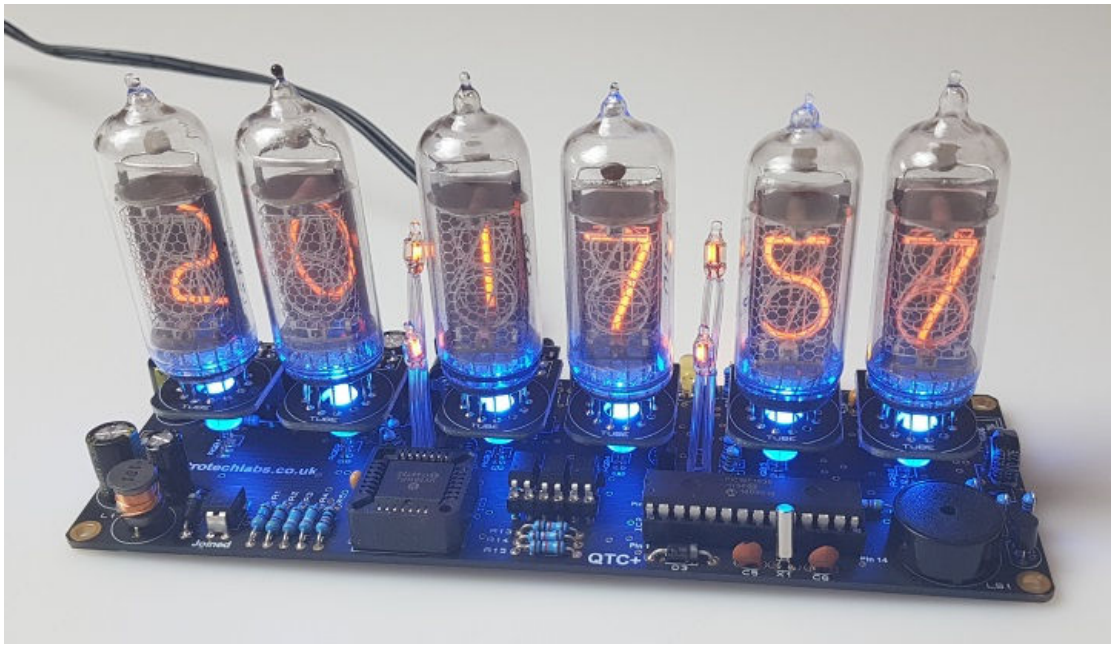
Assembly Instructions
And
User Guide

Nixie Clock Type
'Nixie QTC Plus'

For Parts Bag Serial
Numbers from 000 to 185 onwards



REVISION HISTORY

Issue Number	Date	Reason for Issue
Draft 1	29 August 2018	New document

1. INTRODUCTION

1.1 Nixie QTC Plus - Features

- Hours, Minutes and Seconds display
- Drives a wide range of medium sized solder-in tubes
- Uses a Quartz Crystal Oscillator as the timebase
- 12 or 24 hour modes
- Programmable leading zero blanking
- Date display in either DD.MM.YY or MM.DD.YY or YY.MM.DD format
- Programmable date display each minute
- Scrolling display of date or standard display
- Alarm, with programmable snooze period
- Optional GPS / WiFi / XTERNA synchronisation with status indicator LED
- Dedicated DST button to switch between DST and standard time
- Supercapacitor backup. Keeps time during short power outages
- Simple time setting using two buttons
- Configurable for leading zero blanking
- Double dot colon neon lamps
- 11 colon neon modes including AM / PM indication (top / bottom or left / right), railroad (slow or fast) etc.
- Seconds can be reset to zero to precisely the set time
- Programmable night mode - blanked or dimmed display to save tubes or prevent sleep disturbance
- Rear Indicator LEDs dim at night to prevent sleep disturbance
- Weekday aware 'Master Blank' function to turn off tubes and LEDs on weekends or during working hours
- Separate modes for colon neons during night mode
- Standard, fading, or crossfading with scrollback display modes
- 'Slot Machine' Cathode poisoning prevention routine
- Programmable RGB tube lighting – select your favourite colour palette
- 729 colours possible. Have a different colour or your choosing every hour, or autochanging colours
- Provision for adding switch for independently switching off RGB LEDs
- Not AC frequency dependent – works in all countries
- All user preferences stored to non-volatile memory
- Additional wireless functions if XTERNA module used:
  - Display of outdoor temperature in Celsius or Fahrenheit. Configurable.
  - Min / Max temperature in last 24 hours
  - Wireless, Auto Sync of time from GPS with auxilliary TCXO
  - GPS Sync time, and time since last GPS Fix
  - Voltage of XTERNA module battery

1.2 Tubes Supported

Each tube is soldered to a mini PCB 'Cell', making tubes easily changeable. Through the use of 2 different cell types, and 3 different configurations of the microcontroller, it is possible for the kit to drive a wide range of solder-in tubes as detailed in the table below. There are detailed and specific instructions for mounting each type of tube, in sections 5.1 to 5.8 of this manual.

Tube types	**Code Configuration**	**Section**
IN-14	A	5.1
IN-8-2, ZM1177	A	5.2
Z570M, Z5700M, Z573M, Z5730M, Z574M, Z5740M, GN-9A, B570M, TAF1317A, TAU7030, F9080B, F9080BA, TAF1093A, ZM1080, ZM1082, ZM1134, ZM1135, ZM1136, ZM1136A, ZM1136L, ZM1136R, ZM1138A, ZM1138L, ZM1138R	A	5.3
GNP-17A	A	5.4
GNP-7A, GNP-7AH	A	5.5
ZM1210, ZM1212	B	5.6
IN-16	C	5.7
CD66, ZM1240, ZM1242, XN11, XN12	A	5.8

1.3 SAFETY

DANGER: The clock pcb includes a switched-mode voltage booster circuit. This generates nominally 170 Volts DC. Assembly may only be undertaken by individuals who are suitably qualified and experienced in electronics assembly, and are familiar with safe procedures for working with high voltages. If in doubt, refer to a suitably qualified engineer before proceeding.

The voltages generated by this circuit can give a potentially LETHAL ELECTRIC SHOCK.

DISCLAIMER: This product is supplied as a kit of parts, intended only for suitably qualified electronic engineers, who are suitably qualified and experienced in electronics assembly, and are familiar with safe procedures for working with high voltages. The supplier, his agents or associates accept no liability for any damage, injury or death arising from the use of this kit of parts.

This is not a finished product, and the person assembling the kit is responsible for ensuring that the finished product complies with any applicable local regulations governing electrical equipment, eg. UL, CE, VDE.

2. TOOLS AND EQUIPMENT REQUIRED

2.1 Tools required to assemble the PCB.

The following tools will be required to assemble the PCB:

- Soldering iron with a small tip (1-2 mm).
- Wire cutters to trim the excess component leads after soldering. (TIP: A small pair of nail clippers works very well for this function).
- Wire strippers (TIP: A small pair of scissors is quite suitable).
- Multimeter for voltage tests and for identifying the resistors.
- A small hot air gun will be needed to shrink the heat shrink tubing over the neon lamp wires.

2.2 Materials you will need.

Solder – lead / tin solder is highly recommended.

USE LEAD/ TIN SOLDER!

Lead free solder, as now required to be used in commercial products in Europe, has a much higher melting point and can be very hard to work with.

Desoldering wick (braid) can be useful if you accidentally create solder bridges between adjacent solder joints.

2.3 Other items you will need.

The clock kit does not include a power adapter.

The following type of adapter should be obtained and used with the kit:

Output 12V DC regulated, minimum power output capability of 500mA
Output plug: 2.1mm pin, centre positive.

A suitable adapter is shown below:

3. LIST OF COMPONENTS

3.1 Table of Components – Driver Board

Circuit Designation	Part Description
Resistors	
R1, R2	4.7 KΩ, ¼ Watt
R3, R4	390 KΩ, ¼ Watt
R5	300 KΩ, ¼ Watt
R6 - R11	270 Ω, ¼ Watt
R12	4.7 KΩ, ¼ Watt
R13 – R15	1 KΩ, ¼ Watt
R16 – R21	4.7 KΩ, ¼ Watt
R22 – R25	15 KΩ, ¼ Watt
Capacitors	
C1, C2	220uF Electrolytic
C3	1uF, 250V,
C4	220uF, 16-25V, Electrolytic
C5	10pF Ceramic
C6	33pF Ceramic
C7	100nF Ceramic
C8	0.1F or 0.22F
C9, C10	100nF Ceramic
Transistors	
Q1	IRFD220 MOSFET
Q2 – Q4	EL817 Optocoupler
Q5	MPSA42
Q11 - Q14	MPSA42
Diodes	
D1 – D3	1N5819
D4	1N4148
D5	UF4004
D6	5mm Yellow LED
D7	5mm Green LED
D8	5mm Yellow LED
D9	62V zener
RGB1 – RGB6	APA106 RGB LED
Integrated Circuits	
IC1	LM2576 5V voltage regulator
IC2	PIC16F1938 8-bit microcontroller
IC3	HV5812
Miscellaneous	
L1, L2	100uH inductor
AM1, AM2, PM1, PM2	4mm wire ended neon lamp
ALARM, SET, ADJ, DST	Miniature push button
IC2 Socket	28 Way narrow IC socket for IC2
IC3 Socket	PLCC28 IC socket for IC3
Sockets for Q2 - Q4	12 Way SIL Socket Strip
J1	2.1mm PCB power socket
GPS / RFT	Surface mount 3.5mm jack socket
LS1	Piezo sounder
FUSE	500mA fuse

Insulation	25 cm Clear insulation for neons
NX1 – NX6	2X6 way 0.1” header plug
X1	32.768KHz watch crystal

3.2 Parts list / Packing Sheet - Component Bag

Part Description	Quantity
Resistors	
270 Ω, ¼ Watt	6
1 KΩ, ¼ Watt	3
4.7 KΩ, ¼ Watt	9
15 KΩ, ¼ Watt	4
300 KΩ, ¼ Watt	1
390 KΩ, ¼ Watt	2
Capacitors	
10pF, Ceramic	1
33pF, Ceramic	1
100nF, Ceramic	3
1uF, 250V, Electrolytic	1
220uF, 16-25V, Electrolytic	3
0.1F or 0.22F	1
Transistors	
IRFD220 MOSFET	1
MPSA42	5
EL817 Optocoupler	3
Diodes	
1N5819	3
UF4004 fast recovery diode	1
1N4148	1
5mm Green LED	1
5mm Yellow LED	2
APA106 RGB LED	6
Integrated Circuits	
LM2576 5V voltage regulator	1
PIC16F1938 8-bit microcontroller	1
HV5812	1
Miscellaneous	
100uH inductor	2
4mm wire ended neon lamp	4
Miniature push button	4
28 way narrow IC Socket for IC2	1
PLCC28 IC Socket for IC3	1
12 Way SIL socket strip	1
2.1mm PCB power socket	1
Surface mount 3.5mm jack socket	1
Piezo sounder	1
500mA fuse	1
25cm Clear insulation for neons	1
2X6 way 0.1” header plug	6
2X6 way 0.1” header socket	6
32.768KHz watch crystal	1

We recommend to check against the list above, to ensure all parts are present before commencing assembly.

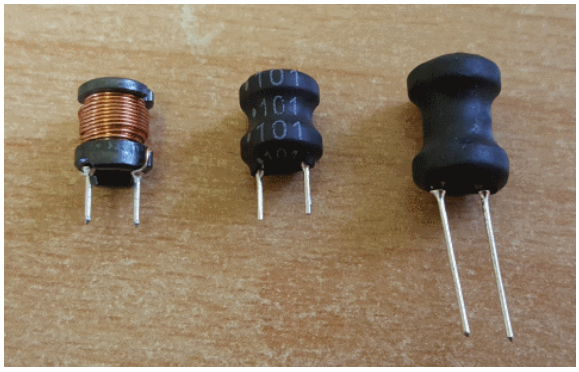
The resistors used in the kit are 1% tolerance metal film. They are marked with 4 coloured bands to identify the value. However it is sometimes unclear in which direction the bands should be read. Therefore, we recommend that the resistors be identified with a multimeter.

Please note the fuse will look like the picture below. It can easily be confused for a capacitor. It is a self-resetting fuse.

The 10pF and 33pF capacitors will be marked 10 and 33 respectively. The 100nF capacitors will be marked 104.

Q1 (IRFD220) is in a very similar package to Q2 – Q4 (EL817). You can tell the difference, in addition to the part marking by looking at the pins. Q1 has two pins that are actually joined at the resin body. Q2 – Q4 have 4 separate pins.

Inductors L1 and L2 may be one of three types:

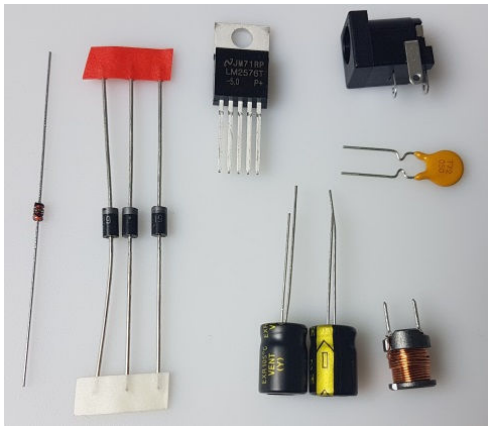


4. ASSEMBLY OF THE PCB

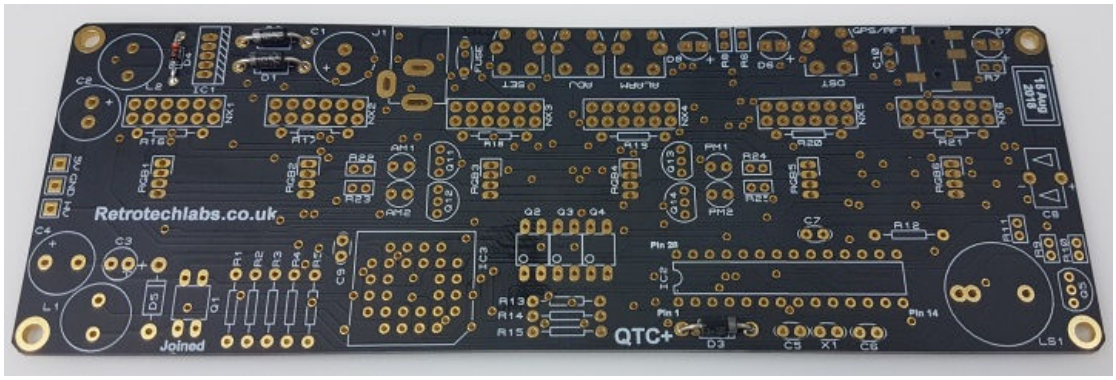
DUE TO PRODUCT DEVELOPMENT AND IMPROVEMENTS, YOUR PCB MAY NOT LOOK EXACTLY LIKE THE ONE PICTURED.

4.1 Low Voltage Power components:

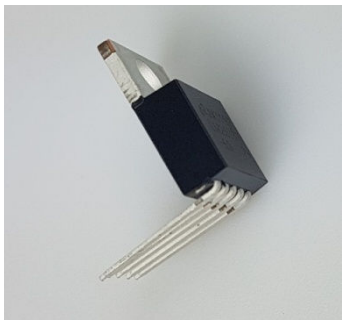
J1, FUSE
D1-D3 (1N5819)
D4 (1N4148)
IC1 (LM2576)
L2 (100uH Inductor)
C1, C2 (220uF)



Start by installing D1-D4. Align the band on the components with the band marked on the PCB.



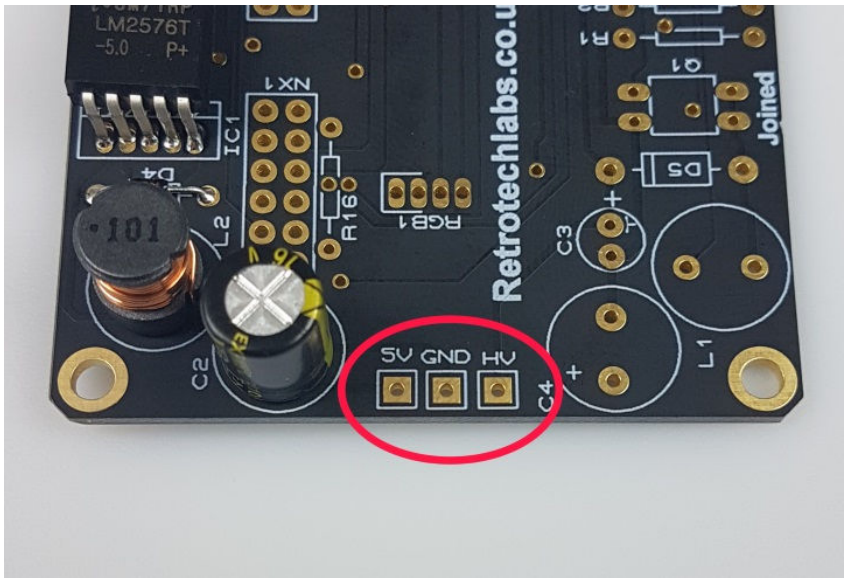
Bend the leads of IC1 as shown below then solder in place.



Continue to mount C1, C2, J1 and FUSE. C1 and C2 are polarized. The longer lead goes in the hole marked '+'.

4.2 Testing Low Voltage Power Supply.

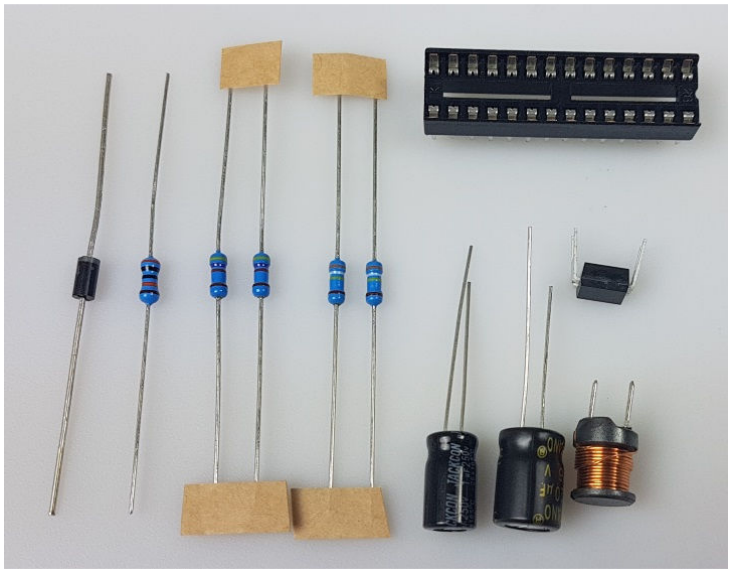
Identify the test GND, 5V and HV test points as shown below.



Plug in the power supply, and then test using a DC voltmeter: Touch the black probe on the GND test point and the red probe on the 5V test point. The voltage should measure between 5.6 and 5.9 Volts. If not, disconnect power and check your work. Do not proceed with the assembly until the error is corrected. Once the test is completed, disconnect the power.

4.3 High Voltage Generator components.

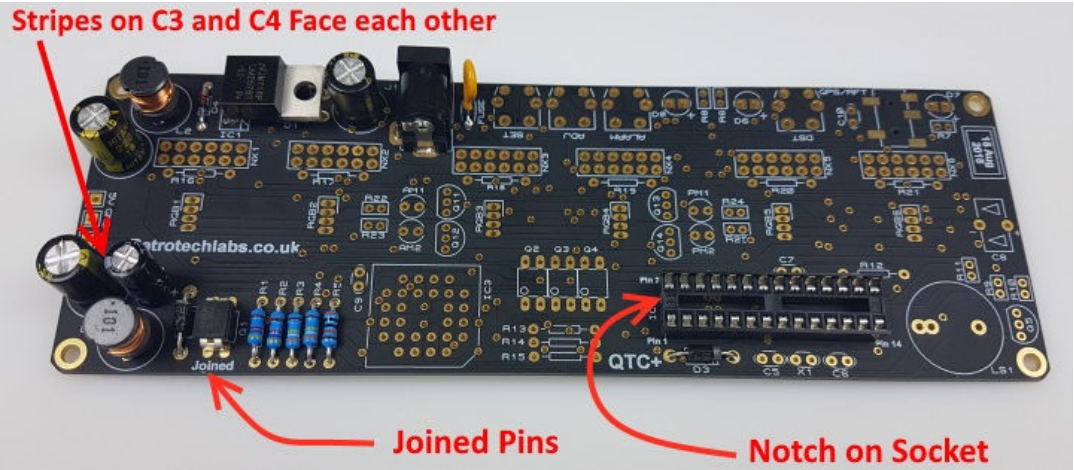
Socket for IC2
R1, R2 (4.7 KΩ)
R3, R4 (390 KΩ)
R5 (300 KΩ)
C3 (1uF)
C4 (220uF)
Q1 (IRFD220)
L1 (100uH Inductor)
D5 (UF4004)



Take care that the notched end of the IC socket is at the end shown. However, if you find you soldered it with the wrong orientation, do not try to remove it. It is perfectly fine with the notch at the wrong end, just be sure to place the IC in the socket with the IC's notch in the correct position.

Also the MOSFET needs to be placed with the two joined pins at the position shown below.

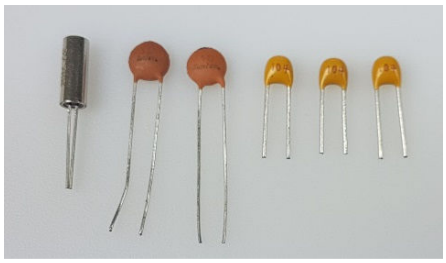
Ensure that the (-) light stripes on C3 and C4 are facing towards each other as shown below.



4.4 High Voltage Generator Test.

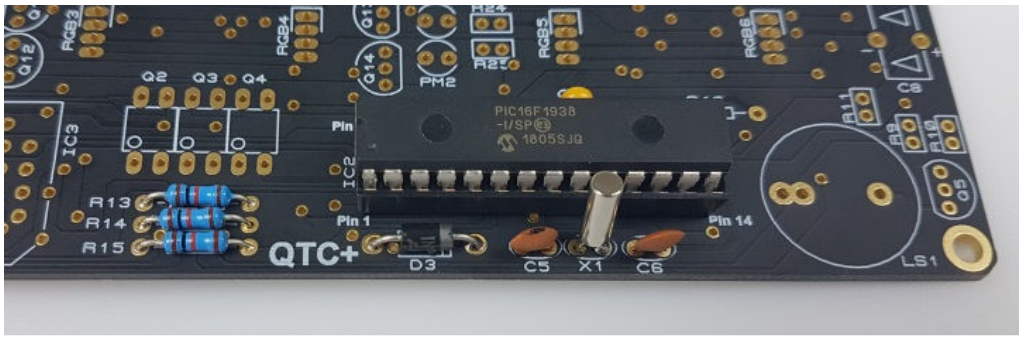
- Refer to the warnings on page 5
- Insert IC2 into its socket. Orient the notch on the IC with the notch on the IC socket and the PCB marking.
- Power up the PCB, and using the GND and HV test points, measure the high voltage generated using a voltmeter on DC setting. It should be between 164 and 176 Volts. If this is in order, disconnect the power supply. If you do not get this voltage, do not proceed. Refer to the troubleshooting section .

4.5 C5 (10pF)
C6 (33pF)
X1 (32.768KHz Crystal)
C7, C9, C10 (100nF but marked '104')

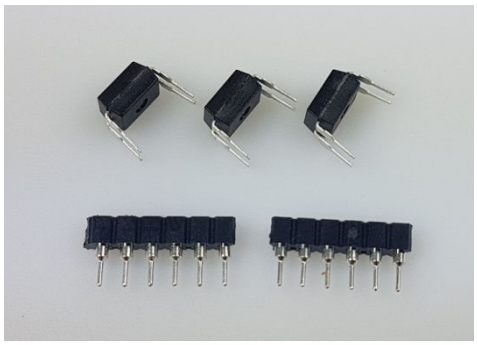


(C7, C9 and C10 may be a different colour)

4.6 R13, R14, R15 (1 KΩ)



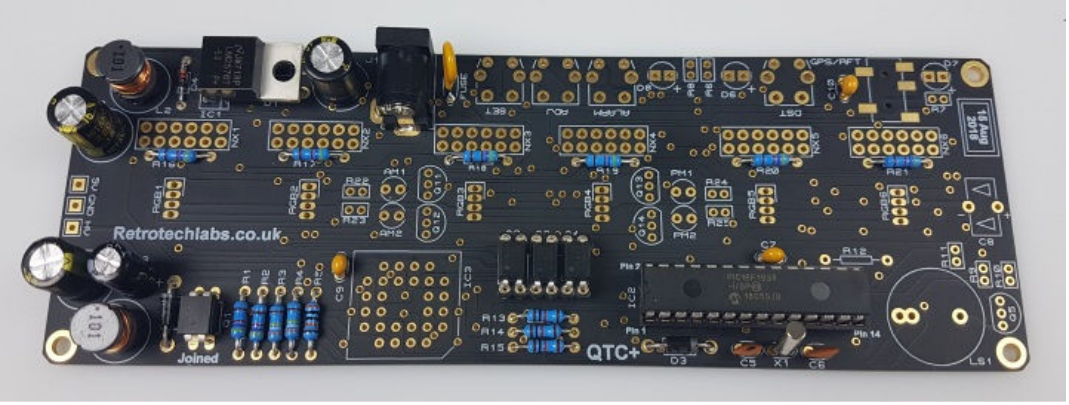
4.7 Q2, Q3, Q4 (EL817)
SIL Socket Strip



You will either receive 2 X 6 Way sockets, or a strip of 12 sockets. If the latter, clip in the middle to get two 6 way socket strips. Assemble the parts as shown below, paying attention to the orientation of the dot on the body of the parts. Then solder the sockets in place. Don't solder the parts to the sockets!

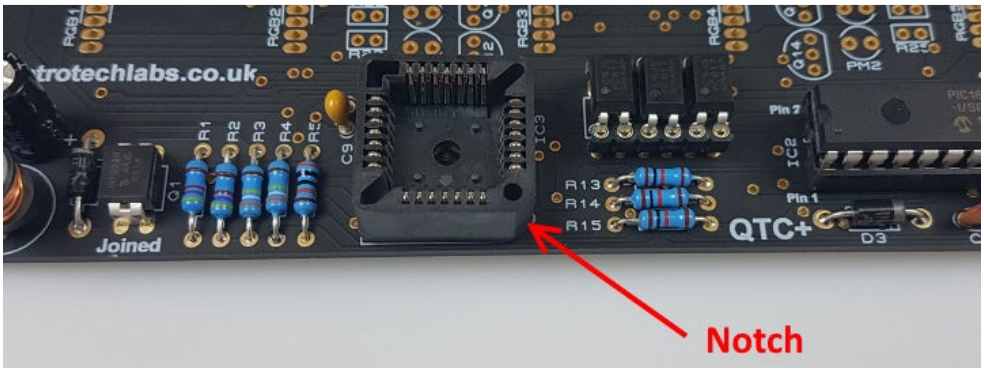
4.8 R16, R17, R18, R19, R20, R21 (4.7 KΩ)

These are the anode resistors.

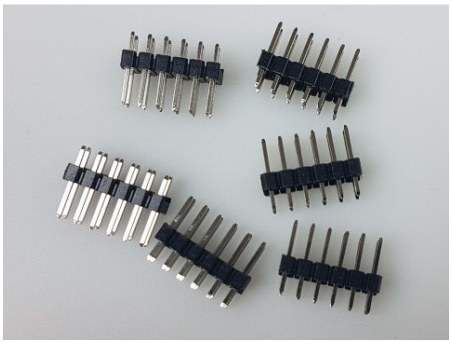


4.9 Socket for IC3

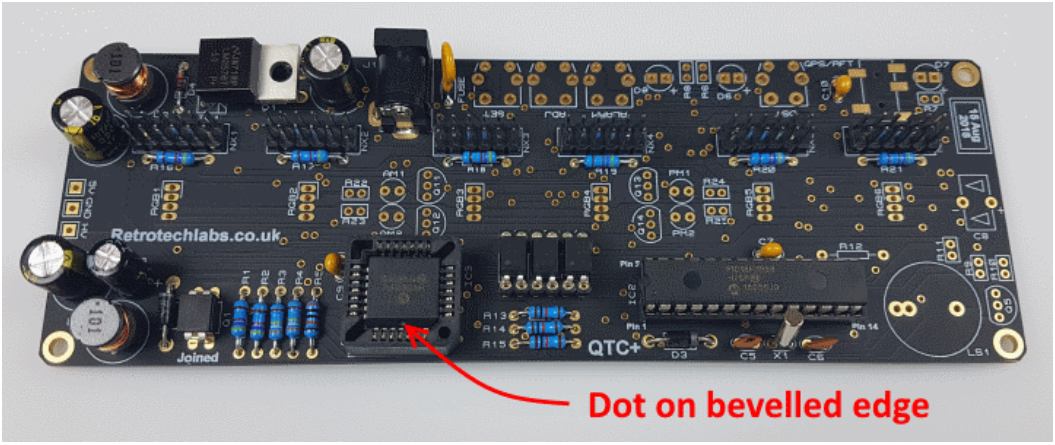
Align the notch on one corner of the socket with the marking on the PCB. Be careful not to force in the socket if all pins are not aligned. Ensure all pins are fully pushed through the holes before soldering in place. If you find you soldered it in the wrong orientation, don't try to remove it. See the troubleshooting section.



4.10 NX1 – NX6 (6X2 way male pin header)



Ensure the connectors are soldered very close to the PCB. Also now insert IC3 into its socket, with the dot on the bevelled face pointing to the front of the PCB.



5. ASSEMBLING THE NIXIE TUBE CELLS

PLEASE REFER TO THE APPROPRIATE SECTION FOR YOUR NIXIE TUBE TYPE.

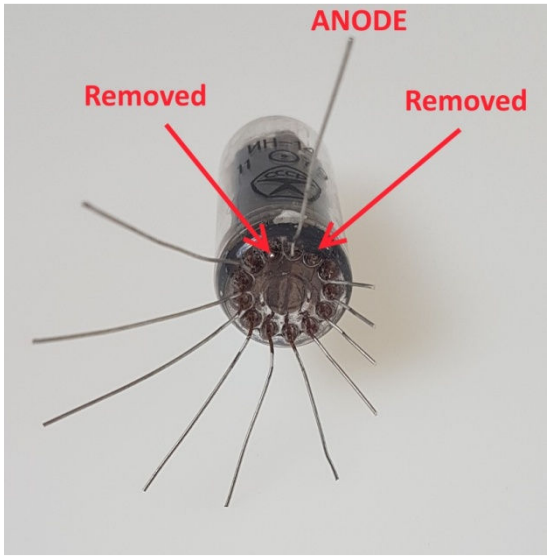
5.1 IN-14 Nixie Tubes.

Code configuration: A (see page 36)
Cell PCB Type:

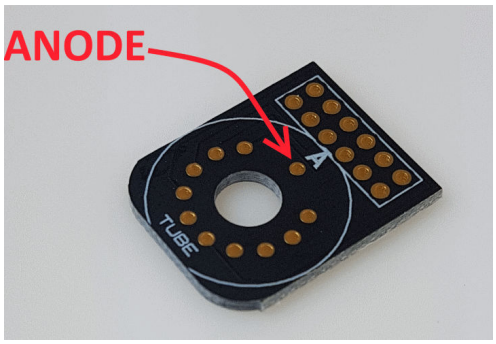
Start by identifying the anode lead at the back of the tube. It has a white coating where it enters the glass. Then remove the wires each side of the anode.

To facilitate easy insertion of the flying leads into the small holes, it helps enormously to trim the flying leads with a pair of scissors as shown below.

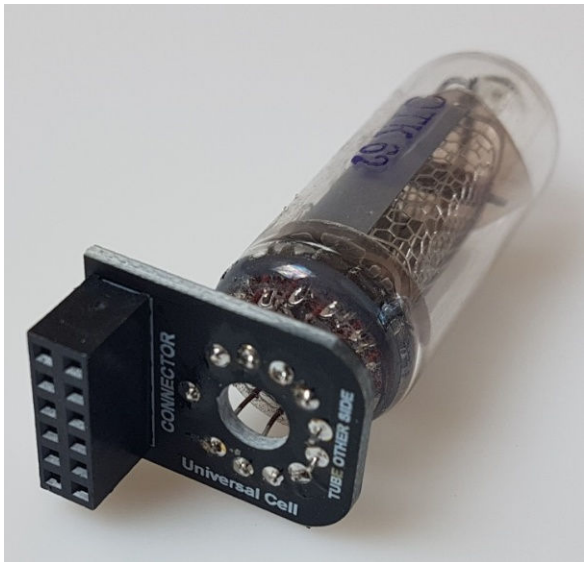
Start at the anode lead, then, working around the tube, cut each sucessive lead approx 2mm shorter than the previous one. This will allow you to feed each lead in in turn.

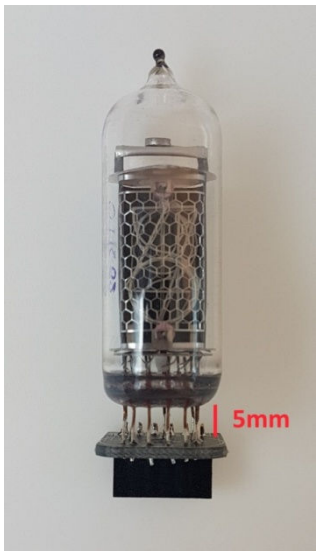


Referring to the picture below, identify the anode pad on the tube cell PCB.



Now you can insert and solder in the tube. Pay attention that the tube sits squarely on the PCB. Then solder on the connector.
Keep the tube 5mm (0.2”) from the PCB. Failure to keep this separation will invalidate any tube warranty claim.





The tube cell is now complete. Repeat for the other 5 tubes. Then move on to step 6.

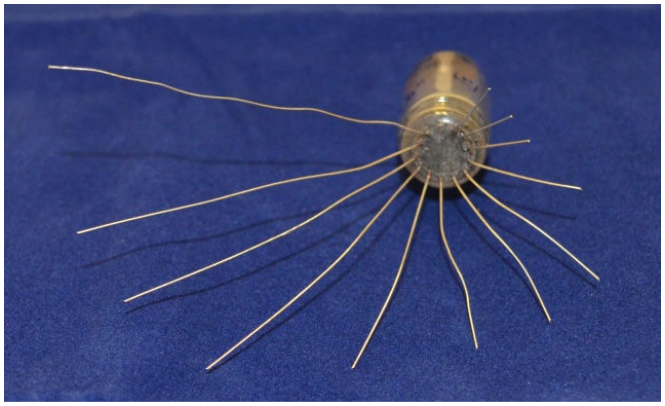
5.2 IN-8-2 and ZM1177 Nixie Tubes.

Code configuration: A (see page 36)
Cell PCB Type:

These tubes have a gap between leads at the back of the tube. The ZM1177 in fact has a small stub of a lead that is trimmed at manufacture. This helps identify the back of the tube, as well as being opposite to the viewing face of the tube.

The ZM1177 also has a gap between tubes near the front. Disregard this gap - the wires at either side will fit into adjacent holes on the PCB. Remember: 12 wires into 12 holes.

To facilitate easy insertion of the flying leads into the small holes, it helps enormously to trim the flying leads with a pair of scissors as shown below. Start at one of the leads at the back of the tube. Then, working around the tube, cut each sucessive lead approx 2mm shorter than the previous one. This will allow you to feed each lead in in turn.



Now you can insert and solder in the tube. Insert the 12 leads into the 12 holes. Pay attention that the tube sits squarely on the PCB. **Keep the tube 5mm (0.2”) from the PCB. Failure to keep this separation will invalidate any tube warranty claim.**

Note that there is one hole without a pad, that is unused - simply trim off this lead without soldering.

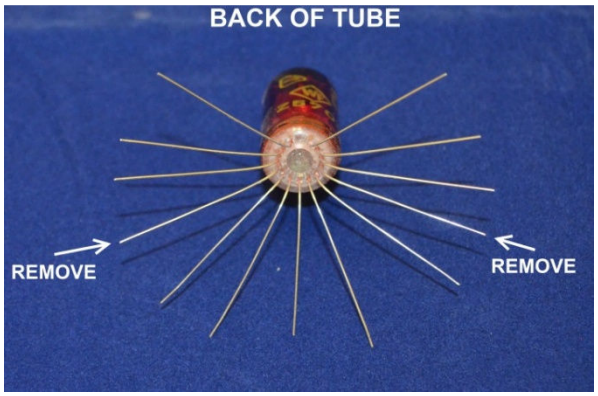
Then solder on the connector.

The tube cell is now complete. Repeat for the other 5 tubes. Then move on to step 6.

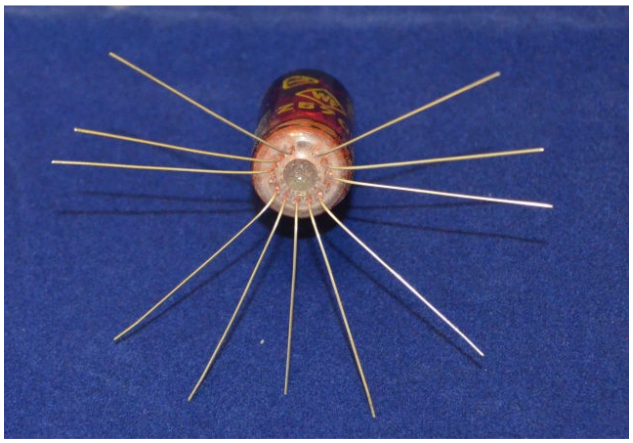
5.3 Z570M, Z5700M, Z573M, ZM1080, ZM1082, GN9A, ZM1136 Nixie Tubes.

Code configuration: A (see page 36)
Cell PCB Type:

It is necessary to clip off two of the Z570M and equivalent tube leads: Clip off the two leads as shown below:

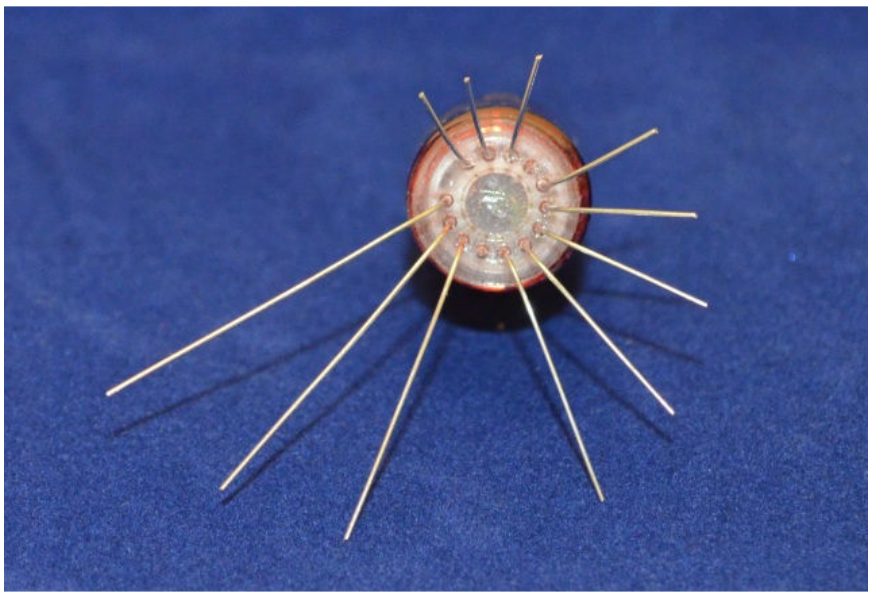


This is how the tube will look after removing the leads:

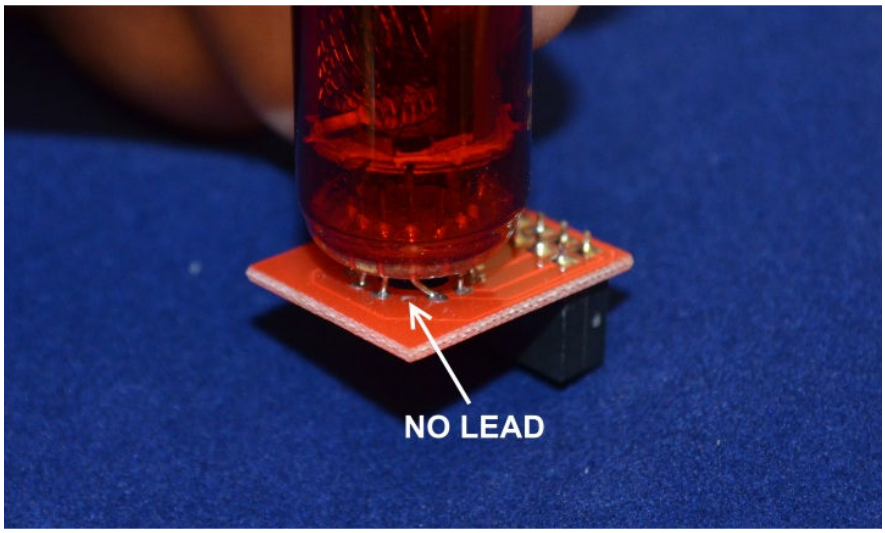


To facilitate easy insertion of the flying leads into the PCB holes, it helps enormously to trim the remaining flying leads with a pair of

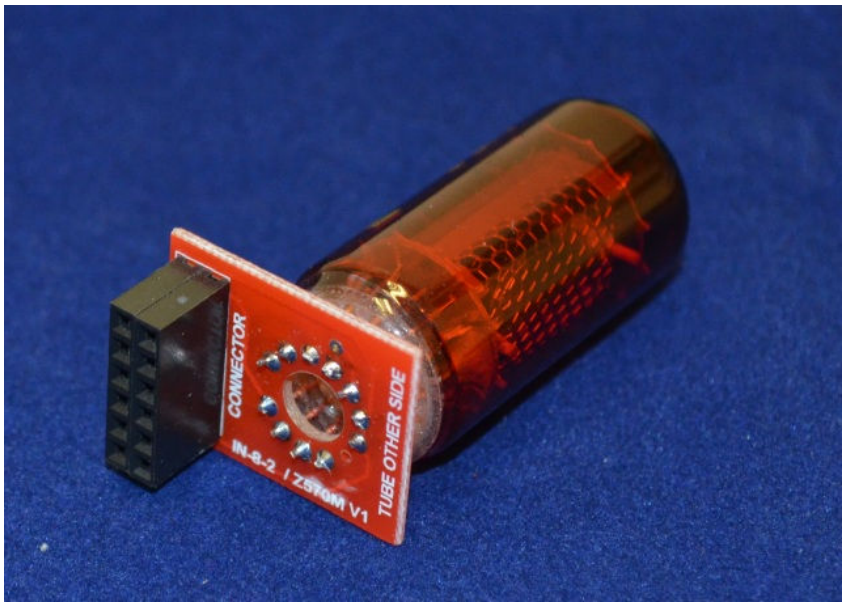
scissors as shown below. Start at one of the leads at the back of the tube.
Then, working around the tube, cut each sucessive lead approx 2mm shorter than the previous one. This will allow you to feed each lead in in turn.



Now you can insert and solder in the tube.
There are 11 leads on the trimmed tube and 12 pads on the PCB. One of the pads on the PCB is unconnected. DO NOT INSERT A LEAD INTO THIS HOLE:



Insert from the side of the PCB with no markings.
Pay attention that the tube sits squarely on the PCB.
Then solder on the connector.

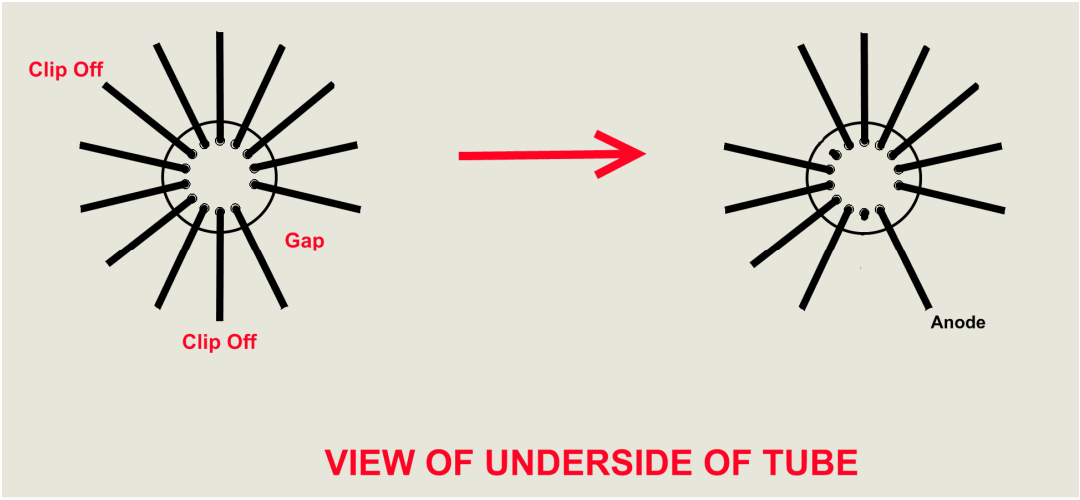


The tube cell is now complete. Repeat for the other 5 tubes. Then move on to step 6.

5.4 GNP-17A Nixie Tubes.

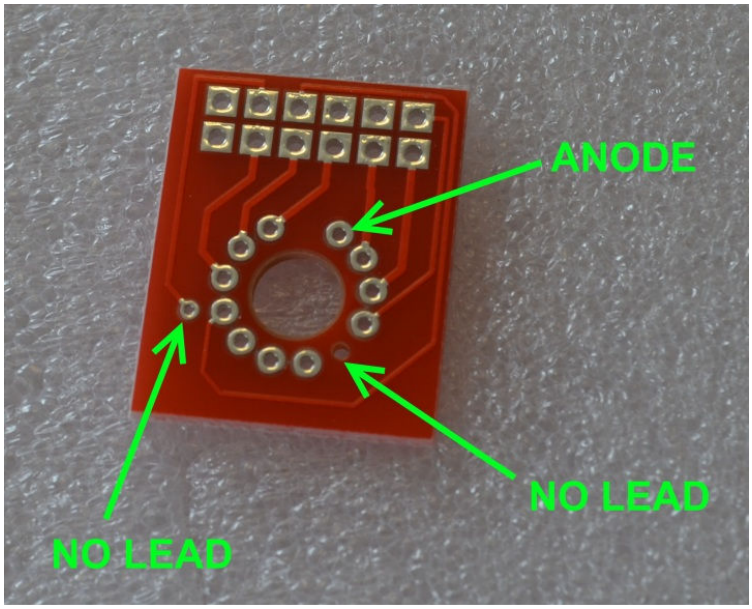
Code configuration: A (see page 36)
Cell PCB Type:

These tubes have 2 leads that need to be removed as shown below. Use the gap to correctly orient the tube:



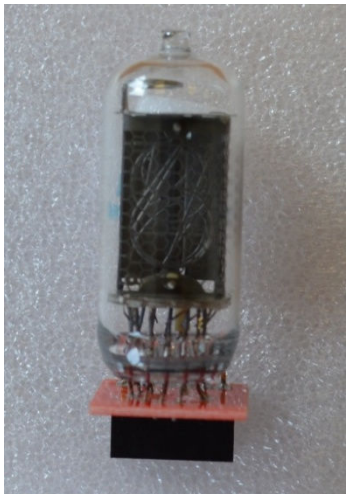
To facilitate easy insertion of the flying leads into the small holes, it helps enormously to trim the flying leads with a pair of scissors. Start at one of the leads at the back of the tube. Then, working around the tube, cut each sucessive lead approx 2mm shorter than the previous one. This will allow you to feed each lead in in turn.

Now you can insert and solder in the tube. Insert the 11 leads into the 11 holes with pads as shown below. Insert from the side of the PCB with no markings.



Pay attention that the tube sits squarely on the PCB. Ensure the tube is facing perfectly forwards before soldering - you may need to twist it a little.

Then solder on the connector .

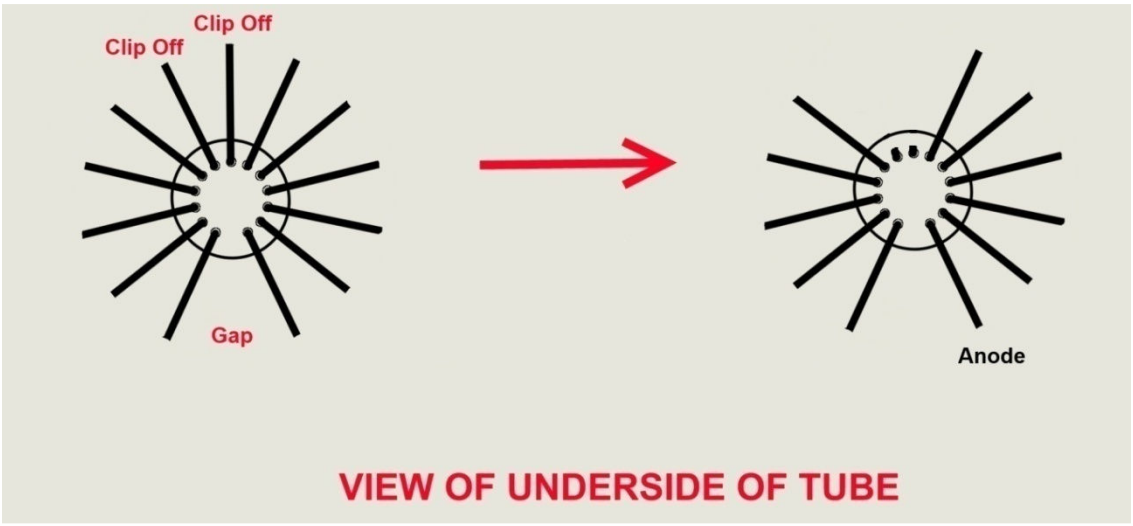


The tube cell is now complete. Repeat for the other 5 tubes. Then move on to step 6.

5.5 GNP-7A and GNP-7AH Nixie Tubes.

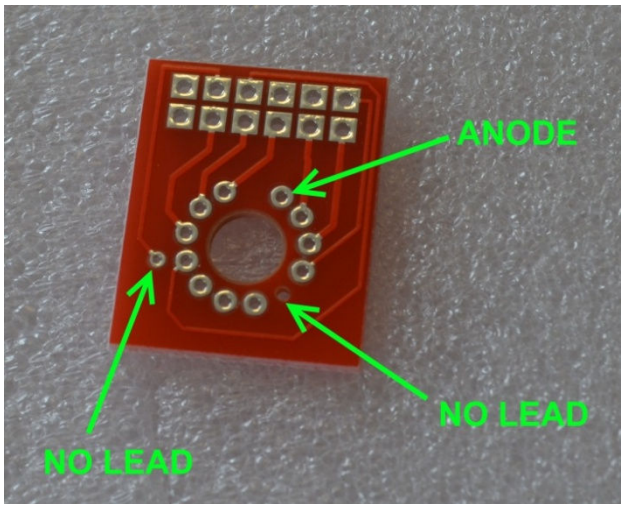
Code configuration: A (see page 36)
Cell PCB Type:

These tubes have 2 leads that need to be removed as shown below. Use the gap to correctly orient the tube:



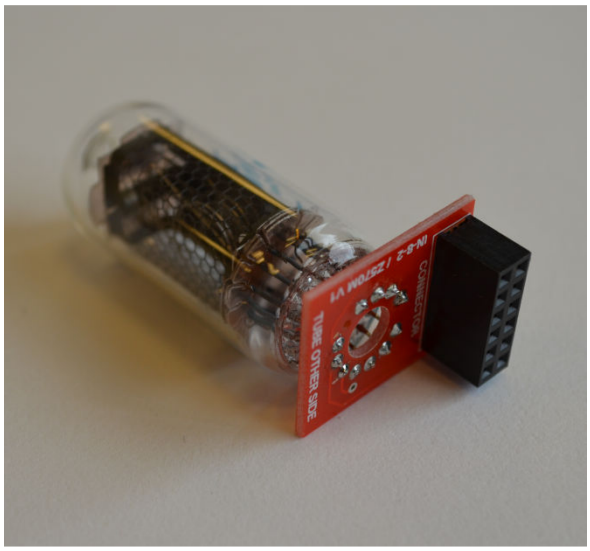
To facilitate easy insertion of the flying leads into the small holes, it helps enormously to trim the flying leads with a pair of scissors. Start at one of the leads at the back of the tube. Then, working around the tube, cut each sucessive lead approx 2mm shorter than the previous one. This will allow you to feed each lead in in turn.

Now you can insert and solder in the tube. Insert the 11 leads into the 11 holes with pads as shown below. Insert from the side of the PCB with no markings.



Pay attention that the tube sits squarely on the PCB. Ensure the tube is facing perfectly forwards before soldering - you may need to twist it a little.

Then solder on the connector.

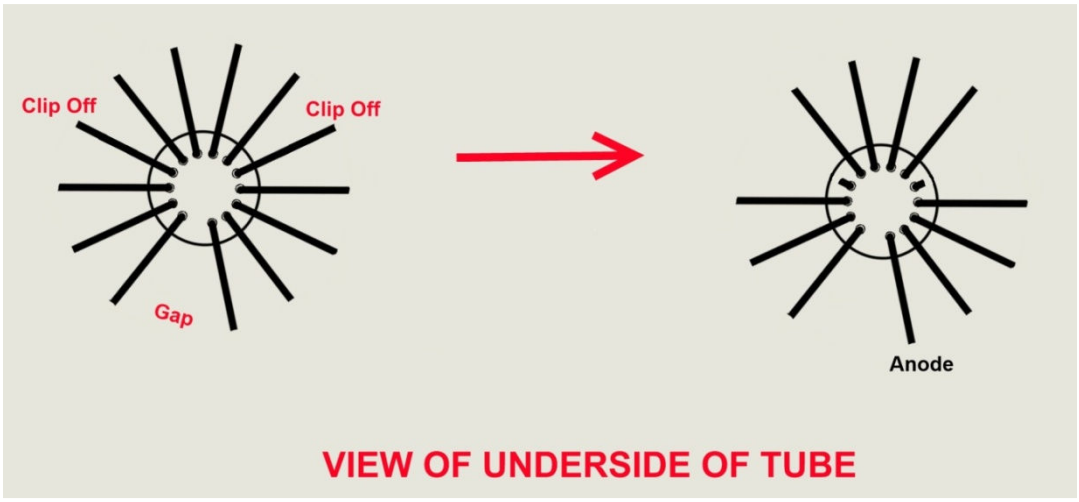


The tube cell is now complete. Repeat for the other 5 tubes. Then move on to step 6.

5.6 ZM1210 and ZM1212 Nixie Tubes.

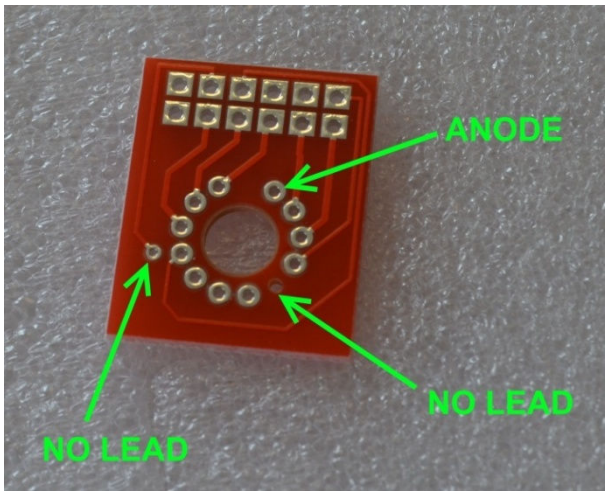
Code configuration: B (see page 36)
Cell PCB Type:

These tubes have 2 leads that need to be removed as shown below. Use the gap to correctly orient the tube:



To facilitate easy insertion of the flying leads into the small holes, it helps enormously to trim the flying leads with a pair of scissors. Start at one of the leads at the back of the tube. Then, working around the tube, cut each sucessive lead approx 2mm shorter than the previous one. This will allow you to feed each lead in in turn.

Now you can insert and solder in the tube. Insert the 11 leads into the 11 holes with pads as shown below. Insert from the side of the PCB with no markings.



Pay attention that the tube sits squarely on the PCB. Ensure the tube is facing perfectly forwards before soldering - you may need to twist it a little.

Then solder on the connector .

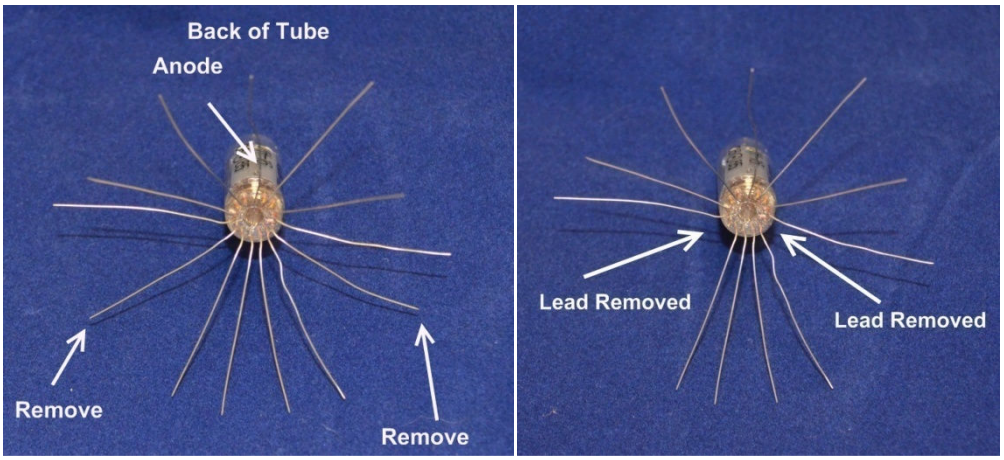
The tube cell is now complete. Repeat for the other 5 tubes. Then move on to step 6.

5.7 IN-16 Nixie Tubes.

PLEASE NOTE: THIS IS FOR IN-16 TUBES – THAT IS WHY THE SECTION IS TITLED 'IN-16' TUBES. FOR IN-14 TUBES, FOLLOW THE SECTION TITLED 'IN-14' TUBES.

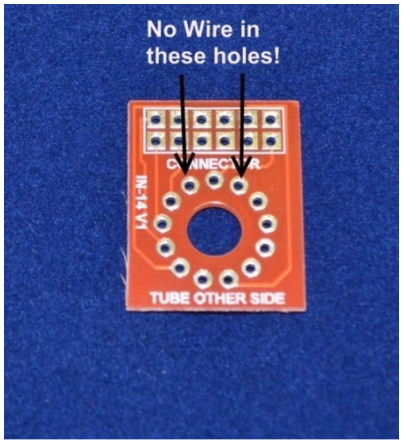
Code configuration: C (see page 36)
Cell PCB Type:

These tubes have 2 leads that need to be removed as shown below. Use the back of the tube to correctly orient the tube:



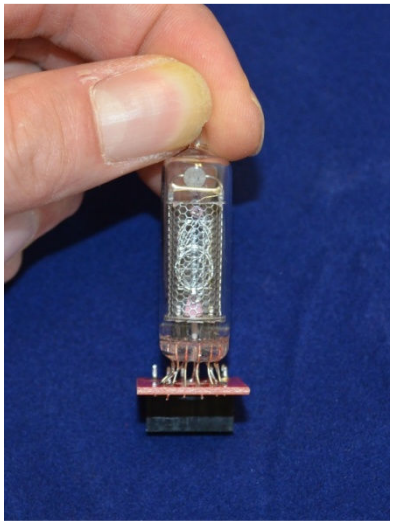
To facilitate easy insertion of the flying leads into the small holes, it helps enormously to trim the flying leads with a pair of scissors. Start at one of the leads at the back of the tube. Then, working around the tube, cut each sucessive lead approx 2mm shorter than the previous one. This will allow you to feed each lead in in turn.

Now you can insert and solder in the tube. Insert the 11 leads into the 11 holes with pads as shown below. Insert from the side of the PCB with no markings.



Pay attention that the tube sits squarely on the PCB. Ensure the tube is facing perfectly forwards before soldering - you may need to twist it a little.

Then solder on the connector .



The tube cell is now complete. Repeat for the other 5 tubes. Then move on to step 6.

5.8 CD66, ZM1242, ZM1240, XN11 and XN12 Nixie Tubes.

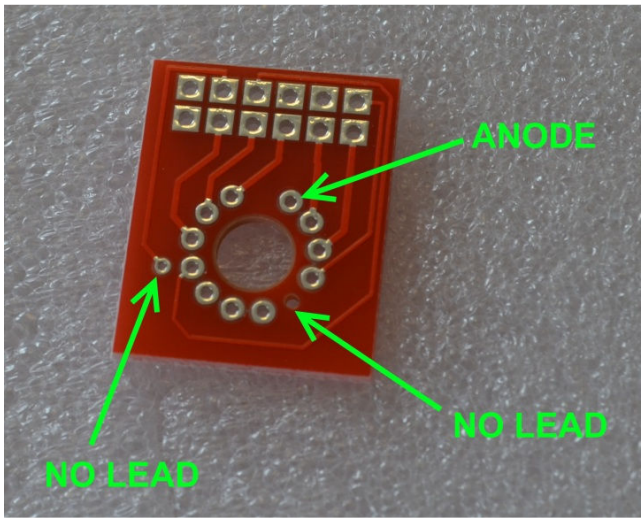
Code configuration: A (see page 36)
Cell PCB Type:

CD66, ZM1240 and ZM1242: These tubes have 1 lead at the very back of the tube that needs to be removed. Ensure you only clip the lead at the very back of the tube, this will leave you with 11 leads remaining and a gap at the back of the tube. Proceed as for XN11 and XN12 below.

XN11 and XN12: These tubes have 11 leads and a gap at the very back of the tube.

To facilitate easy insertion of the flying leads into the small holes, it helps enormously to trim the flying leads with a pair of scissors. Start at one of the leads at the back of the tube. Then, working around the tube, cut each sucessive lead approx 2mm shorter than the previous one. This will allow you to feed each lead in in turn.

Now you can insert and solder in the tube. Insert the 11 leads into the 11 holes with pads as shown below. Insert from the side of the PCB with no markings.



Pay attention that the tube sits squarely on the PCB. Ensure the tube is facing perfectly forwards before soldering - you may need to twist it a little.

Then solder on the connector.
The tube cell is now complete. Repeat for the other 5 tubes.
Then move on to step 6.

6. FIRST CLOCK TEST

It is now time to check that all tubes are working correctly.

6.1 Microcontroller Code Configuration

The Microcontroller IC2 needs to be setup for your tube type as the tube connections differ for the 3 types of pinout that the kit supports. However, most tubes use configuration 'A'. If you are using a tube which requires configuration 'A', you can omit this step as the microcontroller is programmed to this configuration as a factory default. However it is still worth noting the procedure below, in case for some reason you accidentally change the configuration you can then change it back.

To change the configuration, be sure the supercapacitor is discharged. If it is not discharged, leave the clock unplugged for 4 hours to fully discharge it.

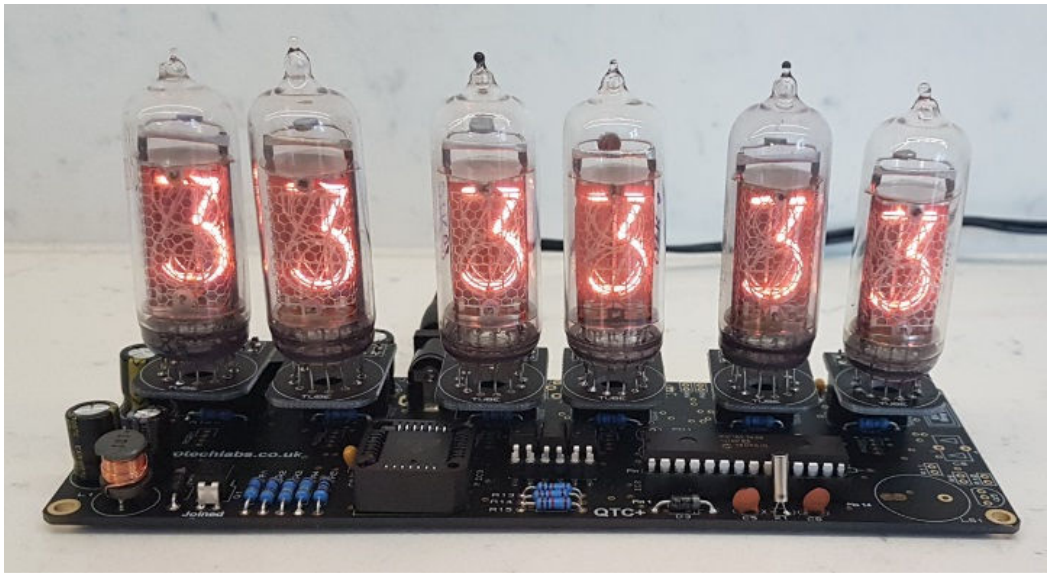
Then keep one of the following buttons pressed whilst re-connecting power. This will reconfigure the controller and the change will be stored to non- volatile memory.

Configuration A: Press the SET button
Configuration B: Press the ADJ button
Configuration C: Press the ALARM button

After configuring the controller as above you can immediately power off the clock, and proceed to the first tube tests below.

6.2 First Tube Test

Now power up. After a short delay, the tubes should light and all start counting from 0 to 9 and repeat. Please note this is a count UP, not a count DOWN. If you contact us with a support issue at this stage, please be clear about the count up. If you refer to a count down, it will be very confusing and slow down your support query!

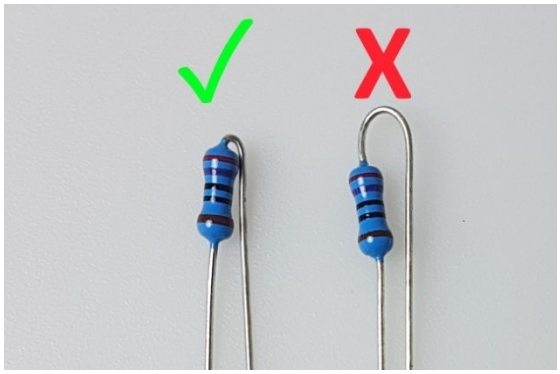


If you do not get this count up, or have missing or overlapping digits, stop and check your work. Try swapping tubes around to see if the problem is with the tube, or the location. Please make these basic tests before contacting us for help and have the results to hand.

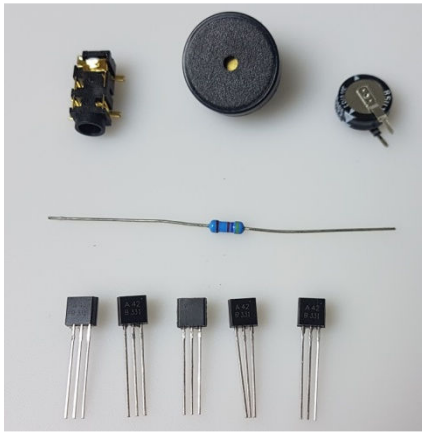
7. PCB ASSEMBLY CONTINUED

7.1 R6, R7, R8, R9, R10, R11 (270 Ω)

These resistors need to be soldered vertically. The leads need to be formed as shown below. Bend the leads of each resistor as shown and solder in to the correct postion, making sure the component body is as close to the board as possible.



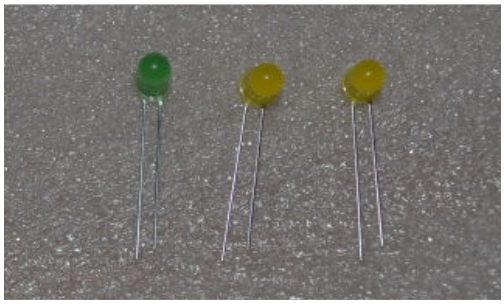
7.2 Q5, Q11, Q12, Q13, Q14 (MPSA42)
R12 (4.7 KΩ)
GPS/ RFT (SMD Jack Connector)
LS1 (Piezo Buzzer)
C8 (0.22F)



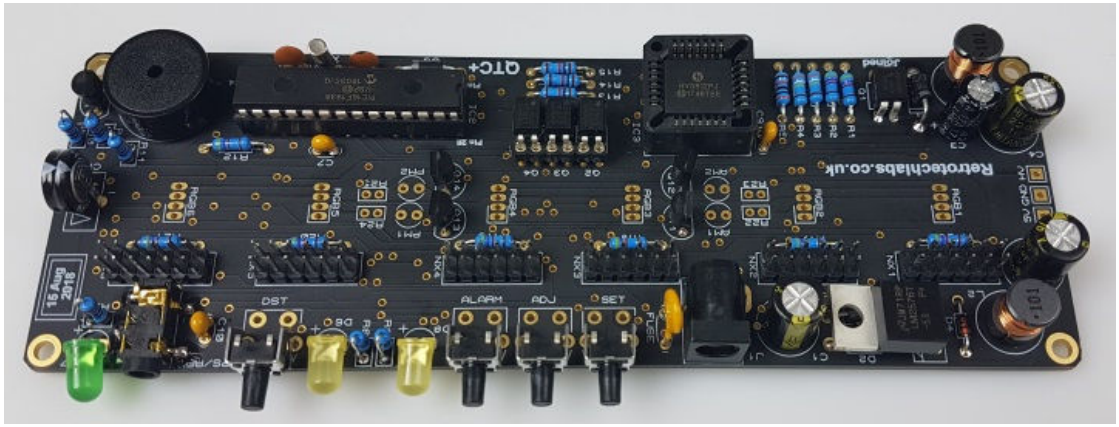
To solder the GPS / RFT connector: First wet one pad on the PCB with solder. Then place the connector in position and re-touch the pad with the soldering iron. This will anchor the component and then you can solder the remaining pads.
Ensure the arrows on C8 are aligned with the corresponding arrows on the PCB

7.3 D7 (5mm Green LED)
D6, D8 (5mm Yellow LED)
SET, ADJ, ALARM, DST (Push switches)

First, bend the leads of the LEDs as shown below, paying attention to the longer (+) lead being on the left hand side. Then solder in place with the body of the LED just touching the PCB.

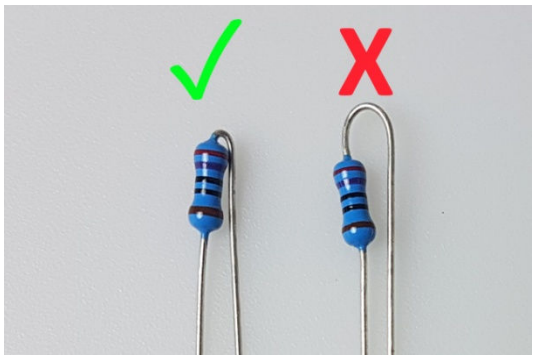


Then place and solder the 4 push button switches:



7.4 R22, R23, R24, R25 (15 KΩ)

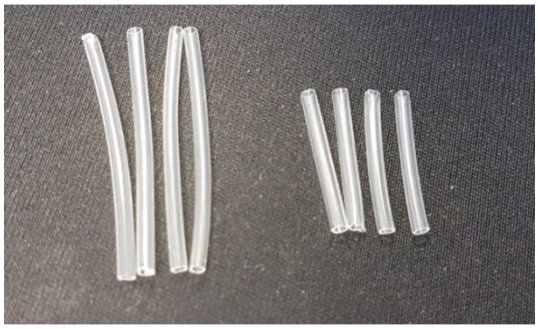
These resistors need to be soldered vertically. The leads need to be formed as shown below. Bend the leads of each resistor as shown and solder in to the correct postion, making sure the component body is as close to the board as possible.



7.5 AM1, AM2, PM1 PM2 (4mm neon lamp)

Each neon is separately addressable, and many flashing and indication modes are implemented – see the configuration setup later in the manual.

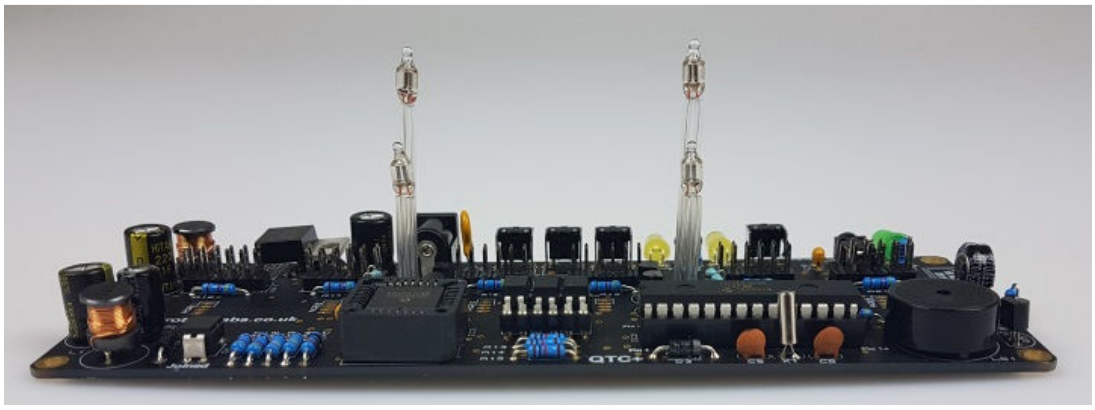
Cut the clear heat shrink tubing into 8 lengths acording to the tube type.



Tube Type	Long Pieces	Short Pieces
IN-14	35mm	20mm
Z570M	30mm	15mm

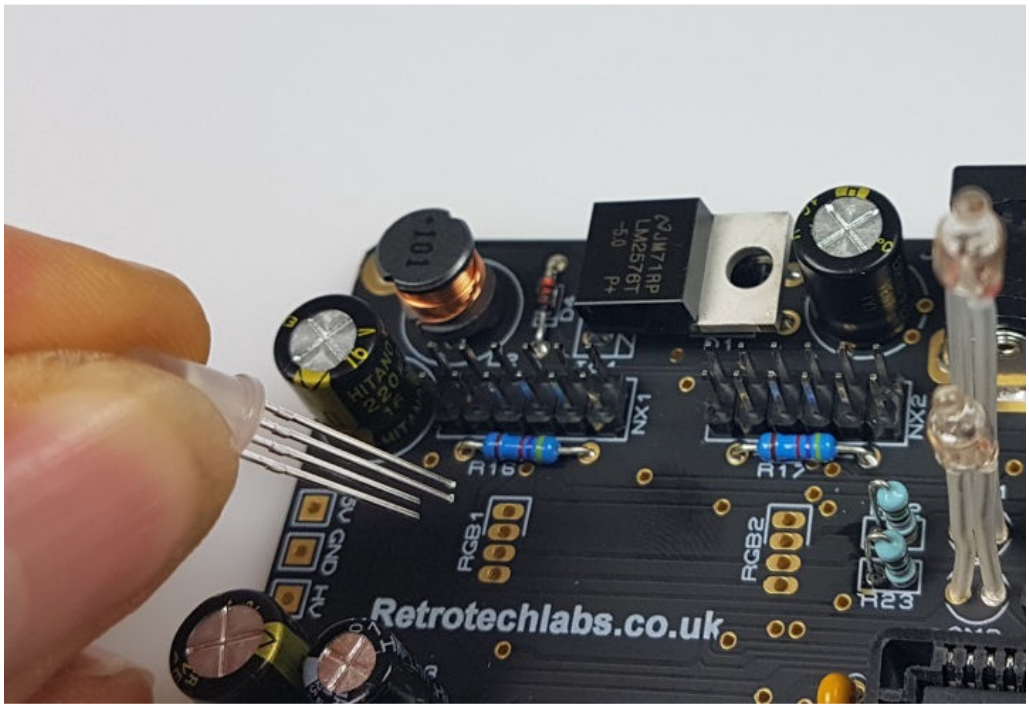
Slip the insulation over the neon lamp leads and with a hot air gun, shrink the tubing:

Finally, solder the neons in place on the PCB, with the taller neons at the back.

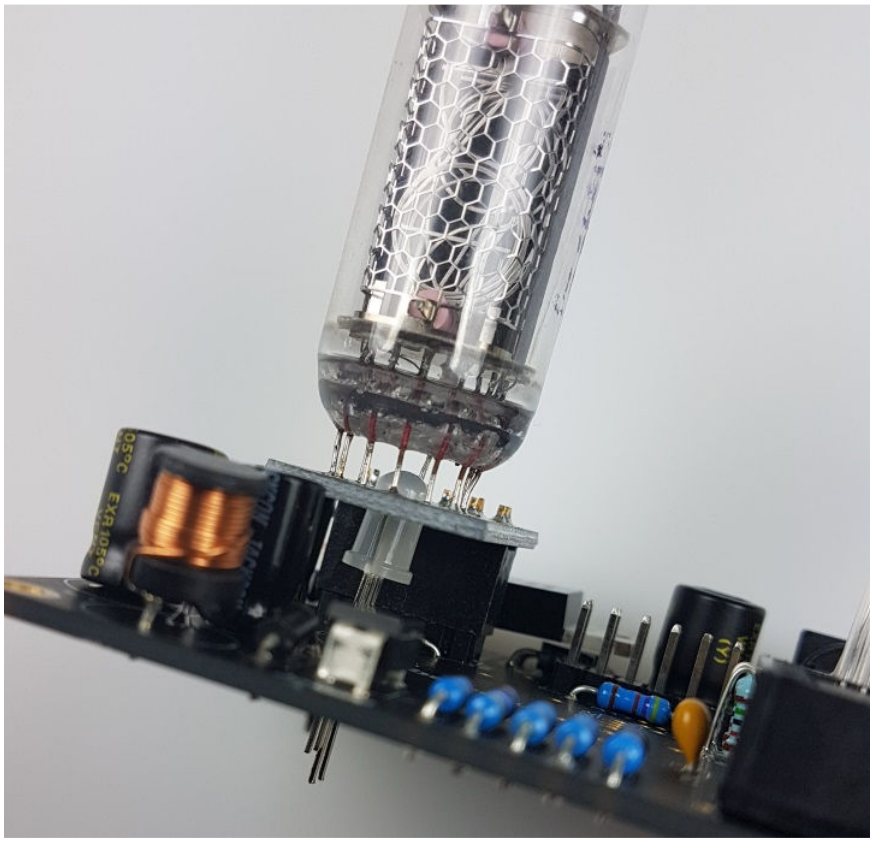


7.6 RGB1 – RGB6 (APA106 RGB LED).

To install the RGB LEDs, first note the 2 longer of the 4 leads and insert as shown below.



Then, place a Nixie Tube assembly into position on the 6X2 connectors. Push the RGB LED gently into position under the tube and then solder in place.



8. HOW TO OPERATE THE CLOCK

The four buttons have the following functions:
SET: Exit tube test routine on cold power-up;
Show date;
Set time and date;
Enter configuration menu;
ADJ: Adjust: time, date, alarm time, configuration parameters;
Enter XTERNA Stats Menu;
ALARM: Set alarm time; snooze; cancel snooze/alarm;
DST: Toggle between DST and Standard Time (+/- 1 Hour)
Enter colour setup menu; scroll through colour / time options

Entering configuration mode:
The principal settings of the clock are stored in flash memory – your preferred configuration is stored even after powering off the clock for extended periods. To access the configuration mode press and hold the 'SET' button. After 2 seconds the seconds will become highlighted. Continue holding the button a further 2 seconds until the clock displays in this format:
00-XX-99. The '99' in the seconds digits tells you that you are in the configuration menu.

In configuration mode the hours digits diplay the current parameter being adjusted, and the minutes digits display the current value stored against the parameter.
For each parameter, and referring to the table below, scroll through the range of possible values by pressing the 'ADJ' button. When the desired value has been reached, move on to the next parameter by pressing the 'SET' button. When the last parameter has been set, pressing 'SET' one more time will revert the clock back to time display mode. The first parameter (0) cannot be changed as it is the software revision number. It will show for several seconds and then move to parameter 1.

In all correspondence on support issues, please quote the board type, revision date and software version.

Parameter	Description	Values
0	Software revision	20 = version 2.0, 12 = version 2.1 etc
1	12 / 24 Hr mode	0 – 12 Hr (default) 1 – 24 Hr
2	Date format	0 = MM.DD.YY (default) 1 = DD.MM.YY 2 = YY.MM.DD
3	Leading zero blanking eg. *0*1:54:32	0 – leading zero blanked (default) 1 – leading zero displayed
4	Night Mode start hour	0 - 23
5	Night Mode end hour	0 - 23
6	Night Mode	0 – Tubes off 1 –5 Dimmed display (default 1)
7	Master Blank start hour[1]	0 - 23
8	Master Blank end hour[1]	0 - 23
9	Master Blank days[1]	0 – Off (default) 1 – Weekdays 2 - Weekends 3 – All days
10	Colon neons mode	0 – Both off 1 – AM/PM Indication, left / right 2 – AM/PM Indication, left / right flashing 3 – AM/PM Indication, top / bottom 4 – AM/PM Indication, top / bottom flashing 5 – All slow flashing 6 – Slow flashing left / right 7 – All flashing 8 – Both illuminated 9 – Railroad fast 10 – Railroad slow
11	Colon neons during night dimmed mode [2]	As per parameter 10
12	Radio time signal source[3]	0 to 3 reserved 4 – GPS 5 - XTERNA
13	GPS Baud rate	0 – 4.8 Kbps 1 – 9.6 Kbps (default)
14	Radio time offset hours	0-13 (default 0)[4]
15	Radio time offset mins	0-45 (default 0)[4]
16	Radio time offset polarity	0 - Minus time (default) 1 – Plus time
17	Reserved	
18	Snooze period	0 – 6 minutes (default) 1 – 9 minutes 2 – 12 minutes 3 – 15 minutes
19	Reserved	
20	Time Calibration Factor	0 - 99 (each unit adjusts by 0.2s per day)
21	Time Calibration Polarity	0 - Make clock slower 1 - Make clock faster
22	Slots Mode[5]	0 – Slots disabled

		1 – Slots every minute 2 - Slots every 10 minutes (default) 3 - Slots every hour 4 – Slots at midnight
23	Reserved	
24	Reserved	
25	Reserved	
26	Display Mode	0 – standard change of digits 1 – fading digits 2 – fading digits with scrollback effect (default)
27	Auto date display each minute	0 – Off 1 - Static display of date 2– Scrolling display of date (default)[6]
28	Night Mode Override minutes	0 – 50 (default 0 gives 15 seconds override)[9]
29	Thermometer Settings	0 – Don't display temperature 1 – Fahrenheit display (default) 2 – Celsius display
30	Reserved	
31	Restore default settings	0 – Keep user settings 1 – Restore original default settings[8]

Notes:

1. Master Blanking Mode has priority over Night Mode. Use to disable the clock on weekends (eg clock is in office), or during office hours (eg clock is at home). Complete HV shutdown to save power and tube life.
2. Night time neons mode is active when night mode is set to dim. During night time blanking the tubes AND neons are disabled.
3. Clock is fully functional without GPS / XTERNA synchronisation. Set time manually.
4. Enter your time zone offset from the synchronisation source. Note that GPS transmits UTC.
5. Visual effect / cathode poisoning prevention – all digits on all tubes are cycled for 10 seconds.
6. Date will be displayed each minute between 50 and 55 seconds past the minute.
7. Press 'SET' briefly during Night Mode to show time for prescribed period.
8. Set this parameter to '1' to restore factory configuration settings. Internal operations will then load all the original settings and restore the value to '0'

Setting the Time and Date:
Before setting the time, press 'DST' briefly to toggle between DST and standard time modes. Set according to whether you are currently in DST time or not. The adjacent DST LED will light or extinguish accordingly.

From time display mode, press and hold 'SET' button for 2 seconds until the seconds digits are highlighted.
Press the 'ADJ' button to reset seconds to zero.

Briefly Press 'SET' again and the hours will be highlighted
Press the 'ADJ' button to set the minutes.

Briefly Press 'SET' again and the hours will be highlighted.
Press the 'ADJ' button to set the hours.

Proceed in this fashion to set the calendar: Year, Month and Day.

Finally, briefly Press 'SET' again to revert to normal clock operation.

Showing Date:
From time display mode, briefly press 'SET' button. Date will be shown for 5 seconds, then revert to time display.

Auto Date Display:
Setting parameter 27 to 1 or 2 will enable auto display of date between 50 and 55 seconds past each minute.

Night Blanking Override:
During programmed night blanking, the blanking may be overridden to see the time by briefly pressing the 'SET' button. Tubes will remain lit for the period defined in parameter 28.

Setting Alarm:
Press the 'ALARM' Button. The seconds digits show the on / off status of the alarm: 00 (off) or 01 (on).

Set on / off status, then minutes followed by hours by using the 'ALARM' and 'ADJ' buttons. When set, the alarm LED will also light.

***Cancelling Alarm*:**
Press 'ALARM' briefly to cancel alarm and enter snooze mode, or a longer press until the clock bleeps, to cancel snooze. Alarm remains set for subsequent days.

Rapid DST Adjustment
Press 'DST' briefly to toggle between DST and standard time. The indicator shows whether DST mode is active or not.

Note, that GPS time data does not contain DST information, so the DST status will need to be set manually in GPS sync mode as well as manual time-set mode.

Invoking Cold Start Tube Test
A cold start is when the Supercapacitor C8 is discharged. On a cold start, time and date are lost and the clock will perform the ascending tube test on power up. To force a Cold Start, do the following:

- Toggle the DST on by pressing the DST button if necessary
- From time display, press ALARM once.
- Press ADJ once to illuminate the ALARM LED
- Immediately disconnect power.

The power sensing / sleep routine is not called from within the Alarm setup, so the clock will drain the supercapacitor via the DST and ALARM LEDs. Wait 2-3 minutes until the LEDs are fully off. On powering up again, you will get the cold start tube test.

Calibration of Timekeeping Accuracy
Over time you may observe the clock runs faster or slower than an accurate time standard. You can finely adjust the timekeeping by setting configuration parameters 20 and 21. We recommend to precisely set the clock against a known accurate clock, and then record the time drift in seconds after 5 full days (120 hours). Program this value into parameter 20.
Set parameter 21 to 0 to slow down the clock and to 1 to speed up the clock.

9. XTERNA FUNCTIONS

9.1 About the XTERNA Module

XTERNA is our new concept for synchronising time and capturing outdoor temperature for display on our clock and thermometer kits. Driven by a PIC microcontroller with advanced low power modes, the XTERNA captures time from GPS satellites every 6 hours, and stores in an on-board Temperature Controlled Crystal Oscillator (TCXO). Further, the device captures outdoor temperature every 10 minutes from an on-board DS18B20 digital temperature sensor. Every 10 minutes XTERNA transmits the time and temperature data, which can be received by our XTERNA compatible clocks.

Additional data is transmitted such as battery voltage and GPS fix time.

Supplied as a complete hobby kit of parts (For shipping reasons, batteries are not included), the kit takes approx 30-40 minutes to comfortably assemble. The TCXO IC is pre-soldered, so there is no fiddly SMD soldering to worry about.

Naturally, XTERNA is sealed against rain ingress. Battery life is estimated between 6 to 12 months. We recommend high quality branded batteries for the longest operation between battery changes.

The module should be placed outdoors. But as close as possible to the indoor clock or thermometer and away from direct sunlight.

9.2 Specification

Working Temperature Range: -40 °C to +60 °C. (-40 °F to +140 °F)
Typical Reception Range: 10 to 30 Metres (30 to 100 ft).

9.3 Configuring for XTERNA Reception

Elite Class Nixie Clocks are configured by default for XTERNA reception. If you have changed your configuration settings, you need to set parameter 12 to value 5. Also parameters 14, 15, 16 need to be set to specify your location's offset from UTC.

9.4 Time Synchronisation Function

XTERNA broadcasts every 10 minutes. After configuring your clock, please be patient in waiting for the first Synchronisation. Upon synchronisation the yellow LED D7 will illuminate. Remember to set DST ('Summer Time') with the DST button.

9.5 Temperature Display

The temperature is also transmitted with the time. Therefore, temperature will not be displayed until after the first synchronisation.
Set Celsius or Fahrenheit using parameter 29:
Fahrenheit: 1
Celsius : 2

Temperature is displayed between 30 and 35 seconds past each minute. Celsius is displayed with 0.5 °C resolution. Fahrenheit is displayed with 1 °F resolution.
Positive and negative temperature is indicated by the left hand neons: Neon indicator PM2 acts as a decimal point.

9.6 Temperature Validity

If no valid data is received on the next scheduled sync (every 10 minutes), the temperature will be deemed to be old and invalid. Temperature will not be shown until a new valid temperature is received.

9.7 XTERNA Stats menu

The Stats menu is accessible only if relevant XTERNA data has been received. From time display, press ADJ to enter the Stats Menu. Six items of data are displayed in sequence, stepped through by pressing the ADJ button sequentially, and finally exiting back to time display. Please see the table below.

Stats Menu Item	Description	Range of Values	Example
1	Minimum Temperature in last 24 hours	-40°C to +60°C 40°F to 140 °F	
2	Maximum Temperature in last 24 hours	-40°C to +60°C 40°F to 140 °F	
3	Voltage of XTERNA Battery	2.5V to 5.0V	
4	Time required for last GPS fix loaded into the TCXO	0 to 98 sec 99 = no fix at last attempt	
5	Hours and minutes since last GPS fix loaded into the TCXO	00:00 to 99:99	
6	XTERNA Firmware version	1.00 onwards	

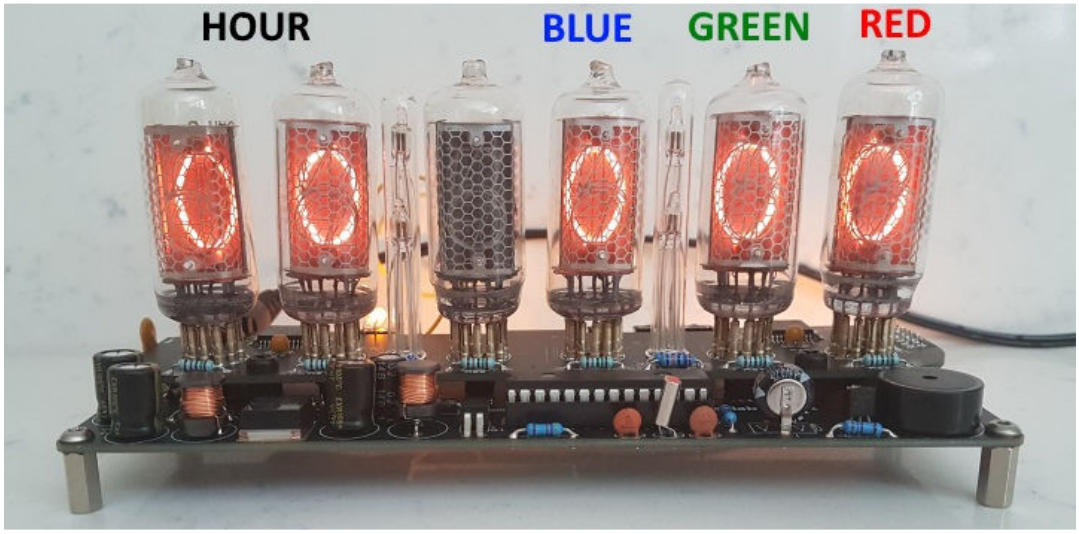
10. CONFIGURING THE RGB LED TUBE LIGHTS

The clock features a separate and dedicated setup menu for the RGB LED lights, accessed from the 'DST' button. All settings are stored to non-volatile memory, so your favourite colours will still be there after even after a long power off.

You can set fixed colours and intensities, or program an auto colour cycling effect at your choice of speed.

10.1 Entering RGB LED menu

Press and hold the 'DST' button until the display shows: 00: 0:00. NX3 will not be lit.



- For each hour (0-23), you can set a custom colour
- Each custom colour can have your choice of BLUE, GREEN and RED values from 0 (colour off) to 8 (maximum brightness)
- Mix the colours using the ALARM, ADJ, SET buttons.
- Use low values (1,2 and 3) for low brightness, eg. For night time
- Set the value to '0' for that colour to be off
- Once you are happy with the colour for that hour, press 'DST' to move to the next hour
- Have fun playing with your favourite colours and intensities!

- Colours are displayed live during RGB menu:

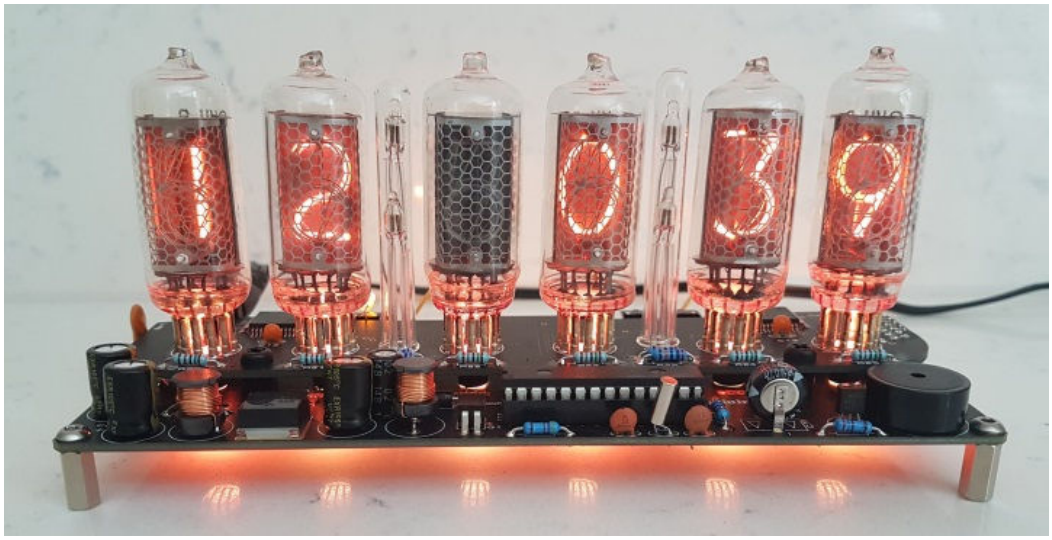
- In the example above, between 11 and 12 hours, the LEDs will be purple (8 blue, 0 green, 8 red)

- In the example below, between 19 and 20 hours, the LEDs will be blue with a hint of green (8 blue, 2 green and 0 red)

10.2 Setting auto colour cycling

Setting colour RED to value 9 has a special meaning:
This will enable auto colour cycling for the specified hour. The speed of the cycling will then be governed by the GREEN value:
0 = very slow change
9 = very fast change

This auto colour cycling mode is explained in the picture below:



Red = 9, therefore Auto Colour Cycling is enabled for 12-13 hours
Green = 3, so speed is 3.
Blue value has no effect.

Note: The colours do not cycle live during Auto Colour Cycling setup. The cycling starts only during normal time and date display.

11. USING A GPS RECEIVER

The clock can receive time from a GPS receiver that transmits information using NMEA-0183 protocol, using the $GPRMC sentence.

11.1 Configuring for GPS Synchronisation.

- Set parameter 12 to value 4.
- Set the baud rate in parameter 13.
- Set parameters 14 and 15 for the hours and minutes your time zone is offset from UTC Time. This is usually only whole hours.
- Set parameter (16) to identify whether the offset is minus (0) or positive (1) of the time source.

D7 will light when the clock has received a recent GPS or XTERNA synchronisation data.

12. CONNECTIVITY DIAGRAM FOR TROUBLESHOOTING

Please refer to the diagram on the next page. If you have problems with missing digits from the display or no digits displaying at all (even though High voltage is present and the clock makes bleeps when pressing the 'SET' Button) then you should check all connections to the HV5812 IC using the chart below.

Set your meter to continuity setting. This is the setting where it bleeps when you touch the two probes together.

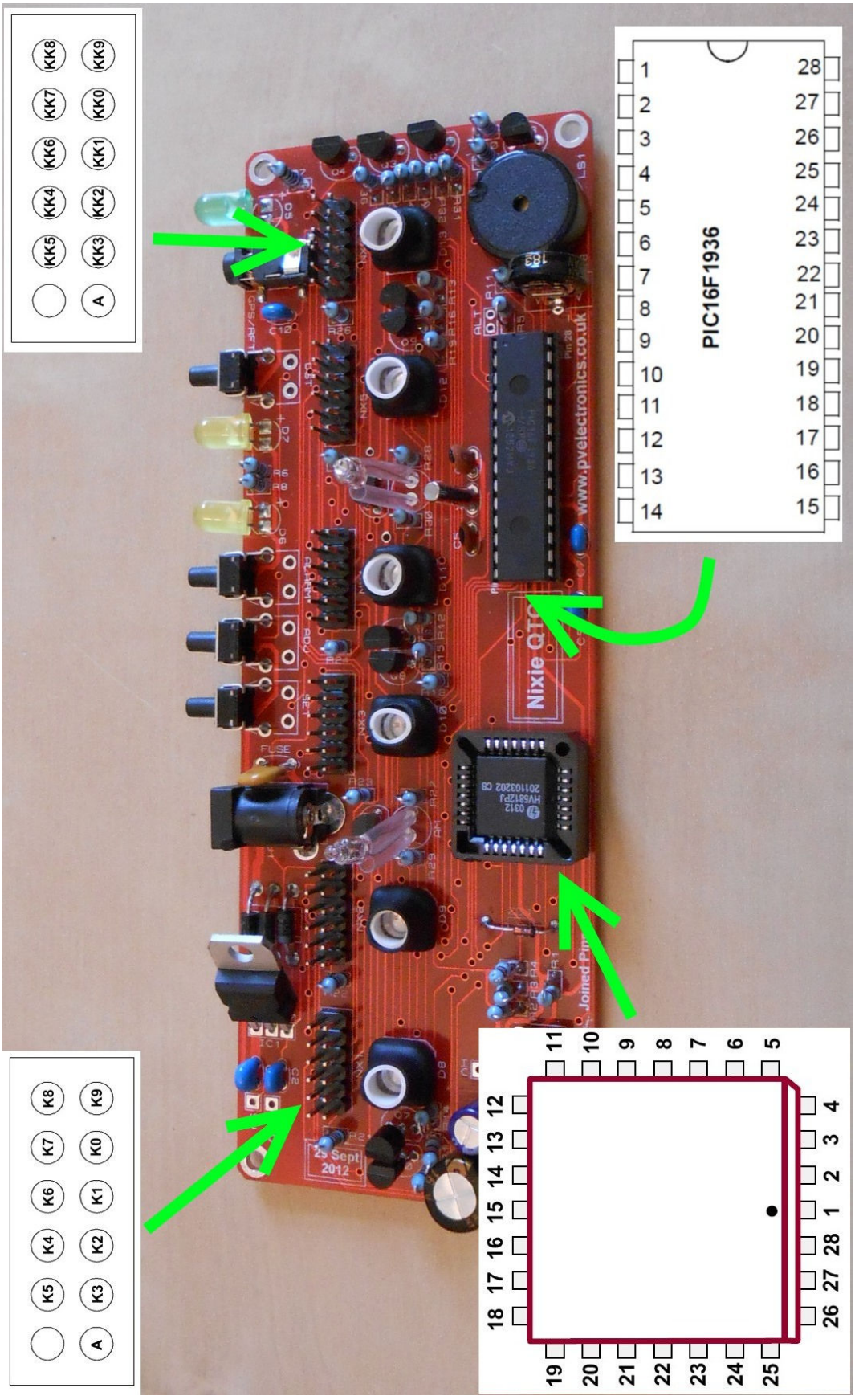
12.1 Data connections from IC2 to IC3

IC3 (HV5812) Pin Number	IC2 (PIC 16F1936) Pin Number	Function
27	3	Data
15	4	Clock
16	5	Strobe

12.2 Cathode connections from IC3 to tube pin headers

IC3 (HV5812) Pin Number	NX1, NX2, NX3 Cathode
17	K5
18	K4
19	K6
20	K7
21	K3
22	K2
23	K1
24	K0
25	K9
26	K8

IC3 (HV5812) Pin Number	NX4, NX5, NX6 Cathode
3	KK9
4	KK8
5	KK7
6	KK6
7	KK4
8	KK5
9	KK0
10	KK1
11	KK2
12	KK3


KK8
KK9
KK7
KK0
KK6
KK1
KK4
KK2
KK5
KK3
A
PIC16F1936
1 2 3 4 5 6 7 8 9 10 11 12 13 14
28 27 26 25 24 23 22 21 20 19 18 17 16 15
www.pvelectronics.co.uk
Nixie QTC
K8
K9
K7
K0
K6
K1
K4
K2
K5
K3
A
25 Sept 2012
11 10 9 8 7 6 5
12 13 14 15 16 17 18
4 3 2 1 28 27 26
19 20 21 22 23 24 25

12.3 Problems getting the correct High Voltage

This is the most common issue. Did you insert IC2? IC2 is needed to generate the HV. If IC2 is in its socket and you don't get HV, please record the following DC voltages with IC2 out of its socket.

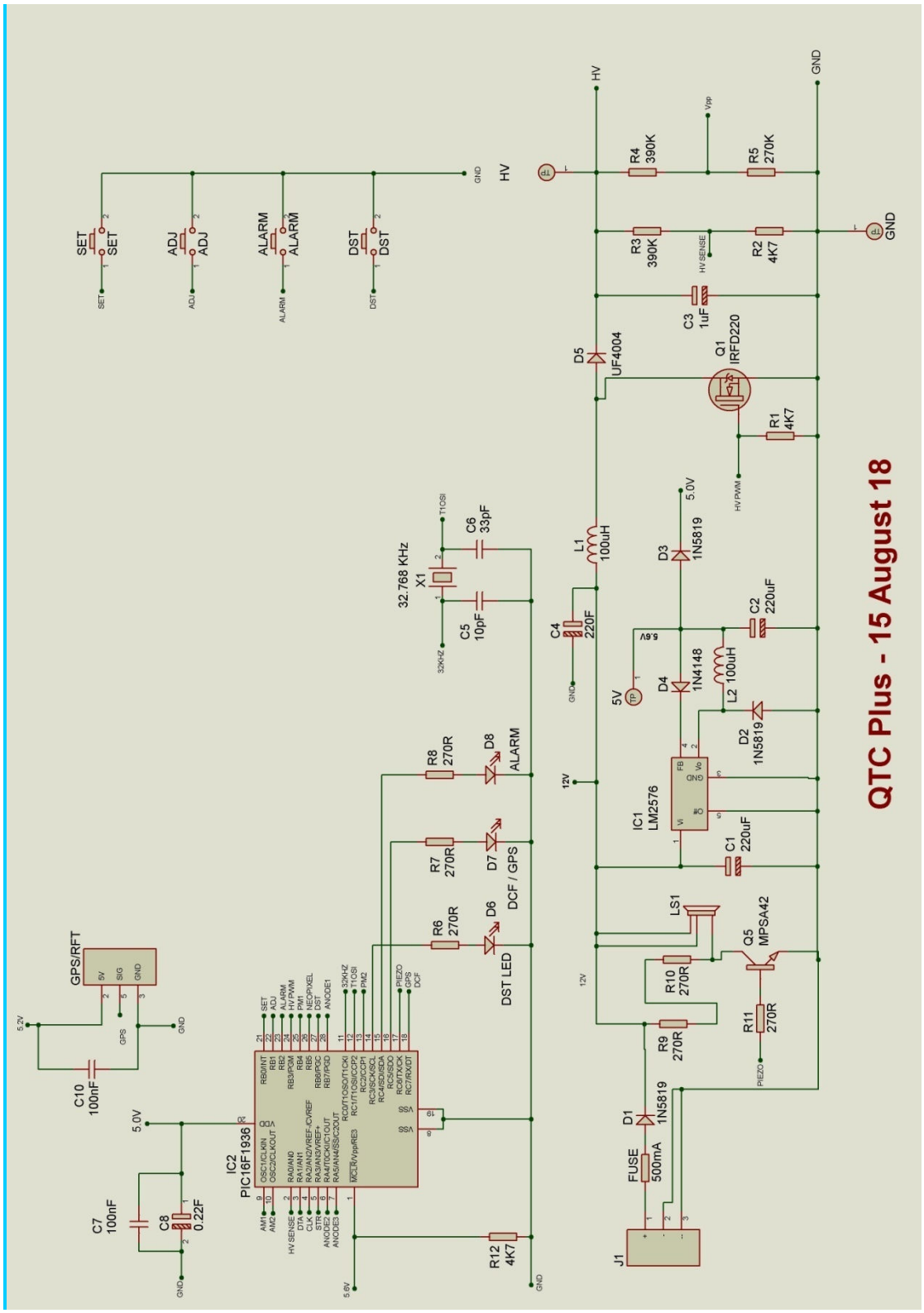
5V test Point	Should be 5.6V
HV test point	Should be approx 12V
IC2 Socket, Pin 1	Should be ~5.6V
IC2 Socket, Pin 2	Should be ~0.14V
IC2 Socket, Pin 13	Should be 0V
IC2 Socket, Pin 20	Should be ~5.2V

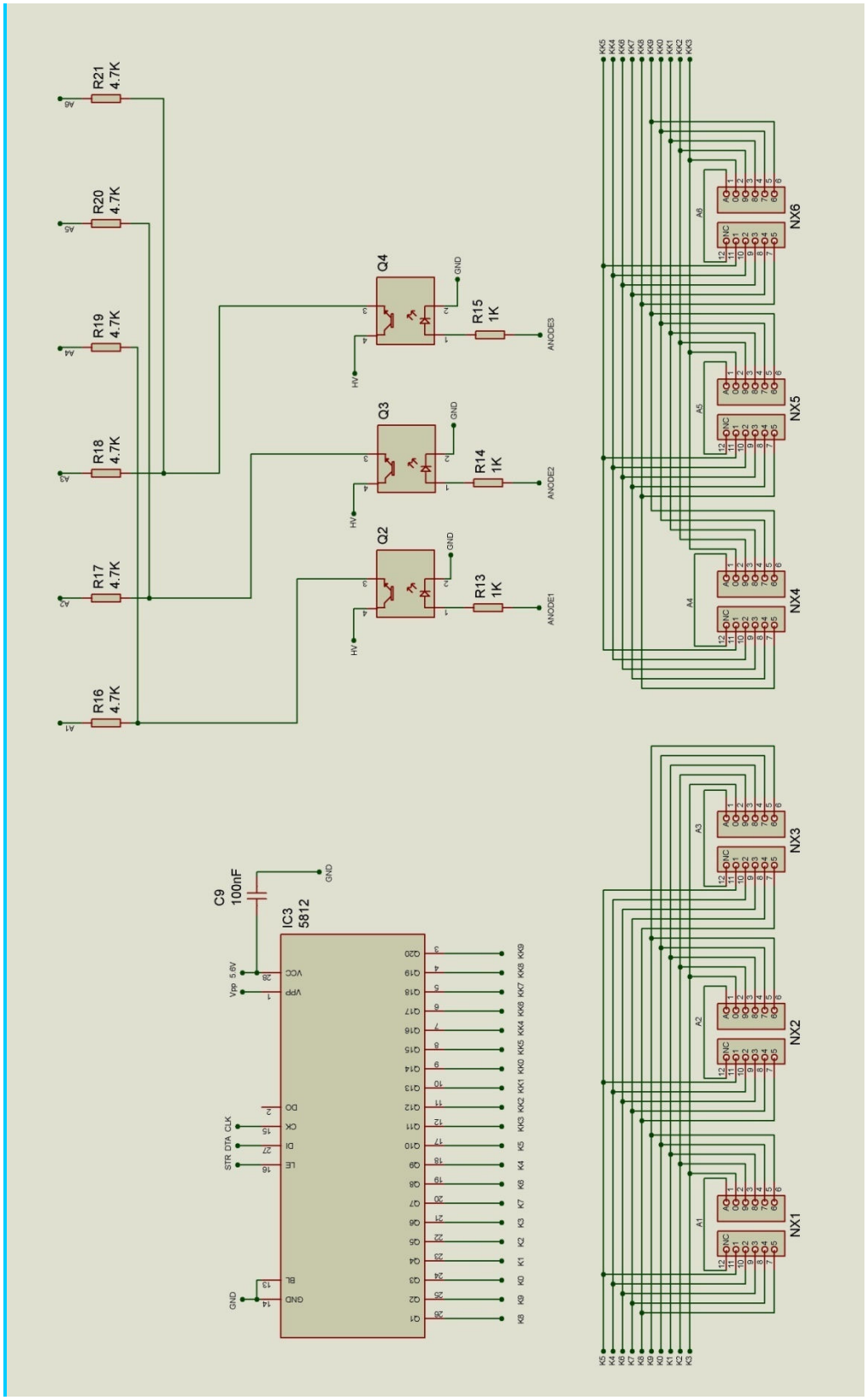
If pin 2 is not to spec, check the feedback resistors R2 and R3 are correct and correctly soldered.

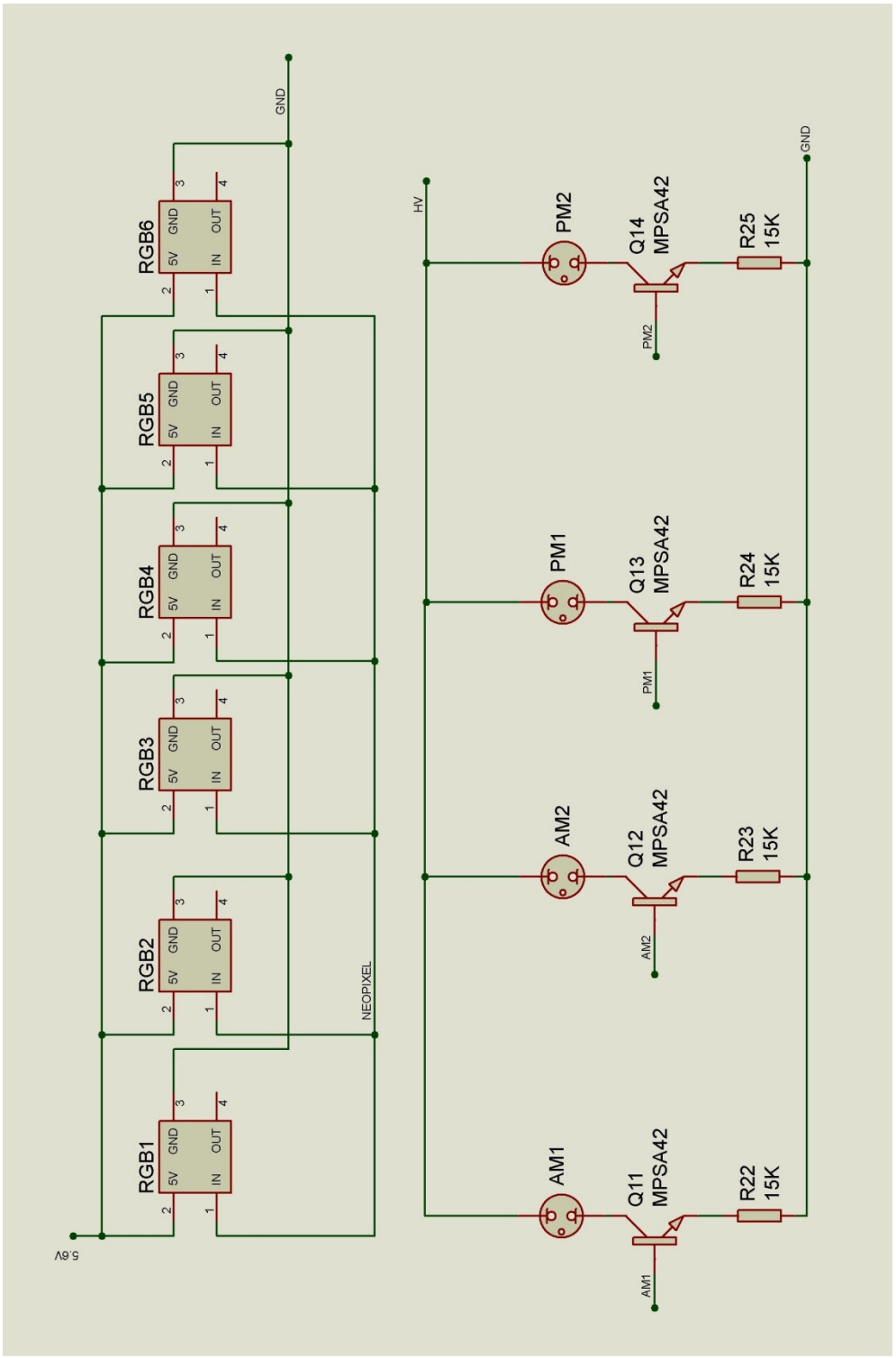
If pin 20 is not to spec, check why the PIC is not getting power via D3 (Orientation?)

If contacting us about an HV issue, please measure give us these voltages in your email.

13. CIRCUIT DIAGRAM




R21 4.7K
R20 4.7K
R19 4.7K
R18 4.7K
R17 4.7K
R16 4.7K
Q4
Q3
Q2
R15 1K
R14 1K
R13 1K
ANODE3
ANODE2
ANODE1
GND
HV
C9 100nF
IC3 5812
Vpp 5.6V
STR DTA CLK
NX1
NX2
NX3
NX4
NX5
NX6


GND
RGB6
RGB5
RGB4
RGB3
RGB2
RGB1
5V
GND
OUT
IN
NEOPIXEL
5.6V
HV
PM2
PM1
AM2
AM1
Q14
Q13
Q12
Q11
MPSA42
R25
R24
R23
R22
15K