Neonixie 6 Digit Nixie Clock Controller – Introduction and Assembly

Thank you for purchasing our 6 Digit Nixie Clock Controller. Our clock controller is user friendly and has many of the features most requested in a nixie clock:

- **User selectable 12/24 Hour mode**
- **Digit cross fade option with adjustable fade duration.**
- **Date display with adjustable format, duration and display interval.**
- **Scrolling time and date display with adjustable speeds.**
- **Automatic daylight savings time correction, user adjustable for most all locations.**
- **Blinking colons are user adjustable, 9 different modes including AM/PM indication.**
- **Digit cycling with many different display modes, prevents cathode poisoning of unused digits.**
- **Cathode poisoning prevention routines, used to preserve operation of unused digits.**
- **Power failure backup, using optional memory backup capacitor.**
- **PWM brightness control, in 10 steps, 10-100%.**
- **Timed dimming of tubes, used to dim or turn off tubes at certain times (weekday aware).**
- **Software adjustable crystal, optional highly accurate TCXO.**

ASSEMBLY

We highly recommend you read through the assembly instructions entirely before beginning assembly.
This will help familiarize you with the clock controller and will give you an understanding of the features that affect the layout of the controller.

If you have any questions during the assembly of your clock, please contact us at nixietubes@neonixie.com
We are always glad to help!

You might have noticed in the schematic that each set of BCD outputs has two digits noted, for example if you look at the lower left hand corner of the schematic (pins 23-26) you will see that both “Sec Ones” and “(Hour Tens)” is mentioned. The clock controller has two output modes. The default mode is to output the digits that are not in parenthesis. Setting option number 52 to enable (1) will change the clock to output alternate digits, which are noted in parenthesis().

Why is this option needed? Turn the schematic upside down and imagine that you are building a nixie clock with side view tubes. The sheet of paper would be your PC Board. If your side view tubes were installed on the PC board directly and pointing up, then the default output mode is correct with the hours on the left and seconds on the right.
Now turn the schematic back to normal and imagine TOP view tubes installed directly onto PC board pointing up towards you. If the default output mode were used, this would result in an incorrect display with ones of seconds on the left and tens of hours on the right. You could wire your clock to account for this, but you would end up with a lot of crossed wires. The digit swap option (#52) is provided for this reason and results in a cleaner layout and easier wiring.

If you will be using the alternate digits you will need to initially set option 52 to enable (1). Note: Option 52 will be initially displayed as “00:00:25” since the digits are swapped, as soon as the option is changed by pressing the Advance button the display will be correct. This setting is stored in EEPROM permanently (or until reset by the user).
It is recommended that you highlight the digits that you will be using to avoid possible confusion during assembly.

There are two other features that help the wiring of your clock to be as compact as possible. One is that a BCD output of ADBC is used, this is done to match the 74141 driver IC inputs in order to avoid cross wiring. The second is the outputs located on the bottom half of the controller. The wires are crossed in the schematic, but if the wires are routed below the controller (instead of leading away from it as in the schematic) the wires will not cross each other.

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ASSEMBLY (continued)

DIGIT BLANKING

By default the controller 'blanks' digits by outputting all ones on the BCD lines. Blanking is required for PWM dimming, leading zero blanking and cross-fading to work properly. This default setting works well with 74141 Nixie Driver ICs, but if you are using other display drivers you might want to review the Digit Blanking option (#53). For example if you are using the controller as a simple LED binary clock, you would want to set this option to either 3 or 4. This will result in a low output on the BCD lines during dimming, correct for individual LEDs. A separate blanking output pin is also provided (pin 27), which can be used for dimming display drivers with separate blanking inputs. It can be set for low or high blanking.

NOTE: If using the blanking output pin of the controller wired to all the displays, the clock will not cross-fade or blank a leading zero properly since each digit needs its own blanking output. A simple solution is to hook up a NAND gate (for drivers with low blanking inputs) or a AND gate (for drivers with high blanking inputs) to the C and D connection of each BCD output (with BCD blanking set to high). Run the output of the gate to the digits blanking input. This works because BCD C and D will only be high when the controller commands a blank digit.

NOTE: If you will be using the blanking pin, it is recommended to install a 3-way jumper in order to disconnect the drivers from the blanking output and connect them to a logic level that will result in an active display. This can be used in case the digit blanking option is accidentally modified to blank the display.

Follow the provided schematic to assemble your nixie clock. Items to note during assembly:

- R13 is the power fail sense resistor. This resistor is **required** even if a capacitor is not used for backup (C1).
- Install C2 (.1uf bypass capacitor) as close as possible to either Vcc pin on the controller.
- A user supplied backup capacitor (C2) can be optionally installed to provide backup in case of a power failure. A 1 farad capacitor will provide approximately 8 hours of backup time, a 0.33 farad approximately 2.5 hours. These figures are quoted for a clock using the optional TCXO, times are doubled when using a watch crystal.
- If a backup capacitor is used (C1) we recommend a 1N5817 Schottky Diode for D1.
- If a backup capacitor (C1) is not used, omit D1 and wire +5v directly to both Vcc pins on the controller and Vcc on the DS32KHZ TCXO (if used).
- If a regular watch crystal is used, we recommend using a crystal with a 12.5pf load capacitance, solder directly to controller pins. There is no need to add external capacitors; internal capacitors are present in the controller.
- Keep high frequency switching sources, such as switching supplies, away from the XTAL input pins.
- The default software time correction is tuned for the DS32KHZ TCXO, if using a regular watch crystal we recommend an initial value of +20 to +25. This will vary with different crystals and mounting methods. Please note this value will revert to factory default if the user manually resets the EEPROM.
- R1 to R6 are the nixie tube anode resistors. Adjust to your particular nixie tubes.
- R7 and R8 are anode resistors for the neon bulbs. Adjust to your particular bulbs.
- If you use a linear regulator for your 5v power supply, take note that each 74141 consumes about 20ma of current. This results in 120ma of current for the drivers only. Depending on your input voltage, the regulator might require heat sinking. Current consumption of the controller itself is small (about 10ma).
- Current sourced or sinked from outputs should not exceed 15ma per pin.

Neonixie 6 Digit Nixie Clock Controller – Operation and Detailed Options

OPERATION

Once powered up the clock will go through a short lamp test routine and will start with a time of 12:00 PM in 12 hour mode. The clock is adjusted using two buttons, Set and Advance.

SETTING THE TIME

Hold down the Set button for a few seconds, the hours or minutes will start to blink. You are now in the time set mode. Pressing the Set button chooses between hours, minutes, and the date. Pressing the Advance button will increment the blinking value. Holding down the Advance button for a few seconds will quickly advance the value. Note that there is no sanity checking for the date when entered by the user, this is done to facilitate easier date adjustment, but allows the user to enter invalid dates.

When adjusting minutes, the clock will reset the seconds counter to 0 at each increment. Seconds are not reset when adjusting hours.

The clock will return to normal operation if no buttons are pressed for a few seconds.

SETTING USER OPTIONS

Many user options are available. These options are stored in non-volatile EEPROM and will be maintained even after a power outage or long term storage of the clock.

The clock options menu can be accessed by holding down both SET and ADVANCE buttons for a few seconds. Release the buttons when the display reads all zeros.

The current option number being adjusted is displayed on the hour digits, the left most nixie tubes. The option value is displayed on the right most tubes. The Set button is used to change the option, and the Advance button is used to modify the option value.

You can clear the EEPROM to its factory defaults by resetting the clock while holding down both Set and Advance buttons. The clock will blink the display with zeros to indicate the EEPROM is being reset.

For values with large ranges, the Advance button will alternate between incrementing and decrementing the value upon each press/release. Options with just a few values will increment on each press and upon reaching the last value will reset back to the first.

● Option #1: 12/24 Hour mode.
Selects between 12 or 24 hour modes.
- 12 hour mode (default)
- 24 hour mode

● Option #2: Leading zero blanking.
Enabling this option will blank the leading 0 of the hours.
- 0: Disabled (default)
- 1: Enabled

● Option #3: Digit Crossfading.
Enabling this option will cause digit changes to cross-fade.

- 0: Disabled (default)
- 1: Enabled

● Option #4: Digit Crossfading duration.
Controls the speed at which digit crossfading occurs.

- 0-10: 0=fast fade, 10=slow fade (default 3)

● Option #5: Blinking Colons.
Controls the operation of the neon colon separators.

- 0: Colons always off
- 1: Colons always on
- 2: Blink at ½ Hz (default)
- 3: Blink at 1 Hz
- 4: Wink (25% duty cycle) at ½ Hz
- 5: Wink (25% duty cycle) at 1 Hz
- 6: Wink (75% duty cycle) at ½ Hz
- 7: Wink (75% duty cycle) at 1 Hz
- 8: AM/PM Indicator, AM=colons on
- 9: AM/PM Indicator, PM=colons on

● Option #6: Blinking colons during date display.
Controls the blinking colons during date display.

- 0: As specified by option #5 (default)
- 1: Always off
- 2: Always on

● Option #7: Date format.
Controls the display format of the date.

- 1: Month – Day – Year (default)
- 2: Year – Month – Day
- 3: Day – Year – Month

● Option #8: Date display, every x seconds.
Controls the frequency of the date display, in increments of 10.
40 and 50 are special in that they do not cause the date to be displayed every 40 or 50 seconds, but every minute at 40 and 50 seconds. This is provided to enable the date display every minute, but move it to a time that doesn't interfere with other options, such as the digit cycling or slot machine effect.

- 0-60 seconds (0 disable, default).

● Option #9: Date display duration.
Controls the duration that the date display is active.

- 1-10 seconds (default 2).

● Option #10: Digit Cycling.
This option, in addition to providing an interesting display, is used to prevent cathode poisoning of digits not used in the normal operation of a clock. It will cycle all the digits at a predefined time.

The slot settings are an interesting digit cycle mode, similar to a slot machine. If enabled, the clock will cycle in this mode for the first 14 seconds of each minute. The stop sequence of the 'slot machine' can be controlled by Option #11.

- 0: No cycling takes place (Default value).
- 1: Cycles at midnight.
- 2: Cycles at the top of every hour.
- 3: Slots, every minute, random digit cycling
- 4: Slots, every minute, incremental digit cycling
- 5: Slots, every minute, wave cycling
- 6: Slots, every minute, peek-a-boo

● Option #11: Slot stop.
This option controls the method of stopping the slot cycling if enabled.

- 1: Left to right (default).
- 2: Right to left.
- 3: All at once.
- 4: Random.

● Option #12: Slot speed.
Controls the speed of slot machine effect.

- 0-104: 0 slowest, 100 fastest (default 97)
- 101: Start fast, slow down with blur
- 102: Start fast, slow down without blur
- 103: Start slow, go faster with blur
- 104: Start slow, go faster without blur

● Option #13: Default brightness.
This controls the default brightness of the clock.

- 10 to 100% in 10 percent increments (default 100%).

● Option #14: Scrolling display.
Optional scrolling of the time and date (date, if enabled by option #8).

- 0: Disabled (default)
- 1: Enable (HHMMSS)
- 2: Enable (HHMM)
- 3: Enable date display only

● Option #15: Scrolling speed.
Controls the speed of the scrolling display.

- 1-30: 1 slow... 30 fast (default 22)

● Option #16: Cathode Poisoning Prevention.
Used to turn on and off the Cathode Poisoning Prevention option of the clock, used in conjunction with options 17 and 18.

- 0: Disable (default).
- 1: Enable.
- 2: Enable, override brightness setting, run at 100%
- 3: Enable, override brightness setting, run at 50%

● Option #17: Cathode Poisoning Prevention, Start Hour.
Specifies the start hour of the Cathode Poisoning Prevention feature.
- 0-23, in 24 hour time format (default 3).

● Option #18: Cathode Poisoning Prevention, Duration.
Specifies the duration in hours for the Cathode Poisoning Prevention feature.
- 1-24 hours (default 1).

● Option #19: Current day of the week.
This option is used to specify the current day of the week. This option is required for proper operation of the timed dimming (if a weekday is selected) and for Daylight Saving Time correction (if the day option is used to specify a weekday as opposed to day of the month).
Set this option after adjusting the date.
- 1:Sunday, 2:Monday, 3:Tuesday, 4:Wednesday, 5:Thrusday, 6:Friday, 7:Saturday

● Option #20: Timed Dim #1, Brightness
This is the first of 4 distinct timed dimming options. There are 5 user adjustable options for each timed dim. This one controls the brightness level.
- 0-100: (in percent brightness, default 50%), 0 will cause the display to turn off

● Option #21: Timed Dim #1, Start day.
This option controls the start day of timed dim #1. Note, if this option is other then 0, make sure to set the current weekday in option #19.
- 0: All days (default)
- 1:Sunday, 2:Monday, 3:Tuesday, 4:Wednesday, 5:Thrusday, 6:Friday, 7:Saturday

● Option #22: Timed Dim #1, Duration in days.
This option control the duration, in days, that timed dim #1 is in effect.
This option has no effect is the Start day is set to 0 (all days).
- 1-7: Default 7

● Option #23: Timed Dim #1, Start Hour.
This controls the hour when timed dim #1 is activated. Formatted in 24 hour mode.
- 0-23: default 0

● Option #24: Timed Dim #1, Duration in hours.
This controls the duration that timed dim #1 is in effect.
- 0-24: default 0 (off)

All other Timed Dim functions below are similar to the ones listed above. These are separate distinct dimming options, if more then one option is enabled, and they overlap, priority will be given to the lowest numbered option, ie #1, then #2, etc..

● Option #25: Timed Dim #2, Brightness.
● Option #26: Timed Dim #2, Start day.
● Option #27: Timed Dim #2, Duration in days.
● Option #28: Timed Dim #2, Start hour.
● Option #29: Timed Dim #2, Duration in hours.

● Option #30: Timed Dim #3, Brightness.
● Option #31: Timed Dim #3, Start day.
● Option #32: Timed Dim #3, Duration in days.
● Option #33: Timed Dim #3, Start hour.
● Option #34: Timed Dim #3, Duration in hours.

● Option #35: Timed Dim #4, Brightness.
● Option #36: Timed Dim #4, Start day.
● Option #37: Timed Dim #4, Duration in days.
● Option #38: Timed Dim #4, Start hour.
● Option #39: Timed Dim #4, Duration in hours.

● Option #40: Daylight Saving Time.
This option, along with options 42-49, controls the automatic Daylight Saving Time correction.
- 0: Disabled (default)
- 1: Enable

● Option #41: Daylight Saving Time, Current Status.
This option is used to indicate if Daylight Saving Time is currently in effect (Summer time), or not in effect (Winter time). It must be set to the correct current value for Daylight Saving Time correction to operate properly.
- 0: Winter time, Daylight Saving Time not in effect.
- 1: Summer time, Daylight Saving Time in effect.

● Option #42: Daylight Saving Time, Spring ahead hour.
This option specifies the hour (in 24 hour mode) that Daylight Saving Time takes effect during the Spring and the clock is moved forward 1 hour.
- 0-23: (default 2)

● Option #43: Daylight Saving Time, Spring ahead day.
This option specifies the day that Daylight Savings Time takes effect.
If Option #44 is set to 0, this option refers to the day of the month in which the adjustment takes place. If Option #44 is set to any value other then 0, this option refers to the Day of the Week in which the correction takes place (ie, 1=Sunday,2= Monday, 3=Tuesday...).
If this option refers to the day of the week, you must make sure the current day of the week (option #19) is properly set.
- 1-31: (default 1)

● Option #44: Daylight Saving Time, Spring ahead week.
This option specifies the week in which the adjustment is made. 0 and 5 are special cases. 0 is used where we do not want to refer to a particular week, but to a particular day of the month in which we want the adjustment made (refer to Option #43). A value of 5 also has special meaning in that it refers to the last week of the month.
- 0-5: (default 1)

● Option #45: Daylight Saving Time, Spring ahead month.
This option specifies the Month in which the Spring time adjustment is made.
- 1-12: (default 4=April)

● Option #46: Daylight Saving Time, Fall back hour.
Fall back hour when clocks are adjusted back to Standard Time.
This option, as well as #47, 48 and 49, behave like the Spring Daylight Saving Time options, but are used for the Fall return to Standard Time.
Refer to the Spring Time correction options for further information.

● Option #47: Daylight Saving Time, Fall back day.
Refer to the Spring Time correction options for further information.

● Option #48: Daylight Saving Time, Fall back week.
Refer to the Spring Time correction options for further information.

● Option #49: Daylight Saving Time, Fall back month.
Refer to the Spring Time correction options for further information.

● Option #50: Software time correction.
This option can have a value from -99.99 to +99.99. Negative values are indicated by lighting the left colon indicator. Use the Advance button to adjust this value. DO NOT adjust this value without taking proper measurements.

- -99.99 to +99.99 (default -2.57)

● Option #51: PWM Frequency.
This option is used to adjust the PWM frequency that is used during dimming and cross fading. There are several instances where the user will want to change this value. If the cross fading duration is increased to a high value, the refresh rate should be increased in order to avoid flickering. A setting of 5 is recommended for high cross fading durations. Be aware that a very high refresh rate will cause the display to be dimmer then indicated by the brightness setting, this is due to the fact that nixie tubes have a relatively slow turn on time. This option can also be used to quiet 'singing' tubes, this usually occurs when PWM dimming and cross fading are active simultaneously, and can be remedied by changing the PWM frequency up or down by a few steps.
This option has little effect if brightness is at 100%.

- 3-20 (default 9)
- 3: high refresh rate, ~1400 Hz
- 9: medium refresh rate, ~600 Hz
- 20: low refresh rate, ~300 Hz

● Option #52: Digit Swap.
Swaps certain digits for easier PCB wiring. See assembly instructions for details.
- 0: Disable (default)
- 1: Enable

● Option #53: Digit Blanking Method.
Controls the digit blanking method and blanking output pin (#27). See assembly instructions for details.
NOTE: This option refers to the logic levels used to BLANK (or turn off) the display.
- 1: BCD all high, BLANK pin high
- 2: BCD all high, BLANK pin low (default)
- 3: BCD all low, BLANK pin high
- 4: BCD all low, BLANK pin low

NOTES ON SOFTWARE TIME CORRECTION

The software time correction value entered by the user refers to the number of seconds per week of correction. For example, if the clock is slow 14 seconds per week, a value of +14 entered into the software correction option will compensate for this drift.

Software time correction is preferred over physically adjusting the crystals load capacitance, since adjustment can be done with no tools by the end user. Software time correction also allows the user to easily compensate for crystal aging.

Regular watch crystal: When taking measurements to find the proper correction value, remember that average temperature plays a large role in the clocks accuracy. A clock corrected to operate precisely at an average temperature of 50 degrees, will drift slightly if operated at 80 degrees, and vice-versa.

The optional TCXO (Temperature Compensated Crystal Oscillator) that serves as the timebase is very accurate. Its frequency is highly stable even during large temperature swings. Adjustment should only be needed after several years of operation to compensate for crystal aging.

When taking time readings for software correction, be sure to use an accurate source. Accurate sources include an atomic clock that has recently synced, a PC that is synced to a time server, or a GPS receiver.

If possible, it is recommended that laboratory grade measuring equipment be used to adjust the clock. Measurements can be taking from the micro-controller output pin that controls the blinking colons, which can be setup for ½ or 1 Hz output. Also remember that the optional TCXO is accurate to approximately 2ppm, any timing instrument you utilize should approach or surpass this level of accuracy in order to provide an accurate correction reading.

If accurate measuring instruments are not available, you can set the clock to a accurate source and take a reading of its drift at a later time. The more time you allow to pass, the greater the accuracy of a manual drift reading will be. It is recommended that you allow at least several weeks to pass before a manual reading is relied upon for correction purposes.

The clock is shipped with a default value of -2.57 seconds. This value has been tested with the current batch of TCXOs used for this controller and was found to be the optimum initial correction value.

IF YOU WILL BE USING A REGULAR WATCH CRYSTAL PLEASE ADJUST THE TIME CORRECTION VALUE. Correction values of +20 to +25 are recommended if you will be using a watch crystal. Timing will vary depending on your particular crystal and mounting variations.

NOTES ON DISPLAY PRECEDENCE

Since many display options can be enabled simultaneously by the user, the display must give precedence to certain options to prevent conflicts. Listed below is the display precedence, from highest to lowest.

- Time Setting menu, or Options menu.
- Cathode Poisoning Prevention, with brightness override
- Timed Dimming of Display
- Cathode Poisoning Prevention, no brightness override
- Digit Cycling (slots, etc).
- Scrolling Display

Example 1: If you have set the timed dim option to turn off all tubes, you can still access the options/time set menu since it has a higher precedence.

Example 2: Digit cycling and Cathode Poisoning Prevention are both enabled, the Cathode Poisoning Prevention will get precedence once it's run time is reached, and will override the digit cycling.

NOTE: Entering the time set or options menu will override all brightness settings and will command the display to full brightness according to option #53 (blanking method).

NOTES ON CATHODE POISONING AND PREVENTION

Cathode poisoning occurs when inactive cathodes in a nixie tube get coated with material released or sputtered from the active cathodes. Cathode poisoning shows up as dark or dim spots in the effected digit. All nixie tubes are vulnerable to this effect in various degrees.

Clocks are especially vulnerable to cathode poisoning because the tens tube of the hour and minute do not utilize all digits during normal operation. If precautions are not taken, you can expect to see cathode poisoning in unused digits in several weeks to a few months of clock operation. Cathode poisoning is not a defect in the tube.

To prevent this from occurring, you have several options. The Digit cycling mode of this clock, namely the 'slots' option which runs every minute, should be able to prevent most all cathode poisoning.
If you do not wish to utilize the slots cycling, or the tubes require more cycling, a more aggressive cathode poisoning prevention method is provided that will cycle digits for a chosen amount of hours per day.
This option also has a full brightness override, which should be able to recover tubes that are already affected by light cathode poisoning.