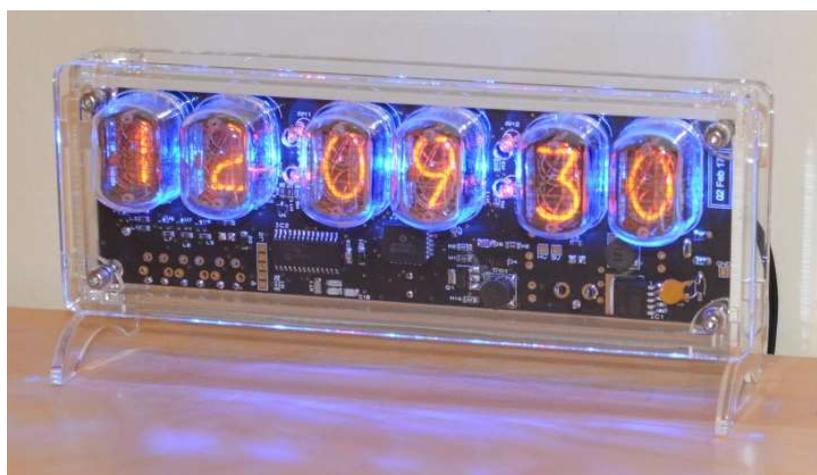


# Assembly Instructions and User Guide

## Nixie Clock Type 'Nixie Maestro'



## REVISION HISTORY

<b>Issue Number</b>	<b>Date</b>	<b>Reason for Issue</b>
5	01 June 2018	New Version PCB
4	01 April 2017	New version with neons for AM / PM
3	10 December 2014	Typing errors corrected. Updated photos. Added MSF and DCF support
2	27 December 2012	GPS Indicator LED function clarified
1	06 December 2012	New document

## 1. INTRODUCTION

Nixie Maestro is a fully-featured nixie clock kit, using a semi - assembled SMD board. The clock shows time and date on six vintage IN-12 Nixie Tubes, which are sourced from the former Soviet Union. Each tube has a RGB LED to illuminate it, which creates a beautiful spectrum of colour effects. Several case designs are available.

New for the 2018 version are some exciting new features. Maestro works best in conjunction with our new XTERNA outdoor, wireless time and temperature transmitter module, to report accurate GPS time and also outdoor temperature with min / max function. Additional highlights of the new Maestro Clock are direct tube drive and independent double dot colon neons.

### Here are the key features of the MAESTRO 2018 kit:

- Hours, Minutes and Seconds display
- Direct drive to six IN-12 Nixie Tubes
- Also fits ZM1100, ZM1162 Tubes
- Noiseless, Direct Drive giving optimum digit clarity
- 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 / 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 HV/ 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
- 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 each minute
  - Min / Max temperature in last 24 hours
  - Wireless, Auto Sync of time from GPS with auxiliary TCXO
  - GPS Sync time, and time since last GPS Fix
  - Voltage of XTERNA module battery
  - Firmware version of XTERNA module

## 1.2 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

Part Description	PCB Marking	QTY
Piezo sounder	LS1	1
220uF Capacitor 16 – 25V	C1, C2, C3	3
1uF Capacitor 250V	C4	1
Vertical 3.5mm jack socket	SYNC CONN	1
Vertical 2.1mm power socket	J1	1
0.22F Capacitor	C5	1
Vertical push switch	SET, ADJ, ALARM, DST	4
5mm Yellow LED	DST LED, ALM	2
5mm Green LED	SYNC	1
4mm Neon lamp	AM1, AM2, PM1, PM2	4
500mA Fuse	F	1
APA106 RGB LED	RGB1 – RGB6	6
2 way Right angle socket	CY18 Module	2
CY18 Module (Supplied if you ordered an XTERNA )		1
Harwin Socket		66
20cm Wire for antenna		1
15cm Clear heat shrink		1
LED Bending jig		1
Self Adhesive insulating sheet		1

It is recommended that the kit is checked against the list above, to ensure all parts are present before commencing assembly. Don't be alarmed if there are some extra components, as some component bags are shared between different kit types.

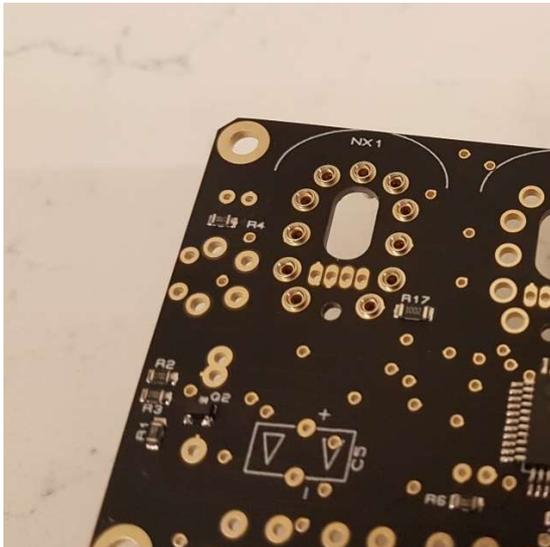
Please note the fuse will look like the picture below. It can easily be confused for a capacitor. It is a self-resetting fuse.



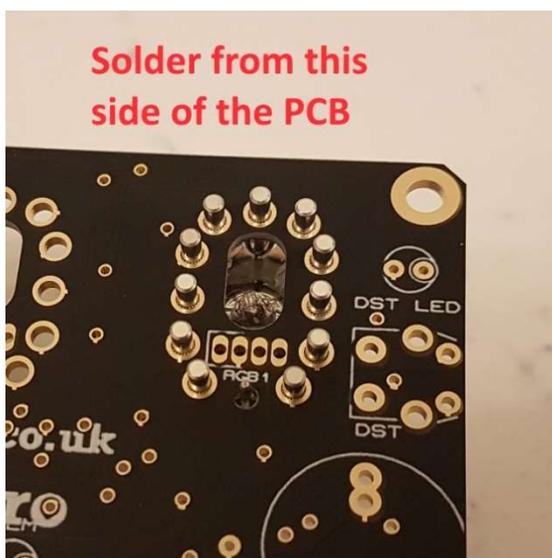
## 4. ASSEMBLY OF THE PCB

### 4.1 66 Harwin Sockets

Install and solder the sockets one tube location at a time, as follows. Be sure to insert from the front of the PCB.



You may need to push in firmly. To hold them in place whilst you solder, insert a IN-12 tube then flip over the PCB and solder the sockets from the back of the PCB. Solder with minimum solder – as soon as you see solder flow around the annulus, you can withdraw the solder and iron.





#### 4.4 Tube Test

Now comes a very exciting part of the assembly – the first tube test. Take your six Nixie Tubes and carefully insert into the sockets.

**Take care, as high voltage will now be generated. Do not touch the PCB when it is powered.**

Now power up. After a short delay, the tubes should light and all start counting from zero 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. 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. If no tubes light, check the 5V and HV test points with your multimeter, with the black probe on the GND test point. The 5V test point should measure 5.3V to 5.9V and the HV test point 165V to 178V.

Once the tube test is complete, remove the tubes until the PCB is fully assembled.

#### 4.5 ALM, DST LED (5mm Yellow LEDs) SYNC (5mm Green LED)

Solder the three LEDs as shown below. The longer LED Lead goes in the hole with a circle marking.

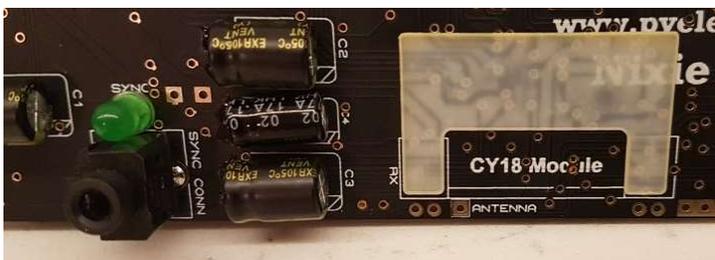


#### 4.6 Sync Conn (Vertical jack socket)

#### 4.7 Insulating Sheet

If you will not be using the CY18 Receiver module, you can omit steps 4.7 to 4.8.

Peel off the white paper backing and attach the insulation as shown below.



#### 4.8 CY18 Module and Connectors

Push the two connectors onto the end pins of the CY18 receiver Module.



Then position on the PCB. Press the black connectors level with the the PCB, and check alignment of the module before soldering the four pads. Then withdraw the CY18 module until later.



Finally, measure out exactly 17cm of the antenna wire cable, strip off 2mm from one end and solder to the ANTENNA Pad. This Antenna wire can be routed conveniently and neatly inside the final enclosure you make or buy.

#### 4.9 Piezo Buzzer (LS1) and Push Button Switches

Solder as shown below. If you prefer you can only solder the 2 pads for each switch that are closest to the PCB edge. The other 2 pads are not used. It could be handy in case you ever need to remove a switch.



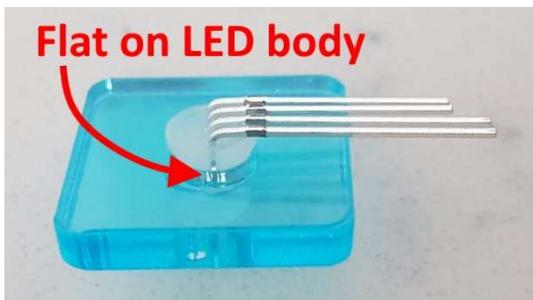
#### 4.10 C5 (0.22F)

Solder as shown below, noting the direction of the arrows on the part.



#### 4.10 RGB1 – RGB6 (APA106 RGB LED)

Using the large hole in the LED jig, bend the LED leads in two steps as shown below, noting the position of the flat on the LED body. The leads of the LED may have a different length configuration than shown below.



Then install the RGB LEDs from the back of the PCB, and solder from the front of the PCB. Clip off the excess leads.



Now solder the remaining RGB LEDs in the same way.

#### **4.12 AM1, AM2, PM1, PM2 (4mm neon lamp)**

Cut the clear heat shrink into eight lengths of 15mm and slip over the neons leads then shrink with a hot air gun.



The four neons can now be soldered onto the PCB.

**4.13** The Maestro is now complete. You can insert again the six tubes and move onto the next section, to learn how to configure and use it.

## 5. 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 display 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. 01:54:32	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 - Dimmed display (default)
7	Master Blank start hour <sup>1</sup>	0 - 23
8	Master Blank end hour <sup>1</sup>	0 - 23
9	Master Blank days <sup>1</sup>	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 <sup>2</sup>	As per parameter 10
12	Radio time signal source <sup>3</sup>	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) <sup>4</sup>
15	Radio time offset mins	0-45 (default 0) <sup>4</sup>
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 <sup>5</sup>	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) <sup>6</sup>
28	Night Mode Override minutes	0 - 50 (default 0 gives 15 seconds override) <sup>9</sup>
29	Thermometer Settings (requires CY18 module and XTERNA)	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 <sup>8</sup>

**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.

***Canceling Alarm:***

Press 'ALARM' briefly to cancel alarm and enter snooze mode, or a longer press until the clock beeps, 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.

***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.

## **6. XTERNA FUNCTIONS**

### **6.1 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.

### **6.2 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).

### **6.3 Configuring for XTERNA Reception**

Your Maestro Clock is 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.

#### 6.4 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.

#### 6.5 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.

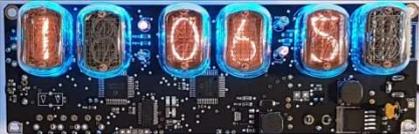
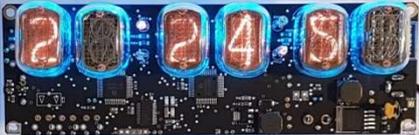
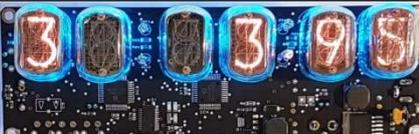
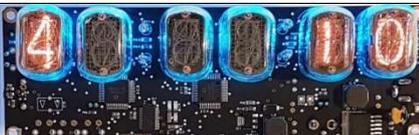
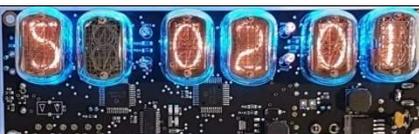
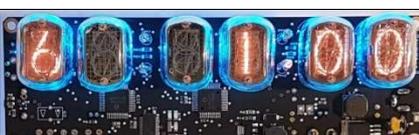


#### 6.6 Temperature Validity

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.

## 6.7 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	

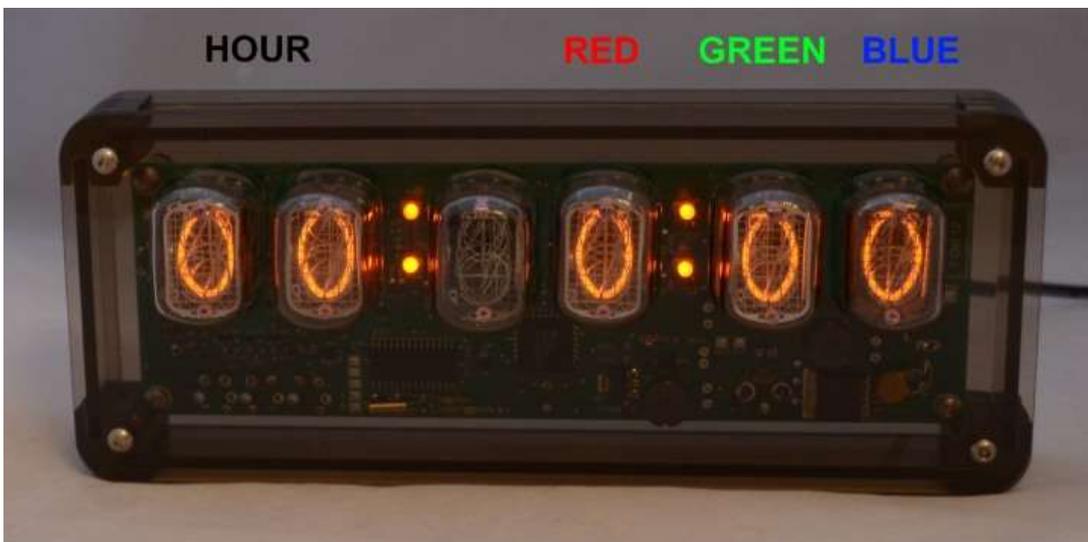
## 7. CONFIGURING THE RGB LED TUBE LIGHTS

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 a long power off.

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

### 7.1 Entering RGB LED menu

Press and hold the 'DST' button until the display shows: 00: 0:00. The first minutes tube will not be lit.



- For each hour (0-23), you can set a custom colour.
- Each custom colour can have your choice of **RED**, **GREEN** and **BLUE** values from 0 (colour off) to 8 (maximum brightness).
- Mix the colours using the **SET**, **ADJ**, **ALARM** 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 8 and 9 hours, the LEDs will be purple (8 red, 0 green and 8 blue).
- In the example below, between 19 and 20 hours, the LEDs will be blue with a hint of green (0 red, 2 green and 8 blue).



## 7.2 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.

## 8. USING A GPS RECEIVER

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

### 8.1 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.



SYNC LED will light when the clock has received recent GPS or XTERNA synchronisation data.