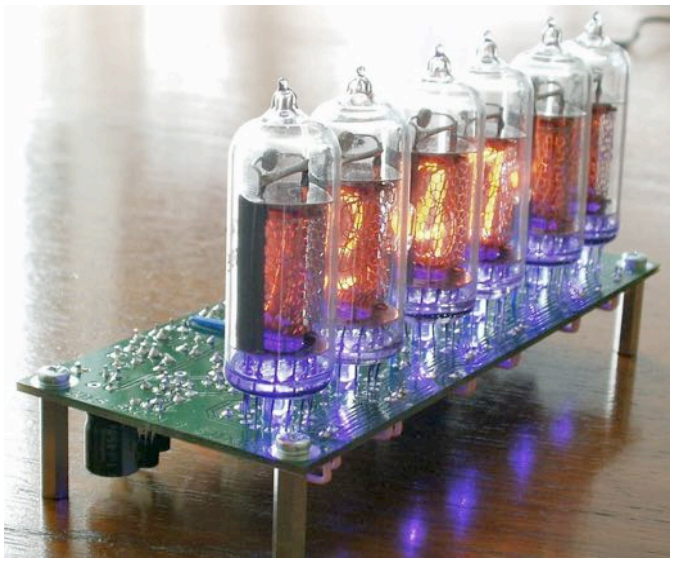
Six Digit Nixie Clock Kit (NIX6 V1.01)

User Manual



UNUSUAL ELECTRONICS

At this stage you should now have a complete clock, (housed in a case of your own design).

WARNING!

This unit generates a high voltage.

High voltages can cause serious injury or death!

Safe operation of this kit is the users responsibility.

This information is provided 'as is'.
No responsibility is accepted for any damage, injury or death as a result of using this kit.

The assembled unit must be properly en-cased to prevent contact with high voltages and kept out of reach of children.

Contents

1. Introduction

Thank you for purchasing this “UnusualElectronics.co.uk” Six digit Nixie Tube Kit.
This kit is unusual because it combines a modern Microcontroller with Nixie tubes from a bygone age electronics.
If you have any questions,comments or problems regarding this clock – please email :
support@unusualelectronics.co.uk
The website is at www.unusualelectronics.co.uk

History
Nixie tubes were believed to have been first introduced in 1954 by the Burroughs Corporation USA.
They were known by other manufacturer names such as “Numicator” - but “Nixie” soon became the most popular.
(“Nixie” is apparently an abbreviation of "Numeric Indicator eXperimental No. 1").

As technology progressed, Nixie tubes were gradually replaced by LED displays in the 1970s mainly because they did not need a high voltage to function.
Most Nixie factories phased-out production with the exception of Russia, where they continued making them until the early 1990s.

When nixies were in production, they were expensive items even then, and were mainly used in scientific and military equipment or early calculators.
Recent interest in their retro appearance has resulted in them being in demand by collectors and clock builders. Some very large or rare tubes can fetch ridiculous prices at auction.

The IN-14 tubes used in this clock were produced by the Russian Sovtec “Reflector” factory.
They are interesting because of their use of an upturned “2” for the digit “5” (saving on production costs).
Nixie tubes have a finite lifetime – it is lowest when they are driven to the manufacturers absolute maximum brightness specification – as was the case when they were intended for industrial use in brightly lit rooms.
However, this clock design drives them at a much lower brightness level and has various dimming and tube switch-off features intended to extend their lifetime.
It may considerably extend the expected lifetime of some nixies when used in clocks.

These tubes are still fairly easy to obtain in sets of 6 or more as “New Old Stock” (NOS) from on-line auction international sellers (ebay) – but as with all nixies, they become rarer and more expensive each year – you may wish to obtain a spare set just in-case any get broken or eventually wear-out.

2. Features

- The core of the clock is a Microchip PIC 16f876A 8-bit CMOS microcontroller ic. It is programmed entirely in assembly language code.
  It drives the nixie displays in a 2*3 line multiplex which provides fast display refresh,lower driver chip count and reduced power consumption.

- Normal clock timing is provided by the cpu crystal which can be finely adjusted using the pushbuttons and stored in EEPROM memory.
  Alternatively, the clock can derive timing from the 50 or 60Hz mains frequency (provided an AC power adaptor (Wall wart) is used).

- It has the option to connect to MSF (UK), DCF (Europe) GPS time receivers or a Windows PC to obtain accurate time and date updates. Or have the time increment under the control of an external 1pps time pulse. An “experimental” WWVB option is also provided – (see the time sources manual)

- The high voltage for driving the nixies is controlled and regulated directly by the microcontroller using Pulse Width Modulation. The voltage is continuously monitored and regulated. It can be finely adjusted if desired using the pushbuttons and stored in EEPROM memory – no need to fiddle with variable resistor controls.

- All clock option settings are easily adjusted using just two pushbuttons and are retained in the controller EEPROM memory during power-off.

- The clock is fully configurable with over 30 main options - scrolling date effects, digit crossfading, digit cycling, manual/timed and optically controlled dimming, Colon neon controls, AM/PM indication,12/24 hour mode, leading zero blanking etc. etc. You can even configure it to switch-over to a completely different saved configuration at the touch of a button!

- Selectable time zone – The clock can offset the time received from MSF/DCF or GPS sources by up to +- 14 hours.

- Has 6 bright tube illumination LEDS (Either Blue or optional UV (Purple) which can be dimmed along with the nixies and configured to be continually on/off or switch on or off during date display etc.

- Dimmable neons for colon display – these can be controlled in various ways to be on/off/flashing or indicate AM/PM.

- A “decimal point” type nixie AM/PM indicator which is configurable and dims.

- Because it is powered from a low voltage, It can be used worldwide (with appropriate adapter)

- Has a user re-settable tube hours usage counter.

- Configurations can be easily reset back to defaults should you wish to.

3. Controls

All settings are adjusted using two pushbuttons.
The **SET** button is usually pressed to allow settings to be changed.
Pressing or holding-down the **UP** button will count-up through the allowed values for each option.
In addition, the **UP** button can be pressed during normal time display to dim the display or toggle other user-selected clock settings if enabled.

4. Setting the Time and Date

Whenever the clock is switched-on, it runs a display diagnostic countdown then shows the default time of 12:00:00.

Press the SET button once during time display and the hours digits begin to flash. Now pressing or holding-down the UP button will count-up the hours.

The next press of the SET button will flash the minutes. As before, the UP button counts up the minutes.

Another press of the SET button will flash the far right pair of digits to show the YEAR and as before, the UP button counts them up (to 99).

The next press of the SET button shows the MONTH on the centre pair of digits.
Pressing UP will count-up the months.

Next the SET button shows the DAYs on the left pair of digits – pressing UP will count-up to the maximum number of days allowed for the month already set.

The final press of the SET button will then show the time and zero the seconds count if the time has been adjusted.

The date and time settings are not normally saved to eeprom memory – however, the current date is automatically saved along with the other settings whenever any normal clock configuration options are changed.

5. Manually Dimming the display

The UP button is configured by default to allow the clock display to be manually dimmed in steps from full to dim whenever it is pressed during normal time display.
An option to change the function of the UP button is described in the clock config section.

6. Changing the normal configuration options

The clock has 33 normal configuration options.
Configuration is retained in non-volatile memory during power-down

Whilst showing the time, enter the config mode as follows-

Press and hold-down the **SET** button for about 3 seconds, until the centre pair of digits blank, and the colons light.

The left pair of digits will flash the option number 01 and the right pair will show either 12 or 24 which is the value for option 01 (12/24 hour mode)

Now, each press of the **UP** button (or holding it pressed) will cycle-up through the available values for that option and pressing the **SET** button stores the setting and moves on to the next option until all 32 options have been accessed.

To avoid having to always step through all the options - you can hold the **SET** button pressed for over 3 seconds, then it will save any changed settings and exit back to normal time display.

Due to the large number of configuration options, it is a good idea to keep a printout of the option list handy.

On the following page is the list of the normal configuration options .

7. Configuration options list		(value in bold is the default)
Opt	***Description***	***Setting***
01	Set 12 or 24 Hour time	**12** or 24
02	Digit crossfading level (**0**=disabled)	**0** - 5
03	Date display every x seconds (**0**=disabled)	**00** - 60
04	Date display duration in seconds (**02** =default)	01 - 10
05	Date scrolling effects (left & right, combined, random) (**0**=disabled)	**0** - 5
06	Date display format (**0**=UK, 1=US, 2=World)	**0** - 2
07	Colon neons **0**=OFF, 1=ON, 2=Blink_Fast, 3=Blink_Slow,4=AM, 5=PM	**0** - 5
08	Colons maximum brightness (**01**=full brightness)	**01** - 20
09	Colons action during Date display (**0**=off,1=on,2= as option 7)	**0** - 2
10	Nixie Tube AM/PM indicator (**0**=off, 1=AM, 2=PM)	**0** - 2
11	Leading zero blanking **0**=disabled 1=12hour, 2=24hour, 3=both	**0** - 3
12	Maximum Nixie brightness 2=dim **5**=full brightness	2 - **5**
13	Light sensor autodim. **0**=disabled,1=dimming only 2=display turn-off 3=both	**0** - 3
14	Light sensor threshold. **40**=default, 41-99=brighter. 39-01=dimmer	01 - 99
15	Timed Dim mode (**0**=disabled, 1=enabled)	**0** -1
16	Timed Dim start hour (24 hour time) (**23**=Default)	00 – **23**
17	Timed Dim end hour (24 hour time) (**07**=Default)	00 – 23
18	Timed dim brightness level (**0**=display off, 4=brightness level 4)	**0** - 4
19	External Time source (**0**=MSF, 1=DCF, 2=GPS/PC ,3=1PPS, 4=WWVB)	**0** - 4
20	Time zone GMT(UTC) offset **0**=Minus, 1=Plus	**0** - 1
21	Time zone GMT(UTC) number of hours offset	**00** - 14
22	Internal clock frequency correction (**0**=Slower, 1=Faster)	**0** - 1
23	Internal clock frequency correction value (**00**=no adjustment)	**00** - 99
24	Mains AC sync Auto or disabled **0**=Auto, 1=Disabled	**0** - 1
25	Digit cycling mode (Tube life enhancer) **0**=disabled	**0** - 9
26	Digit cycling speed 0=Random (**03**=default, 10 is slowest)	00 - 10
27	Digit cycling intervals 0=every min,1=every 15mins,2=every hour,3=midnight for 5mins,4=midnight for 58mins	**0** - 4
28	Tube LEDS mode **0**=off,1=on-dimmable,2=am,3=pm,4=full-on	**0** - 4
29	Tube LEDS action during date **0**=off, 1=on, 2=no change	**0** - 1
30	GPS/WWVB mode DST **0**=disabled, 1= GPS+1hour,2=WWVB off	**0** - 2
31	**UP** button action **0**=dim,1=dim&blank,2=date,3=crossfade,4=12/24,5=toggle alternate clock settings	**0** - 4
32	Save current settings as alternate settings **0**=disabled 1=save	**0** -1
33	Turn off Status LEDs **0**=Normal, 1=Red off,2=Green off,3=Both off	**0** - 3

8. Some Configuration options explained

Option 2 – Digit crossfading

This option creates a pleasant blending between digits as they change.
Setting it to a higher number increases the crossfading delay.
A setting of 3 provides a good effect at all display brightness levels.

Option 5 – Date scrolling effects

If date display has been enabled using options 3&4 then this option will provide a choice of four date scrolling effects. Setting “5” chooses one of the 4 available scroll effects at random on each date display.

Option 7 – 8 Colon Neons

The neons can be set to be always off,on, flash at 1 flash/sec,0.5 flash/sec or indicate AM/PM. Maximum brightness can be adjusted with option 8.
(Some neons may flicker when new. If this happens, reduce the brightness slightly)

Options 13, 14 – Light sensor controlled dimming

Option 13 – enables light level controlled dimming/display turn-off
The setting determines whether the display just dims, turns off completely or dims before turning off.
Option 14 - sets the light level threshold for the display to either turn-off or dim to the lowest level (depending on setting in option 13). A lower number means darker.
To assist in determining this setting value, you can measure the current light level by using the “system information” option 4.
The light sensor control checks many successive light samples and uses hysteresis to minimise false changes to the display brightness.

Options 15 – 18 Timed-dim settings

These settings enable dimming or turning-off the display during the time between the start and stop hours (in 24 hour time)
Note – If the display is turned-off during timed-dim or light sensor controlled dim, it automatically turns on again for a period of 1 minute if a pushbutton is pressed.

Options 19 External time source

If you are using DCF,GPS, PC ,1pps time pulse or WWVB then change this setting as appropriate.
Details on using external time sources are explained in a separate “Time sources” manual.

Options 20,21 Time zone offset settings

These settings only affect the time received from MSF/DCF/GPS/ PC or WWVB time source devices.
After changing a time zone offset setting, it takes affect the during the next time update received from the device.
Note. This clock automatically converts the DCF German time zone time transmissions to GMT (UTC), so European users need to configure their time zone offset here.
MSF,GPS and WWVB use the GMT (UTC) time zone.
PC sync should not need any setting here as the time zone is normally set on the PC.

Options 22,23 Internal Clock frequency correction.

If you use the internal crystal clock oscillator for timekeeping, you can finely adjust the frequency for better accuracy. (between +/- 99ppm (parts per million))
To do this, set the time according to an accurate clock, then check how many seconds are gained or lost over 24 or 48 hours.
Divide the number of seconds error by 0.0864 (for 24 hours) or 0.1728 (for 48 hours) to the nearest unit to give the approximate value to be set in option 23. You may need to make further fine adjustments.
In theory this provides a resolution of up to 1ppm frequency adjustment, which is equivalent to +/- 2.5 seconds per month. In reality it can not be that accurate because crystal oscillators suffer some frequency drift with temperature and crystal ageing.
A stable room temperature will improve timekeeping although the frequency change with crystal age may be +/- several ppm each year.

Option 24 Mains AC sync Auto/disabled

Use this option if you wish to switch-off the AC 50 or 60Hz mains frequency timekeeping when using an AC power adapter.
This may be required if your electricity supply company fails to maintain the mains frequency accurately enough.
Note. The Mains frequency may decrease during the day when power consumption is higher and then increase at night – the overall effect can result in reasonable timekeeping on average.
(Option 24 automatically defaults to “1” (disabled) when using a DC supply adapter)

Options 25 - 27 Digit Cycling modes

A characteristic of all Nixie tubes is that they suffer from “Cathode Poisoning”
This is due to a build-up of contamination deposits on unused digits.
If a digit is not used for some time, it never burns-off cross-contamination deposited from the working digits.
This results in the unused digit becoming “unusable” and **tube life is also reduced**.
It can be a problem with clocks as some digits are never or rarely used – except when accessing the config menu for example.
It is advisable to configure digit cycling regularly and occasionally set the option for a long run at midnight. (long run setting 4 over-rides any display blanking settings)
The digit cycling modes can also make an interesting feature for the clock display.

Option 30 GPS /WWVB DST mode

This setting allows the GPS derived UTC time to be manually adjusted by + 1 hour to account for the time difference in DST or BST (British Summer Time).
After changing this setting, the GPS time is acquired in order to take effect.
This option has no effect on MSF or DCF time reception as they automatically adjust to DST correctly.
Setting to “2” is for switching-off DST for **WWVB receivers** only – some USA states do not use DST
Due to the Worldwide variation in DST implementation a fully automatic adjustment facility for GPS or standalone internal clock time is not currently provided.

Option 31 – UP button action

By default, pressing the UP button during time display allows the display brightness to be adjusted in 5 levels.
This option allows the UP button function to be changed.
It can be set to instead allow display dimming and turn-off, Showing the date, Switching on/off digit crossfade, switching between 12/24 hour mode or toggling between all the current clock settings and a completely separate “alternate” settings which you have saved using option 32. You could for example switch between a very basic clock configuration and one that has many options enabled. (Use it to change between two completely different personal configuration preferences).

Option 32 – Save current settings as alternate settings

This option saves a second complete clock settings configuration.
To use it – configure the clock as normal with your **first** configuration and exit back to the time.
Then go back into configuration mode and set each required option setting for the **second** clock configuration one-by-one as normal – but **without exiting back to the time yet.**
Set option 31 to “5” (to enable the UP button settings toggle).
Then set option 32 to “1” and then exit back to the time.
You should now find that pressing the UP button switches the clock between the two different configurations.
Each clock configuration can then be independently modified and saved.
Note. The Date and Time and “tube hours counters” are common to both configurations.

Option 33 – Turn off status LEDs

Use this option to turn-off the Red,Green or both status LEDs if their flashing action is visible enough to cause annoyance. (it does not affect the power-on test status indication.)

9. Special System Config Options

These are special options which are only intended to be accessed occasionally and are protected from accidental access during normal clock use.

To access these config options, the **SET** button is held pressed whilst applying power to the clock.
These special options are numbered backwards from 99 to 96

The display will now show the first option (Option 99).
The value for each option can be adjusted using the **UP** button just as was done on the normal config.

Opt	*Description*	*Setting*
99	High Voltage Adjustment +/- **0**=Minus, 1= Plus	**0** - 1
98	High Voltage Offset value (**00**=Default) Allows adjustment in 1.4v increments between 159v and 201v	**00**-15
97	Reset tube usage hours counter (1=Reset)	**0** - 1
96	Reset clock settings to defaults (1=Reset)	**0** - 1
95	Reduce HV load monitor sensitivity **0**=default, 1=low, 2=turned off	**0** - 2

Options 99 ,98 – High voltage adjustments

The High Voltage for the nixies is set to 180 Volts in the microcontroller software.
It is sampled by an analogue – digital converter at a much lower voltage via a resistor potential divider network. The resistors have a 1% value tolerance – so the voltage should be fairly close by default – but here you can adjust it if you wish.
You will need to measure the voltage with a multimeter to confirm it is correct.
There is no advantage to setting it above 180v and the microcontroller will trigger software over-voltage or overload protection at around 200V.

Option 97 – Reset Tube usage hours counter.
The clock records tube-lit hours and backs-up the counter to eeprom memory every 4 hours whilst the tubes are lit.
You may wish to reset this counter if you replace the tubes.

Option 96 – Reset clock settings to defaults
If for any reason you need to reset all the configuration settings back to “as-new” defaults – it can be done here. (It does not reset the Tube usage counter).

Option 95 – Reduce HV load monitor sensitivity
The High Voltage generator is normally monitored for high loading (default setting=0)
This option should only be changed if you suffer from frequent mains power supply gliches which could trigger the overload monitor to turn off the clock HV supply.
Setting it to “1” makes it less sensitive to power supply glitches.
Setting it to “2” turns off the HV load monitor completely (although the HV low voltage monitor is still functional).

10. Viewing System Information

Some system information can be viewed by holding down the **SET** button for over 6 seconds whilst in normal time display mode.

The display will then blank and then show the first information – the 6 digit tube hours usage counter.
A second press of the **SET** button will blank the display then show a number 02 followed one second later by the 6 digit clock firmware number.

A third press of the **SET** button blanks the display, followed by the number 03 and then one second later shows the 2 digit number of GPS satellites last detected during time reception from a GPS module sending a GGA NMEA sentence if available. (otherwise it will just show 00).

The fourth press of the **SET** button displays a real-time, three digit indication of the light level detected by the opto-sensor. (For positioning the sensor and determining opto-dim settings).

11. Voltage generator monitoring information

The clock generates a voltage of approx 180v DC to drive the Nixie tubes.
Many Nixie clock designs use a dedicated chip for this function – requiring adjustment by a fiddly variable resistor.
This design does away with that, allowing much more control, built-in regulation and constant monitoring for any abnormal conditions.
At power-on, the voltage is gradually increased whilst monitoring it for any problems.
If a problem is detected, then the Red LED and Tube LEDs flash to indicate an error –

The LEDs indicate the following possible problems.

1. Red stays on, Green goes off – No initial voltage detected in HV circuit (should be same as the supply voltage). - check L1,D11 polarity, and R30,31 values.

2. Red and Tube LEDs flash at 1 second intervals, Green goes off – As the HV level is increased, the HV reading is below the required level – check R30,31 values, check all other components in HV section. Check for short circuits.
   Also check your “Wall-Wart” power adaptor is providing enough voltage (the clock works best with around 12 Volts input if using a DC adaptor. (a 9V rated AC adaptor should be OK)

3. Red and Tube LEDs flash rapidly, Green goes off - As the HV level is increased, the HV reading is Above the required level. - check R30,31 values.

Once the clock is running normally (has completed the digits countdown at startup), the monitoring continues – looking for under-voltage or over-load conditions.
The following error conditions result in flashing LEDs and HV shut-off

1. Red and Tube LEDs flash at 1 second intervals, Green goes off – the HV has dropped below the normal working level.

This can happen if something partially shorted the HV output for example, or the power supply to the clock was interrupted (poor mains supply - dropouts).

2. Red and Tube LEDs flash rapidly, Green goes off - Indicates a possible over-load condition, the HV regulator was working at sustained high power to achieve the required voltage.
   This can happen if the “Wall-Wart” power adaptor voltage is too low, causing the HV generator to have to work hard.
   Also could be due to poor mains supply voltage glitches or dropouts.

These two problem conditions cause the clock to shut-down the HV and require the clock power supply to be turned-off before it can be used again.
If you suffer from frequent mains power dropouts, then you can reduce the sensitivity of the monitor – using “Special system option” 95 (see section 9)

12. Specifications

Power supply adapter requirements:
9-12V AC 50-60Hz or 12V DC adapter rated at 500mA or better.

Power consumption:
@12V DC supply approx 210mA (~2-3Watts) with all tubes and LEDs on.
Minimum consumption: 60mA (~1Watt) with all tubes and LEDS off.

Dimensions:
PCB only - 150mm X 60mm X 1.8mm (5.9” X 2.4” X 0.07”)
Component clearance required under PCB - 20mm (0.79”)
Total height including tubes and pcb mountings - 80mm (3.15”) Approx.

Timekeeping Accuracy:
Standalone crystal timekeeping: Adjustable to within +/- 1 second per day at room temp. (Crystal frequency drifts with temperature changes and crystal age)
Mains synchronisation: Dependant on your electricity supplier.
MSF/DCF/GPS sync: Within +/- 1 second or better providing the clock re-syncs often.
PC sync: Dependant on the accuracy of your PC clock.

Weight: (no case)
Approx 150 grams (0.33 pounds)

Nixie Tube Life:
No manufacturer info on IN-14 lifetime is available as they are no-longer made.
Generic Nixie lifetime can be anywhere between 5000 and 15000 hours depending on the Nixie construction, Manufacturer and how they are used.
Nixie lifetime is shortened by “Cathode Poisoning” of unused digits – please use the digit cycling feature regularly.