

NixiChron AVR Upgrade

NixiChron AVR Upgrade is a processor upgrade board for the original NixiChron Nixie tube clock. It replaces the original Microchip PIC microprocessor, with a circuit board that includes an ATmega 1284P processor, hardware real time clock, supercapacitor backup, level converter, and inputs and outputs for additional sensors and devices.

The NixiChron AVR is a harmless, low voltage device. Opening the NixiChron clock to install it will expose high voltages. Consider this fact, and read the warranty at the end of this document. Return the NixiChron AVR for a full refund before installing it, if for any reason you feel that you cannot safely complete the installation.

The upgrade is fully reversible since no permanent changes are made to the original NixiChron, and only one reversible modification is required. Optional hardware features only connect to the NixiChron AVR Upgrade, and to power.

The software that runs NixiChron AVR is completely new. It is not an enhancement of the original NixiChron software. Operation and options are new and different.

Features of the upgrade include (subject to change):

- RGB LED lighting with a variety of interesting effects. Brightness and color of each intelligent APA102 RGB LED is individually controlled, and custom colors can be set for each hour. Optional RGB LED scrolling with digits.¹
- Three configurable override periods with independent settings for start and end times, Nixie brightness, RGB LED brightness, RGB colors and patterns, and colon patterns. Each period can be enabled for weekdays, weekends, or both. Period override button restores standard settings for user selectable time period.
- Real time clock with accuracy to approximately two second per week.
- Original NixiChron GPS receiver is supported, or substitute an Adafruit, Ublox, or other, TTL level GPS.¹ GPS is no longer required.
- Automatic time zone setting for Daylight Saving Time. Tables are not used! Month, week, day of week, and time, are used to calculate time changes, for easy updating as rules change.
- Scrolling date display with three selectable date formats.
- Scrolling temperature using original sensor, or add a BME280 weather sensor to display temperature, pressure, and humidity.¹
- Ambient light sensor increases brightness at user configurable setting.¹
- PIR sensor optionally enables display only when motion is sensed.¹
- Selectable cathode anti-poisoning helps to keep tubes in good condition.
- Two additional buttons for easier setting.¹

¹ Requires extra hardware and connections to the NixiChron AVR board.

Operation

Button functions

From the time display:

Hold Menu button until first beep, to select time Settings Menu

Hold Menu button until second beep, to select Options Menu

Hold Menu button until third beep, to select RGB Color Menu

Cycle past highest option to save changes.

With optional four button configuration, Menu and Set become Menu Up and Menu Down. Additional buttons are Set Up, and Set Down.

Press Set while time or date is displayed to announce time in Morse code (option 60 controls this setting).

Press Menu in override, to return to standard settings for selected period of time.

Setting the time and date:

Time is always set in 24 hour mode regardless of display setting, and date is always set as MM/DD/YY, regardless of date display format.

When time is displayed, press and hold Menu until first beep, then release. Use Set to adjust hours.

Press Menu to advance to the minutes setting. Again use Set to adjust minutes.

Continue to press Menu to advance to seconds, month, day, and year, using Set to adjust settings.

Date and time settings are not stored until Menu is pressed after setting the year.

When using GPS, the real time clock will be used to display the time, until the GPS synchronizes and sets the time. If the time has not been previously set or power has been removed for a period of time, the displayed time will be incorrect until it has been synchronized. There is no need to manually set the time, just wait until it synchronizes with the GPS.

Option settings:

* is default

From the time display, press Menu and hold until the second beep. Menu cycles through settings, Set changes the setting for each menu item. Settings are not saved until Menu is pressed at the highest option setting.

Some options require a power cycle, indicated by a blinking neon bulb, and a beep every second.

Option	Description	Setting
0	Display firmware revision	Cannot be changed
1	Time display mode	*0 – 12 hour 8 digit 1 – 12 hour 6 digit 2 – 24 hour 8 digit 3 – 24 hour 6 digit
2	Suppress leading zero	0 – no *1 – yes (12 hour mode only, when single digit is displayed, blank leading zero)
3	Date display each minute	0 – off *1 – MM/DD/YY 2 – DD/MM/YY 3 – YY/MM/DD
4	Neon display mode	0 – all off 1 – all on 2 – bottom flash 3 – all flash *4 – cross flash 5 – railroad flash 6 – left → right 7 - AM/PM bottom left/right top off 8 - AM/PM bottom left/right top on
5	Nixie brightness level	1-9 *4 (cannot be off)

Option	Description	Setting
6	RGB LED effect	1 – America Wave (red, white, blue) 2 – Blue – White Wave 3 – Red – White Wave 4 – RGB Wave 5 – Random Color Wave 6 – Red Wave 7 – Green Wave 8 – Blue Wave 9 – Multi-Wave *10 – Rainbow March 11 – Twinkle 12 – Red 13 – Green 14 - Blue
7	RGB LED brightness	0 – off 1 – 9 *8
8	Period 1 override start	*0 – 23 (start = end to disable)
9	Period 1 override end	*0 - 23
10	Period 1 override days	*0 – all 1 – weekdays 2 – weekends
11	Period 1 Nixie brightness	0 – 9 *2 1-2 are the same, except 1 puts clock in 4 digit, “night” mode with dim display
12	Period 1 Neon	Same as #4 *0
13	Period 1 RGB LED effect	Same as #6 *4
14	Period 1 RGB LED brightness	Same as #7 *1
15 - 21	Period 2	Same as Period 1
22 - 28	Period 3	Same as Period 1

Option	Description	Setting
29	Cathode anti-poisoning	0 – off *1 – every minute 3 – every 10 minutes 5 – every hour 7 – midnight 2,4,6,8 – same with full brightness
30	Cathode anti-poisoning run duration	*0 – 5 seconds 1 – 10 seconds 2 – 1 minute 3 – 10 minutes (not active in period overrides, except #29 midnight)
31	Digit change effect	0 – none *1 – cross fade
32	Period override disable	*0 – 15 seconds 1 – 1 minute 2 – 5 minutes (turns on display for selected time when period override is active and SW4 is short pressed)
33	GPS baud rate	0 – no GPS *1 – 4800 baud (NixiChron GPS) 2 – 9600 baud (Ublox, Adafruit GPS) 3 – 19200 baud 4 – 38200 baud 5 – 57600 baud
34	GPS Time offset from UTC	0 – 13 *5:00 (Offset from standard time to UTC, not daylight saving time. Default is EST. Thirty and forty-five minute offsets are supported.)
35	GPS offset direction	*0 - 1 +
36	DST month	0 – 12 *3 0 = no DST
37	DST week of month	1 – 5 *2
38	DST day of week	*1 – 7
39	DST time change	0 – 23 *2

Option	Description	Setting
40	DST offset	*1 – 13
41	DST offset direction	0 - *1 +
42	STD month	1 – 12 *11 (standard time)
43	STD week of month	*1 - 5
44	STD day of week	*1 - 7
45	STD time	0 – 23 *2
46	Temperature	0 – off *1 – Fahrenheit 2 – Centigrade
47	Temperature negative offset	0 – 99 *20 (.1 degree increments to adjust for internal heating) Temperature display is indicated by the upper-right neon.
48	Ambient light level	1 – 50 (display only – note level)
49	Ambient light level switch	*0 - off 1 – 50 (setting at which display switches to bright mode)
50	Ambient light level Nixie brightness	Same as #5 *9
51	Ambient light level RGB LED brightness	Same as #7 *9
52	Motion sensor (PIR)	*0 – off 1 - 10 seconds 2 - 20 seconds 3 - 30 seconds 4 - 1 minute 5 - 5 minutes 6 - 10 minutes When activated, display is off until motion is detected, then on for selected time

Option	Description	Setting
53	Scroll RGB with date and temperature	0 – off *1 – on RGB LEDS follow date and temperature scrolling
54	Pressure	*0=no display, 1=in-hg, 2=millibar Pressure display is indicated by the lower-right neon.
55	Humidity	*0=no display, 1=percentage Humidity display is indicated by the lower-right neon.
56	Add brightness to levels 1-8 for tubes that don't fully light at low settings	*0 – 20 Each step is 1/10 brightness level.
57	AM/PM Neon Indicator	0 – off *1 – on Active in 12 hour mode only
58	Date/Weather Scroll start second	*50 0 - 59 Overlap with anti-poison will cancel anti-poison routine.
59	Anti-Poison start second	*30 0 - 59 Overlap with date/temp scrolling will cancel date/temp display.
60	Buttons	*0 – 2 buttons 1 – 4 buttons
61	Morse code time announcement	*0 - off 1 – off, use Set Up to announce 2 – minute 3 – 5 minutes 4 – 15 minutes 5 – hour
62	Morse code time announcement during overrides	*0 – no 1 - yes
63	Morse words per minute	1 – 10 *2 – 15 3 – 20 4 – 25 5 - 30

Option	Description	Setting
64	Internal 1PPS LED Indicator	0 – off *1 - blink

Custom RGB LED Color Menu

Setting custom colors is tedious, with only two buttons. From time display, press Menu and hold until third beep.

A custom Red, Green, and Blue (RGB) LED color can be set for each hour, using this menu.

A menu will be displayed showing the hour on the left two digits, 0-23. Pressing Menu increments the hour. Further presses cycle between red, green, blue, and the following hour.

Three digits on the right represent red, green, and blue, in that order. Set controls the brightness of the lit color.

With the four button display option activated, Menu Up controls the hour, Menu Down selects the color, and Set Up and Set Down, control brightness for the selected color and hour.

When red and green are set to 0, the Options Menu is used to control RGB colors and effects for that hour, and RGB Menu settings for that hour have no effect.

Setting red and green to 1, allows blue to be set to any of the Options Menu settings specified in #6. For example, 1-1-0 turns off the display for the set hour, 1-1-1 sets the America Wave effect for the set hour.

Colors 2-9 represent increasing brightness levels for each RGB color. By varying the brightness for each color, up to 512 color combinations are available for each hour.

Color settings are only saved by cycling past 23, returning to the time display.

Custom RGB settings always take precedence over other settings. For example, setting an override for 2300 to 0700 and custom RGB for 0100, override settings are used for 2300 to 0700 except for the period between 0100 and 0200, where the custom RGB setting is in effect.

Installation

This probably doesn't need to be said – before you begin, remove the tubes, colon towers, and neon bulb!

Step 1 – Modification

With the power connector facing down, the Microchip PIC16F877 processor chip is on the upper-right. It should be removed carefully using the included chip puller.

Option 1 is easy. Option 2 is more involved.

Option 1 – No Cut Traces

Pin 22 on U1 and U2, the HV5530 chips, must be connected to +12v, instead of ground. This is easiest to do on the chip itself. This modification is easily reversible.

Look carefully at the top of the HV5530 sockets. In the middle of the side facing away from the Microchip PIC16F877 processor chip, a small arrow is visible pointing to the center pin. That is pin one. Yes, pin 1 is in the center of a row, not adjacent to the flattened corner. Count, counter-clockwise to pin 22. Mark it and remove the chip using the included chip puller.

Bend the pin up, very close to the chip. Connect a wire from that pin, to the cathode (black bar) side of diode, D3. The wire can be soldered, or wire wrapped. Push the contact in the socket back toward the edge of the socket, so that it will not touch the pin when the chip is returned to its socket. **Make sure it does not touch the pin, or the fuse will blow** (if it happens, take that opportunity to replace the fuse with a 1 amp polyfuse).

Make this modification to both HV5530 chips, U1 and U2.

Option 2 – Cut Traces

This option is nearly invisible and it is not necessary to connect a wire directly to the chip.

Remove IC U1, and IC U2, using the included chip puller.

On IC U1, cut the wide ground trace on top of the board from pin 22, leading to the adjacent capacitor. On the bottom of the board, cut the ground connection between pins 22 and 24. Using jumpers, connect pin 24 to ground, and pin 22 to +12v. Pin 25 is a good place to find +12v.

On IC U2, cut the ground trace on top of the board from pin 22 to the adjacent capacitor. Cut

the trace on the bottom of the board between pins 22 and 24. Connect pin 22 to +12v at pin 25. Connect pin 24 to ground.

Finish

On U1 and U2, check that pin 24 has continuity to ground. Apply power and check that pins 22 and 25 are at +12v. Reinstall both U1 and U2.

Step 2 – Set Crystal Clearance

If the crystal was mounted vertically, it must be removed or pushed down so that its highest point is below the level of the 44 pin sockets. Connections should be heated with a soldering iron. The crystal is not needed.

Step 3 – Install NixiChron AVR Board

The 44 pin headers on the bottom of the NixiChron AVR board can be angled slightly out, to better hold the board in place. **CAREFULLY** install the board with the header pins inserted into the processor socket. They may have to be pressed toward the center slightly using a small screwdriver or other tool. **Make sure they are aligned with the socket pins!**

Use a few dabs of silicone, epoxy, or other adhesive between the edge of the board and the processor socket, to keep the board in place.

If you can't figure out how to orient the board, you should probably not be doing this upgrade yourself. Consider finding someone to do it for you, and seek professional help.

Step 4 – Connect +12v

Connect a wire from J7, the +12v pad on the NixiChron AVR board, to the cathode (black bar) side of D3, on top of the board. This provides +12v to the level converter chip on the NixiChron AVR board.

This concludes the standard installation procedure.

Step 5 – Power for Accessories

Optional – Advanced users only, and only required if optional hardware is added and powered from the NixiChron AVR Upgrade.

Run a wire (not supplied) from the J6 5v pad on the NixiChron AVR board, to +5v on the NixiChron, and another wire from the J5 ground pad, to ground on the NixiChron. This allows

the J4 connector to power optional sensors and accessories except RGB lighting, which should be powered directly from the NixiChron. **DO NOT** power any accessories from pin 2 on J4 unless these two wires are connected! If these wires are not used, connect all accessories to +5v and GND directly on the NixiChron board, and do not use those pins on the J4 connector. A good place to find +5v and ground, is the three open holes next to the regulator.

Sensors and Accessories

The following are notes for the installation of hardware accessories. This is for advanced users only. Step by step instructions are not provided and support is not offered. If this is not enough information for you to successfully install these accessories, you should probably stop here. **Mistakes in wiring may destroy some or all parts on the NixiChron AVR and the NixiChron, and will void the warranty!**

RGB lighting must be built into the case, obviously. The weather sensor can be added to a short, four wire cable similar to the original temperature sensor, or it can be built into an accessories case, along with other sensors. The weather sensor must not be covered or sealed in an enclosure. The original temperature sensor will be disabled in software if a BME280 is available. It does not have to be removed.

RGB Lighting

The NixiChron AVR board directly connects to APA102 intelligent RGB lighting strips. These can be found on eBay from many sources. Purchase a strip that includes 30 LEDs per meter, and a black background probably works best. Do not purchase the waterproof version.

Cut a strip eleven LEDs long. Remove every other LED, and jumper the clock and data lines, at each removed location. Remove the adhesive backing.

Install the strip so the first LED on the wire side is under the ten hours tube. The strip is folded at several points along its length, so that every LED is aligned with a tube. Wrap the strip in electrical tape and push it down between Nixie tube pins. Use silicone or other adhesive to keep the strip in place, and **make sure the LED contacts do not touch the high voltage pins on the tubes!**

Connect +5v and GND from the strip directly to the NixiChron board, because the LED strip will draw a relatively substantial amount of current compared to other accessories. Connect clock and data to the LEDClock and LEDData pins on the NixiChron AVR. Route the clock and data lines away from the high voltage supply components. Update the Settings Menu.

PIR Sensor

Source an HC-SR501 PIR Infrared sensor, or equivalent. They are easily found on eBay.

Connect to power and PIR input, as indicated. Turn the timer control on the module down all the way because timing is done in the clock software. Adjust sensitivity on the module, as desired. Set threshold in the Settings Menu using options 48 to read the light level, and 49 to set the level.

Weather Sensor

Source a BME280 weather sensor on a breakout board, also commonly available on eBay. The correct boards have four connections, +5v, GND, SCL, and SDA, and they connect using the I2C standard. Other types of boards may work too, as long as they support I2C. Address should be 0x76-0x77. Select settings as desired, in the Settings Menu. Keep the wires as short as possible.

Temperature is displayed first, when all three options are active. Range is 0-99.99.
Pressure display is indicated by the lower-right neon.
Humidity display is also indicated by the lower-right neon, following pressure display.

Light Sensor

Source a TEPT4400 light sensor. Connect the collector (long lead) to the Light input connection on the NixiChron AVR board, along with a 68k resistor in series. Connect the other side of the resistor to +5v. Connect the emitter (short lead) to ground. Enable in the Settings Menu.

SW3 and SW4 Pushbuttons

Two additional pushbuttons ease the process of setting options, especially in the Custom RGB Settings Menu. Connect one side of each button to the SW3 and SW4 contacts on the NixiChron AVR. Connect the same side of each button to a 10k resistor. Connect the other side of each resistor, to GND. Connect the other side of each button to +5v.

Change the Buttons option in the Settings Menu, option 60. The original two buttons become Menu Up and Menu Down. The additional button functions are Set Up, and Set Down.

GPS

The original NixiChron GPS is fully supported. Its default baud rate is 4800. Ublox and Adafruit TTL level GPS modules have been tested and work perfectly. Most any GPS module that provides TTL standard NMEA strings should work.

To use a TTL level GPS, remove the J8 jumper from GPS to internal, and connect GPS to

external. The default baud rate for these modules is probably 9600, so it should be changed in option 33. The MAX232CPE chip can be removed when using an external GPS.

This concludes the installation of optional accessories.

Enjoy the new functionality of your NixiChron!

Warranty Terms and Conditions

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