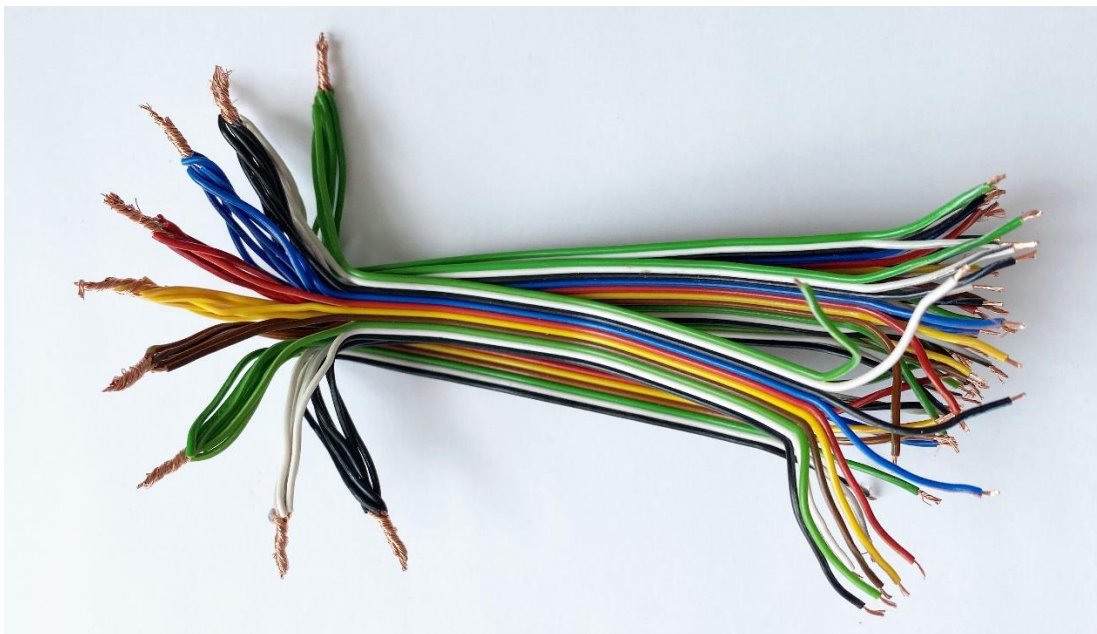


12.1. Cathode connection

12.1.1. Prepare six wires (10 cores):

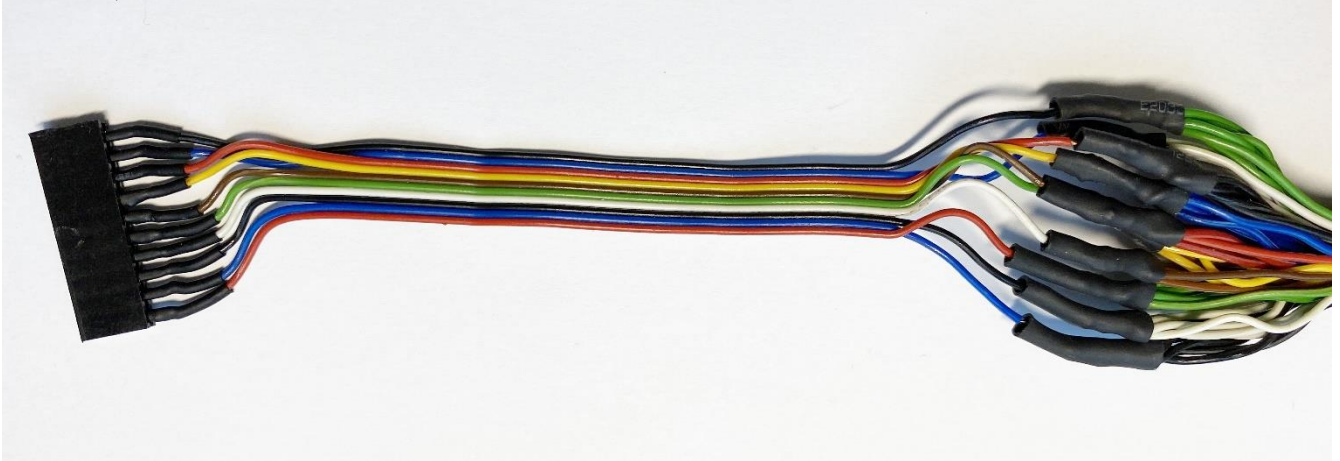


12.1.2. Connect the wires together:

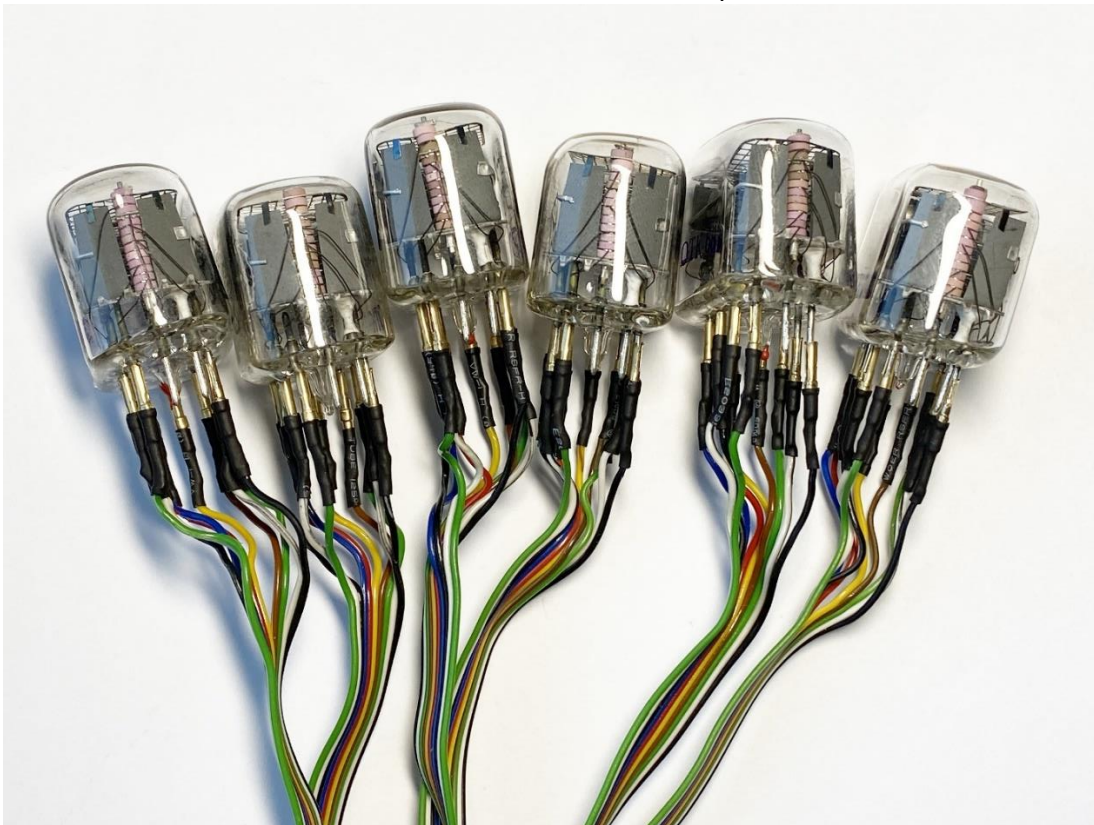


12.1.3. Due to the thickness of the wire, it will be difficult to connect it to the controller. So, solder a single-wire to each connection. Use heat shrink tubing to isolate the joints.

12.1.4. Cut the desired number of female pins and solder them to the cable. Check the tube datasheet to identify cathode numbering.

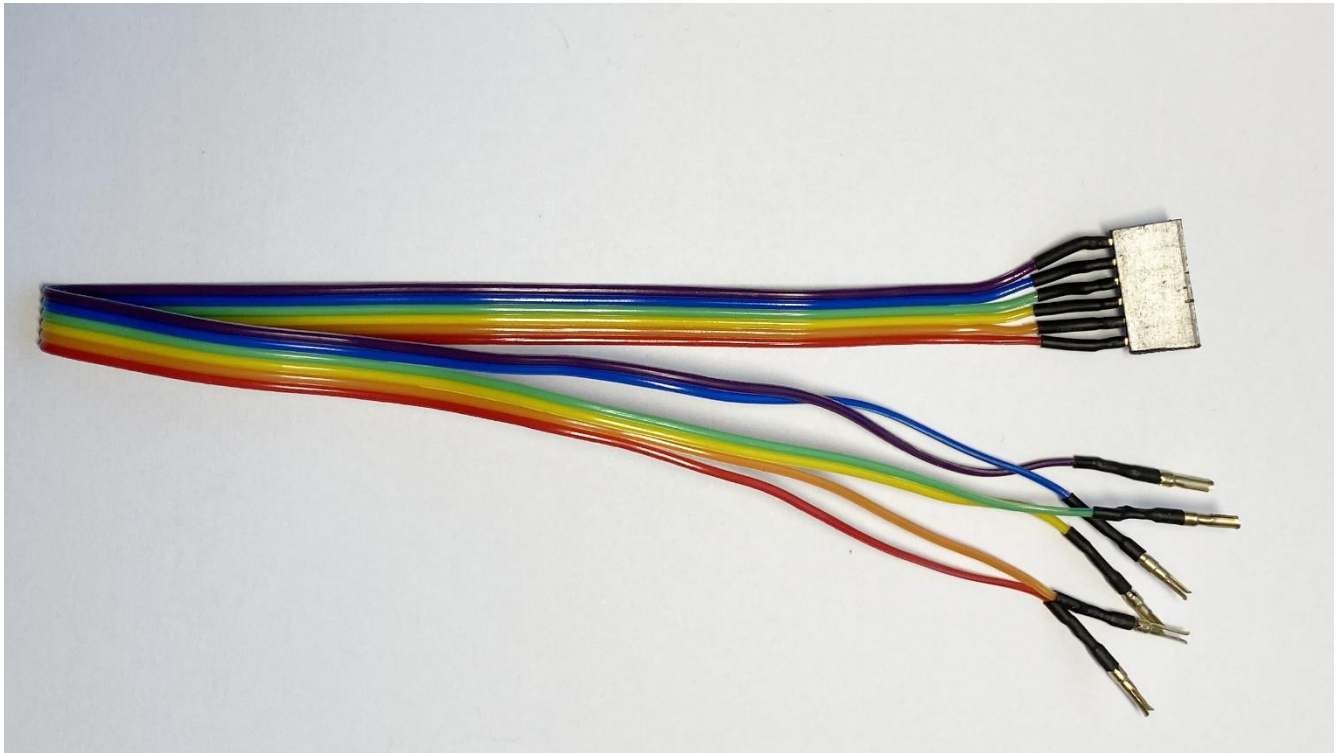


12.1.5. Nixie tubes can be soldered directly to the wires or sockets can be used. It is more convenient to use the sockets, as in case the tube fails, it will be easier to replace it.

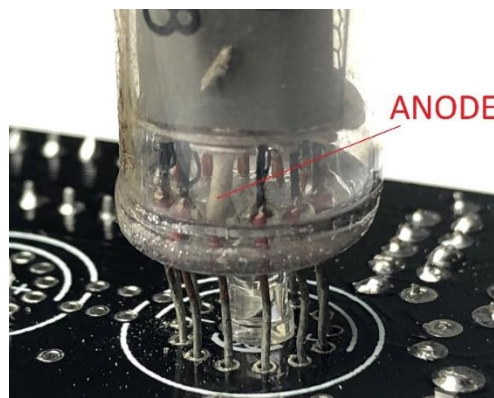
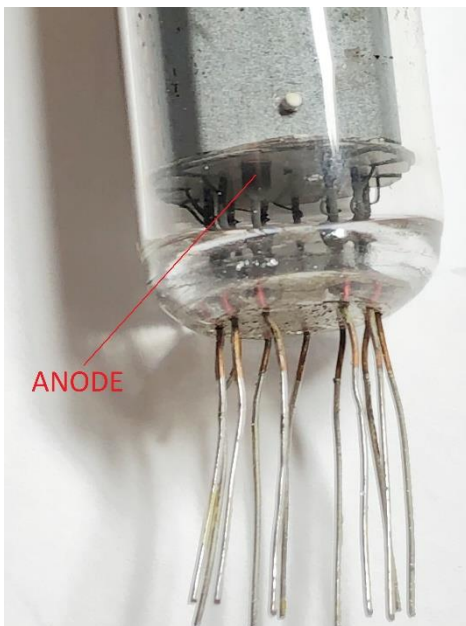


12.2. Anode connection

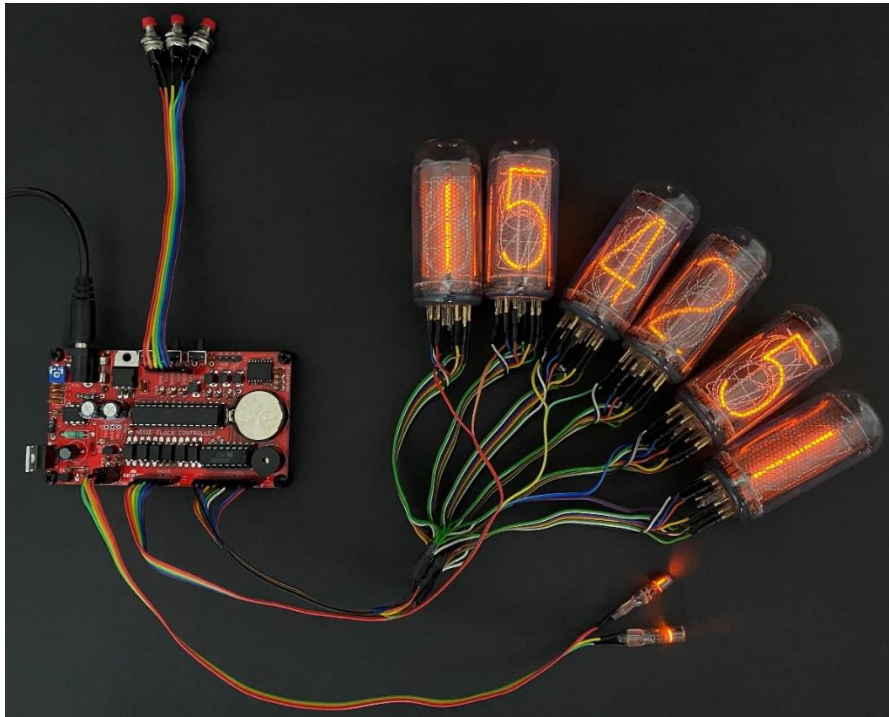
12.2.1. Prepare six wires to connect the tube anodes. Do the same steps as in item 12.1.4 and 12.1.5



12.2.2. Check the tube datasheet to identify the anode. Mostly, the anode is labelled.

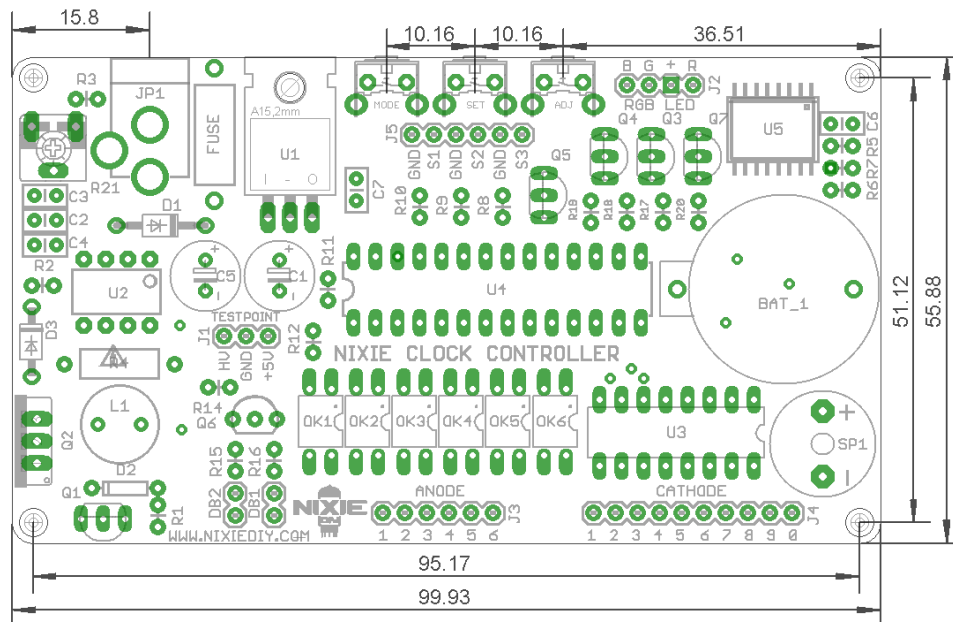


12.3. Plug in the power DC 12V supply. If all components installed and soldered properly the clock shall begin to operate.



13. PCB dimensions

PCB dimensions pointed on the drawing below. They will be necessary if you decide to make the case for clock. All dimensions pointed in millimetres. Highest electronics component height is equal 9 mm.



14. Clock Configuration and Operation

The three buttons of the clock have the following functions:

Button 1 - Mode, Button 2 - Set, Button 3 - Adjust

- Press Button 1 (Mode) to choose mode number
- Press Button 2 (Set) to reach mode settings menu
- Press Button 3 (Adjust) to increase value
- Press Button 2 (Set) to confirm chosen value
- Press Button 1 (Mode) to return to main time display.

Clock Settings:

15 programmable modes:

1. Alarm settings (0 - disable; 1 - enable)
2. Set alarm time HH/MM. Alarm settings supports only 24-hour mode
3. Set time HH/MM/SS. Time can be set only in 24-hour mode.
4. Set date DD/MM/YY
5. 24 or 12-hours mode (0 – Set 24-hour mode; 1 – Set 12-hour mode)
6. Date format (0 – DD/MM/YY; 1 – MM/DD/YY)
7. RGB led settings (0 - Off; 1 - crossfade; 2 - manual RGB brightness)
8. RGB led brightness RR/GG/BB (values from 0 to 99)
9. Leading zero blanking (0 – disable; 1 – enable)
10. Tube effect (0 – disabled, 1 – crossfade, 2 – each tube refresh)
11. Slot Machine frequency (0 – every 5min; 1 – every 10min; 2 – every 15min; 3 – every 20min)
12. Turn off tubes at night (0 – disable; 1 – enable)
13. Set turn off tubes start time HH/MM. Settings supports only 24-hour mode
14. Set turn off tubes end time HH/MM. Settings supports only 24-hour mode
15. Reset settings to default (0 – current settings, 1 – reset)

NOTE: Longer hold a pressed button the selected value automatically increases.

During Clock Operation, the following Hot Buttons are used:

- Button 2: Short press to display date for 3 sec
- Button 3: Short press to OFF alarm when is active.
- When night mode is active, press any of the buttons to turn on the clock for 5 seconds