

# Warm Tube Clock

Assembly Instructions for the “main board”

## Introduction

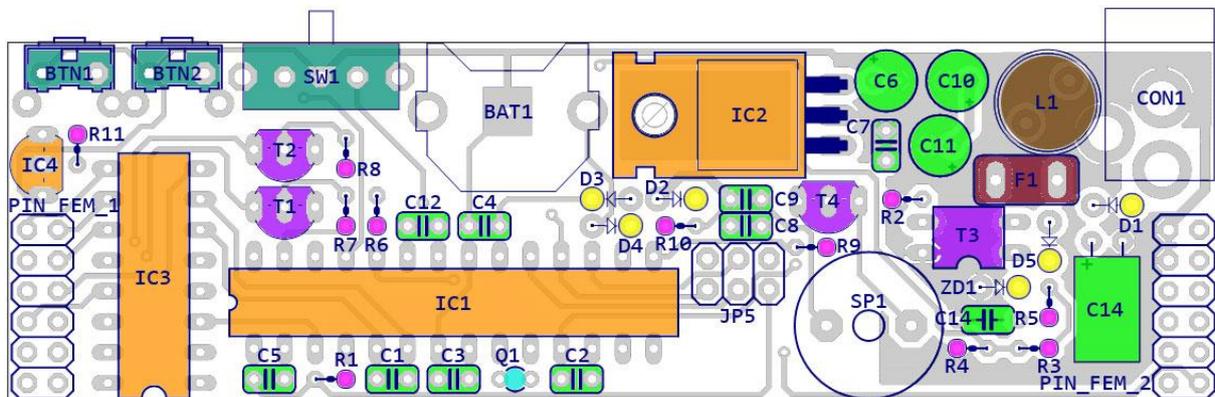
Congratulations on your purchase of OSH Nixie Tube Clock. In this document you will see all steps you need to follow in order to successfully assemble the “main board” of this device.

Before we start, please make sure that you have all required parts that come for the “main board”:

Qty	Value	Device	Parts
2	0.1uF	C-EU025-024X044	C7, C9
1	1N4007	1N400X HORI	D1
3	1N5817	SCHOTTKY-DIOEDO41-HORI	D2, D3, D4
1	1uF/250V	CPOL-EU-HORI	C13
1	2.1MM BARREL DC JACK THM	2.1MMJACKTHM	CON1
2	2x6	PINHD-2X6	PIN_FEM1, PIN_FEM2
1	4k7	R-EU_0204/2V	R2
7	10k	R-EU_0204/2V	R1, R4, R6, R7, R8, R9, R11
1	10nF	C-EU025-024X044	C5
1	22k-27k	R-EU_0204/2V	R5
2	22pF	C-EU025-024X044	C2, C3
1	32,768 kHz	CRYSTALTC26V	Q1
1	47	R-EU_0204/2V	R10
3	47uF/16V	CPOL-EUE2-5	C6, C10, C11
4	100nF	C-EU025-024X044	C1, C4, C8, C12
1	100nF/250V	C-EU050-024X044	C14
1	200V	ZENER-DIODEHORI	ZD1
1	820k	R-EU_0204/2V	R3
1	1000-1200uH	USBBUCK_L	L1
1	7805	LINEAR_7805T	IC2
2	ANGLED	31-XX	BTN1, BTN2
1	ATMEGA328P-PU	AVR_ATMEGA168V-10P	IC1
1	BA159	SCHOTTKY-DIOEDO41-HORI	D5
1	BC547	BC547CBE-WIDE-TRAX	T4
1	CR1220	CR1220 THM	BAT1
1	DS18S20	DS18S20WIDE	IC4
1	IRFD220 (IRFD214)	VFD_IRFD110	T3
1	2X3 ANGLED	PINHEAD-EZ_PINHD-2X3	JP5
1	K155ID1 (74141)	74141N	IC3
2	MPSA42	BC337-16-NPN-TO92-EBC	T1, T2
1	RESET_FUSE_500mA	FUSE_FUSETE5	F1
1	SK-12F14-G7	1P2T SK-12F14-G7 Slide Switch	SW1
1	YBOX2_SPEAKER/AL60P/PC-SPK	YBOX2_SPEAKER/AL60P	SP1

List of all parts for the “main board”

All parts should be assembled in correct order, starting from low profile components to high profile ones. Component locations are not marked on PCB because there was not enough space and it would look messy that way. So, component (Part) locations are in the following image and their values are in the above table.



## Assembly

Heat up your soldering iron, take a deep breath and go for it. Don't worry; the assembly is extremely easy as you will see through the pictures.

### Step 1

First we should solder the CR1220 backup battery holder BAT1.



1. Place the battery holder in place.



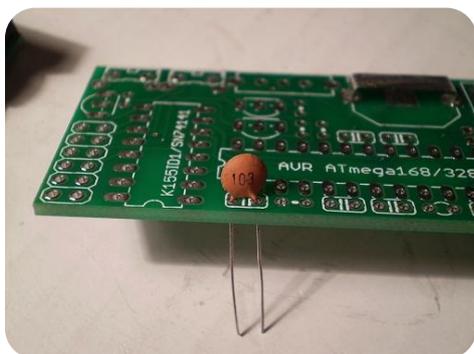
2. Turn the PCB around and solder both leads of the battery holder.



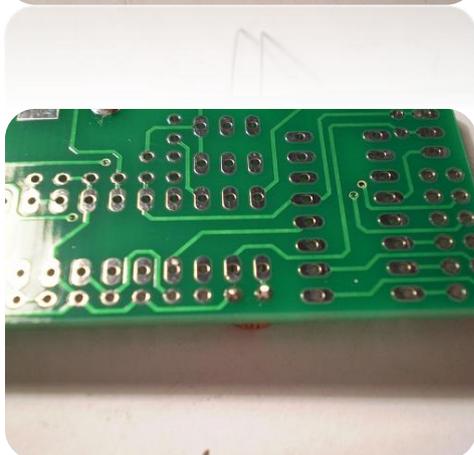
3. In the end, it should look like this.

## Step 2

Now find the “103” capacitor (10nF = 0.01uF) C5.



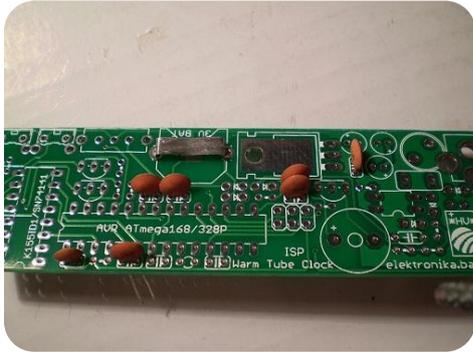
1. Place the capacitor in place.



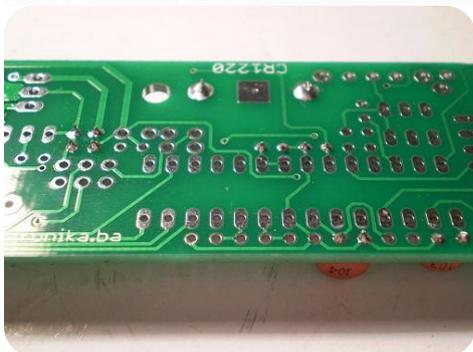
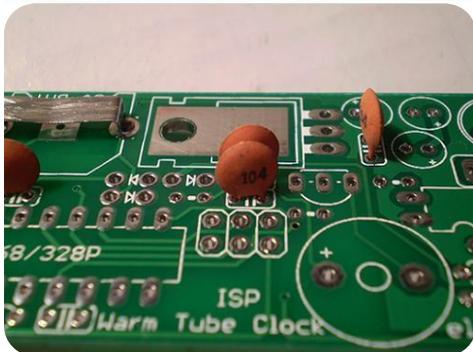
2. Turn the PCB around and solder both leads of the capacitor.

### Step 3

Now find all “104” capacitors (100nF = 0.1uF). There are 6 of these in total: C1, C4, C8, C12 & C7, C9.



1. Place all “104” capacitors in their place.



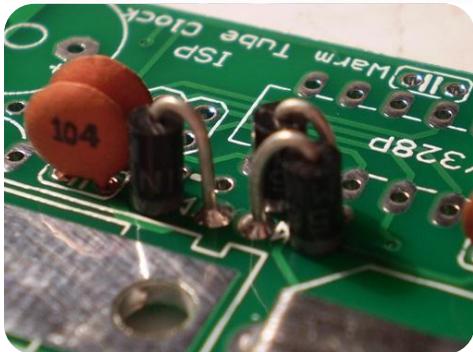
2. Turn the PCB around and solder all “104” capacitors.

## Step 4

Now, bend the 1N5817 diodes D2, D3, D4 like in the picture below.



1. Carefully bend the Anodes of three 1N5817 diodes like in the picture.



2. Place diodes in their place but be careful not to place them in reverse. If you can't read the solder mask (the Diode symbol), place them like shown in the picture.



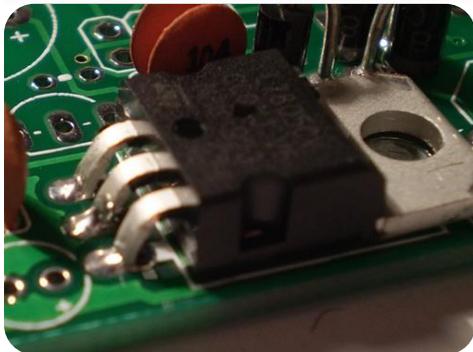
3. Turn the PCB around and solder all three diodes.

## Step 5

Now it is time for the voltage stabilizer LM7805 IC2.



1. Bend its three legs like in the picture and put it in place. You can use a small screw to centre the component like shown in the picture, but you really don't have to.



2. Turn the PCB around and solder all three pins. Keep in mind that you need to increase your soldering iron's temperature just before you solder the middle pin because it is connected to the heat sink and it will cool down your soldering iron making soldering a bit difficult. So, soldering the middle lead (pin) might take a few more seconds than it takes for the remaining two pins. Don't worry if things get really hot here.

## Step 6

Now find (and bend) the 1N4007 (1N4001...1N4007) D1 and BA159 D5 diode.



1. Carefully bend the Cathode of the 1N4007 diode and put it in place. Now, bend the Anode of the BA159 diode and put it in place.

2. Turn the PCB around, solder both diodes and go on to the next step.

## Step 7

Locate the coil L1 and the MOSFET T3 transistor parts.



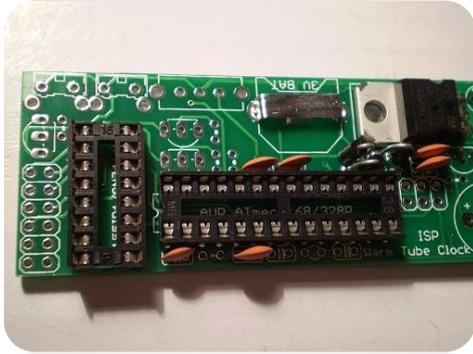
1. Place them in their corresponding locations.



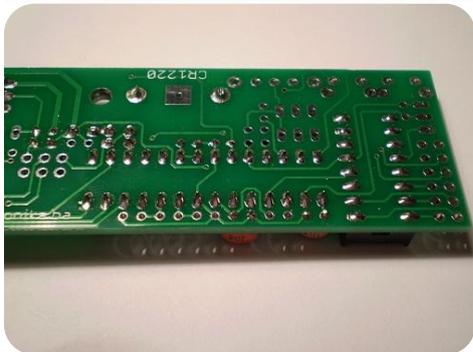
2. Turn the PCB around and solder them, one pin at a time. You will probably have to hold the Coil with your finger to keep it in place while soldering the first pin.

## Step 8

Now take two IC sockets for AVR (28 pin) and BCD decoder (16 pin).



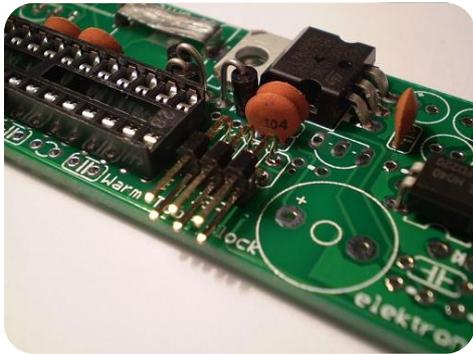
1. Place them in their corresponding locations.



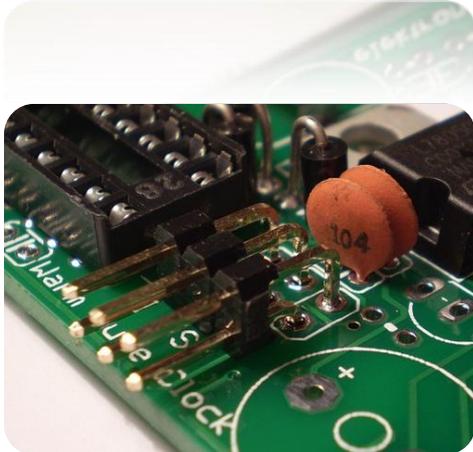
2. Turn the PCB around and solder them, one pin at a time. It is good practise to first solder just two pins of one IC socket and turn the PCB around to see if the IC socket is pushed all the way to the PCB (not floating above it). If it looks like it can go even further through the PCB, you can re-heat those two pins and push it fully through. If the IC socket looks good, you can continue soldering remaining pins.

## Step 9

Now take the JP5 part (2x3 angled) - ISP connector.



1. Place it in its corresponding location.

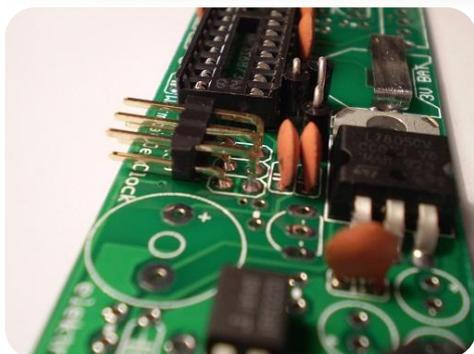


2. Do NOT turn the PCB around! Solder just one pin to hold the component in place (just like in the picture).



3. Now, turn the PCB around and continue soldering remaining pins and then go back to this “tacked” pin and re-solder it also from the bottom side of the PCB.

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*Assembly Instructions for the „main board“*



4. It should look something like this from the top.

## Step 10

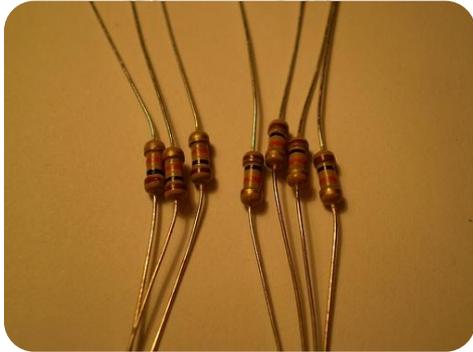
Now we need to solder the ZD1 Zener diode that we forgot previously.



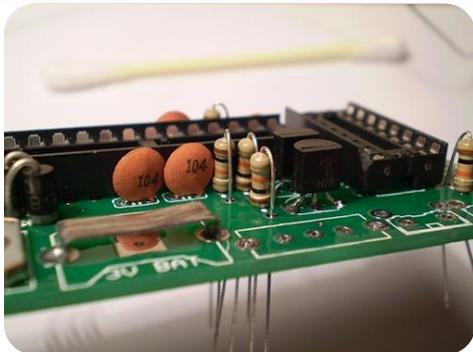
1. Put it to its place but watch out for the polarity. Here it doesn't matter which lead (Anode or Cathode) you bend, just as long as you watch the marking on the PCB. In the picture on the left, I bent the Anode.  
(ZD1 is the centre component in the picture, with the "200" marking).

## Step 11

Okay, now it is time to solder some resistors.



1. Take all 10k resistors (R1, R4, R6, R7, R8, R9, R11) and bend them (it doesn't matter which way you bend them).



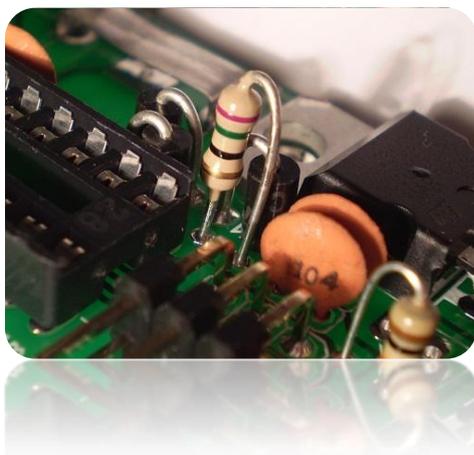
2. Place all 10k resistors to their locations on the PCB.



3. Turn the PCB around and solder them. Clip the leads in the end just like you did with all other components.

## Step 12

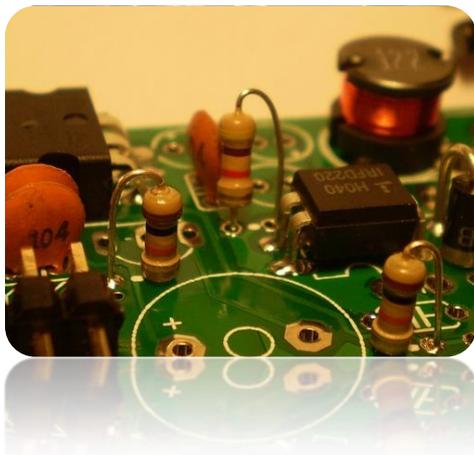
Locate the 75ohm R10 resistor.



1. Put the 75ohm resistor to its location and push it all the way (not like in the picture). Turn the PCB around and solder it.

## Step 13

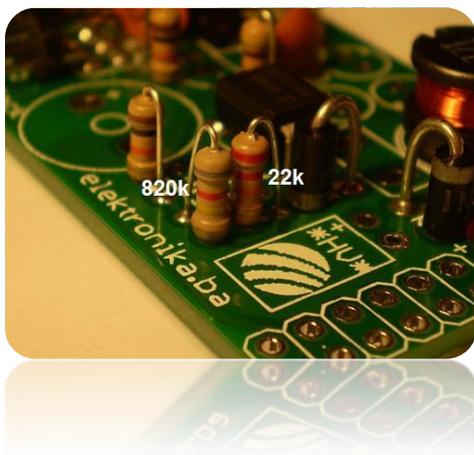
Locate the 4k7 (4.7k) R2 resistor.



1. Put the resistor in its location and push it all the way (not like in the picture). Turn the PCB around and solder it.

## Step 14

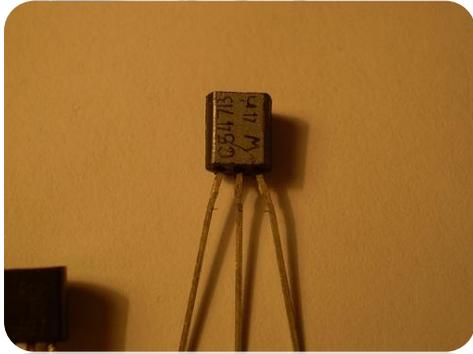
Now locate the remaining two resistors: 820k R3 and 22k R5.



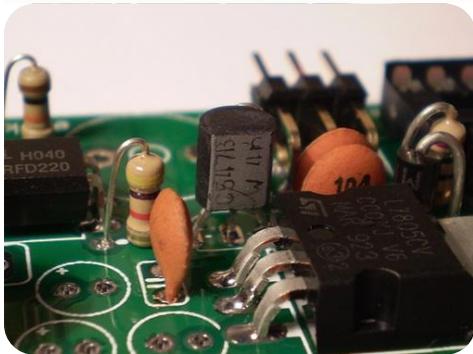
1. Put the last two resistors to their locations and solder them.

## Step 15

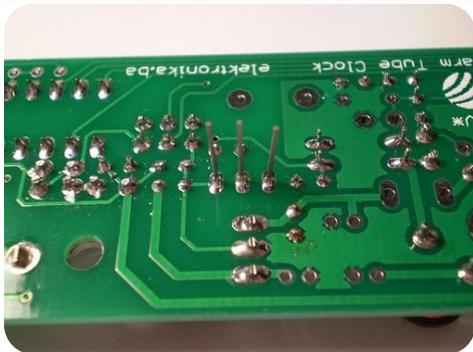
It is time to solder some bipolar (NPN) transistors.



1. Locate the BC547 (BC546) T4 transistor.



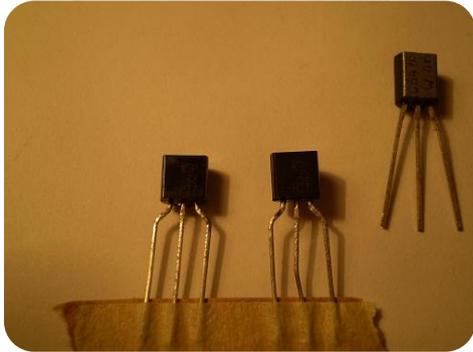
2. Put the transistor correctly in its place.



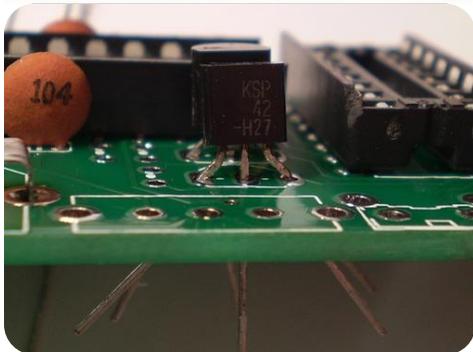
3. Turn the PCB around and solder all three leads (pins).  
Clip them after, of course.

## Step 16

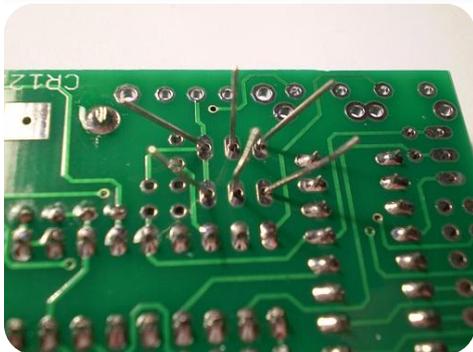
Now, to solder the remaining two NPN transistors: KSP42 (MPSA42) T1 & T2.



1. Locate two remaining transistors that will control two Nixie dots (semicolons).



2. Put the transistors correctly in their place.



3. Turn the PCB around. Now you can bend the leads like in the picture to make sure that they stay in place.

## Warm Tube Clock

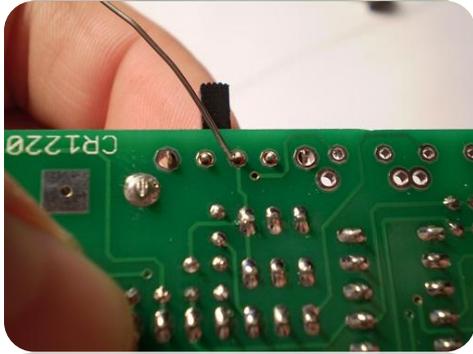
Assembly Instructions for the „main board“



4. Now you can solder the middle pins and straighten the remaining pins and then solder them, or you can solder all six pins at the same time if you don't care how it will look in the end.

## Step 17

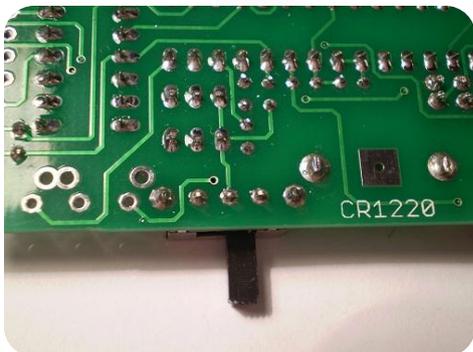
Now find the “slide” switch SW1.



1. Put it in its place. Turn the PCB around while holding the switch. Now it is time to “tack” it – apply just a little solder to its middle pin to hold it in place.



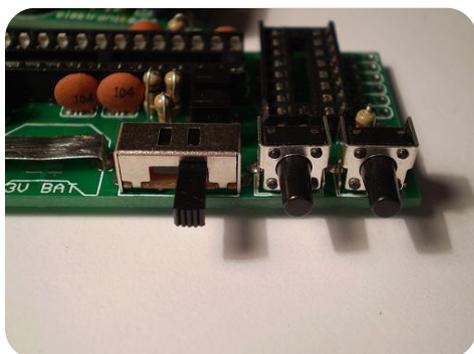
2. It should look something like this. Don't worry if you put too much solder in this step.



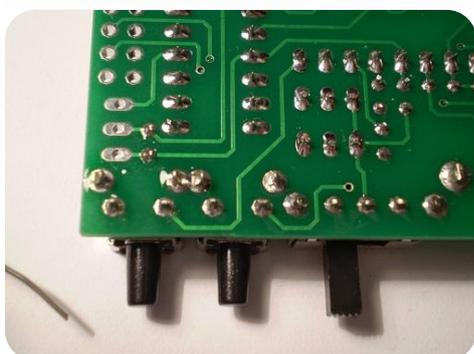
3. Now solder the remaining 4 pins and lastly solder the middle “tacked” pin. You are done with this step.

## Step 18

Now it is time for the two buttons BTN1 & BTN2.



1. Put them in their place, all the way through and they will stay there when you turn the PCB around.



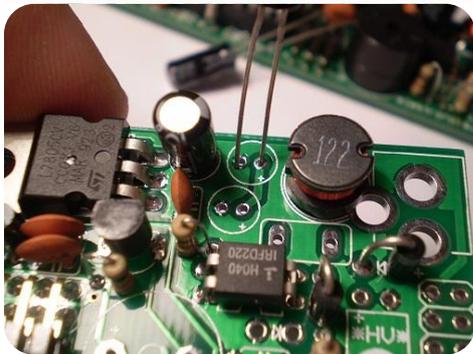
2. Solder all pins and you are done with input devices.

## Step 19

Now locate three 47uF electrolytic capacitors C6, C10, C11.



1. These are polarised capacitors.



2. Put them in their place but watch out for the polarity. You must not make a mistake here! Their positive (+) lead is longer and their negative lead is also marked with white stripe.

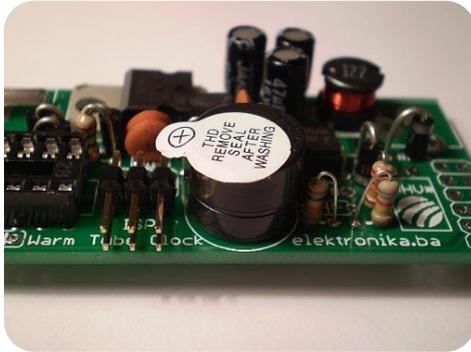
Also, make sure they go fully through the holes because they are the highest components on this PCB.



3. Flip the PCB around and solder them.

## Step 20

Now, it is time for the speaker (buzzer) component SP1.



1. Put it in its place but watch out for the polarity. The positive (+) goes to the left and it is also marked on the PCB. Solder it...

## Step 21

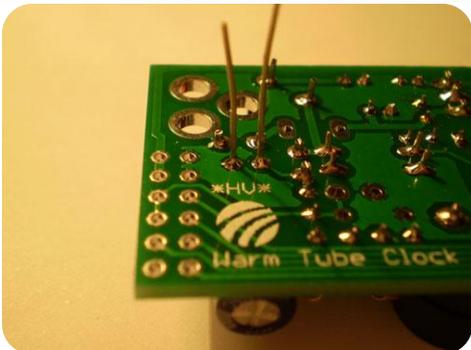
Now, locate the remaining electrolytic capacitor: 1uF / \*high voltage\* - C14.



1. Bend it like in the picture.



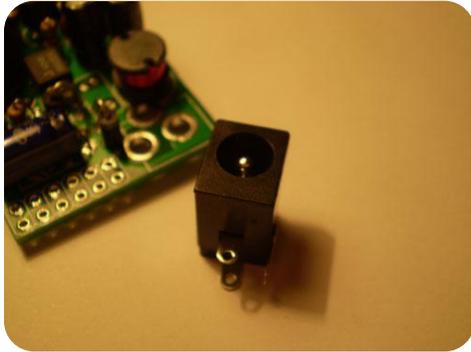
2. Put it in its place.



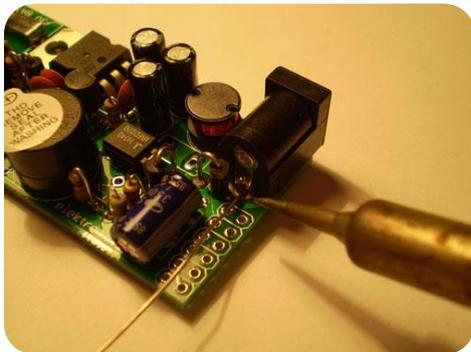
3. Flip the PCB and solder it. Clip the leads after soldering.

## Step 22

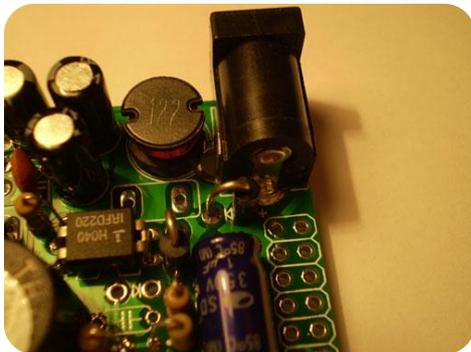
Take the power supply connector called a “DC barrel jack connector” CON1.



1. Hi, I am Jack.



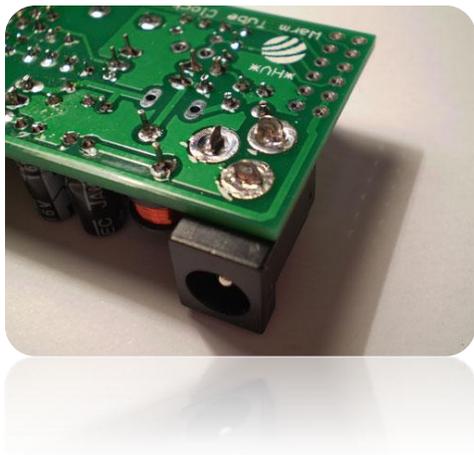
2. Put it in its place. Since holes on PCB are pretty large, it is best to “tack” it in position with a bit of solder like shown in the picture.



3. So it looks something like this.

## Warm Tube Clock

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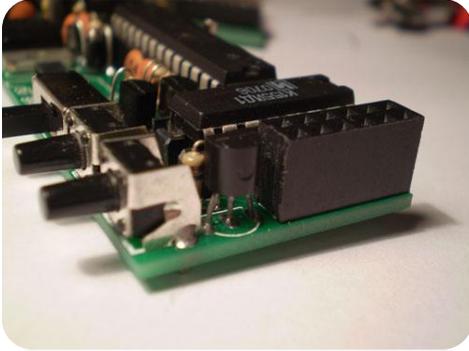


4. Now you can flip the PCB and solder remaining pins – fill in some solder and also don't forget to fill in the previously “tacked” pin.

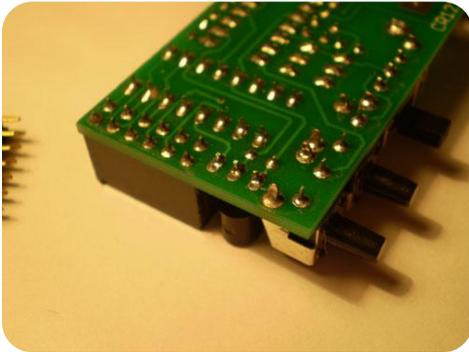
## Step 23

Now locate the DS18S20 temperature sensor IC4. Here you actually have two options:

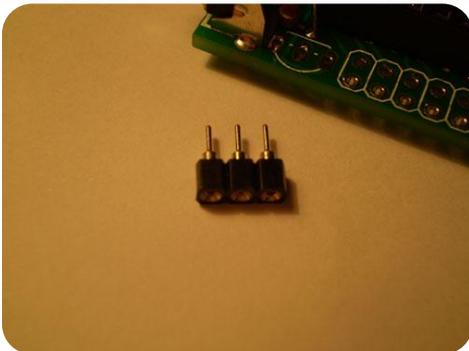
- a) You can solder the DS18S20 to the PCB
- b) You can solder 3-pin female connector so that you can directly “plug” the temperature sensor in it, “plug” it with longer wires to measure the “outside” temperature, or use this port for your own “hacking” and improvements.



a) This is how it looks when you solder the DS18S20 temperature sensor.

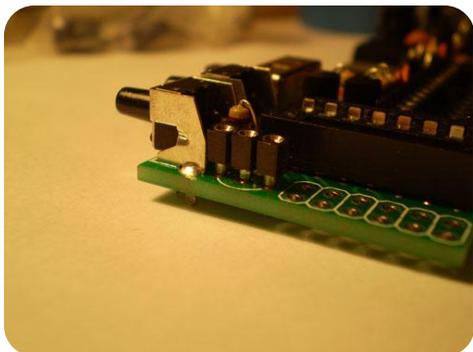


a) And the bottom side...

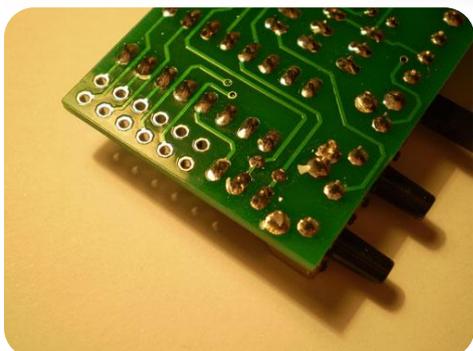


b) And this is how the 3-pin female connector looks like.

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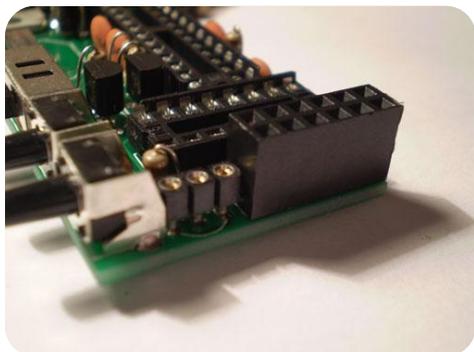
b) You can solder it to the PCB where the DS18S20 temperature sensor usually goes.



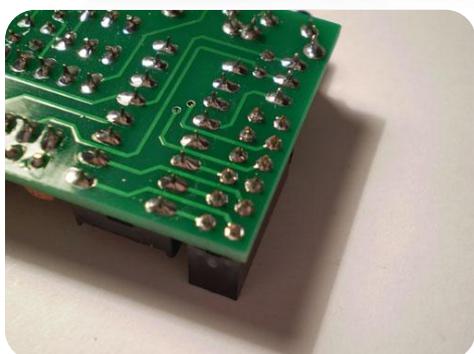
b) So the bottom side looks like this after soldering it.

## Step 24

Now, locate the 2x6 female “pin header” for the PIN\_HEAD\_1 part.



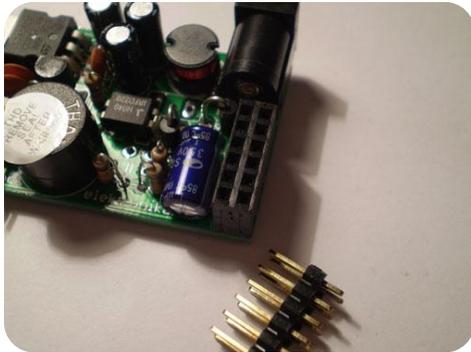
1. Put it in its place.



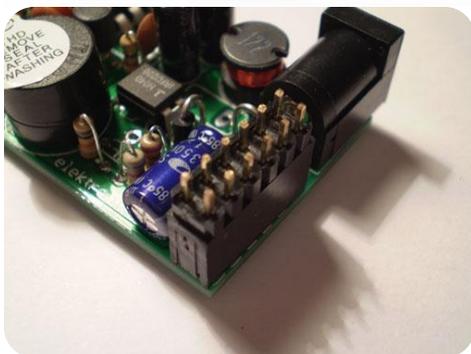
2. Flip the PCB around and solder it.

## Step 25

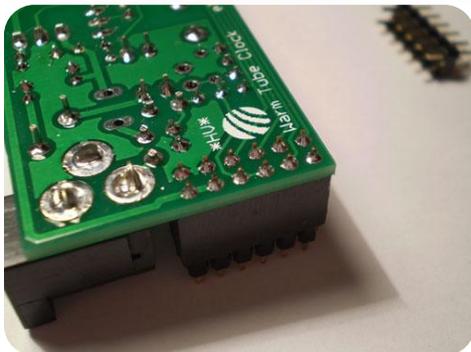
Now, locate the other 2x6 female “pin header” for the PIN\_HEAD\_2 part. Also take the corresponding 2x6 male “pin header”, we will need this part also to help us a little.



1. Put it in its place.



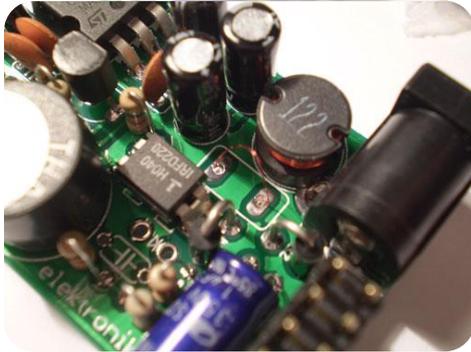
2. Now take the male “pin header” and put it in the female connector. This is just to make this component higher since the previously soldered “DC barrel jack” is the highest on this part of the PCB.



3. Now flip the PCB and solder this component. After soldering you can take the male “pin header” out of the female connector and set it aside.

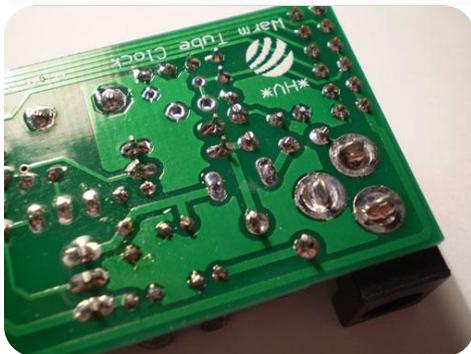
## Step 26

Now find the “self resettable” fuse F1.



1. Put it in its place.

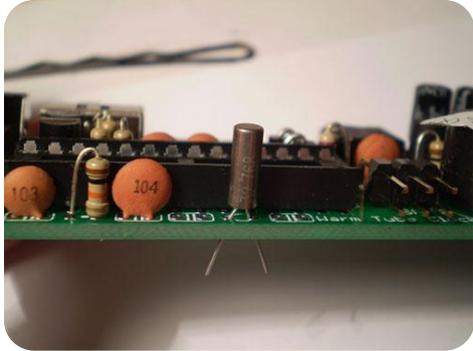
NOTE: In this picture there is no “self resettable” fuse, but a piece of enamelled copper wire acting as a fuse.



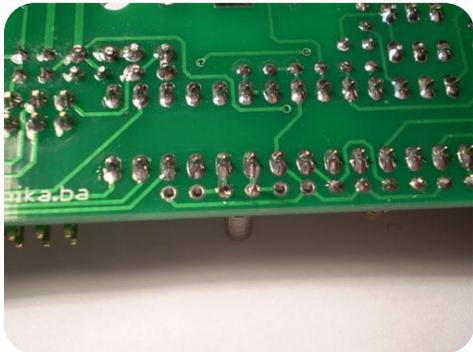
2. After putting the fuse (or a piece of wire in this case) in its position, flip the PCB around and solder it.

## Step 27

Now, the remaining parts to solder on this PCB are the 32.768 kHz crystal (Q1) and the two 22pF capacitors (C2, C3). We will solder those two 22pF capacitors later since they decide how precise will the “time keeping” be.



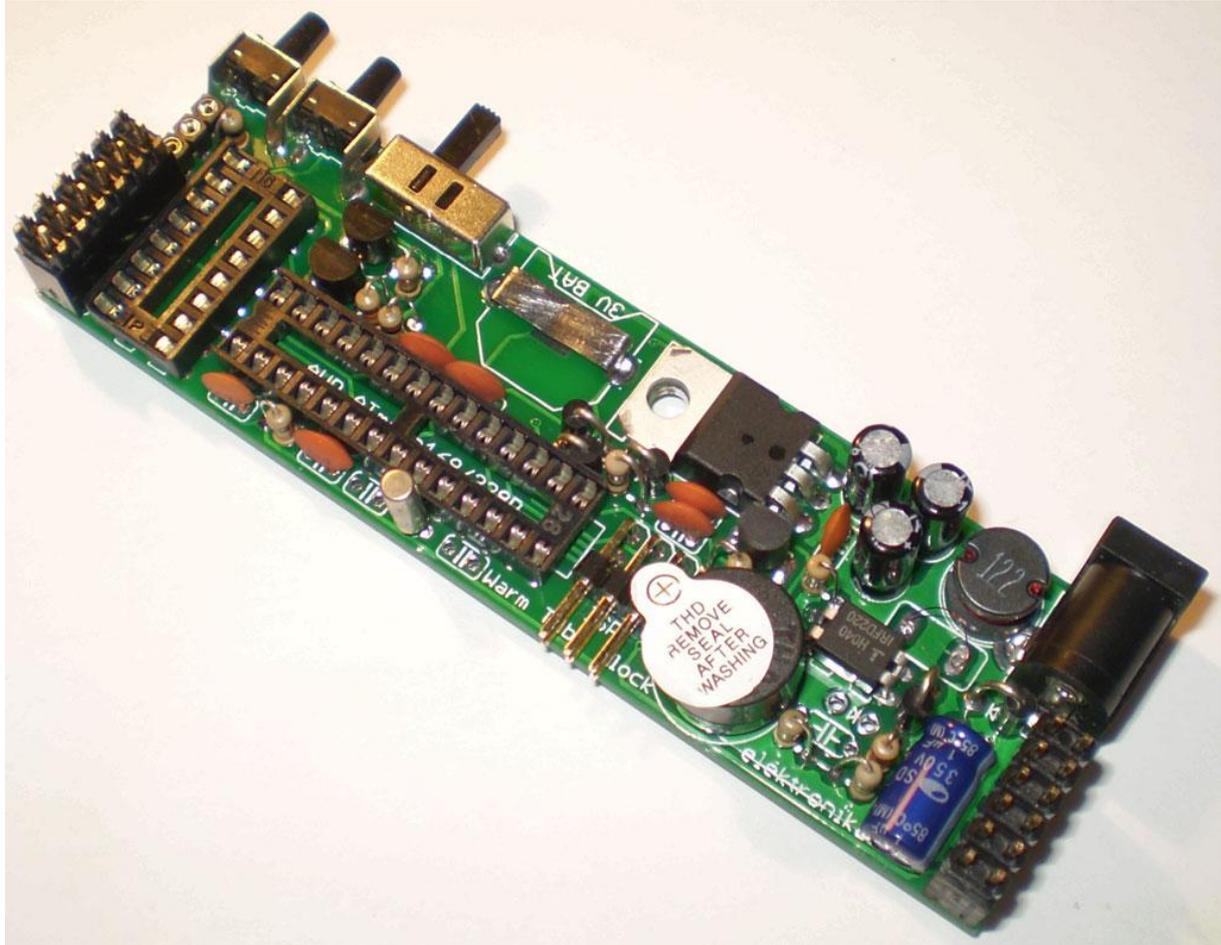
1. Put the crystal in its place.



2. Flip the PCB and solder it. If you want, you can also solder the two 22pF capacitors around the crystal right now.

## Step 28

Admire your work. You should now have something that looks like this:



## Tests

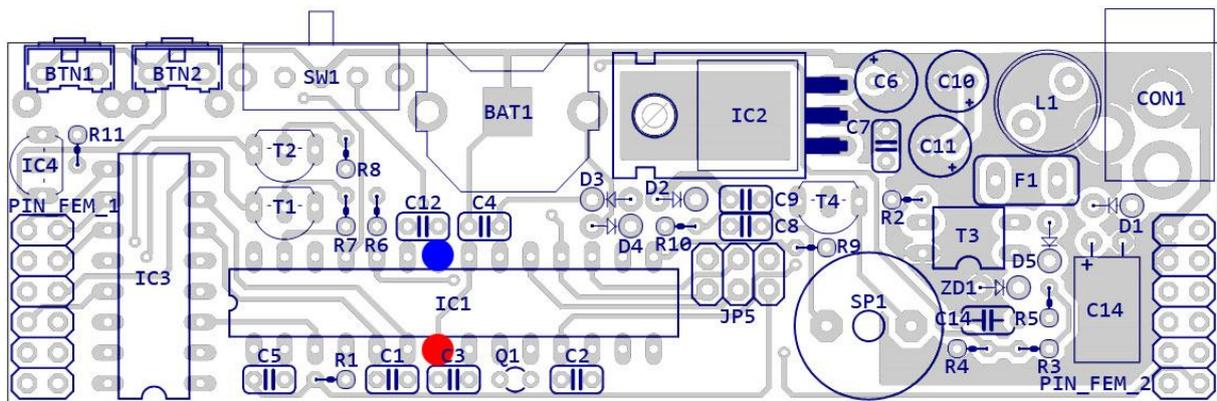
After you finished soldering the “main board” of Warm Tube Clock, it is time to make some measurements before inserting the Atmel AVR microcontroller, and the K155ID1 IC.

Clean your table from the solder remains and wires and put a piece of paper under the PCB. Then continue on with the tests.

### Test 1

Before connecting the DC power supply (7.5V – 14V), take the CR1220 battery and put it in the battery holder. It goes in so that the battery’s positive terminal is up, and the negative terminal touches the PCB.

Now using multimeter, measure the voltage between these red & blue points like shown in the picture:



The voltage should read just a little under the CR1220 battery’s voltage, around 3V.

If not, check if:

1. Diode D4 is soldered correctly and in proper orientation
2. The CR1220 battery is new and not discharged

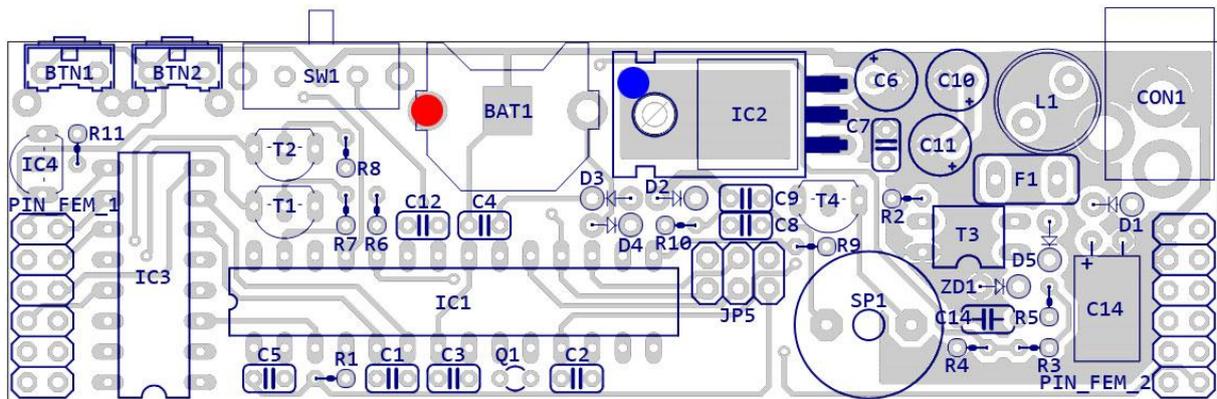
## Test 2

Now connect the DC power supply, to power up the PCB. Take multimeter now and measure the same points as in previous step. The voltage should read just a little less than 5V, around 4.8V.

If not, check if:

1. You soldered the LM7805 voltage stabilizer correctly
2. You soldered the diode D2 correctly and in proper orientation
3. You soldered the diode D1 correctly and in proper orientation
4. Check if the fuse F1 is OK
5. Your power supply is working

If the voltage does read around 4.8V, don't disconnect the power supply yet. Now you should check that the backup battery is NOT being charged. You can do this measuring voltage at these points:



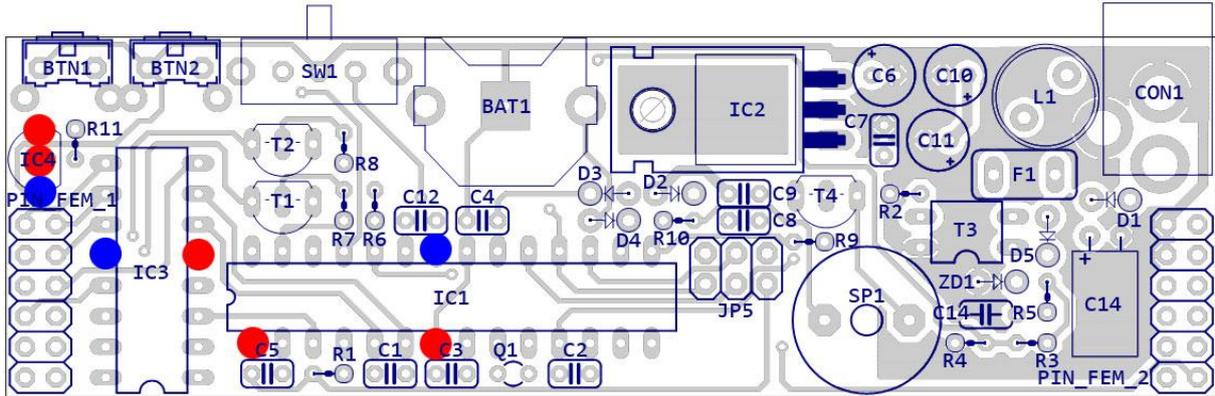
The voltage should read the battery voltage, around 3V. If not, disconnect the power supply right away and check if:

1. The diode D4 is properly soldered and in correct orientation
2. That there are no solder joints between its terminals.

If both are OK, then the diode D4 is broken and needs replacing. In case you can't find the replacement diode, you will not be able to use backup battery in the circuit.

In case you don't have any problems here, you can check the backup circuit by measuring the voltages between points in Test 1. The voltage here should now read around 4.8V and when you disconnect the power supply it should read the voltage from Test 1, around 3V. This means that the power backup circuit is working OK.

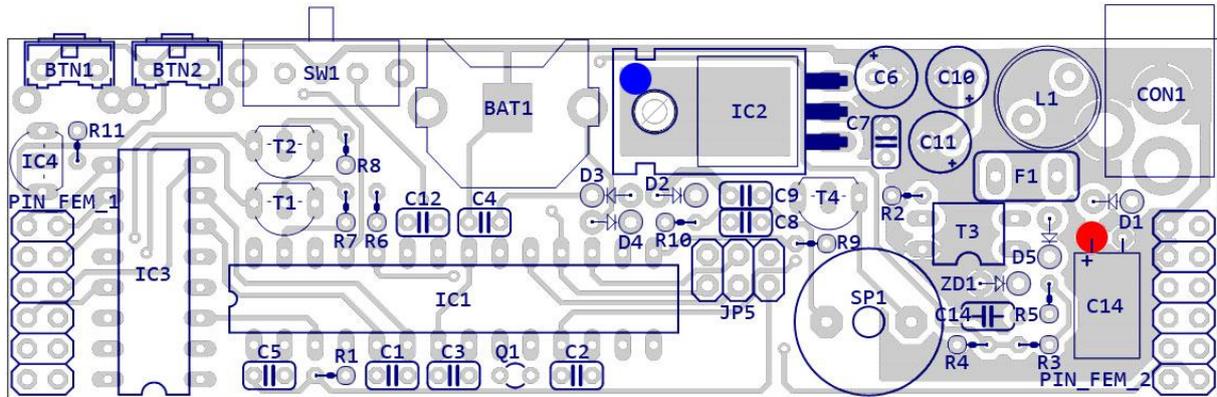
Now, connect the DC power supply again and measure that you have around 4.8V between these red & blue points like in the picture:



All red points should read around 4.8V when you measure them against any of the blue points.

### Test 3

While the DC power supply is still connected, you can test if your power booster components are OK by measuring these points with multimeter:



The voltage in this test should read just a little under the voltage of your DC power supply. If not, check that:

1. Your coil L1 is not damaged and is soldered correctly
2. You soldered the diode D5 correctly and in proper orientation

Now that you have successfully accomplished all important tests, **disconnect the power supply, take out the CR1220 battery** and insert two ICs into their sockets: K155ID1 and Atmel AVR IC. Watch for the IC orientation, don't make a mistake here!

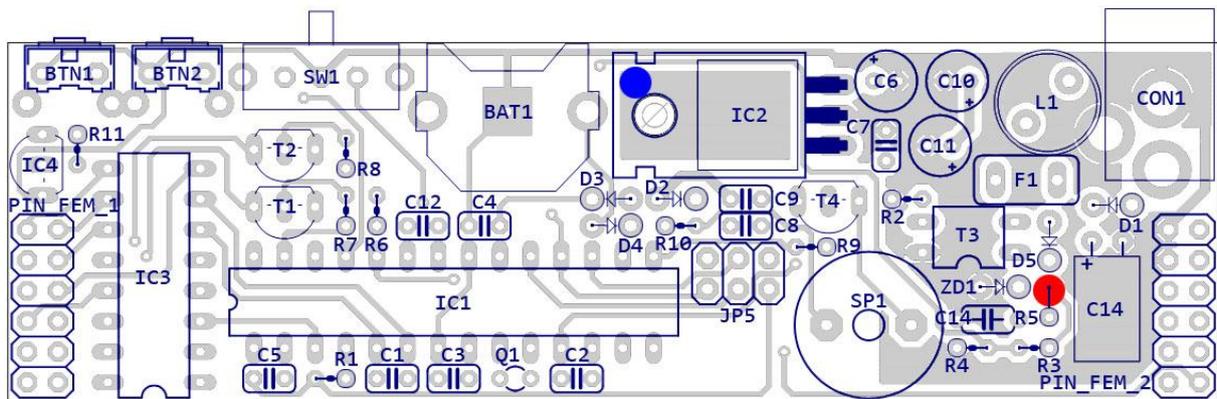
## Test 4

After inserting the K155ID1 and the Atmel AVR microcontroller in IC sockets, you can – but don't have to – test the high voltage generator (booster) circuit.

### WARNING!



**When you now connect the DC power supply, the booster circuit will generate around 200V DC.** If you are not experienced in high voltage work, skip this test. If you however wish to continue, after connecting the DC power supply you can measure voltage between these two points:



Make sure you set your multimeter to high voltage >200V DC range. The voltage between these two points will be well over 200V because there is no load (the Nixie shield PCB is not plugged in).

Be careful to not touch any part of the PCB now, and also don't connect the "red point" to any other component while measuring!

After this test, you must disconnect the DC power supply and leave the PCB for a minute or two to allow the high voltage storage capacitor 1uF to discharge. If later on you get a small shock, don't be scared – you will be OK.

If your multimeter doesn't show the expected high voltage, then make sure you have:

1. Accomplished the Test 3
2. AVR Atmel programmed with correct firmware for the Warm Tube Clock
3. Check the fuse F1 – it should not be hot!
4. Check if you soldered the MOSFET transistor T3 properly and in correct orientation

If the voltage generator (booster) is working OK, you can now plug in the Nixie shield board, or if you didn't assemble the shield yet, you can do it now.